Coastal Forests of Eastern Africa

IUCN's Forest Conservation Programme

IUCN's Forest Conservation Programme coordinates and supports the activities of the IUCN Secretariat and members working with forest ecosystems. The goal of forest conservation is achieved through promoting protection, restoration and sustainable use of forest resources, so that forests provide the full potential range of goods and services.

The programme makes contributions to policy at various levels and uses field projects to derive lessons to feed into the policy debate. The principles of *Caring for the Earth*, published jointly by IUCN, WWF and UNEP in 1991, are applied to these projects, which combine the needs of conservation and those of local communities. One major activity is to develop coherent and informed policies on forest conservation in order to advocate the translation of policies into effective actions. IUCN frequently advises major development institutions on forest issues, to ensure that conservation priorities are adequately addressed in their projects and programmes. The Forest Conservation Programme receives generous financial support from the Government of the Netherlands.

IUCN Forest Conservation Programme

Coastal Forests of Eastern Africa

Edited by

Neil D. Burgess and G. Philip Clarke

IUCN – The World Conservation Union
2000

The production and printing of this book was generously funded by the Royal Norwegian Embassy, (Tanzania) and the Center for Applied Biodiversity Science, a division of Conservation International (USA).

Published by: IUCN, Gland, Switzerland and Cambridge, UK.

Citation: Burgess, N.D. and Clarke, G.P. (Eds.) (2000). *Coastal Forests of Eastern Africa.* xiii + 443pp.

ISBN: 2-8317-0436-7

Cover design by: McHale Ward Associates, Ware, Hertfordshire, UK.

Front cover photo: Legume-dominated eastern African Coastal Dry Forest, Arabuko-Sokoke Forest Reserve, Kenya. Main tree species *Cynometra webberi.* (*Photo: G. P. Clarke)*

Back cover photos: Top: Shimba Hills, Kenya; middle: East Usambara Mountains, Tanzania and bottom: Rondo Plateau, Tanzania. (*Photos: G. P. Clarke)*

Layout by: IUCN Publications Services Unit, Cambridge, UK.

Produced by: IUCN Publications Services Unit, Cambridge, UK.

Printed by: Page Bros (Norwich) Ltd, UK.

Available from: IUCN Publications Services Unit
219c Huntingdon Road, Cambridge CB3 0DL, United Kingdom
Tel: + 44 1223 277894, Fax: +44 1223 277175
E-mail: info@books.iucn.org; http://www.iucn.org

A catalogue of IUCN publications is also available.

The text of this book is printed on Fineblade Extra 90gsm low-chlorine paper

Dedication

This book is dedicated to Jan Kielland who studied the butterflies of Tanzania for many years. He funded most of his own expeditions and was still exploring remote parts of the Tanzanian bush at the age of 60. He used the results of all his studies to write the *Butterflies of Tanzania*, a milestone in Tanzanian butterfly study, published in 1990. Jan did all of this not as a job, or for a career, but out of his love of Tanzanian wildlife (especially butterflies) and his love of exploration. His death in a car accident in Tanzania in 1995 is a sad loss to all of those interested in the inventory and conservation of the biological resources of eastern Africa.

Contents

Contributors

Leon Bennun, Head of Ornithology Department, National Museums of Kenya, P.O. Box 40658, Nairobi, Kenya.

Don Broadley, formerly of the Natural History Museum of Zimbabwe, P.O. Box 240, Bulawayo, Zimbabwe.

Neil Burgess, Danish Centre for Tropical Biodiversity, c/o Zoological Museum, University of Copenhagen, Universitetsparken 15, DK-2100, Copenhagen Ø, Denmark.

G. Philip Clarke, The Hermitage, Hermitage Street, Crewkerne, Somerset, TA18 8ET, UK. Formerly of the Frontier-Tanzania Coastal Forest Research Programme, P.O. Box 9473, Dar es Salaam, Tanzania.

Anya Cockle, Lab d'Ecologie Générale, 4 bis Avenue Petit Château, 91800 Brunoy, France.

Norbert Cordeiro, 1755 Sherwood Road, Highland Park, IL 60035, USA.

Alex Dickinson, c/o Society for Environmental Exploration, 77 Leonard Street, London, EC2A 4QS, UK.

Yvette Evers, formerly of Anthropology Department, University College London, Gower Street, London, WC1E 6BT, UK.

Clare FitzGibbon, c/o Department of Zoology, Downing Place, University of Cambridge, Cambridge, UK.

Jette Raal Hansen, formerly of Botanical Institute, University of Copenhagen, Gothersgade 140, DK-1124, Copenhagen, Denmark.

Vibeke Hørlyck, Botanical Museum, University of Copenhagen, Gothersgade 130, DK-1123 Copenhagen, Denmark.

Richard Hoffman, Virginia Museum of Natural History, 1000 Douglas Avenue, Martinsville, Virginia, USA.

Paul Honess, Department of Anthropology, Oxford Brookes University, Gipsy Lane Campus, Headington, Oxford, OX3 0BP, UK.

Kim Howell, Zoology Department, University of Dar es Salaam, P.O. Box 35064, Dar es Salaam, Tanzania.

Paula Jenkins, Mammal Group, The Natural History Museum, Cromwell Road, London, SW7 5BD, UK.

Jonathan Karoma, Department of Archaeology, University of Dar es Salaam, P.O. Box 35060, Dar es Salaam, Tanzania.

Jan Kielland (deceased), P.O. Box 4916, Boröy, Norway.

Dieter Kock, Forschungsinstitut und Naturmuseum Senckenberg, Senckenberganlage 25, 60325, Frankfurt am Main, Germany.

Charles Kweyunga, Department of Microbiology, University of Dar es Salaam, P.O. Box 35060, Dar es Salaam, Tanzania.

Jon Lovett, Environment Department, University of York, Heslington, York, YO1 5DD, UK.

Andrew Lowe, Department of Plant Sciences, University of St. Andrews, St. Andrews, Fife, UK.

Jane Madgwick, Broads Authority, 18 Colegate, Norwich, NR3 1BQ, UK.

Paul Matthews, c/o Society for Environmental Exploration, 77 Leonard Street, London, EC2A 4QS, UK.

Saidi Mbwana, Environment Division, P.O. Box 426, Dar es Salaam, Tanzania.

Charles Mlingwa, Zoology Department, University of Dar es Salaam, P.O. Box 35064, Dar es Salaam, Tanzania.

Leonard Mwasumbi, Department of Botany, University of Dar es Salaam, P.O. Box 35060, Dar es Salaam, Tanzania.

John Poynton, 14 Mordern House, Harewood Avenue, London NW1 6NR, UK.

S. Ann Robertson, P.O. Box 162, Malindi, Kenya.

W. Alan Rodgers, Chief Technical Advisor, FAO/GEF, P.O. Box 2, Dar es Salaam, Tanzania.

Line Sørensen, Zoological Museum, University of Copenhagen, Universitetsparken 15, DK-2100, Copenhagen Ø, Denmark.

Leigh Stubblefield, Society for Environmental Exploration, 77 Leonard Street, London, EC2A 4QS, UK.

Bernard Verdcourt, Royal Botanic Gardens, Kew, Richmond, Surrey, TW9 3AB, UK.

Kaj Vollesen, Royal Botanic Gardens, Kew, Richmond, Surrey, TW9 3AB, UK.

Edward Waiyaki, Ornithology Department, National Museums of Kenya, P.O. Box 40658, Nairobi, Kenya.

Kerry Woodcock, Tanzania Forest Conservation Group, P.O. Box 23410, Dar es Salaam, Tanzania.

Acknowledgements

Dr Alan Rodgers of the FAO/UNDP/GEF Biodiversity Support Programme for East Africa provided considerable advice, assistance with locating data for many of the Chapters, and contacts to be written to for further help. He also undertook to make detailed, perceptive, and often highly critical comments on many of the draft Chapters in this book.

The Norwegian Development Assistance Agency (NORAD), through the Royal Norwegian Embassy in Dar es Salaam, provided three separate grants to support this book. The first was for the hosting of a workshop on the Coastal Forests of eastern Africa in Dar es Salaam in 1993, the second was funding for the production of a series of Status Reports summarising data relating to the management of the Tanzanian Coastal Forests, and the third was for the printing costs of this book. We are pleased to acknowledge their very important contribution towards the completion of this book.

We would also like to acknowledge the generous financial contribution to the printing and distribution costs from the Center for Applied Biodiversity Science, a Division of Conservation International.

The Danish Centre for Tropical Biodiversity allowed the senior editor to complete this book in 1995–97 as part of its programme to investigate, describe and explain the patterns of biodiversity in eastern African forests. The Danish Centre for Tropical Biodiversity also supported the work of Jon Lovett, Vibeke Hørlyck, Jette Raal Hansen and Jon Fjeldså, who have all made a contribution to this book, the latter through his many valuable comments and useful discussions on the Coastal Forests and the montane forests of eastern Africa.

The Frontier-Tanzania Coastal Forest Research Programme (1989–94) of the Society for Environmental Exploration and the University of Dar es Salaam provided the initial impetus for this book. Particular thanks are extended to Prof. Juma Kapuya, Prof. Adelaide Semesi, Prof. Kim Howell and Dr Felister Urasa of the University of Dar es Salaam, and Ms. Eibleis Fanning, Mr Nicholas Payne and Mr David King of the Society for Environmental Exploration for their efforts to start up this programme. Data from six years of surveys of Tanzanian Coastal Forests are used in many of the chapters in this book. The use of these data is gratefully acknowledged and the contribution of Frontier-Tanzania's expeditions is especially important. Since 1995 Frontier has worked in the lowlands of the East Usambaras, sponsored by FINNIDA, and published results of these studies are also used here.

BirdLife International, through the Royal Society for the Protection of Birds – the BirdLife partner in the UK, allowed the senior editor to initiate this project whilst being employed in its International Department from 1990–94. Their contribution is also gratefully acknowledged.

The World Wide Fund for Nature (WWF), in collaboration with the National Museums of Kenya (NMK), supported a major survey of the status and vascular plants of the Coastal Forests of Kenya. This survey also provided some of the data used in this book, for which we are grateful.

Thanks are also expressed to the Tanzanian Ministry of Tourism, Natural Resources and Environment (Forestry Division), World Wide Fund for Nature (WWF) – Tanzania, Wildlife Conservation Society of Tanzania (WCST), World Conservation Monitoring Centre (WCMC), Tanzania Commission for Science and Technology (COSTECH, Tanzania), Tanzania Forestry Research Institute (TAFORI, Tanzania) for their support and provision of data.

The following individuals within their respective organisations were particularly helpful during the gathering of data and writing of this book:

K. Howell, J. Kapuya, P. Kasigwa, K. Kayombo,P. Kihaule, C. Kiyunga, H. Lyaruu, F. Mbago, C. Mlingwa, B. Mponda, L.B. Mwasumbi, C. Msuya, P. Munyenyembe, A. Nikundiwe, Z. Rulangaranga, A. Semesi, H. Suleiman, F. Urasa (University of Dar es Salaam, Tanzania); S. Mbwana (Tanzanian Environment Division); P. Akitanda, H. Fottland, S. Iddi, S. Johanson, M. Katigula, B. Kessy, Z. Kitale, R. Maganga, L. Massawe, G. Mbonde, R. Njana, R. Sagampa, G.E. Saria (Tanzanian Forestry Division); N. and E. Baker, H. Blom, S. Davies, J. Frössling, J. Kiure, E. Lagerstedt, P. Nnyiti (Wildlife Conservation Society of Tanzania); M. Apado, C. Kimini (Kenyan Forestry Division); A. Robertson and Q. Luke, L. Bennun and E. Waiyaki, G. Davies (National Museums of Kenya); J. Allen, C. Ansell, J. Bayliss, J.J. Brade, M. Brewin, J. Bryan, C. Clunies-Ross,

A. Chepstow-Lusty, G. P. Clarke, A. Cockle, A. Dickinson, R. Douglas, G. Elliot, B. Hayes, J. Kingdon, A. Lowe, P. Matthews, R. McCaffrey, K. McClusky, C. Muir, V. Petitt, K. Ponder, H. Rowan, J. Rubens, K. Salusbury, D. Sheil, J. Smith, L. Stubblefield, T. Waters, S. Willott, L. Thorburn (Frontier-Tanzania Coastal Forest Research Programme); S. Bidgood, B. Verdcourt, K. Vollesen (Royal Botanic Gardens, Kew); J. Dyck, Z. Bhatia, J. Fanshawe and N. Coulthard (BirdLife International); J. Boshe, T. Cunningham, A. Hamilton, J. Hellin, Y. Nsemwa (World Wide Fund for Nature); A. Tye, S. Stuart (IUCN – The World Conservation Union); J. Fjeldså, V. Hørlyck, J. Hansen, T. Lehmberg, J. Lovett, N. Scharff, L. Sørensen (Botanical and Zoological Museums of the University of Copenhagen); A. Hipkiss, A. Perkin, T. Evans and L. Watson (Kambai Forest Conservation Project, UK and Tanzania); N. Kimaro (IUCN East Usambaras Project, Tanzania); D. Eaton (University College London, UK); B. Clarke (The Natural History Museum, London, UK); A. Schiøtz (Danmarks Akvarium, Denmark); M. Huxham (University of Aberdeen, UK); S. Bearder (Oxford Brookes University, UK); K. Murira (Tanzania Forest Research Institute, TAFORI, Tanzania); Camilla da Sousa and P. Duarte Mangue (Forestry Research Institute in Maputo, Mozambique); K. Tinley (Gaia-Zygy Ecological Consultants, Australia); B. Best and C. Clarke (Ecuadorian Dry Forest Project, UK); A. Githitho (KIFCON project, Kenya); T. Williams (Liverpool University, UK); J-P. Lequeux, (France); T. Pócs (Esterhazy Teaching College, Hungary); R. Doggett (UK); G.S. and B. Clarke (UK); J. Hatton (Department of Biology, University Eduardo Mondlane, Maputo); Dr. Saket (Maputo, Mozambique); J. Timberlake (Forestry Division, Harare, Zimbabwe); D. Broadley (Natural History Museum of Zimbabwe, Bulawayo).

Moreover, the following Frontier-Tanzania staff and volunteers also collected data from the Coastal Forests of Tanzania between 1989 and 1995, some of which are used here: A. Reid, Adele Ratcliffe, Adrian Cudmore, Adrian Hall, Adrian Pawley, Alan Don, Alastair Malkin, Alastair Semple, Alex Chepstow-Lusty, Alex Dickinson, Alex Preston, Alexander Buske, Alexandra Rowden, Alice Plunkett, Alison Bennet, Alison Taylor, Alison Thompsett, Amanda Hawthorne, Amanda Lawton, Amy Docherty, Amy Francis, Amy MacKinven, Andrea Duffy, Andrea Green, Andrew Cook, Andrew Cooke, Andrew Hart, Andrew Lowe, Andrew Marlton, Andrew Nicholson, Andrew Radford, Andy Goodwin, Angela Mitchell, Angela Thompson, Anita Gribben, Ann Pegg, Anna Christie, Anna Marriott, Anna Nesling, Annelise Nehammer, Annuka Vahasarja, Antonia Williamson, Anya Cockle, Åsa Nyberg, Ashley Matthews, Augusta Grand, Barbara Payne, Barnaby Phillips, Barry Jarvis, Belinda Aird, Belinda Kirk, Ben Hayes, Ben Mooney, Benjamin Chance, Benjamin Ticehurst, Bernard Mponda, Beverly Warburton, Bridgett Marshall, Bruce Smith, Caitlin Bodrugan, Carmel Downey, Carol Ryder, Caroline Boffey, Caroline Gratwick, Cassandra Clunies-Ross, Cassandra Van Aalsum, Caroline Malcolm, Catharine Muir, Catherine Lightfoot, Catherine Prasad, Catherine Simmonds, Catriona Smith, Cecilia Luttrell, Celine Cullum, Charlotte Jenkins, Charlotte Moreton, Charlotte Aybes, Chris Vincent, Christine Ngoyani, Christopher Barnett, Christopher Cutts, Christopher Eng, Christopher Farnell, Christopher Jones, Christopher Meredith, Clare Ansell, Clare Gilliam, Clare Patten, Clare Smiley, Clare Tenner, Claire Quinn, Claire Martindale, Cleo Small, Clive Morrow, Clive Turner, D. Hillier, D. Nicholas McCowen, Damien Wache, Damon Pattison, Dan Harder, Daniel Emlyn-Jones, Daniel McLachlan, Daniella Pezzato, Darren Withers, David Albrecht, David Fountain, David Green, David Schley, David Shorten, David Storer, Deborah Mackenzie, Dinesh Chauhan, Dominic Johnson, Dorothy Smith, Douglas Sheil, Edward Shelton-Agar, Edward Smith, Elaine Buckland, Eleanor Clarke, Elisabeth Ramsay, Elizabeth Burns, Elizabeth Goldman, Elizabeth Mead, Elizabeth Morris, Elizabeth Rhoda Holmes, Emily Axton, Emily Funnel, Emily Woods, Emma Cornish, Emma Jacques, Emma Millward, Emma-May Harrison, Eve Horner, Ewan Dryburgh, Fatima Imari, Fiona McIntosh, Finlay Scott, Fran Ansell, Francis Tarimu, François Boudsocq, Frank Clarke, Garry White, Gaspar Mushi, Georgina Offord, Georgina Sturrock, Giles Elliot, Giles Gurney, Giles Stokes, Gita Prabhu, Gordon Miles, Graham Sherratt, Greg Pilley, H. George Fowkes, Hanna Siurua, Harriet Marshall, Hazel Williams, Heather Bailey, Heather Rowan, Helen Bainbridge, Helen Newton, Helen Pelly, Helen Stark, Hilary Gamon, Howard Rogers, Hugh Kleinberg, Ian Johnson, Ingrid Holmes, Jack Trevelyan, Jackie Metcalfe, Jacqueline White, Jacob Davies, James Murray, James Murray-Jones, James Pickavance, James Smith, James Spurgeon, James Telfer, James Urquhart, James Wakibara, Jane Stout, Janet Bryan, Janet Dinsdale, Janet Smith, Janet Spensley, Jason Rubens, Jeffrey Goddard, Jennifer Kinns, Jeremy Johnson, Jeremy Webb, Jessica Ostler, Jo Tufton, Jo Wright, Joanna Watson, Joanna Shooter-Holt, John Allen, John Brockbank, John Cope, John Staniforth, John Wilson, Jon Hellin, Jonathan Banner, Jonathan Kingdon, Jonathon Bradley, Jonathan Latchford, Jonathon Wibberley, Judith Noon, Juli-Marie Kett, Julia Still, Julia Harrison, Julia Holland, Julian Bayliss, Julian Kivell, Julie Grainger, Justin Anderson, Jussi-Pekka Rasinmaki, Karen Crawley, Karen Sidwell, Karyn McClusky, Kate Salusbury, Kate Westmacott, Katharine Ardouin, Katharine Liston, Katherine Kennedy, Katharine Watkins, Katie Parsons, Katrina Tilbrock, Katriona Shea, Katty Ponder, Kerry Woodcock, Laura Smith, Lauren Blencowe, Lawrence Gill, Lea Ewing, Leigh Stubblefield, Lesley Dowling, Liana Joseph, Lisa Brunwin, Lil Stevens, Lisa Proudlock, Lisa Shorey, Lizzie Harper, Louise Elsworth, Lucy Astle, Lucy Cadbury, Lucy Kopanska, Lucy Smailes, Lucy Thorburn, Lynda Mathewson, Lynn Hughes, Marie Lewis, Mark Dixon, Mark Huxham, Mark Johnson, Mark Lawrence, Mark Leney, Mark Lucien Weyermann, Mark Miodownik, Mark Shears, Mark Terrington, Markus Fraval, Mary Lane, Mary MacSweeney, Matthew Boardman, Matthew Gould, Matthew Stables, Maureen Exton, Melanie Salmon, Michael Ako, Michael Mooney, Michael Smith, Michael Verasingham, Mike Brewin, Mike Skilbeck, Mukisa Jackson, Muriel Goudet, Murtaza Mohammed, Natasha Grist, Neil Burgess, Neil Walke, Nick Beale, Nicola Hill, Nick Chapman, Nick Smith, Nick Yeo, Nicole Ledwith, Noreen Matheson, Oliver Flieger, Omi Parikh, Owen Matthews, Paul Matthews, Paul Smith, Paul Twynham, Paula Carney, Paula Kiss, Penelope Brodribb, Peter Foster, Peter Kairanya, Piers Locke, Phil Clarke, Philip Bowen, Philip Smythe, Polly Goodwin, Prama Bhardwaj, Rachael Carson, Rachel Hirst, Rachel Hughes, Rachel McCaffrey, Rebecca Clarke, Rebecca Gunning, Rebecca Perks, Rhiwena Slakc, Richard Alderson, Richard Douglas, Richard Waddington, Richard Preston, Richard Selman, Richard Sheil, Richard Telford, Rigby Jerram, Robbie Banda, Robert Barnes, Robert Gooday, Robert Tolhurst, Robert Young, Rosalyn Doggett, Sally Wood, Samantha Munn, Sara Willis, Sarah Barry, Sarah Beaumont, Sarah Bruce, Sarah Cowan, Sarah Feore, Sarah Grimshaw, Sarah Jupp, Sarah Morton, Sarah Parry-Jones, Sarah Proctor, Sarah Thompson, Serena Maddocks, Sharyn Ayres, Shivaun Scanlan, Shona Hunter Dunn, Simon Cox, Simon Ogle, Simon Rooke, Simon Saunders, Sonia Hudson, Sophie Rowlatt, Sophie Walton, Stan Davies, Stephen Duncan, Stephen Kilmurray, Stephen Jacques, Stephen Perry, Stephen Willott, Steven Pyer, Stuart Perry, Susan Fuller, Tabitha Mason, Tamsin Knight, Tanya Green, Terry O'Hara, Tertia Waters, Theresa Huvisa, Thomas Bean, Thomas Parker, Thomas Savage, Tim Bowden, Timothy Hellen, Timothy Holden, Toby Jones, Tracey Blunn, Vanessa Bainbridge, Vicky Petit, Victoria Dodwell, Virginia Curry, W. Robert Baldock, Wendy Champion, William 'Chad' Marshall, William Hynd.

Neil D. Burgess
Danish Centre for Tropical Biodiversity,
c/o Zoological Museum, University of Copenhagen,
Universitetsparken 15, DK-2100,
Copenhagen Ø, Denmark

and

G. Philip Clarke
The Hermitage, Crewkerne,
Somerset, TA18 8ET, UK

List of abbreviations

ABRI	African Butterfly Research Institute
BMNH	The British Museum of Natural History (now The Natural History Museum)
DANIDA	Danish International Development Agency
DOF	Dansk Ornitologisk Forening – the BirdLife partner in Denmark
EBA	Endemic Bird Area
EU	European Union
FAO	Food and Agriculture Organisation of the United Nations
FINNIDA	Finnish International Development Assistance Agency
GEF	Global Environment Facility
IBA	Important Bird Area
ICBP	International Council for Bird Preservation (now BirdLife International)
IUCN	The World Conservation Union
KIFCON	Kenyan Indigenous Forest Conservation Project
NGO	Non-Governmental Organisation
NMK	National Museums of Kenya
NORAD	Norwegian Agency for Development
ODA	The Overseas Development Administration (British Government), now DfID.
OECD	Organisation of Economic Cooperation and Development
RSPB	The Royal Society for the Protection of Birds – the BirdLife partner in the UK
SVS	Swedish Volunteer Service
UDSM	The University of Dar es Salaam (Tanzania)
UNDP	United Nations Development Programme
VSO	Voluntary Service Overseas
WCST	Wildlife Conservation Society of Tanzania– the BirdLife partner in Tanzania
WWF	World Wide Fund for Nature (World Wildlife Fund – in North America)

Section 1

Introduction and definition

The introduction presents a personal view of the changes in the perception of these forests over the last two decades, and of the efforts to ensure their conservation. This is written by Dr Alan Rodgers, who spearheaded the group of academics at the University of Dar es Salaam who realised the potential importance of these formerly neglected forests, and who is now involved in their conservation, as a part of an initiative arising from the 1992 Rio Conference on Environment and Development.

The second part of the section presents a formal definition of the Coastal Forests of eastern Africa, based on a detailed assessment of species, geographical and other data relevant to the coastal region of eastern Africa.

Figure 1 Dry scrub forest, Namakutwa-Nyamuete Forest Reserve, Matumbi Hills, Coast Region, Tanzania. The 8m deciduous canopy of this vegetation type has caused some scientists to label it as either thicket or woodland, even though it has an even forest canopy structure and contains many forest species. The dry nature of many of the Coastal Forests, together with confusion over the identity of some of their vegetation types (such as at Namakutwa-Nyamuete), formerly obscured their biological importance. (*Photo: G.P. Clarke*)

1.1 Why a book on Coastal Forests?

W. A. Rodgers

Prologue

Looking back to twenty years ago, when I and other conservationists and biologists in Dar es Salaam first began to document the values of the Coastal Forests of Tanzania, our primary interest at that time was in having somewhere to go for the short-weekend break away from university duties. There was insufficient time to reach the more spectacular (and cooler!) mountain forests, and so the Coastal Forests were the only option. That attitude of "second best" continues to pervade much of the professional attitude to the resources of the coastal area today, be it conservation, development or science – the coastal plain is the flat, hot, sticky, boring bit you have to cross over to get to more interesting parts of the hinterland.

But what a biological treasure house we began to discover in those Coastal Forests, and still continue to discover!! We now realise that many of the isolated forest patches have exceptional levels of localised endemism within many major taxa. Most forest patches differ in their community structure and species composition, and so the forest types are not easy to classify or generalise. But, being fragmented, small and surrounded by people, they are extremely vulnerable, and are rapidly being degraded.

Coastal Forests as a conservation unit

Conservationists and their funding agencies need working definitions as to what is a Coastal Forest. At first sight this appears easy, with the obvious answer – "they are the forests of the coastal strip of eastern Africa". Tanzania's Tropical Forest Action Plan (TFAP, 1989) is based on such a definition, and neatly divides the country's closed forest resources into three separate blocks:

- The mangrove forests of the salt-water coasts (Figure 1.1.1)
- The forests of the mountain systems (Figure 1.1.2)
- The lowland forest patches – 'the Coastal Forests' (Figure 1.1.3)

(Note that the woodland resources (Figure 1.1.4) form separate categories).

But setting the exact limits as to where 'coastal', 'montane' and 'woodland' start or end is rather difficult. Coastal Forest has not hitherto had a watertight definition, although the next Chapter in this book attempts a definition based on their physical and biological characteristics (Chapter 1.2), followed by a comparison with the montane forests (Chapter 3.4). But any definition must allow for the dynamics of vegetation itself. Much of the past Coastal Forest is now transformed into cultivation steppe and thicket. Given time the thicket will regenerate into forest, so from a conservation viewpoint Coastal Forest should not be too rigidly defined.

The Coastal Forest resource

What we see today is almost certainly the remains of a once widespread forest cover along the eastern African seaboard. There are several sets of evidence for this, including historical accounts and maps (see for example the account of 19th century trade in Gum Copal, derived from the Coastal Forest tree *Hymenaea verrucosa,* Rodgers (1996); and Kjekshus (1975/1996) for a more general coverage of ecological history). But today the eastern African coast is mapped as a moist savannah complex, for the forest has largely gone (Kingdon, 1971; White, 1983), leaving a little over 250 patches of forest (Chapter 3.1). Within this moist savannah we see a wide range of floristic associations and localised endemism, including different forest types (Chapter 3.2). This distinctiveness cannot have arisen

Figure 1.1.1 Mangrove forest, Simba Uranga Island, Rufiji Delta, Coast Region, Tanzania. (*Photo: G.P. Clarke*)

Figure 1.1.2 Montane forest (1600m altitude), Uluguru North Forest Reserve, Morogoro Region, Tanzania. (*Photo: G.P. Clarke*)

Figure 1.1.3 Coastal Forest (300m in altitude), Gendagenda South Forest Reserve, Tanga Region, Tanzania. (*Photo: G.P. Clarke*)

Figure 1.1.4 Woodland (800m in altitude), Rondo Plateau, Lindi Region, Tanzania. (*Photo: G.P. Clarke*)

through fragmentation of a once widespread and homogenous forest cover. There must have been distinct communities, including different types of closed forest, since before the onset of fragmentation by humans. This complexity is due to both substrate (e.g. geological and soil variations; Chapters 2.1; 2.2), and climate (e.g. rainfall variability, annual and seasonal totals, number and duration of dry seasons etc., due to local differences in topography; Chapter 2.3).

The resulting biology of the Coastal Forests is of great interest, but there is more to the Coastal Forest issue than studies of their biology. As a Tanzanian conservationist said about wildlife problems, "Counting elephants does not save them!" Science will not save the Coastal Forests either.

These forests, unfortunately, epitomise the difficulties of maintaining biodiversity values in the tropics, in that they show virtually all of the conservation problems faced by conservation planners and protected area managers. The Coastal Forests are:

- Small, and highly fragmented, consisting of many (over 250) separate forest patches, most of which are less than 500ha in size.
- Surrounded by relatively impoverished rural communities with a high and growing demand for, and dependence on, natural resources.
- Individually distinctive, with a high level of local forest endemism, and a great array of different communities, making prioritisation difficult.
- Without the national level pragmatic resource values such as timber or water catchment, which interest national and district governments. The presence of these resources would have allowed biodiversity values to piggy-back on their continuation.
- Relatively little protected by Government agencies.

What does this mean? It means that conservationists are still unable to:

- Decide how many of the 250 forest patches are essential, or of high or medium priority for biodiversity conservation. What criteria should conservationists use to make such decisions? How do we weigh up the different priorities between a small degraded patch of high biological value, and a larger and still little damaged patch which has less biological value? Can we employ a system of 'triage'[1] to develop priority action for conservation?
- Devise a realistic core and buffer zonation strategy, where the forest edge can be used to provide resources to local people, and the centre is maintained as a more inviolate refuge. With patches which may be of a few hundred hectares, there is no space for internal buffer zones to satisfy the demands of many villagers!
- Sell the concept of conservation to rural people because of essential water conservation properties. Or to the national Government because of the obvious large scale commercial timber value. It may be that these small patches are one of the few natural areas which will need some level of strict policing to maintain biodiversity values!

At the heart of providing answers to these questions is the need for information. WHAT are the specific values of WHICH forests? WHAT is their status? HOW are these values used, and by WHOM? This book summarises much of what is known today and highlights the gaps in our knowledge (Sections 3, 4 and 5). This allows the first start at planning a comprehensive conservation scheme for the Coastal Forests of the region.

---

[1] Triage refers to the separation of cases into three categories: those that are lost causes, those that are doing all right without immediate support, and those that will recover *if* given immediate support. It is this last category which should be the priority for action.

Conserving the Coastal Forests

Why does society care, or why should society care, about the fate of the Coastal Forests?

Kingdon (1990) provides the start of the answer. Africa has four major Centres of Endemism, these are: the Cape flora; the Mountain fauna and flora; the Arid Zone fauna and flora; and the Moist Coasts fauna and flora, including the eastern African coast. By conserving Coastal Forests a great part of Africa's biodiversity will be protected. The degree of local variation and endemism suggests that there would be significant conservation gain for an investment in a few tens of square kilometres. Coastal Forest conservation is highly cost effective!

But it is obvious that we know more about the threats facing the forests than we do about finding potential answers to the threats. Experience with NGO support to the Coastal Forests in Tanzania suggests that solutions have to be found at a political level – developing a WILL to conserve (see Chapter 5.4). Coastal people however have material needs – land, fuel, cash (obtained by cutting forest for charcoal etc.). Eastern African society cannot afford to be as interested in biodiversity as their western counterparts. Forces for conservation do not as yet come from within the coastal residents themselves. It is still largely driven from outside these communities.

In conclusion, this book is about willpower. We have witnessed the will of a small scientific community, led by the biologists who have studied these forests. We are seeing now the willpower of the equally small conservation group. This fight is against lethargy within the under-paid and under-motivated Government agencies charged with conservation, and against the increasing demand for land, a demand satisfied by legal and illegal allocations and encroachment. The Minister for Tourism, Natural Resources and Environment for Tanzania stated at a Coastal Forest Conservation seminar outside Dar es Salaam in January 1995, "If we cannot conserve the Pugu Forest (a small forest 22km from the capital, Figure 3.1.2) right on our doorstep, then we cannot conserve a forest anywhere in Tanzania". The Coastal Forests therefore act as a laboratory for proving conservation methodology – AND for demonstrating the political will to conserve resources[2].

The world conservation movement must now recognise the Coastal Forests of eastern Africa as a MAJOR area of biodiversity for both plants and animals. **We now test the will of this global lobby to invest in the conservation movement to provide the motivation to keep the forests intact!**

References

Kingdon, J. (1971). *East African Mammals: An Atlas of Evolution in Africa, vol. 1.* Academic Press, London.

Kingdon, J. (1990). *Island Africa.* Collins, London.

Kjekshus, H. (1975/1996). *Ecological Control and Development.* Heinemann, Nairobi. (Reprinted in 1996, with a new introduction).

Rodgers, W.A. (1996). *A History of Gum Copal Exploitation in Tanzania.* Typescript.

TFAP (1989). *Tanzania's Forest Action Plan.* Forest and Beekeeping Division, Dar es Salaam .

White, F. (1983). *The vegetation of Africa.* UNESCO, Paris.

[2] As shown in Chapter 5.5, this will was demonstrated in mid 1997 when the Vice President of Tanzania visited an area of Coastal Forest outside Dar es Salaam which was being cleared illegally. The Vice President gave very clear instructions to stop such activity immediately.

1.2 Defining the eastern African Coastal Forests

G. P. Clarke

Introduction

The Coastal Forests of eastern Africa are broadly synonymous with the forests of White's (1983a) Zanzibar-Inhambane regional mosaic, but an examination of other attempts to classify these forests reveals a wide spectrum of opinions about their geographical distribution, their biological affinities, and the main vegetation formation type to which they belong (compare Rea, 1935; Dale, 1939; Milne-Redhead, 1955; Monod, 1957; Greenway, 1973; Lebrun, 1960; Leroy, 1978; White 1983a; Hawthorne, 1993; Lovett, 1992 and 1993). The reasons behind this apparent confusion are examined in this Chapter, and brought together to propose a refined definition for the Coastal Forests, based on the analysis of much new data on the key characteristics of the forests, where they are distributed, and the specific values that make them unique and therefore distinct from other forests in Africa. This definition is set within White's (1976; 1979; 1983a; 1983b; 1993) chorological framework.

Main vegetation formation type

The term 'forest' is still used indiscriminately in both scientific and conservation literature to describe dense stands of trees (e.g. Murphy and Lugo, 1986), even though some recent vegetation classifications (e.g. White 1983a p.44–55) identify a clear difference between forest and woodland. The application of recognised standard vegetation classifications to the eastern African coastal zone nonetheless confirms the existence of forest *sensu stricto* in this area. For example, under the Holdridge *et al.* (1971) life zone system (which is applicable globally, but formulated from data on Central America), the eastern African coastal strip north of the Zambezi River would be expected to support Tropical Dry Forest and Tropical Very Dry Forest as the vegetation climax, given its mean annual precipitation of between 510 and 2000mm and a mean annual temperature exceeding 23°C (Chapter 2.3). Furthermore, descriptive vegetation classification systems, such as by White (1983a) for the whole of Africa, and by Greenway (1973) for East Africa, both recognise the existence of a number of small areas of dense closed canopy tree stands in the coastal lowlands of eastern Africa which fit their forest classifications. The 'Coastal Forests' encompass all such forests, excluding the halophytic mangrove forests.

The drier and more deciduous Coastal Forests are occasionally confused with woodland (e.g. in Ruffo, 1992), due to the physiognomic similarity between some types of forest and woodland (particularly as both formations can contain a continuous canopy of large trees). Woodland formations are widespread throughout the eastern African coastal strip, and are normally distinguished from the Coastal Forests on the basis of the physiognomic differences between these main formation types. Such differences are usually unambiguous, especially regarding certain features of their tree canopies and ground layers (Table 1.2.1; see also Swaine, 1992 and Menaut *et al.*, 1995). Vegetation types

Table 1.2.1 Comparison of major differences between forest and woodland where both main vegetation formation types have continuous stands of large (10m) trees.

Characteristic	Woodland	Forest
Tree crowns	Touch, but do not overlap	Overlap
Ground layer	Grasses well developed	Sparse or absent

Source: White (1983a).

which appear to be intermediary between physiognomic definitions for forest and woodland can be additionally categorised on an ecological basis, since forest and woodland require different conditions for species recruitment and the attainment of their climax communities (Trapnell, 1959; Granger, 1984; Swaine *et al.*, 1992; Menaut *et al.,* 1995). In general, regular fire burning will favour the more open woodland formation, where the combustion of woody vegetation enables increased light levels to reach the ground, thus allowing the development of a dense grass layer which in turn renders the habitat more susceptible to fire, thereby perpetuating the woodland state *if it is repeatedly burnt* (Swaine, 1992; Menaut *et al.,* 1995). Conversely an absence of fire permits an increase in the development of woody vegetation, which in turn causes greater shading of the ground layer and thereby hinders, and eventually extinguishes, the development of a grass layer. This then makes the resulting vegetation type less prone to fire burning, thereby perpetuating the existence of the forest state. Repeated *intensive* burning however leads to the conversion of both forest and woodland to grassland (Menaut *et al.,* 1995). Areas of dense closed-canopy tree stands in the eastern African coastal strip that are intermediate between White's (1983a) physiognomic descriptions for woodland and forest should then be labelled as forest (i.e. Coastal Forest) where that vegetation type depends on an absence of fire to perpetuate itself. Borderline cases of this type are discussed in greater detail later in this Chapter.

Other cases where Coastal Forests have been mislabelled as woodland occurred prior to the generation of formal definitions for the main vegetation formation types. During the early botanical explorations of the eastern African coastal area (in the nineteenth and early twentieth centuries: Chapter 4.1; Exell and Wild, 1960; Gillet, 1961; Timler and Zepernick, 1987), the words 'woodland' and 'forest' were used interchangeably, in the same way that they are in Europe. The majority of the botanists collecting in eastern Africa at that time were either German or British, and in both languages *wald*/woodland is more commonly used than *forst*/forest to describe dense closed canopy tree stands. Many of the plants collected in Coastal Forests during this period were cited as occurring in 'woodland', even though they came from vegetation formations that would now be called forest, e.g. Schlieben's collections from Litipo Forest (Lake Lutamba) in southern Tanzania.

Geographical distribution

Attempts over the last hundred years to divide or group vegetation into a number of regions based on the geographical distribution of plant species (see review in Iversen, 1991) have recognised that there are certain distinct vegetation blocks (phytochoria) in which many or most of the plants are found nowhere else. The actual delineation of these blocks is normally rather vague on the local scale, and different methods have been proposed to define them more precisely (see review in White, 1993). The phytochoria of Africa are defined by White (1976; 1983a and 1993; Figure 1.2.1) according to their vegetation physiognomy and the richness of their endemic flora, where the dominant fraction of the total number of species of higher plants in a particular geographical area is restricted in distribution to that area. White's system will be adopted in this Chapter, in recognition that *The Vegetation of Africa* (White, 1983a) is hitherto the definitive work on African phyto- geography.

A distinct area of plant endemism (encompassing all vegetation types) along the coastal strip of eastern tropical Africa (between the Limpopo River and the equator) was first identified by White (1976) in 1974, and named as the Zanzibar-Inhambane floristic region. The delineation of this phytochorion was based on a high level of floristic endemism that was found to exist to about 200–300km inland of the Indian Ocean (especially north of Moçambique town) where approximately 35% of the larger woody plants were found to be endemic to that part of the Indian Ocean coastal belt (Moll and White, 1978). The highly modified and complex nature of the vegetation of this area, together with an initial low estimate of 131 endemic vascular plant species (later revised to at least several hundred species in White, 1983a), led to the classification of the Zanzibar-Inhambane as a 'regional mosaic' rather than a 'regional centre of endemism' (White, 1976 and 1983a; Moll and White, 1978, p.567). Subsequent botanical collections and taxonomic studies confirm White's observation that the majority of the endemic plants of the Zanzibar-Inhambane regional mosaic occur to the north of Moçambique town, but have shown that endemic plant species are present in

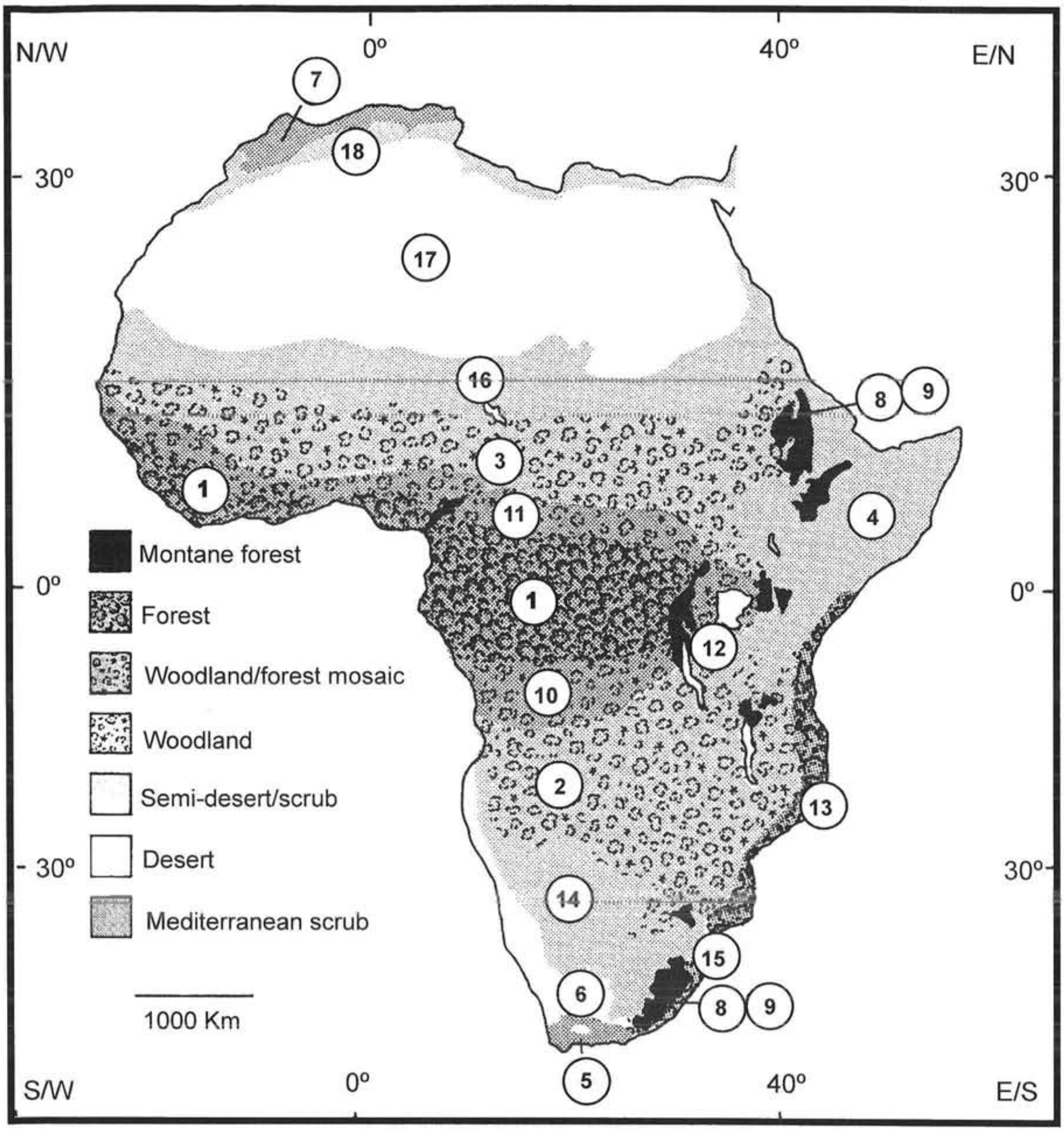


Figure 1.2.1 The phytochoria of Africa as defined by White (1983a).

Regional Centres of Endemism:

1. Guineo-Congolian, 2. Zambezian, 3. Sudanian, 4. Somalia-Masai, 5. Cape, 6. Karroo-Namib, 7. Mediterranean, 8. Afro-montane archipelago-like regional centre of endemism.

Regions of extreme floristic impoverishment:

9. Afro-alpine archipelago-like region of extreme floristic impoverishment.

Regional transition zones:

10. Guineo-Congolian/Zambezia, 11. Guineo-Congolian/Sudania, 14. Kalahari-Highveld, 16. Sahel, 17. Sahara, 18. Mediterranean/Sahara.

Regional Mosaics:

12. Lake Victoria, 13. Zanzibar-Inhambane, 15. Tongaland-Pondoland.

Main habitat types are also indicated. Phytochorion no. 15 subsequently renamed as the Tongaland-Maputaland regional transition zone (by van Wyk), and phytochorion no.13 subsequently enlarged, divided and renamed as the Swahilian regional centre of endemism/Swahilian-Maputaland regional transition zone (Clarke (1998); see Figure 1.2.2).

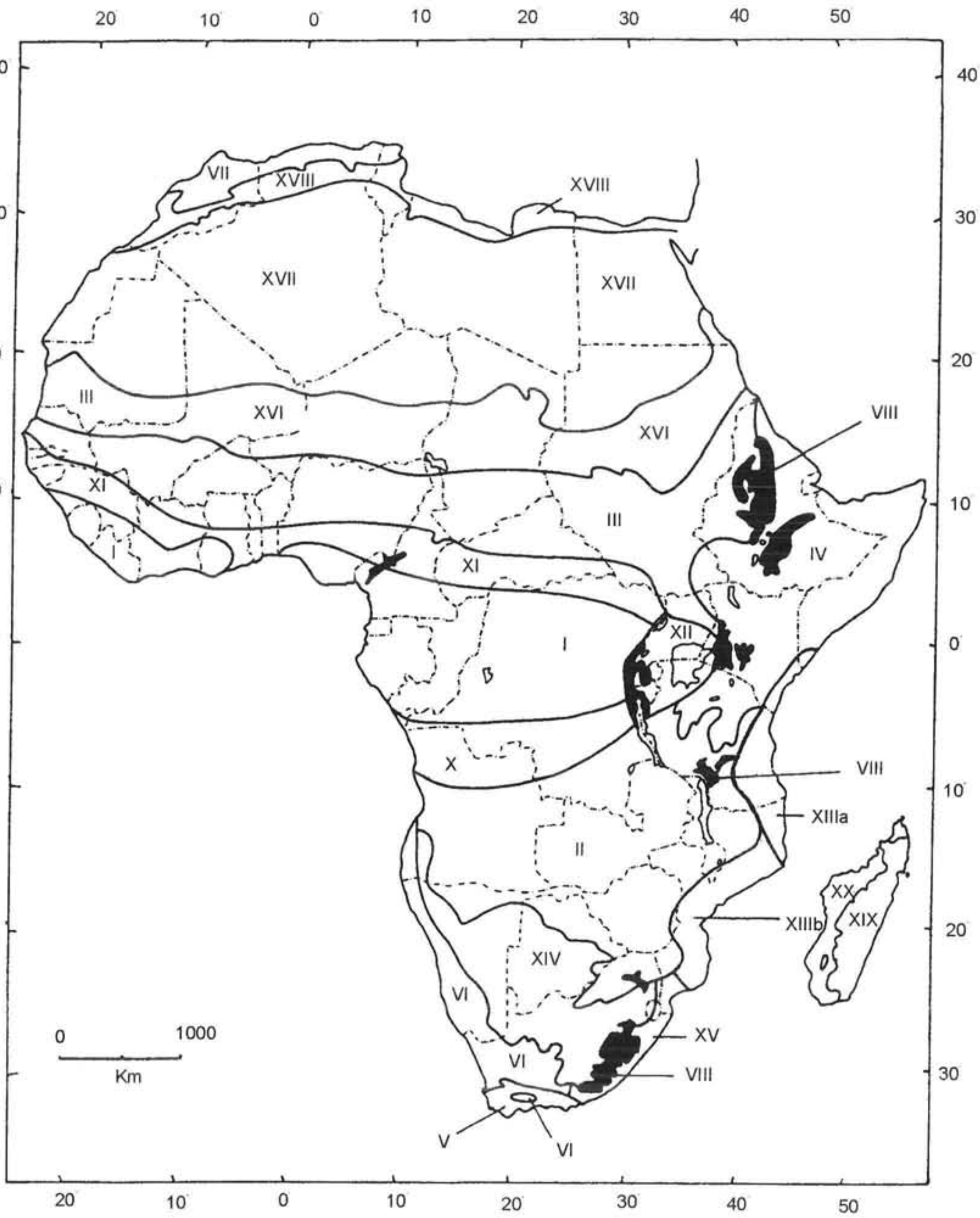


Figure 1.2.2 Modifications to the phytochoria of eastern Africa (Clarke, 1998). XIIIa Swahilian regional centre of endemism, XIIIb Swahilian-Maputaland regional transition zone. Other phytochoria unchanged from White (1983).

sufficiently high numbers (i.e. >1000) to enable this northern part to be separated as a regional centre of endemism in its own right, leaving a depauperate regional transition zone in the southern part (Clarke, 1998; Figure 1.2.2). The low number of endemic plant species recorded from either Zanzibar Island or Inhambane Province have meant that the name 'Zanzibar-Inhambane' was deemed to be an inappropriate label for this floristic region, so the northern part of this region has been renamed as the 'Swahilian regional centre of endemism' with an adjacent 'Swahilian/Maputaland regional transition zone' to the south (Clarke, 1998). The term Swahilian region *sensu lato* hereafter encompasses both this regional centre of endemism and the regional transition zone.

The Zanzibar-Inhambane phytochorion (Swahilian region *sensu lato*) comprises a vegetation mosaic of unique types of forest, thicket, woodland, bushland and grassland, interspersed with areas presently under cultivation and fallow (Hawthorne, 1993). Four lowland forest types were identified by White (1983a): (1) Zanzibar-Inhambane lowland rain forest (occurring predominantly at the base of the Eastern Arc montane blocks); (2) Swamp forest, which is limited to poorly-drained, often rocky, conditions; (3) Zanzibar-Inhambane scrub forest; and (4) Zanzibar-Inhambane undifferentiated forest, both the latter of which are usually present on low hills and in riverine areas. The term 'Coastal Forest' (which predates White's nomenclature, e.g. in Troup, 1923; Greenway, 1938 etc.) broadly encompasses these four formation types/sub-types, and has continued to be widely used (e.g. Friis and Tadesse, 1990; Hawthorne, 1993; Sheil 1992) since all four of these formation types/sub-types can occur together as a complex mosaic in a single small (i.e. $< 1km^2$) forest block (Clarke, 1995b; Clarke and Dickinson, 1995; Clarke and Stubblefield, 1995). 'Coastal Forest' is then a useful name to collectively identify these forests (which share a similar fauna and flora), and is less cumbersome than either 'Zanzibar-Inhambane forest' or 'Swahilian forest *sensu lato*'.

Defining the precise extent of the Coastal Forests (and the Swahilian region *sensu lato* in which they occur) is currently rather difficult as too few data are available from the vegetation at the periphery of the Zanzibar-Inhambane regional mosaic (*sensu* White, 1983a and b), which is further complicated by the marginal intrusion of many typical Zanzibar-Inhambane forest plant species into the neighbouring Zambezian regional centre of endemism. The Swahilian regional centre of endemism together with the neighbouring Swahilian/Maputaland regional transition zone are therefore defined to occupy a somewhat larger area than White's Zanzibar-Inhambane region. Some definitions limit the extent of the Coastal Forests to forest growing on coastal sedimentary rocks (e.g. Hawthorne, 1993) which is a useful definition along the Kenyan coast, but becomes more problematic further south, particularly in Mozambique where metamorphic rocks of the African basement reach the sea (Chapter 2.1; Figure 2.1.2). Indicator species (of both animals and plants) can be used to suggest the geographical limits of Coastal Forests, although in reality the limit will not be a fixed line, but there will instead be a transitional zone between this and the surrounding phytochoria (cf. Hawthorne, 1993).

Biological Affinities

No standard method for comparing the floristic affinities of two areas has yet been formalised. A number of methods are currently in use, each of which gives a different result and lends a different weight to the argument for Coastal Forests either as a distinct vegetation unit, or as an outlier of another phytochorion. The comparisons may involve plant species, genera or geographical 'elements' (*sensu* White, 1993 and 1979), and may be qualitative (based on the presence/absence of species) or quantitative (giving a weighting according to the abundance of each species). These different methods of comparison reveal a complex set of relationships between the Coastal Forests/Swahilian region *sensu lato* and the flora of other phytochoria:

1. The Swahilian Element

The identification of a distinct phytochorion along the eastern African coastal strip was based on the presence of an estimated total of 'at least several hundred' endemic vascular plant species (White, 1983a, p.186). Estimates in this book (Chapter 4.1 and Appendix 3) reveal a much higher total of at least 1356 endemic vascular plant species, and at least 33 endemic genera, which reinforce the classification of the Swahilian region as a distinct centre of endemism (Clarke, 1998).

Inventories from 13 Coastal Forests in Tanzania (Clarke, 1995a; Chapter 4.1) found 33% of the vascular plant species to be restricted in distribution to the Swahilian region *sensu lato*. However, quantitative studies in a number of Coastal Forests (Chapter 3.3) demonstrate that tree species which are restricted in distribution to the Swahilian regional centre of endemism may account for the majority (> 50 %) of individual trees with a DBH above 10cm, even where the regional endemics comprise a low proportion of a florula/list of plant species. In areas of riverine forest the dominance usually shifts to widespread tropical African tree species (Hawthorne, 1993) that are characteristic of groundwater and riparian forest (Medley, 1992).

2. The Guineo–Congolian Element

Milne-Redhead (1955) was the first to recognise that the East African lowland forests are floristically distinct from the forests of West and Central Africa, yet the forests of the eastern African coastal strip are still considered by some scientists to be an outlier of the Guineo-Congolian rain forest zone (e.g. Brenan, 1978; Lebrun, 1960; Lovett, 1993; Monod, 1957). The argument for uniting these forests is however weak when based on floristic evidence at the species level, for a combined inventory sample from thirteen Coastal Forests in Tanzania (Table 4.1.6 of Chapter 4.1) demonstrates that just 3.4% of their florula is shared only with the Guineo-Congolian regional centre of endemism. Similarly less than 1% (2.4% if ecological and chorological transgressors are included) of a sample of 288 Guineo-Congolian species were found to be strictly shared with the Indian Ocean Coastal Belt, compared to 90.6% which were endemic or near endemic (White, 1979).

Most Coastal Forest trees belong to widespread tropical forest genera that are also well represented in the Guineo-Congolian region, and in this respect the generic similarity between these two forest types is greater than between the Coastal Forests and other vegetation types in Africa. This similarity supports the hypothesis that the two forest blocks were formerly joined (Davis *et al.,* 1994; Hamilton and Faden, 1973; Hamilton, 1982; Axelrod and Raven, 1978; Lovett, 1992 and 1993; Chapters 2.1 and 2.3), yet many of the widespread genera of the Congolian forest are absent from the Coastal Forests (Davis *et al.,* 1994, p.132), and only 2.24% of the genera endemic to African tropical forests *sensu lato* are shared yet discontinuous between these two areas. Only ten vascular plant genera are known to be shared only between the Swahilian region and the Guineo-Congolian regional centres of endemism (Table 4.1.3 of Chapter 4.1, though Brenan (1978) records 11 genera), compared to at least 33 endemic Coastal Forest vascular plant genera (Table 4.1.1 of Chapter 4.1).

3. The Afromontane (including Eastern Arc) Element

The merging of Coastal Forests with the Eastern Arc montane forests was recognised by White (1993) through the existence of 'rain forest transitional between Zanzibar-Inhambane [Swahilian] and Afromontane rain forest'. Quantitative studies in the forests of the moister, eastward facing slopes of the Eastern Arc mountains reveal a gradual and ultimately complete replacement of Coastal Forest plant species by upland and montane species as altitude increases (Lovett, 1993; Chapter 3.4). The pattern and rate of such changes is extremely complex, and varies according to which montane block is being examined, and whether the altitudinal change is being recorded along a ridge or up a valley. In spite of the continuum of these changes, Coastal Forests that are geographically isolated from the Eastern Arc mountains are very different from the sub-montane and montane Eastern Arc forests (at both the species and genus levels of classification), even where they reach sub-montane altitudes (e.g. on the Rondo Plateau – Vollesen, 1994).

4. The Zambezian Woodland Element

Coastal Forests are usually surrounded by woodland formation types which are dominated by tree species that are otherwise restricted in distribution to White's (1983a) Zambezian regional centre of endemism. White (1993) notes the presence of 'small patches, and in Mozambique more extensive areas, of floristically impoverished woodland of Zambezian affinity, but often with some 'Zanzibar-Inhambane [i.e. Swahilian] endemics' within the Swahilian region *sensu lato.* Some of the tree species that are only known from the Swahilian and Zambezian phytochoria are important constituents in the canopies of some Coastal Forests, e.g. *Afzelia quanzensis.*

5. The Madagascan Element

The eastern African coastal strip has also been considered to be part of a wider Madagascan floral region *sensu lato* (Leroy, 1978), since the closest relatives to some of the plants of the eastern African coastal strip are in Madagascar. Whilst affinities do undoubtedly exist between certain elements in the Coastal Forest flora and the Madagascan flora, a detailed analysis of the entire flora of both areas is required to determine the importance of this link. Of the 13 plant genera that are known to be strictly shared between the Swahilian and the Madagascan/Mascarene phytochoria (Chapter 4.1), ten are monotypic or contain a species which is common to these phytochoria, and their disjunct distributions may then result from relatively recent long-distance dispersal (cf. Hall and Swaine, 1981, p.38; White, 1983c). Phylogenetic relicts of the separation of Madagascar from the eastern African coast may be poorly represented at species level in the vascular plant flora, since that separation occurred during the earliest development of the phanerogams, and are much better represented in the more ancient cryptogams (Pócs, 1975).

Two vegetation plots in Kisiju Forest on the coast of Tanzania (Clarke and Dickinson, 1995) are dominated (56% and 60% of individuals in 1600ha plots) by tree species greater than 10cm DBH which are shared only by the Swahilian and the Madagascan/Mascarene regional centres of endemism. None of the vegetation plots situated away from the coast (Clarke, 1995b; Clarke and Dickinson, 1995; Clarke and Stubblefield, 1995) demonstrate such a strong Madagascan/Malagasy affinity, but the Kisiju plots nonetheless suggest that a transitional zone between the Swahilian and the Madagascan/Mascarene phytochoria may exist along the eastern African shore.

6. Widespread species

Plants that are widespread in distribution form the dominant fraction (over 50% in a combined sample of 13 Coastal Forest inventories) of any species inventory of the Coastal Forests (Hawthorne, 1993), and most of the plant genera in the Coastal Forests are also of widespread distribution (Chapter 4.1). The dominance of widespread species may reflect the small and fragmented distribution of the Coastal Forests, which makes them more susceptible to invasion by generalist species. The high percentage of widespread species is not however unusual, for introduced species alone usually account for a third of all species now found on tropical islands (Usher, 1986).

Discussion

Previous delineations of African phytochoria have attempted to separate floras into discrete geographical regions (with the exception of White's (1983a) Afromontane and Afroalpine archipelago-like regional centres of endemism, which are separated on an altitudinal basis). Such an approach makes it difficult to distinguish a distinct lowland forest phytochorion in the eastern African coastal strip, since there is a complex interaction of floral regions in this area (cf. Hawthorne, 1993; White, 1993, p.241).

Within this chorological mosaic there are two major forest phytochoria, which are dependent on (and differentiated by) different climatic regimes. The upland sub-montane and montane forest phytochorion receives a higher and more reliable rainfall together with cooler temperatures compared to the lowland forest phytochorion. A transition zone exists between these two phytochoria where climatic conditions are intermediate between the characteristic climates of each phytochorion, *and* where this intermediate climate occurs adjacent to both phytochoria. Such conditions are only present at the base of the Eastern Arc mountains of Kenya and Tanzania, and at the base of the Eastern Highlands of Zimbabwe, where just tiny fragments of the former extent of this forest type now remain. Most of the eastern African Coastal/Afromontane transition forest has long been cleared for agriculture (Chapter 5.1), but the remaining areas are rich in their own endemic species.

A further forest type is present within the eastern African chorological mosaic, which occurs where there is an additional groundwater moisture supply (except in areas of high and regular rainfall where an extra moisture supply from groundwater sources becomes less important in counteracting a moisture deficit). This forest type cannot be assigned to any single phytochorion as it is dominated by tree species which are widespread throughout tropical Africa (see White, 1983a p.117), although regional variations do occur (Medley, 1992). It is predominantly the tree flora that is modified by the availability of the extra groundwater moisture supply, whereas herbs, lianas and shrubs etc. are usually more characteristic of the local flora. It would be incorrect to label the trees which are characteristic of these groundwater/riverine forests as Guineo-Congolian, since these species are present throughout tropical Africa. These forests will therefore be considered to be azonal in eastern Africa, and will be classified as eastern African Riverine/Groundwater/Swamp Forest.

The woodland and grassland formations present in the eastern African coastal strip are not climax communities (as suggested on a theoretical basis by Holdridge *et al.*, 1971), and are derived formations caused by the introduction of widespread and frequent fire-burning by early humans (Chapter 5.1). Repeated fires (especially when combined with forest clearance for cultivation) have caused the extensive loss of forest, with the possible local extinction of many Swahilian endemic plant species that may have been unable to regenerate in areas which are regularly burned. These fires may

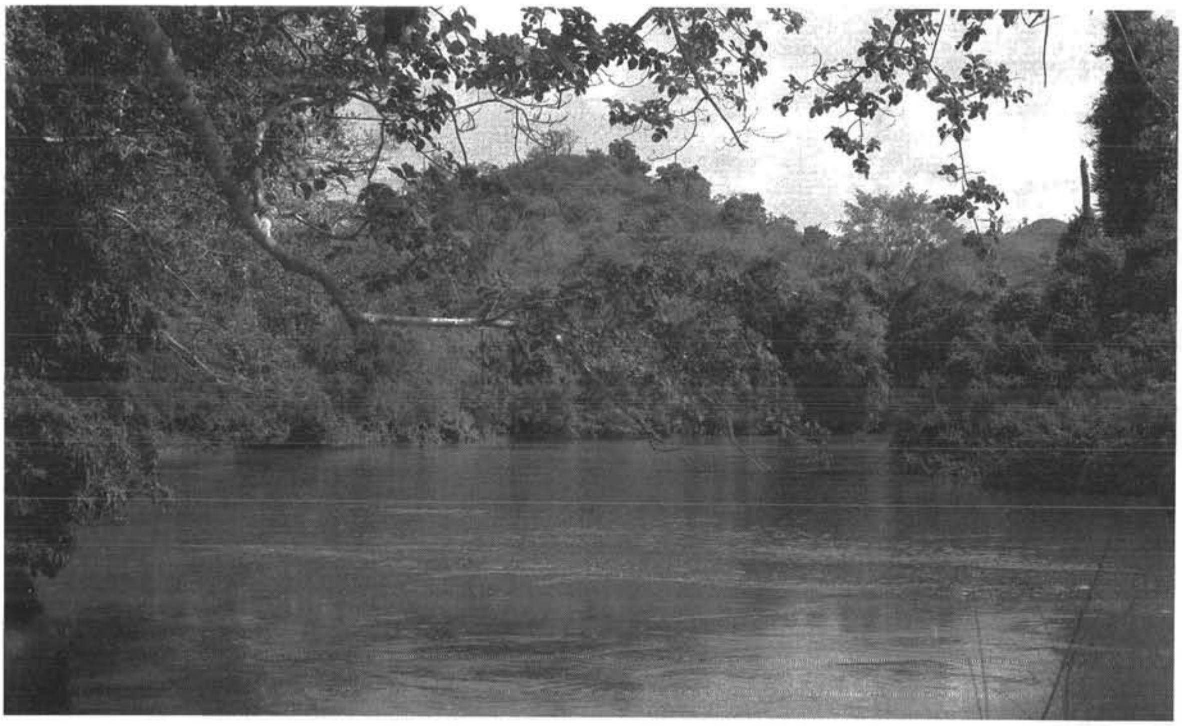


Figure 1.2.3 Riverine forest along the Pangani River, Tanga region, Tanzania, forming a thin corridor of forest through open woodland. (*Photo: G.P. Clarke*)

Figure 1.2.4 Deciduous *Brachystegia spiciformis* over a smaller stratum of evergreen *Julbernardia magnistipulata*, Arabuko-Sokoke Forest Reserve, Kenya. Photo taken in March 1997, at the end of a prolonged period of severe drought when leaf fall was at a maximum. Elephant damage may be responsible for the open grassy glade in the foreground. (*Photo: G.P. Clarke*)

then have encouraged the incursion of plant species characteristic of the Zambezian region, and may therefore have increased the chorological complexity of this area. Many Swahilian endemic plant species are nonetheless able to tolerate some fire, and can be found in woodland/grassland formations.

Only by isolating the lowland forest formation type and ignoring the trees that are associated with groundwater and riverine forests is it possible to distinguish a separate eastern African lowland forest flora distinct from the other African floras at the species level of taxonomic classification, which may be considered as an archipelago-like local centre of endemism (*sensu* White, 1993) occurring throughout the Swahilian regional centre of endemism and the adjoining Swahilian/Maputaland regional transition zone. The forests which are dominated by this flora are the eastern African Coastal Forests.

Borderline cases

The groundwater and riverine forests (Figure 1.2.3) in the eastern African coastal strip are dominated by trees of a widespread distribution (e.g. *Milicia excelsa, Antiaris toxicaria, Ficus* spp.), but these areas of forest are often found alongside drier forest areas which are dominated by trees which are endemic to the Swahilian region *sensu lato*. Some of the smaller tree, liana, shrub and herb species in these riverine/groundwater/swamp forests are also endemic to the Swahilian region *sensu lato* (e.g. *Pandanus rabaiensis* etc.). It would be difficult in practice to separate many such riverine forest areas from areas of forest which are dominated by the Swahilian trees, as many of the forest patches in the eastern African coastal strip contain mosaics of riverine and groundwater forest within drier forest types dominated by Coastal Forest endemic tree species. From a practical conservation perspective, it is convenient to include the riverine /groundwater/swamp forest areas within the overall definition of the Coastal Forests, as a formation sub-type that is transitional with a widespread eastern African riverine and groundwater forest type (for which Greenway's (1973) rather general definition can be used, with the proviso that it is extended to incorporate the whole of eastern Africa). A similar argument applies for the inclusion of scrub forest within the definition for Coastal Forest, since this vegetation type interdigitates with typical Coastal Forest (Hawthorne, 1993).

A further vegetation type exists in the coastal strip of eastern Africa, which eludes an easy classification. This vegetation type is dominated by *Brachystegia* trees (either *Brachystegia microphylla* or *Brachystegia spiciformis*), which are elsewhere characteristic of the 'miombo' woodland formations in the Zambezian regional centre of endemism (*sensu* White, 1983a). Along the eastern African coastal strip these trees may form a closed canopy over a dense shrub layer dominated by species restricted to the Swahilian region *sensu lato* (Figure 1.2.4). Grasses are sparsely present to absent, and are mostly species associated with forests. The vegetation physiognomy is therefore of a woodland tree canopy over a forest understorey, and so appears to be transitional between forest and woodland. White (1983a and 1993) classified this vegetation type as 'transition woodland', Greenway (1973) as 'deciduous forest' and Rodgers (1979) called it '*Brachystegia* thicket' as he considered the understorey layer to consist of thicket species. '*Brachystegia* forest' is here considered a more appropriate label as the 10–12m high tree canopy is clearly too high to be considered a thicket (*sensu* White, 1983a), whilst the dense shrub layer and sparsely developed grass layer are inconsistent with both the White (1983a) and Greenway (1973) physiognomic classifications for woodland. Although the wide tree crowns rarely overlap, this vegetation type satisfies all the other physiognomic criteria for classification as a forest. It is also not a fire-climax vegetation type and is unique to the eastern Africa coastal strip, so it will be included as a Coastal Forest variant since it is clearly different from woodland which has the same or a similar tree species composition, as recognised by Greenway (1973). It has been suggested to be the xerosere climax for south-eastern Tanzania (Rodgers, 1979, *cit.* Glover, 1968), but may be a forest climax over eroded soils, occurring in areas that would have formerly supported true Coastal Forest but where soil erosion has since occurred and now only a depauperate forest is able to develop. The cause of this soil erosion may be anthropic (due to clearance for cultivation), or may be a natural result of the rapid retreating scarp erosion of the friable sandstone plateaux and hills that are present in this area.

Formal definition

1. Name

Eastern African Coastal Forests.

2. Chorological position

Archipelago-like regional sub-centre of endemism in the Swahilian regional centre of endemism and the Swahilian/Maputaland regional transition zone (*sensu* White 1979, 1983a and 1993; Clarke, 1998).

3. Main vegetation formation type

Forest *sensu* White (1983a):

'Forest is a continuous stand of trees. The canopy varies in height from 10m to 50m or more, and more usually consists of several layers or storeys. The crowns of individual trees interdigitate or overlap each other and are often interlaced with lianes. A shrub layer is normally present. It is usually densest in those types of forest with a more open canopy. The ground layer is often sparse and may be absent or consist only of bryophytes. In tropical and subtropical types, grasses, if present, are comparatively localised and inconspicuous, though lianes are usually well represented. Epiphytes, including ferns, orchids and large mosses are characteristic of the moister tropical and subtropical types, but vascular epiphytes are virtually absent from the more temperate types, if the word temperate is used in a latitudinal rather than a strictly climatic sense. Large epiphytic lichens, especially Usnea, *are often conspicuous, especially in upland types.'*

4. Floristic composition

Forest dominated (i.e. containing more than 50% of all individuals of trees with a diameter at breast height of 10cm or more) by Swahilian near endemic (*sensu* White, 1979 and 1993) tree species, i.e. tree species whose global distribution is limited to the area outlined in Figure 1.2.5. Forests in which Swahilian near endemic tree species comprise the greatest fraction of non-widespread individual trees, but where that fraction is less than 50%, are here considered to be depauperate.

5. Typical vegetation formation types, sub-types, variants and transitions

The term 'Eastern African Coastal Forest' is here defined as a collective term to encompass the typical vegetation formation type (eastern African Coastal Dry Forest) as well as variant and transitional formation types/sub-types. Variant formation types or sub-types occur where all but one of White's (1983a, p.45) forest characteristics (such as overlapping tree crowns or an evergreen understorey) are present in a non-fire climax vegetation type. Forests that share features of Coastal Forests with the forests of other phytochoria are treated as transitional formations, where transitional is used in a chorological rather than a seral sense (Figure 1.2.4).

5.1 Eastern African Coastal Dry Forest (typical vegetation formation type)

Semi-evergreen or evergreen undifferentiated dry forest *sensu* White (1983a), with the amendments that (1) eastern African Coastal Dry Forests can occur where atmospheric humidity is high throughout the dry season, and (2) these eastern African Coastal Dry Forests may have a lower canopy (to 7m) than the minimum limit of 10m adopted in White (1983a).

Partial synonyms (in chronological order):

- Lowland Tropical Forest *'Untere Tropenwald'* (Engler, 1894 *cit.* Iversen 1991).
- Coastal Forest *'Kustenwald'* (Kerner von Marilaun and Hansen, 1916).
- Coast Forest (Troup, 1923; Battiscombe, 1936).
- Coastal Tropical Evergreen Forest (Phillips, 1931).
- Evergreen Coastal Forest (Greenway, 1938).
- Evergreen Dry Forest; Lowland Evergreen Rain-forest (Dale, 1939).

- Lowland Dry (Mist) Forest; Deciduous Forest (Gillman, 1949).
- Lowland Dry Forest; Lowland Rainforest; Lowland Dry Forest on Coral Rag (Moomaw, 1960).
- Moist Forest *'Floresta higrofila'* ; Semi-moist Forest *'Floresta sub-higrofila'* (Gomes e Sousa, 1966).
- Moist Evergreen, Moist Semi-Deciduous, Dry Semi-Deciduous and Dry Deciduous Forest (Wild and G. Barbosa, 1967).
- Dry Lowland Evergreen Forest (Polhill, 1968).
- Lowland seasonal rain forest (Chapman and White, 1970).
- Lowland Dry Evergreen Forest; Lowland Rainforest; Freshwater Swamp Forest (Greenway, 1973).
- Coastal rain forest; Coastal forest (Hamilton and Faden, 1973).
- Dry semi-evergreen forest with succulents (Pócs, 1976).
- Coastal Dry Evergreen Forest (Rodgers, 1979).
- Zanzibar-Inhambane Undifferentiated Forest (White, 1983a).

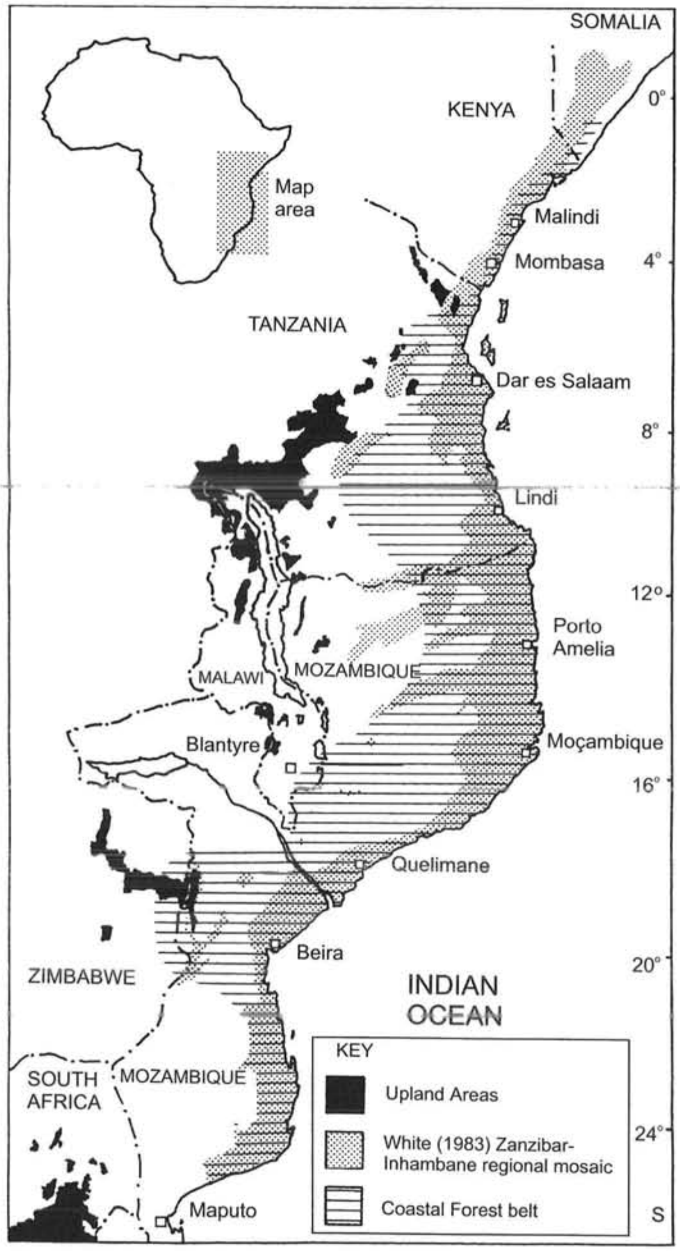


Figure 1.2.5 Extent of major upland areas in eastern and south-eastern Africa, the Zanzibar-Inhambane regional mosaic (*sensu* White, 1983a and b), and the Coastal Forest belt as defined in this Chapter (which encompasses the Swahilian regional centre of endemism and the Swahilian/Maputaland regional transition zone).

- Coastal Forest (Hawthorne, 1984).
- Dry Lowland Forest (Lovett, 1992 and 1993).
- Coastal Forest; Dry Forest (Hawthorne, 1993).

Representative samples include the '*Cynometra [webberi]-Manilkara [sulcata]*' community of the Arabuko-Sokoke Forest, Kenya (Moomaw, 1960); the forests on Gendagenda Hill, Tanzania (Clarke and Stubblefield, 1995); Inhansato and Inhamitanga Forests, Cheringoma, Mozambique (Gomes e Sousa, 1966); Matandwe forest, Malawi Hills (Chapman and White, 1970); Haroni and Rusitu Forests, Zimbabwe (Timberlake, 1994).

5.2 Eastern African Coastal Scrub Forest (variant vegetation formation type)

Scrub Forest *sensu* White (1983a) which is intermediate in structure between forest (canopy height >10m) and bushland or thicket (canopy height <10m). In eastern Africa scrub forest may have a lower canopy (to 4m) than the lower 7m limit imposed by White (1983a), but retains other forest features such as overlapping tree crowns, abundant lianes, a leaf-litter layer and emergent trees which often exceed 10m in height. Herbs are scarce to absent. White (1993) recognises that scrub forest occurs as 'a narrow band separating Zanzibar-Inhambane [Swahilian] forest from the much drier vegetation of the Somalia-Masai Region', but this variant vegetation formation type occurs elsewhere in eastern Africa, particularly over coral rag near the coast (Hawthorne, 1993).

Partial synonyms (in chronological order):

- Evergreen Coastal Scrub (Phillips, 1931).
- Secondary Scrub on Coral Limestone; Secondary Scrub on Coastal Sands; Evergreen Dry-forest (Dale, 1939).
- Bushland and Thicket (Gillman, 1949).
- Lowland Dry Forest on Coral Rag (Moomaw, 1960).
- Bushland (Birch, 1963).
- Thicket '*Macico*' (Gomes e Sousa, 1966).
- Dry Tall Mixed Thicket; Dry Deciduous Thicket (Wild and Grandvaux Barbosa, 1967).
- Evergreen and Semi-Evergreen Woodland; Coastal Evergreen Bushland (Greenway, 1973).
- Zanzibar-Inhambane Scrub Forest (White, 1983a).
- Somalia-Masai Scrub Forest (White, 1983a) - [the community described on the north face of the West Usambaras].
- Scrub forest (Hawthorne, 1993).

Representative examples include scrub forest near Raas Kaamboni, Somalia (Friis and Vollesen, 1989); at Msambweni, Kenya (Moomaw, 1960); on the northern slopes of the Western Usambara Mountains (White 1983a, p.117), Msua Thickets (Gillman, 1949) and on Mbudya Island near Dar es Salaam, Tanzania (Hall *et al.,* 1984); also on Mefunvo Island, Quirimba Islands, Mozambique (Gomes e Sousa, 1966).

5.3 Eastern African Coastal Brachystegia *Forest (variant vegetation formation sub-type)*

Transition Woodland *sensu* White (1983a) dominated by either *Brachystegia spiciformis* (Arabuko-Sokoke forest in Kenya, and forests in Mozambique) or *Brachystegia microphylla* (southern Tanzania). Occurs on degraded/poor soils. Canopy tree crowns rarely touch and do not interlock. Lianes are usually scarce. Grasses are scarce to absent. Fire does not normally penetrate this vegetation type.

Partial synonyms (in chronological order):

- Deciduous Forest (Greenway, 1973).
- *Brachystegia* Thicket (Rodgers, 1979).
- Zanzibar-Inhambane Transition Woodland (White, 1983a and 1993).

Representative examples include Chiniziua Forest, Cheringoma, Mozambique (Gomes e Sousa, 1966); parts of Arabuko-Sokoke Forest, Kenya (White, 1983a, p.188; Moomaw, 1960) and parts of Tong'omba Forest, Tanzania (Clarke, 1995b).

5.4 Eastern African Coastal Riverine/Groundwater/Swamp Forest (transitional vegetation formation sub-type)

Forest *sensu* White (1983a) in areas where the water table is high or where drainage is poor. Dominant canopy trees are predominantly of species with wide tropical African distributions (Medley, 1992). Understorey trees and shrubs are dominated by species restricted to the Coastal Forest belt. This formation sub-type is transitional with Greenway's (1973) Riverine Forest and with White's (1983a) Somalia-Masai Riparian Forest, which are present throughout East Africa.

Partial synonyms (in chronological order):

- Lowland Evergreen Edaphic Forest (Dale, 1939).
- Groundwater and Fringing Forest (Gillman, 1949).
- Fringing Forest *'Galerias Florestais'* (Gomes e Sousa, 1966).
- Fringing Forest (Chapman and White, 1970).
- Riverine Forest; Ground Water Forest (Greenway, 1973).
- Lowland semi-evergreen or evergreen rain forest on graniolite; Riverine or fringing forest (Pócs, 1976).
- Lowland evergreen and semi-evergreen rain forest on dolomitic marble (Pócs, 1976).
- Groundwater Forest (Rodgers, 1979).
- Zanzibar-Inhambane Undifferentiated Forest; Swamp Forest (White, 1983a).
- Somalia-Masai Riparian Forest (White, 1983a, p.117).
- Moist Forest (Hawthorne, 1993).

Representative examples include riparian forest areas along the Jubba River at Bu'ale, Somalia (Madgwick, 1988); along the Tana River, Kenya (Medley, 1992); Gendagenda Forest (Clarke and Stubblefield, 1995), valley bottom areas of the Pugu (Hawthorne, 1993) and Kazimzumbwi forests, swamp forest areas of Mchungu Forest and Kimboza Forest, Tanzania (Clarke and Dickinson, 1995); and riverine forest in the Massenjere Forest Reserve, Malawi (Dowsett-Lemaire, 1990).

5.5 Eastern African Coastal/Afromontane transition forest ('transitional' vegetation formation type)

Forest *sensu* White (1983a) in lowland areas at the base of the Eastern Arc and Chimanimani Mountains, and near the summit of the Shimba Hills, where rainfall is high. In well-drained areas (such as on ridge-tops at Kambai Forest in the East Usambaras), the eastern African Coastal/ Afromontane transition forest is replaced by eastern African Coastal Dry Forest.

Partial synonyms (in chronological order):

- Lowland Rain Forest (Greenway, 1973).
- Lowland Evergreen Rainforest (Moomaw, 1960).
- Zanzibar-Inhambane Lowland Rainforest (White, 1983a).
- Lowland Forest (Lovett, 1993).
- Rainforest transitional between Zanzibar-Inhambane and Afromontane forest (White, 1993).

Representative examples include forest on the summit of the Shimba Hills, Kenya; on the summit of Tongwe Hill (Clarke and Stubblefield, 1995), in Kimboza Forest, Tanzania (Clarke and Dickinson, 1995; Rodgers *et al.,* 1983), and in the lowlands of the East Usambaras (Clarke, pers. obs.); dry forest on Machemba Hill, Malawi (Dowsett-Lemaire, 1990); and Chirinda Forest, Zimbabwe (Timberlake and Shaw, 1995; White 1983a).

White has classified these forests as Zanzibar-Inhambane lowland rain forest, and the rain forest label is consistent with Whitmore's (1986) definition for 'Tropical semi-evergreen rain forest', but they would be classified as tropical dry forest under the Holdridge *et al.* (1971) life zone system.

6. Geographical Range

EASTERN AFRICA

The geographical range of eastern African Coastal Forests as defined above (Section 5, this Chapter) occurs within the following limits, hereafter referred to as the 'Coastal Forest belt' and comprising the Swahilian regional centre of endemism and the Swahilian/ Maputaland regional transition zone (see Figure 1.2.5 for map) as refined from mapping unit 16b of White (1983b).

Eastern limit: Eastern African seaboard, including the off-shore islands of Pemba, Zanzibar and Mafia and all islands up to 100km east of the continental African coast between 2° – 25°S but may also include Inhaca Island at 26°S. Mangrove forests are not included as eastern African Coastal Forests, since they are treated as an azonal vegetation unit outside of the Zanzibar-Inhambane [i.e. Swahilian] region (White, 1983a, p.260).

Northern limit: Somalia, where the northernmost Coastal Forest variant formation types and transitional formation sub-types are the scrub forest and a riverine forest between Bad Daada and Raas Kaamboni, as described in Friis and Vollesen (1989) and mapped in Friis and Tadesse (1991). The coastal extent of the Coastal Forest belt occurs further south at the Kenya-Somali border, where the Mundane Range of hills meets the sea (A. Robertson, pers. comm.).

An outlying island of eastern African Coastal Riverine Forest occurs further north along the Jubba River at Bu'ale, 1°10'N, 2°35'E (Madgwick, 1988).

North-western limit: Kenya, boundary of Zanzibar-Inhambane regional mosaic as indicated by White (1983a), and Beentje (1990). An outlying island of eastern African Coastal Riverine Forest occurs further to the northwest along the Tana River (Medley, 1992).

Western limit: Tanzania, eastern basement edge of the Eastern Arc Mountains as defined by Lovett (1990) south to lowland Udzungwas at Matundu Forest Reserve, within the Kilombero Valley and at Mahenge (as indicated by collections of *Stephopaedes loveridgei* – Poynton, 1991), and *Dasypeltis medici* (Chapter 4.4). Thence south and then west to Mitucue Mountain and Nova Freixo as indicated by collections of *Bufo lidneri* (Clarke, 1989), and then to Machembe and the Malawi Hills in southern Malawi (Figure 1.2.6) as defined by Chapman (1968), Chapman and White (1970), Dowsett-Lemaire

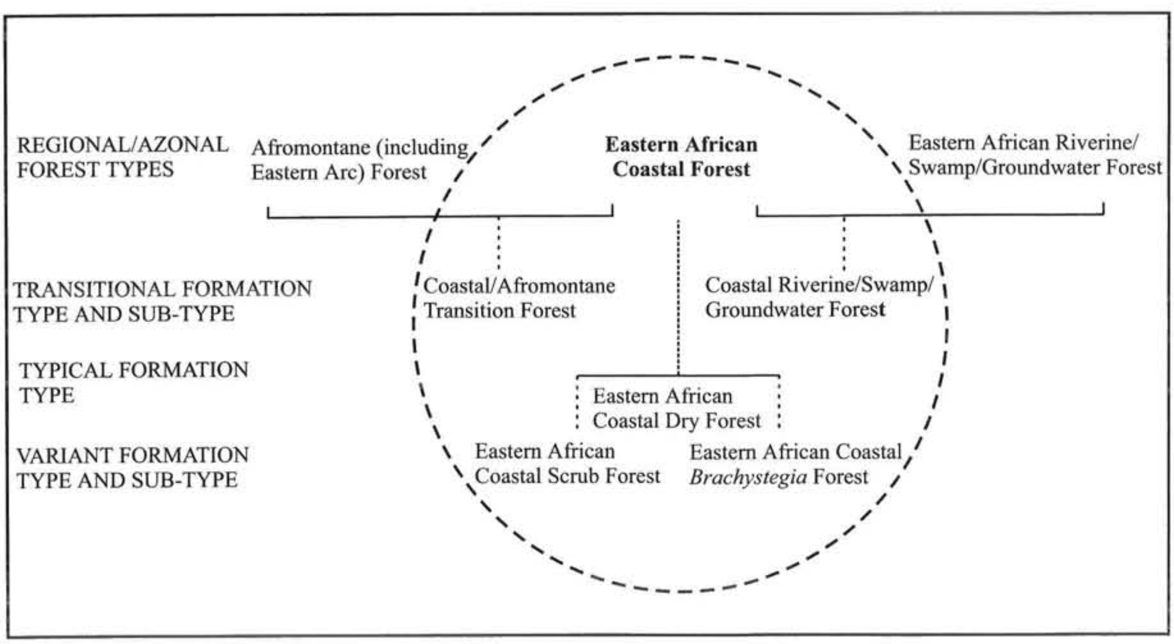


Figure 1.2.6 Relationships between the different kinds of eastern African Coastal Forest, as well as to other regional and azonal forests. Eastern African Coastal Forest additionally merges with Maputaland-Pondoland forest in southern Mozambique and northern Natal, but forest of this type is not included here since it should be included as a transitional formation belonging to the Maputaland-Pondoland regional mosaic.

(1990) and further by the western distributional limit of the tree species *Burttdavya nyasica, Tabernaemontana elegans, Sterculia appendiculata, Inhambanella henriquesii* and *Fernandoa magnifica* (Exell and Wild, 1960). Distance from the coast varies but is nowhere more than 450km.

***South-western limit*:** Zimbabwe, Haroni and Rusitu forests as indicated by the south-western distributional limits of *Commiphora zanzibarica, Cassipourea euryoides, Inhambanella henriquesii* and *Sterculia appendiculata.* The nearby Chirinda forest is transitional with Afromontane Forest (Timberlake *et al.*, 1995; White, 1983a p.187).

***Southern limit*:** Mozambique, southern edge of Zanzibar-Inhambane regional mosaic as defined by Moll and White (1978) and White (1983a). Forest transitional between the neighbouring Tongaland-Pondoland (now Maputaland-Pondoland) and the eastern African Coastal Forests extends into northern Natal.

***Altitudinal range*:** Sea-level to a maximum altitude which varies according to local ecological conditions, but is nowhere more than 1100m. The maximum altitude reached by eastern African Coastal Forest increases away from the coast, and appears to be greater on small isolated inselbergs compared to larger mountain blocks, e.g. Coastal Forests extend to 400m on the Uluguru and Usambara Mountains (pers. obs.), to 750m on the Udzungwa mountains (Lovett *et al.*, 1988) and to 1030m on Handeni Hill (pers. obs.) (see Chapter 3.1 for sites).

***Climate*:** Tropical monsoon climate of the Indian Ocean with a unimodal (south of Dar es Salaam) to bimodal (north of Dar es Salaam) mean annual rainfall of between 510 and 2000mm (see Chapter 2.3). Eastern African Coastal Riverine Forest may develop in areas with a lower mean annual rainfall of just 470mm (Medley, 1992), since these forests depend on a river for their water supplies (Hughes, 1988).

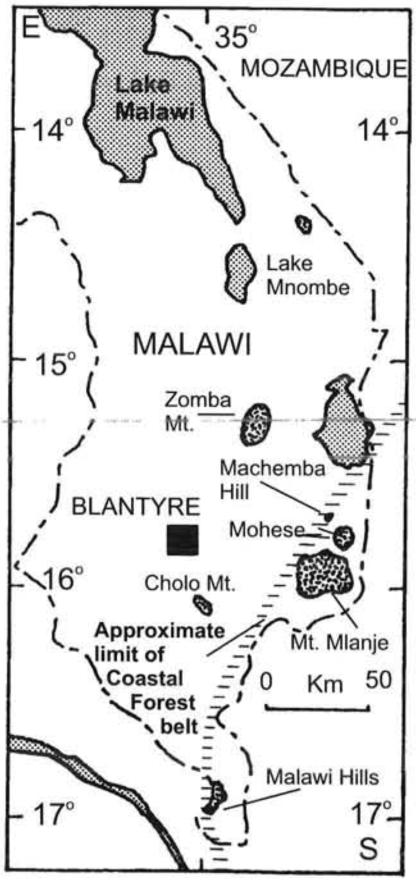


Figure 1.2.7 Approximate limit of the Coastal Forest belt (Swahilian/ Maputaland regional transition zone) in southern Malawi, with the location of the main forested areas (based on data from Chapman and White, 1970 and Dowsett-Lemaire, 1990).

Areas beyond the geographical extent outlined above are either too dry (i.e. to the north, west and southwest), too wet (i.e. upland Afromontane areas) or too cool (to the south) to support eastern African Coastal Forest (Chapter 2.3).

Acknowledgements

I am indebted to Alan Rodgers for extensive comments on this Chapter. Thanks also to Neil Burgess, Jon Fjeldså, Anne Robertson, Jon Lovett and William Hawthorne for further comments and discussion.

References

Axelrod, D.I. and Raven, P.H. (1978). Late Cretaceous and Tertiary vegetation history of Africa. In Werger, M.J.A. (ed.) with assistance of Van Bruggen, A.C. (1978). *Biogeography and Ecology of Southern Africa.* Dr. W. Junk Publishers, The Hague.

Battiscombe, E. (1936). *Trees and Shrubs of Kenya Colony.* Government Printer, Nairobi.

Beentje, H.J. (1990). The forests of Kenya. *Mitt. Inst. Allg. Bot. Hamburg* **23a**: 265–286.

Birch, W.R. (1963). Observations on the littoral and coral vegetation of the Kenya coast. *Journal of Ecology* **51**: 603–615.

Brenan, J. P. M. (1978). Some aspects of the phytogeography of tropical Africa. *Ann. Miss. Bot. Gard.* **65**: 437–478.

Chapman, J.D. (1968). Malawi. In Hedberg, I. and Hedberg, O. (eds.). *Conservation of Vegetation in Africa South of the Sahara. Acta Phytogeographica Suecica* **54**: 215–224. Uppsala.

Chapman, J.D. and White, F. (1970). *The Evergreen Forests of Malawi.* Commonwealth Forestry Institute, Oxford.

Clarke. B.T. (1989). Real vs. apparent distributions of dwarf amphibians: *Bufo lindneri* Mertens 1955 – a case in point. *Amphibia-Reptilia* **10**: 297–306.

Clarke, G.P. (1995a). *Checklist of the Vascular Plants from 13 Coastal Forests in Tanzania.* Frontier-Tanzania Technical Report No. 15. The Society for Environmental Exploration/The University of Dar es Salaam, London and Dar es Salaam.

Clarke, G.P. (1995b). *Status Reports for 6 Coastal Forests in Lindi Region, Tanzania.* Frontier-Tanzania Technical Report No. 18. The Society for Environmental Exploration/The University of Dar es Salaam, London and Dar es Salaam.

Clarke, G.P. (1998). A new regional centre of endemism in Africa. In Huxley, C.R., Lock, J.M. and Cutler, D.F.(eds.). *Chorology, Taxonomy and Ecology of the Floras of Africa and Madagascar.* Pp. 53–65. Royal Botanical Gardens, Kew.

Clarke, G.P. and Dickinson, A. (1995). *Status Reports for 11 Coastal Forests in Coast Region, Tanzania.* Frontier-Tanzania Technical Report No. 17. The Society for Environmental Exploration/The University of Dar es Salaam, London and Dar es Salaam.

Clarke, G.P. and Stubblefield, L.K. (1995). *Status Reports for 7 Coastal Forests in Tanga Region, Tanzania.* Frontier-Tanzania Technical Report No. 16. The Society for Environmental Exploration/The University of Dar es Salaam, London and Dar es Salaam.

Dale, I.R. (1939). *The Woody Vegetation of the Coast Province of Kenya.* Imperial Forestry Institute, Oxford.

Davis, S.D., Heywood, V.H. and Hamilton, A.C. (1994). *Centres of Plant Diversity. A Guide and Strategy for their Conservation.* WWF and IUCN, Godalming and Cambridge.

Dowsett-Lemaire, F. (1990). The flora and phytogeography of the evergreen forests of Malawi II: Lowland forests. *Bull. jard. Bot. Nat. Belg. Bull. Nat. Plantentuin Belg.* **60**: 9–71.

Engler, A. (1894). Uber die gliederung der vegetation von Usambara und der angrenzenden gebiete. *Abh. konigl. Akad. Wiss. zu Berlin* : 1–86.

Exell, A.W. and Wild, H. *et al.* (1960). *Flora Zambesiaca.* Vol. 1. London: Crown Agents for Overseas Governments and Administrations, and managing committee on behalf of the contributors to Flora Zambesiaca.

Friis, I. and Tadesse, M. (1990). The evergreen forests of tropical N.E. Africa. *Mitt. Inst. Allg. Bot. Hamburg* **23a**: 249–263.

Friis, I. and Tadesse, M. (1991). Forests and forest trees of Northeast Tropical Africa. – their natural habitats and distributions in Ethiopia, Djibouti and Somalia. *Kew Bulletin Additional Series* **15**: i–iv and 1–396.

Friis, I. and Vollesen, K. (1989). Notes on the vegetation of southernmost Somalia, with some additions to the flora. *Willdenowia* **18**: 455–477.

Gillet, J.B. (1961). History of the botanical exploration of the area of 'the Flora of Tropical East Africa' (Uganda, Kenya, Tanganyika, Zanzibar). *Comptes Rendus de la IV^e Réunion Plénière de AETFAT*, pp. 205–229.

Gillman, C. (1949). A vegetation types map of Tanganyika Territory. *The Geographical Review* **XXXIX**: 7–37.

Glover, P.E. (1968). The role of fire and other influences on the savannah habitat, with suggestions for further research. *East African Wildlife Journal* **6**: 131–137.

Gomes e Sousa, A. (1966). *Dendrologia de Moçambique. Estudo geral.* Instituto de Investigação Agronomica de Moçambique, Lourenço Marques.

Granger, J.F. (1984). Fire in Forest. In Booysen, P. de V. and Tainton, N.M. (eds.) *Ecological Effects of Fire.* Springer-Verlag, Berlin.

Greenway, P.J. (1938). 'The Natural History of Mafia Island, Tanganyika Territory'. Unpublished typescript. University of Dar es Salaam, Dar es Salaam.

Greenway, P.J. (1973). A classification of the vegetation of East Africa. *Kirkia* **9**: 1–68.

Hall, J.B., Rodgers, W.A., Mwasumbi, L.B. and Swai, I. (1984). 'Woody vegetation on Tanzanian Coral Rag: A reconnaissance'. Unpublished typescript. Forest Working Group of the University of Dar es Salaam, Dar es Salaam.

Hall, J.B. and Swaine, M.D. (1981). *Distribution and Ecology of Vascular Plants in a Tropical Rain Forest. Forest Vegetation in Ghana.* Dr. W. Junk Publishers, The Hague.

Hamilton, A.C. (1982). *Environmental History of East Africa.* Academic Press, London.

Hamilton, A.C. and Faden, R.B. (1973). The history of the vegetation. Pp. 188–209. In Lind, M. and Morrison, M.E.S. (eds.). *East African Vegetation.* Longman, London.

Hawthorne, W.D. (1984). *Ecological and Biogeographical Patterns in the Coastal Forests of East Africa.* PhD Thesis. University of Oxford, Oxford.

Hawthorne, W.D. (1993). East African Coastal Forest botany. Pp. 57–99. In Lovett, J.C. and Wasser, S.K. (eds.). *Biogeography and Ecology of the Rain forests of Eastern Africa.* Cambridge University Press, Cambridge.

Holdridge, L.R., Grenke, W.C., Hatheway, W.H., Liang, T. and Tosi, T. (1971). *Forest Environments in Tropical Life Zones.* Pergamon, Oxford.

Hughes, F.M.R. (1988). The ecology of African floodplain forests in semi-arid zones: a review. *Journal of Biogeography* **15**: 127–140.

Iversen, S.T. (1991). The Usambara Mountains, NE Tanzania: Phytogeography of the vascular plant flora. *Sym. Bot. Uppsaliensis* **XXIX**: 1–234.

Kerner von Marilaun, A. and Hansen, A. (1916). *Pflanzenleben. Dritter Band: Die Pflanzenarten als Floren und Genossenschaften.* Bibliographisches Institut, Leipzig und Wien.

Lebrun, J. (1960). Sur la richesse de la flore de divers territoires Africains. *Bull. Seanc. Acad. r. Sci. Outre-Mer* **6**: 669–690.

Leroy, J.F. (1978). Composition, origin and affinities of the Madagascan vascular flora. *Ann. Miss. Bot. Gard.* **65**: 535–589.

Lovett, J.C., Bridson, D.M. and Thomas, D.W. (1988). A preliminary list of the moist forest angiosperm flora of the Mwanihana Forest Reserve, Tanzania. *Ann. Miss. Bot. Gard.* **75**: 874–885.

Lovett, J.C. (1990). Classification and status of the moist forests of Tanzania. *Mitt. Inst. Allg. Bot. Hamburg* **23a**: 287–300.

Lovett, J.C. (1992). *Classification and Affinities of the Eastern Arc moist forests of Tanzania.* PhD Thesis. University of Wales, Bangor.

Lovett, J.C. (1993). Eastern Arc moist forest flora. Pp. 33–55. In Lovett, J.C. and Wasser, S.K. (eds.). *Biogeography and Ecology of the Rain Forests of Eastern Africa.* Cambridge University Press, Cambridge.

Madgwick, J. (1988). Riverine forest in the Jubba Valley: a vegetation analysis and comments on forest conservation. *Biogeographica* **XIV**. *The Biogeography of Somalia*, Pp. 67–88.

Medley, K.E. (1992). Patterns of forest diversity along the Tana River, Kenya. *Journal of Tropical Ecology* **8**: 353–371.

Menaut, J-C., Lepage, M. and Abbadie, L. (1995). Savannas, woodlands and dry forests in Africa. In Bullock, S.H., Mooney, H.A. and Medina, E. (eds.). *Seasonally Dry Tropical Forests*. Cambridge University Press, Cambridge.

Milne-Redhead, E. (1955). Distributional ranges of flowering plants in tropical Africa. *Proc. Linn. Soc. London* **165**: 25–35.

Moll, E.J. and White, F. (1978). The Indian Ocean Coastal Belt. In Werger, M.J.A. (ed.) with assistance of Van Bruggen, A.C. (1978). *Biogeography and Ecology of Southern Africa.* Dr. Junk Publishers, The Hague.

Monod, T.L. (1957). *Les grandes divisions chorologiques de l'Afrique*. CCTA/CSA, London. **24**: 1–147.

Moomaw, J.C. (1960). *A Study of the Plant Ecology of the Coast Region of Kenya Colony.* Government Printer, Nairobi.

Murphy, P.G. and Lugo, A.E. (1986). Ecology of tropical dry forest. *Annual Review of Ecology and Systematics* **17**: 67–88.

Phillips, J.V.F. (1931). A sketch of the floral regions of Tanganyika Territory. *Transactions of the Royal Society of South Africa* **19**: 363–372.

Pócs, T. (1975). Affinities between the bryoflora of East Africa and Madagascar. *Boissiera* **24**: 125–128.

Pócs, T. (1976). Vegetation mapping in the Uluguru Mountains (Tanzania, East Africa). *Boissera* **24**: 477–498.

Polhill, R.M. (1968). Tanzania. In Hedberg, I. and Hedberg, O. (eds.). Conservation of vegetation in Africa South of the Sahara. *Acta Phytogeogr. Suecica* **54**: 166–78.

Poynton, J.C. (1991). Amphibians of southeastern Tanzania, with special reference to *Stephopaedes* and *Mertensophryne* (Bufonidae). *Bull. Mus. Comp. Zool.* **152**: 451–473.

Rea, R.J.A. (1935). The forest types of vegetation in Tanganyika Territory. *Empire Forestry Journal* **14**: 202–208.

Rodgers, W.A. (1979). *The Ecology of Large Herbivores in the Miombo Woodlands of South East Tanzania.* PhD Thesis. University of Nairobi, Nairobi.

Rodgers, W.A., Hall, J.B., Mwasumbi, L.B., Griffiths, C.J. and Vollesen, K. (1983). *The Conservation Values and Status of Kimboza Forest Reserve, Tanzania.* University of Dar es Salaam Forest Conservation Working Group, Dar es Salaam.

Ruffo, C.K. (1992). 'Report on a Survey of Species in Kitulang'alo Forest Reserve'. Unpublished report. Faculty of Forest Science, Sokoine University of Agriculture, Morogoro.

Sheil, D. (1992). Tanzanian Coastal Forests – unique, threatened, and overlooked. *Oryx* **26**: 107–114.

Swaine, M.D. (1992). Characteristics of dry forest in West Africa and the influence of fire. *Journal of Vegetation Science* **3**: 365–374.

Swaine, M.D., Hawthorne, W.D. and Orgle, T.K. (1992). The effects of fire exclusion on Savannah vegetation at Kpong, Ghana. *Biotropica* **24**: 166–172.

Timberlake, J. (1994). Changes in the extent of moist forest patches in the Eastern Highlands: case studies based on aerial photographs. *Zimbabwe Forestry Commission Research Paper* **7**: 1–15.

Timberlake, J., Muller, T. and Mapaure, I. (1995). Vegetation. In Timberlake, J. and Shaw, P. (eds.). *Chirinda Forest. A Visitors' Guide.* Forestry Commission, Harare.

Timberlake, J. and Shaw, P. (eds.) (1994). *Chirinda Forest. A Visitors' Guide.* Forestry Commission, Harare.

Timler, F.K. and Zepernik, B. (1987). German colonial botany. *Ber. Deutsch. Bot. Ges.* **100**: 143–168.

Trapnell, C.G. (1959). Ecological results of woodland burning in Northern Rhodesia. *Journal of Ecology* **47**: 129–68.

Troup, R.S. (1923). Forestry in Kenya Colony. *Empire Forestry Journal* **2**: 46–60.

Usher, M. B. (1986). Invasibility and wildlife conservation: invasive species on nature reserves. *Phil. Trans. R. Soc. Lond.* B **314**: 695–710.

Vollesen, K. (1994). Rondo Plateau, Tanzania. Pp. 225–226. In Davis, S.D., Heywood, V.H. and Hamilton, A.C. (eds.). *Centres of Plant Diversity. A Guide and Strategy for their Conservation.* WWF and IUCN, Godalming and Cambridge.

White, F. (1976). The vegetation map of Africa: the history of a completed project. *Boissiera* **24**: 659–666.

White, F. (1979). The Guineo-Congolian Region and its relationships to other phytochoria. *Bull. Jard. Bot. Nat. Belg./ Bull. Nat. Plantentuin Belg.* **49**: 11–55.

White, F. (1983a). *The Vegetation of Africa. A Descriptive Memoir to Accompany the UNESCO/ AETFAT/UNSO Vegetation Map of Africa.* 356 pp. UNESCO, Paris.

White, F. (1983b). *UNESCO/AETFAT/UNSO Vegetation Map of Africa.* Scale 1:5,000,000 (in colour). UNESCO, Paris.

White, F. (1983c). Long distance dispersal, overland migration and extinction in the shaping of tropical African floras. *Bothalia* **14**: 395–403.

White, F. (1993). The AETFAT chorological classification of Africa: history, methods and applications. *Bull. Jard. Bot. Nat. Belg. Bull. Nat. Plantentuin Belg.* **62**: 225–281.

Whitmore, T.C. (1986). *Tropical Rainforests of the Far East.* 2nd edition. Oxford University Press/ELBS, Oxford.

Wild, H. and Grandvaux Barbosa L.A. (1967). *Vegetation Map of the Flora Zambesiaca Area.* Descriptive memoir: 71pp. M.V.O. Collins (Pvt.) Ltd, Salisbury, Harare.

Section 2

Physical background

This section describes the physical conditions within which the eastern African Coastal Forests are found. The key features of the physical environment are the substrate upon which the forests grow (solid rocks, unconsolidated marine and fluviatile sediments, and soils developed from these materials), and the climate of the area. Separate Chapters are devoted to Geology and Geomorphology, Soils, and Climate and Climatic History.

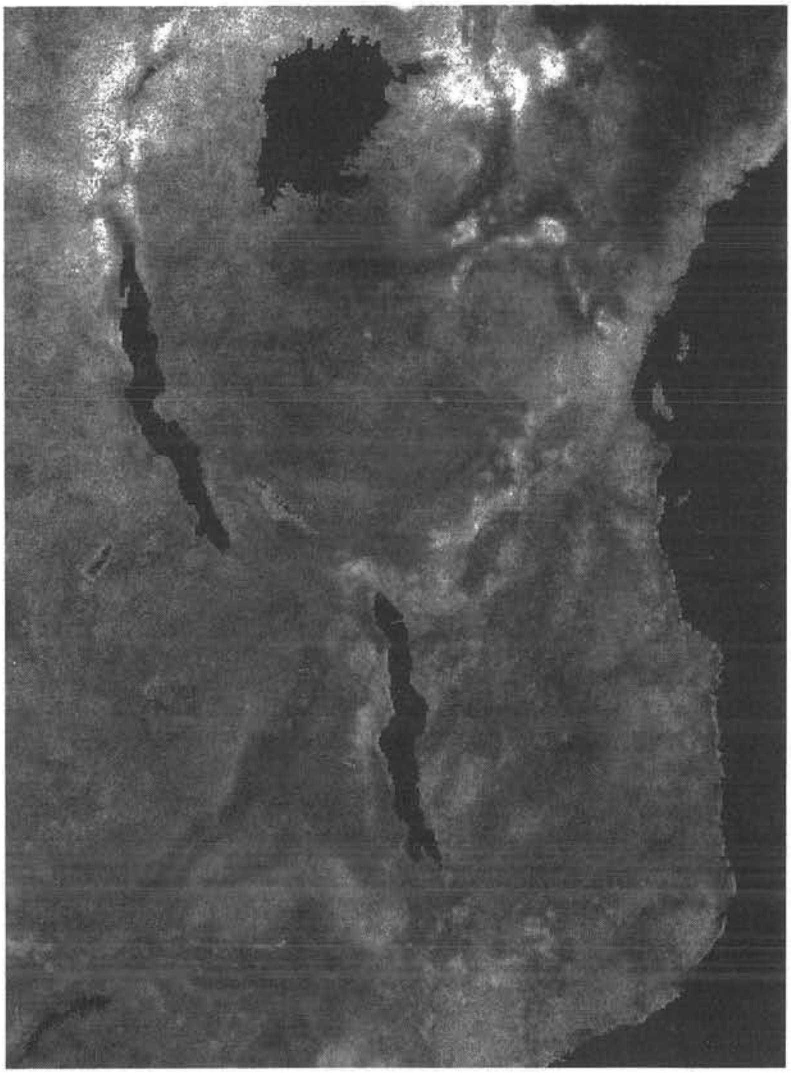


Figure 2 Ecoclimatic variability in tropical Africa over ten years. Light areas show high interannual differences in surface conditions (Ts/NDVI), and dark areas show low interannual differences. This map gives the average for 12 maps calculated on a monthly basis using the daily scenes from the NOAA-AVHRR meterological satellites from 1981–1991. The Coastal Forest belt here appears somewhat unstable, especially in comparison to some of the mountains of the Eastern Arc, and the scarp of the Udzungwa Mountains can be seen as a distinct break between the two ecoclimatic regimes. Ts = is the brightness surface temperature. NDVI = Normalised Difference Vegetation Index. Ts/NDVI = Coefficient of variation of the ratio between these two variables. Pixel size is 5km x 5km.

This illustration is derived from Figure 4 in Fjeldså *et al.* (1997) and is reproduced with the kind permission of the authors. These authors present evidence that many mountain biodiversity hotspots are located in areas of low interannual variability (small dark areas on the map), the Coastal Forest belt and its endemics are found in a somewhat more unstable climatic regime.

Fjeldså, J., Ehrlich, D., Lambin, E. and Prins, E. (1997). Are biodiversity 'hotspots' correlated with current ecoclimatic stability? A pilot study using the NOAA-AVHRR remote sensing data. *Biodiversity and Conservation* 6: 401–423.

2.1 Geology and geomorphology

G. P. Clarke and N.D. Burgess

Introduction

Surface geology (rock types) and geomorphology (landscape topography) indirectly influence the characteristics of the vegetation that grows on them, both through their effect on the chemical composition and particle size of the parent material from which local soils are derived, and through the local effect of topography on hydrology and climate (Chapter 2.3). We briefly summarise the processes which have produced the present geology (Figure 2.1.1) and associated geomorphology of coastal eastern Africa, describe the current pattern of exposed rock types, and discuss their influence on the overlying Coastal Forests.

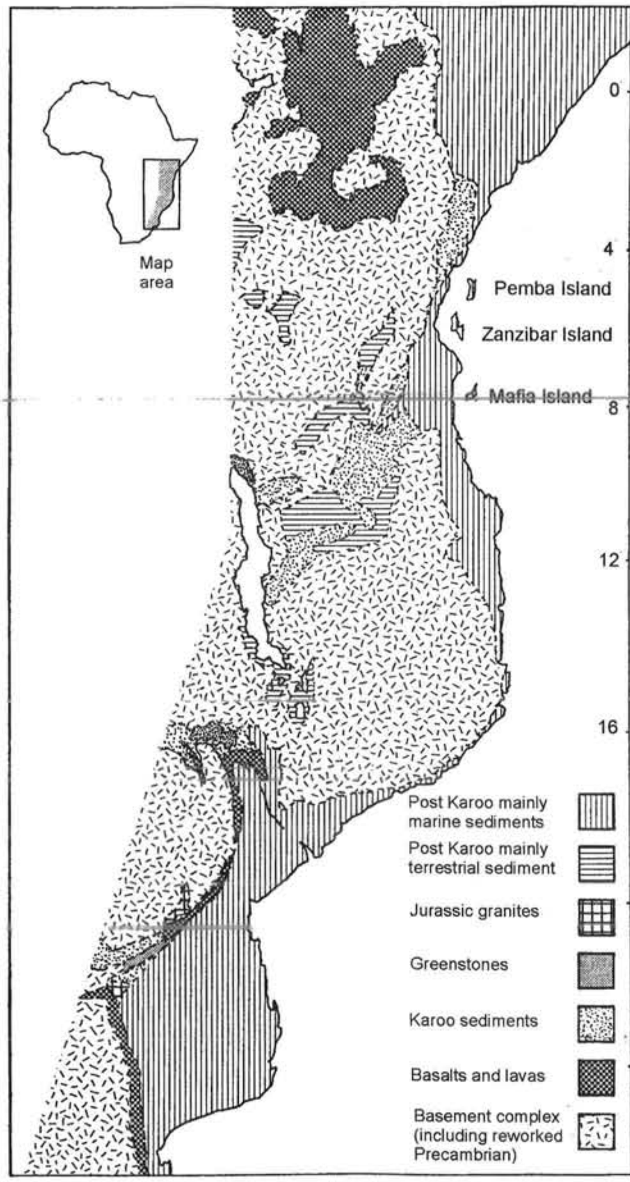


Figure 2.1.1 Simplified surface geology of eastern Africa (sources: ASGA-UNESCO, 1963; de Freitas, 1956; Ministerio de Colonais, 1948; Kent *et al.*, 1971).

Geological and Geomorphological Development of eastern Africa

Only tiny fragments of the present surface of Africa are thought to be more than 200 million years old (King, 1978), since most of the surface that existed before this time has now been either eroded away or is covered by deposits from subsequent weathering. The historical evolution of the eastern part of the continent since this period is therefore relevant to understanding how the existing geomorphology and its associated geology are derived, and how old these features are.

Before Continental Africa: The Gondwana Landmass [Pre-Jurassic]

Prior to the gradual fragmentation of Gondwanaland (i.e. before 290 million years ago – see Dietz and Holden, 1970; Griffiths, 1993), Africa and the other southern continents were united in a rather featureless landscape consisting of a flat eroded plateau of Precambrian (>570 million years old – see Figure 2.1.2) basement rocks, in which wide basins had subsided. Erosion over the last few hundred million years has both scoured the Gondwanaland rocks to below the surface level that existed during Gondwanaland times, and covered some of those surfaces with deposits from erosion (King, 1978). Only fragments of the original Gondwanaland surface are still thought to remain exposed, e.g. the tops of some inselbergs and plateaux (such as those of northern Mozambique, Figure 2.1.3).

Throughout Gondwanaland ancient fissure lines and rifts (cracks) existed between the primitive cratons, which were welded together by emissions of basalt during the Precambrian (King, 1978). Further rifting and further basaltic upwellings occurred during the Karoo epoch (especially during the early/mid Cretaceous), coinciding with the development of a system of horsts and grabens over much of the face of the Central Plateau, which initiated the Eastern Arc mountain fault blocks (Lovett and Wasser, 1993). Subsequent faulting has often reactivated these ancient fault lines (Griffiths, 1993). Towards the end of the Karoo epoch, a

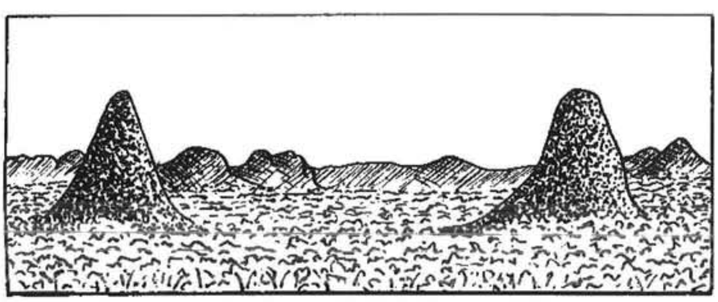


Figure 2.1.3 Typical inselberg landscape of northern Mozambique. Koldwi, north of the Mtupa Pass near Ribaue. From a sketch by E.J. Wayland.

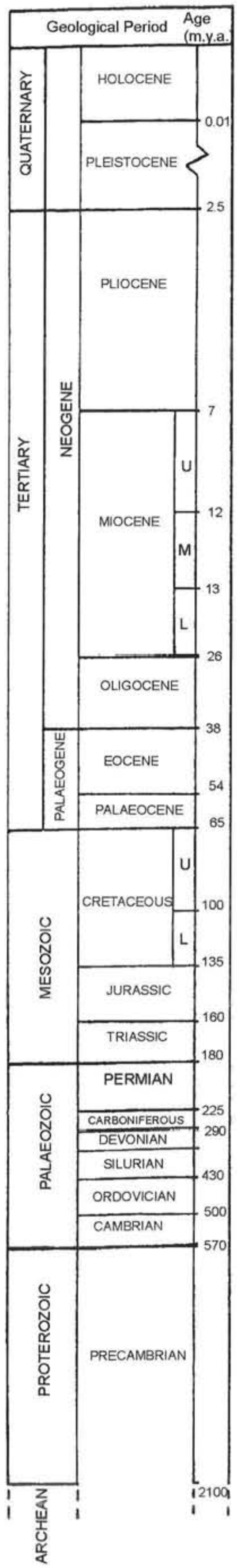


Figure 2.1.2 Geological timescales (vertical scale logarithmic).

tongue of sea entered Gondwanaland along the line of the present eastern African coast, following one of these ancient faulted troughs (Kent, 1972; 1974), so that marine Karoo facies were laid down over the earlier terrestial facies. These Karoo beds are presently exposed in parts of eastern Tanzania and Kenya (Spence, 1957).

Post Gondwanaland Fragmentation [Late Jurassic to mid-Tertiary]

Gondwanaland fractured over *c.* 100 million years, beginning during the Mesozoic (about 200 million years ago), during which the present southern continents broke away at different times from the Gondwanaland 'parent' continent. Earlier Karoo fractures were widened by basaltic intrusions (Griffiths, 1993), such as those along the present day Mozambique/Zimbabwe border, and in some areas massive basaltic outpourings occurred e.g. in coastal Mozambique and western Madagascar during the early/middle Cretaceous (Kent, 1972). Further seawater incursions occurred into the widening rifts which led to the appearance of the Indian Ocean about 165–120 million years ago. Africa as a whole then broke away from the remainder of Gondwanaland about 120 million years ago (Griffiths, 1993).

The new seas surrounded the African landmass at a much lower elevation than the plains, thereby initiating a phase of erosion from the edges of the new continent, so that river and scarp retreat erosion gradually cut into the Gondwana surface. The rivers that were eroding away the eastern part of the continental surface began to deposit their sediment at the coast, thereby initiating the building out of a marine sedimentary lens onto the crystalline rocks of the continental shelf basement, beginning with upper Jurassic and Cretaceous marine sediments (Kent *et al.*, 1971; Kent, 1972; Figure 2.1.4).

Such river and gravity erosion acted on the continent throughout an 80 million year long stable period (late Cretaceous to the mid-Tertiary), without interruption by tectonic activity (King, 1978). The continous erosion denuded the central parts of the continent into great flat plains, many of which still exist, particularly on the South African Highveld, and the Central African Plateau of Zimbabwe, northern Mozambique, Tanzania and southern Kenya. Material eroded from the central continental plateau continued to be deposited into the sea, such that shoreline regression was more or less continuous through the Cretaceous and into the lower Tertiary, expanding the eastern seaboard of Africa outwards in the process. This build-up of material reached the present shoreline during the middle Eocene (45 million years ago) when the Pugu Hills near Dar es Salaam were first exposed

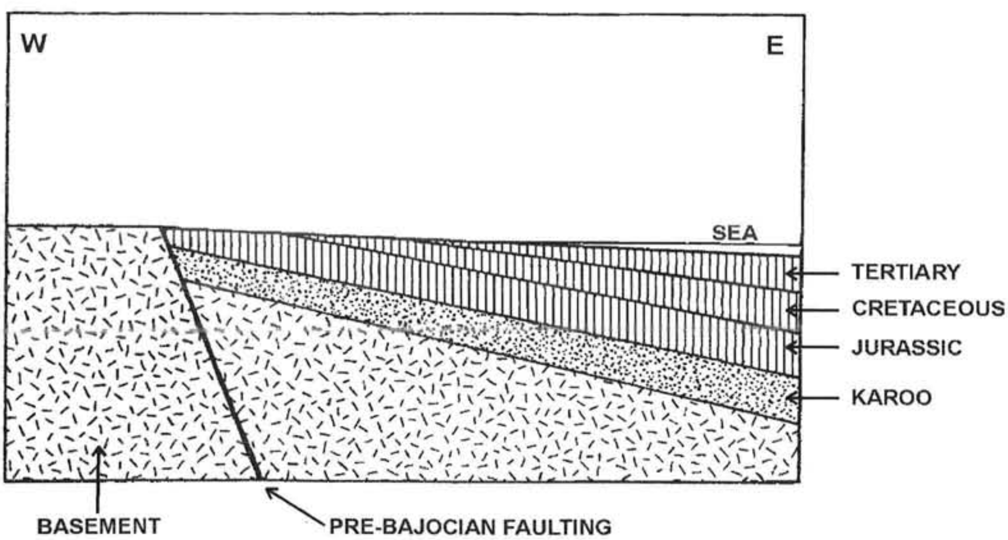


Figure 2.1.4 Simplified geological cross-section of the northern Tanzanian coastal plain (from Kent *et al.*, 1971). Post-Bajocian faulting is not shown.

(Kent *et al.*, 1971). Only in the area around old Moçambique Island has there been little or no build up of marine sediments, possibly due to this being the region where the narrowest constriction of the Mozambique Straits occurs.

Uplifting, Tectonic Warping and Marine Transgression [Mid-Tertiary to Miocene]

The first of two major periods of uplifting occurred during the mid-Tertiary (30 million years ago), which raised the Central Tanganyikan Plateau, thereby separating the tropical lowlands of West and Central Africa from those of the eastern African coast (Axelrod and Raven, 1978). From the early Miocene (26–23 million years ago, after Africa had drifted to its present position) the continent was warped by further tectonic activity into a series of arches and basins, giving a characteristic 'rolling' surface to the older planations. This warping was accompanied by further uplifting, accelerating the process of river erosion (due to the increased relief), and the older planation surface is in places only retained over the crest of the arches (King, 1978). A remnant of this 'rolling Miocene' surface may be present in SE Tanzania, for a cross-section of the plateaux inland from Lindi suggests the outline of the original Miocene swell (Figure 2.1.5), which has since been fragmented and eroded away through the combined action of hydrological erosion by rivers and retreating scarp erosion by gravity. Six major plateau fragments are all that now remain of that original surface.

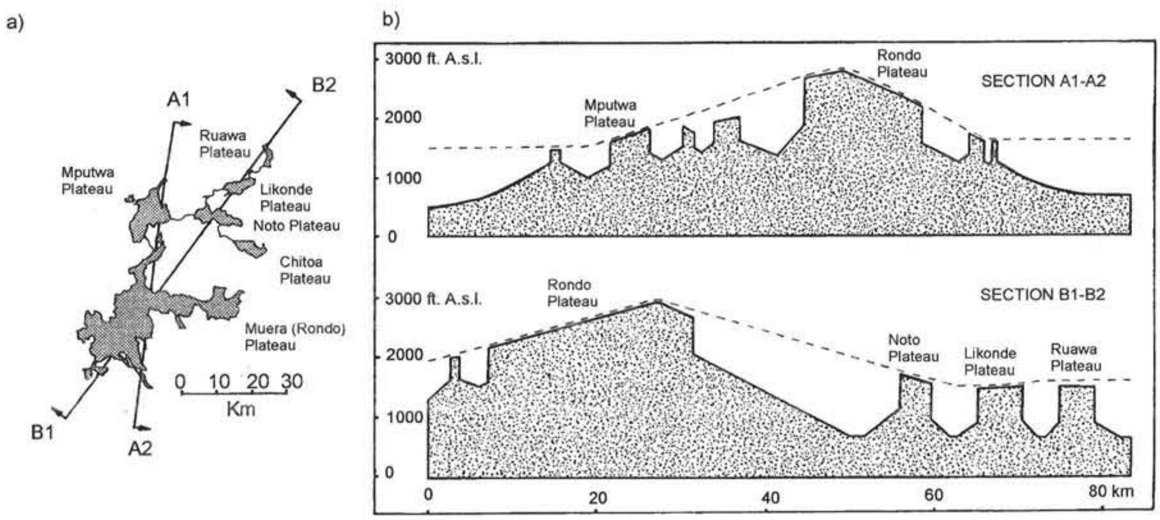


Figure 2.1.5 Plan (a) and cross sections (b) of the current topography of the plateau areas inland of Lindi in southern Tanzania. Inferred surface/extent of the former Miocene swell from which they are derived is shown in broken outline.

By the end of the Oligocene (26 million years ago), continued shoreline regression had extended the 'Tanzanian' coastline as far out as Zanzibar [and presumably also Mafia Island], where the oldest surface rocks date from the lower Miocene (26–18 million years ago, Kent *et al.,* 1971). The subsequent warping and faulting then tilted the East African coast downwards such that the sea came further inland by some tens of miles (Kent *et al.*, 1971), although Zanzibar and the Bweni peninsula on Mafia Island were not completely inundated by this marine transgression. Ancient coral rag formations occurring at about 250m altitude on hillsides and escarpment edges near the coast may date from this time (e.g. at Gendagenda and Ruawa forests in Tanzania).

Shoreline regression did not start again until the middle Miocene (18–12 million years ago), after which the coastline eventually reached as far as Pemba Island.

Uplifting, Rifting and Coastal Regression [Pliocene and Quaternary]

Further uplifting occurred towards the end of the Miocene (8 million years ago), which caused rivers to be rejuvenated. Hydrological and scarp erosion combined to cut many new basins into the continental relief (King, 1978). Pemba Island was then separated from the African mainland by faulting that produced the Pemba Channel, possibly during the Pliocene (six million years ago).

Major uplifting again occurred during the end of the Pliocene (2.5 million years ago), when the Central Plateau in Tanzania was raised by an additional 1000m and the coastal monocline was steepened. Further rejuvenations have followed, most notably in southern Kenya (0.6 million years ago). In between the uplifts, erosion has continued to denude the landscape to new levels, repeated faulting has warped and exposed various layers of the marine sedimental strata, coral reefs have formed where conditions have been suitable, and the sea level has fluctuated as a result of lesser uplifting and downwarping (cf. Cooke, 1974).

The complex changes in the topography of eastern Africa have resulted in considerable changes in the position of the palaeo-coastline (Figure 2.1.6), such that many sites which now support Coastal Forest have been underwater several times during the past few million years. The rate of such changes would however have been very gradual, so any forests present would have been able to disperse to more suitable areas elsewhere.

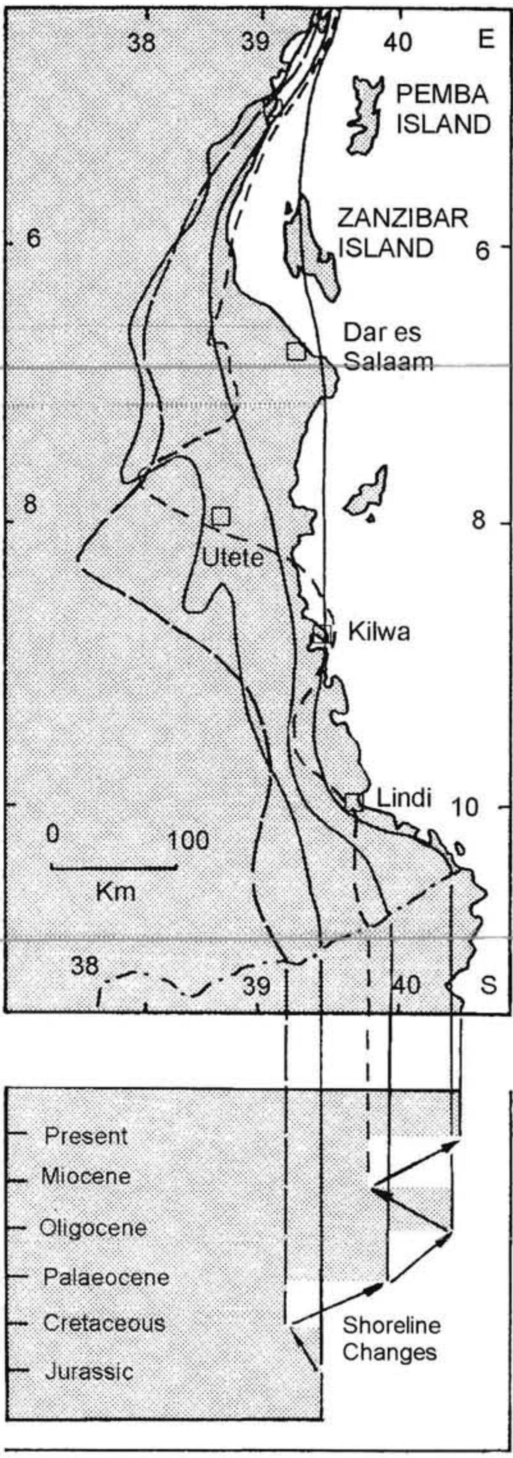


Figure 2.1.6 Inferred shoreline changes in Tanzania since the Jurassic (from Kent *et al.*, 1971). The shaded area on the upper part of the diagram represents the present extent of land.

Present geology and geomorphology of eastern Africa

The tectonic, denudational and occasionally volcanic processes which have been operating over the last 200 million years have resulted in the present eastern African landscape which is broadly characterised by a coastal plain/monocline which slopes gently upwards away from the sea, interrupted in places by low hills. A chain of high mountains (to 2600m) rises steeply out of the central and southern parts of this coastal plain, but elsewhere the plain merely rises more steeply at its western end after reaching an altitude of between 200–300m, to eventually reach the Central African Plateau that stretches from southern Kenya to Zimbabwe at between 1300m and 1500m (Buckle, 1978; King, 1978).

The Coastal Plain/Monocline

The coastal 'plain' of eastern Africa is more accurately described as a gentle monocline, running from sea level to an elevation of about 300m. The width of the plain is very variable; at the northern and southern limits of the Coastal Forest belt (northern Kenya/southern Somalia and southern

Mozambique) it is very wide (over 300km) but becomes very narrow (less than 30km) along the south Kenyan and northern Tanzanian coasts, and again along the northern Mozambique coast (north of Moçambique Island, cf. Tinley, 1971; White, 1983).

The surface geology of the coastal plain comprises a complex sequence of relatively recent (post-Jurassic, <*c*.135 million years old), predominantly marine/estuarine sedimentary rocks (sandstones, limestones, marls, shales and mudstones), which are generally of progressively younger age the closer they are to the present shoreline (see Hawthorne, 1984 for a geological summary of Tanzanian and Kenyan coastal areas). Geological unconformities caused by marine transgressions are present in some areas where sedimentary rocks of widely different ages are found side by side, or where older rocks are situated to the seaward of younger rocks. More recent deposits are superimposed onto this pattern (Figure 2.1.7).

The surface rocks of the coastal plain vary in composition, but are generally calcareous and base-rich since they are predominantly marine in origin. Uplifted areas of ancient coral reefs outcrop to form limestone karsts which produce base-rich soils (e.g. around Tanga, Mombasa, and at Ruawa in southern Tanzania). Elsewhere more nutrient-poor terrestrial Karoo (Upper Carboniferous to Jurassic) and Neogene (Pliocene/Miocene) sedimentary rocks are exposed in parts of the Tanzanian and Kenyan coastal zone (see Figure 2.1.1). Hills and ridges of Neogene age are found throughout the area, many resulting from Neogene tectonic upheavals. In some places, especially close to the coast, older rocks are covered by recent (Holocene) water-deposited materials of various types, particularly red-weathering sands (Kent *et al.*, 1971). Tertiary basalts are present on part of the Mozambique coast (Tinley, 1971), and post-Triassic igneous rocks intrude through the Karoo series in southern Kenya (Hawthorne, 1993). Recent limestone deposits (coral rag) are present along much of the Kenyan, Tanzanian and Mozambiquan shoreline (Frazier, 1993; Tinley, 1971). Ridges of sand are found along

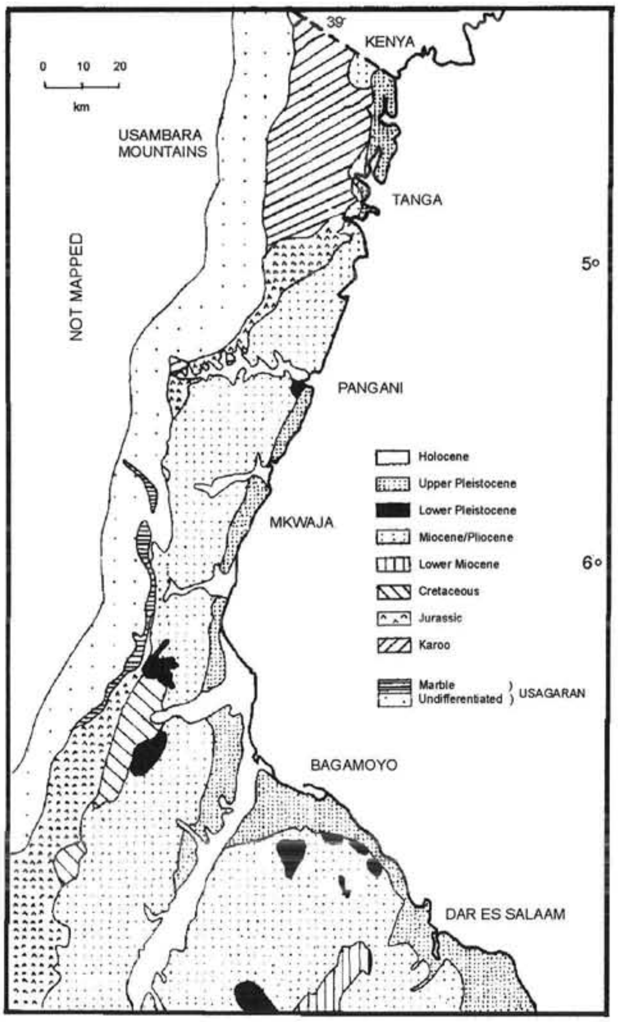


Figure 2.1.7 Surface geology and unconsolidated sediments of Dar es Salaam to the Tanzania-Kenya border (Moore, 1963). Areas inland of the Undifferentiated Usagaran sediments are not mapped.

much of the coastline of eastern Africa and have been deposited since the end of the last Ice Age, some 10,000 years ago (Alexander, 1969; Cooke, 1974).

Coastal Forests are predominantly located within the coastal plain, where they occupy a range of different geomorphological features, from flat and low-lying areas next to the sea (e.g. Arabuko-Sokoke), to river valleys dissecting the plain (e.g. Sigi and Pangani Rivers), to low ridges (e.g. Zaraninge, Pande, Pugu Hills), and higher areas which rise up to 800m a.s.l. (e.g. Matumbi Hills and the Rondo Plateau). Transects through the coastal plain coinciding with locations of some Coastal Forests (Figure 2.1.8) show the variation of locations where these forests are found, although raised topographical features are common.

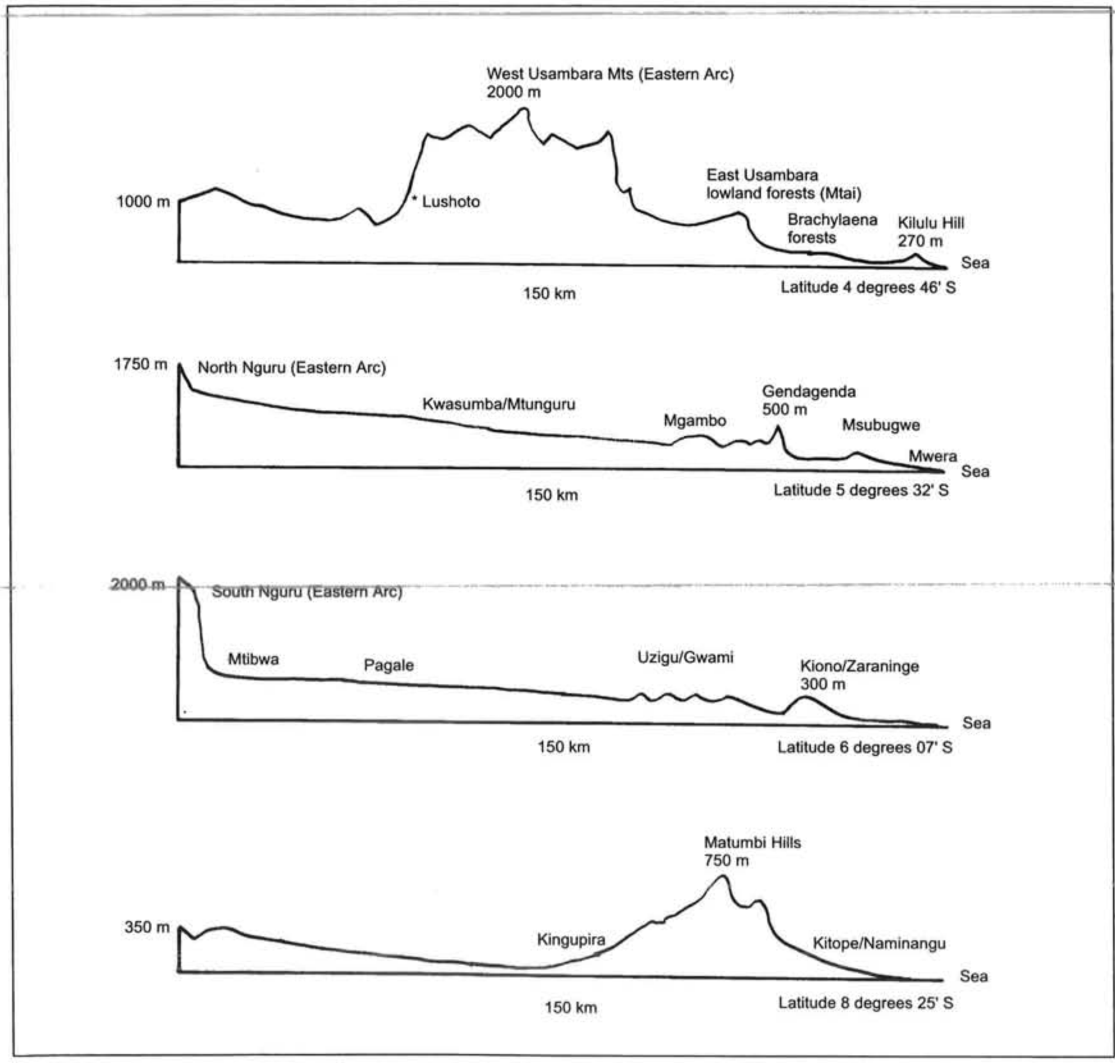


Figure 2.1.8 Four west to east cross-sections through coastal Tanzania, showing the geomorphological positions of some Coastal Forests (vertical scales not consistent).

The Central African Plateau

The Central African Plateau occurs inland of the eastern African coastal plain, where the exposed rocks consist mainly of ancient Precambrian (>570 million years old) crystalline rocks (granulites, gneisses and schists). In some areas (in a belt running from Ethiopia to Mozambique) these Precambrian rocks have been modified during the Upper Precambrian to Ordovician (650–450 million years ago), to produce highly deformed, high grade metasedimentary crystalline rocks (granitoid gneisses, hornblende-pyroxene granulites, marbles and graphite schists) known collectively as the Mozambique Series. Much older low grade metamorphic greenstones from the Archaean (>2500 million years old) outcrop in a few places on the Central Plateau. Deposits of Palaeozoic to mid-Mesozoic (290–180 million year old) conglomerates, sandstones, limestones, shales, marls, evaporites and coals (Spence, 1957) as well as more recent Tertiary to Quaternary (<c.66 million years old) terrestrial sedimentary rocks are found in some of the low lying basins. Coastal Forests are present on the eastern edge of the Central African Plateau, in eastern Zimbabwe, southern Malawi (e.g. the Malawi Hills) and particularly in northern Mozambique, where rocks of the Mozambique Series almost reach the coast (Figure 2.1.1). In Tanzania, Coastal Forests are present on graniolite and dolomitic marble substrates at the base of the Uluguru Mountains (Pócs, 1976), and gneisses in the East Usambara lowlands (cf. Hamilton, 1994), and on outlying metamorphic hills elsewhere such as Mtunguru and Handeni Hill (Lovett and Pócs, 1993).

Discussion

Geological and geomorphological influences on vegetation

Both geology and geomorphology can be important influences on the vegetation that grows above them, although it is difficult to quantify the extent of these effects as they may be local in character, may have accumulated over millions of years, or may depend on a complex set of interactions with other factors such as climate, fire and disturbance. The process by which surface rocks are weathered and release nutrients into the surrounding soils may be countered by the washing out (leaching) of those nutrients during times of high rainfall. Topography likewise affects the rate at which soils are drained (and therefore leached) and eroded, as well as the amount by which the parent rocks are exposed to the weather (and therefore release nutrients). Climatic influences on these factors are complex, such that different climatic/topographic combinations will lead to different rates of nutrient release by the parent rocks, as well as different rates of nutrient leaching from the overlying soils.

Although Coastal Forests are present on a variety of geomorphological features, the majority of the forests are now found on low hills, residual plateaux and at the base of exfoliated inselbergs, sometimes rising only a few hundred metres above the surrounding plain and therefore unlikely to be the result of climatic factors alone (Chapter 2.3). This pattern of forest distribution matches that of lowland dry forests elsewhere in Africa, where it had been attributed to better soil rejuvenation on these hills (cf. Cole, 1963; Swaine, 1992), although fire-shadow patterns caused by the interaction between prevailing winds and terrain physiography have recently been suggested as an additional explanation (Geldenhuys, 1994, from studies in the neighbouring Maputaland-Pondoland forests).

Raised topographical features (low hills and plateaux) have been present along the eastern African coastal plain since the Miocene, and a further explanation for the persistence of forest on these features may be because these may have provided stable sites where Coastal Forests could have persisted over thousands, or even millions, of years.

Excluded geological-geomorphic combinations

Although Coastal Forests occur on a wide range of rock types and geomorphological features, too few data are currently available to determine whether certain geological-geomorphic combinations do not support forest. For example, rather little is currently known about the extent and distribution of Coastal Forest in northern Mozambique, particularly over the Precambrian Basement rocks. To our knowledge however, forest is scarce to absent on these planated basement sufaces, but does occur on hills (Wild and Grandvaux Barbosa, 1967) and at the base of inselbergs. Given that (a) parent rocks with a high quartz content (such as the crystalline basement rocks and their derived sandstones) tend to produce poor sandy soils which are rapidly drained and therefore have a poor drought-resistance (Griffiths, 1993), and (b) that soils on residual plateaux where no rock erosion is occuring (e.g. on ancient planation surfaces) will be less fertile than those on the hillsides (Swaine *et al.*, 1992), we believe that the rapidly drained, nutrient poor soils on the planated basement surfaces may be

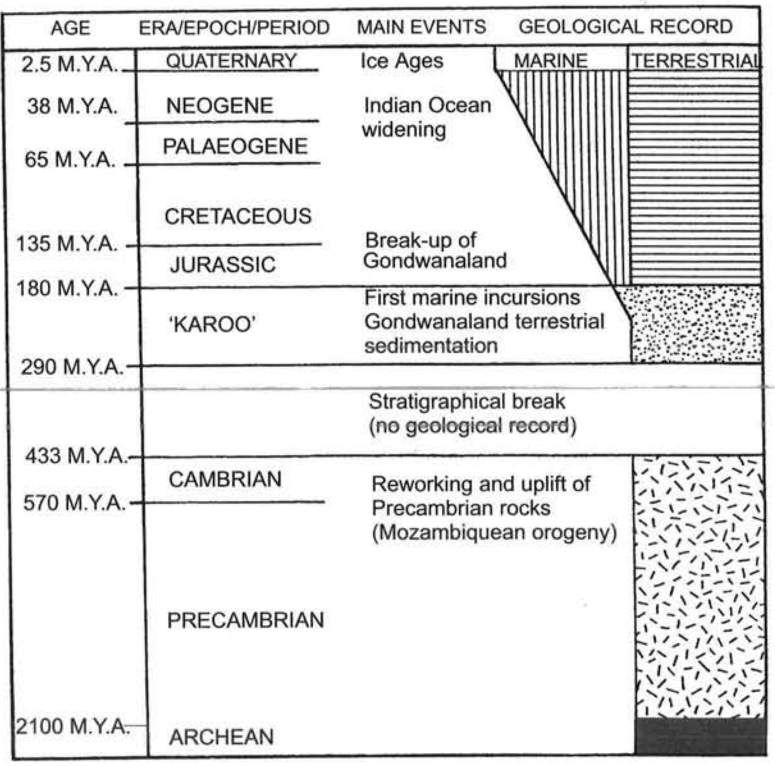


Figure 2.1.9 Summary of the main geological events which have shaped the present geology and geomorphology of eastern Africa. Patterns used to represent the surface geological record in the right hand column correspond with those used in Figure 2.1.1. Vertical scale logarithmic.

unfavourable to Coastal Forests, particularly when combined with the drier climate of northern Mozambique (cf. Chapter 2.3). Swaine *et al.* (1976) have found that parent rock plays an important role in determining the ratio and distribution of forest and woodland at the forest-woodland boundary in Ghana, where rainfall is just insufficient to guarantee the presence of forest. Dry forest with a similar rainfall to the Coastal Forests (Chapter 2.3) is found here in areas with a lower rainfall than neighbouring areas that contain woodland, and this is attributed to the woodlands being distributed over rapidly drained and infertile sandstones, whilst the forests are to be found on basement complex rocks from which more nutrient rich clay soils are derived from the basic Gneiss inselbergs (Swaine, 1992). Similar results have been found in studies near the forest-savannah boundary in South America, where forest occurs on clay-rich soils and savannah on coarser soils (Swaine *et al.*, 1976, quoting Askew *et al.,* 1970).

Elsewhere in the Coastal Forest belt, where rainfall is higher and over steeper relief, the presence of the Precambrian basement substrate does not appear to limit the development of Coastal Forest.

Summary

Most of the present geomorphological features of coastal eastern Africa have developed over the last 200 million years, although some of the exposed rocks are much older. In addition to the continued erosion of the ancient African basement, major geological events (Figure 2.1.9) include the incursion of a seaway into Gondwanaland (eventually becoming the Indian Ocean) into which marine and fluviatile sediments have been deposited, together with the tectonic events which have uplifted and downwarped these sediments periodically since the Miocene. Tectonic activity has also been responsible for the uplift of the Central Tanganyikan Plateau during the Miocene, which separated the formerly continuous pan-African lowland forest, thereby isolating the Coastal Forests from the Guineo-Congolian forests further west (Axelrod and Raven, 1978).

The entire age range of geological substrate that is found in Africa (cf. Swaine, 1992) is represented in the Coastal Forest belt, with forests being present on Precambrian (up to 2500 million year old) rocks to recent alluvial deposits that have yet to consolidate, and that are still being built up. Similarly, forest habitats can be found over a wide range of geomorphological features, from ancient planations and plateaux, to marine and lacustrine deposits, to erosion features such as scarp edges and river gullies. The age of the surfaces on these features varies; some have been exposed by recent erosion or built up by recent deposition, whereas others may have been stable for millions of years. All of these factors contribute to the great diversity in vegetation types that is seen today in the Coastal Forests (Chapter 3.2), which is further heightened by the variety of climatic regimes and soil types which exists in the Coastal Forest belt. The influence of these two factors on the Coastal Forests is described in greater detail in the following two Chapters.

Acknowledgements

Many thanks to John Trusswell for discussions and comments on an earlier draft of this Chapter, and to the staff of the map room of the Royal Geographical Society, London for providing access to the geological maps in their care. Comments on the Chapter were received from Jon Fjeldså and Alan Rodgers. Leigh Stubblefield and Anya Cockle drew Figures 2.1.7 and 2.1.8 respectively.

References

Alexander, C.S. (1969). Beach ridges in north-eastern Tanzania. *The Geographical Review* **59**: 104–122.

ASGA-UNESCO (1963). *Carte Géologique de l'Afrique.* Sheets 6, 8 and 9. Scale 1: 5,000,000. UNESCO, Paris.

Askew, G.P., Moffat, D.J., Montgomery, R.F. and Searl, P.L. (1970). Interrelationships of soils and vegetation in the savanna-forest boundary zone of north-eastern Mato Grosso. *Geographical Journal* **136:** 370–376.

Axelrod, D.I. and Raven, P.H. (1978). Late Cretaceous and Tertiary vegetation history of Africa. In Werger, M.J.A. (ed.) with assistance of Van Bruggen, A.C. (1978). *Biogeography and Ecology of Southern Africa.* Dr. W. Junk Publishers, The Hague.

Buckle, C. (1978). *The Landforms of Africa.* Longman, London.

Cole, M.M. (1963). Vegetation and geomorphology in N. Rhodesia: an aspect of the distribution of the savanna in Central Africa. *Geographical Journal* **129**: 290–310.

Cooke, H.J. (1974). The coastal geomorphology of Tanga, Tanzania. *Geographical Review* **64**: 515–535.

de Freitas, A.J. (1956). *Esboco Geologica.* Scale 1: 2,000,000. Lourenço Marques.

Dietz, R.S. and Holden, J.C. (1970). Reconstruction of Pangea: break-up and dispersion of continents, Permian to Present. *Journal of Geophysical Research* **75**: 4939–4956.

Frazier, J.G. (1993). Dry coastal ecosystems in Kenya and Tanzania. In van der Maarel, E. (ed.). *Ecosystems of the World 2B – Dry Coastal Ecosystems: Africa, America, Asia and Oceania.* Elsevier, Amsterdam.

Geldenhuys, C.J. (1994). Bergwind fires and the location pattern of forest patches in the southern Cape landscape, South Africa. *Journal of Biogeography* **21**: 49–62.

Griffiths, C.J. (1993). The geological evolution of East Africa. Pp. 9–21. In Lovett, J.C. and Wasser, S. (eds.) *Biogeography and Ecology of the Rain Forests of Eastern Africa.*. Cambridge University Press, Cambridge .

Hamilton, A.C. (1994). East Usambara Mountains, Tanzania. Pp. 248–252. In Davis, S.D., Heywood, V.H. and Hamilton, A.C. (eds.). *Centres of Plant Diversity. A guide and strategy for their conservation. Volume 1. Europe, Africa, South West Asia and the Middle East.* WWF and IUCN, Gland.

Hawthorne, W.D. (1984). Ecological and Biogeographical Patterns in the Coastal Forests of East Africa. (unpublished PhD thesis). University of Oxford, Oxford.

Hawthorne, W.D. (1993). East African Coastal Forest botany. Pp. 57–99. In Lovett, J.C. and Wasser, S.K. (eds.). *Biogeography and Ecology of the Rain forests of Eastern Africa.* Cambridge University Press, Cambridge.

Kent, P.E. (1972). Mesozoic history of the east coast of Africa. *Nature* **238**: 147–148.

Kent, P.E. (1974). Continental margin of East Africa – a region of vertical movements. Pp. 313–320. In Burk, C.A. and Drake, C.L. (eds.). *The Geology of Continental Margins*. Springer-Verlag, New York.

Kent, P.E., Hunt, J.A. and Johnstone, M.A. (1971). The geology and geophysics of coastal Tanzania. *Institute of Geological Sciences, Geophysical Paper No.6*. HMSO, London.

King, L.C. (1978). The geomorphology of central and southern Africa. Pp.1–17. In Werger, J.C.A with assistance of van Bruggen, A.C. (eds.). *Biogeography and Ecology of Southern Africa*. Dr. W. Junk Publishers, The Hague.

Lovett, J.C. and Pócs, T. (1993). *Assessment of the condition of the Catchment Forest Reserves. A botanical appraisal.* The Catchment Forestry Project (Forestry and Beekeeping Division), Dar es Salaam.

Lovett, J.C. and Wasser, S.K. (eds.) (1993). *Biogeography and Ecology of the Rain Forests of Eastern Africa*. Cambridge University Press, Cambridge.

Ministerio de Colonais (1948). Esboco Geologico e Mineiro de Moçambique. Escala 1:6,000,000. *Atlas de Portugal Ultramarino*. Ministerio de Colonais, Lisbon.

Moore, W.R. (1963). *Records of the Geological Survey of Tanganyika, Annual Report Vol. XII (1962)*. Government Printer, Dar es Salaam.

Pócs, T. (1976). Vegetation mapping in the Uluguru Mountains (Tanzania, East Africa). *Boissera* **24**: 477–498.

Spence, J. (1957). The geology of part of the Eastern Province of Tanganyika. *Bulletin of the Geological Survey of Tanganyika* No. 28.

Swaine, M.D. (1992). Characteristics of dry forest in West Africa and the influence of fire. *Journal of Vegetation Science* **3**: 365–374.

Swaine, M.D., Hall, J.B. and Lock, J.M. (1976). The forest-savanna boundary in west-central Ghana. *Ghana Journal of Science* **16**: 35–52.

Swaine, M.D., Hawthorne, W.D. and Orgle, T.K. (1992). The effects of fire exclusion on Savannah vegetation at Kpong, Ghana. *Biotropica* **24**: 166–172.

Tinley, K.L. (1971). Determinants of coastal conservation: dynamics and diversity of the environment as exemplified by the Moçambique coast. Pp. 126–153. In *Nature Conservation as a Form of Land Use.* Proceedings of the SARCCUS Symposium, Gorongosa, Mozambique.

White, F. (1983). *The Vegetation of Africa. A Descriptive Memoir to Accompany the UNESCO/AETFAT/UNSO Vegetation Map of Africa*. 356 pp. UNESCO, Paris.

Wild, H. and Grandvaux Barbosa L.A. (1967). *Vegetation map of the Flora Zambesiaca area.* Descriptive memoir: 71pp. M.V.O. Collins (Pvt.) Ltd, Salisbury, [Harare].

2.2 Soils

N.D. Burgess, L.K. Stubblefield and C. Kweyunga

Introduction

The soils of an area reflect a complex interaction between rainfall, time, topography, organic material, parent material, living organisms and disturbance (often by humans). In eastern Africa these factors vary considerably, giving rise to a large number of different soils (e.g. Milne, 1963; Scott, 1962).

Most information on the soils of coastal eastern Africa is found in older publications (e.g. Vageler, 1933; Milne, 1935; 1936; 1947; 1963; Godinho Gouveia and Azevedo, 1948; Mohr and Van Barren, 1954; Moomaw, 1960; EAAFRO, 1961; UK Directorate of Overseas Surveys, 1961; Anderson, 1963a, b; Moore, 1963; Moss, 1968; Baker, 1970; Hathout, 1972a, b; Young, 1976; FAO/UNESCO, 1977; Grove, 1978; FAO, 1988; Kenya Soil Survey, 1978). There is little recent information, as reviewed by Hawthorne (1984), Frazier (1993) and Griffiths (1993). Most of the published studies focus either on broad scale soil mapping and/or mapping the capacity of the soil for agriculture. There is also almost no published literature on the soils of the Coastal Forests. Hawthorne (1984) described patterns in the plant species composition of the East African Coastal Forests and briefly outlined the influence of geology, soils and climate on the trends he observed. He concluded that the available data were too sparse to allow meaningful correlation with his results. Some additional data are found in Högberg (1982; 1992), who investigated specialised aspects of the soil beneath forests (including Coastal Forests) in Tanzania, and in Schmidt (1991) who worked in the Shimba Hills of Kenya.

In this Chapter we summarise the published information on the soils of coastal eastern Africa, focusing on data for soils of Coastal Forests in Tanzania, and present the results of some further preliminary investigations into the soil properties of four Coastal Forest sites in Tanzania (Box 2.2.1).

Soils of the coastal plain of eastern Africa

Distribution of major soil types

There are approximately 12 main soil types in the area supporting Coastal Forests. These range from soils which are 'sandy with imperfect drainage', 'sandy loams with excessive drainage', 'loams with moderately good drainage', 'loams with imperfect drainage', and 'clays with imperfect drainage'. This wide variation of types encompasses most of what can be found through eastern Africa as a whole (Hathout, 1972b).

The potential of these soils for agriculture has also been previously assessed (Hathout 1972b), showing that 50% of the land area has major fertility problems, and 45% of the remainder has nutrient levels which will limit crop yield. Hathout (1972b) further suggested that the poorest soils of the coastal area are most suitable for forestry and wildlife conservation uses, and that the slightly better soils are most suited to forestry, or shifting agricultural practices which require no input of fertiliser. He did not regard any soils in this area as suitable for intensive agriculture.

Importance of smaller-scale variation in the soils of eastern Africa

Broad-scale soil maps are misleading when discussing the Coastal Forests, as there is considerable local soil variation at a small scale. In Tanzania soils of the coastal area often vary according to the classic 'catenary succession' down available slopes (e.g. Milne, 1935; Scott, 1962). In general, the soils of these catenas comprise light coloured sands on the 'ridge-top', which pass down slope into sandy black or grey clays in waterlogged areas in the 'valleys' (Milne, 1935; Hawthorne, 1984; Brady, 1990). Such catenary patterns are dominant in much of coastal Tanzania, and are found in many sites supporting Coastal Forests (e.g. the Pugu Hills in Tanzania).

Deep and sandy red earths are also found overlying the broad, low ridges in northern and central Tanzania (Hawthorne, 1984; Milne, 1947). Typically overlying Neogene sands, these red earths are related to the 'Mchanga' soils of Zanzibar, which are derived from mainly non-calcareous sandstones (Calton *et al.*, 1955). Coastal Forests are found growing on these soils (e.g. Pande in Tanzania), and also on unconsolidated sands of recent deposition (e.g. Mchungu and Kisiju in Tanzania; see Chapter 3.2).

Thin and shallow 'Rendzina' soils are typically developed over limestone areas along the coast, including on uplifted coral rag. Coastal Forests and coastal thickets are found growing on such soils in Kenya and Tanzania (e.g. Tanga Limestone, Mafia Island; see Chapter 3.2).

In flatter areas with impeded drainage, 'black cotton' soils (Vertisols) may form. Quite extensive areas of the coastal plain in Tanzania between Pangani and Bagamoyo, and especially between the Rufiji river and Lindi support such soils. Coastal Forests are not known to occur on such soil types.

Box 2.2.1 The soils of Tanzanian Coastal Forests

In an attempt to investigate the characteristics of the soils of the Coastal Forests in more detail, soils have been collected from four separate Coastal Forests (Pangani Falls, Ruvu North, Kisiju and Tong'omba). A general description of the sampling areas is presented in Table 2.2.1, and results of various physical and chemical analyses are presented in Table 2.2.2.

***Texture*:** The texture of the soils varies widely between the four forests studied. At Pangani Falls, for example, most of the soils lack sand, whereas in all the other samples from other forest sites sand accounts for over 60% and typically over 85% of the soil. The Pangani Falls soils have the highest clay fractions on the ridge tops and along the river bed. There is also a trend towards increasing clay content at greater depths, which is consistent with soil weathering patterns under leaching conditions.

***Organic matter*:** The Coastal Forest soils studied all have a rather low organic matter content. Samples from Tong'omba and Ruvu North forests have a higher organic content that those from Pangani Falls and especially those from Kisiju, which are extremely low.

***pH*:** All forest samples taken near the surface (0–15cm depth) have a pH close to neutral (n = 34, mean pH = 6.2). There does not seem to be any difference between the pH of the soil on the catena, or in disturbed vs. undisturbed forest sites. However the soil pH does decline on increasing depth of the sample position; samples from 30–40cm depth (n = 18) having an average pH of 6.3, and samples from 60cm depth (n = 18) having a mean pH of 5.77. The low pH of 4.1 at 1m depth alongside the river at Pangani Falls may be caused by anaerobic conditions because of the decay of organic material derived from flooding by the river. The pH of the samples from Kisiju are typically just over seven, which may reflect the occurrence of shell fragments in these soils, or the very close proximity to the sea.

***Cation Exchange Capacity (CEC)*:** This measure of the inherent capacity of the soil to retain positively charged ions (cations) varies considerably between samples, and between forests. These soils generally have low CEC values which is consistent with their sandy texture and high weathering influence. The Pangani Falls soils show increasing CEC values at lower sites along the catena, which is also consistent with catena theory (Milne, 1935).

***Exchangeable Bases (Na, K and Ca)*:** The exchangeable base content of these soils is very low. Expressed as Base Saturation the values are from 10–35 %. The K values are in the low to medium range. Calcium is especially low as it normally has values of 102meq/100g on low CEC soils. Sodium is adequate for plant nutritional needs but sufficiently low that it is of no consequence for soil physical characteristics.

***Phosphate-phosphorus (PO_4-P)*:** Values of PO_4-P are very variable, but low in most samples and may influence the types of plants which are able to survive, favouring those which produce ectomycorrhizae.

***Nitrate (NO_3)*:** Concentrations are variable, but are also generally low and would limit growth of maize or other crop plants in most samples.

Table 2.2.1 Description of soil sampling sites in four Tanzanian Coastal Forests.

Sites	Geology/Landform	Soil Type	Vegetation : dominant tree species
Pangani Falls forest	Valley in coastal plain	Red-brown silt loams on ridgetops. Silty sand and clay in valley bottoms	Dry evergreen forest: *Euphorbia* sp., *Cynometra* sp. Riparian elements: *Sorindeia madagascariensis*
Ruvu North Forest Reserve	Coastal plain (40–140m a.s.l) of Miocene-Pleistocene deposits	Pale red-brown coarse or loamy sands	Dry semi-evergreen forest: *Hymenaea verrucosa*
Kisiju forest	Quaternary sand terraces (0–10m a.s.l)	Thick, pale loamy sands overlying recent beach sand	Dry evergreen forest: *Hymenaea verrucosa, Baphia kirkii*. Riverine elements: *Sorindeia madagascariensis*
Tong'omba Forest Reserve	Matumbi Massif (150–540m a.s.l) Mesozoic (Jurassic) sandstone and limestone overlain by red Neogene sands	Red-brown sandy loams and alluvial deposits. Vertisols in valley bottoms	Dry evergreen forest grading to scrub forest at lower altitudes. Riparian elements

Discussion

Comparison of the data collected here with those of other studies is difficult due to the small number of sources of data. The only other Coastal Forest site where soils have been analysed is the Shimba Hills in Kenya (Schmidt, 1991). Soil physical and chemical data were collected from 12 pits in different forest types. The soils of Shimba Hills were variable in terms of nutrient levels and physical characteristics, and thus similar to those presented here. Although Schmidt (1991) presented the soil data with the vegetation assemblages, no causal relationship between the soils and vegetation-types was demonstrated. Indeed recent studies (Hawthorne, 1984; Schmidt, 1991; Hawthorne, 1993; Mwasumbi *et al.*, 1994) have added little to previous assessments of the relationship between vegetation and soil types (e.g. Moomaw, 1960; Langdale-Brown, 1968). This is a serious barrier to advancing understanding of the causes of vegetation variation, and should form the basis of future studies of the area.

The low level of phosphorus in many of the Coastal Forest soils sampled in Tanzania may be one important influence on vegetation type. Many Coastal Forests contain areas with large numbers of Caesalpinioideae trees, and studies of the Korup National Park in Cameroon (Newbery *et al.*, 1988) have previously shown that there is a strong association between legumes of the subfamily Caesalpinioideae and soils with $<5\ \mu g\ g^{-1}$ extractable phosphorus. Similar associations have previously been suggested by Moomaw (1960) and Hawthorne (1984) for coastal East Africa. Caesalpinioideae legumes form ectomycorrhizae which probably give them a competitive advantage on soils with low phosphate content, such as those seen in Coastal Forests. Högberg (1992) also showed that mycorrhizae were common on *Scorodophloeus fischeri* in the Kitulanghalo Forest in Tanzania.

Soil samples from the four Coastal Forests in Tanzania are widely variable in their suitability for agriculture. However, most of the soils sampled have poor agricultural potential, and samples from Ruvu North were very poor indeed. It could be that forests survive in these areas because they are adapted to the poor soils, but it is also possible that the forests have been left in these areas because the agricultural potential of the land upon which they are growing was extremely limited. This possibility could be explored further by a comparison between the soils of the forests, and the surrounding agricultural lands. Further discussion on the soils of the forested areas in Africa can be found in Guo and Wilding (1996), focusing on the Guineo-Congolian forest.

Table 2.2.2 Results of physical and chemical analyses of soil samples from four Coastal Forests in Tanzania.

	Texture (%)			Moisture[1] Factor	Organic Matter	pH	CEC[2] MEQ/100g	Exchangeable bases[3] (mg/g)				
	Sand	Silt	Clay	Dry (g)	(g)			Na	K	Ca	PO_4	NO_3
Pangani Falls												
Ridge 15cm	0	60	40	9.88	0.005	6.4	6.71	1.36	2.16	1.00	0.07	2.01
Ridge 30cm	0	60	40	9.88	0.009	6.1	8.11	1.47	2.15	2.11	0.08	1.82
Ridge 60cm	0	57	43	9.82	0.020	6.0	9.23	1.28	1.16	2.21	0.11	2.00
Mid-slope 15cm	0	50	50	9.85	0.001	6.4	9.64	0.31	1.22	3.01	1.62	2.41
Mid-slope 30cm	0	80	20	9.81	0.002	6.2	13.04	0.04	0.91	3.13	0.73	2.61
Mid-slope 50cm	0	49	52	9.81	0.009	6.2	10.20	0.32	1.40	0.90	0.01	5.40
Low-slope 15cm	0	51	49	9.87	0.010	5.4	8.16	0.11	2.22	2.15	0.08	5.01
Low-slope 30cm	0	80	20	9.87	0.021	6.4	16.09	0.11	1.00	1.14	0.02	2.12
Valley bottom 15cm	26	70	4	9.89	0.001	6.3	16.21	0.12	1.23	1.22	0.09	2.81
Valley bottom 25cm	17	70	13	9.81	0.002	6.4	17.01	0.34	1.12	2.16	0.06	2.61
River side 15cm	20	65	15	9.86	0.001	6.0	10.61	0.31	1.16	3.11	0.01	2.33
River side 30cm	0	52	48	9.87	0.002	6.5	11.67	0.21	1.18	3.00	0.10	2.42
River side 60cm	0	2	98	9.88	0.003	4.1	25.00	0.22	1.16	3.00	0.60	4.20
Ruvu North												
0cm (4 samples)	91	7.75	1.2	9.84	0.029	5.3	4.05	0.01	4.85	0.06	0.08	0.37
0–0.5cm (2 samples)	87	9.6	3.4	9.91	0.030	5.5	3.60	0.02	1.10	0.42	0.07	0.44
10–15cm (2 samples)	90	8.5	1.5	9.81	0.019	5.3	3.60	0.01	1.10	0.53	0.10	0.34
30–40cm (2 samples)	88	9.5	2.5	9.82	0.020	5.9	4.20	0.01	1.10	0.25	0.06	0.39
60cm (2 samples)	85	11.5	3	9.86	0.024	5.4	3.30	0.03	1.23	1.82	0.04	0.26
Kisiju												
Forest samples												
0cm (6 samples)	91	7.5	1.96	9.93	0.0013	6.8	3.76	0.02	0.54	1.73	0.09	4.56
10–15cm (3 samples)	92	2.6	5	9.93	0.003	7.2	3.10	0.04	0.62	0.30	0.03	0.97
30–40cm (3 samples)	92	4.5	3	9.97	0.001	7.2	3.30	0.03	0.18	0.40	0.02	0.05
60cm (3 samples)	93	5	2.4	9.97	0.001	7.2	3.20	0.03	0.2	0.20	0.01	0.60
Shamba samples												
Shamba 1 (6 samples)	90	7.7	1.9	9.95	0.002	7.2	3.30	0.04	0.36	0.94	0.78	0.51
Shamba 2 (6 samples)	91	6.9	1.7	9.93	0.002	7.3	3.90	0.03	0.24	1.00	1.03	0.70
Shamba 3 (6 samples)	90	7.0	2.1	9.93	0.002	7.2	3.10	0.02	0.27	0.99	1.20	0.70
Tong'omba												
Disturbed forest												
0cm (5 samples)	75	17	8	9.86	0.04	6.3	8.90	0.20	0.57	1.50	0.06	0.28
30–40cm (4 samples)	73	16	11	9.86	0.05	5.9	7.60	0.27	1.21	0.90	0.09	0.25
60cm (5 samples)	60	28	12	9.87	0.03	5.8	8.80	0.25	0.36	0.46	0.06	0.29
Ridge-top forest												
0cm (5 samples)	84	9	7	9.85	0.06	6.3	6.50	0.33	0.51	3.30	0.08	0.37
30–40cm (4 samples)	65	17	17	9.87	0.03	5.8	5.60	0.30	0.35	1.00	0.10	0.25
60cm (5 samples)	74	15	11	9.94	0.03	6.0	4.15	0.24	0.85	0.93	0.05	0.19
Riverine forest												
0cm (1 sample)	69	31	11	9.82	0.02	7.2	5.00	0.32	0.04	0.40	1.00	0.46
30–40cm (1 sample)	62	23	15	9.81	0.05	6.8	8.00	0.32	0.12	–	0.10	0.20
60cm (1 sample)	60	25	15	9.71	0.04	5.5	5.20	0.30	0.20	–	0.10	0.16

Notes:

[1]Air-dry sample of 10g

[2]Cation Exchange Capacity (in millequivalents per 100g)

[3]Na : available sodium (in milligrams per gram); K : available potassium; Ca : available calcium; PO_4 : available phosphate; NO_3 : total nitrate

Acknowledgements

Comments and assistance with interpretation of the soil data from the various Coastal Forests were provided by Jim Friedericks of the Department of Botany at the University of Dar es Salaam. Soil samples were collected by the Frontier-Tanzania Coastal Forest Research Programme. Mrs Minja of the Microbiology Department, UDSM provided valuable advice and assistance. Further comments were received from William Hawthorne of the Oxford Forestry Institute.

References

Anderson, G.D. (1963a). A comparison of red and yellowish upper-slope soils of the East Usambara foothills, Tanganyika. *African Soils* **8**: 431–443.

Anderson, G.D. (1963b). *Soils of Tanganyika.* Ministry of Agriculture Bulletin No.16, Dar es Salaam.

Baker, R.M. (1970). *The Soils of Tanzania (with maps).* FAO, Rome.

Brady, N.C. (1990). *The Nature and Properties of Soil, tenth edition.* MacMillan, London.

Calton, W.E., Tidbury, G. and Walker, G. (1955). A study of the more important soils of Zanzibar Protectorate. *East African Agricultural Journal* **21**: 53–60.

East African Agriculture and Forestry Research Organisation (EAAFRO) (1961). *Soil Map of Tanganyika at 1 : 4 000 000.* Department of Lands and Surveys, Dar es Salaam.

FAO/UNESCO (1977). *Soil Map of the World: Volume VI Africa.* FAO, Rome.

FAO (1988). *FAO/UNESCO Soil Map of the World. revised legend.* World Soil Resources report 60, FAO, Rome.

Frazier, J.G. (1993). Dry coastal ecosystems in Kenya and Tanzania. In van der Maarel, E. (ed.). *Ecosystems of the World 2B – Dry Coastal Ecosystems: Africa, America, Asia and Oceania.* Elsevier, Amsterdam.

Godinho Gouveia, D.H. and Azevedo, A.L. (1948). *Cartas dos solos de Moçambique (1 : 6 000 000).* Centro de Investigação Cientifica Algodoeira, Lisbon.

Griffiths, C.J. (1993). The geological evolution of East Africa. Pp. 9–21. In Lovett, J.C. and Wasser, S. (eds.). *Biogeography and Ecology of the Rain Forests of Eastern Africa.* Cambridge University Press, Cambridge.

Grove, A.T. (1978). *Africa: South of the Sahara (3rd edn.).* Oxford University Press, Oxford.

Guo, A.S.R. and Wilding, L.P. (1996). Soils of the lowland forests of West and Central Africa. Pp. 15–31. In Alexander, I.J., Swaine, M.D. and Watling, R. (eds.). *Essays on the Ecology of the Guinea-Congo Rain Forest. Proceedings of the Royal Society of Edinburgh* **104B**.

Hathout, S.A. (1972a). *Soil Resources of Tanzania.* Tanzania Publishing House, Dar es Salaam.

Hathout, S.A. (1972b). Soil map. In *Atlas of Tanzania, 5th edition.* Government Printer, Dar es Salaam.

Hawthorne, W.D. (1984). *Ecological and Biogeographical Patterns in the Coastal Forests of East Africa.* University of Oxford (unpublished PhD thesis).

Hawthorne, W.D. (1993). East African Coastal Forest botany. Pp. 57–99. In Lovett, J.C. and Wasser, S.K. (eds.). *Biogeography and Ecology of the Rain Forests of Eastern Africa.* Cambridge University Press, Cambridge.

Högberg, P. (1982). Mycorrhizal associations in some woodland and forest trees and shrubs in Tanzania. *New Phytologist* **92**: 407–415.

Högberg, P. (1992). Root symbioses of trees in African dry tropical forests. *Journal of Vegetation Science* **3**: 393–400.

Kenya Soil Survey (1978). *Soils of the Kwale–Mombasa–Lungalunga area.* Reconnaissance Soil Survey Report No. R3, by Michieka, D.O., Van der Pouw, B.J.A., Vleeshouwer, J.J. Ministry of Agriculture, Nairobi.

Langdale-Brown, I. (1968). The relationship between soils and vegetation. In Moss, R. P. (ed.). *The Soil Resources of Tropical Africa.* Cambridge University Press, Cambridge.

Milne, G. (1935). Some suggested units of classification and mapping, particularly for East African soil. *Soils Research* **4:** 183–198.

Milne, G. (1936). *A Provisional Soil Map of East Africa.* Crown Agents for the Colonies, London.

Milne, G. (1947). A soil reconnaissance journey through parts of Tanganyika Territory. December 1935 to February 1936. *Journal of Ecology* **35**: 192–265.

Milne, G. (1963). A provisional soil map of East Africa. *Trans. Int. Cong. Soil Sci.* **1**: 266–270.

Mohr, E.C.J. and Van Baren, F.A. (1954). *Tropical Soils.* N.V. Uitgerij and W. Van Hoeve, The Hague and Bandung.

Moomaw, J.C. (1960). *A Study of the Plant Ecology of the Coast Region of Kenya Colony.* Government Printer, Nairobi.

Moore, W.R. (1963). *Records of the Geological Survey of Tanganyika, Annual Report Vol. XII (1962).* Government Printer, Dar es Salaam.

Moss, R.P. (ed.) (1968). *The Soil Resources of Tropical Africa.* Cambridge University Press, Cambridge.

Mwasumbi, L.B., Burgess, N.D. and Clarke, G.P. (1994). The vegetation of Pande and Kiono monsoon forests, Tanzania. *Vegetatio* **113**: 71–81.

Newbery, D.M., Alexander, I.J., Thomas, D.W. and Gartlan, J.S. (1988). Ectomycorrhizal rain-forest legumes and soil phosphorus in Korup National Park, Cameroon. *New Phytologist* **109**: 433–450.

Scott, R.M. (1962). Soils. Pp. 95–108. In Russell, E.W. (ed.). *Natural Resources of East Africa.* East African Literature Bureau, Nairobi.

Schmidt, R. (1991). *Ecology of a Tropical Lowland Rain Forest: Plant Communities, Soil Characteristics and Nutrient Relations of the Forests of the Shimba Hills National Reserve, Kenya.* Dissertationes Botanicæ, Band 179. Berlin-Stuttgart.

United Kingdom Directorate of Overseas Surveys (1961). *Soils Map of East Africa (1 : 4 000 000).* Directorate of Overseas Surveys, London.

Vageler, P. (1933). *An Introduction to Tropical Soils.* Macmillan, London.

Young, A. (1976). *Tropical Soils and Soil Survey.* Cambridge University Press, Cambridge.

2.3 Climate and climatic history

G. P. Clarke

Introduction

Climate is one of the most important natural influences on vegetation structure and growth. Temperature and moisture are the key elements of any climate (both in their total amount and in their seasonality) but other atmospheric variables may be involved, such as sunlight, windspeed and humidity. These components of a climate have daily (diurnal), seasonal and annual variations, as well as patterns of change over thousands of years, hundreds of thousands of years and more (Bennet, 1990). This chapter describes the current and historical characteristics of the climate in the coastal area of eastern Africa, to attempt a provisional assessment of its influence on the existing vegetation.

Climatic data from the Coastal Forest belt are still rather scarce, and are limited to five meteorological stations in coastal Kenya (East African Meteorological Department, 1975a); 12 meteorological stations in coastal Tanzania (East African Meteorological Department, 1975b) and 14 meteorological stations in coastal Mozambique (Servico Meteorologico Nacional, 1951). Just eight of these stations lie more than 20km inland from the coast (listed in Table 2.3.1).

Table 2.3.1 Major meteorological stations in the Coastal Forest area.

Meteorological station	Grid reference	Altitude	Data source
Jelib, Somalia	00°26'N, 42°48'E	23m	Walter and Leith, 1967
Lamu, Kenya	02°17'S, 40°54'E	9m	E.A. Met. Dept., 1975a
Malindi, Kenya	03°14'S, 40°06'E	20m	E.A. Met. Dept., 1975a
Kilifi, Kenya	03°40'S, 39°51'E	3m	E.A. Met. Dept., 1975a
Mombasa Airport, Kenya	04°02'S, 39°37'E	56m	E.A. Met. Dept., 1975a
Kilindoni Port, Mombasa, Kenya	04°03'S, 39°39'E	19m	E.A. Met. Dept., 1975a
Wete, Pemba Island	05°15'S, 39°49'E	20m	E.A. Met. Dept., 1975b
Mlingano, Tanzania	05°08'S, 39°52'E	?100m	E.A. Met. Dept., 1975b
Tanga, Tanzania	05°03'S, 39°03'E	28m	E.A. Met. Dept., 1975b
Chukwani, Zanzibar Island	06°15'S, 39°13'E	19m	E.A. Met. Dept., 1975b
Kisauni Airport, Zanzibar	06°13'S, 39°13'E	15m	E.A. Met. Dept., 1975b
Morogoro, Tanzania	06°50'S, 37°39'E	526m	E.A. Met. Dept., 1975b
Dar es Salaam Kurasini, Tanzania	06°47'S, 39°18'E	8m	E.A. Met. Dept., 1975b
Dar es Salaam Airport, Tanzania	06°50'S, 39°18'E	14m	E.A. Met. Dept., 1975b
Kilindoni, Mafia Island	07°55'S, 39°40'E	21 m	E.A. Met. Dept., 1975b
Nachingwea, Tanzania	10°21'S, 38°45'E	465m	E.A. Met. Dept., 1975b
Lindi, Tanzania	10°00'S, 39°42'E	41m	E.A. Met. Dept., 1975b
Mtwara, Tanzania	10°61'S, 40°11'E	113m	E.A. Met. Dept., 1975b
Pemba/P. Amelia [Murrebue], Mozambique	13°06'S, 40°32'E	60m	Ser. Met. Nac., 1951
Ribaue, Mozambique	14°57'S, 38°19'E	531m	Ser. Met. Nac., 1951
Mossuril, Mozambique	14°57'S, 40°40'E	15m	Ser. Met. Nac., 1951
Alto Moloque, Mozambique	15°38'S, 37°41'E	563m	Ser. Met. Nac., 1951
Errego [Ile], Mozambique	16°02'S, 37°11'E	533m	Ser. Met. Nac., 1951
Angoche [Antonio Enes], Mozambique	16°14'S, 39°55'E	6m	Ser. Met. Nac., 1951
Pebane, Mozambique	17°16'S, 38°09'E	25m	Ser. Met. Nac., 1951
Quelimane, Mozambique	17°53'S, 36°53'E	6m	Ser. Met. Nac., 1951
Manica [Macequece], Mozambique	18°56'S, 32°52'E	723m	Ser. Met. Nac., 1951
Beira, Mozambique	19°50'S, 34°51'E	8m	Ser. Met. Nac., 1951
Chimoio [Vila Pery], Mozambique	19°06'S, 33°28'E	707m	Ser. Met. Nac., 1951
Vilanculos, Mozambique	22°00'S, 35°20'E	20m	Ser. Met. Nac., 1951
Inhambane, Mozambique	23°58'S, 32°36'E	59m	Ser. Met. Nac., 1951
Inharrime, Mozambique	24°29'S, 35°01'E	43m	Ser. Met. Nac., 1951

Additional rainfall data are available from hundreds of rainfall stations (cf. East African Meteorological Department, 1975a and b). These data are recorded for different lengths of time over different periods and are sometimes incomplete over these periods. The recording of such data has declined in continental Africa over the last two decades (Nicholson, 1994), compiled records of the data are few and are only known to have been published by the East African Meteorological Department in 1953, 1964 and 1975, and by the Portuguese National Meteorological Service in 1951. Only preliminary comparisons can therefore be attempted.

Rainfall

Average annual rainfall

Average annual rainfall in the Coastal Forest belt varies from 510mm at Kiunga on the north Kenya coast (Frazier, 1993) to almost 2000mm on the islands of Pemba (1926mm at Wete) and Mafia (1918mm at Kilindoni), although average annual rainfalls of between 900 and 1400mm are more typically encountered in most of the Coastal Forests (Figure 2.3.1). These figures are similar to the 850–1350mm range of average annual rainfall that has been recorded for the dry forests of West Africa (Swaine, 1992).

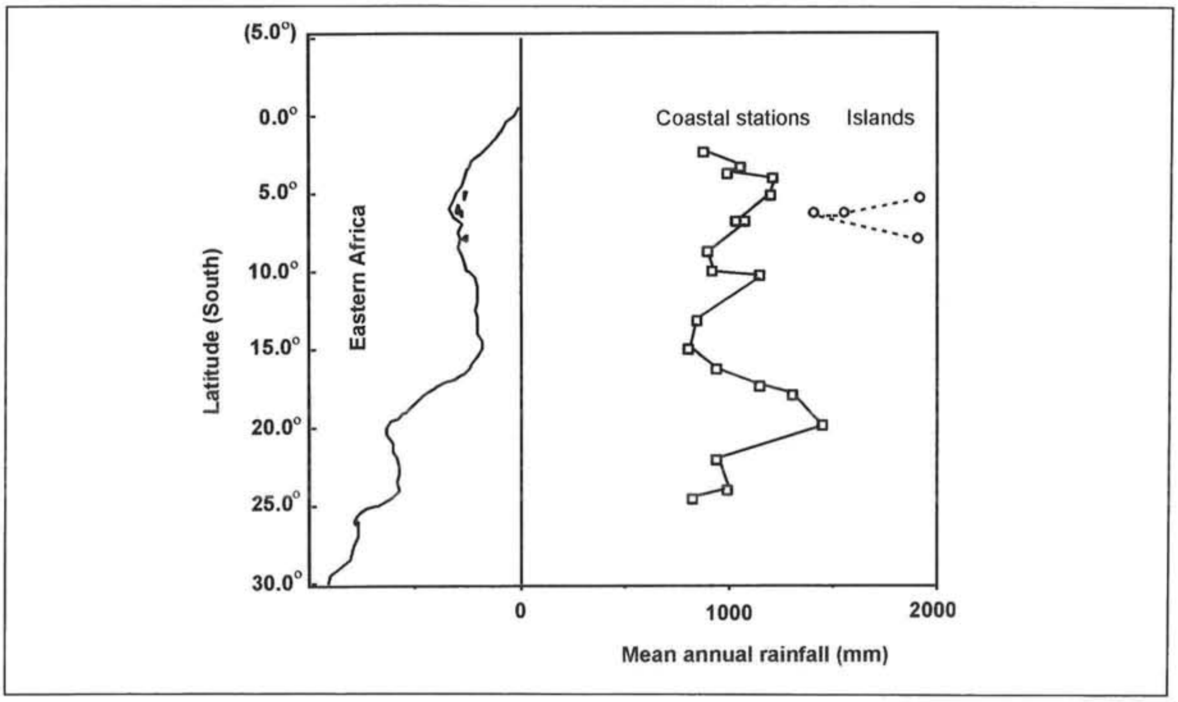


Figure 2.3.1 Mean annual rainfalls (mm) along the eastern African coast (East African Meteorological Department, 1975a and b; Servico Meteorologico Nacional, 1951).

Altitudinal and orographic variations in rainfall

The minimum altitude above which rainfall conditions become sufficiently favourable to support forest might appear to increase with increasing distance from the coast, as forest is present at sea-level on the coast (e.g. at Kisiju and Mchungu forests in Tanzania – see Clarke and Dickinson, 1995) but has a higher minimum altitudinal limit inland (e.g. does not occur below 550m in the Malawi Hills, except along the banks of streams – Chapman and White, 1970). While this may be partially accounted for by a lessening influence of the Indian Ocean maritime climate as distances from the coast increase, an additional explanation lies in the topography of the African continent, which is effectively a plateau with monoclines sloping into the sea around its edges (see King, 1978). The mean altitude of the African surface therefore increases inland with increasing distance from its coasts. The greater historical human influence (i.e. through forest clearance) at lower altitudes may further account for the scarcity of low altitude forests at inland locations, e.g. much lowland forest was cleared from the lowland East Usambara Mountains 2000 years ago (Schmidt, 1989). Only tiny fragments of the former extent of lowland forests at the base of the Eastern Arc Mountains at the western (inland) limit of the Coastal Forests now remain, but fragments may be found as low as 300m altitude some 300km from the coast, e.g. at Nambiga forest at the edge of the Kilombero Valley in Tanzania.

Very high average annual rainfalls (3000–4000mm/year in some locations) occur at higher altitudes on the upland 'Eastern Arc' Mountains at the western edge of the Coastal Forest belt, where cooler temperatures and a higher and a more reliable rainfall permits the development of Afromontane rather than Coastal Forest (see Lovett and Wasser, 1993).

Variations in precipitation due to aspect

South-east facing slopes appear to support moister/more evergreen forest assemblages than those found on other aspects of the same hill (cf. Iversen, 1991; Hamilton, 1989; Hawthorne, 1993; Chapman and White, 1970; Swynnerton, 1917) which may be due to the orientation of these slopes normal to the SE trade winds which prevail during the drier season when moisture availability becomes more critical (Figure 2.3.5). Examples of this effect occur at Handeni Hill (Lovett and Pócs, 1993), Gendagenda and Tongwe (pers. obs.) and forests elsewhere.

Daily variations in rainfall

Daily (24 hour) rainfall in coastal eastern Africa varies from completely dry days to extreme peaks, such as the 381mm recorded at Vanga in October 1953 and the 335mm recorded at Witu in October 1961 (Griffiths, 1969). There is a trend for lower daily rainfall peaks at lower latitudes, e.g. the 24-hour maximum of 152mm recorded from Dar es Salaam Kurasini is less than half that of the maxima recorded from the Kenya coast (Figure 2.3.2). There is a further trend for higher 24-hour rainfall maxima to have been recorded from the large offshore islands than for corresponding weather stations at the same latitude on the coast, e.g. 286mm at Wete on Pemba Island compared to 207mm at Mlingano; 247mm at Kisauni Airport on Zanzibar Island and 208mm at Kilindoni on Mafia Island compared to 152mm at Dar es Salaam Kurasini (Figure 2.3.2).

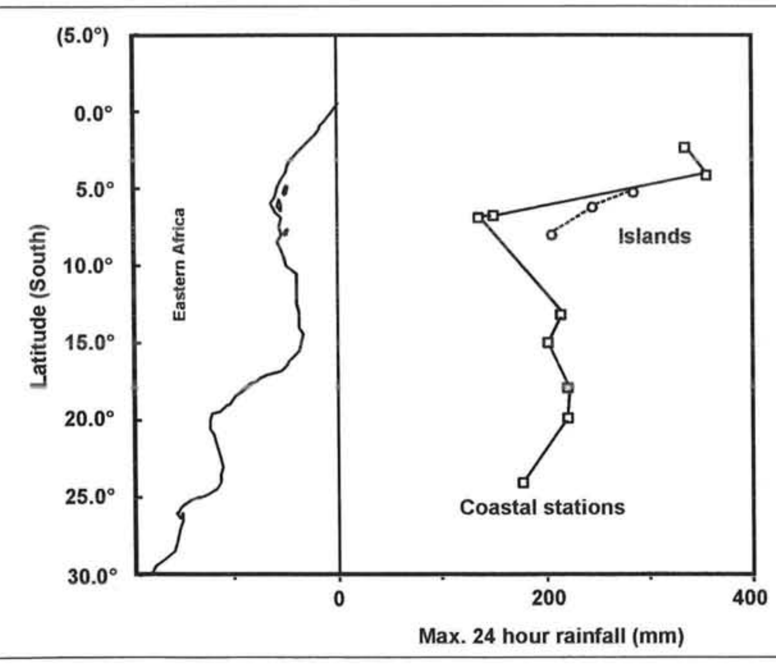


Figure 2.3.2 Maximum rainfall (mm) recorded over 24-hour periods along the eastern African coast (East African Meteorological Department, 1975a and b; Servico Meteorologico Nacional, 1951).

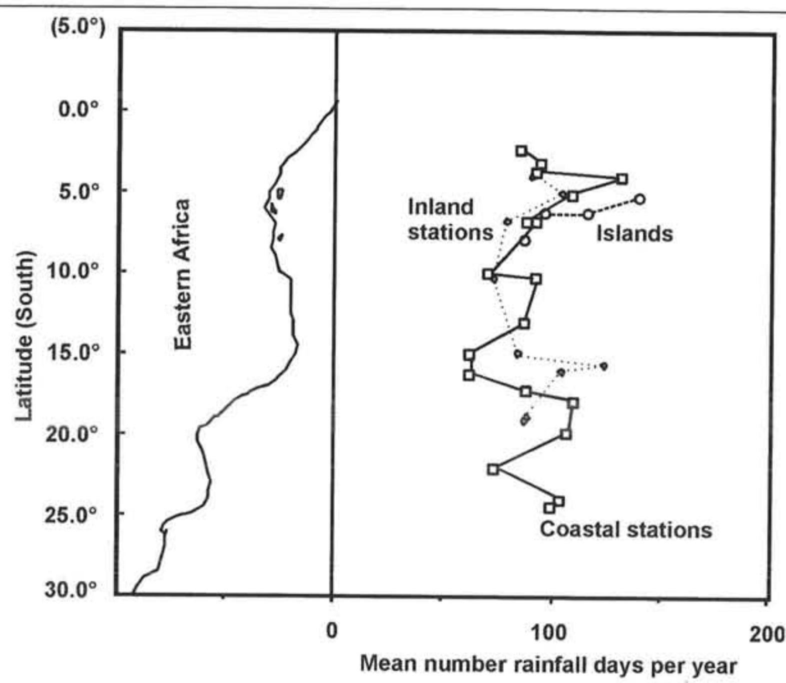


Figure 2.3.3 Average number of days of rainfall per year along the eastern Africa coast (East African Meteorological Department, 1975a and b; Servico Meteorologico Nacional, 1951).

The average number of days receiving rainfall along the eastern African coast varies from 63 days per year at Mossuril and Angoche and 64 days at Mtwara, to 140 days at Wete in Pemba and 139 days at Mombasa (Figure 2.3.3; Servico Meteorologico Nacional, 1945; East African Meteorological Department, 1975a and b; Moomaw, 1960).

Monthly variations in rainfall

A total of 1237mm of rainfall has been recorded at Malindi in a single month (Moomaw, 1960), and monthly rainfalls exceeding 1000mm have also been recorded on the Tanzanian coast (Griffiths, 1969). The months which receive a 'reasonable rainfall' (considered to be 50mm per month by Griffiths, 1969; see Moreau, 1938 for discussion) also vary enormously, even between sites a few kilometres apart; Griffiths (1969) notes that north-west Zanzibar and Pemba receive more than 50mm monthly rainfall during March to December while south-eastern parts of these islands receive more than 50mm per month from November to August. Variation in the number of months that receive at least 50mm rainfall (Figure 2.3.4) broadly mirrors the variation in mean number of days receiving rainfall per year (Figure 2.3.3). The occurrence of at least two dry months throughout the Coastal Forest belt means that all Coastal Forests are seasonal, since 'as few as two or three dry months are sufficient to alter significantly the composition and structure of an ecosystem which might otherwise qualify as moist, wet or rain forest' (Murphy and Lugo, 1986).

Seasonal variations in rainfall

There is a general pattern of two rainy seasons at the northern end of the Coastal Forest belt and a single wet season at the southern end (Hawthorne, 1993), which is caused by the seasonal movement of the Inter-Tropical Convergence Zone (ITCZ). Rainfall peaks are associated with the times when the ITCZ passes through an area, although these peaks 'blur' into a single peak south of Dar es Salaam, where the southward and northward passing of the ITCZ occur only a short time apart. Up to 85% of the total annual rainfall falls during the wettest three months of the year in SE Tanzania (Bennet *et al.*, 1979) compared to 50–70% during the wettest three months on the Kenyan coast.

The dry season(s) in the Coastal Forest belt may bring a severe moisture stress for plant growth, although no month is consistently entirely dry (White, 1983) except at the northern limit where January and February are usually without any rainfall in Lamu (Moomaw, 1960) and in southern

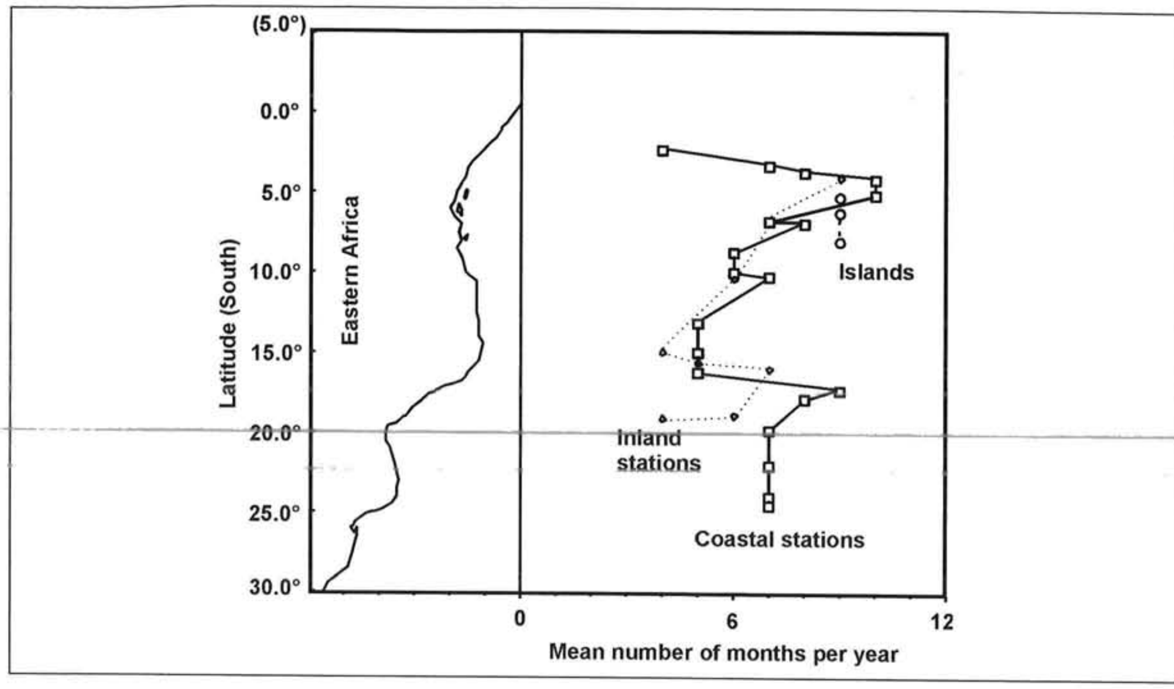


Figure 2.3.4 Average annual number of months receiving more than 50mm of rainfall along the eastern African coast (East African Meteorological Department, 1975a and b; Servico Meteorologico Nacional, 1951).

Somalia (Walter and Leith, 1967). The dry season in the north coincides with peak rainfall in the southern part of the Coastal Forest belt, and may be caused by the orientation of the coastline parallel to the NE Trade Winds which are continental in origin (see Figure 2.3.5). Climate diagrams for some of the towns along the eastern African coast are shown in Figure 2.3.6.

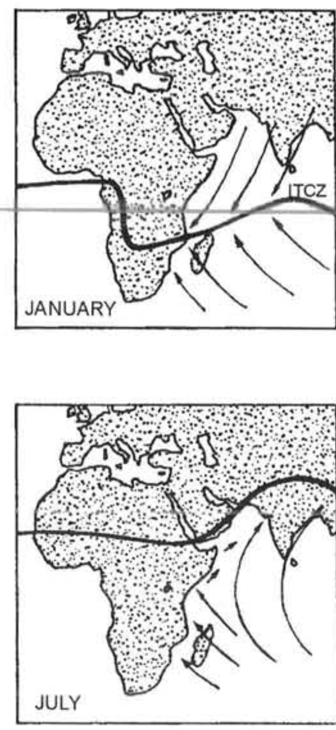


Figure 2.3.5 Prevailing wind directions from the Indian Ocean in relation to the positions of the Inter-Tropical Convergence Zone (ITCZ) in eastern Africa in January and July.

Annual variations in rainfall

The annual rainfall recorded at a single site can vary enormously from year to year (cf. East African Meteorological Department, 1975a and b; Servico Meteorologico Nacional, 1919–1951; Nicholson, 1994), and many rainfall stations in East Africa have recorded maximum annual rainfalls of more that four times the minimum (Griffiths, 1969), although 2.7–3.5 times the minimum are more typically encountered along the coast in any 30-year period (Figure 2.3.7). Greater extremes have been recorded over longer periods, e.g. 5.5 times the minimum from Dar es Salaam during this century. Standard deviations in annual rainfall are typically 25% of the means (FINNIDA, 1990; Moomaw, 1960).

Annual rainfall is more reliable (i.e. less variable) on Tanzania's large offshore islands, e.g. at Utmaini on Mafia Island where the minimum recorded annual rainfall is 57% of the maximum recorded (Greenway with Rodgers *et al.*, 1988).

Other causes of variation in rainfall

The presence of the large island of Madagascar off the coast of Mozambique may reduce the rainfall along part of this coast, by 'absorbing' a portion of the rainfall that would otherwise have reached the African mainland. The distance between eastern Africa and the Madagascan west coast along the line of the prevailing SE (140° bearing) winds are superimposed on

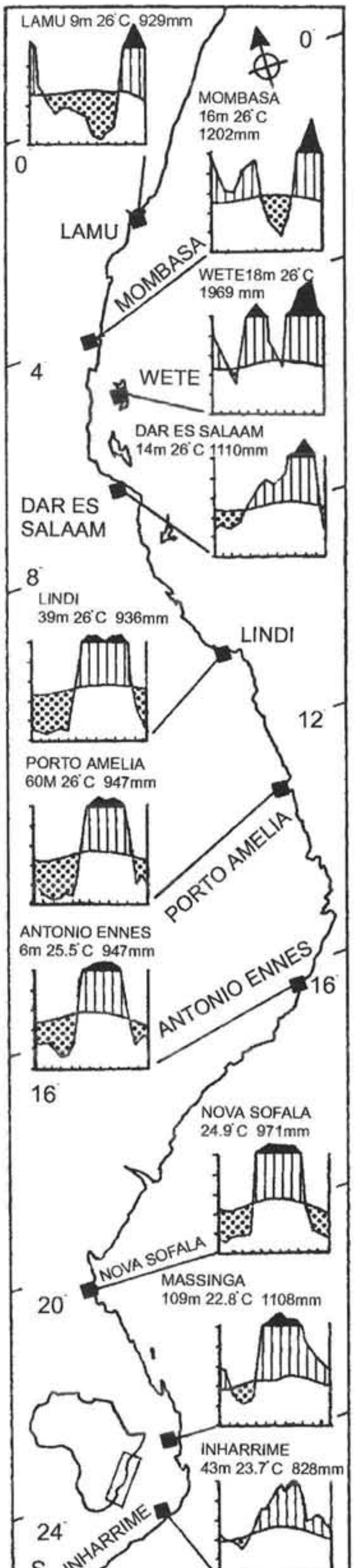


Figure 2.3.6 Climate diagrams for some towns along the eastern African coast (from White, 1983).

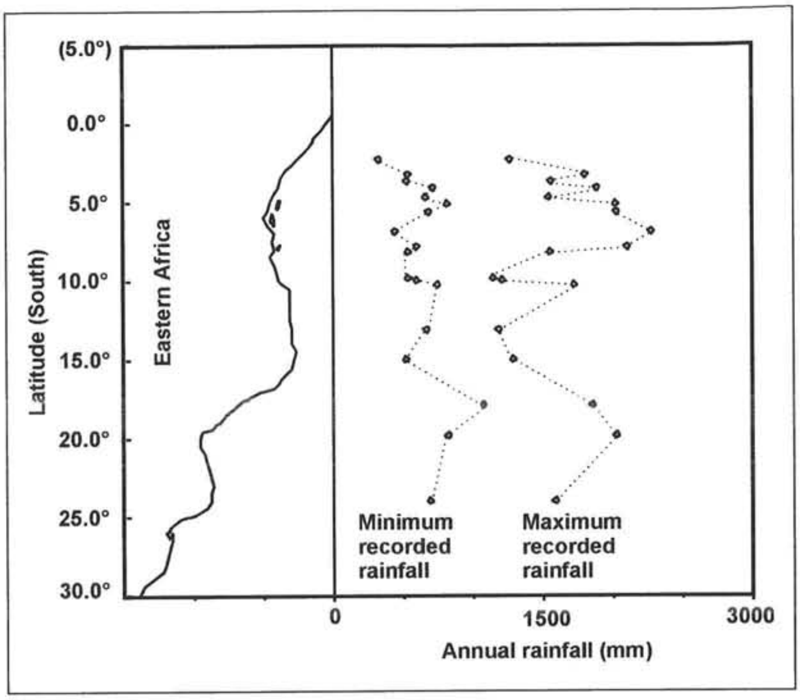


Figure 2.3.7 Recorded 30 year variations in annual rainfall along the eastern African coast (East African Meteorological Department, 1975a and b; Servico Meteorologico Nacional, 1951).

the mean annual rainfall diagram in Figure 2.3.8, and suggest a correlation between coastal rainfall patterns and the proximity of Madagascar, especially between 10°S and 18°S where south-easterlies prevail throughout the year.

Other moisture sources

Moister variants of Coastal Forest are often developed at the bottom of valleys, where the supply of groundwater is increased by drainage from the surrounding upper slopes (Hawthorne, 1993). In the same way steep hills may contain forest at lower altitudes than might otherwise be expected due to a combination of an additional orographic rainfall, and an additional groundwater supply draining from greater and less seasonal rainfall on higher ground. Rivers may also permit the development of Coastal Forest in areas which are otherwise too dry to support forest, e.g. along the banks of the lower Tana River where mean annual rainfall is just 400mm (Hughes, 1988).

Occult precipitation (from condensing mists) may occur on steep seaward-facing slopes and ridges above 300m altitude, resulting in an abundance of the epiphytic lichen *Usnea* in the tree crowns, e.g. at Kiwengoma forest (Kingdon, 1989). The extra moisture supplied by this occult precipitation is thought to be significant in East Africa (Moreau, 1938), and has been sufficient to produce a light rainfall effect in Rondo forest (800m) from moisture dripping off trees as a result of the condensation of morning and evening mists (Loveridge, 1942). Mists have also been described as being fairly frequent during the dry season on the Malawi Hills (Chapman and White, 1970). Occult precipitation is now believed to be less common than formerly, perhaps as a result of deforestation (Schmidt, 1991).

Evapotranspiration

Potential Evapotranspiration remains fairly constant along the coast where Moomaw (1960) calculated values of between 59 and 66 for Thornton's Evapotranspiration Index. In SE Tanzania rainfall exceeds potential evaporation during only two or three months of the year (Nieuwolt, 1973; Bennet *et al.*, 1979).

Swaine (1992) notes that the distribution of dry forest in West Africa is closely correlated with areas where annual rainfall equals annual Potential Evapotranspiration (PET), but it has not been possible to locate sufficient evapotranspiration data for eastern Africa in order to test this correlation for the Coastal Forests.

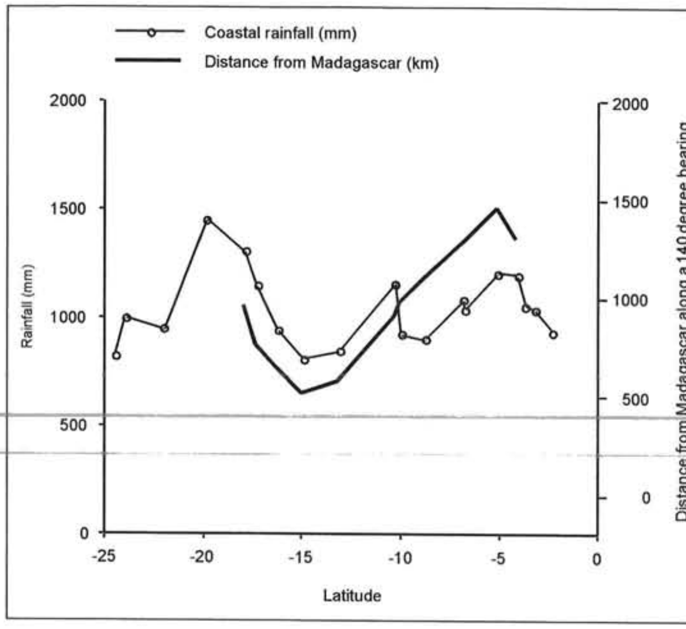


Figure 2.3.8 Correlation between the mean annual rainfall for eastern African coastal stations and the distance from these stations to the Madagascan coast in the direction of the prevailing SE winds.

Temperature

Average temperatures

Mean annual temperatures in the lowland areas of the eastern African coast are high (23°C or more north of the Limpopo River in southern Mozambique), and there is a general trend of increasing temperatures towards the Kenya-Tanzania border, reaching a maximum of 26.9°C at Chukwani on Zanzibar Island and 26.8°C at Mombasa (Figure 2.3.9).

Altitudinal temperature variations

Mean annual temperatures drop as altitude increases. A lapse rate of 0.5°C per 100m is recorded for dry forest and woodland areas in Tanzania (Moreau, 1938; Pócs, 1976). A similar lapse rate is present in the East Usambara mountains, but annual temperatures here are 2–3°C lower than at similar altitudes in other parts of Tanzania (Hamilton, 1989; Moreau, 1938). Altitudinal lapse rates in other parts of the Coastal Forest belt are not known.

Extreme temperatures

The minimum temperature along the eastern African coast varies from 7.7°C (July in Nachingwea), 8°C (June, July and September at Chimoio) and 8.2 °C (June at Tanga Airport), to extreme maxima of 40.7°C (February in Ribaue), 38.8°C (March at Chukwani, Zanzibar) and 38.5°C (November and December in Nachingwea). Frosts are absent (White, 1983).

Diurnal temperature variations

The annual mean of diurnal temperature variations along the Kenyan and Tanzanian coasts is in the region of 6–12°C (East African Meteorological Department, 1975b; Griffiths, 1969) rising to 15°C at inland stations in southern Mozambique (Servico Meteorologico Nacional, 1919–1951). There appears to be a trend towards a greater difference between the annual mean of daily maximum temperatures and the annual mean of daily minimum temperatures from the coast to stations further inland. For example, the annual mean of diurnal fluctuations between 21.9°C to 29.7°C (7.8°C difference) at Dar es Salaam Kurasini may be compared with 18.6 °C to 30.0°C (11.4°C difference) at

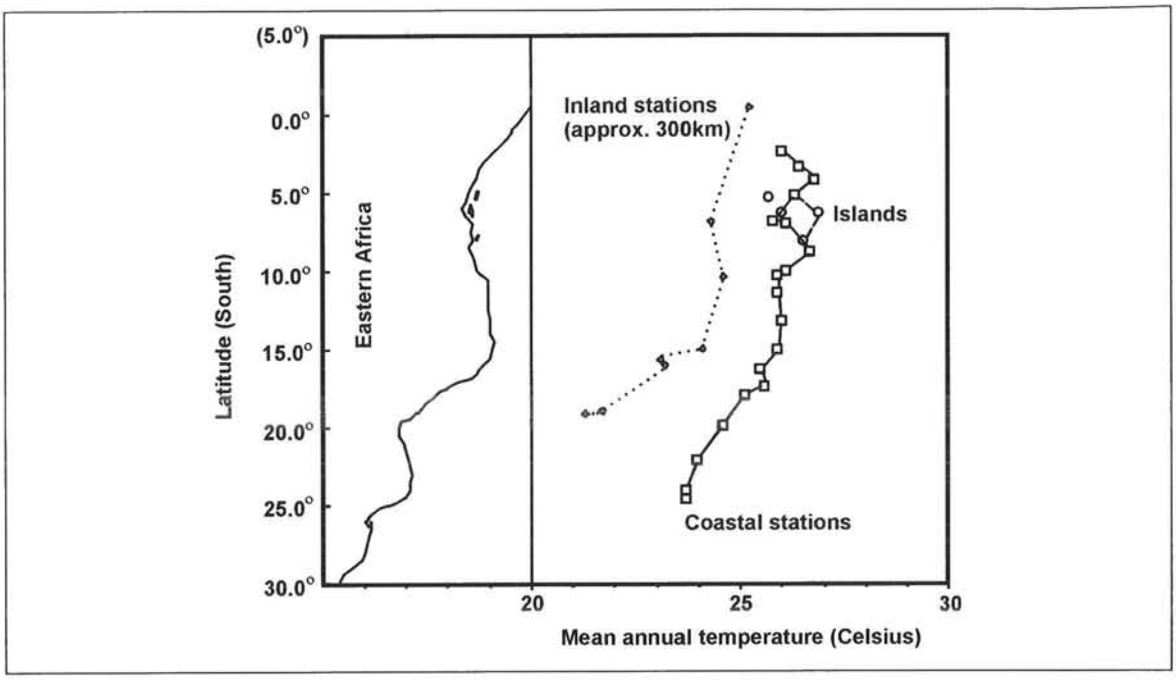


Figure 2.3.9 Mean annual temperatures along the eastern African coast (East African Meteorological Department, 1975a and b; Servico Meteorologico Nacional, 1951).

Morogoro at the same latitude, while a 21.7°C to 30.5°C (8.8°C difference) at Lindi may be compared with a 18.7°C to 30.2°C (11.5°C difference) at Nachingwea at the same latitude. There seems to be little latitudinal variation in the annual mean of daily maximum temperatures (less than 1°C along the Tanzanian coast) compared to a much higher variation in the annual mean of daily minimum temperatures (>5°C along the Tanzanian coast).

Monthly temperature variations

Monthly temperature variations are in the order of 3–6°C between mean temperatures recorded for the hottest month (normally December, January, February or March) and the coolest month (normally June or July) along the Kenyan and Tanzanian coasts (East African Meteorological Department, 1975b; Griffiths, 1969; Frazier, 1993; Moreau, 1938), rising to a difference of almost 8°C along the southern Mozambique coast (Servico Meteorologico Nacional, 1951). There is a trend of greater monthly temperature variations from the northern to the southern end of the Coastal Forest belt, and from the coast to inland e.g. a 3.8°C difference at Wete on Pemba Island to a 7.4°C difference at Beira, and an 8°C difference at Manica (763m altitude).

Micro-climatic temperature variations

Variations in air temperature occur from the ground to the tree canopy within Coastal Forests, since the canopy acts as a buffer against climatic conditions outside of the forest. Diurnal temperature fluctuations are thereby reduced (Figure 2.3.10), usually by lowering the maximum temperature compared to that outside of the forest (Moreau, 1935). The buffering is usually in the order of 2–4°C in the Tanzanian Coastal Forests (Moreau, 1935; unpublished Frontier data; compare Menaut *et al.*, 1995), and is never as dramatic as the extreme difference of 20°C between forest and cultivated (open) areas reported in the nearby Eastern Arc mountains above 2000m altitude (Lovett, 1993).

Variations in soil temperature

Soil temperatures have been measured in Dar es Salaam, where the mean soil temperature is 3°C higher than the mean air temperature (Griffiths, 1969). In forests the difference is lower (Figure

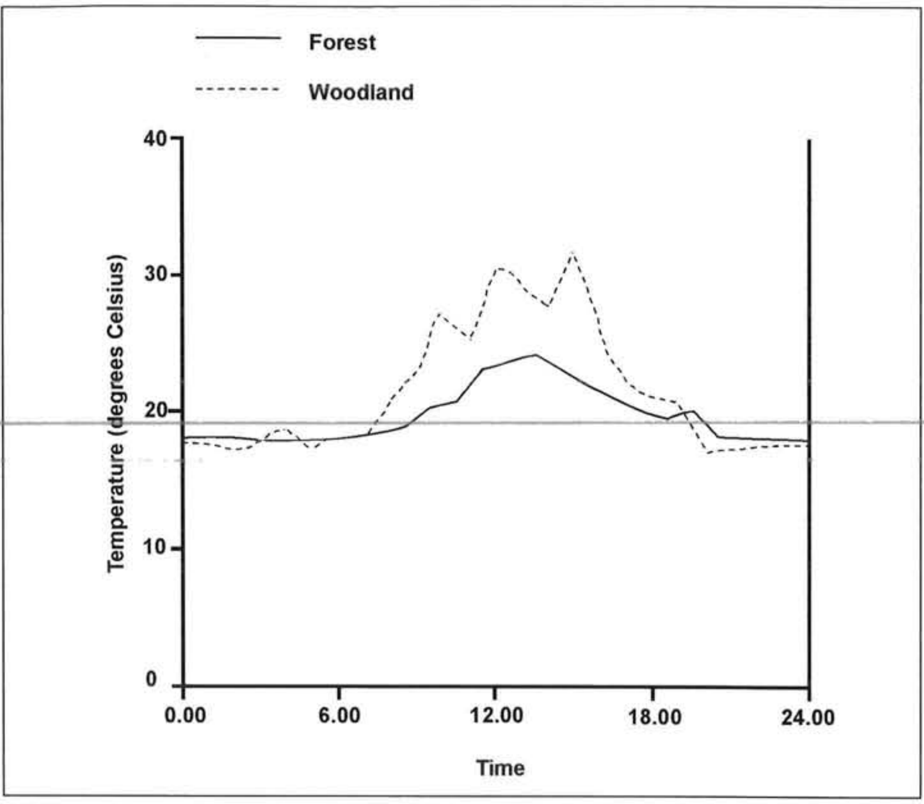


Figure 2.3.10 Temperatures in forest and woodland at Namburika Hill, Tong'omba Forest Reserve, 16th August 1992 (data from the Frontier- Tanzania Coastal Forest Research Programme).

2.3.11) as forest soils are usually protected from being heated by sunlight due to shading from both the tree canopy and the leaf-litter layer, and are therefore cooler than nearby woodland soils (Figure 2.3.12). More striking variations in soil temperatures occur on cultivated land, which have been recorded to heat up to 58°C at 750m altitude (Pócs, 1974) where bare ground is exposed to strong sunlight.

Humidity

Daily variations in humidity

Humidity along the eastern African coast is always high, and diurnal variations in humidity follow a constant pattern throughout the Coastal Forest belt where maximum relative humidities are reached at night (usually 90–95% for all sites throughout the year, Figure 2.3.13). Greater variations are found in the minimum daily humidities, both between sites and at different times of the year (Frontier-Tanzania, unpublished).

Average annual diurnal humidity minima

Annual average relative humidity at 3pm (the approximate time when daily humidity is at its lowest) never falls below 50%. Maximum values for annual average humidity at 3pm are recorded from islands, i.e. 79% at Lamu (Moomaw, 1960), 72% at Kilindoni on Mafia Island and 71% at Chukwani on Zanzibar Island. The lowest annual average humidities at 3pm are recorded inland of the coast, e.g. 55% at Morogoro and 53% at Nachingwea (East African Meteorological Department, 1975b).

Monthly variations in minimum humidity

Minimum extremes of the monthly average humidity at 3pm vary from 40% (Nachingwea in August), 45% (Morogoro in October) and 54.2% (Beira in June) to 65% (Tanga Airport in February, March and

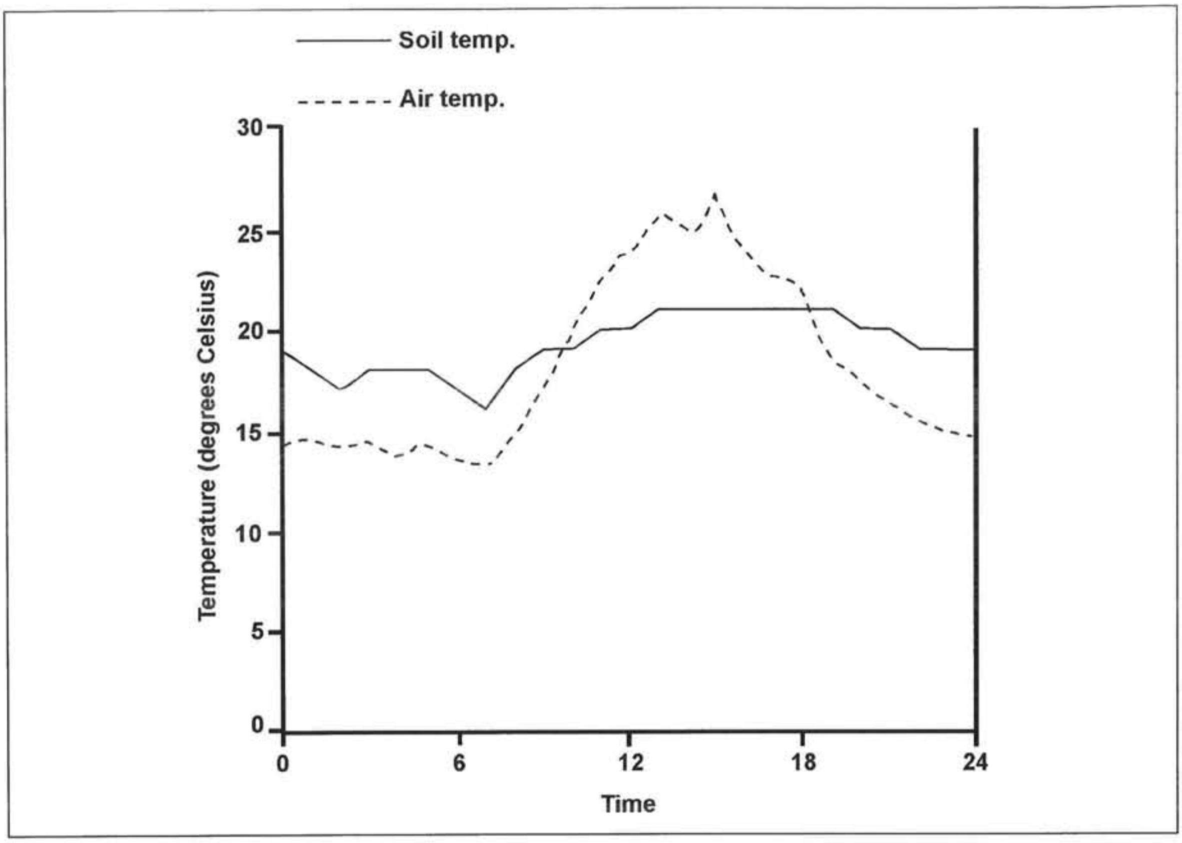


Figure 2.3.11 Forest soil and air temperatures at Nanyangu, Tong'omba Forest Reserve, 8th August 1992 (data from the Frontier-Tanzania Coastal Forest Research Programme).

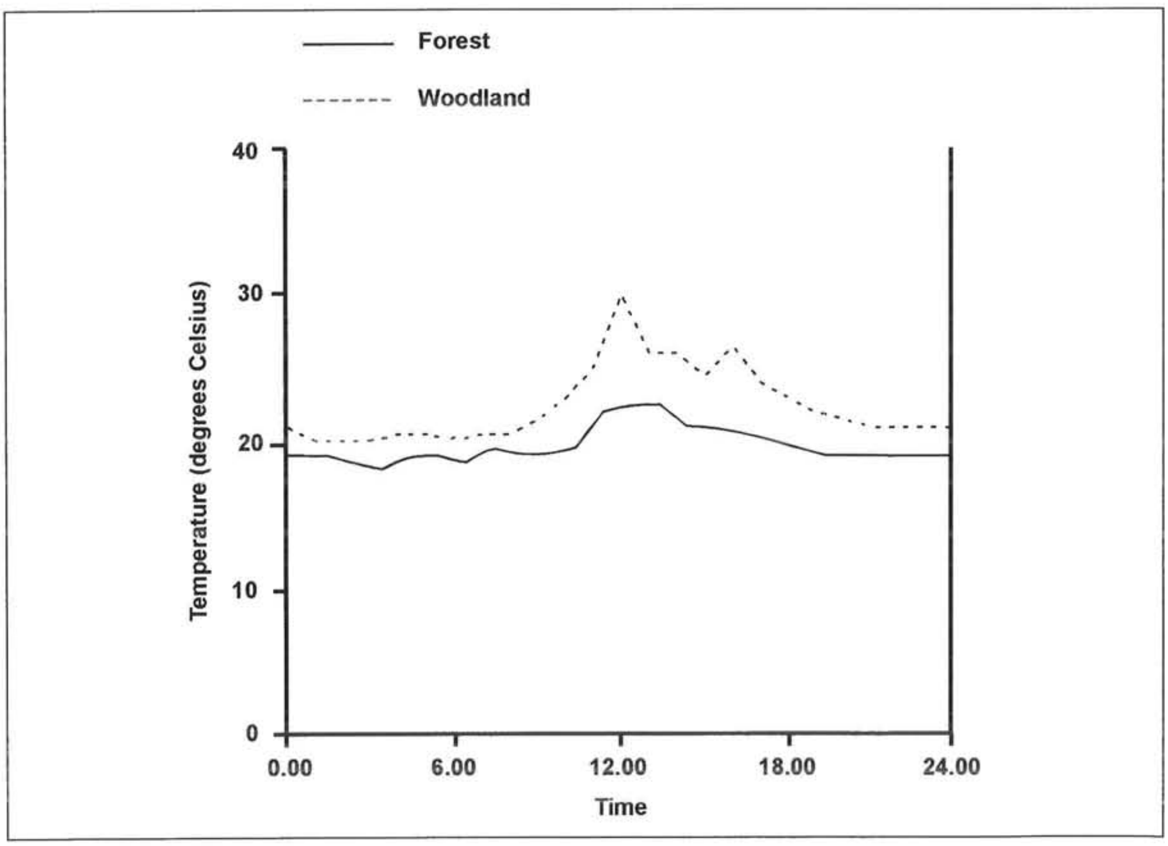


Figure 2.3.12 Forest and woodland soil temperatures at Namburika Hill, Tong'omba Forest Reserve, 16th August 1992 (data from the Frontier-Tanzania Coastal Forest Research Programme).

September) and 66% (Chukwani, Zanzibar in January). There is a general trend for monthly average humidities to drop to their lowest values during the dry season months (East African Meteorological Department, 1975b; Servico Meteorologico Nacional, 1919–1951).

Micro-climatic variations in humidity

Coastal Forests modify the humidity of their micro-climates by reducing diurnal humidity fluctuations through higher minimum humidity levels (cf. Moreau, 1935; Figure 2.3.13). High canopy forest may be expected to have a stronger modifying role than low canopy forest since the former usually contains sub-canopy layers (i.e. understorey trees) which further buffer the forest floor from external conditions. Natural disturbances to the forests, such as canopy gaps created by a treefall reduce the effect of micro-climatic modification by the forest (Figure 2.3.14), although major disturbances are required (such as clearance) to remove it entirely. The amount by which Coastal Forests are able to raise the mean annual relative humidity has not been quantified, but may be similar to the 10–17% increment above that recorded for savannah (grassland) and woodland in SE Zaïre (Menaut *et al.,* 1995).

Although the Coastal Forests are able to raise the average humidity of their micro-climates, this is insufficient to prevent the leaf litter from drying out completely during the dry season, such that it will even burn (pers. obs.).

Sunlight

Daylight

Day length varies little in the Coastal Forest belt over the year, as the forests are almost entirely located within the tropics where the zenith sun migrates between 23.5°N and 23.5°S. The northern end of the Coastal Forest belt (on the equator) receives a constant 12 hours of sunlight every day whereas at 25°S in southern Mozambique there is a maximum of 13.5 hours sunlight in the austral (southern) summer and a minimum of 10.5 hours in the austral winter.

Sunshine in forest

Coastal Forest canopies reduce the amount of light reaching the forest floor to just 0.2% of the full sunlight reaching their canopies (Moreau, 1935), but the amount of shading varies considerably from site to site due to differences in forest structure, disturbance, the degree of deciduousness of the forest and the season (due to different levels of leaf and cloud cover). Menaut *et al.* (1995) record a 97.3% reduction in solar radiation from canopy to forest floor in a dry forest in SE Zaïre.

The dry-season shading produced by a Coastal Forest canopy approaches zero in parts of the almost deciduous Arabuko-Sokoke forest in Kenya and Litipo and Namakutwa forests in southern Tanzania, where the forest canopy loses all of its foliage during the dry season (pers. obs.). Heliophilic grasses may be prevented from colonising the ground layer of these forests by the shade cast by the forest canopy during the wet season, and by the severe drought during the dry season. The absence of such grasses reduces the likelihood of fires entering the forest, and of a subsequent succession of burnt forest to woodland.

Bright sunshine and cloud cover

Few data exist for eastern Africa of the annual mean number of hours of bright sunshine per day, which are affected by latitude and cloud. The known range is from a maximum of 8.5 hours per day in Mombasa (Moomaw, 1960), to 7.7 hours and 5 hours in Dar es Salaam and Morogoro respectively (Griffiths, 1969).

The monthly average number of hours of bright sunshine per day varies from 5.2 to 9.0 hours for Dar es Salaam and 3.7 to 5.1 hours for Morogoro (Griffiths, 1969) which are at approximately the

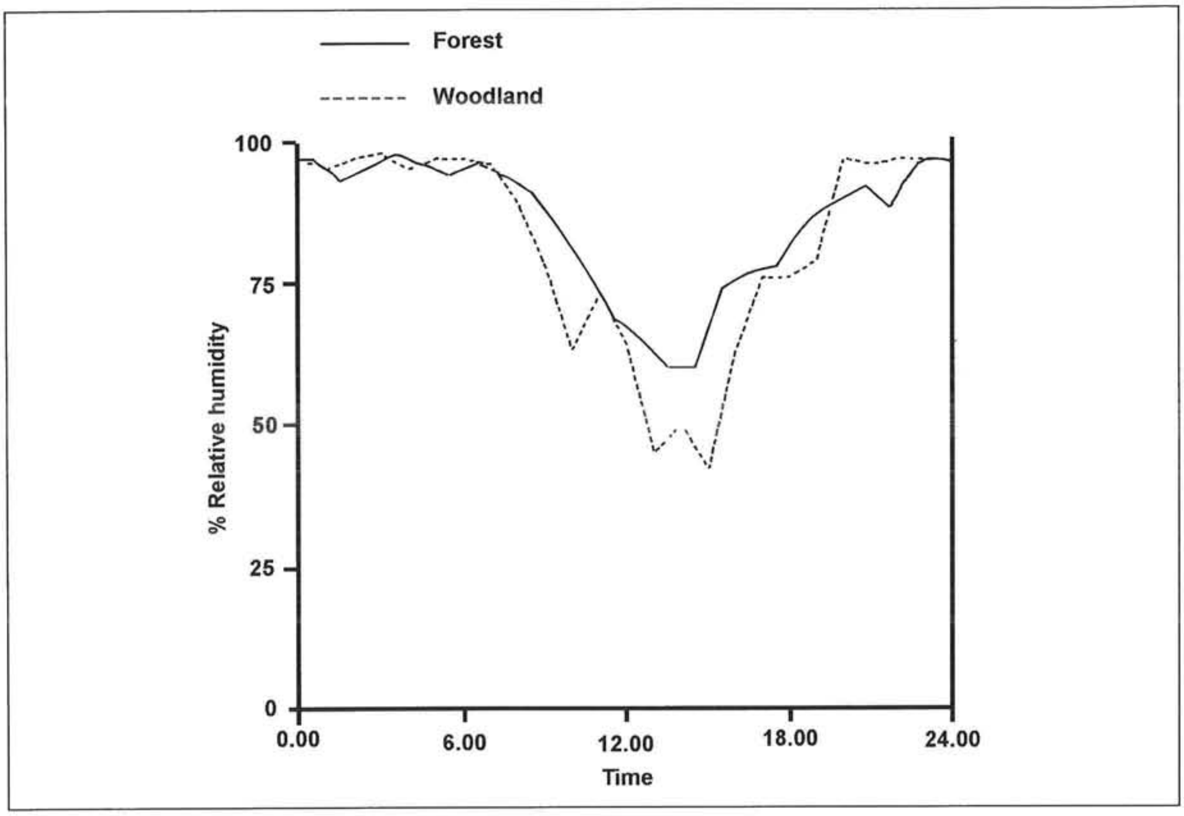


Figure 2.3.13 Forest and woodland humidities, Namburika Hill, Tong'omba Forest Reserve, 16th August 1992 (data from the Frontier-Tanzania Coastal Forest Research Programme).

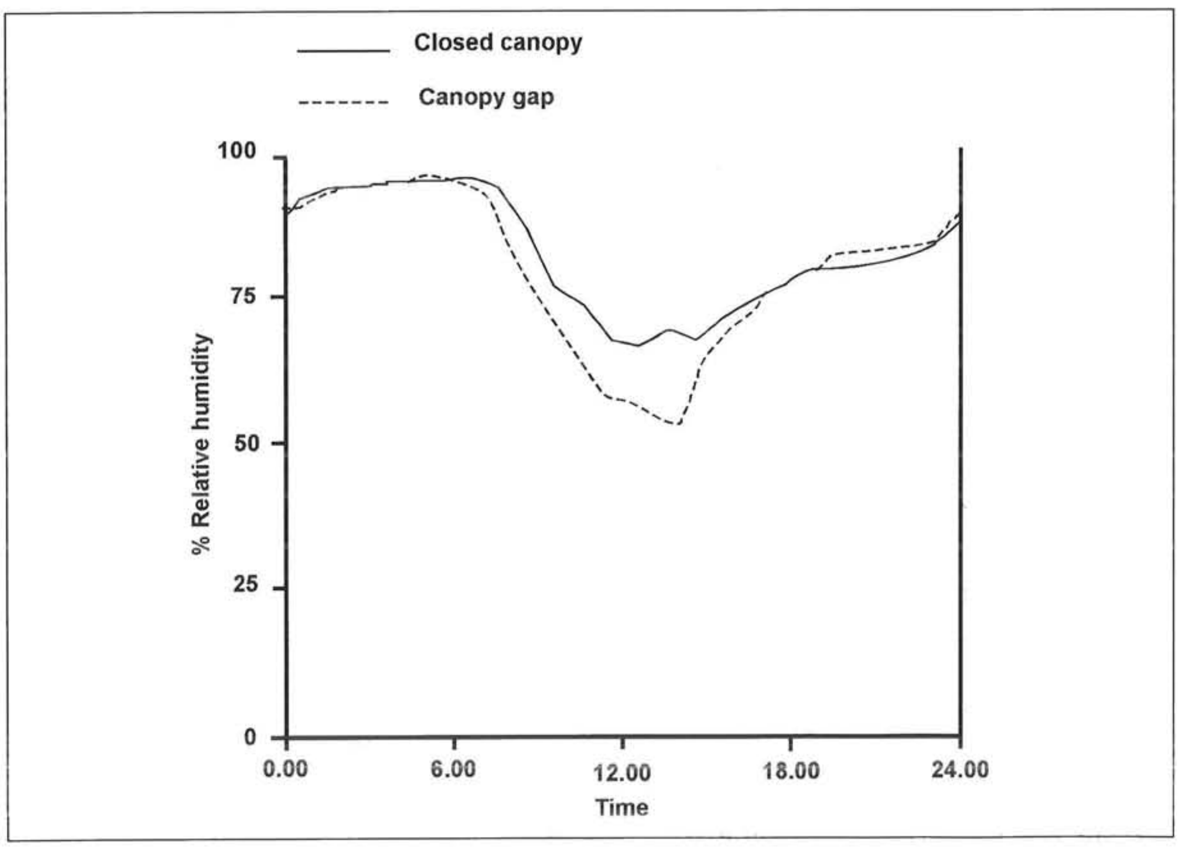


Figure 2.3.14 Closed canopy and canopy gap humidities, Kisiju forest, 27th November 1992 (data from the Frontier-Tanzania Coastal Forest Research Programme).

same latitude (the lower figure from Morogoro can be ascribed to cloud over the neighbouring Uluguru Mountains). However, even during cloudy conditions there is abundant sunlight to power photosynthesis, and the amount of sunshine is not a limiting factor for plant growth in the Coastal Forest belt, except in the forest understorey.

Wind

Latitudinal variations in prevailing wind direction

The direction of prevailing winds in the Coastal Forest belt is determined by the position of the Inter-Tropical Convergence Zone (ITCZ), a band of low atmospheric pressure lying near the equator whose axis follows the solar zenith by about one month. Airstreams converge in the Inter-Tropical Convergence Zone which migrates between a northern limit over southern Sudan in July, to a southern limit at a latitude of 15°S in January (Moomaw, 1960) (Figure 2.3.5). Two major wind pattern zones affect the Coastal Forest belt:

1. The northern monsoon zone from the northern limit of the Coastal Forest belt to 15°S. The ITCZ moves through this zone during the austral summer, so that the prevailing wind changes direction as it passes, with a general pattern of north-easterly trade winds north of the ITCZ (from October/November to February/March) and south-easterly trade winds south of the ITCZ (from March/May to August/September). Local variations exist in the direction of the prevailing winds when high pressure areas are present over the African continent, e.g. south-westerly winds occur at the northern limit of the Coastal Forest belt from May to December (Moomaw, 1960).
2. The southern seasonal zone from 15°S to the southern limit of the Coastal Forest belt. This area is always south of the ITCZ, so receives easterly anti-cyclonic winds off the Indian Ocean (Tinley, 1971), and the prevailing winds are from the south-east throughout the year.

Average windspeeds

An average run of the wind of 88km per day has been recorded from the Mlingano Research Station (East African Meteorological Department, 1975b). Large diurnal variations in surface wind velocities are recorded, and vary from a monthly mean of two knots per hour at 9am to a monthly mean of 12 knots per hour at 3pm (East African Meteorological Department, 1975b). A consistent average speed of $30 kmh^{-1}$ is recorded by Frazier (1993) for the SE Trade Winds, but this is inconsistent with data from Beira and Mossuril which record average SE windspeeds of $17.2\ kmh^{-1}$ and $11.5\ kmh^{-1}$ respectively (Servico Meteorologico Nacional, 1951).

Onshore and offshore breezes occur on the coast, with a short fetch (Tinley, 1971), reaching a maximum speed at about 16.00 hrs (Moomaw, 1960). Patterns in the variation of the windspeeds are hard to detect.

Extreme windspeeds

Cyclones are rare in the Coastal Forest belt, but occasional heavy treefalls due to storms do occur, e.g. at the Pangani Falls forest in February 1993 where large numbers of mature trees blew down on the more exposed ridges (pers. obs.). In Zaraninge Forest an area of high treefall density is ascribed by local tradition to a storm in 1977 following a prolonged drought during 1973 and 1974, affecting a third of the forest (Clarke and Dickinson, 1995; Sheil, 1992).

Seasonal variations of windspeed

Seasonal variations of windspeed in East Africa are in the order of only +/- 30% from the average (Griffiths, 1969; cf. data in East African Meteorological Department, 1975b). Greater seasonal windspeed variations are recorded in Mozambique, where the average windspeed in the windiest month may be two and a half times greater than in the slackest month (Servico Meteorologico Nacional, 1951).

Micro-climatic variations in windspeed

Air movement within Coastal Forests is usually minimal (pers. obs), even in predominantly deciduous forests during the dry season when the windbreak effect of the trees is much reduced by a lower foliage cover. Low windspeeds cause the forests to feel (to the human observer) much hotter than surrounding non-forest areas (this effect is compounded by the higher humidities in the forests), but the water stress for plants is reduced as evapotranspiration rates are lowered by the lower average windspeeds (and the higher humidities).

Historical climatic variations

There are no accurate data on climatic variations in eastern Africa prior to the start of meteorological data collection at the end of the last century. However, geological and palynological evidence from various parts of the African continent can be used to infer past climatic variations (Axelrod and Raven, 1978; Hamilton, 1982; and data from Bonnefille and Mohammed, 1994; Fredoux, 1994; Jolly *et al.*, 1994; Vincens, 1991; Bonnefille *et al.*, 1990; Livingstone, 1990). Here, climatic changes over the past *c.* 100 million years are described to determine when the climate may have been unfavourable for the development of forest, and therefore to infer how long the Coastal Forests have been present. The changes are presented in reverse chronological order to describe these changes from the datum of the present (and known) climate and vegetation.

The recent past (present to 1 AD)

Strong rainfall fluctuations are known to have occurred throughout Africa during the last two centuries (Nicholson, 1994), and evidence from flood level records from the Nile River suggest further rainfall fluctuations in the East African highlands during the last 2000 years (Dale, 1954). Droughts are recorded in 1840, 1325–1280 and 800 to 760 AD, but their severity along the eastern African coast cannot be assessed as this area falls under a different climatic regime to the highlands.

Ice Age climatic fluctuations (1 BC to 2.3 million years Before Present)

The last Ice Age finished about 10,000 years Before Present (BP)/ 8000 years BC. However, evidence from elsewhere in Africa suggests that there may have been continuing fluctuations in the climate of the Coastal Forest belt since that time. For example, a dry period is recorded from 1250–1850 BC, which weakened the montane forests of Burundi (Jolly *et al.*, 1994). This also corresponds to a noticeable forest decrease elsewhere in Central Africa (e.g. Taylor, 1990; Marean *et al.*, 1994) although distinguishing climatic change from human impacts is problematic (Jolly *et al.*, 1994). The dry period was preceded by a moister climate than today until 8650 BC, corresponding with findings elsewhere in Africa of a moister climate before 3–4000 BC in NE Africa (Bonnefille and Mohammed, 1994; Marean *et al.*, 1994) and also in the Sahelian region (Gasse *et al.*, 1990). The potential extent of forest in Africa is thought to have been greater at that time, particularly during the peak wet period of 5500–7300 BC when rainfall in the Sahel is estimated to have been 125–135% higher than at present (Gasse *et al.*, 1990). It is possible that the rainfall was also elevated in the Coastal Forest belt during this period (and that the extent of the forests may have been greater), but there is no direct evidence for this.

The last Ice Age is only one of a suggested 21 major fluctuations in the global climate between warm and cold extremes during the past 2.3 million years (Lovett, 1992, citing van Donk, 1976), which are thought to have been forced by the 'Milankovitch' cyclical variations in the earth's orbit (Bennet, 1990). There is considerable circumstantial evidence that the climate of Africa was markedly drier and cooler during the cold phases of these Ice Age cycles. Particularly dry periods are associated with the maximum periods of ice cover at northern and southern latitudes, for example during the

'Last Glacial Maximum' (LGM) of the last Ice Age, which ended between 11–13,000 BC (Gasse *et al.*, 1990). Bonnefille *et al.* (1990) have estimated an average temperature drop of 4 +/- 2°C, with a corresponding average rainfall reduction of 30% in Burundi at 2240m altitude from 11,000–28,000 BC, and this is supported by similar results from the southern end of the Lake Tanganyika basin (Vincens, 1991), from S.W. Uganda (Taylor, 1990) and from the central Kenyan highlands (Marean, 1992). A further dry period is identified before 30,000 BC (Taylor, 1990). The transition from arid to humid conditions is known to have occurred over a series of lesser climatic oscillations at the end of the LGM, some of which were extremely rapid (Gasse *et al.*, 1990).

Importantly, it is believed that during Ice Age periods the temperature and rainfall did not decline appreciably along the eastern African coast. This is because the sea surface temperature along this coast north of 25°S is not considered to have fallen by more than 1°C at any time, while the average temperature of the whole Indian Ocean is believed to have only dropped by 1–2°C during the Last Glacial Maximum (Prell *et al.,* 1980). Such a small decline in sea surface temperature would have only slightly reduced the amount of moisture evaporating from the ocean and falling as rain in coastal eastern Africa. In comparison, the temperature of the Atlantic Ocean is believed to have fallen by much more, and the quantity of rain in West and Central Africa may have declined quite dramatically (Gasse *et al.*, 1990), although rain forest pollens have nonetheless been found in all levels in a core off the Gulf of Guinea which contains a continuous record of the last 225,000 years (Fredoux, 1990).

Climatic conditions along the East (and to a lesser extent the south-east) African coast are therefore thought to have been fairly stable throughout the Ice-Age period, so most of the Coastal Forests that exist today are expected to predate the Pleistocene fluctuations. However, there remains considerable controversy surrounding the interpretation of the available evidence for past climatic conditions (cf. White, 1993), and the extent of forest cover elsewhere in East Africa is certainly thought to have changed during the Ice Ages (Hamilton, 1981 and 1982). Further interpretations of past vegetation changes in the Coastal Forest belt are hampered by the absence of any palynological studies in the area which would provide more direct evidence of vegetation change or stability over this period.

The pre-Ice Age climate

Prior to the Ice Ages, climate changes took place due to the movement of the continents which led to major changes in ocean and wind currents.

In eastern Africa the trend of these changes has been towards greater aridity through time. A climate which was warmer and more humid than today is thought to have existed before the Ice Ages, between 2.43 and 4.6 million years ago (Lovett, 1992). Before that, the world climate may have been even moister as the development of an ice cap on Antarctica (five million years ago) may have started the general drying and cooling of the global climate. Many species are thought to have become extinct from the African tropical forests following the formation of the ice cap (Axelrod and Raven, 1978), and a subsequent drier climate may have reduced forest extent in Africa (Lovett, 1992). An absence of fossilised wood from the Pliocene Mkindu beds of eastern Tanzania (Spence, 1957) may be related to this period.

Before the development of the polar ice cap, i.e. from the middle of the Pliocene (five million years ago) to the beginning of the Pliocene (seven million years ago) the climate was warm and humid, and there is fossil evidence of West African rain forest connections with Ethiopia at this time (Lovett, 1992).

A pan-African tropical forest is assumed to have once united the now disjunct forest blocks of West/Central Africa and East Africa (Axelrod and Raven, 1978). The fragmentation of this pan-African forest occurred sometime between the start of the Pliocene and the early Miocene (25 million years ago), during which time the Central Tanganyikan Plateau was uplifted. This geological activity is believed to have altered the continental climate such that moist air from the Atlantic Ocean was no longer able to penetrate as far eastwards as it did formerly, and it is this plateau which now determines the eastern margin of the West and Central African forest block. The uplift also created new upland catchments and rainshadows, which divided the formerly continuous lowland forest by an arid corridor between two moist montane forest belts (i.e. the Albertine Rift and the Eastern Arc Mountains).

Fossil evidence from the area of the central Tanganyikan uplift is for tropical semi-deciduous forest during the lower to middle Miocene (12.2 and 19 million years ago) in the Kenyan rift valley, in an area that is now *Acacia* woodland (Lovett, 1992; Axelrod and Raven, 1978). Miocene fossils of a rain forest flora have also been identified from Rusinga Island in Lake Victoria (Axelrod and Raven, 1978). Fossil leaves at Bugishu near Mt. Elgon in Uganda, from the time of the start of uplifting during the early Miocene (23–25 million years ago), are of a small-leaved tree flora that include the genera *Bauhinia*, *Berlinia*, *Cassia*, *Dalbergia*, *Parinari*, *Pittosporum* and *Terminalia*. This flora has been interpreted to represent a dry savannah-woodland (Axelrod and Raven, 1978), but may equally well represent a dry evergreen forest flora, since all of these genera except *Pittosporum* are represented today in eastern Africa's Coastal Forests. The fossils are deposited on a lateritic surface, implying a seasonal rise and fall in the water table, and therefore a seasonal climate.

No fossil evidence is yet available for the occurrence of forest along the eastern African coast prior to the start of the uplifting of the Central Tanganyikan Plateau, but a pan-African tropical forest would presumably have reached to the east coast of Africa at least as far south as the present day Tanzania-Mozambique border.

Global climate changes during tectonic drifting of the African continent

Before the end of the Oligocene (26 million years ago), the African continent lay to the south-west of its present position, so the equatorial forest belt was then to the north of its present position (Figure 2.3.15). The northern African climate is thought to have been much wetter during this time, as the present Mediterranean Sea (referred to as the Tethys Sea to distinguish its earlier extent) was then much larger and would have exerted a moister influence on the North African climate. There is a general trend for the fossils from this area to represent moister forest types in increasingly older sediments.

Prior to the late Oligocene (35 million years ago) the global tropical rain forest zone is believed to have been much broader than at present, due to the warmer and moister global climate prevalent before the separation of Antarctica from southern Australasia (Axelrod and Raven, 1978; Figure 2.3.15). This separation event has caused an increase in the thermal gradient between the poles and the equator (eventually leading to the formation of the polar ice caps), such that the climate of the whole of Africa has since become drier and more seasonal than before (Axelrod and Raven, 1978). The sudden appearance of numerous woody legumes in the tropical forests dates from this time (Axelrod and Raven, 1978, citing Lakhanpal, 1970). Woody legumes now dominate the tree flora of much of tropical Africa, i.e. *Acacia* savannah, miombo (*Brachystegia*) woodland, mopane (*Colophospermum*) woodland, and much of the lowland forests of the Guineo-Congolian and Coastal Forests (Hart, 1990; Chapters 3.2 and 4.1).

A wetter global climate before the separation of Antarctica and southern Australasia is partly supported by leaf fossils from the upper to middle Eocene (40–50 million years ago), which suggest that a dry forest existed in North Africa at this time, occurring together with woodland/savannah vegetation (Axelrod and Raven, 1978). Still earlier, fossil leaves from the Palaeocene (60 million years ago) indicate a moister tropical rain forest climate in North Africa, which was covered by forest at least as far back as the late Cretaceous (80 million years ago), when the flora included palms and figs (Axelrod and Raven, 1978). However, as the African continent was then located 15–18 degrees to the south of its present position, the equator (as well as the equatorial forests) were then located in the present Sahara Desert area (Figure 2.3.15). At this time, only the very northern end of the Coastal Forest belt would have been located within the tropics, hence it is unlikely that the existence of tropical forest in the Coastal Forest belt predates the mid/late Cretaceous (max. 100 million years ago).

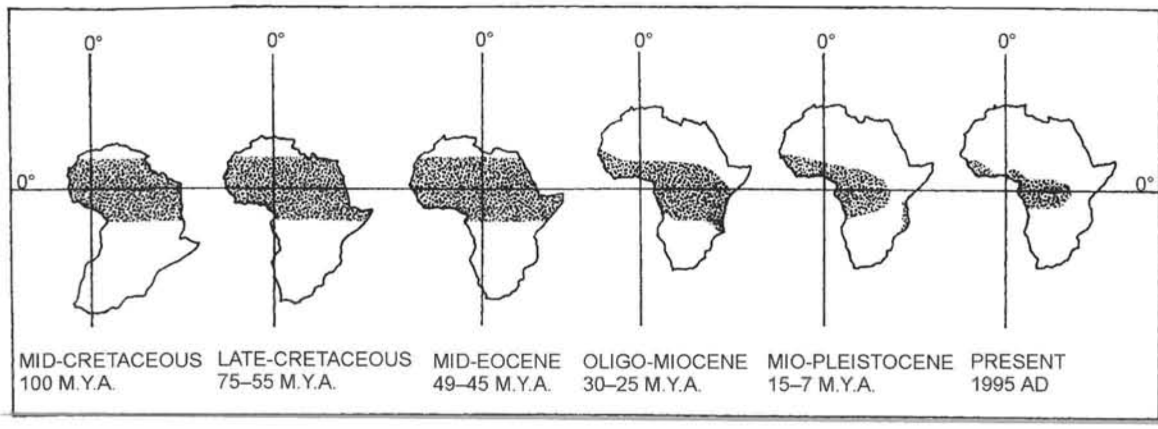


Figure 2.3.15 Inferred changes to the extent and distribution of forest cover in Africa since the mid- Cretaceous. Shoreline changes (Chapter 2.1) are not represented. Changes in the position and orientation of the African continent are due to continental drift.

Discussion

Climate and vegetation

Climatic conditions throughout the Coastal Forest belt should be suitable to support dry forest given the existing average annual temperature and rainfall in relation to the altitude (c.f. Holdridge *et al.*, 1971 for theory). Even in northern Kenya, which has the driest climate in the Coastal Forest belt, *Manilkara-Diospyros* lowland dry forest occurs in an area where the average annual rainfall drops below 500mm for three years out of 10, and where the long-term annual average is about 760mm (Moomaw, 1960). Yet in spite of a theoretically favourable climate, forest is now restricted to just 1.2% of the Coastal Forest belt/Swahilian region *sensu lato* (Chapter 4.1). It is widely recognised that these forests were formerly more widespread (Gomes e Sousa, 1951; Hawthorne, 1993; Moll and White, 1978; Sheil, 1992; Troup, 1923; Chapters 1.1 and 5.1). This, and the continued existence of patches of forest in the driest parts of the Coastal Forest belt, suggest that here it is not the climate which limits forest growth. Forest cover may instead have been reduced by the combination of fire and the loss of a forest microclimate which takes place when forest is cleared by people (leading to reduced humidity levels and higher ground temperatures), which together can prevent forest regeneration.

Climate does, however, appear to limit the extent of the Coastal Forest belt (Figure 1.2.2), which reinforces the link identified by White (1983, p. 41) between plant endemism and vegetation physiognomy, such that areas dominated by one main formation type (e.g. forest, woodland, grassland etc.) support very different floras to areas dominated by another main formation type.

North, north-west and south-west of the Coastal Forest belt there is a marked reduction in rainfall (from 788mm per year at Jelib, to 363mm per year at Giumbo and 232mm per year at Wajir in the Somalia-Masai regional centre of endemism) with slightly higher average temperatures (27.5°C (Wajir) and 27.8°C (Giumbo) compared with 25.2°C at Jelib), thereby preventing the development of forest. This drier climate to the north-west of the Coastal Forest belt may be attributed to the rainshadow caused by the Horn of Africa, such that the north-easterly monsoon airstreams are continental in origin. Reductions in rainfall also occur to the southwest of the Coastal Forest belt, in the Zambezi Valley (e.g. at Tete with 545mm per annum and a mean annual temperature of 34°C), and also in Gaza region which is in the rain shadow of the Lebombo Mountains (e.g. 590mm at Punda Maria and 570mm at Canicado).

To the south, rainfall becomes more evenly distributed over the year and average temperatures are lower (below 23°C), permitting the development of moist sub-tropical forests of White's (1983) Tongaland-Pondoland regional mosaic (since renamed as the Maputaland-Pondoland regional mosaic). It is only to the west (in White's (1983) Zambezian regional centre of endemism) that rainfall and temperature patterns are very similar to those of the Coastal Forest belt (e.g. Songea with

1130mm annual rainfall and a mean temperature of 20.9°C), and this is reflected by a number of woodland species which are common within and unique to both phytochoria (e.g. *Afzelia quanzensis, Combretum schumannii, Terminalia sambesiaca, Lecaniodiscus fraxinifolius*) as well as by the intrusion of Coastal Forests into the eastern side of the Zambezian woodland areas (Figures 1.2.2 and 1.2.3). The climatic similarity of the two phytochoria obscures the exact westward extent of the Coastal Forest belt, and White (1983) may have used the transition between different woodland and grassland types to set the boundary between the Zambezian and Zanzibar-Inhambane phytochoria (subsequently renamed as the Swahilian region *sensu lato* to encompass the entire Coastal Forest belt; Chapter 1.2), noting that islands of Zanzibar-Inhambane vegetation occur to the west of this boundary. The western limit of the Swahilian vegetation types is therefore difficult to define precisely (cf. Chapter 1.2).

Climate and endemism

Tropical forest areas with high species diversity and endemism are usually associated with ecologically stable areas of high rainfall/mist condensation and/or stable long-term climates (cf. Whitmore, 1986; Gentry, 1992; Hamilton, 1981; Fjeldså, 1995; Fjeldså *et al.*, 1997; Fjeldså and Lovett, 1997). The Coastal Forests contain a large number of endemic species (see Chapters 4.1–4.9), yet their climate is presently strongly seasonal, unreliable and very variable. Moreover, it is the drier Coastal Forest types which have the greatest numbers of endemic plant species (Hawthorne, 1993; Chapter 4.1). The Coastal Forests on Mafia and Pemba Islands which receive almost the 2000mm of average annual rainfall needed to permit the development of tropical rain forest (cf. Holdridge *et al.*, 1971) contain few endemic plant species when compared to some of the Coastal Forests on the mainland which receive little more than half the average annual rainfall of these islands (e.g. at Litipo and Rondo forests: Clarke, 1995).

Today, the Coastal Forests and their unique species are evidently able to withstand the severe water stresses caused by a strongly unpredictable and variable dry season. The presence of endemic plant genera in the Coastal Forests, and of genera shared only with West African and/or Madagascan forests are evidence however of an ancient history for these plant taxa, long predating the start of the Ice Ages (Chapter 4.1; White, 1979; Brenan, 1978). Given that the general pattern of climatic change, inferred from fossil and palynological records over the last hundred million years, is of increasing aridity with time, with Milankovitch cycles superimposed onto this trend (cf. Bennet, 1990), then the dry periods associated with the most recent Ice-Ages must have been the most arid since the Cretaceous. Assuming that Coastal Forests predate the Ice Ages, then the ever moister climates prior to this time would permit a continuous forest history in coastal eastern Africa, dating back to the former pan-African tropical forest which once stretched from the Atlantic to the Indian Oceans.

Summary

The climate of the eastern African Coastal Forests can be generally characterised by high temperatures and incident sunlight with little seasonal or annual variation (Moreau, 1938), combined with very variable rainfall patterns (cf. Nicholson, 1994; Murphy and Lugo, 1986). Daily, monthly and annual fluctuations in rainfall may be much more significant than the Quaternary historical rainfall variations which are interpreted to have been less severe along the eastern African coast than elsewhere on the continent. An adaptation to such a variable rainfall regime (in ecological time) may have enabled the Coastal Forests to survive the Milankovitch climatic fluctuations that have been inferred from palynological, geological and geochemical studies (Bennet, 1990), and this may account for the high levels of plant species endemism in the forests (Chapter 4.1). Various kinds of evidence suggest that Coastal Forests may be partial relicts of the former pan-African tropical forest, i.e. fragments of a formerly contiguous lowland refugium/accumulation centre for ancient species (cf. Fjeldså *et al.*, 1997; Fjeldså and Lovett, 1997). Favourable sites which have continuously supported Coastal Forest throughout the driest periods of the Quaternary are therefore important, both as ancient species refugia, and as source areas from where species are able to recolonise other areas during periods of climatic amelioration.

Acknowledgements

Comments on this chapter were received from Alan Rodgers (who also provided climatic data), Neil Burgess, William Hawthorne, Ben Lodge and Jon Fjeldså (who provided copies of many of the references). Climatic data were obtained from the libraries of the Royal Geographical Society in London, and of the University of Dar es Salaam, Tanzania. Fieldwork for the micro-climatic experiments was carried out by the Frontier-Tanzania Coastal Forest Research Programme under the direction of Leigh Stubblefield and Mike Brewin.

References

Axelrod, D.I. and Raven, P.H. (1978). Late Cretaceous and Tertiary vegetation history of Africa. In Werger, M.J.A. with assistance of A.C. van Bruggen (eds.). *Biogeography and Ecology of Southern Africa*. Dr. W. Junk Publishers, The Hague.

Bennet, J.G., Brown, L.C., Geddes, A.M.W., Hendy, C.R.C., Lavelle, A.M., Sewell, L.G. and Rose-Innes, R. (1979). *Mtwara/Lindi Regional Integrated Development Programme – Report of the Zonal Survey Team in Phase 2 Volume 1 The Physical Environment*. Ministry of Overseas Development, London.

Bennet, K.D. (1990). Milankovitch cycles and their effects on species in ecological and evolutionary time. *Paleobiology* **16**: 11–21.

Bonnefille, R. and Mohammed, U. (1994). Pollen-inferred climatic fluctuations in Ethiopia during the last 3000 years. *Palaeogeography, Palaeoclimatology, Palaeoecology* **109**: 331–343.

Bonnefille, R., Roeland, J.C. and Guiot, J. (1990). Temperature and rainfall estimates for the past 40,000 years in equatorial Africa. *Nature* **346**: 347–349.

Brenan, J. P. M. (1978). Some aspects of the phytogeography of tropical Africa. *Ann. Miss. Bot. Gard.* **65**: 437–478.

Chapman, J.D. and White, F. (1970). *The Evergreen Forests of Malawi*. Commonwealth Forestry Institute, Oxford.

Clarke, G.P. (1995). *Status Reports for 6 Coastal Forests in Lindi Region, Tanzania*. Frontier-Tanzania Technical Report No. 18. The Society for Environmental Exploration/The University of Dar es Salaam, London and Dar es Salaam.

Clarke, G.P. and Dickinson, A. (1995). *Status Reports for 11 Coastal Forests in Coast Region, Tanzania*. Frontier-Tanzania Technical Report No. 17. The Society for Environmental Exploration/The University of Dar es Salaam, London and Dar es Salaam.

Dale, I.R. (1954). Forest spread and climatic change in Uganda during the Christian Era. *Empire Forestry Review* **33**: 23–29.

East African Meteorological Department (1975a). *Climatological Statistics for East Africa. Part II Kenya*. Meteorological Department, Nairobi.

East African Meteorological Department (1975b). *Climatological Statistics for East Africa. Part III Tanzania*. Meteorological Department, Nairobi.

FINNIDA (1990). *Project Preparation Mission for Projects Related to Animal Protein Production. Mission Report. Mtwara and Lindi Regions*. Government of Tanzania and FINNIDA, Dar es Salaam.

Fjeldså, J. (1995). Geographical patterns of neoendemic and relict species of Andean forest birds: the significance of ecologically stable areas. Pp. 89–102. In Churchill, S.P. *et al.* (eds.). *Biodiversity and Conservation of Neotropical Montane Forests*. New York Botanical Gardens, New York.

Fjeldså, J. and Lovett, J.C. (1997). Geographical patterns of old and young species in African forest biota: the significance of specific montane areas as evolutionary centres. *Biodiversity and Conservation* **6**: 325–347.

Fjeldså, J., Ehrlich, D., Lambin, E. and Prins, E. (1997). Are biodiversity "hotspots" correlated with current ecoclimatic stability? A pilot study using the NOAA-AVHRR remote sensing data. *Biodiversity and Conservation* **6**: 401–423.

Frazier, J.G. (1993). Dry coastal ecosystems of Kenya and Tanzania. Pp. 129–150. In van der Maarel, E. (ed.). *Dry Coastal Ecosystems. Africa, America, Asia and Oceania*. Ecosystems of the World **2B**. Elsevier, Amsterdam.

Fredoux, A. (1994). Pollen analysis of a deep-sea core in the Gulf of Guinea: vegetation and climatic changes during the last 225,000 years B.P. *Palaeogeography, Palaeoclimatology, Palaeoecology* **109**: 317–330.

Gasse, F., Tehet, R., Durand, A., Gibert, E. and Fontes, J-C. (1990). The arid transition in the Sahara and the Sahel during the last deglaciation. *Nature* **346**: 141–146.

Gentry, A.H. (1992). Tropical forest biodiversity: distribution patterns and their conservation significance. *Oikos* **63**: 19–28.

Gomes e Sousa, A.F. (1951). *Dendrology of Mozambique, vol. 1 some commercial timbers*. English translation of (1950). *Dendrologia de Moçambique* [vol. 1]. Algumas Madeiras Comerçais.

Greenway, P.J. with Rodgers, W.A., Wingfield, R.J. and Mwasumbi, L.B. (1988). The vegetation of Mafia Island, Tanzania. *Kirkia* **13**: 197–238.

Griffiths, J.F. (1969). Climate. In Morgan, W.T.W. (ed.) *East Africa: its Peoples and Resources*. Oxford University Press, Nairobi.

Hamilton, A.C. (1981). The Quaternary history of African forests: its relevance to conservation. *African Journal of Ecology* **19**: 1–6.

Hamilton, A.C. (1982). *Environmental History of East Africa.* Academic Press, London.

Hamilton, A.C. (1989). The climate of the East Usambaras. In Hamilton, A.C. (ed.) (1989). *Forest Conservation in the East Usambara Mountains, Tanzania.* IUCN, Gland, Switzerland and Cambridge, UK.

Hart, T.B. (1990). Monospecific dominance in tropical rain forests. *Trends in Ecology and Evolution* **5**: 6–11.

Hawthorne, W.D. (1993). East African Coastal Forest botany. Pp. 57–99. In Lovett, J.C. and Wasser, S.K. (eds.). *Biogeography and Ecology of the Rain Forests of Eastern Africa.* Cambridge University Press, Cambridge.

Holdridge, L.R., Grenke, W.C., Hatheway, W.H., Liang, T. and Tosi, T. (1971). *Forest Environments in Tropical Life Zones.* Pergamon, Oxford.

Hughes, F.M.R. (1988). The ecology of African floodplain forests in semi-arid zones: a review. *Journal of Biogeography* **15**: 127–140.

Iversen, S.T. (1991). The Usambara Mountains, NE Tanzania: Phytogeography of the vascular plant flora. *Sym. Bot. Upsaliensis* **XXIX**: 1–234.

Jolly, D., Bonnefille, R. and Roux, M. (1994). Numerical interpretation of a high resolution Holocene pollen record from Burundi. *Palaeogeography, Palaeoclimatology, Palaeoecology* **109**: 357–370.

King, L.C. (1978). The geomorphology of central and southern Africa. Pp. 1–17. In Werger, J.C.A with assistance of van Bruggen, A.C. (eds.). *Biogeography and Ecology of Southern Africa.* Dr. W. Junk, The Hague.

Kingdon, J. (1989). 'Frontier Tanzania Expedition 1989–1994; Matumbi Interim Report'. Unpublished Report. Society for Environmental Exploration, London.

Lakhanpal, R.N. (1970). Tertiary floras of India and their bearing on the historical geology of the region. *Taxon* **19**: 675–694.

Livingstone, D.A. (1990). Evolution of African climate. In Goldblatt, P. (ed.). *Biological Relationships Between Africa and South America.* Yale University Press, New Haven and Boston.

Loveridge, A. (1942). Scientific results of a fourth expedition to forested areas in East and Central Africa – part IV, Itinerary and Comments. *Bulletin of the Museum of Comparative Zoology* **94**: 204–213.

Lovett, J.C. (1992). *Tanzanian Moist Forests*. Ph.D Thesis. University of Wales, Bangor.

Lovett, J.C. (1993). Eastern Arc moist forest flora. In Lovett, J.C. and Wasser, S.K. (eds). *Biogeography and Ecology of the Rain Forests of Eastern Africa.* Cambridge University Press, Cambridge.

Lovett, J.C. and Pócs, T. (1993). *Assessment of the Condition of the Catchment Forest Reserves*. The Catchment Forestry Project-Forestry and Beekeeping Division, Dar es Salaam.

Lovett, J.C. and Wasser, S.K. (eds.) (1993). *Biogeography and Ecology of the Rain Forests of Eastern Africa.* Cambridge University Press, Cambridge.

Marean, C.W. (1992). Implications of late Quaternary mammalian fauna from Lukenya Hill (South-Central Kenya) for Paleoenvironmental change and faunal extinctions. *Quaternary Research* **37**: 239–255.

Marean, C.W., Mudida, N. and Reed, K.E. (1994). Holocene paleoenvironmental change in the Kenyan Central Rift as indicated by micromammals from Enkapune Ya Muto rockshelter. *Quaternary Research* **41**: 376–389.

Menaut, J-C., Lepage, M. and Abbadie, L. (1995). Savannas, woodlands and dry forests in Africa. In Bullock, S.H., Mooney, H.A. and Medina, E. (eds.). *Seasonally Dry Tropical Forests.* Cambridge University Press, Cambridge.

Moll, E. and White, F. (1978). The Indian Ocean Coastal Belt. In Werger, M.J.A. (ed.) with assistance of Van Bruggen, A.C. *Biogeography and Ecology of Southern Africa.* Dr. W. Junk, The Hague.

Moomaw, J.C. (1960). *A Study of the Plant Ecology of the Coastal Region of Kenya Colony, British East Africa.* Government Printer, Nairobi.

Moreau, R.E. (1935). Some eco-climatic data for closed evergreen forest in Tropical Africa. *The Linnean Society's Journal – Zoology* **39**: 285–293.

Moreau, R.E. (1938). Climatic classification from the standpoint of East African biology. *Journal of Ecology* **26**: 467–496.

Murphy, P.G. and Lugo, A.E. (1986). Ecology of tropical dry forest. *Annual Review of Ecology and Systematics* **17**: 67–88.

Nicholson, S.E. (1994). Recent rainfall fluctuations in Africa and their relationships to past conditions over the continent. *The Holocene* **4**: 121–131.

Nieuwolt, S. (1973). *Rainfall and Evaporation in Tanzania*. Research paper no. 24. Bureau of Resource Assessment and Land Use Planning, University of Dar es Salaam, Dar es Salaam.

Pócs, T. (1974). Bioclimatic studies in the Uluguru Mountains (Tanzania, East Africa) I. *Acta Bot. Acad. Scientiarum Hungaricae* **20**: 115–135.

Pócs, T. (1976). Bioclimatic studies in the Uluguru Mountains. (Tanzania, East Africa) II. Correlations between orography, climate and vegetation *Acta Bot. Acad. Scientiarum Hungaricae* **22**: 163–183.

Prell, W.L., Hutson, W.H., Williams, D.F., Be, A.W.H., Geitzenauer, K. and Molfino, B. (1980). Surface Circulation of the Indian Ocean during the Last Glacial Maximum, approximately 18,000 years BP. *Quaternary Research* **14**: 309–336.

Schmidt, P.R. (1989). Early Exploitation and Settlement in the Usambara Mountains In Hamilton, A.C. (ed.) (1989). *Forest Conservation in the East Usambara Mountains, Tanzania*. IUCN, Gland, Switzerland and Cambridge, UK.

Schmidt, R. (1991). Ecology of a tropical lowland rain forest. *Dissertationes Botanicæ* **179**: 1–213.

Servico Meteorologico Nacional (1919–1951). *Anais Meteorologicos das Colonias. Volume V – XXXII – Ano de 1918–1945*. Coimbra and Lisbon: Direção dos servicos diplomaticos geograficos e de marinha/ Direcção tecnica do fomento (Repartição do estudos geograficos)/ Comissão de cartografia.

Sheil, D. (1992). Tanzanian Coastal Forests – unique, threatened, and overlooked. *Oryx* **26**: 107–114.

Spence, J. (1957). The geology of part of the Eastern Province of Tanganyika. *Geological Survey of Tanganyika, Bulletin no. 28*. Government Printer, Dar es Salaam.

Swaine, M.D. (1992). Characteristics of dry forest in West Africa and the influence of fire. *Journal of Vegetation Science* **3**: 365–374.

Swynnerton, C.F.M. (1917). Some factors in the replacement of the ancient East African forest by wooded pasture land. *South African Journal of Science* **14**: 493–518.

Taylor, D.M. (1990). Late Quaternary pollen records from two Ugandan mires: evidence for environmental change in the Rukiga Highlands of southwest Uganda. *Palaeogeography, Palaeoclimatology, Palaeoecology* **800**: 283–300.

Tinley, K.L. (1971). Determinants of coastal conservation: dynamics and diversity of the environment as exemplified by the Moçambique coast. Pp. 126–153. In *Nature Conservation as a Form of Land Use*. SARCCUS Symposium Proceedings, Gorongosa.

Troup, R.S. (1923). Forestry in Kenya Colony. *Empire Forestry Journal* **2**: 46–60.

van Donk, J. (1976). An ^{18}O record of the Atlantic Ocean for the entire Pleistocene. *Memoirs of the Geological Society of America* **145**: 147–64.

Vincens, A. (1991). Quaternary vegetation history of the South-Tanganyika Basin. Climatic implications in South Central Africa. *Palaeogeography, Palaeoclimatology, Palaeoecology* **86**: 207–226.

Walter, H. and Leith, H. (1967). *Klimadiagramm – Weltatlas*. 3rd edition. Gustav Fischer, Jena.

White, F. (1979). The Guineo-Congolian Region and its relationships to other phytochoria. *Bull. Jard. Bot. Nat. Belg./ Bull. Nat. Plantentuin Belg.* **49**: 11–55.

White, F. (1983). *The Vegetation of Africa. A Descriptive Memoir to Accompany the UNESCO/AETFAT/UNSO Vegetation Map of Africa*. UNESCO, Paris.

White, F. (1993). Refuge theory, ice-age aridity and the history of tropical biotas: an essay in plant geography. *Fragmenta Floristica et Geobotanica* **2**: 385–409.

Whitmore, T.C. (1986). *Tropical Rainforests of the Far East*. 2nd edition. Oxford University Press/ELBS, Oxford.

Section 3

Status and vegetation

In this section the current distribution of the Coastal Forests in eastern Africa is summarised. The status of the forests in terms of their legal protection, their area, and their altitudinal variation is analysed. A preliminary description of the highly heterogeneous vegetation is presented. Vegetation species composition and vegetation structure is also analysed from sample plot data from a number of the Coastal Forests. Finally the vegetation of the Coastal Forests is compared with that of the Eastern Arc Mountain forests to illustrate the similarity and differences between these two neighbouring forest vegetation types.

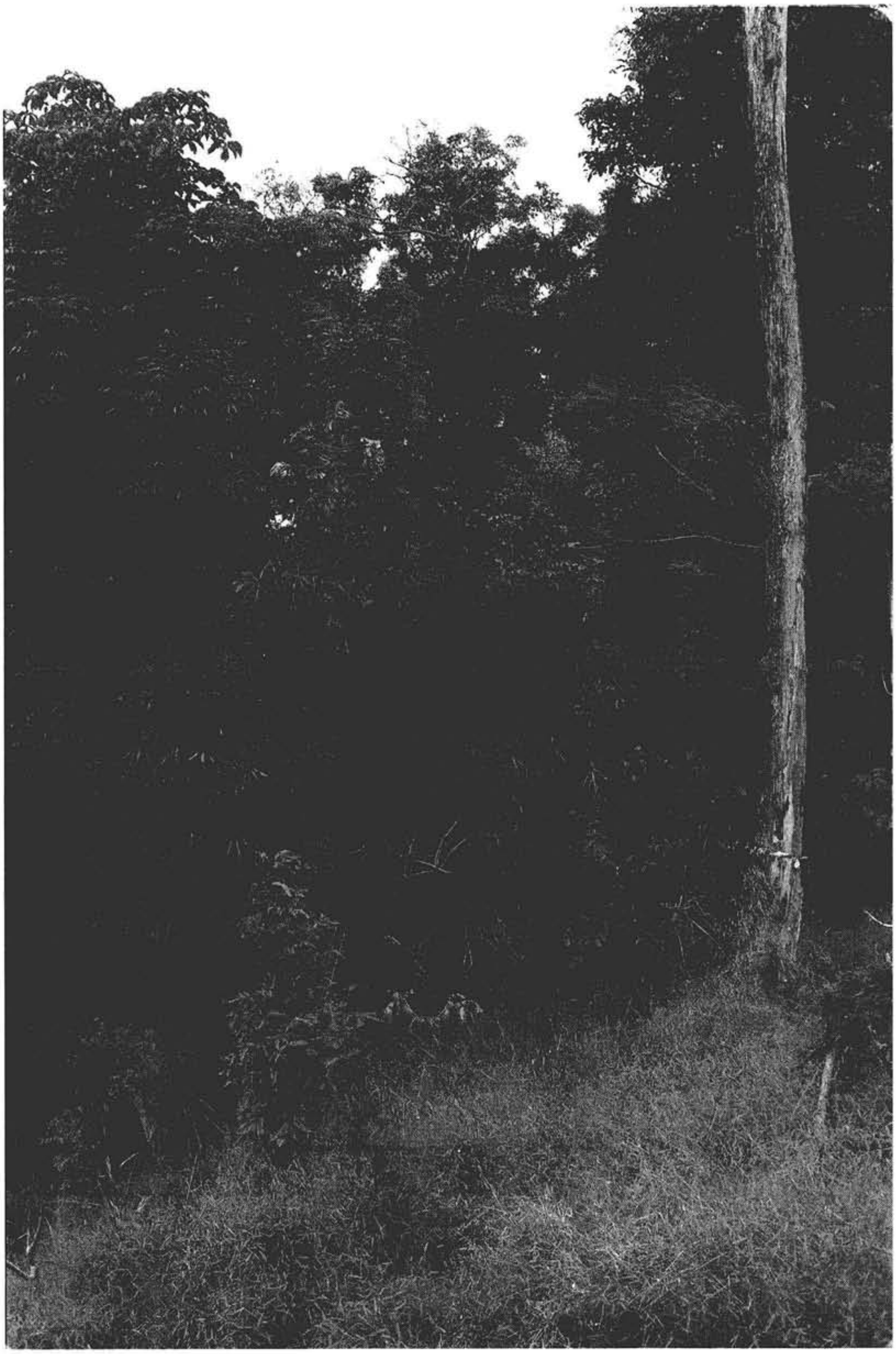


Figure 3 Fire-maintained forest edge in the ungazetted Mlungui forest, Tanzania. Forest boundary is maintained by fires spreading from cultivated areas nearby. The commonly recorded Coastal Forest endemic tree species *Cussonia zimmermannii* is regenerating in disturbed areas of forest in the foreground. (*Photo: G.P. Clarke*)

3.1 Distribution and status

N.D. Burgess, G.P. Clarke, J. Madgwick, S.A. Robertson and A. Dickinson

Introduction

Most previous assessments of the forest cover in eastern Africa have utilised satellite images (Rodgers *et al.*, 1985; Sayer *et al.*, 1992), and the records of the government Forestry Departments (e.g. FAO, 1982). Recent field programmes in the Coastal Forests of Somalia, Kenya, Tanzania, Malawi and Zimbabwe have built on this information by further compiling existing Forestry records, and undertaking programmes of field visits to locations which might possess forest vegetation (Madgwick, 1988; Madgwick *et al.*, 1988; Dowsett-Lemaire, 1990; Robertson and Luke, 1993; Burgess *et al.*, 1992; 1993; Burgess and Muir, 1994; Timberlake, 1994; Clarke, 1995; Clarke and Dickinson, 1995; Clarke and Stubblefield, 1995). One of the aims of these research programmes has been to assess the location and extent of Coastal Forests, and to define their legal status. Information on the forests of Mozambique remains poor due to the civil war which has prevented field work in much of the country for up to 30 years, and is largely based on older information (e.g. Tinley *et al.*, 1974), maps produced from satellite photographs (Mapa Florestal, 1980), plus a few field visits.

Extent of Coastal Forest

Recent collations of existing information on the Coastal Forests throughout their eastern African range (Burgess and Muir, 1994; Clarke, 1995; Clarke and Dickinson, 1995; Clarke and Stubblefield, 1995) shows approximately 3170km^2 of forest in six countries (Table 3.1.1).

Table 3.1.1 Numbers[1] and areas[2] of Coastal Forests in different size classes in eastern African countries (based on 194 forests with area data from total of 224 known forests) (from data in Appendix 1).

Size class (km^2)	Somalia		Kenya		Tanzania		Mozambique		Malawi		Zimbabwe		Totals	
	n	km^2	n	km^2	n	km^2	n	km^2	n	km^2	n	km^2	n	km^2
0–1	0	0	58	12.5	7	2.3	0	0	0	0	5	1.18	70	15.9
1–5	2	2	24	37.5	18	45.9	2	3	2	6	1	1.7	49	92.8
5–15	0	0	11	93	24	211.7	5	37	1	10	0	0	41	351.7
15–50	0	0	4	86	17	440	0	0	0	0	0	0	21	526
50+	0	0	2	431	0	0	11	1750	0	0	0	0	13	2181
Total	**2**	**2**	**99**	**660**	**66**	**699.9**	**18**	**1790**	**3**	**16**	**6**	**2.88**	**194**	**3170.8**

***Notes*:**

[1] Only sites with area data have been included. There are 32 additional forests for which there is no area data, or the data are regarded as too unreliable to be included (see note 2).

[2] A few Kenyan sites given a very large forest area in Robertson and Luke (1993) have been omitted because of uncertainty about their vegetation composition. These are Boni National Reserve, North Kilifi *Brachystegia* woodlands, Dodori National Reserve, Boni proposed Forest Reserve, Wayu I, II, III and Kokani forests, Ras Tenewi and Lunghi proposed Forest Reserve. These are given a total area of 2382 km^2 (Robertson and Luke, 1993). Ruvu South in Tanzania has also been reduced in area from 98 to 20km^2 of forest as much of it is best regarded as thicket. Eleven forests in Mozambique are given an area of at least 100km^2 by the Mozambique Forest Department (total area = 1750km^2). These are retained at their stated area until they have been visited.

Sources: Data from Tanzania and Mozambique are from Burgess and Muir (1994), for Somalia from Madgwick *et al.* (1988) and Clarke (pers. comm.), and for Zimbabwe and Malawi from Müller (1991), Timberlake (1994), Dowsett-Lemaire (1990) and Broadley (*in lit.*). The figure for Kenya quoted here is based on an assessment of the data in Robertson and Luke (1993), and for Mozambique on data provided by the Mozambique Forest Department.

However, 1790km^2 of this is in Mozambique and very poorly known, thus the minimum area of this forest type is just 1380km^2. The total area of eastern African Coastal Forest is probably the smallest of any major forest type in Africa, and it is also highly fragmented (Table 3.1.1).

Numbers of sites

The number of forests recorded in different countries to some extent reflects the degree of detailed study by the programmes which have collected the data. In Kenya even the tiniest patches have been recorded (Robertson, 1987; Robertson and Luke, 1993). In Tanzania most of the data are from the Frontier-Tanzania Coastal Forest Research Programme, which specifically collected data on forests over 2km^2 in area and ignored most of the many small forest patches. In Mozambique, data are from Forestry Division records which suggest that only a few sites exist, but that they are all large.

Areas of sites

Forests in the size-classes 15–50km^2 and 50+km^2 comprise the majority of the remaining forest resource (Table 3.1.1). However, this finding may be somewhat biased as most of the smallest Coastal Forests in Tanzania and Mozambique have not been recorded, and 11 sites which have been given an area of 100km^2 or more by the Mozambique Forest Department require further survey work to confirm these estimates. The largest Coastal Forest with a confirmed size is the 370km^2 Arabuko-Sokoke forest in Kenya. All other Coastal Forests where the area is confirmed are less than 100km^2, and only 19 sites are greater than 30km^2 (including those in Mozambique). The full list of sites is presented in Appendix 1.

Geographical and altitudinal distribution of Coastal Forest

Coastal Forests in Kenya and northern Tanzania are located close to the Indian Ocean, but forests are found further inland in Central Tanzania (Figures 3.1.1 and 3.1.2). This distribution is climatically controlled, with Kenya having very dry conditions inland of the coast, but the belt of land which can potentially support Coastal Forest is much broader to the southwest (Chapter 2.3). In southern Mozambique this belt stretches as far as the eastern margins of Malawi and Zimbabwe, where there are outliers of Coastal Forest at the bases of mountain areas (see Chapter 1.2).

Most Coastal Forest sites are isolated from each other. Isolation can vary from less than 1km, to several tens of kilometres and the vegetation between the forests is a mixture of farmland, savannah-woodland and thicket. Only a few Coastal Forests, at the base of the Eastern Arc Mountains of Tanzania and those in Malawi and Zimbabwe, have close proximity to another (sub-montane) forest type, and in some cases the forest is continuous.

Table 3.1.2 Numbers of Coastal Forests[1] in different altitudinal bands[2] in eastern African countries (n=192 forests with altitude data from total of 224 known forests) (from data in Appendix 1).

Altitude categories	Somalia	Kenya	Tanzania	Mozambique	Malawi	Zimbabwe	Total
0–50m	2	49	15	4	0	0	70
50–100m	0	26	10	1	0	0	37
100–200m	0	33	24	3	0	0	60
200–300m	0	17	18	1	0	0	36
300–500m	0	11	21	2	0	3	37
500–1000m	0	5	21	1	3	2	32

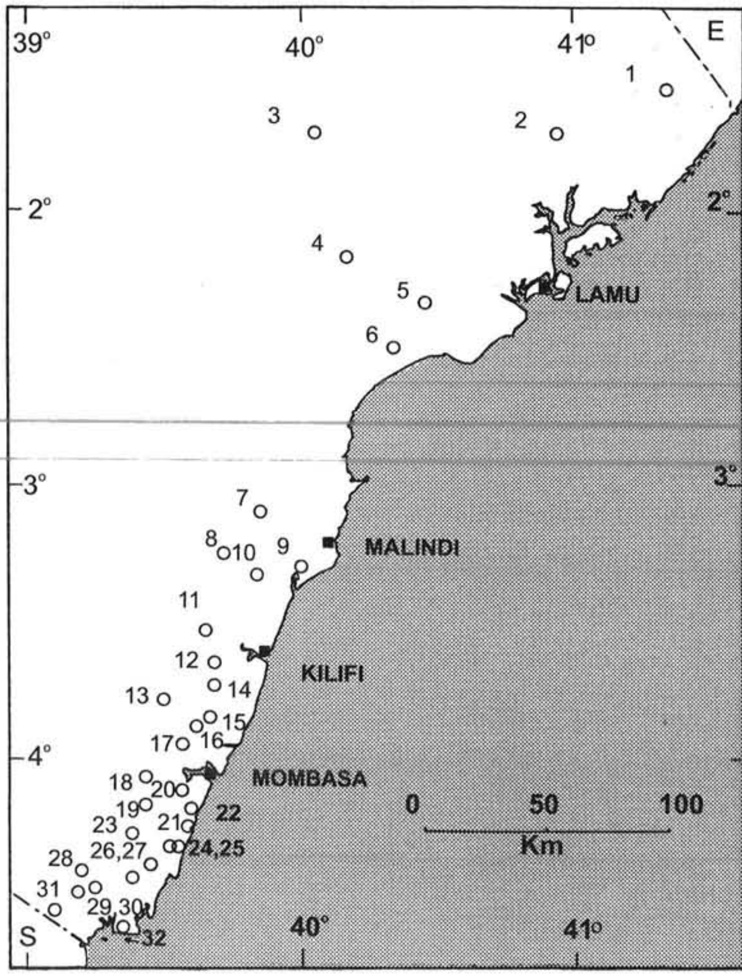
***Notes*:**

[1] Not all forests have altitude data; those that do not have been omited from this table.

[2] Many forests cover a range of altitudes. For each forest site, forest is scored in every altitude category within which it occurs.

Figure 3.1.1 Position of main Coastal Forest sites in Kenya

Key: **1. Boni, 2. Dodoni, 3. Tana River Primate, 4. Lower Tana, 5. Witu, 6. Tana Delta, 7. Kaya Singwaya, 8. Mangea Hill, 9. Gede, 10. Arabuko-Sokoke, 11. Kambe Sacred Rocks, 12. Kaya Starehe, 13. Kaya Fungo, 14. Cha Simba, 15. Pangani Rocks, 16. Kaya Ribe, 17. Kaya Rabai, 18. Mkongani, 19. Kaya Jibana/Kwale, 20. Kaya Bombo, 21. Kaya Tiwi, 22. Kaya Waa, 23. Shimba Hills, 24. Kaya Kambe (Nuhaka), 25. Diani (Jadini), 26. Mafisini, 27. Gongoni, 28. Jombo Hill, 29. Kaya Dzombo, 30. Mrima Hill, 31. Gonja, 32. Shimoni.**



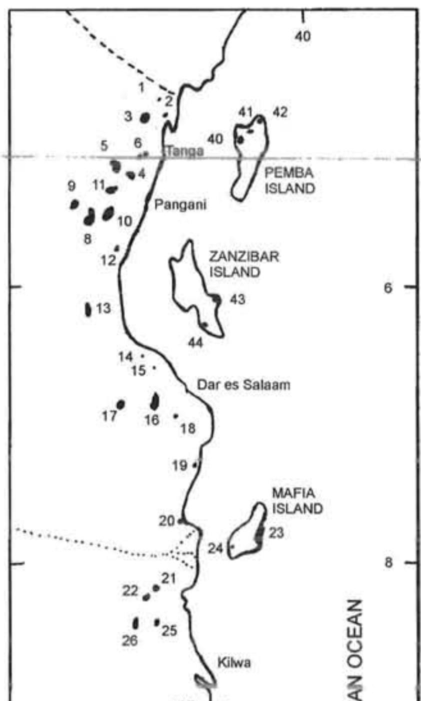


Figure 3.1.2 Distribution of main Coastal Forests in Tanga, Coast and Lindi Regions of Tanzania.

Key: **1. Horohoro, 2. Kilulu Hill, 3. Lowland Usambaras, 4. Tongwe, 5. Kwani/Makinyumbi, 6. Mkulumuzi Gorge (Amboni caves), 7. Yambe Island, 8. Gengagenda North and South, 9. Mgambo, 10. Msubugwe, 11. Pangani River, 12. Mkwaja, 13. Kiono/Zaraninge, 14. Ruvu North, 15. Pande, 16. Pugu/Kazimzumbwi, 17. Ruvu South, 18. Vikindu, 19. Kisiju, 20. Mchungu, 21. Namakutwa/Nyamuete, 22. Kiwengoma, 23. Mafia eastern Seaboard (inc. Mrora), 24. Kilindoni, 25. Tong'omba, 26. Mbinga, 27. Mitundembea, 28. Rungo, 29. Ngarama North and South, 30. Pindiro, 31. Rondo, 32. Litipo, 33. Chitoa, 34. Nyangamara, 35. Ndimba, 36. Ruawa, 37. Matapwa, 38. Chilangala, 39. Mahuta, 40. Ngezi, 41. Msitu Mkuu, 42. Ras Kiuyu, 43. Jozani, 44. Muyani.**

Legal status of Coastal Forest

The legal status of the Coastal Forests has been assessed to determine the degree to which they are currently protected (Table 3.1.3).

Table 3.1.3 Legal status of the Coastal Forests of Kenya and Tanzania (n = 171 forests with legal status data from total of 194 known forests in Kenya and Tanzania) (from data in Appendix 1).

Categories of status*	Kenya		Tanzania	
	number	area (km^2)	number	area (km^2)
National Park	1	6	1	2
National Reserve	2	74	–	–
National Monument	21	6	–	–
Game Reserve	0	0	2	10+
Forest Reserve	14	469	41	532
Sacred forest	23	13	–	–
Private land	35	95	3	13
No known status	0	0	21	145
Totals	**95**	**684 ****	**66**	**702 ****

Notes:

* These status categories are arranged in descending order of protection and are briefly explained below.

** These areas are somewhat higher than in Table 3.1.1 because some sites have more than one status, e.g. a small National Park within the Arabuko-Sokoke Forest Reserve in Kenya.

National Park. Managed by the Wildlife Sector of government, principally for the conservation of large mammal species. This level of reservation provides any forest within it with good protection.

National Reserve. Kenya only; sites managed by the Wildlife Sector of government, principally for the conservation of large mammal species. The level of forest protection is generally high in these reserves.

National Monument. Kenya only; sites managed by the National Museums of Kenya, principally for their historical importance. The level of forest protection is variable.

Game Reserve. Tanzania only. Sites managed by the Wildlife Department, principally for large mammals.

Forest Reserve. Sites managed by the Forestry Divisions of government. Sites are split into 'protection reserves' where no extraction is legally allowed, and 'production reserves' where extraction is allowed on a 'licence' basis. The level of forest protection is variable, but in both protection and production reserves is generally weak, with considerable forest exploitation being undertaken in both sub-categories of Forest Reserve status, often illegally and in an uncontrolled way.

Sacred forest. Protection is from the local population and depends on the authority of the 'elders', but can be very strong.

Private land. Includes both private and government-owned ranches and estates. Forests in such areas can have high protection to no protection depending on the individual owners.

No official status. Forest is generally unprotected here.

– Categories not present in Tanzania.

Coastal Forest is most commonly located in 0–50m and 300–500m altitude bands (Table 3.1.2). However, there are some sites with Coastal Forest at more than double this upper limit, and here the forest starts to become transitional with sub-montane forest types (e.g. Dowsett-Lemaire, 1990; Chapter 1.2). Isolated Tanzanian sites with Coastal Forest at higher than average altitude are Handeni Hill (up to 1040m), Tongwe (up to 648m), Kiwengoma on the Matumbi Hills (up to 750m), and the Rondo Plateau (up to 885m).

Most Coastal Forest (80.3% in Kenya and 82.3% in Tanzania) is under some form of government protection. However, only small areas (*c.*10km^2 or 0.26% of the total area of Coastal Forest) are found in the National Parks of Kenya, Tanzania, Malawi and Zimbabwe. The largest National Park area, some 6.2km^2, is within the 416km^2 Arabuko-Sokoke Forest Reserve in Kenya. In Kenya there is also

63km^2 of Coastal Forest in the Shimba Hills National Reserve (2.1% total area), 11km^2 in Tana River National Primate Reserve, and unknown areas in Boni and Dodori National Reserves. A small area of forest is also found in Game Reserves, such as Pande (10km^2) and the Selous (forest area unknown) in Tanzania.

A much greater proportion of the Coastal Forest is found in Forest Reserves (e.g. 68% in Kenya and 82% in Tanzania), which are managed by the national Forestry Departments in these countries (see Chapter 5.2 for further discussion). Approximately 70 Coastal Forests are also protected as religious areas by local populations, principally the Kaya forests of Kenya (Robertson, 1987; Robertson and Luke, 1993) and northernmost Tanzania (Clarke, in press). These areas are generally extremely small (typically less than 0.5km^2), and less than 20km^2 is protected in this way.

About 130km^2 of Coastal Forest is also found on private or government estates and ranches. Some estate owners are known to be sympathetic towards forest conservation, e.g. Mkwaja Ranch in Tanzania (which is now sold and is to become a Game Reserve), and in such locations the forests were well-protected. However, other estates (e.g. sisal estates at the base of the East Usambaras and at Vipingo in Kenya) have in the past removed very considerable areas of forest (perhaps hundreds of square kilometres) to plant their crops.

Other forest areas, totalling some 114km^2, have no formal status. Some of these, e.g. Ras Tenewi, Tana Delta, North Kilifi *Brachystegia* woodland, Mangea Hill and Kilibasi Hill in Kenya and Kiono/Zaraninge, Kisiju, Kiwengoma in Tanzania are proposed for gazettement as Forest Reserves (see Table 3.1.4). For some of these sites the process of gazettement has proceeded to some extent already. For example, forest sites at Zaraninge/Kiono and Kiwengoma in Tanzania are regarded by the local population and authorities as Forest Reserves, but the process was either never completed during colonial times (Kiono), or the reserves were degazetted (Kiwengoma).

Focus on Somalia

Little forest remains in Somalia. The forest which used to exist along the main rivers (particularly the Jubba river) has been mostly cleared for settled agriculture, and the other forests were always small in extent.

Extent of forest resource

In the past, the best lowland forest in Somalia extended along two rivers, the Jubba (the only perennial river) and the Shabeelle. At one time forest extended for most of the length of these rivers. Virtually all the forest has been cleared from the Shabeelle floodplain, with only a small, degraded, fragment remaining at the Balcad Reserve near Mogadishu.

For the Jubba valley the recent loss of riverine forest has been quantified by comparing aerial photographs from three different dates (Deshmukh, 1987; Madgwick *et al.*, 1988). From 1960 to 1987 forest was reduced in area from 93.5km^2 to 9.0km^2. Most of what remained in 1986 was fragmented and sizeable areas of riverine forest only existed in the Middle Jubba between Fanoole and Bu'aale. Even in this area, over 8.5km^2 of forest was cleared between 1983/4 and 1987, a loss of 63% in less than four years. The impact of the recent civil war on these forests is poorly known, but aerial surveys of the area in 1994 have shown that at least some (perhaps 2km^2) forest remains (J. Bauer, pers. comm.).

Moomaw (1960) and LRDC (1985) also refer to the Holowajir and Boni reserves in the Bushbush area as supporting forest, principally along seasonal watercourses.

Legal status of forest resource

The riverine forest along the Jubba and Shabeelle rivers was unprotected in 1986; this has not changed. In 1986 the remaining forests were heavily disturbed and logged for timber (Madgwick *et al.*,1988). A number of species, such as *Diospyros cornii*, had already been 'logged out' in comparison with the records of Luchini (1948). In 1986 there was no control over human activities in the forests and no mechanism or funds for their management. The situation has not improved since then.

These forests have long been recognised as prime candidates for increased protection in legal reserves (Funaioli and Simonetta, 1966; Abel and Kille, 1975; Simonetta and Simonetta, 1983; Deshmukh, 1987; Douthwaite, 1987; Madgwick *et al.*, 1988). When the civil war ends any Coastal Forests which remain in these areas should immediately be given greater levels of protection if they are to survive.

Focus on Kenya

The Coastal Forests of Kenya have recently been studied in detail by the Coast Forest Survey of the National Museums of Kenya (Robertson and Luke, 1993), and some additional information is summarised by Wass (1995).

Extent of forest resources

Coastal Kenya is presently divided into the Districts of Lamu, Lower Tana River, Mombasa (urban), Kilifi, Malindi and Kwale. Coastal Forests are found all along the coast, although they are most frequent in Kwale to the south. The Coast Forest Survey (see Robertson and Luke, 1993) visited all Coastal Forests to the south of the Tana river, mapped the area of woody vegetation and compiled lists of the plants at each site. The total area of closed Coastal Forest in Kenya is, however, difficult to assess accurately, as a broad definition for forest was used by Robertson and Luke (1993). We have calculated the total closed forest area in Kenya as *c.*660km^2. Much of this forest is degraded and some is being cleared for farmland or building sites.

Legal status of forest resources

Legally gazetted Coastal Forests in Kenya were mostly declared in the 1930s through to the early 1960s, with only two gazetted in the 1970s, none in the 1980s and one in the 1990s (so far). Eight sites containing Coastal Forest are currently proposed for gazettement as protected areas (Table 3.1.4).

Table 3.1.4 Proposed protected areas of forest in coastal Kenya (from Robertson and Luke, 1993).

District	Name	Proposed reserve area (km^2)	Area of forest (km^2)
Lamu	Boni proposed FR	184	?100
	Lunghi proposed FR	95	?80
Lamu/Tana River	Ras Tenewi Coastal Zone National Reserve	105	20+
Tana River	Wayu I–III, Kokani	?1120	?100
Tana River	Tana Delta National Wetlands Reserve	3400	20
Malindi	North Kilifi *Brachystegia* Woodlands FR	500	–
	Mangea Hill FR	35	35
Kwale	Kilibasi Hill FR or National Reserve	4	4

There are 68 small Coastal Forest sites which are mainly 'Kaya' sites of religious significance to the local people (see Robertson, 1987). The decline of the traditional religions and the authority of traditional rulers has resulted in encroachment into many of these sites. Some Kayas are found within existing protected areas and others (see Appendix 1) were gazetted as National Monuments in 1992, in recognition of their cultural significance. Further protection of these sites has also been advocated (Robertson and Luke, 1993).

Focus on Tanzania

Over the past few years the distribution and status of Coastal Forests in Tanzania has become much better known (see Iversen, 1991; Burgess *et al.,* 1992; 1993; Lovett and Pócs, 1993; East Usambara Catchment Forestry Project, 1994; Eriksen *et al.*, 1994; Clarke, 1995; Clarke and Dickinson, 1995; Clarke and Stubblefield, 1995).

Extent of forest resources

Before the influence of man, Coastal Forest covered large areas of coastal Tanzania (see Chapter 5.1). Even as recently as the 1950s there were large areas of lowland forest inland of Tanga, which were cleared for the planting of sisal in estates (see Hamilton and Bensted-Smith, 1989). At least three former Forest Reserves (Gombero, Steinbruch and Bassi) around Tanga have been degazetted as they have been cleared of forest vegetation. Forest on and around the Pugu Hills near Dar es Salaam was also previously more extensive, and has been cleared for agriculture by an expanding human population. Several reserves in Kisarawe District near Dar es Salaam have been degazetted due to these pressures; Kiregese (1962), Kisarawe (1966), Mogo (1966), Mpiji Valley (1963), Mkonore (1963) and Tongoro (1963). These were all small (less than $10km^2$) production reserves containing Coastal Forest. Other areas which supported larger forests in the past were the lowlands of the Matumbi Hills, Rondo Plateau area and Makonde Plateau area. Farming and logging have been the major causes of forest contraction in these areas.

Currently there is at least $700km^2$ of Coastal Forest in Tanzania (Appendix 1). The forests are found throughout the coastal strip inland to the base of the Eastern Arc Mountains.

Legal status of forest resource

The status of Coastal Forests in Tanzania has been compiled from various sources (Burgess and Muir, 1994; Clarke, 1995; Clarke and Dickinson, 1995; Clarke and Stubblefield, 1995; Forestry Division in Dar es Salaam). Most Coastal Forests are in Forest Reserves gazetted during the Colonial period (pre-1961) (Chapter 5.2). The total land area of these reserves is much greater than the area of forest because much of the land is not forest covered, but is woodland or thicket, and this buffer zone has often helped prevent the degradation of the forest areas.

A number of sites are currently unprotected; some have been degazetted in the past and others have never been officially gazetted even though the process for several sites was initiated in the late 1960s or 1970s. There are plans to gazette most remaining sites without status into Forest Reserves (see Chapter 5.2).

Focus on Mozambique

Mozambique has the longest coastline (2400km) of any of the countries supporting Coastal Forest, and contains approximately half of the Swahilian region *sensu lato*. The possible location of Coastal Forests in Mozambique may, however, be somewhat more constrained than this: although White (1983) placed the southern limit of his Zanzibar-Inhambane regional mosaic [Swahilian region *sensu lato*] approximately half-way between Maputo and Inharrime, Coastal Forests are not found quite as far south, and may not occur south of Inhambane.

Extent of Coastal Forest

Sim (1909) estimated Mozambique to contain 'many thousands of square miles of forest'. However, his estimate is largely based on the reports of others and not on first hand experience, hence it is conceivable that the forest referred to might have been dense woodland, or thicket. Gomes e Sousa (1951) also considered that the majority of the country was once thickly forested ['covered by vast and luxuriant groves'].

We have examined old maps which identify areas that were possibly formerly forested. The old maps show forest on the coast to the immediate north of Beira (Companhia de Moçambique, 1921), and on the coast to the south of the Rovuma River mouth (Admiralty, 1874). Dense forest has also been previously described on the Inhaminga Hills by Pardy and Dorrbecker (1891).

It is difficult to estimate how much forest has been destroyed over the last 100 years as both the current and former forest extent are so poorly known (Stuart *et al.*, 1990). Forestry Division records in Maputo and vegetation maps produced from satellite photographs from the 1970s (Mapa Florestal, 1980) both suggest that there may still be considerable areas of Coastal Forest in Mozambique, but the prolonged civil war in the country has prevented an accurate assessment of many of these areas. Potential areas of forest and thicket in coastal provinces of Mozambique have been compiled from locations marked as 'forest' and 'thicket' on the Mapa Florestal (1980) (Table 3.1.5).

Table 3.1.5 Maximum potential areas of forest and thicket areas in coastal provinces of Mozambique (from Mapa Florestal, 1980 and Saket, 1994).

Province	Potential area of forest (km^2)	Potential area of thicket (km^2)	Potentially important sites
Cabo Delgado	142.5	18,038	Western Macondes Plateau
Nampula	102.5	14,933	Inselbergs south of Lurio river Malema and base of Ilemas Mountains
Zambezia	150	23,012	Murrumbala, Maema, Chiperone and Namuli Mountains Zambezi Delta
Manica	No data	No data	Chimanimani Mountains Mt. Gorogosa
Sofala	3962.5	5187.5	Inhaminga Hills (which include the Inhamitanda and Dondo forests) Ancient dunes at Cheringoma and Marromeu
Inhambane	225	7362.5	Ancient dunes between Inhambane and the Sabi (Save) River
Gaza	No data	No data	Banhine National Park
Potential total areas (Excluding Provincia de Manica)	High Forest [*Floresta alta*] Thicket [*Floresta baixa*]		= 4583km^2 = 68,533km^2

These data give a potential area of forest in coastal provinces of Mozambique of 4583km^2. Discussions in 1993 with P. Duarte-Mangue of the Mozambique Forestry Division allowed a further appraisal of these data, and the extent of Coastal Forest in Mozambique is currently estimated as 1790km^2 (Burgess and Muir, 1994). We believe that this estimate must still be too high, but a programme of ground survey is required to assess this, and the large number of land-mines in Mozambique makes this problematic in many regions.

Given the problems caused by the civil war in Mozambique (Sill, 1992), which led to a concentration of people in the Coastal Zone (estimated to have been 75 inhabitants per square kilometre), the recent/current pressure on natural resources is likely to be intense. Deforestation has already been identified as a problem (Sill, 1992; Dutton, *in lit.*). The return to stability and peace in Mozambique provides an opportunity for potential Coastal Forest areas to be visited, studied and perhaps given greater levels of protection, but it has also opened up areas for logging.

Focus on Malawi

Most of the evergreen forest in Malawi is montane to sub-montane, but there are three small remnant areas of Coastal Forest (Dowsett-Lemaire, 1990). One consists of two small Forest Reserves and various smaller patches near Nkhata Bay. The second consists of the Ruo Gorge Forest and other small patches surviving in the tea estates at the southern foot of the Mulanji Mountain. The third patch is on the Malawi Hills in the extreme south of the country. The total area of these forests is only 16km^2 (Burgess and Muir, 1994).

Focus on Zimbabwe

A small amount (3km^2) of Coastal Forest is found in two sites in eastern Zimbabwe at altitudes of 350–780 metres.

In the Lower Pungwe valley, Nyanga District, nearly all the forest has been cleared for tea estates and cultivation by communal farmers. The largest surviving patches of forest are Rumbise Hill Forest (0.147km^2), Pungwe Bridge Forest (0.0875km^2) and a riparian strip along the Chitema river just inside the Nyanga National Park (Timberlake, 1994). There are also extensive areas of high to medium altitude forest on the eastern face of Nyangani Mountain, but these are considered to be Afromontane rather than Coastal Forest.

At an altitude of 300–350 metres in the Haroni-Rusitu area of Chimanimani District there was originally an area of 30–40km^2 of Coastal Forest, which included some *Milicia excelsa* (Müller, 1991). The surviving forest patches are located in the Rusitu and Haroni Botanic Reserves (0.8km^2 and 0.04km^2 respectively) and the Makurupini Forest in the Chimanimani National Park (1.70km^2). This last area is the largest Coastal Forest surviving in Zimbabwe (Timberlake, 1994).

Acknowledgements

We thank the staff of the Map Room of the Royal Geographical Society for their help in retrieving maps of Mozambique, and to the Library staff at the Herbarium of the Royal Botanic Gardens, Kew for providing literature references on Mozambique. Thanks to Tom Müller of the Botanical Gardens of Harare and Jonathan Timberlake for providing information on the Coastal Forests of Zimbabwe, and Don Broadley for information on Malawi.

Comments on the chapter were received from Don Broadley of the Natural History Museum of Zimbabwe, Alan Rodgers of the FAO/GEF East African Biodiversity Conservation Project in Tanzania and Julian Bayliss of the Frontier-Tanzania East Usambara Lowland Forests project in Tanzania.

References

Abel, N.O.J. and Kille, M.E. (1975). *Conservation and Exploitation of the Wildlife of South-eastern Somalia.* FAO Field document No. 5.UNDP, Mogadishu.

Admiralty (1874). *Africa – East Coast – Cape Delgado to Mikindani Bay.* Admiralty, London.

Burgess, N.D., Mwasumbi, L.B., Hawthorne, W.D., Dickinson, A. and Doggett, R.A. (1992). Preliminary assessment of the status, distribution and biological importance of the Coastal Forests of Tanzania. *Biological Conservation* **62**: 205–218.

Burgess, N.D., Dickinson, A. and Payne, N.P. (1993). Tanzanian Coastal Forests – new information on status and biological importance. *Oryx* **27**: 169–173.

Burgess, N.D. and Muir, C. (eds.) (1994). *The Coastal Forests of Eastern Africa: biodiversity and conservation.* Society for Environmental Exploration, London and University of Dar es Salaam, Dar es Salaam.

Clarke, G.P. (1995). *Status Reports for 6 Coastal Forests in Lindi Region, Tanzania.* Frontier-Tanzania Technical Report No.18. The Society for Environmental Exploration, London, and the University of Dar es Salaam, Dar es Salaam.

Clarke, G.P. and Dickinson, A. (1995). *Status Reports for 11 Coastal Forests in Coast Region, Tanzania.* Frontier-Tanzania Technical Report No.16. The Society for Environmental Exploration, UK and the University of Dar es Salaam, Dar es Salaam.

Clarke, G.P. and Stubblefield, L.K. (1995). *Status Reports for 7 Coastal Forests in Tanga Region, Tanzania.* Frontier-Tanzania Technical Report No.17. The Society for Environmental Exploration, UK and the University of Dar es Salaam, Dar es Salaam.

Clarke, G.P. (in press). Digo Kayas in Tanzania. *Azania.*

Companhia de Moçambique. Reparticao de Agrimensura. (1921). *Levantamento da costa do Territorio desde a Beira ate ao Rio Milambe.* 1:100,000.

Deshmukh, I. (1987). *Terrestrial Baseline Studies (TEBS) of Jubba Environmental and Socio-economic Studies (JESS).* Associates in Rural Development, Vermont.

Douthwaite, R.J. (1987). Lowland forest resources and their conservation in southern Somalia. *Environmental Conservation* **14:** 29–35.

Dowsett-Lemaire, F. (1990). The flora and phytogeography of the evergreen forests of Malawi. II. Lowland Forests. *Bull. Jardin Botanique Nat. Belgique* **60**: 9–71.

East Usambara Catchment Forestry Project (1994). *Phase 2: 1995–1998. Main Document.* Tanga Catchment Forestry, Tanga.

Eriksen, T., Halberg, K., Lehmberg, T. and Petersen, F.S. (1994). *A Survey of Bird Life in Five Coastal Forests of South-eastern Tanzania, 1993 – with Notes on Vegetation and the Occurrence of Mammals and Butterflies.* BirdLife Denmark and Department of Population Biology, Copenhagen.

FAO (1982). *Tropical Forest Resources: Africa.* Forest Resources Division, FAO, Rome.

Funaioli, U. and Simonetta, A.M. (1966). The mammalian fauna of the Somali Republic. Status and conservation problems. *Monitore Zoologico Italiano* **74**: 285–347.

Gomes e Sousa, A.F. (1951). *Dendrology of Mozambique, vol. 1 Some Commercial Timbers.* English translation of (1950). *Dendrologia de Moçambique* [vol. 1]. Algumas Madeiras Comercais.

Hamilton, A.C. and Bensted-Smith, R. (eds.) (1989). *Forest Conservation in the East Usambara Mountains, Tanzania.* Forest Division, Ministry of Lands, Natural Resources and Tourism – United Republic of Tanzania. IUCN, Gland, Switzerland and Cambridge, UK.

Iversen, S.T. (1991). *The Usambara Mountains, N.E. Tanzania, Vegetation and Conservation.* Uppsala University, Uppsala.

LRDC (1985). *Land Use in Tsetse Affected areas of Southern Somalia.* C.R.C. Hendy (ed.). Prepared for the N.T.T.C.P. by the Land Resources Development Centre, Tolworth Tower, Tolworth, Surbiton, UK.

Lovett, J.C. and Pócs, T. (1992). *Assessment of the Condition of the Catchment Forest Reserves, a Botanical Appraisal.* Dar es Salaam: Catchment Forestry Report no. 3. Ministry of Tourism, Natural Resources and Environment, Dar es Salaam.

Luchini, R. (1948). Legami Utilizzabili della Somalia Italiana. *Rivista di Agricultura Subtropicale e Tropicale* **42**: 55–60.

Madgwick, F.J. (1988). Riverine forest in the Jubba Valley: vegetation analysis and comments on forest conservation. In *The Biogeography of Somalia, Biogeographia* **14**: 67–88.

Madgwick, F.J., Wood, B., Varty, N. and Maunder, M. (1988). *Somalia Research Project Report – an Ecological Study of the Remaining Areas of Riverine Forest in the Jubba Valley, Southern Somalia.* University College London, London.

Mapa Florestal. (1980). *Provincia de Cabo Delgado, Nampula, Zambezia, Beira, Inhambane, Gaza and Maputo.* Projecto UNDP-FAO. Ministerio da Agricultura do Florestal e de Fauna Bravia. Maputo.

McKinnon, J., Child, G. and Thorsell, J.W. (1986). *Managing Protected Areas in the Tropics.* IUCN, Gland, Switzerland and Cambridge, UK.

Moomaw, J.C. (1960). *A Study of the Plant Ecology of the Coast Region of Kenya Colony, East Africa.* Government Printer, Nairobi.

Müller, T. (1991). *The Rainforests of Zimbabwe.* National Herbarium, Harare.

Pardy, J.R. and Dorrbecker, P.A. (1891). *Authentic Map of Beira Harbour and Surrounding Country.* Approx. 1:25,000. (Copy in Royal Geographical Society Library, London).

Robertson, S.A. (1987). 'Preliminary Floristic Survey of Kaya Forests in Coastal Kenya'. Unpublished internal report. National Museums of Kenya, Nairobi.

Robertson, S.A. and Luke, W.R.Q. (1993). *Kenya Coastal Forests: the report of the NMK/WWF Coast Forest Survey.* National Museums of Kenya, Nairobi.

Rodgers, W.A., Mizray, W. and Shishra, E.K. (1985). The extent of forest cover in Tanzania using satellite imagery. *University of Dar es Salaam Institute of Resource Assessment Research Paper* **12**: 1–15.

Saket, M. (1994). *Report on the Updating of the Exploratory National Forest Inventory.* Ministry of Agriculture, Directorate of Forests and Wildlife, Maputo.

Sayer, J.A., Harcourt, C.S. and Collins, N.M. (1992). *The Conservation Atlas of Tropical Forests: Africa.* WCMC/IUCN, Cambridge.

Sill, M. (1992). A geography of war. *Geographical Magazine* **LXIV**: 45–50.

Sim, T.R. (1909). *Forest Flora and Forest Resources of Portuguese East Africa.* Taylor and Henderson, the Adelphi Press, Aberdeen.

Simonetta, A. M. and Simonetta, J. (1983). An outline of the status of the Somali fauna and of its conservation and management problems. *Rivista di Agricultura Subtropicale e Tropicale* **77**: 457–483.

Stuart, S.N., Adams, R.J. and Jenkins, M.D. (1990). *Biodiversity in Sub-Saharan Africa and its Islands.* Occasional Papers of the IUCN Species Survival Commission No. 6. IUCN, Gland, Switzerland and Cambridge, UK.

Timberlake, J. (1994). Changes in the extent of moist forest patches in the Eastern Highlands: case studies based on aerial photographs. *Zimbabwe Forestry Commission Research Paper* **7**: 1–15.

Tinley, K.L., Rosinha, A.J., Lobão-Tello, J.L.P. and Dutton, T.P. (1974). Wildlife and wild places in Mozambique. *Oryx* **XIII**: 344–350.

Wass, P. (ed.). (1995). *Kenya's Indigenous Forests: Status, Management and Conservation.* IUCN, Gland, Switzerland and The Overseas Development Administration, London, UK.

White, F. (1983). *The Vegetation of Africa.* UNESCO, Paris.

3.2 Vegetation communities

G.P. Clarke and S.A. Robertson with illustrations by L.L. Sørensen

Introduction

The Coastal Forests consist of highly heterogeneous and diverse assemblages of forest types which have hitherto eluded a comprehensive description, even at the broadest level. Previous attempts to classify the bewildering variety of vegetation communities which occur in these forests (e.g. Dale, 1939; Edwards, 1940; Burtt, 1942; Moomaw, 1960; Wild and Grandvaux Barbosa, 1967; Greenway, 1973; Moll and White, 1978; Hawthorne 1993) have tended to suffer from presenting a rather detailed and synoptic vegetation synthesis from the (usually small) area under study, which in all cases has failed to be applicable to all Coastal Forests throughout the eastern African coastal zone. White (1983, p.187) recognised the difficulty of separating this variety of different vegetation types, and chose instead to include most of that variation under the broad classification of 'undifferentiated forest' within his Zanzibar-Inhambane regional mosaic [= Swahilian region *sensu lato*, cf. Chapter 1.2].

Although we recognise that variations in Coastal Forest vegetation are continuous in both time (due to succession) and space (across altitudinal, latitudinal and ecotonal gradients), we nonetheless believe that a number of recognisable vegetation community 'noda' (*sensu* Hawthorne, 1993 *cit.* Poore, 1962) do reoccur within the Coastal Forests. We present here a brief description of the most important of these noda, combining our own field experience with published vegetation descriptions.

Existing descriptions of Coastal Forest vegetation

Many of the vegetation types which are present in the Coastal Forests have already been described in varying degrees of detail, especially for the Kenya coast (e.g. Dale, 1939; Burtt, 1942; Moomaw, 1960; Birch, 1963). More detailed vegetation studies in the Kenyan forests include those of the Tana river forests by Andrews *et al.* (1975), Hughes (1990) and Medley (1990 and 1992), the Gedi forest by Gerhardt and Steiner (1986), and an extremely detailed account of the Shimba Hills forest by Schmidt (1991). The few remaining forest patches in Somalia have been described by Friis and Vollesen (1989), and in greater detail by Madgwick (1988) for the Jubba River forests. Tanzanian Coastal Forests are less well described, and early accounts by German authors are rarely referred to as they are written in German and difficult to obtain (e.g. Busse, 1902; Schlieben, 1939). Recent studies include the study of several forests by Hawthorne (1984, 1993), a broad account of the forests of the Selous Game Reserve by Vollesen (1980), and more detailed studies of the forest and scrub forest on coral rag by Hall *et al.* (1982), Kimboza Forest by Rodgers *et al.* (1983), together with other lowland forests in the Uluguru mountains by Pócs (1976), Mafia Island by Greenway with Rodgers *et al.* (1988), Rondo Forest by Bidgood and Vollesen (1992), Pindiro Forest by Hørlyck (1995), with notes on other forest patches in SE Tanzania by Vollesen and Bidgood (1992) and Eriksen *et al.* (1994). The 26 Coastal Forests visited by the Frontier-Tanzania Coastal Forest Research Programme are described by Clarke (1995), Clarke and Dickinson (1995) and Clarke and Stubblefield (1995), while Lovett and Pócs (1993) provide a brief description of the vegetation of many Coastal Forests in Morogoro and Tanga Regions. Ngezi Forest on Pemba Island is described by Beentje (1990b), whilst Jozani Forest on Zanzibar has been dealt with by both Robins (1976) and Beentje (1990a). The lowland forests of Malawi are described briefly by Chapman and White (1970), and in more detail by Dowsett-Lemaire (1990). Wild and Grandvaux Barbosa (1967) provide an excellent overall summary of the forests of Mozambique, much of which is repeated by Moll and White (1978).

Detailed investigations of vegetation assemblages within single Coastal Forests are described by Hawthorne (1984) for eight forests in Tanzania, by Schmidt (1991) for the Shimba Hills forest, and by Mwasumbi *et al.* (1994) for the Pande and Kiono forests. These studies have revealed that local variations in vegetation relate to ecological factors such as the location of the forest in relation to soils, topography, prevailing wind directions etc., and also to the level of forest disturbance (cf. Chapter 3.3). Detailed studies are currently underway in the Pugu Hills of Tanzania to try and relate vegetation types to characteristics of the soil, aspect, position on slope etc. (Mwasumbi *in lit.*), but these results will undoubtedly be heavily influenced by the considerable human disturbance that has been suffered by this forest (Clarke and Dickinson, 1995, p.57).

Much further work is required before the vegetation communities within the Coastal Forests can be fully defined statistically (i.e. through computer ordination of quantitative species community data), and then related to environmental variables such as soils, climate, aspect, disturbance etc. Quantitative data on Coastal Forest vegetation are few and the majority of this data has been collected in northern Tanzania and Kenya, especially in the Arabuko Sokoke forest (21 plots of $2500m^2$ each by Wairungu *et al.*, 1993; 48 plots containing a total of 3958 trees by Blackett, 1994b), the Shimba Hills forests (26 plots of $4000m^2$ each by Blackett, 1994a), and in the Tana River floodplain forests (95 plots of $200m^2$ each by Njue, 1992). The Frontier-Tanzania Coastal Forest Research Programme has added plot data from 21 forests (Clarke, 1995; Clarke and Dickinson, 1995; Clarke and Stubblefield, 1995; Chapter 3.3), but the total of 3000 trees are insufficient to permit an adequate statistical analysis of species assemblages (Chapter 3.3). Given that there are at least 194 Coastal Forests in eastern Africa (Chapter 3.1), and that a number of plots would be needed at each site to sample the vegetation adequately, the task of generating sufficient data for a statistical analysis of the different vegetation types would require the identification of thousands of tree samples, many of which would be sterile botanical specimens and would present a formidable task to identify correctly.

Attempts to compare the vegetation of different forests based on their florulas/plant species lists (e.g. Hawthorne, 1984) are prone to the errors associated with different forest sizes and highly uneven collection intensities for different sites, as well as the absence of ecological information contained in a presence/absence list (i.e. information on which species are the most abundant, and which are the canopy trees that maintain a forest micro-climate). Species lists may also be biased towards common and conspicuous species, and towards those which are often in flower or fruit and therefore most frequently collected. Tall trees with an inconspicuous bark and which flower and fruit irregularly are usually overlooked, yet such trees (especially in the legume sub-family Caesalpinioideae) dominate the tree canopy in some areas of Coastal Forest. Their omission from the species list will then lead to a misrepresentation of the actual vegetation communities present.

We therefore present a broad description of the main vegetation noda encountered in the Coastal Forests, set within the framework of the major forest types classified according to vegetation physiognomy in Chapter 1.2. Our descriptions are based on a survey of the available literature (Appendix 2), as well as on our combined fieldwork experience (which collectively amounts to over a decade spent in the forests themselves, albeit predominantly in Kenya and Tanzania). Given the virtual absence of any quantitative data on the vegetation of these forests, our vegetation communities [noda] are descriptive and have not been defined statistically. Errors associated with comparing florulas are avoided by comparing lists of dominant tree species only.

Eastern African coastal dry forest

Dry forest *sensu* White (1983, p.46) is the predominant vegetation type of the eastern African Coastal Forests, and is also the most complex and variable of the Coastal Forest vegetation types. We recognise legume dominance to be a recurring community node within the eastern African Coastal Dry Forests, and place the remaining variation within a further node which we label simply as mixed dry forest. We believe that much of the eastern African coastal zone was formerly (prior to human intervention) covered by dry forest, particularly legume (especially Caesalpiniodeae)-dominated dry forest.

Legume-dominated dry forest

Many areas of Coastal Forest on well drained sites are dominated by trees of the legume [Fabaceae/Leguminosae] family, where one or two species from this family may account for 50–95% of all tree individuals >10cm DBH (diameter at breast height, i.e. 1.3m) in a forest stand. The sub-family Caesalpinioideae is particularly well represented, especially the genera *Scorodophloeus* (Figure 3.2.1), *Cynometra* (Figure 3.2.2), *Julbernardia* (Figure 3.2.3), *Hymenaea* (Figure 3.2.4), *Berlinia, Guibourtia*, *Erythrophloeum* (Figure 3.2.5), *Paramacrolobium* (Figure 3.2.6) and *Dialium* (Figure 3.2.7), as summarised in Table 3.2.1. Legumes belonging to the genera *Baphia* (Figure 3.2.8) and *Craibia* (Figure 3.2.9), both from the sub-family Papilionoideae, and *Albizia* (Figure 3.2.10), *Millettia* and *Newtonia* from the sub-family Mimosoideae are occasionally associated with these Caesalpinioids, and may even dominate certain assemblages. Legume-dominated dry forest has been found on infertile white coastal sands, on clay soils and on limestone karsts, and appears not be limited by edaphic conditions, apart from requiring free-draining sites.

Legume-dominated dry forest usually comprises a rather simple vegetation structure, without the multiple tree strata recorded in many tropical forest types elsewhere (cf. Whitmore, 1986). Shrubs are generally frequent, often dominated by the same species as the tree canopy, which is indicative of a stable (i.e. climax) non-pioneer forest community (cf. Schmidt, 1991). Herbs are usually rare, and are usually limited to xerophytic species such as *Sansevieria* and *Dorstenia.* Lianes are usually scarce, although an area of *Berlinia orientalis* legume-dominated dry forest at Litipo in Tanzania has been found to have the highest known stem density of lianes (>2.5cm diameter) in the world, which may have been caused by disturbance to this forest patch earlier this century (Bailey, 1994; Clarke, 1995). The liane flora here matches the tree flora with virtual mono-specific dominance of the legume *Millettia impressa*, contrasting with the neighbouring mixed dry forest vegetation which has a very diverse liane flora (Bailey, 1994).

Figure 3.2.1 ***Scorodophloeus fischeri*** **Harms**

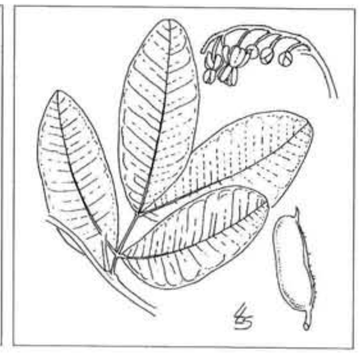


Figure 3.2.2 ***Cynometra suaheliensis*** **(Taub.) Baker f.**

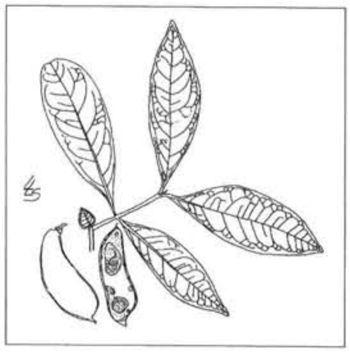


Figure 3.2.3 ***Julbernardia magnistipulata*** **(Harms) Troupin**

Figure 3.2.4 ***Hymenaea verrucosa*** **Gaertn.**

Figure 3.2.5 ***Erythrophleum suaveolens*** **(Guill. and Perr.) Brenan**

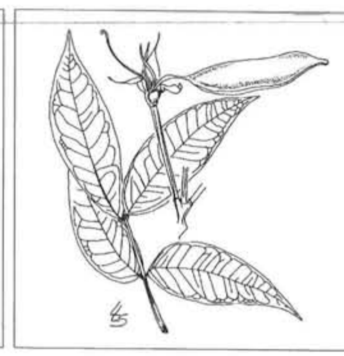


Figure 3.2.6 ***Paramacrolobium coeruleum*** **(Taub.) Léon**

Figure 3.2.7 ***Dialium holtzii*** **Harms**

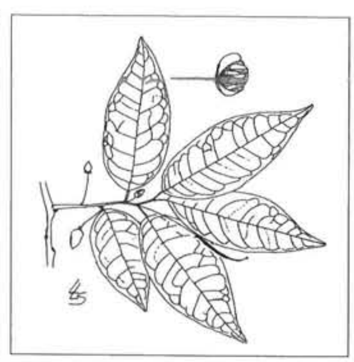


Figure 3.2.8 ***Baphia puguensis*** **Brummitt**

Table 3.2.1 Some eastern African Coastal Forests containing areas of legume-dominated dry forest (including *Brachystegia* forest).

Forest	Dominant tree species	Data source
Watamu Dune Forest	*Cynometra greenwayi*	Robertson, pers. obs.
Arabuko-Sokoke	*Cynometra webberi*	Robertson and Luke, 1993
Arabuko-Sokoke	*Brachystegia spiciformis, Afzelia quanzensis, Hymenaea verrucosa*	Robertson and Clarke, pers.obs.
Arabuko-Sokoke	*Brachystegia spiciformis, Julbernardia magnistipulata*	Robertson and Clarke, pers. obs.
Arabuko-Sokoke	*Julbernardia magnistipulata*	Robertson and Clarke, pers. obs.
Shimba Hills (west)	*Scorodophloeus fischeri*	Robertson, pers. obs.
Shimba Hills, Kivumoni	*Paramacrolobium coeruleum*	Dale, 1939; Schmidt, 1991
Shimba Hills	*Erythrophleum suaveolens*	Robertson and Clarke, pers. obs.
Kilulu Hill	*Cynometra webberi, Scorodophloeus fischeri*	Clarke and Stubblefield, 1995
Kwamgumi-Segoma	*Scorodophloeus fischeri*	Clarke, pers. obs.
Mlungui Hill	*Cynometra webberi, Scorodophloeus fischeri*	Clarke, pers. obs
Kambai Public Lands	*Julbernardia magnistipulata*	Clarke, pers. obs.
Kambai Forest Reserve	*Cynometra webberi, Scorodophloeus fischeri*	Clarke, pers. obs.
Longuza[1]	*Cynometra* sp. A and B of FTEA, *C. longipedicellata* ?	FTEA (Caesalpinioideae)
Tongwe Hill	*Cynometra brachyrrachis, Scorodophloeus fischeri*	Clarke and Stubblefield, 1995
Pangani Falls	*Cynometra brachyrrachis, Scorodophloeus fischeri*	Clarke and Stubblefield, 1995
Gendagenda North	*Cynometra brachyrrachis, Scorodophloeus fischeri*	Clarke and Stubblefield, 1995
Msubugwe	*Scorodophloeus fischeri, Cynometra webberi*	Clarke and Stubblefield, 1995
Gendagenda South	*Scorodophloeus fischeri*	Clarke and Stubblefield, 1995
Mkwaja	*Julbernardia magnistipulata*	Clarke and Stubblefield, 1995
Zaraninge	*Cynometra suaheliensis*	Clarke and Dickinson, 1995
Zaraninge	*Cynometra webberi* and *C. suaheliensis, Scorodophloeus fischeri*	Clarke and Dickinson, 1995
Pande	*Scorodophloeus fischeri, Cynometra webberi*	Clarke and Dickinson, 1995
Pande	*Julbernardia magnistipulata*	Hawthorne, 1993
Pugu	*Dialium holtzii, Baphia kirkii*	Hawthorne, 1993
Pugu	*Scorodophloeus fischeri*	Clarke and Dickinson, 1995
Kimboza	*Scorodophloeus fischeri, Cynometra* sp. A of FTEA	Clarke, pers. obs.
Kisiju	*Hymenaea verrucosa, Craibia zimmermannii, Baphia kirkii*	Clarke and Dickinson, 1995
Mchungu	*Hymenaea verrucosa, Baphia kirkii*	Clarke and Dickinson, 1995
Chunguruma (destroyed)	*Hymenaea verrucosa, Dialium holzii, Baphia kirkii*	Greenway *et al.*, 1988
Kiwengoma	*Scorodophloeus fischeri*	Clarke and Dickinson, 1995
Namakutwa	*Brachystegia microphylla*	Clarke and Dickinson, 1995
Tong'omba	*Scorodophloeus fischeri, Cynometra sp. cf. longipedicellata*	Clarke, 1995
Tong'omba	*Brachystegia microphylla*	Clarke, 1995
Ngarama North	*Hymenaea verrucosa, Scorodophloeus fischeri*	Clarke, 1995
Mchinga	*Cynometra filifera, Scorodophloeus fischeri*	Clarke, 1995
Ruawa	*Scorodophloeus fischeri, Craibia* sp. aff. *zimmermannii*	Clarke, 1995
Litipo	*Scorodophloeus fischeri, Cynometra webberi*	Clarke, 1995
Litipo	*Erythrina sacleuxii* and formerly *E. schliebenii* ?	Clarke, 1995
Litipo	*Berlinia orientalis*	Clarke, 1995
Rondo[2]	*Xylia africana* ?	Clarke, pers. obs.
Mlinguru[3]	*Cynometra filifera, Scorodophloeus fischeri* ?	FTEA (Caesalpinioideae)
Masasi Hill (Mbangala)	*Millettia stuhlmannii*	Vollesen and Bidgood, 1992
Sudi[4]	*Hymenaea verrucosa, Scorodophloeus fischeri* ?	FTEA (Mimusoideae)
Makonde Plateau (base)	*Cynometra* sp., *Guibuortia schliebenii, Baphia macrocalyx*	Gillman, 1945
Northern Mozambique	*Berlinia orientalis*	Gomes e Sousa, 1966
North of Beira	*Hymeanea verrucosa, Albizia adianthifolia, Afzelia quanzensis*	Wild and Grandvaux Barbosa, 1967

***Notes*:**

In this list we cite the occurrence of legume-dominated forest only. In all the sites mentioned other forest types also exist, and in many of these, trees of the Leguminosae/Fabaceae may be scarce to absent.

[1]FTEA accounts cite the occurrence of *Cynometra* sp. A of FTEA; *Cynometra* sp. B of FTEA and *Cynometra longipedicellata* from German collections (pre 1916), prior to the establishment of the present teak plantation in the reserve. Given that Caesalpinioideae dominant forest occurs further to the north in the same Sigi-Musi valley (at Kambai, Kwamgumi-Segoma and Manga), it is likely that at least one of these *Cynometras* would have formerly dominated Longuza forest.

[2]Little is known about the natural forest vegetation climax on the Rondo Plateau, except that the forest has been severely disturbed over the last 100 years (Clarke, 1995). The well documented high concentration of *Milicia excelsa* is probably a seral regeneration stage on the plateau. On the escarpment edges, however, remains of dry forest dominated by *Xylia africana* have been found.

[3]Assuming the same species composition as at Mchinga, the only other known location of *Cynometra filifera*.

[4]FTEA accounts cite collections in 'Mpande woodland', i.e. *Scorodophloeus fischeri* forest.

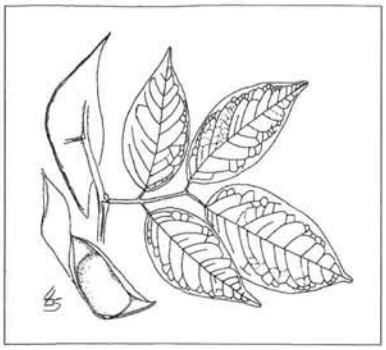


Figure 3.2.9 ***Craibia zimmermannii*** **(Harms) Dunn**

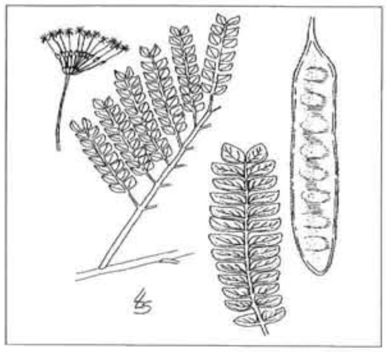


Figure 3.2.10 ***Albizia adianthifolia*** **(Schumach.) W. Wight**

Within the legume-dominated dry forests, the *Scorodophloeus fischeri* and/or *Cynometra* sp. association, which often occurs with *Manilkara sulcata* (Figure 3.2.11)/*M. sansibarensis* (Figure 3.2.12), and/or *Brachylaena huillensis* (Figure 3.2.13) is frequently found in the Kenyan and Tanzanian Coastal Forests (Polhill, 1968; Hawthorne, 1993), giving rise to Moomaw's (1960) *Cynometra-Manilkara* forest type. The canopy height of this forest type varies from 4m in the unusual 'dwarf' forest on the north-western side of the Arabuko-Sokoke forest in Kenya (Figure 3.2.46), and 6m in the *Cynometra filifera – Scorodophloeus fischeri* association at Mchinga in southern Tanzania (where mean annual rainfall is just 899mm; Clarke, 1995) to over 25m on Mlungui Hill in the East Usambara mountains (where mean annual rainfall is estimated to be 1250mm), although a canopy height of 12–15m is more typical elsewhere. Succulent spiny euphorbias (e.g. *Euphorbia nyikae*) and cycads *Encephalartos hildebrandtii* are often present in the small tree stratum (Figure 3.2.47). The 'West African Dry Coastal Forest' (which occurs on the coastal plain of Ghana in the Guineo- Congolian/Sudanian regional transition zone) contains a similar tree community at the generic level, with a *Cynometra-Manilkara* dominated canopy and emergents of *Antiaris*, *Celtis* and *Nesogordonia* (cf. Moomaw, 1960; Hawthorne, 1984 and 1993; White, 1983, p.176–178).

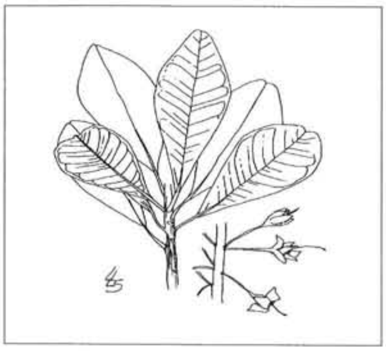


Figure 3.2.11 ***Manilkara sulcata*** **(Engl.) Dubard**

Monospecific Caesalpinioideae tree stands have been noted in other tropical forests in Trinidad and Central Africa (Hart *et al.*, 1989; Hart, 1990; Connell and Lowman, 1989; Hamilton, 1989; Schmidt, 1991), and are attributed to poor soils (especially white sands), and also to the presence of ectomycorrhizae (Chapter 2.3; Malloch *et al.*, 1980; Newbery *et al.*, 1988) and vesicular-arbuscular mycorrhizae (Högberg, 1992). Caesalpinioideae-dominated forest is considered to represent the final stages of a successional climax of phases of forest growth on dry hilltops in Uganda (Dale, 1954), and may represent a long term vegetation community climax in the Coastal Forests as well (Chapters 3.3 and 4.1).

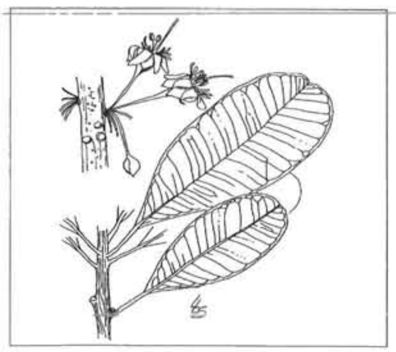


Figure 3.2.12 ***Manilkara sansibarensis*** **(Engl.) Dubard**

Mixed dry forest

Classifying mixed dry forest communities which are not dominated by legumes remains a difficult task given the paucity of available data. We recognise that a great many associations occur, the majority of which are unique to a particular forest and therefore a description of these here would be of little value. Our own experience indicates that the more forests we visit, the harder it becomes to distinguish any recurring vegetation community nodes within these mixed dry forests.

Figure 3.2.13 ***Brachylaena huillensis*** **O. Hoffm.**

Figure 3.2.14 ***Afzelia quanzensis*** **Welw.**

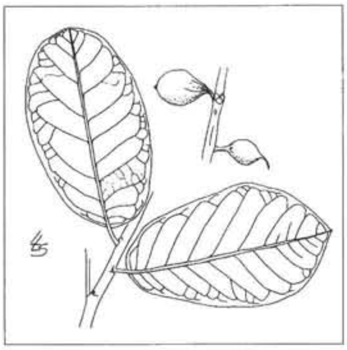


Figure 3.2.15 ***Antiaris toxicaria*** **Leschen.**

Figure 3.2.16 ***Bombax rhodognaphalon*** **K. Schum.**

Figure 3.2.17 ***Cordyla africana*** **Lour.**

Figure 3.2.18 ***Croton sylvaticus*** **Krauss**

Figure 3.2.19 ***Cussonia zimmermannii*** **Harms**

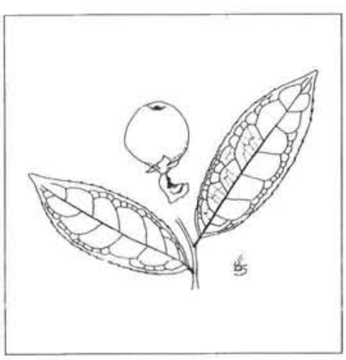


Figure 3.2.20 ***Drypetes natalensis*** **(Harv.) Hutch.**

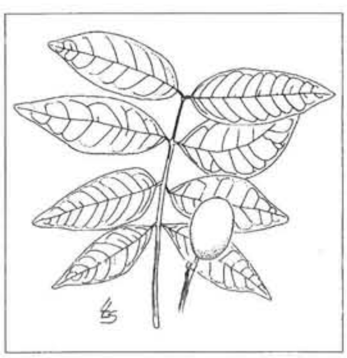


Figure 3.2.21 ***Lecaniodiscus fraxinifolius*** **Baker**

The complexity of mixed dry forest communities is well illustrated from an examination of the literature, where 152 different tree species have been recorded as being dominant in at least one forest or forest area, with a further 94 species recorded as being either common or frequent (Appendix 2, this volume). The most frequently encountered dominant tree species include *Afzelia quanzensis* (Figure 3.2.14), *Albizia adianthifolia, Antiaris toxicaria* (Figure 3.2.15), *Bombax rhodognaphalon* (Figure 3.2.16), *Brachylaena huillensis, Cassipourea euryoides, Combretum schumannii, Cordyla africana* (Figure 3.2.17), *Croton sylvaticus* (Figure 3.2.18), *Cussonia zimmermannii* (Figure 3.2.19), *Dialium orientale, Drypetes natalensis* (Figure 3.2.20), *Erythrophleum suaveolens, Hymenaea verrucosa, Julbernardia magnistipulata, Lannea schweinfurthii, Lecaniodiscus fraxinifolius* (Figure 3.2.21), *Manilkara discolor, Manilkara sansibarensis, Manilkara sulcata, Milicia excelsa* (Figure 3.2.22), *Nesogordonia holtzii, Pteleopsis myrtifolia* (Figure 3.2.23), *Ricinodendron heudelotii* (Figure 3.2.24), *Scorodophloeus fischeri, Sorindeia madagascariensis* (Figure 3.2.25), *Sterculia appendiculata* (Figure 3.2.26), *Synsepalum brevipes* (Figure 3.2.27), *Terminalia boivinii* and *Terminalia sambesiaca* (Figure 3.2.28), as well as many species in the genus *Diospyros* (most of which are only recorded as dominant in a few sites). *Newtonia buchananii* (Figure 3.2.29) is additionally frequently encountered in the moister dry forests of Mozambique and Zimbabwe (Wild and Grandvaux Barbosa, 1967). Many of these species are geographically widespread with a wide ecological amplitude, or are distinctive or economically important timber species. Their frequent mention in the literature may then be partially biased by these species being well-known, rather than these species being the most common mixed dry forest dominants. The seeds of most of these species are wind or animal dispersed (especially by hornbills and bats), suggesting that some areas of mixed dry forest may represent a dry forest regeneration climax in the absence of competition from the much slower dispersed legume (and especially Caesalpinioideae) seeds. Apart from *Combretum schumannii,* the virtual absence of species in the genera *Combretum* and *Grewia* (which are frequently encountered in scrub forest) is notable.

The floristic complexity of mixed dry forest is matched by its structural complexity (Chapter 3.3), with canopy heights ranging from 10m up to a maximum of 30–40m at Ngezi forest on Pemba Island (Beentje, 1990b). Sub-canopy tree layers tend to become more distinct with increasing moisture availability, and as dry forest becomes moister, there is less of a tendency towards local dominance (Hawthorne, 1993), and probably a tendency towards greater local species diversity as noted in forests elsewhere in Africa (Hamilton, 1989). Lianes may be frequent (particularly in the drier types). Shrubs are usually common. Herbs are usually infrequent. Epiphytes are rare, even in Ngezi forest (Beentje, 1990b) where an annual rainfall of nearly 2000mm is almost enough to classify the forest as true tropical rainforest (cf. Holdridge *et al.,* 1971).

Mixed dry forest may develop on coral rag (limestone) substrates under favourable soil, rainfall and edaphic conditions, e.g. in some areas where old coral is more easily penetrated by tree roots and where the water table can be less than 10m below ground level. Such forest is however depauperate compared with the much moister dry forest types inland (Birch, 1963). Most of the dominant species include those listed above, which are frequently encountered as dominant/ common in mixed dry forest elsewhere.

Figure 3.2.22 ***Milicia excelsa*** **(Welw.) Berg**

Figure 3.2.23 ***Pteleopsis myrtifolia*** **(Lawson) Engl. and Diels**

Figure 3.2.24 ***Ricinodendron heudelottii*** **(Baill.) Heckel**

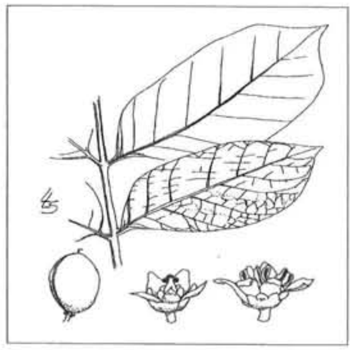


Figure 3.2.25 ***Sorindeia madagascariensis*** **DC.**

Fig. 3.2.26 ***Sterculia appendiculata*** **K. Schum.**

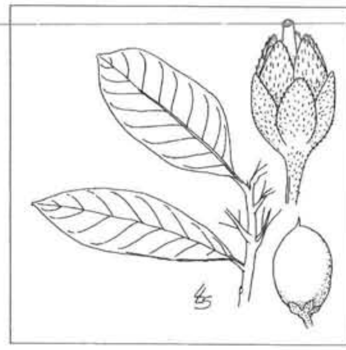


Fig. 3.2.27 ***Synsepalum brevipes*** **(Baker) Pennington**

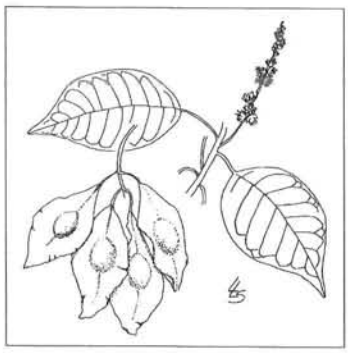


Fig. 3.2.28 ***Terminalia sambesiaca*** **Engl. and Diels**

Fig.3.2.29 ***Newtonia buchananii*** **(Baker) Gilb. and Bout.**

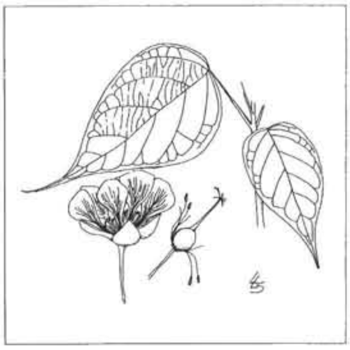


Figure 3.2.30 ***Caloncoba welwitschii*** **(Oliv.) Gilg**

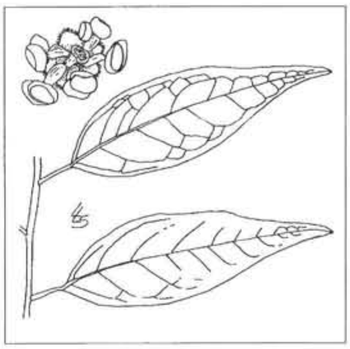


Figure 3.2.31 ***Hymenocardia ulmoides*** **Oliv.**

Figure 3.2.32 ***Oldfieldia somalensis*** **(Chiov.) Milne-Redh.**

Figure 3.2.33 ***Suregada zanzibariensis*** **Baill.**

Eastern African coastal scrub forest

Scrub forest (*sensu* White, 1983) is a rather common feature of the Coastal Forest belt, but is often mislabelled as forest or thicket. Most scrub forest types are probably seral, and result either from heavily disturbed forest, or are an intermediate regeneration phase to subclimax forest following clearance (Dale, 1939; Andrews *et al.*, 1975), or seasonal burning. Scrub forests developed on rocky (usually coral rag) substrates may however represent a vegetation climax whose physiognomy is limited by the rocky substrate (Birch, 1963; Chapter 3.3). We recognise that scrub forest found along the eastern African seaboard (which may intergrade with thickct vegetation) is sufficiently distinctive to be treated as a separate scrub forest node, perhaps as a result of its association with species tolerant of the hot saline sea breezes. Too few data are currently available to distinguish further scrub forest noda due to the complexity of this forest type, so the remaining scrub forest types are here treated collectively as mixed scrub forest.

Mixed scrub forest

Single species dominance is rarely encountered in mixed scrub forests, and 141 tree species are recorded in the literature to be dominant or common in this vegetation type (Appendix 2). The most frequently encountered dominant tree species include *Afzelia quanzensis, Bombax rhodognaphalon, Brachylaena huillensis, Caloncoba welwitschii* (Figure 3.2.30), *Combretum schumannii, Grewia conocarpa, Hymenocardia ulmoides* (Figure 3.2.31), *Manilkara sulcata, Oldfieldia somalensis* (Figure 3.2.32), *Pteleopsis myrtifolia, Suregada zanzibariensis* (Figure 3.2.33) and *Zanthoxylum holtzianum* (Figure 3.2.48). The genera *Albizia, Combretum, Diospyros, Grewia, Manilkara, Strychnos* and *Vitex* are also well represented by many species, although some of these are only recorded from a few forests. Lianes may be frequent to scarce, and herbs are usually absent.

Mixed scrub forest is prominent in southern Tanzania, particularly on the Makonde Plateau where it may become virtually impenetrable (Busse, 1902; Schlieben, 1939). The main canopy typically reaches to six metres with interspersed emergents such as *Millettia stuhlmannii, Milicia excelsa, Parinari excelsa, Vitex* spp. and *Rawsonia lucida* (Schlieben, 1939). Lianes are abundant, especially *Landolphia* spp. (Busse, 1902). The historical local practice of shifting cultivation on the Makonde Plateau left farmland fallow for at least seven years, to enable a woody thicket/scrub forest to regenerate, which was then cleared again and the cycle repeated (Gillman, 1945). This practice gives support to the opinion that this vegetation type is seral or possibly subclimax where the clearance cycle is not perpetuated (Schlieben, 1939).

Vegetation labelled as bushland which consists of clumps of thicket in grassland can be considered to be an archipelago of miniature islands of subclimax scrub forest, where both the spread of these subclimax scrub forest patches, and of their complete succession to forest, is prevented by human and elephant disturbance, periodic cultivation (Welch, 1960), soils, fires (Greenway with Rodgers *et al.*, 1988) and termite activity (which limits the extent of the termitaria on which the thicket clumps are developed). Welch (1960) describes how such thickets/scrub forest patches are often surrounded by a fire barrier of shrubs/small trees, e.g. of *Acacia brevispica* which protect other pyrophobic species in these thickets/scrub forests.

Maritime scrub forest

Scrub forest and thicket developed on coral rag (surface limestone derived from recent corals) is found at intervals along the coast of eastern Africa. The associated soils tend to be shallow, and so are more prone to desiccation than would be expected given the mean annual rainfall of 800–2000mm (Chapter 2.3). The canopy is typically 6–10m high with little vertical stratification, and has occasional emergents 8–15m tall (which are associated with pockets of deeper soil). Woody and herbaceous climbers and thorny plants are common, forming impenetrable stands when the vegetation is heavily disturbed. Herbs are virtually absent. Maritime scrub forest plants often have extremely thick coriaceous leaves to withstand the severe desiccation effect of the strong salt-laden sea breezes (Hall *et al.,* 1982). Many of these species are also found in forests further inland, especially over dry rocky outcrops, and have therefore been labelled as 'maritime element' species by Hawthorne (1984 and 1993).

Dominance by one of a few species is rarely encountered in maritime scrub forest, although monospecific stands of *Spirostachys venenifera* have been recorded on coral rag near Mikindani in southern Tanzania (Vollesen and Bidgood, 1992). An examination of the literature has found 106 tree species that are recorded as common/frequent in this vegetation type, although many of these are recorded in one publication only (Appendix 2). Only the species *Adansonia digitata* (Figure 3.2.34), *Diospyros consolatae* (Figure 3.2.35), *Grewia glandulosa, Lannea schweinfurthii, Manilkara sulcata, Sideroxylon inerme* (Figure 3.2.36) and the genera *Combretum, Euphorbia, Grewia, Haplocoelum, Sterculia* and *Zanthoxylum* are mentioned in three or more sources. Maritime scrub forest is recognised to be rather depauperate compared to the other forest types occurring further inland (Hall *et al.,* 1982).

Figure 3.2.34 ***Adansonia digitata*** **L.**

The strong association between maritime scrub forest and coral rag may be because such forests have been selectively ignored by cultivators due to the thin, easily desiccated layer of soils overlying the coral rag (Birch, 1963), which is present along much of the coastline of eastern Africa, from the Jubba River south to Quelimane (Frazier, 1993; Tinley, 1971). Under favourable conditions (deeper soil and high rainfall) true dry forest (canopy >10m) may develop on coral rag (e.g. at the Gede ruins in coastal Kenya), although most of this has now been cleared for agriculture (Birch, 1963).

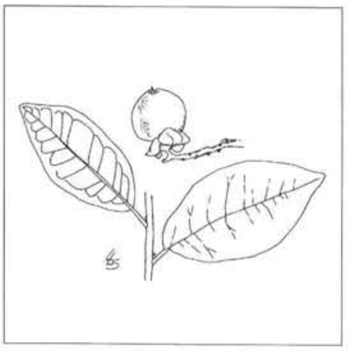


Figure 3.2.35 ***Diospyros consolatae*** **Chiov.**

On the Islands of Pemba and Mafia there is an unusual form of maritime scrub forest on sandy soils, with large emergent trees over a dense canopy formed by the giant heath bush *Phillippia mafiensis* (Greenway with Rodgers *et al.*, 1988; Beentje, 1990b). Maritime scrub forest on sand dunes is also recorded elsewhere, e.g. at Nyali (Birch, 1963, but now destroyed) and Watamu on the Kenyan coast, and along much of the Mozambique coast (Wild and Grandvaux Barbosa, 1967; Moll and White, 1978), but too few data are available to determine whether this warrants separation as a further distinct vegetation community node.

Figure 3.2.36 ***Sideroxylon inerme*** **L.**

Eastern African coastal *Brachystegia* forest

Fire-excluded closed-canopy formation types dominated by either *Brachystegia spiciformis* (Figure 3.2.37) or *Brachystegia microphylla* are considered to be a forest type in this volume (Chapter 1.2). This vegetation type has been rather poorly studied, so only 19 tree species are listed in the literature as being dominant/common, in addition to the two species of *Brachystegia* (Appendix 2). Of these, only *Hymenaea verrucosa* and *Julbernardia magnistipulata* have been frequently recorded as co-dominants with *Brachystegia*. Lianes are scarce to absent, whilst shrubs may be scarce to frequent. Grasses are scarce to absent in the *Brachystegia* forests of southern Tanzania, but are more common in the Arabuko-Sokoke forest, though they do not burn regularly as in the *Brachystegia* woodlands of the Zambezian regional centre of endemism. It is not known whether the presence of grasses in the *Brachystegia* dominated areas of Arabuko-Sokoke forest is natural or the result of disturbance.

Figure 3.2.37 *Brachystegia spiciformis* Benth.

Brachystegia forest occurs on well drained, nutrient poor or heavily leached soils, especially on slopes or white sand. In a sense this forest type is a variant of the aforementioned legume-dominated dry forest node (though the non-interlocking tree crowns separate it on the basis of vegetation physiognomy, see Chapter 1.2), since *Brachystegia, Julbernardia* and *Hymenaea* are all legumes.

Eastern African Coastal/Afromontane transitional forest

In areas of higher rainfall (typically over 1500mm at the base of the Eastern Arc mountains) vegetation closer in physiognomy to lowland rainforest may develop. Most of such areas in coastal eastern Africa are on higher locations, particularly where drainage is additionally impeded, e.g. on the Shimba Hills in Kenya, Tongwe and Tong'omba (Matumbi Hills) in Tanzania, and in the foothills of the Eastern Arc Mountains (e.g. the East Usambaras, Ulugurus and Udzungwas). These forests equate broadly to Moomaw's (1960) *Sterculia-Chlorophora (=Milicia)* lowland rain forest, and include emergents to 45m, over a canopy of up to 30–40m in height (Pócs, 1976). Multiple tree strata are usually present, often with a dense shrub layer. Lianes and epiphytes are rare (e.g. Chapman and White, 1970), although more species and a greater number of epiphytes are present than in the scrub and dry forest types (e.g. Pócs, 1976). Herbs are fairly scarce, although in some areas the grass *Olyra latifolia* may be abundant (Dowsett-Lemaire, 1990).

Figure 3.2.38 *Khaya anthotheca* (Welw.) C. DC.

A review of the literature has demonstrated that 68 tree species are recorded as being dominant, with a further 53 species as common in Coastal/Afromontane transitional forest (Appendix 2, this volume). The most frequently encountered dominant tree species include *Antiaris toxicaria, Bombax rhodognaphalon, Dialium holtzii, Drypetes natalensis, Ficus* spp., *Khaya anthotheca* (Figure 3.2.38), *Milicia excelsa, Newtonia buchananii, Parkia filicoidea* (Figure 3.2.39), *Pouteria pseudoracemosa, Sorindeia madagascariensis, Sterculia appendiculata* and *Zahna golungensis.* These species include both widespread trees associated with riverine and groundwater forests, as well as those associated with submontane forest.

Eastern African coastal riverine/swamp/ groundwater forest

Riverine and groundwater forest types are in practice difficult to separate, as areas of riverine forest away from the edges of rivers are effectively groundwater forests since they do not have direct contact with river water. A few species are however unique to each of these forest types, even where areas of riverine and groundwater forest are geographically close to one another (Vollesen, 1980). Our survey of the literature has identified 87 tree species which are cited as being dominant in riverine/groundwater forest, with another 28 tree species cited as common/frequent (Appendix 2, this volume). The most frequently encountered of these species are *Antidesma venosum, Barringtonia racemosa* (Figure 3.2.40), *Bridelia micrantha, Burrtdavya nyassica* (Figure 3.2.41), *Celtis phillippensis, Cordia goetzei, Diospyros mespiliformis, Ficus scassellattii, Ficus sycomorus* (Figure 3.2.42), *Garcinia livingstonei* (Figure 3.2.43), *Khaya anthotheca, Kigelia africana, Milicia excelsa, Mimusops obtusifolia, Parkia filicoidea, Sorindeia madagascariensis, Sterculia appendiculata, Synsepalum brevipes, Syzygium guineense, Terminalia sambesiaca* and *Trichilia emetica* (Figure 3.2.44).

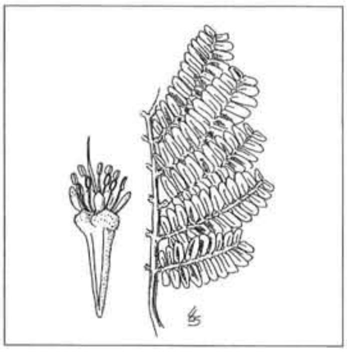


Figure 3.2.39 *Parkia filicoidea* Welw. ex Oliv.

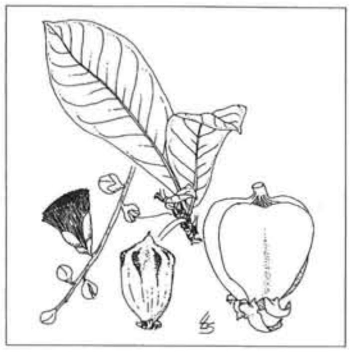


Figure 3.2.40 *Barringtonia racemosa* (L.) Spreng.

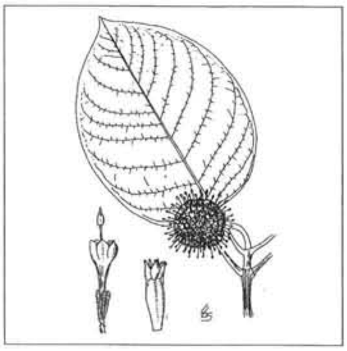


Figure 3.2.41 *Burttdavya nyassica* Hoyle

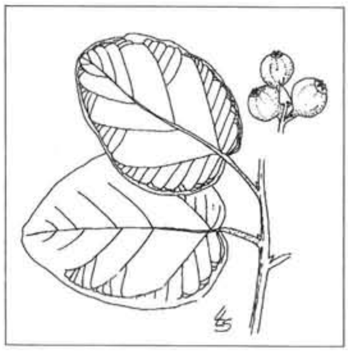


Figure 3.2.42 *Ficus sycomorus* L.

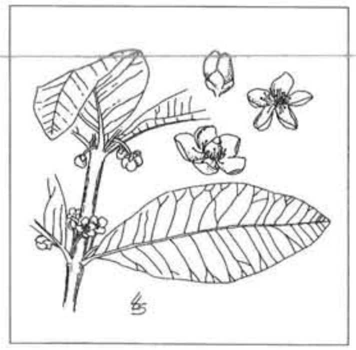


Figure 3.2.43 *Garcinia livingstonei* T. Anderson

Groundwater forest

In forests with undulating or dissected topography there are seasonal and permanent drainage courses which are moister than surrounding slopes and ridge-tops, since the collection of both surface and groundwater provides an additional moisture supply (probably equivalent to a mean annual rainfall of over 1500mm). Valley bottoms with moderate supplies of groundwater, as well as slopes of impeded drainage, are frequently interspersed with large and characteristic emergents, some of which are valued timber species. The emergent trees are typically deciduous, although the length of their leaf fall varies according to the quantity and availability of the additional non-precipitation moisture supply and the severity of the dry season (cf. Hamilton, 1989). The forest canopy is typically 25–35m tall and many of the trees have larger and less desiccation-adapted leaves than found in other Coastal Forest vegetation types. The Moraceae family (e.g. *Antiaris, Ficus, Milicia, Trilepesium*) is prominent, and these and many

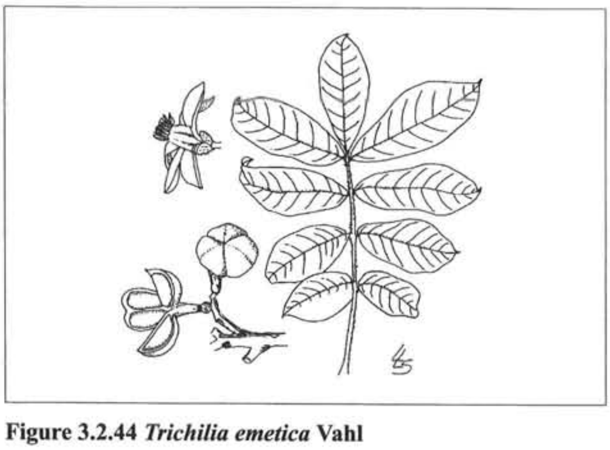


Figure 3.2.44 *Trichilia emetica* Vahl

of the other tree species associated with groundwater forest are dispersed by birds and bats. Shrubs and lianes may be frequent (Medley, 1992).

Riverine forest

Riverine forest develops along the course of permanent or near-permanent water courses, and is characterised by the scattered occurrence of large trees which may also be found along watercourses far beyond the Coastal Forest belt. The canopy is usually composed of a diverse assemblage of species although *Garcinia livingstonei* and *Synsepalum brevipes* have been recorded to form virtually monospecific stands in the Tana River floodplain in Kenya (Andrews *et al.*, 1975). Floodplain forests occur along the major rivers (Tana, Umba, Jubba) crossing the dry coastal hinterland of Kenya and southern Somalia, and their species composition is dependent both on the interval between the flooding events, and by the dynamics of areas drying up following changes in the river course (Andrews *et al.*, 1975; Madgwick, 1988; Medley, 1992). The density of the shrub layer in these forests depends on whether or not they are frequently inundated, with regular annual flooding leading to a very depauperate shrub layer (Andrews *et al.*, 1975). Lianes are recorded as abundant and herbs rare in the forests along the Tana River (Medley, 1992).

Seasonal watercourses which are reduced to permanent pools during the dry season appear to produce a sufficiently high year-round humidity to permit the survival of herbs characteristic of moister montane forests (e.g. *Saintpaulia* spp. and *Impatiens walleriana*, together with abundant epiphytic orchids on the trees). Permanent watercourses may provide a less favourable habitat for these moist forest herbs since permanent rivers in eastern Africa's strongly seasonal climate will be too wide during the rainy season to permit the forest trees on either side to form a closed canopy above the water, and to thereby retain the humid air evaporating off the water's surface. Seasonal watercourses however are invariably enclosed by the forest canopy (Clarke, pers. obs.).

Swamp forest

Freshwater swamp conditions are rather rare in the Coastal Forest belt, with only 22 tree species recorded in the literature to be dominant/common in this vegetation type (Appendix 2). As elsewhere in Africa, swamp forest is vegetatively distinct from other forest types (cf. Hamilton, 1989), with many of these containing very distinctive areas of monocotyledon-dominated forest, e.g. both Jozani Forest, Zanzibar, and Kimboza Forest, Tanzania contain monodominant stands of *Pandanus rabaiensis* (Robins, 1976; Clarke and Dickinson, 1995). Smaller areas of such forest are present elsewhere, e.g. Kazimzumbwi (Figure 3.2.46) and Pangani Falls in Tanzania, with another screw pine *Pandanus* sp. reported to occur in swampy glades in Mozambique (Moll and White, 1978). Monocotyledenous trees are prominent in other areas of coastal swamp forest, e.g. the palms *Raphia farinifera* (Figure 3.2.45) and *Elaeis guineensis* in coastal Kenya, Pemba, Zanzibar and Mafia Islands (Greenway, 1973), and the aroid *Typhonodorum lindleyanum* in some areas of swamp forest on Pemba Island (Greenway, 1973; Beentje, 1990b).

Figure 3.2.45 *Raphia farinifera* (Gaertn.) Hylander

The dicotyledon *Barringtonia racemosa* is a frequent constituent of swamp forest in Tanzania and Mozambique (Clarke and Dickinson, 1995; Moll and White, 1978). The dominance of *Calophyllum inophyllum* in Jozani forest, Zanzibar (Robins, 1976), is ascribed to the species having been planted (Beentje, 1990a), as this species was not mentioned in an earlier study (Greenway, 1973 based on fieldwork prior to 1942). *Calophyllum* was however formerly common behind the mangroves in the Lamu area, but most of this has since been cut for boat building.

Discussion

Patterns in vegetation communities

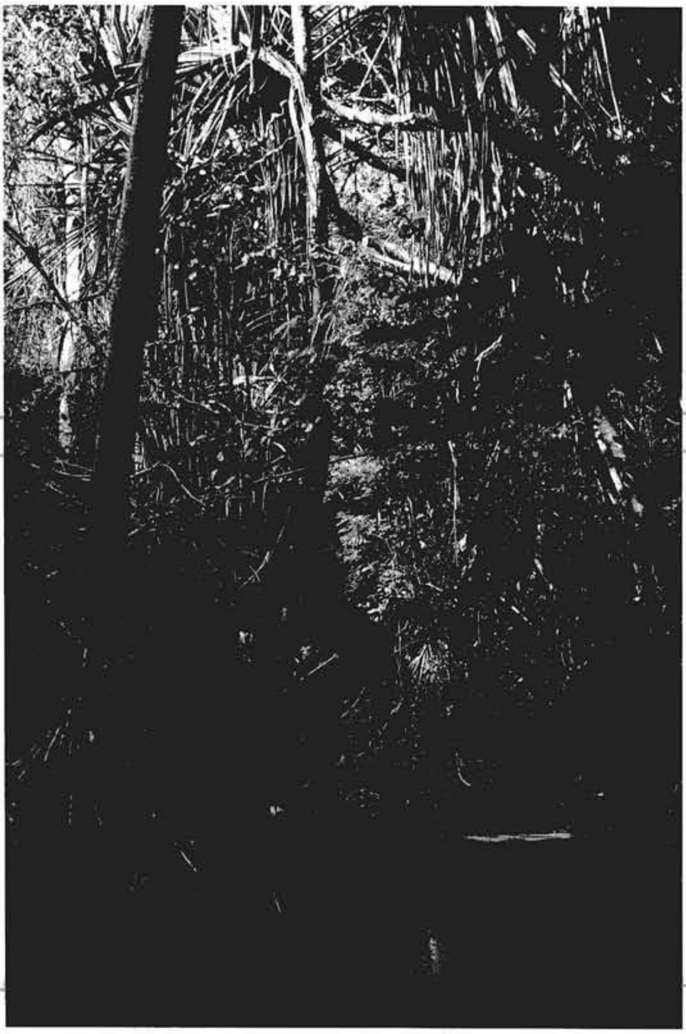


Figure 3.2.46 Eastern African Coastal Swamp Forest dominated by the screw pine *Pandanus rabaiensis*, Kazimzumbwi Forest Reserve, Coast Region, Tanzania. (*Photo: G.P. Clarke*)

Although recurring vegetation communities can be found at the local level in the Coastal Forests (e.g. Schmidt, 1991), these communities are rarely, if ever, repeated further afield (e.g. Medley, 1992). The highly heterogeneous climate, geology, geomorphology, soils etc. present in the eastern African coastal zone create a complex of influences (Hawthorne, 1993) which may not be repeated at different sites, and are therefore responsible for creating the highly complex mosaic of vegetation types throughout the Coastal Forest belt. The vegetation of any single site will then be composed of a geographically/historically influenced component, combined with an edaphic component, e.g. vegetation plots constructed in Gendagenda South Forest Reserve suggest an underlying *Combretum schumannii-Strychnos henningsii-Lecaniodiscus fraxinifolius-Ludia mauritiana* vegetation community which appears to be unique to Gendagenda, interspersed with typical riverine and groundwater species along streams and in valleys, typical thicket species in the drier limits of the forest, and typical dry forest species elsewhere (Clarke and Stubblefield, 1995). A few kilometres to the north, conditions change sufficiently to allow an underlying *Cynometra brachyrrachis* dominant forest type. A similarly rapid turnover in the underlying species types must be occurring throughout the eastern African coastal zone, and is exemplified by the presence of at least 484 tree species which have been recorded in literature to be locally dominant or common in at least one Coastal Forest (Appendix 2, this volume).

The apparent recurrence of various legume-dominated assemblages may be ascribed to the phenomenon of one to few species dominance in this vegetation type. When the same species again dominate another site, the majority of individuals in a tree stand will be the same, presenting an apparent similarity, although the less frequent species may be different and will reflect the geographical position of that forest (cf. Hawthorne, 1984).

Similarities and differences in vegetation types

Comparing lists of dominant and common species from each of the vegetation noda identified in this Chapter (excluding swamp forest and *Brachystegia* forest for which too few species have been recorded in the literature to make a realistic comparison) demonstrates a low overlap between the different forest types, with Jaccard similarity indices ranging from 0.06 to 0.26 (Table 3.2.2), Sørensen similarity indices ranging from 0.1 to 0.4 (Table 3.2.3) and percentage presence values ranging from 11 to 62% (Table 3.2.4).

Table 3.2.2 Jaccard's similarity indices between different Coastal Forest types, based on dominant and common tree species.

	Mixed dry forest	Coastal/Afromontane transition	Riverine and groundwater forest	Mixed scrub forest
Coastal/Afromontane transition	0.252			
Riverine and groundwater forest	0.199	0.180		
Mixed scrub forest	0.205	0.101	0.118	
Maritime scrub forest	0.169	0.061	0.073	0.128

Indices calculated from Jaccard's formula $C_J = j/(a+b-j)$, where *a* is the number of species in habitat *a*, *b* is the number of species in habitat *b*, and *j* is the number of species common to both.

Table 3.2.3 Sørensen's similarity indices between different Coastal Forest types, based on dominant and common tree species.

	Mixed dry forest	Coastal/Afromontane transition	Riverine and groundwater forest	Mixed scrub forest
Coastal/Afromontane transition	0.403			
Riverine and groundwater forest	0.331	0.305		
Mixed scrub forest	0.340	0.183	0.211	
Maritime scrub forest	0.290	0.115	0.136	0.227

Indices calculated from Sørensen's formula $C_S = 2j/(a+b)$, where *a* is the number of species in habitat *a*, *b* is the number of species in habitat *b*, and *j* is the number of species common to both.

Table 3.2.4 Percentage species presence comparisons between different Coastal Forest types, based on dominant and common tree species.

also in: / Percentage of:	Mixed dry forest	Coastal/ Afromontane transition	Riverine and groundwater forest	Mixed scrub forest	Maritime scrub forest
Mixed dry forest	100	31	24	27	21
Coastal/Afromontane transition	62	100	30	21	11
Riverine and groundwater forest	52	31	100	23	13
Mixed scrub forest	47	18	19	100	20
Maritime scrub forest	48	12	14	26	100

Source: Appendix 2 (this volume).

Mixed dry forest is the most similar to each of the other forest noda, confirming dry forest to be the typical Coastal Forest vegetation type, with the other vegetation types being sub-types, variants and transitions of dry forest (Chapter 1.2). Coastal/Afromontane Transitional forest and mixed scrub forest are the most similar to mixed dry forest, as these are respectively moister and drier climatic facies of dry forest. Riverine/groundwater forest is approximately equally dissimilar to mixed dry forest and Coastal/Afromontane Transitional forest as it is mainly dependent on groundwater rather than climatic conditions, but is much more dissimilar to the drier scrub forest types. Maritime scrub forest shows the least similarity to the other forest types, especially when compared to the moist riverine/groundwater forest and Coastal/Afromontane Transitional forest types, since maritime scrub forest is the most desiccation-adapted vegetation type and can therefore be considered to be at the extreme dry end of the Coastal Forest vegetation spectrum. Too few quantitative studies have been carried out in legume-dominated dry forest to produce a representative list of the tree species which are common (here >5% of individuals >10cm DBH), compared to the dominant species which are well known (Table 3.2.1). 91% of the 33 tree species listed as common in legume-dominated dry forest are also listed as dominant or common in mixed dry forest, compared with just 61% of the 31 tree species listed as dominant. We believe that further studies will demonstrate that a much higher number of tree species are common in some stands of legume-dominated dry forest, most of which will also be recorded in mixed dry forest.

Relict vegetation of the former pan-African lowland forest

Areas of Caesalpinioideae-dominated dry forest within the Coastal Forests may represent relicts of the former pan-African lowland forest, since (a) many of these are dominated by plant genera whose distribution in Africa is limited to the Coastal Forests and the Guineo-Congolian Forests, i.e. *Cynometra* and *Scorodophloeus*, with the species *Paramacrolobium coeruleum* also having a disjunct distribution between these areas, (b) vast tracts of the Guineo-Congolian forest are likewise dominated by Caesalpinioideae legumes (including *Cynometra, Scorodophloeus* and *Brachystegia*; Hamilton, 1989), (c) Caesalpinioideae-dominated forest has been demonstrated to be very stable with healthy understorey regeneration and cannot then be a pioneer community (Schmidt, 1991). Many of these Caesalpinioideae tree species, particularly *Scorodophloeus, Cynometra* and *Paramacrolobium,* produce heavy seeds of short viability which germinate immediately and do not appear to tolerate desiccation (cf. Hart, 1990). We believe that the total clearance of such forests (e.g. for agricultural land) would remove any possibility of this forest type regenerating on the same site, since their seeds do not remain viable in the seed bank, require forest conditions (shaded, high humidity microclimate) to germinate, are pyrophobic and are not dispersed by wind or beast. This Coastal Forest vegetation type may be the most vulnerable to fire and the axe, yet could (if allowed to survive) be usefully harnessed in the future for silvicultural purposes.

Vegetation community degradation

Attempts to explain why a particular Coastal Forest vegetation community occurs at a particular site require an understanding of the history of that site, and therefore of some of the contributing factors that have resulted in a given vegetation type being present there today. Many of these factors have changed within the generation span of most Coastal Forest trees, often as a result of human intervention. For example, the prized timber tree *Brachylaena huillensis* is recorded by Dale to have comprised 75% of the canopy of Lungi Forest in Kenya in 1939, but demand for the species is now so great that mature trees have become scarce in all coastal Kenya and Tanzania (Dale, 1939; see also Clarke and Stubblefield, 1995). Similarly a re-examination of Birch's (1963) study area of coral rag forest at Jadini found that the taller trees were no longer present, probably because they had been cut down (Rasmussen, 1972; Hall *et al.*, 1982). The present degradation of vegetation communities is not necessarily the result of direct exploitation, for example species which rely on elephants for seed dispersal (e.g. *Balanites* spp., *Kigelia africana* and *K. moosa*) may gradually become moribund in these forests as elephants become rarer in coastal regions, while the construction of dams may affect the vegetation dynamics of floodplain forests (Madgwick, 1988). The effects of anthropic disturbance are undoubtedly present to a greater or lesser extent in all the Coastal Forests (Hawthorne, 1993; Chapter 3.1), and the level of that disturbance is a significant influence on the vegetation communities present, with severe disturbance leading to a reduced presence of endemic species (cf. Mwasumbi *et al.*, 1994). If human disturbance is not controlled, we fear that all remaining Coastal Forests will eventually become dominated by the easily dispersed pioneer tree species which are characteristic of regenerating and mixed scrub forest.

Figure 3.2.47 ***Cynometra webberi*** **thicket/ 'dwarf forest' with understorey/shrub layer recently cleared for cultivation, Arabuko-Sokoke forest, Kenya. The 4m high trees retain a forest tree structure, even though this vegetation type should technically be classified as thicket on the grounds of its low canopy height.** (*Photo: G.P. Clarke*)

Figure 3.2.48 Cycads ***Encephalartos hildebrandtii*** **in the understorey of legume-dominated eastern African Coastal Dry Forest (dominated by** ***Scorodophloeus fischeri*** **and** ***Julbernardia magnistipulata*****), Bamba Ridge, East Usambara Mountains, Tanzania. Altitude 450m.** (*Photo: G.P. Clarke*)

Figure 3.2.49 ***Zanthoxylum holtzianum*****, a frequently recorded deciduous tree in Mixed Eastern African Coastal Scrub Forest. Litipo Forest Reserve, Lindi Region, Tanzania.** *(Photo: G.P. Clarke)*

Summary

Coastal Forest vegetation communities appear to be far more diverse and variable than has hitherto been recognised. At least 484 different tree species are recorded in the literature as being dominant or common in at least one forest type, leading to thousands of potential assemblage permutations. Recurring communities are rare, except for areas of dry forest dominated by legumes (particularly of the sub-family Caesalpinioideae). The mixed dry forest vegetation community is the most diverse and shows the greatest similarity with other types of Coastal Forest. Maritime scrub forest displays the greatest difference to the other forest types, especially to the moister riverine/groundwater and Coastal/Afromontane transitional forests. Increasing human disturbance may be driving a long term change in tree community composition, towards associations that are increasingly dominated by the more widespread and vigorous pioneer species, at the expense of both endemic species and of community associations that may be relicts of the ancient pan-African lowland forest.

Acknowledgements

Thanks to Neil Burgess and Alan Rodgers for advice and assistance with the drafting of this chapter.

References

Andrews, P., Groves, C.P. and Horne, J.F.M. (1975). Ecology of the Lower Tana floodplain (Kenya). *Journal of the East African Natural History Society and National Museum* **151**: 1–31.

Bailey, H. (1994). An Assessment of the Patterns in the Ecology of Lianas and their Host Trees in Two Different Forest Types in Africa. Unpublished B.Sc dissertation. University of East Anglia, Norwich.

Beentje, H.J. (1990a). *A Reconnaissance Survey of Zanzibar Forests and Coastal Thicket.* Zanzibar Environmental Study Series No. 7. Commission for Lands and Environment, Zanzibar.

Beentje, H.J. (1990b). *Botanical Assessment of Ngezi Forest, Pemba.* Zanzibar Environmental Study Series No. 8. Commission for Lands and Environment, Zanzibar.

Blackett, H.L. (1994a). *Forest Inventory Report No. 4. Shimba Hills, Mkongani North and Mkongani West.* KIFCON, Nairobi.

Blackett, H.L. (1994b). *Forest Inventory Report No. 2. Arabuko-Sokoke.* KIFCON, Nairobi.

Bidgood, S. and Vollesen, K. (1992). *Bauhinia loeseneriana* reinstated, with notes on the forests of the Rondo Plateau, SE Tanzania. *Kew Bulletin* **47**: 759–764.

Birch, W.R. (1963). Observations on the littoral and coral vegetation of the Kenya coast. *Journal of Ecology* **51**: 603–615.

Burtt, B.D. (1942). Some East African vegetation communities. *Journal of Ecology* **30**: 65–146.

Busse, W. (1902). Forschungsreise durch den Südlichen Teil von Deutsch-Ost Afrika. *Beiheft zum Tropenpflanzer* **6**: 93–119.

Chapman, J.D. and White, F. (1970). *The Evergreen Forests of Malawi.* Commonwealth Forestry Institute, Oxford.

Clarke, G.P. (1995). *Status Reports for 6 Coastal Forests in Lindi Region, Tanzania.* Frontier-Tanzania Technical Report No. 18. The Society for Environmental Exploration/The University of Dar es Salaam, London and Dar es Salaam.

Clarke, G.P. and Dickinson, A. (1995). *Status Reports for 11 Coastal Forests in Coast Region, Tanzania.* Frontier-Tanzania Technical Report No. 17. The Society for Environmental Exploration/The University of Dar es Salaam, London and Dar es Salaam.

Clarke, G.P. and Stubblefield, L.K. (1995). *Status Reports for 7 Coastal Forests in Tanga Region, Tanzania.* Frontier-Tanzania Technical Report No. 16. The Society for Environmental Exploration/The University of Dar es Salaam, London and Dar es Salaam.

Connell, J.H. and Lowman, M.D. (1989). Low-diversity tropical rain forests: some possible mechanisms for their existence. *The American Naturalist* **134**: 88–119.

Dale, I.R. (1939). *The Woody Vegetation of the Coast Province in Kenya.* Imperial Forestry Institute Paper No.18: 1–38.

Dale, I.R. (1954). Forest spread and climatic change in Uganda during the Christian Era. *Empire Forest Review* **33**: 23–29.

Dowsett-Lemaire, F. (1990). The flora and phytogeography of the evergreen forests of Malawi II: Lowland forests. *Bull. Jard. Bot. Nat. Belg./Bull. Nat. Plantentuin Belg.* **60**: 9–71.

Edwards, D.C. (1940). A vegetation map of Kenya. *Journal of Ecology* **28**: 377–385.

Eriksen, T., Halberg, K., Lehmberg, T. and Schoubo Petersen, F. (1994). *A Survey of Bird Life in Five Coastal Forests of South-eastern Tanzania, 1993.* Zoological Institute and BirdLife International, Copenhagen.

Frazier, J.G. (1993). *Dry coastal ecosystems in Kenya and Tanzania.* In van der Maarel, E. (ed.). *Ecosystems of the World 2B – Dry Coastal Ecosystems: Africa, America, Asia and Oceania.* Elsevier, Amsterdam.

Friis, I. and Vollesen, K. (1989). Notes on the vegetation of southernmost Somalia, with some additions to the flora. *Willdenowia* **18**: 455–477.

Gerhardt, K. and Steiner, M. (1986). *An Inventory of a Coastal Forest in Kenya at Gedi National Monument, Including a Check-list and a Nature Trail. Report from a Minor Field Study.* 25pp. + appendices. Swedish University of Agricultural Sciences, Uppsala.

Gillman, H. (1945). Bush fallowing on the Makonde Plateau. *Tanganyika Notes and Records* **19**: 34–44.

Gomes e Sousa, A. (1966 and 1967). *Dendrologia de Moçambique.* Volume I and II. Lourenço Marques: Instituto de Investigaçao Agronomica de Moçambique.

Greenway, P.J. (1973). A classification of the vegetation of East Africa. *Kirkia* **9**: 1–68.

Greenway, P.J., Rodgers, W.A., Wingfield, R.J. and Mwasumbi, L.B. (1988). The vegetation of Mafia Island, Tanzania. *Kirkia* **13**: 197–238.

Hall, J.B., Rodgers, W.A., Mwasumbi, L.B. and Swai, I. (1982). 'Woody vegetation on Tanzanian Coral Rag: a Reconnaissance'. Unpublished. Forestry working group of the University of Dar es Salaam, Dar es Salaam.

Hamilton, A. (1989). African Forests. In Leith, H. and Werger, M.J.A. (eds). *Tropical Rain Forest Ecosystems: Biogeographical and Ecological Studies.* Elsevier, Oxford.

Hart, T.B., Hart, J.A. and Murphy, P.G. (1989). Monodominant and species-rich forests of the humid tropics: causes for their co-occurrence. *The American Naturalist* **133**: 613–633.

Hart, T. B. (1990). Monospecific Dominance in Tropical Rainforests. *Trends in Ecology and Evolution* **5**: 6–11.

Hawthorne, W.D. (1984). *Ecological and Biogeographical Patterns in the Coastal Forests of East Africa.* PhD thesis. University of Oxford, Oxford.

Hawthorne, W.D. (1993). East African coastal forest botany. Pp. 57–99. In Lovett, J.C. and Wasser, S.K. (eds.). *Biogeography and Ecology of the Rain Forests of Eastern Africa.* Cambridge University Press, Cambridge.

Högberg, P. (1992). Root symbioses of trees in African dry tropical forests. *Journal of Vegetation Science* **3**: 393–400.

Holdridge, L.R., Grenke, W.C., Hatheway, W.H., Liang, T. and Tosi, T. (1971). *Forest Environments in Tropical Life Zones.* Pergamon, Oxford.

Hørlyck, V. (1995). 'Structure and Diversity of a Coastal Forest in Tanzania'. Unpublished Masters Thesis. Faculty of Natural Sciences, Botanisk Museum, Copenhagen.

Hughes, F.M.R. (1990). The influence of flooding regimes on forest distribution and composition in the Tana river floodplain, Kenya. *Journal of Applied Ecology* **27**: 475–491.

Lovett, J.C. and Pócs, T. (1993). *Assessment of the Condition of the Catchment Forest Reserves. A Botanical Appraisal.* The Catchment Forestry Project (Forestry and Beekeeping Division), Dar es Salaam.

Madgwick, F.J. (1988). Riverine forest in the Jubba Valley: vegetation analysis and comments on forest conservation. *The Biogeography of Somalia, Biogeographia* **14**: 67–88.

Malloch, D.W., Pirozynski, K.A. and Raven, P.H. (1980). Ecological and evolutionary significance of mycorrhizal symbioses in vascular plants (A Review). *Proc. Nat. Acad. Sci. USA* **77**: 2113–2118.

Medley, K.E. (1990). Forest Ecology and Conservation in the Tana River National Primate Reserve, Kenya. Unpublished PhD thesis. Michigan State University, Michigan.

Medley, K. (1992). Patterns of forest diversity along the Tana River, Kenya. *Journal of Tropical Ecology* **8**: 353–371.

Moll, E.J. and White, F. (1978). The Indian Ocean Coastal Belt. In Werger, M.J.A. (ed.) with assistance of Van Bruggen, A.C. (1978). *Biogeography and Ecology of Southern Africa.* Dr. Junk Publishers, The Hague.

Moomaw, J.C. (1960). *A Study of the Plant Ecology of the Coast Region of Kenya Colony, British East Africa.* Government Printer, Nairobi.

Mwasumbi, L.B., Burgess, N.D. and Clarke, G.P. (1994). The vegetation of Pande and Kiono monsoon forests, Tanzania. *Vegetatio* **113**: 71–81.

Newbery, D.M., Alexander, I.J., Thomas, D.W. and Gartlan, J.S. (1988). Ectomycorrhizal rain-forest legumes and soil phosphorus in Korup National Park, Cameroon. *New Phytologist* **109**: 433–450.

Njue, A. (1992). 'The Tana River floodplain Forest, Kenya: Hydrologic and Edaphic Factors as Determinants of Vegetation Structure'. Unpublished PhD thesis. University of California, Davis.

Pócs, T. (1976). Vegetation mapping in the Uluguru Mountains (Tanzania, East Africa). *Boissiera* **24**: 477–498 + map.

Polhill, R.M. (1968). Tanzania. In Hedberg, I. and Hedberg, O. (eds.). Conservation of Vegetation in Africa South of the Sahara. *Acta Phytogeogr. Suecica* **54**: 166–78.

Poore, M.E.D. (1962). The method of successive approximation in descriptive ecology. *Advances in Ecological Research* **1**: 35–68.

Rasmussen, F. (1972). Lowland forest vegetation. In The Study Tour to East Africa, 1970. Unpublished report. University of Copenhagen, Copenhagen.

Robertson, S.A. and Luke, W.R.Q. (1993). *Kenya Coastal Forests: Report of the NMK/WWF Coast Forest Survey.* World Wide Fund for Nature, Nairobi.

Robins, R.J. (1976). The composition of the Jozani forest, Zanzibar. *Botanical Journal of the Linnean Society* **72**: 223–234.

Rodgers, W.A., Hall, J.B., Mwasumbi, L.B., Griffiths, C.J. and Vollesen, K. (1983). *The Conservation Values and Status of Kimboza Forest Reserve, Tanzania.* University of Dar es Salaam Forest Conservation Working Group, Dar es Salaam.

Schlieben, H.J. (1939). Die forstlichen Vegetationsverhaltnisse Deutsch-Ostafrikas. *Kolonialeforstliche Mitteilungen* **1**: 406–424.

Schmidt, R. (1991). Ecology of a tropical lowland rain forest. *Dissertationes Botanicæ* **179**: 1–213.

Tinley, K.L. (1971). Determinants of coastal conservation: dynamics and diversity of the environment as exemplified by the Moçambique coast. Pp. 126–153. In *Nature Conservation as a Form of Land Use.* Proceedings of the SARCCUS Symposium, Gorongosa, Mozambique.

Vollesen, K. (1980). Annotated check-list of the vascular plants of the Selous Game Reserve, Tanzania. *Opera Botanica* **59**: 1–117.

Vollesen, K. and Bidgood, S. (1992). 'Kew Expedition to Tanzania and Malawi Jan–April 1991'. Unpublished report. Royal Botanic Gardens, Kew.

Wairungu, S., Awimbo, J. and Kigomo, B. (1993). An ecological study of the Nature reserve within the Arabuko-Sokoke Forest Reserve. In Robertson, S.A. and Luke, W.R.Q. (eds.). *Kenya Coastal Forests: Report of the NMK/WWF Coast Forest Survey.* World Wide Fund for Nature, Nairobi.

Welch, J.R. (1960). Observations on deciduous woodland in the Eastern Province of Tanganyika. *Journal of Ecology* **58**: 557–573.

White, F. (1983). *The Vegetation of Africa.* UNESCO, Paris.

Whitmore, T.C. (1986). *Tropical Rainforests of the Far East.* 3rd edition. Oxford University Press/ELBS, Oxford.

Wild, H. and Grandvaux Barbosa, L.A. (1967). *Vegetation Map of the Flora Zambesiaca Area.* Descriptive memoir: 71pp. M.V.O. Collins (Pvt.) Ltd, Salisbury, Harare.

3.3 Vegetation structure

A.J. Lowe and G.P. Clarke

Introduction

The preceding chapter has attempted to produce a qualitative summary of the community (species composition) complexity of the Coastal Forests, concentrating on the canopy trees. There are currently insufficient quantitative data on these forests to carry out a statistical analysis/ordination of their tree species communities, and we believe that this situation is unlikely to change in the foreseeable future given the amount of data required. Sufficient dimensional data are nonetheless available to summarise variations in Coastal Forest tree sizes from different forest areas, and to group structurally similar forest plots using multivariate statistical methods. We present here the results of such an analysis, using data from 50 plots in 21 forests (amounting to nearly 3000 trees covering a combined area of over 4.4ha), sampled along the entire length of the Tanzanian coast (Figure 3.3.1), and discuss the influence on forest physiognomy of (a) disturbance, edaphic and climatic conditions, and (b) the percentage of legumes in the tree canopy.

Method

Data were collected over a five-year period (1989–1994) in plots of varying sizes, although the selection of plot sites was in every case consistent and based on the criteria of Johns (1988), i.e. sites confined to ridge tops, hillsides or valleys, without evidence of recent human disturbance, and in an apparently uniform vegetation type. Plots were located at random within the chosen sites, either as a single large plot or as 16 smaller 100m^2 plots (following Greig-Smith, 1983). The large plots used for this analysis varied in size from 0.012 to 0.25ha as they were originally constructed to produce transect diagrams, to assess disturbance and/or to measure structural and species-composition differences. However, we believe that structural data from all of these plots can be justifiably compared in a single analysis given (a) the preliminary nature of this comparison, which is based on mean values, rather than variances, (b) the scarcity of other data, (c) the standardised random selection of sites, and (d) that plot area is taken into account where appropriate, by carrying out the analysis on stem density rather than on the absolute number of stems. The total plot areas for each site and the number of trees measured are presented in Table 3.3.1.

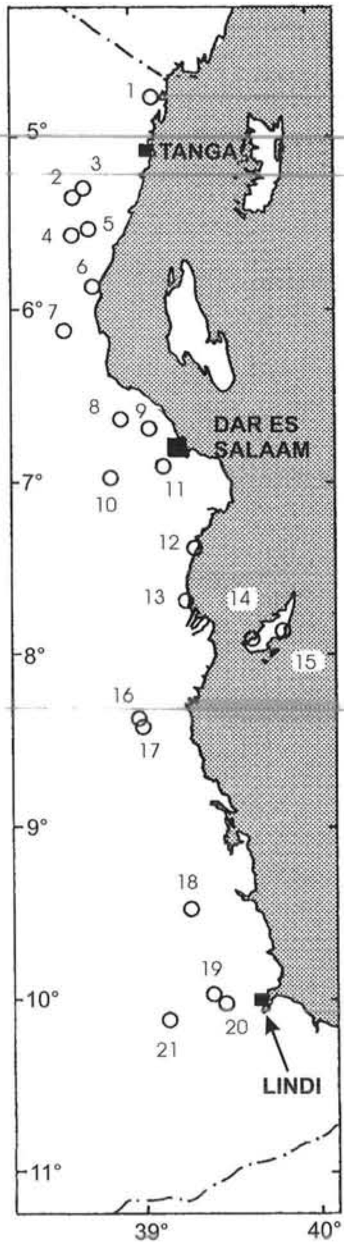


Figure 3.3.1 Locations of Coastal Forest plot sites used in this study. 1. Kilulu, 2. Pangani Falls, 3. Tongwe, 4. Gendagenda, 5. Msubugwe, 6. Mkwaja, 7. Kiono, 8. Ruvu North, 9. Pande, 10. Ruvu South, 11. Kazimzumbwi, 12. Kisiju, 13. Mchungu, 14. Kilindoni, 15. Mrora, 16. Namakutwa, 17. Tong'omba including Namburika Hill, 18. Pindiro, 19. Chitoa, 20. Litipo, 21. Rondo.

Structural measurements were recorded for all trees in each plot with a DBH (Diameter at Breast Height, i.e. 1.3m above ground) exceeding 10cm. These structural

Table 3.3.1 Structural parameters for each of the 50 forest areas analysed; plot area (ha), sample size (n), estimated canopy height (m), mean tree height (m), mean tree DBH (m), total stem density/ha, stem density/ha of tree DBH classes 10–20cm, 20–50cm and >50cm, basal area/ha and legume dominance class.

Site	Area (ha)	Sample size (n)	Est. canopy height (m)	Mean tree height (m)	Mean tree DBH (m)	Total stem density (trees/ha)	Stem density/ha by DBH class			Basal area (m^2/ha)	Legume dominance class
							10–20 (cm)	20–50 (cm)	>50 (cm)		
Kilulu A	0.030	21	12.7	11.4	0.269	700	300	400	0	28.8	4
Kilulu B	0.030	21	14.5	12.0	0.180	700	400	300	0	17.8	3
Kilulu C	0.030	13	12.7	10.1	0.173	433	300	133	0	10.2	3
Tongwe A	0.030	16	21.7	21.7	0.355	533	267	100	167	53.1	1
Tongwe B	0.030	12	19.8	19.8	0.401	400	0	267	133	50.5	1
Pangani Falls	0.160	58	21.9	19.6	0.200	360	119	206	35	11.3	4
Gendagenda A	0.025	14	15.5	12.6	0.296	560	40	480	40	38.5	1
Gendagenda B	0.030	15	13.9	14.0	0.277	500	267	200	33	30.1	2
Gendagenda C	0.030	10	9.2	10.3	0.160	333	267	67	0	6.6	1
Gendagenda D	0.030	15	15.5	16.0	0.273	500	167	300	33	29.2	1
Gendagenda E	0.030	20	12.6	11.5	0.288	667	233	300	133	43.7	2
Gendagenda F	0.030	20	11.3	11.3	0.233	667	333	267	67	28.4	1
Gendagenda G	0.030	27	14.9	12.2	0.243	900	500	333	67	41.7	4
Gendagenda H	0.030	20	16.4	16.4	0.246	667	333	333	0	31.9	1
Gendagenda I	0.030	27	15.8	14.4	0.264	900	467	333	100	49.3	2
Gendagenda J	0.250	114	13.9	10.2	0.259	456	168	268	20	24.0	1
Msubugwe	0.030	16	21.3	18.4	0.220	533	333	167	33	20.2	4
Mkwaja	0.030	17	11.3	10.5	0.184	567	367	200	0	15.1	4
Kiono	0.053	28	17.1	15.4	0.267	530	302	133	95	31.3	3
Ruvu North	0.160	47	19.8	14.1	0.222	294	70	212	12	11.4	2
Pande	0.050	8	15.7	14.1	0.225	160	80	80	0	6.4	4
Ruvu South	0.250	49	9.8	10.7	0.238	196	104	84	8	8.9	1
Kazimzumbwi 1	0.250	93	12.2	9.9	0.167	372	300	24	48	8.2	1
Kazimzumbwi 2	0.075	40	14.4	9.9	0.204	533	373	133	27	16.4	1
Kazimzumbwi 3	0.250	148	16.1	11.4	0.169	592	444	144	4	13.3	1
Kazimzumbwi 4	0.025	11	14.3	13.5	0.248	440	280	80	80	21.3	1
Kisiju 1	0.160	49	22.0	18.4	0.281	306	125	156	25	19.0	4
Kisiju 2	0.160	35	21.6	17.6	0.295	219	75	119	25	14.9	2
Mchungu	0.150	66	17.0	15.1	0.285	440	100	327	13	28.1	4
Mrora 1	0.050	17	12.2	8.5	0.269	340	200	60	80	19.3	1
Mrora 2	0.250	72	9.5	9.5	0.222	288	*	*	*	11.2	1
Mrora 3	0.050	22	15.5	9.9	0.277	440	240	140	60	26.5	1
Mrora 4	0.240	82	12.2	9.7	0.186	342	*	*	*	9.3	1
Kilindoni	0.040	10	17.0	15.8	0.445	250	50	100	100	38.9	3
Namakutwa 1	0.160	88	17.4	15.2	0.226	550	331	181	38	22.0	1
Namakutwa 2	0.160	95	15.3	12.7	0.162	594	456	138	0	12.2	1
Namakutwa 3	0.160	54	16.2	12.7	0.234	338	187	131	18	14.5	1
Tong'omba Hill	0.160	49	25.1	18.8	0.277	310	92	193	25	18.7	1
Tong'omba Riverine	0.160	22	19.6	18.2	0.290	138	*	*	*	10.0	1
Namburika Hill	0.160	22	18.2	12.3	0.259	138	68	56	12	7.3	1
Pindiro 1 (A+B)	0.012	10	12.9	12.5	0.358	833	500	167	167	29.8	1
Pindiro 2 (C+D)	0.012	11	14.8	13.3	0.215	917	583	333	0	17.7	1
Pindiro 3 (E+F)	0.012	11	15.4	14.9	0.269	917	333	500	83	22.2	1
Chitoa	0.030	30	15.2	12.6	0.221	1000	533	433	33	38.3	1
Litipo 1	0.160	49	17.0	14.6	0.210	306	156	125	25	10.7	4
Litipo 2	0.160	62	14.8	12.1	0.178	387	244	143	0	9.7	1
Litipo Lake	0.030	13	12.3	8.6	0.208	433	300	67	67	13.6	1
Rondo Plantation	0.160	48	14.9	13.4	0.189	300	238	50	12	8.4	1
Rondo Transect	0.030	24	26.3	22.2	0.339	800	300	333	167	72.3	1
Rondo Control Plot	0.062	30	30.2	17.0	0.254	484	210	145	129	24.5	1

Notes: Forest locations arranged north to south. Structural characters calculated from original data on sample size, total area, tree height and DBH collected from each forest plot. Missing data indicated by an asterisk. Legume dominance classified such that: Class 4 = >75% legumes; Class 3 = 50–75% legumes; Class 2 = 25–50% legumes; and Class 1 = < 25% legumes.
Sources: Clarke, 1995; Clarke and Dickinson, 1995; Clarke and Stubblefield, 1995; Unpublished Frontier data; Hørlyck, 1995.

measurements included tree height, DBH and crown area (methodology after Johns, 1988), enabling standard ecological parameters to be calculated for all trees above 10cm DBH in each plot, i.e. average tree height, average tree DBH, total stem density/ha, stem density/ha of trees split into DBH classes (10–20cm, 20–50cm and greater than 50cm) and basal area/ha. In addition, by reconstructing transect diagrams, canopy height was estimated by averaging the height of trees that formed a continuous upper canopy. A summary of the results is presented in Table 3.3.1.

Qualitative notes on the condition (level of human disturbance where evident, and past disturbance where known), aspect and other important edaphic features were taken for each site. Specimens of trees which could not be identified in the field were collected and then identified as far as possible at the University of Dar es Salaam herbarium, at the Royal Botanic Gardens, Kew, and at the Botanisk Museum, Copenhagen. A brief description of the sites, including forest character, latitude, altitude and distance from the sea and their tree species assemblages is given in Table 3.3.2, and the data are also summarised elsewhere (see Clarke, 1995; Clarke and Dickinson, 1995; Clarke and Stubblefield, 1995). From field and specimen identifications, sites were placed into one of four classes based on the degree of legume dominance of trees >10cm DBH (Table 3.3.1).

Hierachical cluster analysis was used to group forest sites based on their structural measurements (following Manly, 1986). Firstly, structural data were correlated to examine the relationship between variables (Table 3.3.3). Due to highly significant inter-correlation between total stem density and stem densities of most of the three DBH classes, and between mean tree height and estimated canopy height, only the following four measurements were used in the multivariate analysis; mean tree height, mean tree DBH, total stem density and basal area. To ensure equal weighting of these four variables, they were standardised to a mean of zero and unit standard deviation. Squared euclidean distances, calculated using the statistical package SPSS 6.0 (Norusis, 1993), were used to construct a dendrogram by averaging between group linkages, otherwise known as the unweighted pair-group method using arithmetic averages (UPGMA).

Table 3.3.3 Statistical inter-correlation between all structural parameters measured from the 50 plots (expressed as correlation coefficients and level of significance for a two tailed coefficiency test, *P*).

					Stem density/ha		
	Est. canopy height (m)	**Mean tree height (m)**	**Mean tree DBH (m)**	**Total stem density/(ha)**	**DBH 10–20(cm)**	**DBH 20–50(cm)**	**DBH >50(cm)**
Basal area/ha	0.254	0.447	0.682	0.561	0.118	0.528	0.726
P	0.075	0.001	0.000	0.000	0.431	0.000	0.000
Stem density/ha	0.282	0.378	0.683	0.291	0.041	0.064	
(DBH >50cm) *P*	0.055	0.009	0.000	0.047	0.784	0.667	
Stem density/ha	-0.026	0.153	0.191	0.724	0.236		
(DBH 20–50cm) *P*	0.861	0.304	0.198	0.000	0.111		
Stem density/ha	-0.354	-0.280	-0.366	0.803			
(DBH 10–20cm) *P*	0.015	0.057	0.011	0.000			
Total stem	-0.146	-0.015	0.018				
(density/ha) *P*	0.311	0.919	0.899				
Mean tree DBH	0.342	0.516					
P	0.015	0.001					
Mean tree height	0.825						
P	0.000						

Table 3.3.2 Forest type, latitude, altitude, distance from the coast and main tree species composition.

Site name	Type of forest and main edaphic features	Latitude (decimal)	Altitude (m)	To sea (km)	Dominant species
Kilulu A	Dry forest, hill top	4.76	250	5	*Cynometra webberi* and *Scorodophloeus fischeri* with *Manilkara sulcata.*
Kilulu B	Dry forest, hill top	4.76	250	5	*Scorodophloeus fischeri* and *Cynometra webberi.*
Kilulu C	Dry forest, hill top, logged during 1950s	4.76	250	5	*Cynometra webberi* and *Scorodophloeus fischeri* with *Craibia* sp. and *Cola* sp.
Tongwe A	Dry forest, hillside	5.30	400	40	Diverse tree assemblage with *Scorodophloeus fischeri, Pancovia holtzii, Sorindeia madagascariensis* and *Sterculia appendiculata.*
Tongwe B	High altitude/ moist forest on well drained ridgetop	5.30	500	40	*Pachystela msolo* with *Tabernaemontana pachysiphon.* Other species not identified.
Pangani Falls	Dry forest, hillside	5.33	180	40	*Cynometra brachyrrachis* with *Manilkara sansibarensis* and *Scorodophloeus fischeri.*
Gendagenda A	Mixed dry forest, hillside/ridge	5.33	350	40	*Diospyros kabuyeana* and *Ludia mauritiana* with *Combretum schumannii, Lecaniodiscus fraxinifolius, Cola* sp., *Dalbergia* sp. and *Drypetes* sp.
Gendagenda B	Moist forest, valley bottom, disturbed	5.53	150	40	*Strychnos henningsii, Combretum schumannii* and *Scorodophloeus fischeri* with *Lecaniodiscus fraxinifolius* and *Afzelia quanzensis.*
Gendagenda C	Dry scrub forest, disturbed	5.53	130	40	*Grewia holstii* and *Lecaniodiscus fraxinifolius* with *Combretum schumannii, Dobera loranthifolia* and *Strychnos henningsii.*
Gendagenda D	Moist riverine forest	5.53	180	40	*Scorodophloeus fischeri* and *Cola* sp. with *Strychnos henningsii, Pandanus rabaiensis, Milicia, Sorindeia, Bombax* and *Celtis africana.*
Gendagenda E	Dry forest	5.53	200	40	*Scorodophloeus fischeri* and *Croton jatrophoides* with *Balanites maughamii, Ludia mauritiana, Manilkara sulcata* and scattered *Adansonia digitata.*
Gendagenda F	Dry evergreen forest, rocky outcrops	5.53	350	40	*Diospyros kabuyeana* with *Julbernardia magnistipulata* and *Diospyros consolatae.*
Gendagenda G	Dry evergreen forest	5.53	250	40	*Cynometra brachyrrachis* with *Croton jatrophoides, Afzelia quanzensis* and *Scorodophloeus fischeri.*
Gendagenda H	Dry evergreen forest	5.53	350	40	*Strychnos henningsii* with *Lecaniodiscus fraxinifolius.*
Gendagenda I	Dry mixed forest	5.53	250	40	*Craibia brevicaudata* and *Combretum schumannii* with *Croton jatrophoides* and *Diospyros kabuyeana.*
Gendagenda J	Mixed dry forest, on a hillside/ridge	5.33	350	40	*Diospyros kabuyeana* and *Ludia mauritiana* with *Combretum schumannii, Lecaniodiscus fraxinifolius, Cola* sp. and *Drypetes* sp.
Msubugwe	Dry forest on a small rise	5.53	110	40	*Scorodophloeus fischeri, Cynometra webberi* and *Manilkara sulcata* with *Croton pseudopulchellus, Hymenaea verrucosa* and *Croton jatrophoides.*
Mkwaja	Dry forest, hill top	5.76	100	7	*Julbernardia magnistipulata* with *Hymenocardia ulmoides* and *Baphia kirkii.*
Kiono	Dry forest, plateau	6.11	300	18	*Cynometra webberi* with *Angylocalyx braunii, Sideroxylon inerme* and *Diospyros verrucosa.*
Ruvu North	Dry forest, shallow hill, highly disturbed	6.55	90	31	*Haplocoelum* sp., *Dialium holtzii, Afzelia quanzensis* and *Cola clavata* with *Dovyalis hispidula, Paropsia braunii* and *Baphia kirkii.*
Pande	Dry forest	6.70	150	16	*Scorodophloeus fischeri* and *Manilkara sulcata* with *Baphia kirkii* and *Manilkara sansibarensis.*
Ruvu South	Dry scrub forest on a shallow hill	6.88	190	74	*Grewia conocarpa, Hymenocardia ulmoides, Zanthoxylum holtzianum, Grewia holstii, Drypetes arguta* and *Haplocoelum* sp.
Kazimzumbwi 1	Dry forest, disturbed	7.10	200	49	*Drypetes natalensis, Zanthoxylum holtzianum, Cussonia zimmermannii, Cassia petersiana, Vitex zanzibarensis* and *Grewia conocarpa.*
Kazimzumbwi 2	Dry forest, disturbed	7.10	200	49	*Mimusops* sp., *Manilkara sulcata* and *Manilkara sansibariensis* with *Grewia conocarpa* and *Millettia* sp.
Kazimzumbwi 3	Moist forest, groundwater, disturbed	7.10	150	49	Prominent *Antiaris toxicaria* with *Pouteria alnifolia, Milicia excelsa, Baphia puguensis, Scorodophloeus fischeri, Trilepesium madagascariensis* etc.
Kazimzumbwi 4	Moist forest, groundwater, disturbed	7.10	150	49	*Grewia conocarpa, Newtonia paucijuga, Albizzia* sp. and *Rinorea* sp.
Kisiju 1	Dry forest, coastal	7.40	10	0	*Hymenaea verrucosa* and *Craibia zimmermannii* with *Sorindeia madagascariensis* and *Sideroxylon inerme.*
Kisiju 2	Dry forest, coastal, disturbed	7.40	10	0	*Hymenaea verrucosa* and *Manilkara sansibarensis* with *Sorindeia madagascariensis* and *Drypetes natalensis.*

Table 3.3.2 Forest type, latitude, altitude, distance from the coast and main tree species composition (cont.)

Site name	Type of forest and main edaphic features	Latitude (decimal)	Altitude (m)	To sea (km)	Dominant species
Mchungu	Dry forest, coastal, close to swamp forest areas	7.70	10	0	*Hymenaea verrucosa* and *Baphia kirkii* with *Afzelia quanzensis* and *Manilkara* sp.
Mrora Coral Rag	Dry forest with occasional coral blocks	7.88	5	0	*Diospyros consolatae, Tarenna nigrescens* and *Xylotheca tettensis.*
Mrora Pavement	Dry scrub forest on a coral rag pavement	7.88	5	0	*Diospyros consolatae* and *Lannea schweinfurthii* with *Tarenna nigrescens, Vepris, Ricinodendron heudelottii, Sideroxylon inerme* and *Xyloteca tettensis.*
Mrora Ecotone	Forest on deep soil to coral rag transition	7.88	5	0	*Lannea schweinfurthii* and *Diospyros consolatae.*
Mrora Forest	Dry forest on deep soil	7.88	5	0	*Lannea schweinfurthii* and *Diospyros consolatae* with *Memecylon sansibaricum, Sterculia africana* and *Terminalia boivinii.*
Kilindoni	Dry forest, on a slope by the coast	7.92	60	0	*Hymenaea verrucosa* and *Baphia kirkii* with naturalised exotic mango trees *Mangifera indica.*
Namakutwa 1	Semi-deciduous dry forest cleared in 1912	8.38	380	31	*Lettowianthus stellatus* and *Ricinodendron heudelottii* with *Croton sylvaticus, Diospyros verrucosa, Leptactina platyphylla* and *Markhamia obtusifolia.*
Namakutwa 2	Dry forest cleared in 1962	8.38	380	31	*Ricinodendron heudelottii* with *Croton sylvaticus, Leptactina platyphylla, Vismia orientalis, Bauhinia tomentosa, Markhamia acuminata* and *Millettia bussei.*
Namakutwa 3	Moist forest, in a steep sided valley	8.38	150	31	*Pouteria alnifolia, Sorindeia madagascariensis* and *Ricinodendron heudelottii* with *Diospyros kabuyeana, Dialium holtzii* and *Bridelia micrantha.*
Tong'omba Hill	Moist ground water forest at high altitude	8.41	560	28	*Trilepesium madagascariensis* with *Dichapetalum stuhlmannii, Tabernaemontana pachysiphon* and *Drypetes natalensis.*
Tong'omba Riverine	Moist riverine forest	8.41	330	28	Diverse tree assemblage with *Dichapetalum stuhlmannii, Syzygium guineensis, Pouteria alnifolia, Drypetes arguta* and *Baphia* sp.
Namburika Hill	Dry forest on a hill, site of an old mission station	8.41	450	28	Diverse tree assemblage, partially dominated by an unidentified tree species, with *Rauvolfia* sp. and *Trilepesium madagascariensis.*
Pindiro 1 (A + B)	Dry forest on a low hill	9.50	115	49	Diverse tree assemblage dominated by *Markhamia obtusifolia, Olax pentandra* and *Calancoba welwitschii.*
Pindiro 2 (C + D)	Dry forest on a low hill	9.50	115	49	*Hymenocardia ulmoides* with *Caloncoba welwitschii, Grewia conocarpa, Salacia madagascariensis* and *Strychnos spinosa.*
Pindiro 3 (E + F)	Dry forest on a low hill	9.50	115	49	*Diospyros squarrosa, Euphorbia* sp., *Markhamia obtusifolia, Monodora grandidieri* and *Acacia* sp.
Chitoa	Dry forest on a plateau	9.93	420	45	*Cola clavata* with *Diospyros* sp. aff. *verrucosa, Diospyros quiloensis, Strychnos* sp. aff. *henningsii, Manilkara discolor* and *Terminalia zambesiaca.*
Litipo 1	Dry forest, coppice regenerated since 1900	10.03	180	40	*Berlinia orientalis* with *Rinorea angustifolia* ssp. *ardisiiflora.*
Litipo 2	Dry semi-deciduous forest with some recent logging	10.03	200	40	*Hymenocardia ulmoides* and *Grewia conocarpa* with *Ricinodendron heudelottii, Dialium holtzii, Zanthoxylum holtzianum, Vitex mossambicensis* etc.
Litipo Lake	Moist forest along the shores of Lake Lutamba	10.03	200	40	*Grewia goetzeana, Rinorea elliptica* and *Markhamia obtusifolia* with *Cussonia zimmermannii, Grewia holstii, Mkilua fragans* and *Rhus* sp.
Rondo Plantation	Moist forest on a plateau, disturbed, high altitude	10.13	870	108	*Milicia excelsa* with *Albizzia gummifera* (moribund), *Albizzia petersiana, Celtis africana* and *Cussonia zimmermannii.*
Rondo Transect	Natural moist forest on a plateau, high altitude	10.13	870	108	*Cleistanthus* sp. nov. (= Bidgood *et al.* 1463) with a diverse assemblage of other tree species (*Newtonia, Ricinodendron, Teclea, Dialium, Baphia* etc.).
Rondo Control Plot	Natural moist forest used as control plot, high altitude	10.13	870	108	Diverse tree assemblage with *Milicia excelsa.*

***Note*:** Forest locations arranged north to south. ***Sources*:** Clarke, 1995; Clarke and Dickinson, 1995; Clarke and Stubblefield, 1995; Hørlyck, 1995.

Results

In the total 50 plot sample, the mean height of trees (DBH >10cm) varies from 8.5 to 22.2m, estimated canopy height varies from 9.5 to 30.2m, mean DBH of trees (DBH >10cm) varies from 0.160 to 0.445m, total tree stem (DBH >10cm) density varies from 138 to 1000 stems/ha, and basal area (trees >10cm DBH) varies from 6.4 to 72.3m^2/ha. Maximum values for mean tree height and basal area are recorded from the undisturbed forest plots on the Rondo Plateau (Table 3.3.1).

Structural variations both within and between forest areas can be visualised with the aid of transect diagrams (drawn after the methodology of Richards, 1983). For example, some of the variation between the different sites in Gendagenda forest is demonstrated in Figs. 3.3.2a–d, where the trees in site Gendagenda F (Fig. 3.3.2a) are short with wide tree crowns, in site Gendagenda B (Fig. 3.3.2b) are short with narrow tree crowns, and in site Gendagenda D (Fig. 3.3.2c) are tall with broad tree crowns. Differences in stem density are also clearly demonstrated by the transect diagrams, where Gendagenda G is a site with a very high total stem density (Fig. 3.3.2d) and sites Gendagenda B and D have much lower stem densities (Figs. 3.3.2b and c). The tree physiognomies of dry hilltop forests such as in the Kazimzumbwi 2 (Fig. 3.3.2g) and Mkwaja sites (Fig. 3.3.2h), which are typified by short and widely separated trees, likewise clearly contrast with the moist/riverine forest sites, such as at Mchungu (Fig. 3.3.2e) and in site Tongwe A (Fig. 3.3.2f), which typically contain tall trees with large DBH and narrow crowns. Transect diagrams can, however, only demonstrate the most extreme differences in the structural characteristics of forest sites.

Table 3.3.4 Vegetation structural groupings reoccurring in 50 plot sites from the Coastal Forests of Tanzania.

Group	Structural characteristics	Example sites
1	Very high mean tree height, low mean DBH, low stem density	Pangani Falls, Kisiju 1 and 2, Tong'omba Hill and Riverine
2	Low basal area, low mean DBH, low mean tree height, intermediate stem density	Kilulu B, Mkwaja, Kazimzumbwi 2 and 3, Namakutwa 2
3	Low basal area, low/med. mean tree height, low mean DBH and stem density	Kilulu C, Gendagenda C, Ruvu North, Pande, Ruvu South, Kazimzumbwi 1, Mrora 2 and 4, Namakutwa 3, Namburika, Litipo 1, 2 and Lake, Rondo Plantation
4	Med./high basal area, med./high mean tree height, intermediate DBH and stem density	Gendagenda B, D and H, Msubugwe, Kiono, Kazimzumbwi 4, Mchungu, Namakutwa 1, Rondo Control Plot
5	High basal area, low mean tree height, intermediate mean DBH and stem density	Kilulu A, Gendagenda A, E, F and J, Mrora 1 and 3
6	Very high stem density, intermediate mean tree height, DBH and basal area	Gendagenda G and I, Chitoa, Pindiro 1, 2 and 3
7	Very high mean tree height, very high mean DBH and basal area	Tongwe A and B, Kilindoni, Rondo Transect

Hierarchical cluster analysis, based on mean tree height, mean tree DBH, basal area and total stem density, highlights seven main groups of structurally similar forest sites. The UPGMA dendrogram is shown in Fig. 3.3.3 and the general characters of each of these groups are described in Table 3.3.4. The structural groupings do not follow the geographical proximity of the sites (i.e. the Gendagenda sites are placed in four different groups), but contain sites from many different forest areas. For example, Group 7, which comprises forest sites containing tall trees with large DBH and basal area, is represented by sites located on the Tongwe ridge (one of the most northerly sites) through Kilindoni on Mafia Island to the Rondo plateau (the most southerly site sampled here). The structural groupings are predominantly split by differences in tree stem density, with Groups 4, 5, 6 and 7 comprising sites of intermediate/high tree stem density and basal area, and Groups 1, 2 and 3 comprising sites of low tree stem density. Mean tree height is also an important influence on group classification, for Groups 1, 4, 6 and 7 comprise sites with intermediate to high mean tree height, while Groups 2, 3 and 5 contain

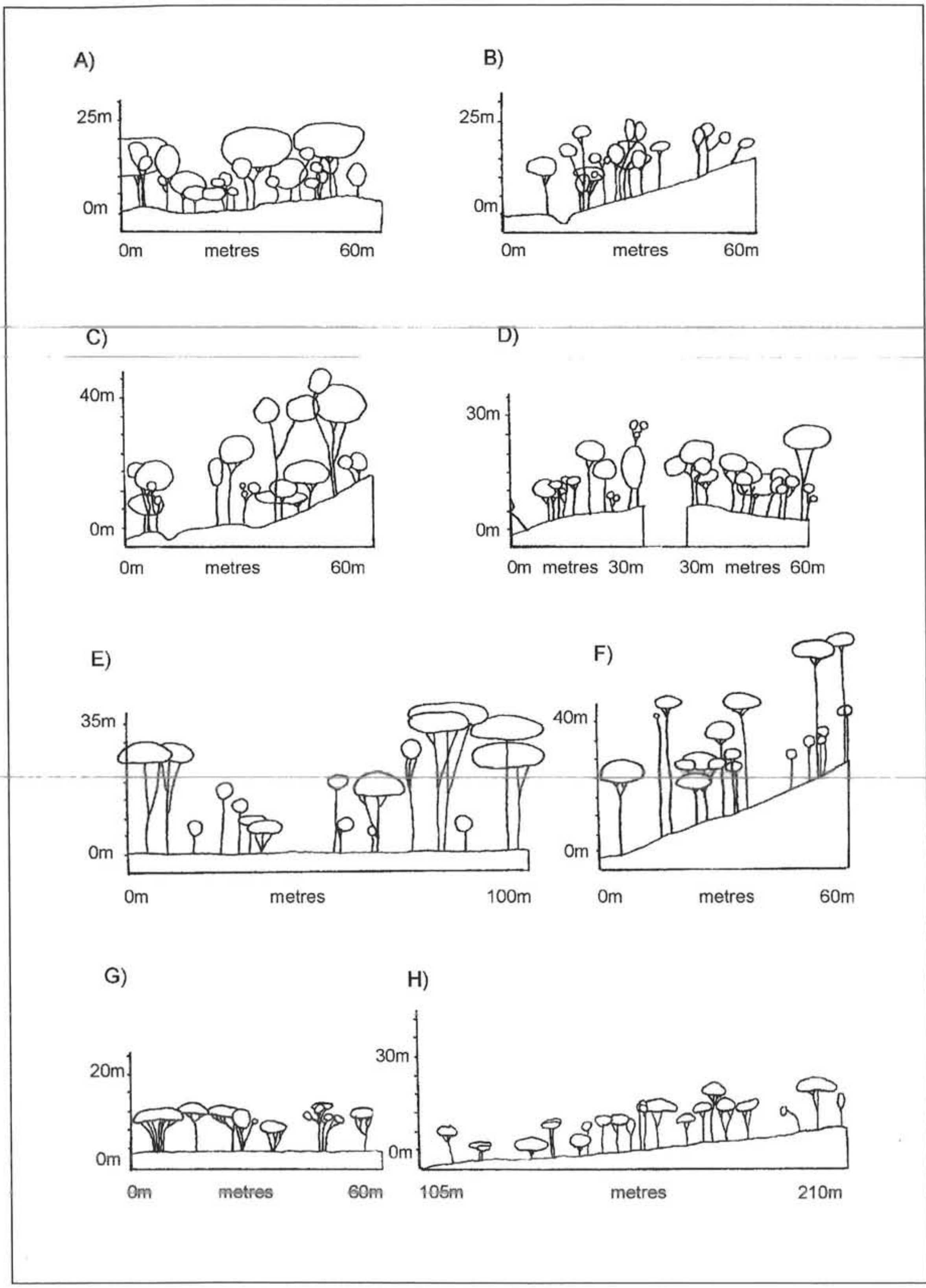


Figure 3.3.2 Eight forest transects showing some of the structural variation within the Coastal Forests of Tanzania. (a) Gendagenda F, dry evergreen forest; (b) Gendagenda B, moist forest in valley bottom; (c) Gendagenda D, moist riverine forest; (d) Gendagenda G, dry evergreen forest; (e) Mchungu, moist semi evergreen forest (data from this transect not included in this study); (f) Tongwe A, moist forest; (g) Mkwaja, dry hilltop forest; (h) Kazimzumbwi 2, dry hill top forest.

sites with low mean tree height. Mean tree DBH is not always correlated with mean tree height, for Group 7 comprises sites with high mean tree height and DBH, whereas Group 1 comprises sites with high mean tree height but low mean tree DBH. In addition, Groups 2 and 3 contain sites with trees of low mean DBH and low mean tree height, whereas Group 5 comprises sites with trees of intermediate mean DBH which also have a low mean tree height.

Discussion

Although many areas of eastern African Coastal Forest were collectively classified as undifferentiated forest by White (1983), due to the difficulty of sub-dividing the highly diverse vegetation communities (cf. Hawthorne, 1993; Chapter 3.2), our study indicates that seven recurring structural forest groupings are nonetheless identifiable from the Coastal Forests of Tanzania. Many of these groups include forest sites that are located hundreds of kilometres apart, and the groups do not necessarily consist of forest blocks from the same geographical area, but are nonetheless demarcated by their structural parameters. Further studies are required to determine whether these groupings recur

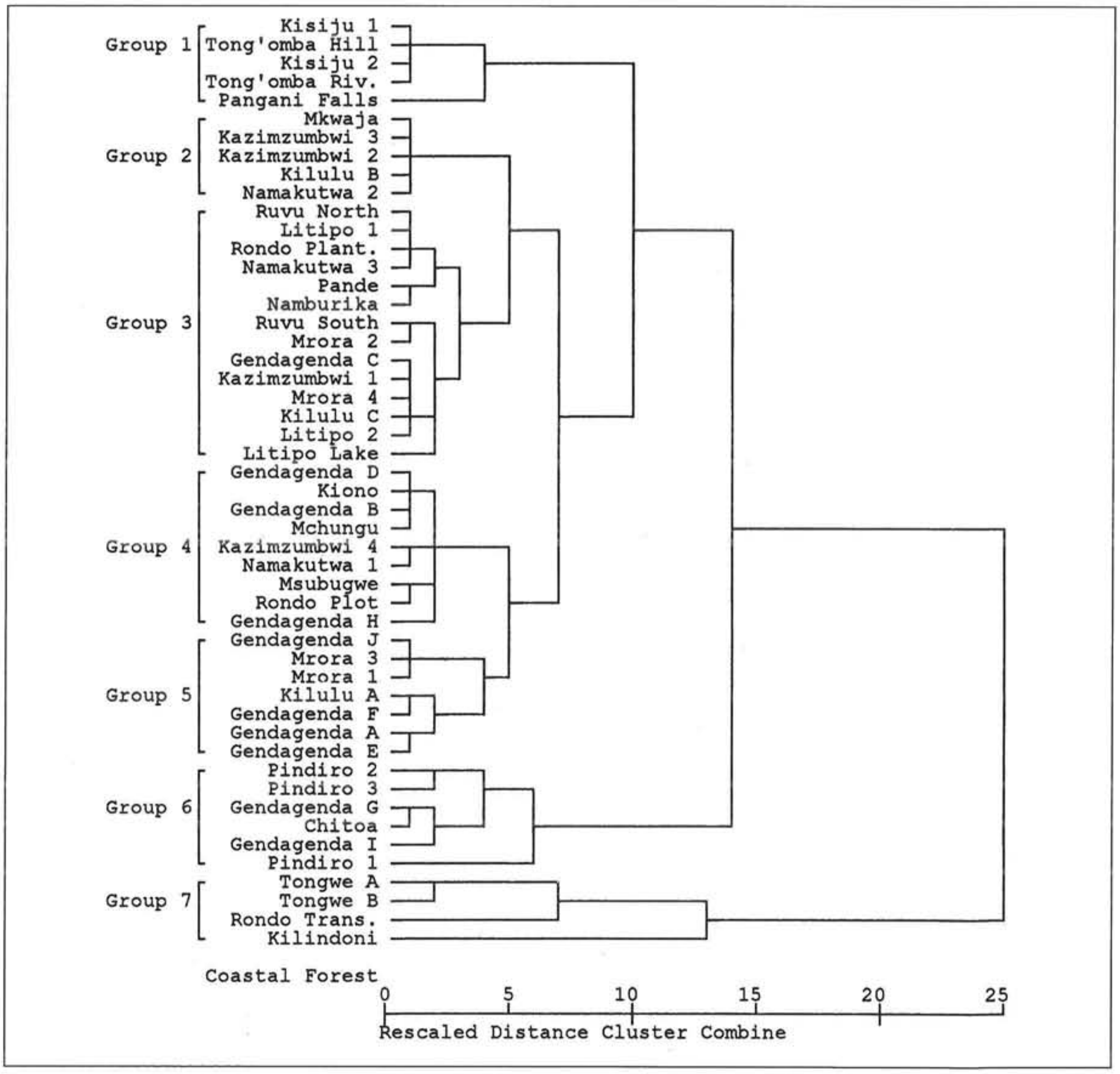


Figure 3.3.3 Dendrogram produced by average linkage among groups (UPGMA) of squared euclidean distances between forest plots. The degree of homology of Coastal Forest plots is expressed by the distance between adjoining nodes and derived by hierarchical cluster analysis of the following standardised, structural parameters; mean tree height, mean tree DBH, total stem density, and basal area (Table 3.3.1).

in other Coastal Forest sites (especially outside Tanzania), and whether the number and degree of separation between the groupings remains constant or is an artefact of our relatively small sample size. However, our findings do suggest that certain structural types may recur, and that rather than being wholly undifferentiated, as they may be floristically, the Coastal Forests consist of a conglomeration of several structural types, a number of which may be present in any single forest.

Influence of edaphic features and human disturbance on structural parameters

It is probable that human disturbance, altitude, water availability and other edaphic features all affect the vegetation structure of forest blocks in the Coastal Forests (cf. Ashton, 1984). While it is not possible to precisely predict the structure of a forest block given certain environmental influences, it is possible to crudely assess the importance of these influences by examining whether they are present or absent (as listed in Table 3.3.2) in each of the previously identified structural groups.

Major human disturbance (particularly agricultural clearance and logging) will reduce the basal area and stem density of a forest stand, and both factors appear to have a consistently important influence on the forest structure of many Coastal Forest sites. Thirteen out of the 14 sites with a known history of disturbance are grouped into the structural classes which are characterised by low to intermediate basal area and stem density (Groups 1, 2, 3 and 4), whilst the remaining site has an intermediate stem density and basal area. These sites include Gendagenda B and C, Kilulu C, Ruvu North, Kazimzumbwi 1, 2, 3 and 4, Namakutwa 1 and 2, Namburika, Litipo 1 and 2 and Rondo Plantation. This result suggests that major human disturbance is a key influence on the vegetation physiognomy of the Coastal Forests, and furthermore that such disturbance remains detectable in the resulting forest physiognomy for many years. For example, the Coastal Forest sites that have been heavily disturbed and have then been allowed to regenerate free from further disturbance may appear to the casual observer to be in pristine condition, but still retain evidence of that disturbance – even 30–80 years after that disturbance took place. This is certainly the case with the Namakutwa plateau forests (Namakutwa 1 and 2), which were completely cleared in 1912 and 1962 respectively, and have since been left to regenerate without further major disturbance, yet still have a low stem density. The forest plots at Litipo 1 and Kilulu C have also been left to regenerate following selective logging (at the turn of the century for Litipo 1, during the 1950s for Kilulu C) and likewise have a low stem density. The Rondo Plantation plot is an untended commercial Mvule (*Milicia excelsa*) plantation from 1960, which also has a low stem density of trees of small stature, whilst the other natural forest plots on the Rondo plateau are structurally much larger and have a higher stem density. Although other factors may restrict the stem density in these plots, we consider that disturbance must be partially responsible for the low stem densities at these sites. Indeed, 42% of the sites in the low stem density plot groups (Groups 1, 2, 3 and 4) have been subjected to some form of known human disturbance, compared with no plots in those higher stem density groups (Groups 5, 6 and 7). This result compares with those from tropical rainforests, in which a disturbed forest block does not recover its original character even centuries after that disturbance took place (Tivy, 1993).

Sites with rocky outcroppings and those containing shallow soil will restrict tree development and may be more prone to desiccation (Chapter 3.2). All four sites on such areas (Gendagenda F, Mrora 1 and 2 and Namakutwa 3) have a tendency towards a lower average tree height (Groups 3 and 5). Conversely, the presence of groundwater and deep soils should produce large, well spaced trees. This is certainly the case for the Tong'omba Hill and Riverine sites, which are in Group 1 and are characterised by a very high mean tree height and a low stem density. The other groundwater plots might have also conformed to this pattern were it not for the interaction of other disturbance/ ecological factors. For example, recent disturbance at Gendagenda B, Kazimzumbwi 3 and 4, and rocky outcrops at Gendagenda D and Namakutwa 3, may both have negated the larger growth promoted by the presence of groundwater, as these sites cluster in Groups 2, 3 and 4, and all exhibit low to intermediate mean tree height and an intermediate stem density.

Five of the seven higher altitude forests are classified as structurally large plots. Of these, Tongwe A and B and Rondo Transect and Control Plot contain tall trees with high DBH at intermediate density

(Groups 4 and 7), while Tong'omba Hill is a plot containing tall canopy trees with large DBH at lower stem density (Group 1). Locally higher rainfall at these sites, due to their greater elevation, is probably responsible for the larger size of trees in these areas. The other two higher altitude sites (Namburika and Rondo Plantation) both have a history of human disturbance, which may obscure any benefit from a favourable climate, until these forests have fully recovered.

Legume dominance

As mentioned previously, the lack of sufficient data precludes comparisons between structural and species composition ordinations. However, it is possible to examine the degree of legume dominance of sites in the identified structural groups, which is an important consideration as legume-dominated assemblages are considered to be the community climax in some types of Coastal Forest (Chapter 3.2), and are characteristic of many forests and woodlands elsewhere in Africa (e.g. White, 1983). Legume-dominated sites are present in all the structural groups, but no particular structural groupings are strongly associated with legume dominance or absence. However, all sites where legumes are strongly dominant (>50%) are dry forests (Kilulu A, B, C, Pangani Falls, Gendagenda G, Msubugwe, Mkwaja, Kiono, Pande, Kisiju 1, Mchungu, Kilindoni and Litipo 1), and there is a notable paucity of legumes in undisturbed forests in groundwater or high rainfall sites (Tongwe A, B, Gendagenda D, Kazimzumbwi 3, 4, Namakutwa 3, Tong'omba Hill, Riverine, Namburika Hill, Rondo Plantation, Transect and Control Plot). Thus, there appears to be a negative association between the moisture availability of sites and legume dominance in the tree assemblage. The frequency with which legume-dominated assemblages occur in the Coastal Forests is also of interest (26% of the sites in this study; see also Chapter 3.2), and further that the legume-dominated assemblages do not appear to be weighted towards a greater woody biomass, in spite of the availability of beneficial nodulating and/or ectomycorrhizal symbiotic associations, which are elsewhere able to increase biomass production on leached nutrient poor soils (Tivy, 1993).

Summary

Coastal Forests contain recurring structural patterns, and seven structural groupings have been delineated from the Tanzanian Coastal Forests. Non-climatic environmental factors (recent disturbance, rocky outcrops and the presence of groundwater) appear to be important influences on the structure of a Coastal Forest. Forests with a history of disturbance have a comparatively low tree stem density, those on a rocky substrate tend to have a comparatively low mean tree height, and groundwater forests tend to have a comparatively high mean tree height. However, when two or more of these influences are present at a site, it is not easy to predict the resulting structural physiognomy, which may in addition be affected by other, unquantified, factors. Higher altitude and groundwater forests, which are subject to a reduced moisture stress, contain a low proportion of trees from the legume family, and tend towards mixed floristic assemblages, whereas all sites which are dominated by legumes are located in dry forests.

This preliminary study supports earlier observations that the highly heterogenous nature of Coastal Forests is the result of complex interactions between climate, groundwater availability, soils, substrate, aspect, disturbance, and biogeographical influences (Hawthorne, 1993). The relative importance of each of these is difficult to unravel, although the effects of disturbance, moisture availability, and the presence/absence of a rocky substrate appear to be very important influences on forest structure. These factors, however, may be less important than climatic, geographical, geological and historical factors in determining vegetation floristics and community associations.

Acknowledgements

Plot data used in this Chapter were collected by the Frontier-Tanzania Coastal Forest Research Programme, a joint initiative of the Faculty of Science of the University of Dar es Salaam (Tanzania) and the Society for Environmental Exploration (UK). Thanks are offered to all who assisted the collection and formulation of the data, especially the Frontier Research Assistants who constructed the plots, and Leigh Stubblefield, Mike Brewin, Paul Matthews, Tertia Waters, Alex Dickinson and Doug Sheil who organised the data collection, Katty Ponder who transcribed much of the data onto computer, Fiona MacIntosh and Paul Smith for diagrammatic interpretation of transect data, and Leonard Mwasumbi, Frank Mbago and Haji Suleiman of the Botany Department of the University of Dar es Salaam and Dr Kaj Vollesen of the Royal Botanic Gardens, Kew for identifying many of the plant specimens. Many thanks also to Neil Burgess for much editorial help in developing this chapter, and to Doug Sheil, Alan Rodgers, William Hawthorne, Jon Fjeldså and Jon Lovett for critical comments on earlier drafts.

References

Ashton, P.S. (1984). Biosystematics of tropical forest plants: a problem of rare species. Pp. 497–518. In Grant, W.F. (ed.). *Plant Biosystematics.* Academic Press, Canada.

Clarke, G.P. (1995). *Status Reports for 6 Coastal Forests in Lindi Region, Tanzania.* Frontier-Tanzania Technical Report No. 18. The Society for Environmental Exploration/The University of Dar es Salaam, London and Dar es Salaam.

Clarke, G.P. and Dickinson, A. (1995). *Status Reports for 11 Coastal Forests in Coast Region, Tanzania.* Frontier-Tanzania Technical Report No. 17. The Society for Environmental Exploration/The University of Dar es Salaam, London and Dar es Salaam.

Clarke, G.P. and Stubblefield, L.K. (1995). *Status Reports for 7 Coastal Forests in Tanga Region, Tanzania.* Frontier-Tanzania Technical Report No. 16. The Society for Environmental Exploration/The University of Dar es Salaam, London and Dar es Salaam.

Greig-Smith, P. (1983). *Quantitative Plant Ecology.* Blackwell Scientific Publications, Oxford.

Hawthorne, W.D. (1993). East African coastal forest botany. Pp. 57–99. In Lovett, J.C. and Wasser, S.K. (eds.). *Biogeography and Ecology of the Rain Forests of Eastern Africa.* Cambridge University Press, Cambridge.

Hørlyck, V. (1995). 'Structure and diversity of a Coastal Forest in Tanzania'. Unpublished Masters Thesis. Faculty of Natural Sciences, Botanisk Museum, Copenhagen.

Johns, R.J. (1988). *Methods of Data Collection in Topical Rainforest Communities.* Paper prepared for the workshop on Forest Ecology and Management, Papua New Guinea University of Technology, Lae, Papua New Guinea.

Manly, B.F.J. (1986). *Multivariate Statistical Methods, a Primer.* Chapman and Hall, London.

Norusis, M.J. (1993). *SPSS for Windows.* Advanced statistics release 6.0. SPSS Inc., Chicago.

Richards, P.W. (1983). The three dimensional structure of tropical rain forest. Pp. 3–10. In Sutton, S.L., Whitmore, T.C. and Chadwick, A.C. (eds.). *Tropical Rain Forest Ecology and Management.* Blackwell, Oxford.

Tivy, J. (1993). *Biogeography; a Study of Plants in the Ecosphere.* Longman, London.

White, F. (1983). *The Vegetation of Africa. A Descriptive Memoir to Accompany the UNESCO/AETFAT/UNSO Vegetation Map of Africa.* 356pp. UNESCO, Paris.

3.4 Comparison with Eastern Arc Forests

J. C. Lovett, J. R. Hansen and V. Hørlyck

Introduction

Different forest types result from an interaction between ecological factors and history: a particular species association may reflect a soil type, a successional stage, a certain climate or species specific characteristics. As the capacity of an assemblage to respond to management intervention will depend on the individual and collective resilience of its biota, the terminology used to describe forest types for management purposes needs to at least approximate to natural ecological divisions, making it easier for the application of appropriate management regimes. From the perspective of conservation, terminology needs to reflect basic underlying differences and gradients in vegetation, so that, for example, a system of protected areas covers representative samples of ecosystems. Eastern African forests are variable in both species composition and structure (Chapters 3.2 and 3.3), and there are many forest type terminologies. In this chapter, two broad divisions of forest type, lowland Coastal Forest and montane Eastern Arc are compared and related to continent-wide phytogeographical classifications.

The Eastern Arc is defined geologically and climatologically as the disjunct range of ancient crystalline mountains in south-eastern Kenya and eastern Tanzania under the direct climatic influence of the Indian Ocean south equatorial current (Lovett, 1990). They range from Mufindi just north of the Makambako gap (which is north of the Lake Nyasa climatic influence), to the Taita Hills of south-east Kenya (Fig. 3.4.1). The Eastern Arc forests are characterised by a high number of restricted range taxa in their biota, which can occur in only a few localities, or are found throughout much of the Arc but not elsewhere (Lovett, 1988, 1993a; Dinesen *et al.*, 1993). In this respect they differ markedly from

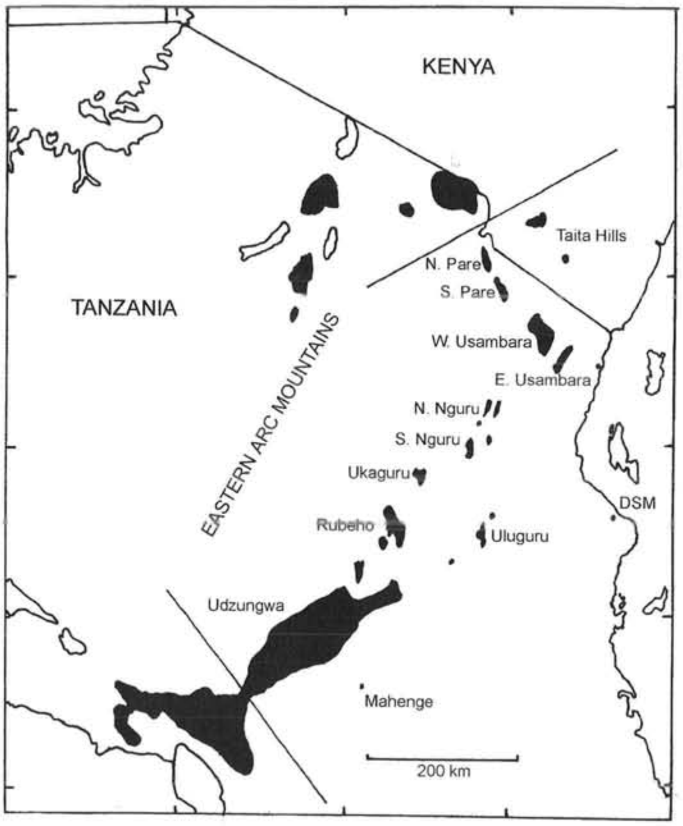


Figure 3.4.1 Location of the Eastern Arc mountains (after Wasser and Lovett, 1993).

forests on the volcanic mountains of Kilimanjaro, Meru and Hanang in northern Tanzania, and from forests south of the Makambako Gap along the Lake Nyasa rift. However, some taxa do range from the Lake Nyasa rift through the Eastern Arc, a pattern recognised by associating the forests together in the Tanganyika-Nyasa Montane Forest Group (Moreau, 1966; Scharff, 1993; Stuart *et al.*, 1993).

The Eastern Arc Mountains rise from the coastal plain at an altitude of 100 to 400 metres, and reach altitudes of over 2000m at distances of 50 to 300km from the coast (Table 3.4.1). Rainfall can be high, exceeding 3000mm/year with perhumid conditions of greater than 100mm of rain in every month of the year on the eastern slopes of the Uluguru Mountains. However, it is more commonly around 1000 to 1500mm/year with two rainy seasons in the northern half and one rainy season in the southern mountains. Geologically these mountain comprise Precambrian crystalline gneiss, with metamorphosed limestone on the eastern foothills in some areas, for example at Kimboza in the Uluguru Mountains, and the Mahenge Mountains in the southern part of the range where even the upper parts are basic rocks. For this Chapter, Coastal Forest is defined as forest on the sedimentary and intrusive volcanic rocks of the coastal plains and plateaux (Hawthorne, 1993), although a wider definition is proposed in Chapter 1.2 (to encompass examples such as Handeni Hill which is composed of gneissic basement rock, but contains species typical of Coastal Forest; Lovett and Pócs, 1993). The highest altitude Coastal Forests are on the Makonde Plateau in Mozambique at around 1000m and the Rondo Plateau in southern Tanzania at just under 900m; the lowest are close to sea-level. Although the Coastal Forests extend from southern Somalia to southern Mozambique, and the Eastern Arc forests are also in south eastern Kenya, only Tanzanian forests are considered in this Chapter as we have no field experience of the other areas. In addition, by limiting the geographical range of our analysis, regional ecological variation can be reduced.

Table 3.4.1 Eastern Arc mountain ranges with elevation, distance from coast and distance to the nearest Eastern Arc mountain to the south.

Name of Eastern Arc mountain range	Maximum elevation (to nearest 10m)	Distance from the coast	Nearest Eastern Arc mountain to the south
Taita	2140m	165km	75km
North Pare	2090m	220km	65km
South Pare	2430m	150km	40km
West Usambara	2280m	100km	10km
East Usambara	1490m	50km	11 km
North Nguru (Nguu)	1500m	150km	50km
South Nguru	2090m	150km	65km
Ukaguru	2240m	220km	65km
Rubeho (Usagara)	2080m	300km	40km
Uluguru	2660m	180km	50km
Malundwe	1250m	270km	50km
Mahenge	1040m	300km	75km
Udzungwa	2580m	270km	

But how different, or similar, are the Eastern Arc and Coastal Forests? The question is more than purely academic, as a difference between Eastern Arc and Coastal Forest is recognised for management purposes, with each forest type being considered separately in the Tanzania Forest Action Plan (Bensted-Smith and Msangi, 1989). Is their separation a matter of convenience or are there physiognomic and floristic differences that can be correlated with environmental factors? The most obvious differences are in the greater altitudinal range and higher rainfall of the Eastern Arc. Physiognomic variation reflects wetter conditions in the mountains. Montane, submontane and lowland Eastern Arc forests in high rainfall areas have a canopy 30–40m tall with emergents to 60m; whereas the relatively drier Coastal Forests are rarely so well developed, having a canopy 8–20m high with emergents to 40m and many more thick woody lianes (see Chapters 1.2 and 3.3). If changes in species composition are correlated with altitude, then a replacement of Coastal Forest trees by montane forest trees would be expected in higher altitude parts of the Eastern Arc. Similarly, if species distributions are related to rainfall, then the wetter Eastern Arc forests would be expected to be more different from the drier Coastal Forests. Any comparison of the two forests needs to make sure that these environmental factors are clearly distinguished to avoid lumping together forest types that are being influenced by quite different factors.

This Chapter aims to compare Coastal and Eastern Arc Forests by analysing the composition and ecology of the tree floras found in each. Division of forest types based on the geographical distribution of their component species are termed phytogeographical classications. By way of example, we will briefly discuss two phytogeographical classifications applied to the forests of eastern Tanzania, that of Monod (1957) and White (1983), which differ in their approach to dividing the forests in the following ways:

1. Eastern African forests should be divided into a lower altitude Zanzibar-Inhambane and higher altitude Afromontane region (White, 1983).
2. High and low elevation eastern African moist forests should be classified together as eastern outliers of the Guineo-Congolian region (Monod, 1957).

In the discussion, some examples of phylogenetic relationships between upper and lower elevation forests are given, together with examples of east-west distribution patterns of Eastern Arc and Coastal Forest tree species.

Phytogeographical classification

Although the Coastal Forests and lower altitude Eastern Arc forests have always been classified together phytogeographically, there is some discussion as to the chorological position of lowland and montane forests. Monod (1957) placed the Coastal and Eastern Arc forests together in a distinct eastern outlier of the Guineo-Congolian region, with the montane forests as a montane facies of the lowland forests, but divided the montane species into those which were true montane plants and those which came from the lowland forests. In contrast, White (1965, 1970) regarded the montane floras on African mountains as being similar, and sufficiently different to those of the surrounding lowlands, to justify the creation of an Afromontane region with a lower altitudinal limit of between 1065 and 1525m. White departed still further from Monod's approach by erecting an eastern phytogeographical region containing the Coastal Forests and lower altitudes of the Eastern Arc forests (White and Moll, 1978). This latter approach is used in the *Vegetation of Africa* (White, 1983), a continent-wide synthesis that is generally accepted and has been widely followed (e.g. MacKinnon and MacKinnon, 1986; Sayer *et al.*, 1992; White, 1993). Additional support for this division was found in altitudinal differences between lowland and montane tree floras in north-east tropical Africa (Friis, 1992). However, Monod's system can be considered preferable for the purposes of phytogeographical classification of the Eastern Arc forests on the basis that there is no clear boundary between lowland and montane tree species associations and there are affinities to the Guineo-Congolian region throughout the elevational range of the forests (Lovett, 1993a; Lovett, in prep.).

Methods

Trees of the Tanzanian Eastern Arc and Coastal Forests included in the analysis were defined as those greater than 10m tall or 20cm diameter at breast height (DBH) recorded from closed canopy forest. Because the Coastal Forest canopy is generally lower than in the Eastern Arc, the use of a consistent height limit means relatively fewer Coastal Forest trees were included in the analysis. The list was compiled from our own field notes, the Copenhagen general herbarium (C), the *Flora of Tropical East Africa* (Turrill and Milne-Redhead *et al.*, 1952-), and published and unpublished reports and papers (Hawthorne, 1993; Lovett, 1992; 1993a; Lovett and Pócs, 1993; Bidgood and Vollesen, 1992; Vollesen, 1980; Moyer, 1992). The species were divided into Eastern Arc and Coastal based on their presence in the geographical areas defined above (with the Kimboza lowland forests included in the

Eastern Arc, although in Chapter 1.2 Kimboza is regarded as a Coastal Forest) and their occurrence in different closed canopy forest formations given in Table 3.4.2. In addition, occurrence in groundwater and riverine forests was also noted, as well as occurrence in the open canopy or non-forest formations of thicket, woodland, grassland and upland heath. A total of 495 species were recorded with 393 species in Eastern Arc and 232 species in Coastal Forest, of which 130 species occurred in both.

Table 3.4.2 Definitions of forest formations used here. Terminology is based on that of Pócs (1976a; 1976b).

Forest	Altitude (m)	Rainfall (mm/yr)
Dry lowland	0–800	1000–1500
Lowland	0–800	1500 >2000
Dry submontane	800–1250	1500–2000
Submontane	800–1250	2000–>3000
Dry montane	1250–2900	900–1500
Montane	1250–1800	1500–>3000
Upper montane	1800–2900	1500–>3000

Three different ecological matrices were compiled. One for all the tree species in this list which occur in Coastal Forests; one for all tree species in this list which occur in Eastern Arc Forests; and one for the species which occur in both Coastal Forest and the Eastern Arc. The matrices were compiled by adding up the numbers of species occurring in different combinations of vegetation formations. Because the table is two dimensional, a species with a wide ecological amplitude can occur in more than one combination of vegetation formations.

Composition of different forest formations for all Coastal Forest and all Eastern Arc species was compared in terms of how broad the ecological range of the species occurring in them was, using an Ecological Amplitude Index (EAI) where:

Ecological Amplitude Index = $(\Sigma v_i)/n_i$

v_i = number of vegetation types in which each species $_i$ occurs.

n_i = total number of species $_i$ in each vegetation type.

The Ecological Amplitude Index thus gives the mean number of different vegetation types the species of each forest type occur in.

An index of similarity was calculated by comparing the tree species occurring in different forest types in the Eastern Arc with the total Coastal Forest tree flora using Dice's Similarity Index (Dice, 1945) where:

Dice's Similarity Index = C/n_{min}

C = number of species occurring in both Coastal Forest and Eastern Arc in each vegetation type.

n_{min} = the lowest number of species from the two samples being compared.

For the forest type comparisons n_{min} is always the number of trees in one of the Eastern Arc vegetation types, as this is lower than the total number of trees in the Coastal Forests. Total similarity between the Eastern Arc and the Coastal Forests was calculated using the same method.

Results

The total number of all Coastal Forest species, all Eastern Arc species and species which are found in both Coastal Forest and Eastern Arc in each vegetation type are shown in Fig. 3.4.2. As would be expected, most of the Coastal Forest species are found in riverine, dry lowland and lowland forests, with progressively fewer species occurring in higher altitude forest types. However, a relatively high proportion of Coastal Forest trees also occur in the non-forest or open canopy formations of woodland and thicket. Eastern Arc species show a peak in abundance in wetter low to mid-altitude forests, with fewer species in drier and higher altitude forest types.

Ecological matrices for all Coastal Forest species, all Eastern Arc species and species which are found in both Coastal Forest and Eastern Arc in each vegetation type are presented in Table 3.4.3. Few of the Coastal Forest species in our sample have a narrow ecological amplitude, with most species occurring in several different vegetation types. By contrast, many Eastern Arc species are restricted to a single vegetation type. The mid-altitude peak of 149 species in submontane forests in the Eastern Arc, is largely composed of a mixture of lowland and montane trees with 68 species also occurring in lowland forests, and 66 in montane forests. Both montane and submontane forests have relatively large numbers of species restricted to a single formation (40 and 47 species respectively).

The Ecological Amplitude Indices for Coastal Forest and Eastern Arc species occurring in different vegetation types are shown in Fig. 3.4.3. Coastal Forest species which occur in high altitude forests or grassland also occur in a number of other vegetation types giving a high EAI. However, Coastal Forest species occurring in woodlands and thicket are found in a similar number, or fewer, vegetation types as species occurring in lowland forest formations, suggesting that species in the latter formation are tolerant of as wide a range of ecological conditions. In contrast, Eastern Arc higher altitude species are found in relatively few other vegetation types, suggesting that the higher up the mountains the species are found, the more specialised they become.

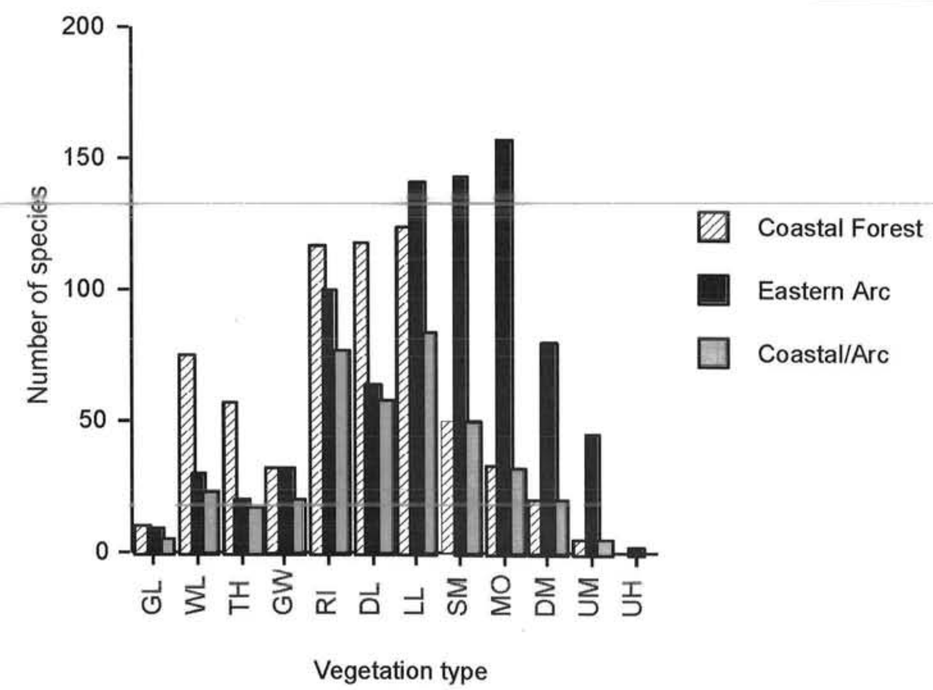


Figure 3.4.2 Total number of all Coastal Forest species, all Eastern Arc species and species which are found in both Coastal Forest and Eastern Arc vegetation types. Vegetation types: GL–grassland, WL –woodland, TH–thicket, GW–groundwater, RI–riverine, DL–dry lowland, LL–lowland, SM–sub-montane, MO–montane, DM–dry montane, UM–upper montane, UH–upland heath.

Table 3.4.3 Ecological matrices of numbers of tree species occurring in different vegetation formations for: Coastal Forest (232 species); Eastern Arc (393 species); and both Coastal Forest and Eastern Arc (130 species).

Coastal Forest

	GL	WL	TH	GW	RI	DL	LL	SM	MO	DM	UM
GL	*0*	7	3	1	4	10	3	1	1	2	1
WL		*0*	30	4	30	38	29	1	2	3	1
TH			*0*	3	20	43	20	2	2	3	0
GW				*0*	29	7	25	11	5	1	1
RI					*2*	52	74	28	18	11	2
DL						*6*	35	11	9	16	2
LL							*14*	42	24	3	4
SM								*1*	23	4	1
MO									*0*	6	4
DM										*0*	3
UM											*0*

Eastern Arc

	GL	WL	TH	GW	RI	DL	LL	SM	MO	DM	UM
GL	*0*	4	2	2	4	6	3	1	1	5	1
WL		*0*	7	2	19	16	16	8	6	6	2
TH			*0*	2	10	11	9	2	2	6	0
GW				*0*	28	5	26	15	7	3	1
RI					*3*	38	64	33	22	15	2
DL						*3*	34	12	10	18	3
LL							*19*	68	32	4	4
SM								*40*	66	9	8
MO									*47*	30	35
DM										*22*	23
UM											*7*

Coastal Forest and Eastern Arc

	GL	WL	TH	GW	RI	DL	LL	SM	MO	DM	UM
GL	0	3	1	0	2	6	2	1	1	2	1
WL		*0*	7	1	14	16	15	8	3	5	2
TH			*0*	1	7	11	9	2	2	3	0
GW				*0*	20	5	19	10	5	1	1
RI					*2*	37	55	26	17	11	2
DL						*0*	29	12	8	17	2
LL							*4*	42	22	2	3
SM								*1*	21	4	1
MO									*0*	7	4
DM										*0*	3
UM											*0*

Key: GL–grassland, WL–woodland, TH–thicket, GW–groundwater, RI–riverine, DL–dry lowland, LL–lowland, SM–submontane, MO–montane, DM–dry montane, UM–upper montane. Figures in italics are for trees which occur in only one vegetation formation.

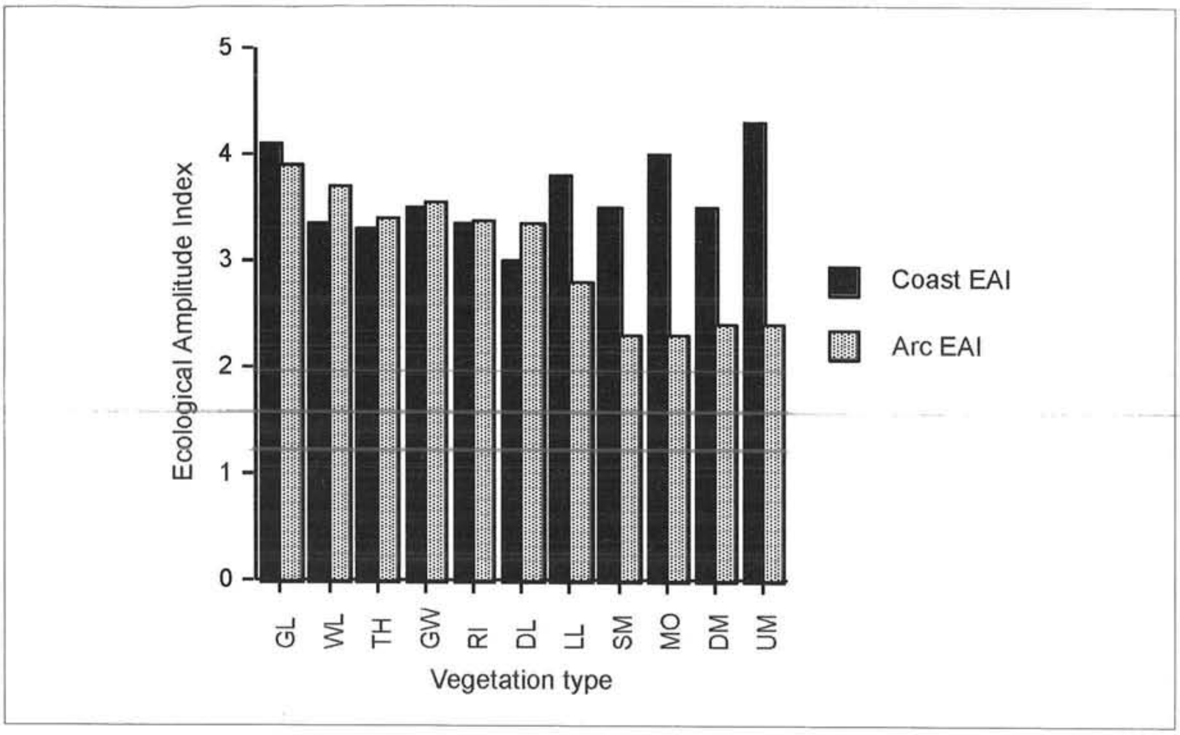


Figure 3.4.3 Ecological Amplitude Indices (EAI) for Coastal Forest and Eastern Arc species occurring in different vegetation types. Vegetation types: GL–grassland, WL–woodland, TH–thicket, GW–groundwater, RI–riverine, DL–dry lowland, LL–lowland, SM–sub-montane, MO–montane, DM–dry montane, UM–upper montane.

Table 3.4.4 Similarity between Coastal Forest and different forest formations in the Eastern Arc calculated using Dice's Similarity Index (Dice, 1945).

Forest formation	Similarity index
Dry lowland	0.85
Lowland	0.63
Submontane	0.35
Montane	0.19
Dry montane	0.25
Upper montane	0.11
Total similarity	0.56

Similarity indices comparing all the Coastal Forest species with species from each Eastern Arc forest type are given in Table 3.4.4. Nearly 60% (similarity index = 0.56) of the species found in the Coastal Forests are also found in the Eastern Arc. Dry lowland forest of the Eastern Arc is most similar to the Coastal Forests with a similarity index of 0.85 (although in both cases the presence of widespread species accounts for much of this similarity). In the moister forest types, similarity declines with increasing altitude. However, 25% of dry montane forest species are also found in Coastal Forest compared to only 19% of species in the montane forest.

Discussion

Initially we will discuss elevational relationships between the Coastal and Eastern Arc forests, and then discuss some examples of east-west distribution patterns. The conservation management implications of the findings are considered in the conclusion.

The results show a progressive decline with altitude of the number of Coastal Forest tree species in different forest types in the Eastern Arc. It should be noted, however, that these data are for large trees, and Coastal Forest species in particular occur at sizes below the sampling limit. Against this general trend, one quarter of the Dry Montane Forest species are also found in Coastal Forests (mainly widespread species). This observation supports the suggestion that species exposed to seasonal environmental fluctuations will be expected to have a wider geographical or elevational range than those in a less seasonal climate, as each individual of the species must have broad climatic tolerance to survive (Stevens, 1992). Similarly, the Ecological Amplitude Indices show that Coastal Forest species occur in a greater range of vegetation types than Eastern Arc montane species. This could reflect the relatively more seasonal climate in the coastal lowlands compared to the moist mid-altitudes of the mountains, and furthermore suggests that species differences between the Coastal Forests and wet montane Eastern Arc forests are due to the environmental parameter of climatic seasonality rather than an underlying difference in phytogeographical affinity. The more seasonal and drier the climate in the montane forests, the greater the similarity with the Coastal Forests. The phytogeographical implication is that there is no particular reason to separate the montane and lowland forests into an Afromontane and Zanzibar-Inhambane region.

Many moist submontane and montane species may be relatively restricted ecologically compared to trees in drier forest formations, but their closest extant phylogenetic relatives may nonetheless be lower elevation taxa. This might not be true of all taxa, for some montane species are 'true montane plants without lowland affinities' (Monod, 1957), just as many Coastal Forest species are restricted to the lowlands. An example of a montane species with lowland affinities is the Eastern Arc endemic *Hirtella megacarpa* which is ecologically separated from the coastal *Hirtella zanzibarica*, but is sufficiently similar for some botanists to consider them to be the same species (White, 1976). Similarly, the montane *Zenkerella perplexa* appears to be derived from the lowland *Zenkerella egregia* (Temu, 1990a). Both species are restricted in distribution to the Eastern Arc and tropical eastern African Coastal Forests. An example of related lowland and montane taxa which are distinguished below species level, is *Drypetes usambarica* which has five varieties ranging from lowland Coastal Forests to submontane Eastern Arc forests (Radcliffe-Smith, 1990). Some species have disjunct lower and higher altitude populations, for example, the montane forest *Campylospermum scheffleri*, an Eastern Arc endemic, has high altitude populations in the West Usambara and Uluguru Mountains at around 1900–2000m and a lower altitude population in the East Usambaras at around 1000m. Similarly, *Synsepalum cerasiferum*, a widespread lowland forest tree, has high altitude populations at around 1900m in the Nguru and Uluguru Mountains; and *Khaya anthotheca*, a lowland and riverine tree, has high altitude populations in the Udzungwa mountains at 1700m.

The second point considered here is differentiation of the forests into eastern and western phytogeographical regions. At the species level, 78% of the Eastern Arc low altitude trees also occur in the West and Central African forests (Lovett, 1993a and 1993b). In north-east tropical Africa, lowland forests from the eastern coast and south-west Ethiopia cluster together on the basis of species presence and absence using Jaccard's Coefficient of Similarity and clustering with the Unweighted Pair-Group Method (Friis, 1992). In the Eastern Arc, both montane and lowland species (Lovett, 1993a and 1993b) and genera show similar distribution patterns. Generic links with the Guineo-Congolian region are illustrated by the distributions of *Allanblackia*, *Zenkerella*, *Angylocalyx* and *Scorodophloeus* (Fig. 3.4.4). *Allanblackia* has two Eastern Arc endemics and seven West and Central African species. The Eastern Arc submontane and montane *A. stuhlmannii*, and montane and upper montane *A. ulugurensis*, are more closely related to different species in West and Central Africa than to each other. *Zenkerella* has three eastern forest endemics: the lowland *Z. egregia*, the montane *Z. capparidacea* and the montane *Z. perplexa*. The only West and Central African species is *Z. citrina* with a wide altitudinal and ecological range in primary, secondary and riverine forests, from altitudes of 500–2100m. *Angylocalyx* has one Coastal and Eastern Arc species, *A. braunii*, in lowland and riverine forests, with five West and Central African species. The species most closely related to *A. braunii* is *A. pynaertii*, found in southern Central Africa. *Scorodophloeus fischeri* is a dry lowland Coastal Forest tree, and the only other species in the genus is the Central African *S. zenkeri*. These relationships, together with the occurrence of many widespread African forest species also found in the Guineo-Congolian region, suggest that the Coastal and Eastern Arc forests could be regarded as an eastern outlier of the Guineo-Congolian region, with the montane forests as a montane facies of the lowland forests (Monod, 1957).

In conclusion, we return to the question posed earlier: how different, or similar, are the Eastern Arc and Coastal Forests? Clearly the forests are very different, with there being a steep gradient of species replacement with elevation. The implication is that there is no particular reason why a management prescription applied to the lowland Coastal Forests will be relevant to the montane Eastern Arc, and from a conservation perspective as wide a range of forest types as possible should be protected. Thus their separation is both a matter of convenience and can be justified on marked floristic differences that can be correlated with environmental factors. With respect to similarities between the two areas, it is notable that together they represent a peak of high localised endemism. A third adjacent area, the arid Eastern Arc rainshadow to the west also contains a number of narrow range endemics (Lovett, 1988). Together the three areas form a super-regional centre of botanical endemism which is not represented in either of the phytogeographical classifications discussed here, and crosses several traditional phytogeographic boundaries (Lovett, in prep).

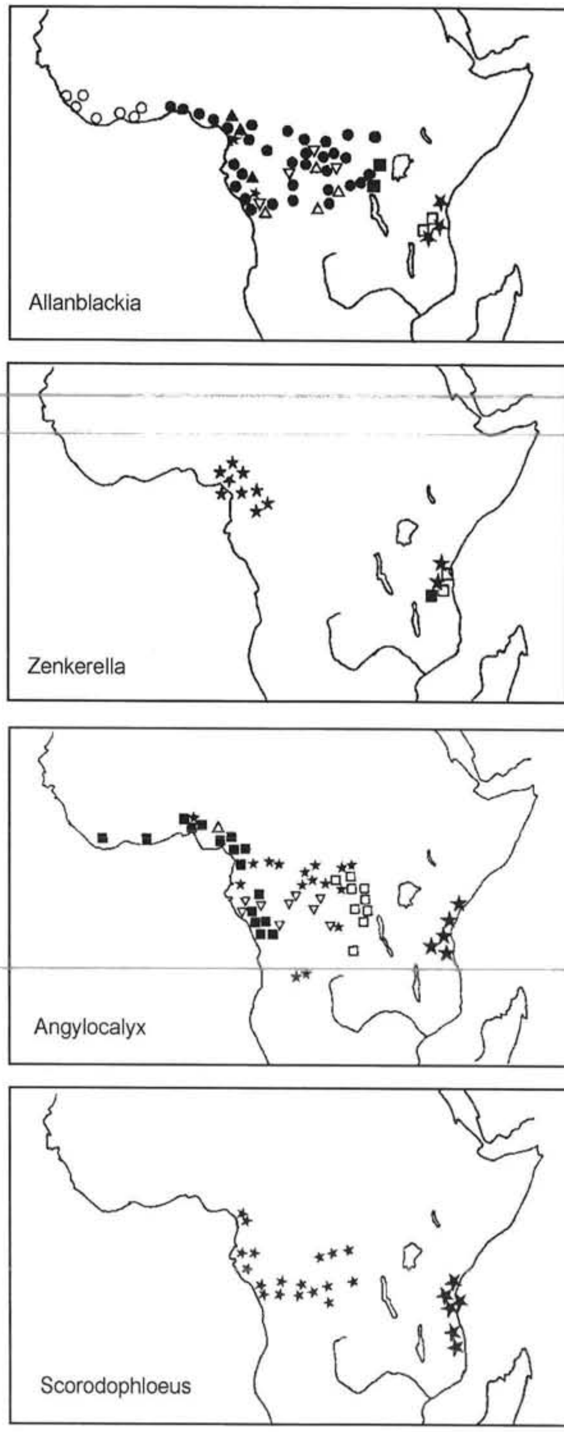


Figure 3.4.4 Distribution of species in the genera *Allanblackia*, *Zenkerella*, *Angylocalyx* and *Scorodophloeus* (from Bamps, 1969; Temu 1990b; Yakovlev *et al.*, 1968).

Acknowledgements

We are grateful to Henning Adsersen for helping with numerical analysis and suggesting the Ecological Amplitude Index. The Tanzania Commission for Science and Technology gave us permission to conduct research in the Coastal Forests and Eastern Arc. The University of Dar es Salaam helped with logistics and drying of plant materials, especially Dr Z. K. Rulangaranga, Leonard Mwasumbi, Frank Mbago, and Herji Suleiman. Field work by JL was supported by the World Wide Fund for Nature, the National Geographic Society, Caltex Corporation and Missouri Botanical Garden. Field work of JH and VH were supported by Engineer Svend G. Fiedler and Wife's Foundation, Danlin Environmental Foundation, and the Botanical Institute, Ecological Department, Copenhagen University. The data were analysed under the auspices of the Danish Centre for Tropical Biodiversity, supported by the Danish Natural Science Research Council. Neil Burgess, Phil Clarke, Anne Robertson, Alan Rodgers, William Hawthorne, Jon Fjeldså and Carsten Rahbek commented on an earlier draft of the manuscript.

References

Bamps, P. (1969). Guttiferae. *Distributiones Plantarum Africanum* **1**: cartes 1–29.

Bensted-Smith, R. and Msangi, T.H. (1989). Report on the Conservation of Ecosystems and Genetic Resources. Tanzania Forestry Action Plan, United Republic of Tanzania, Dar es Salaam.

Bidgood, S. and Vollesen, K. (1992). *Bauhinia loeseneriana* reinstated, with notes on the forests of the Rondo Plateau, SE Tanzania. *Kew Bulletin* **47**: 759–764.

Dice, L.R. (1945). Measures of the amount of ecologic association between species. *Ecology* **26**: 297–302.

Dinesen, L., Lehmberg, T., Svendsen, J.O., and Hansen, L. A. (1993). Range extensions and other notes on some restricted-range forest birds from West Kilombero in the Udzungwa mountains, Tanzania. *Scopus* **17**: 48–59.

Friis, I. (1992). Forests and forest trees of Northeast Tropical Africa. *Kew Bulletin Additional Series* **15**: 1–396.

Hawthorne, W.D. (1993). East African coastal forest botany. Pp. 57–99. In Lovett, J.C. and Wasser, S.K. (eds.). *Biogeography and Ecology of the Rain Forests of Eastern Africa.* Cambridge University Press, Cambridge.

Lovett, J.C. and Pócs, T. (1993). *Assessment of the Condition of the Catchment Forest Reserves, a Botanical Appraisal.* Catchment Forestry Report 93.3, Dar es Salaam.

Lovett, J.C. (1988). Endemism and affinities of the Tanzanian montane forest flora. *Monographs in Systematic Botany from the Missouri Botanical Garden* **25**: 591–598.

Lovett, J.C. (1990). Classification and status of the moist forests of Tanzania. *Mitteilungen aus dem Institut für Allgemeine Botanik Hamburg* **23a**: 287–300.

Lovett, J.C. (1992). 'Classification and Affinities of the Eastern Arc Moist Forests of Tanzania'. Unpublished PhD thesis. University College of North Wales, Bangor.

Lovett, J.C. (1993a). Eastern Arc moist forest flora. Pp. 33–55. In Lovett, J.C. and Wasser, S.K. (eds.). *Biogeography and Ecology of the Rain Forests of Eastern Africa.* Cambridge University Press, Cambridge.

Lovett, J.C. (1993b). Temperate and tropical floras in the mountains of eastern Tanzania. *Opera Botanica* **121**: 217–227.

Lovett, J.C. (in prep.). Testing phytogeographic hypothesis in eastern Tanzanian forests.

MacKinnon, J. and MacKinnon, K. (1986). *Review of the Protected Areas System in the Afrotropical Realm.* IUCN, Gland, Switzerland and Cambridge, UK.

Monod, T. (1957). *Les Grandes Divisions Chorologiques de l'Afrique.* CCTA/CSA, London.

Moreau, R.E. (1966). *The Bird Faunas of Africa and its Islands.* Academic Press, London.

Moyer, D.C. (1992). Report on the natural resources consultancy for the Udzungwa forest management project preparation mission. Annex 4. In Lovett, J.C. (ed.). *Udzungwa Forest Management Project.* Ministry of Foreign Affairs, Copenhagen.

Pócs, T. (1976a). Bioclimatic studies in the Uluguru mountains (Tanzania, East Africa) II. Correlations between orography, climate and vegetation. *Acta Botanica Academiae Scientiarum Hungaricae* **22**: 163–183.

Pócs, T. (1976b). Vegetation mapping in the Uluguru mountains (Tanzania, East Africa). *Boissiera* **24**: 477 498.

Radcliffe-Smith, A. (1990). Notes on African Euphorbiaceae XXIV: *Drypetes* (ii). *Kew Bulletin* **45**: 671–675.

Sayer, J.A., Harcourt, C.S. and Collins, N.M. (1992). *The Conservation Atlas of Tropical Forests: Africa.* Macmillan, Basingstoke.

Scharff, N. (1993). The Linyphiid spider fauna (Araneae: Linyphiidae) of mountain forests in the Eastern Arc mountains. Pp. 115–132. In Lovett, J.C. and Wasser, S.K. (eds.). *Biogeography and Ecology of the Rain Forests of Eastern Africa.* Cambridge University Press, Cambridge.

Stevens, G.C. (1992). The elevational gradient in altitudinal range: an extension of Rapoport's latitudinal rule to altitude. *The American Naturalist* **140**: 893–911.

Stuart, S.N.. Jensen, F.P., Brøgger-Jensen, S. and Miller, R.I. (1993). The zoogeography of the montane forest avifauna of eastern Tanzania. Pp. 203–228. In Lovett, J.C. and Wasser, S.K. (eds.). *Biogeography and Ecology of the Rain Forests of Eastern Africa.* Cambridge University Press, Cambridge.

Temu, R.P. C. (1990a). A new species of *Zenkerella* (Leguminosae-Caesalpinioideae) from Tanzania. *Nordic Journal of Botany* **10**: 421–423.

Temu, R P.C. (1990b). Taxonomy and biogeography of woody plants in the Eastern Arc Mts, Tanzania: case studies in *Zenkerella, Scorodophloeus* and *Peddiea.* Uppsala: *Acta Universitatis Upsaliensis.* Comprehensive summaries of Uppsala Dissertations from the Faculty of Science **286**.

Turrill, W.B. and Milne-Redhead, E. *et al.* (eds.) (1952-). *The Flora of Tropical East Africa.* A.A. Balkema, Rotterdam.

Vollesen, K. (1980). Annotated check-list of the vascular plants of the Selous Game Reserve, Tanzania. *Opera Botanica* **59**: 1–117.

Wasser, S.K. and Lovett, J.C. (1993). Introduction to the biogeography and ecology of the rain forests of eastern Africa. Pp. 3–7. In Lovett, J.C. and Wasser, S.K. (eds.). *Biogeography and Ecology of the Rain Forests of Eastern Africa.* Cambridge University Press, Cambridge.

White, F. and Moll, E.J. (1978). The Indian Ocean coastal belt. I. Phytogeography. Pp. 563–575. In Werger, M.J.A. (ed.). *Biogeography and Ecology of Southern Africa.* Dr. W. Junk, The Hague.

White, F. (1965). The savanna woodlands of Zambezian and Sudanian Domains: an ecological and phytogeographical comparison. *Webbia* **19**: 651–681.

White, F. (1970). Floristics and plant geography. Pp. 38–77. In Chapman, J.D. and White, F. (eds.). *The Evergreen Forests of Malawi.* Commonwealth Forestry Institute, University of Oxford, Oxford.

White, F. (1976). The taxonomy, ecology and chorology of African Chrysobalanceae (excluding Acioa). *Bulletin du Jardin Botanique National de Belgique* **46**(3/4): 265–350.

White, F. (1983). *The Vegetation of Africa.* UNESCO, Paris.

White, F. (1993). The AETFAT chorological classification of Africa: history, methods and applications. *Bulletin du Jardin Botanique National de Belgique* **62**: 225–281.

Yakovlev, G P., Yatsenko-Khmélévsky, A.A. and Zoubkova, I.G. (1968). Taxinomie et phylogénie du genre *Angylocalyx* et de la tribu des Angylocalyceae. *Adansonia* ser. 2, **8** (3): 317–335.

Section 4

Biodiversity values

In this section the values of the Coastal Forests in terms of species-richness and endemism for some major biological groups are presented. Data on vascular plants, vertebrates and invertebrate groups provide an assessment of the biodiversity importance of these forests in the African and global context. Where possible comparisons are also made with other forest types in Africa, especially the Guineo-Congolian forests to the west and the montane forests of the Eastern Arc. The final Chapter summarises the key biological results from the other Chapters, and outlines some of the highest priority areas for biodiversity conservation in the Coastal Forests.

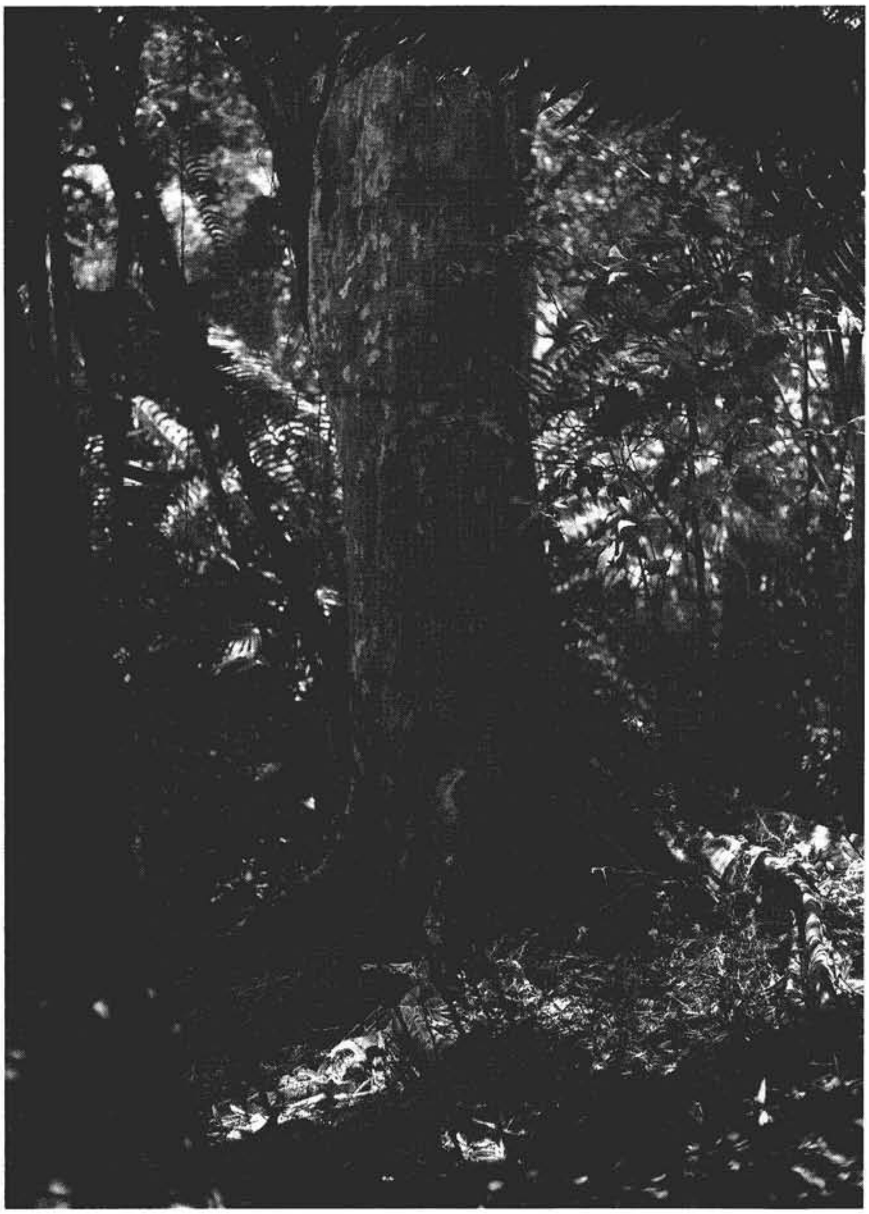


Figure 4 The canopy tree *Cynometra brachyrrachis*, known only from about 4km[2] of Coastal Forest, yet locally producing virtually monodominant stands in which the species accounts for over 70% of all trees greater than or equal to 10cm DBH. The genus *Cynometra* comprises forest trees which are restricted in Africa to the Guineo-Congolian Forests and the Coastal Forests, and are an indication of an ancient connection between these lowland forest areas. (*Photo: G.P. Clarke*)

4.1 Vascular plants

G.P. Clarke, K. Vollesen and L.B. Mwasumbi

Introduction

The coastal zone of eastern Africa has long been recognised to contain a different flora from that further inland, yet the floristic importance of this area was only quite recently recognised by its classification as a distinct vegetation region [phytochorion], based on the high number of plant species limited to this area (White, 1976 and 1983, pp.184–189; review in Chapter 1.2). White's definition encompassed all vegetation types in his 'Zanzibar-Inhambane' phytochorion, noting the particular importance of the forest flora (i.e. the Coastal Forest flora).

Recent botanical surveys of the Coastal Forests have coincided with ongoing work to revise the taxonomy and to make inventories of the entire plant flora of East and South-Central Africa, which are being published as monographs under the respective titles *Flora of Tropical East Africa* [FTEA] (Turrill and Milne-Redhead *et al.*, 1952-) (Figure 4.1.1a) and *Flora Zambesiaca* (Exell and Wild *et al.*, 1960-) (Figure 4.1.1b). About 60–70% of these floras have so far been published, along with two volumes of the *Flora of Somalia* (Thulin *et al.*, 1993-). Together the floras cover the entire extent of both the Zanzibar-Inhambane and the Swahilian region *sensu lato*/Coastal Forest belt (as defined in Chapter 1.2), and make a significant contribution to the understanding of how many vascular plants are found in these areas, how they are distributed, and how many of these species are endemic to the area.

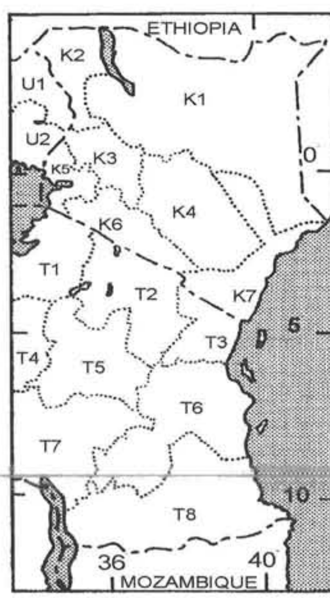


Figure 4.1.1(a) Geographical divisions (with codes) of the *Flora of Tropical East Africa* (Turrill and Milne-Redhead *et al.*, 1952-).

Figure 4.1.1(b) Geographical divisions (with codes) of the *Flora Zambesiaca* (Exell and Wild *et al.*, 1960-).

We present the results of an analysis of these floras, together with further data from published checklists, herbarium collections and other taxonomic monographs (Appendix 3), to identify patterns in vascular plant endemism and diversity along the eastern African coastal zone (covering all habitat types in the Coastal Forest belt), and further to determine the relative importance of the Coastal Forests that occur within this area. We then compare the floristic values of the Coastal Forests with some of the other tropical forest types in Africa, and comment on the patterns in floristic endemism which occur in the eastern African coastal zone.

History of the botanical exploration of eastern Africa

The coastal zone was the first part of eastern Africa to receive the attention of botanists, who from the end of the eighteenth century (1781) conducted collections in the vicinity of the ports controlled by the Portuguese and by the Zanzibar Sultanate (Exell and Hayes, 1975; Exell and Wild, 1960; Gillet, 1961; Hawthorne, 1993). A number of plants found in this area therefore carry the species epithets *mombassensis, mossambicensis* or *zanzibariensis,* reflecting that these were the first areas to be surveyed, rather than necessarily indicating that these areas contain a large number of endemic species.

The European colonisation of Kenya and Tanzania at the end of the nineteenth century shifted the focus of botanical exploration away from Mozambique, and away from the coastal zone to inland areas, especially in areas made accessible by the establishment of farms, plantations and towns (Exell and Wild, 1960; Gillet, 1961; Mendonça, 1961; Timler and Zepernick, 1987; Iversen, 1991). In particular, the founding of the Biological Research Station at Amani in the East Usambara Mountains in 1902 with two botanists among the permanent staff (Verdcourt, 1952) provided the impetus for intensive botanical surveys in the area, and by 1950 the Amani Herbarium contained 68,000 plant specimens, of which approximately 450 were types collected in the Usambaras (Iversen, 1991). Botanical collections in East Africa following the second World War have concentrated on the inventory of the National Parks, Game Reserves and the montane forests (e.g. Bjørnstad, 1976; Greenway, 1969; Greenway and Vesey-Fitzgerald, 1969; Vollesen, 1980; Lovett *et al.*, 1988). Apart from a few studies in Kenya (e.g. Moomaw, 1960; Lucas, 1968) the coastal zone of eastern Africa was comparatively neglected by botanists (Frazier, 1993), until recently.

The 1980s and 1990s have seen a resurgence in botanical interest in the East African coastal zone, which has concentrated on the Coastal Forests, particularly in Kenya with the detailed surveys of the Kaya forests (Robertson, 1987), the Tana River forests (Medley, 1992) and all Coastal Forests and other woody vegetation (Gerhardt and Steiner, 1986; Robertson and Luke, 1993). Much botanical survey work has also been conducted recently in Tanzania, especially in northern and central coastal areas with the activities of the Forestry Working Group of the University of Dar es Salaam (Greenway with Rodgers *et al.,* 1988; Hall *et al.*, 1982; Rodgers *et al.* 1983, 1984 and 1986), a PhD study by one of Frank White's students (Hawthorne, 1984), and the activities of the Frontier-Tanzania Coastal Forest Research Programme (Clarke, 1995a,b; Clarke and Dickinson, 1995; Clarke and Stubblefield, 1995; Sheil, 1992). In contrast, coastal areas of southern Tanzania have been comparatively neglected except by botanists from the Royal Botanic Garden, Kew (Vollesen, 1980; Vollesen and Bidgood, 1992) and a few visits by Frontier-Tanzania (Clarke, 1995b). Botanical inventories of the forests of Zanzibar and Pemba have been carried out on behalf of the Commission for Natural Resources (Beentje, 1990; Ruffo, 1991); and those in Somalia have been surveyed by the Somalia Research Project (Madgwick, 1988) and in conjunction with work for the *Flora of Somalia* (Friis and Vollesen, 1989). Coastal Forests in southern Malawi and eastern Zimbabwe have also been surveyed recently (e.g. Dowsett-Lemaire, 1990 and Muller, 1991). By contrast, the flora of the coastal areas, and of the forests in particular, are little known in Mozambique, especially in the north of the country which remains almost unsurveyed (cf. Davis *et al.,* 1994, p.133).

Many new plant species have been discovered during the recent surveys (Vollesen, 1994), even in the comparatively better known Kenyan coast (Luke, 1988; Robertson and Luke, 1993). We believe that further collections will ultimately lead to the discovery of at least 150 more vascular plant species, especially in south-east Tanzania and northern Mozambique.

Importance of forest and closed canopy habitats

Coastal Forests presently extend to some 3172km^2 (Chapter 3.1), accounting for *c.*1% of the total area of White's (1983) Zanzibar-Inhambane regional mosaic/Swahilian region *sensu lato* (Chapter 1.2). In spite of their restricted distribution, the forests contain 70% of the region's endemic plant species and 91% of its endemic genera (Table 4.1.1). In addition, 42.4% of the region's endemic species (544 species) and 69% of its endemic genera have only ever been recorded from forest, and are therefore considered to be forest dependent. Closed canopy vegetation types (forest, woodland, bushland and the thicket) collectively contain most (92%) of the endemic plant species and all of the endemic plant genera of this phytochorion (figures from Appendix 3, this volume).

Table 4.1.1 Vascular plant genera endemic or near endemic (*sensu* White, 1979) to the Coastal Forest belt.

Genus	Family	Habitat	Growth form	Distribution
Aerisilvaea [1,c]	Euphorbiaceae	F	T	T6 (Kimboza Forest)
Asteranthe [a]	Annonaceae	F,W,B,T	T	K7; T3,6,8; Z
Baptorhachis [b]	Poaceae	?	Grass	MN
Burrtdavya [a]	Rubiaceae	F	T	T3,6,8; Z; MN,MT,MMS; S.Mal
Callopsis [a]	Araceae	F	H	K7; T3,6 and poss. Cameroon
Cladoceras [a]	Rubiaceae	F,B	S	K7; T3,6; Maf
Dielsothamnus [a]	Annonaceae	F,BW	T,S	T8; MN, MZ; C. Mal
Farrago [a]	Poaceae	Ro	Grass	T8 (Nachingwea)
Grandidiera [a]	Flacourtiaceae	F	T,S	S.Som; K7; T3,6,8; Z; MMS
Hyalocalyx [2,d]	Turneraceae	F	H	T8; MN
Hystrichophora [e]	Asteraceae	F	?	T8 (Rondo)
Lamprothamnus [a]	Rubiaceae	F,W,B,T	T,S	Som; K1,7; T3,6,8; Maf
Lettowianthus [a]	Annonaceae	F	T	K7; T3,6,8; Maf
Mkilua [a]	Annonaceae	F	T,S	K7; T3,6,8; Z; P
Ophrypetalum [a]	Annonaceae	F	T,S	K7; T3,6,8
Paranecepsia [a]	Euphorbiaceae	F,T	T,S	T6; MN
Phellocalyx [a]	Rubiaceae	W,T	T,S	T8; MN; S.Mal
Pseudobersama [a]	Meliaceae	F	T	K7; T3,6,8; MMS,MSS,MLM; Natal
Sanrafaelia [f]	Annonaceae	F	S	T3 (E. Usambaras at Kwangumi)
Schlecterina [a]	Passifloraceae	F,B	L,S	K7;T3,6,8;Z;MN,MZ,MMS,MSS,MLM;Natal
Stephanostemma [g]	Apocynaceae	F	S	T6 (Gongolamboto)
Streptosiphon [h]	Acanthaceae	F	H	T8 (Rondo and Litipo)
Stuhlmannia [a]	Fabaceae	F	T	K7; T3,8
Thespesiopsis [b]	Malvaceae	F?	T,S	MN
~~*Trichaulax* [i]~~	~~Acanthaceae~~	~~F~~	~~H~~	~~K7; T3,6~~
Vismianthus [a,i]	Connaraceae	F,B,T	S	T8 (Rondo and Makonde Plateau)
Zamioculcas [a]	Araceae	F	H	K1,7; T3,6; Z; P; Moz; Zim; Mal; Natal
gen. nov. [j]	Acanthaceae	F	H	K7 (Gongoni)
gen. nov. of FTEA [a]	Rubiaceae	F	T or S?	T8 (Rondo)
gen. unknown of FZ [b]	Rubiaceae	F	S	MZ (Milange)
gen. indet. of FTEA [a]	Annonaceae	F	T	T6 (Kimboza)
gen. indet. [k]	Annonaceae	F	S	T6 (Pugu)
gen. indet [l]	Fabaceae	W	T	T8 (Selous)

Key to abbreviations contained in Appendix 3, this volume.

Notes: This list only includes the endemic genera which could be identified from existing publications; a full list of all disjunct genera awaits the publication of completed Floras for East and south-central Africa.

[1] Considered by Lovett (1993) to be an Eastern Arc endemic. This species is however limited to *Pandanus rabaiensis* swamp forest at 500m altitude in Kimboza forest (Clarke and Dickinson, 1995, p.98), which is similar to the swamp forest at Jozani on Zanzibar Island. We therefore include it as a Coastal Forest endemic.

[2] ~~Considered to be cultivated on Madagascar, where it is also recorded (see *Kew Bulletin* **1950**~~: 335).

The genus *Cleistochlamys* (Annonaceae) has been cited as a Swahilian *sensu lato* endemic (e.g. in Vollesen, 1992; Davis *et al.*, 1994), but extends somewhat further inland (distribution T6,8; MN,MZ,MT,MMS,MSS; E.Zam, N.Zam; E.Zim, S.Zim; Malawi).

The genus *Primularia* (Melastomaceae) has been cited as a Swahilian *sensu lato* endemic (from the Rondo plateau in T8) but is now considered to be congeneric with the genus *Cincinnobotrys*.

The Asclepiadaceae gen. indet. in Robertson and Luke (1993) is now recognised to be a new taxon of *Dregea*. Likewise the Rubiaceae gen. nov. aff. *Coffea* in Vollesen (1980) is now recognised to be *Psilanthus semseii*.

All genera listed are monotypic except *Asteranthe* (3 spp.), and *Lettowianthus* (2 spp.).

Sources: [a] Turrill and Milne-Redhead *et al.*, 1952-; [b] Exell and Wild *et al.*, 1960-; [c] *Kew Bulletin* **45**: 147–156; [d] Leroy, 1978; [e] *Kew Bulletin* **43**: 249; [f] Verdcourt, 1996; [g] Hawthorne, 1984; [h] *Kew Bulletin* **49**: 401–407; [i] Vollesen, 1992; [j] Robertson and Luke, 1993; [k] UDSM; [l] Vollesen, 1980.

These percentages may however remain underestimates of the actual importance of the Coastal Forests within their mosaic, for much work is required to accurately assess the habitat requirements of much of the flora of this area, especially concerning which plants are strictly forest dependent. Although the *Floras* cite the habitats in which a plant has been collected, much of these data have been compiled from the amalgamation of notes on the labels of herbarium specimens, many of which predate the creation of formal definitions for forest and woodland. This problem is further compounded by continuing disagreements over differences between forest and woodland (Burgess and Muir, 1994), the difficulty in identifying whether certain Coastal Forest types are forest or woodland, and the failure of some plant collectors to adhere to the formal definitions for these main formation types. Language poses a further problem, where German collectors have used a word that directly translates as woodland for Coastal Forest since the beginning of the century (e.g. '*Kustwald*' in Kerner von Marilaun and Hansen, 1916), even though the German word '*Wald*' (like the English word 'woodland') can be equally well applied to either woodland or forest when used with its colloquial European meaning (Chapter 1.2). Many of the plant species that have been recorded as growing in 'woodland', were then in reality collected in habitats that would now be classified as forest. We therefore recognise that the actual number of forest dependent species may exceed the number which are recorded in literature as only having been found in forest, and that yet other essentially forest dependent plant species may only marginally intrude into non-forest habitats (conversely some of the species hitherto recorded as forest dependent may also occur in other habitats). For this reason, this Chapter will extend its analysis to all the plants that are near endemic (*sensu* White, 1993) to the Zanzibar-Inhambane regional mosaic, i.e. are endemic to the Swahilian region *sensu lato*/Coastal Forest belt of Chapter 1.2 (hereafter Coastal Forest belt regional endemics), as these can be considered to represent an upper limit for a revised Coastal Forest flora once a full examination of the habitat requirements of its plant species has been made.

Floristic diversity

Diversity of plant species and genera

We estimate that at least 1050 plant genera are present in the Swahilian region *sensu lato*/Coastal Forest belt, basing our estimate on the 1035 genera recorded from K7 by Robertson and Luke (1993) together with the 19 endemic Coastal Forest belt genera not recorded in K7. Our estimate is comparable with the number of genera estimated for the Guineo-Congolian region and the Eastern Arc montane forests (Table 4.1.3). The Coastal Forests themselves probably contain no more than 750 plant genera, given that their endemic species are distributed among 495 genera.

Previous estimates of 3000 plant species (Davis *et al.*, 1994; White 1983 and 1993) have under-estimated the 'species richness' (*sensu* McIntosh, 1967; Peet, 1974) of the Zanzibar-Inhambane regional mosaic/Swahilian region *sensu lato*/Coastal Forest belt. We estimate that at least 4500 plant species occur in this area, given that a total of 3040 taxa are recorded from coastal Kenya (i.e. coastal K7) by Robertson and Luke (1993), and that at least 780 species (Appendix 3) are endemic to the Zanzibar-Inhambane regional mosaic/Swahilian region *sensu lato*/Coastal Forest belt outside K7. We further estimate that 3000 of these species are found in the Coastal Forests.

Comparisons with other tropical forests in Africa

Species richness comparisons between the Coastal Forests and other African tropical forests need to take habitat area into account, to 'factor out' the effect of habitat area on diversity (cf. Connor and McCoy, 1979). We use the power function relationship $S = cA^z$, which has been found to most often provide the best fit model to the species-area curve (but see Connor and McCoy, 1979), adopting $z = 0.12–0.17$ for large non-isolated sample areas on continents (MacArthur and Wilson, 1967) to calculate the species richness index c for each forest type. The results in Table 4.1.3 demonstrate that the Coastal Forests are intrinsically more species rich than the neighbouring Eastern Arc forests (i.e. $c_{\text{Coastal Forest}}$ is greater than $c_{\text{Eastern Arc}}$), but are less species rich than the Guineo-Congolian forests.

Table 4.1.2 Vascular plant genera with disjunct distributions between the Coastal Forest belt and other areas.

Genus	Family	Distribution
Aoranthe	Rubiaceae	4 spp. Guineo-Congolian; 1 sp. Coastal Forests (T3,6,8)
Anchomanes	Araceae	4 spp. Guineo-Congolian; 1 sp. Coastal Forests (K7; T3,6,8)
Aphloia	Flacourtiaceae	Monotypic genus; Madagascar, Mascarenes, E. and SE Africa
Bivinia	Flacoutiaceae	Monotypic genus; Madagascar and Coastal Forests and bushland
Bosqueiopsis	Moraceae	Monotypic genus; Guineo-Congolian and Coastal Forest belt
Brexia	Brexiaceae	5 spp. Madagascar; 1 common sp. Seychelles, Comoros and E. Africa
Buchnerodendron	Flacourtiaceae	1 sp. Guineo-Congolian; 1 sp. Coastal Forest belt (T6, 8; MN, MZ)
Camptolepis	Sapindaceae	3 spp. Madagascar with 1 additional sp. common to Coastal Forests
Carpodiptera	Tiliaceae	South American genus with 1 species in Coastal Forest belt
Dolichandrone	Bignoniaceae	7 species Asia and Australia; 1 species Coastal Forests (MSS, MLM)
Foetidia	Lecythidaceae	5 spp. Madagascar and Mauritius with 1 sp. common to Pemba Island; and 1 sp. in Coastal Forest (T6)
Gossypioides	Malvaceae	1 sp. Madagascar; 1 sp. throughout Coastal Forest belt
Grevea	Montiniaceae	2 species Coastal Forests, 1 common to Madagascar
Haplocoelopsis	Sapindaceae	Monotypic genus; Angola and Coastal Forests (K7; T6,8)
Humbertochloa	Poaceae	1 species Madagascar; 1 species Coastal Forests (T6)
Inhambanella	Sapotaceae	1 sp. Guineo-Congolian, 1 sp. Coastal Forests (Kenya to Natal)
Ludia	Flacourtiaceae	23 spp. Madagascar and Mascarenes, 1 sp. common to Coastal Forests
Macphersonia	Sapindaceae	8 spp. Madagascar and Comoros, 1 sp. common to Coastal Forests
Mildbraedia	Euphorbiaceae	1 sp. Guineo-Congolian; 2 spp. Coastal Forests
Musa	Musaceae	35 spp. Tropical Asia; 1 sp. Coastal Forest on Pemba Island
Paramacrolobium	Fabaceae (Caes.)	Monotypic genus; Guineo-Congolian and Coastal Forests
Plioceras	Apocynaceae	4 spp. Guineo-Congolian; 1 sp. in Coastal Forests (T8; MZ; MMS)
Schizozygia	Apocynaceae	Monotypic genus; Madagascar, Zambezian and Coastal Forests
~~*Scorodophloeus*~~	~~Fabaceae (Caes.)~~	~~1 sp. Guineo-Congolian; 1 sp. Coastal Forests (K7; T3,6,8; MN)~~
Strombosiopsis	Olacaceae	1 sp. Guineo-Congolian; 1 sp. Coastal Forests (K7)
Stadmannia	Sapindaceae	Monotypic genus; Madagascar, Zambezian and Coastal Forests
Typhonodorum	Araceae	Monotypic; Madagascar, Mascarenes, Comoros, Pemba and Zanzibar

Key to abbreviations contained in Appendix 3, this volume

This list only includes the disjunct genera which could be identified from existing publications; a full list of all disjunct genera awaits the publication of completed Floras for East and south-central Africa.

There is still some doubt concerning the actual position of *Trachylobium* (Fabaceae: Caesalpinioideae), which is sometimes included within the South American genus *Hymenaea*, but sometimes considered as a distinct genus, in which case it could be included as a further monotypic genus shared between the Coastal Forests, Madagascar and the Mascarene Islands.

Sources: *Distributiones Plantarum Africanarum*; Exell and Wild *et al.*, 1960-; Iversen, 1991; Mabberley, 1987; Pennington, 1991 p.140; Robertson and Luke, 1993; Turrill and Milne-Redhead *et al.*, 1952-; White, 1979.

Relative diversities of different plant species growth forms

Trees account for the greatest proportion of the Coastal Forest flora. For example, 48.4% of the 1038 species recorded from 13 Tanzanian Coastal Forests (data in Clarke, 1995a) were trees (some of which are also recorded as shrubs), 13.5% were lianes (some of which are also recorded as shrubs), 13.7% were shrubs (some of which are also recorded as herbs), 14.6% were herbs, 3.9% were grasses, 2.3% were sedges, 2.1% were ferns, and the remaining 1.1% were epiphytes and parasites (mistletoes). Lianes and climbers may actually be a more important constituent of these forests as they are often neglected by collectors. Gentry (1991) reports that the world's highest recorded liane density (no. of stems per hectare, stem diameters greater than or equal to 2.5cm) occurs in Pugu Forest in Tanzania, and recent research has found an even higher density in Litipo Forest in Tanzania (Bailey, 1994).

Table 4.1.3 Theoretical values of the floristic species richness index for the Guineo-Congolian, Eastern Arc and Coastal Forests, compared to the total recorded/ estimated number of species and genera.

Forest type	No. of genera	No. of species	Area (km^2)	c ($0.12 \leq z \leq 0.17$)
Eastern Arc	1150[1]	2000[2]	9000[2]	425–671
Coastal Forests	750[3]	3000[3]	3193[4]	761–1139
Guineo-Congolian	1050[5]	12,000[6]	1,854,000[7]	1032–2123

Sources: [1]Iversen, 1988 for the Usambara Mountains only. We estimate that the entire Eastern Arc flora will therefore be distributed over a greater number of genera; [2]Lovett, 1990 and 1993; [3]This Chapter; [4]Chapter 3.1 (this volume); [5]See note 2 in Table 4.1.2; [6]Davis *et al.*, 1994, assuming that all species estimated to occur in White's Guineo-Congolian regional centre of endemism (covering 2,800,000km²) are found in the remaining areas of forest; [7]Sayer *et al.*, 1992.

Diversity of plant communities

Whittaker (1960) identifies three levels of diversity, such that the overall (landscape) diversity is a composite of the γ (between site) diversity, the β (intracommunity) diversity and the α (community) diversity. Considering each Coastal Forest as a community and all Coastal Forests collectively as a landscape gives a typical α diversity of 300–800 vascular plant species per forest (estimates from unpublished Frontier data; Robertson and Luke, 1993; Timberlake and Muller, 1994; Vollesen, 1994), with correspondingly high β and γ diversities to produce an overall Coastal Forest diversity of 3000 species. γ diversity is an important component of the overall Coastal Forest species richness because the species composition of each forest can be highly dissimilar (due to a high species turnover between geographically isolated forests), e.g. Kiono and Kiwengoma forests which are just 240km apart at roughly the same altitude and distance from the coast have 20% of their plant species in common, i.e. just 10% of the total inventory for the two sites is shared (data from Clarke, 1995a). Similar differences between other Coastal Forests are noted by Hawthorne (1984 and 1993) and Mbwana *et al.* (1991).

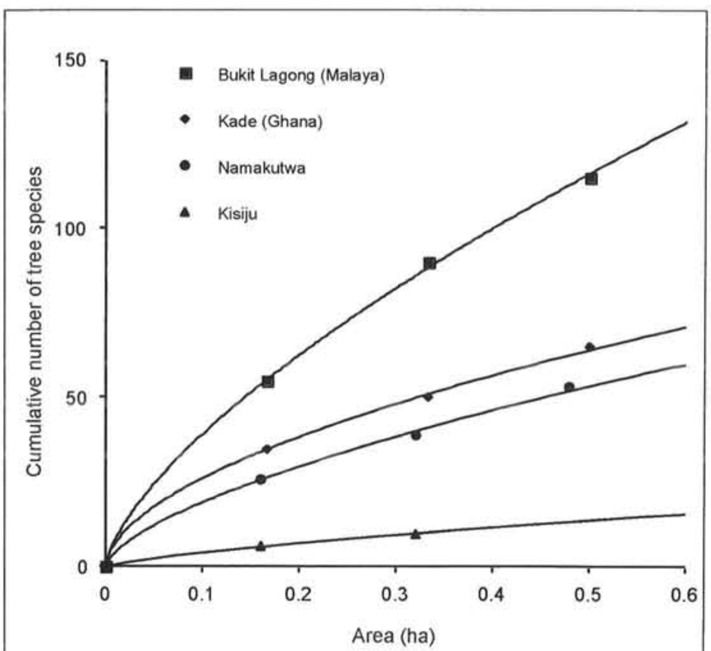


Figure 4.1.2 Comparative species-area curves for trees ≥ 10cm DBH for two Coastal Forests, one Guineo-Congolian and one south- east Asian forest (Coastal Forest data from Clarke and Dickinson, 1995; other data from Hall and Swaine, 1981).

Diversity of plant species assemblages

Many of the species recorded in the Coastal Forests occur at low densities or are marginal intruders into the Coastal Forest flora, often as a result of disturbance (Hawthorne, 1993). Usually up to five species account for 80% of all canopy trees (individuals) in any 1ha block of forest (Clarke, 1995b; Clarke and Dickinson, 1995; Clarke and Stubblefield, 1995; Chapter 3.3), which contrasts with many types of lowland rain forest, where all tree species account for approximately the same proportion of the total composition (Whitmore, 1986), but compares to other lowland forests in tropical Africa where monospecific canopy dominance is commonplace (cf. Connell and Lowman, 1989; Hart *et al.*, 1989). Even where a few trees make up most of the canopy, the number of other tree species can be high; Gould *et al.* (1994) recorded 98 species of trees, shrubs and lianas above 2cm DBH in just 0.15ha of Coastal Forest. This is comparable to some of the richest forests elsewhere when such a small plot size is considered (cf. Whitmore *et al.*, 1985), but if larger areas are compared then the species diversity in the Coastal Forests (and especially in the Caesalpinioideae-dominated stands, e.g. Kisiju Forest in Figure 4.1.2) is below that recorded in many other tropical rain forests (cf. Gentry, 1986; Connell and Lowman, 1989; Hall and Swaine, 1981). Highly disturbed Coastal Forests, such as Namakutwa, nonetheless approach the diversity recorded in some of the moist semi-deciduous Guineo-Congolian forest types (Figure 4.1.2).

Even where Coastal Forests have similar species lists (florulas), they can still be remarkably variable in terms of which species dominate (Hawthorne, 1993). Altitudinal variation within the forests is low, but other factors such as climate, soils, geology, geomorphology, human disturbance, aspect (Mwasumbi *et al.*, 1994), historical factors and even termites (Gould *et al.*, 1994) may all influence the resulting forest assemblages (see Chapters 2.2–2.3 and Hawthorne, 1993 for discussion).

Floristic endemism

Endemic genera

White (1983) listed four genera which he considered to be endemic to the Zanzibar-Inhambane regional mosaic, two of which we now consider to be more appropriately assigned to the Eastern Arc forests. Later estimates revised this figure to 50 (Vollesen, 1992) and then to 25 endemic genera (Davis *et al.*, 1994). We list 33 endemic genera based on our literature survey in Table 4.1.1, and estimate that this figure could ultimately reach 40 endemic genera. Most (94%) of these genera are monotypic and the majority (69%) are limited to the Coastal Forests (Table 4.1.1); some have only recently been described (Verdcourt 1996; Vollesen, 1992), whilst others still await description.

Endemic species

White (1983) estimated 'a few hundred' vascular plant species to be endemic to the Zanzibar-Inhambane regional mosaic. Davis *et al.* (1994, p.132) revised this figure to 450 species. We identify 1356 species in Appendix 3 (which are distributed over 493 genera), and estimate that further collecting and taxonomic revisions may raise this figure to 1500 species. At least 554 species (42%) are restricted to the Coastal Forests (forest dependent), and we estimate that a thorough investigation into the habitat requirements of the endemic species will reveal a total of approximately 800 (53% of 1500) plant species which are dependent on Coastal Forests, or nearly so.

Composition of the endemic species

The Rubiaceae contribute the greatest fraction of the Coastal Forest belt regional endemics (195 species, 14.3% of the total), and are also noted to be the largest family in the Ghana forest flora (Hall and Swaine, 1981). Other important families include Fabaceae (comprising sub-families Caesalpinioideae, Papilionoideae and Mimosoideae) with 116 species (8.5% of the total), Euphorbiaceae (73 species, 5.4% of the total), Acanthaceae (66 species, 4.9% of the total, but certainly an under-estimate since data on this family are scarce as it has yet to be treated by either the *FTEA* or the *Flora Zambesiaca*), Annonaceae (55 species, 4.0% of the total), Asclepiadaceae (36 species, 2.7% of the total), Cucurbitaceae (35 species, 2.6% of the total), Poaceae (33 species, 2.4% of the total), Vitaceae (27 species, 2.0% of the total), Asteraceae (27 species, 2.0% of the total) and Verbenaceae (26 species, 1.9% of the total).

Few genera contain 10 or more regional endemic species, but these include *Pavetta* (Rubiaceae), 28 species; *Diospyros* (Ebenaceae) and *Tricalysia* (Rubiaceae), 19 species; *Grewia* (Tiliaceae), 18 species; *Combretum* (Combretaceae), 17 species; *Ipomoea* (Convulvulaceae) and *Cyphostemma* (Vitaceae), 16 species; *Justicia* (Acanthaceae), *Cynometra* (Fabaceae [Caesalpinioideae]) and *Rytigynia* (Rubiaceae), 15 species; *Dichapetalum* (Dichapetalaceae) and *Memecylon*

(Melastomaceae), 14 species; *Ochna* (Ochnaceae), 13 species; *Psydrax* (Rubiaceae), 12 species; *Uvaria* (Annonaceae), *Ceropegia* (Asclepiadaceae), *Cordia* (Boraginaceae), *Indigofera* (Fabaceae [Papillionoideae]), *Adenia* (Passifloraceae), *Coffea* (Rubiaceae) and *Cola* (Sterculiaceae), 11 species; *Vernonia* (Asteraceae), *Cyperus* (Cyperaceae), *Euphorbia* (Euphorbiaceae), *Nesaea* (Lythraceae), *Canthium* and *Psydrax* (Rubiaceae), *Premna* (Verbenaceae) and *Cissus* (Vitaceae), 10 species.

Growth form of the endemic species

The endemic Coastal Forest plant species are predominantly woody; 58% of all Zanzibar-Inhambane/Swahilian region *sensu lato*/Coastal Forest belt endemic species and 69% of the endemic genera are woody. 30% of the endemic species and 53% of the endemic genera are trees (36% of the forest dependent species), which are considered to represent more ancient endemics compared to shrubs and herbs which are considered to be of more recent origin (Cronk, 1992; Gentry, 1986). Many of the endemic tree species are limited to the drier forest types (Hawthorne, 1993), suggesting that these may represent a more persistent environment than the other forest types. Important families include Rubiaceae (which account for 17% of the endemic tree species), Caesalpinioideae (8.2%), Annonaceae (8.2%), Euphorbiaceae (7.7%), Sterculiaceae (4.8%), Ebenaceae (4.3%) and Papilionoideae (4.0%).

Lianes (woody) and climbers (non-woody) account for 4.2% and 10.7% of all Coastal Forest belt regional endemic plant species, and are well represented by the Asclepiadaceae (which account for 15.1% of the endemic species), Cucurbitaceae (11.9%) and Vitaceae (11.4%). 17% of the forest dependent species are climbers or lianes.

Shrubs account for the greatest percentage of the Coastal Forest belt regional endemics (42% of the total have been recorded as shrubs, although only 22.4% of the total are not recorded as either trees or lianes), and are well represented in the endemic Coastal Forest flora (24.3% of all forest dependent endemics). Important families include Rubiaceae (which account for 34.0% of the endemic shrub species), Euphorbiaceae (7.6%), Annonaceae (6.3%), Fabaceae (5.3%), Verbenaceae (4.0%) and Tiliaceae (3.4%).

Herbs account for 26.4% of the Coastal Forest belt endemic species (24.6% if species which are also recorded as shrubs and/or climbers are excluded), but account for only 17.6% of the endemic genera. The endemic herbs are well represented by the Acanthaceae (comprising 13.8% of the endemic herb species), Papilionoideae (9.4%), Rubiaceae (5.8%), Araceae (5.5%), Asteraceae, Euphorbiaceae and Lythraceae (4.6% each), Liliaceae (4.0%), Commelinaceae (3.6%), and Amaranthaceae (3.3%). 27.7% of the endemic herbs are recorded as being forest dependent, which account for 17% of the forest dependent endemic species.

Grasses and sedges account for 26.9% and 17.2% respectively of the Coastal Forest belt endemic flora, and include two endemic grass genera. Although orchids represent the largest family in the *FTEA* area, these account for very few Coastal Forest belt regional endemics (just 20 species, 1.4% of the total number of regional endemics).

Habitats in which endemic species are found

The majority of the endemic taxa of the Coastal Forest belt are found in fire-excluded habitats. 70% of the endemic species and 91% of the endemic genera are found in forest, supporting earlier opinions that forest was the most widespread original climax vegetation formation type in the Zanzibar-Inhambane regional mosaic/Swahilian region *sensu lato* (Swynnerton, 1917; Schlieben, 1939; White, 1983, p.186). Many of the 104 (7.8%) endemic plant species that are not recorded from closed canopy vegetation communities are restricted to fire-excluded habitats where trees and shrubs are naturally absent in the vegetation climax, e.g. seasonally inundated (edaphic) grasslands and wetlands, swampy areas and shore-line vegetation (Appendix 3, this volume).

Abundance of endemic species

35.9% of the Zanzibar-Inhambane/Swahilian region *sensu lato*/Coastal Forest belt endemic plant species appear to be rare as they are only known from a few collections or have been collected in few (≤5) sites. Some are locally abundant, e.g. *Cynometra brachyrrachis*, which is known from just four forests in the Pangani River basin but may account for 75% of the canopy trees where it occurs (Clarke and Stubblefield, 1995). Other infrequently collected plant species are only known from a few living specimens, e.g. *Stephanostemma stenocarpum*, a monotypic shrub known only from about 40 individuals in a graveyard near Dar es Salaam (Hawthorne, 1984; Clarke and Mwasumbi, pers. obs.) and *Karomia gigas*, known formerly from just one tree at Mwara Kaya sacred forest in Kenya, which has now been felled (Beentje, 1988), although the species has since been rediscovered in a tiny fragment of forest in south-eastern Tanzania (Clarke, 1995b, p.8).

Concentrations of endemic species

The majority (67%) of the Coastal Forest belt regional endemic species and 61% of the endemic genera are confined to the Kenyan and Tanzanian coastal zone, which accounts for just 36% of the coastline length of the Zanzibar-Inhambane regional mosaic/Swahilian region *sensu lato* (Figures 4.1.3–4.1.5). We believe that many of the endemic species recorded from Kenya and Tanzania will be found to extend into northern Mozambique, although much botanical collecting will be required in this area to validate our prediction. Nonetheless, this result confirms the results of Moll and White (1978, p.564) who in a study of 'about 1000' species of woody plants of their 'Indian Ocean Coastal Belt' (which combines the Zanzibar-Inhambane and the Tongaland-Pondoland phytochoria) found *c*.35% of the 'larger woody plant species' to be endemic to the area north of the town of Moçambique (16°S), with relatively few endemics south of this. Within this block, particular geographic concentrations of vascular plant species endemism occur along the southern Kenyan coast, between the Tanzanian border and Mombasa (which we here define as the Kwale local centre of endemism *sensu* White, 1993), and around the dissected plateaux of Lindi District in southern Tanzania (which we here define as the Lindi local centre of endemism; Chapter 4.9).

522 (39%) of the Coastal Forest belt endemic plant species are known only from a single Coastal Forest, with particularly important concentrations in the Rondo Forest (two endemic and two near-endemic genera, 60 endemic species), Kimboza Forest (two endemic genera, 16 endemic species), the East Usambara lowland forests below 400m altitude (one endemic genus, 17 endemic species), Lake Lutamba/Litipo Forest (one near-endemic genus, 16 endemic species), the Pugu-Kazimzumbwi forest block (one undetermined genus, 12 endemic species) and the Shimba Hills (12 endemic species). The Selous Game Reserve (which extends over a much greater area than the aforementioned sites) contains one undetermined genus and 46 endemic species, many of which have only been collected in forest and thicket. The highly restricted distribution of these species may be an artefact of the loss of much of their former habitat through human intervention and habitat destruction, and they can therefore be considered to be 'anthropogenic endemics' *sensu* Gentry (1986).

42.8% of the endemic plant species are only known from a single geographical division of the *Floras* (Figure 4.1.5), contrasting with 10.6% which are restricted to two neighbouring geographical divisions, supporting Brenan's (1978) observation that floristic endemism in East Africa is characterised by narrow species ranges compared to the Guineo-Congolian forests where the endemics tend to have a much wider distribution (cf. Milne-Redhead, 1955; White, 1979).

Perhaps surprisingly, the Indian Ocean Islands are rather depauperate in both endemics that are confined to these islands (with four species each) and in Zanzibar-Inhambane/Swahilian *sensu lato* regional endemics (Zanzibar 93 species; Pemba 79 species; Mafia 73 species), yet are important faunal centres of endemism (Chapters 4.2–4.8). The small size of these islands is an insufficient explanation for this phenomenon given that over 100 plant species and three genera are endemic to the Rondo-Chitoa-Litipo-Noto Forests in SE Tanzania, which cover just 105km^2.

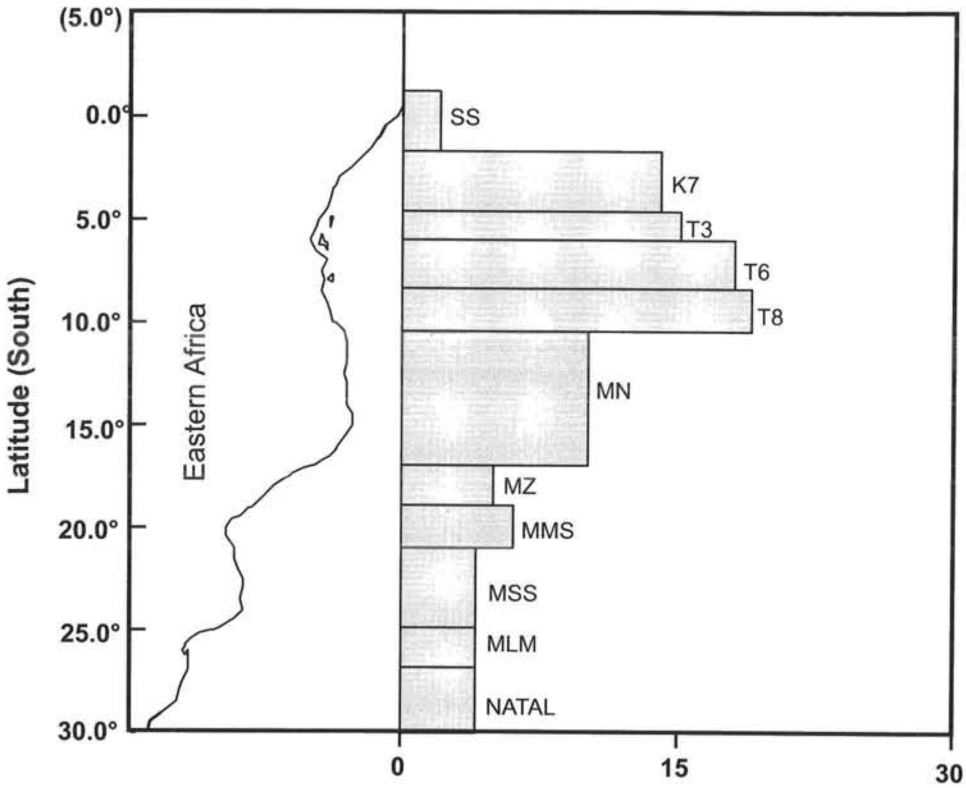


Figure 4.1.3 Number of Swahilian *sensu lato* regional endemic plant genera recorded in each geographical division of the Floras.

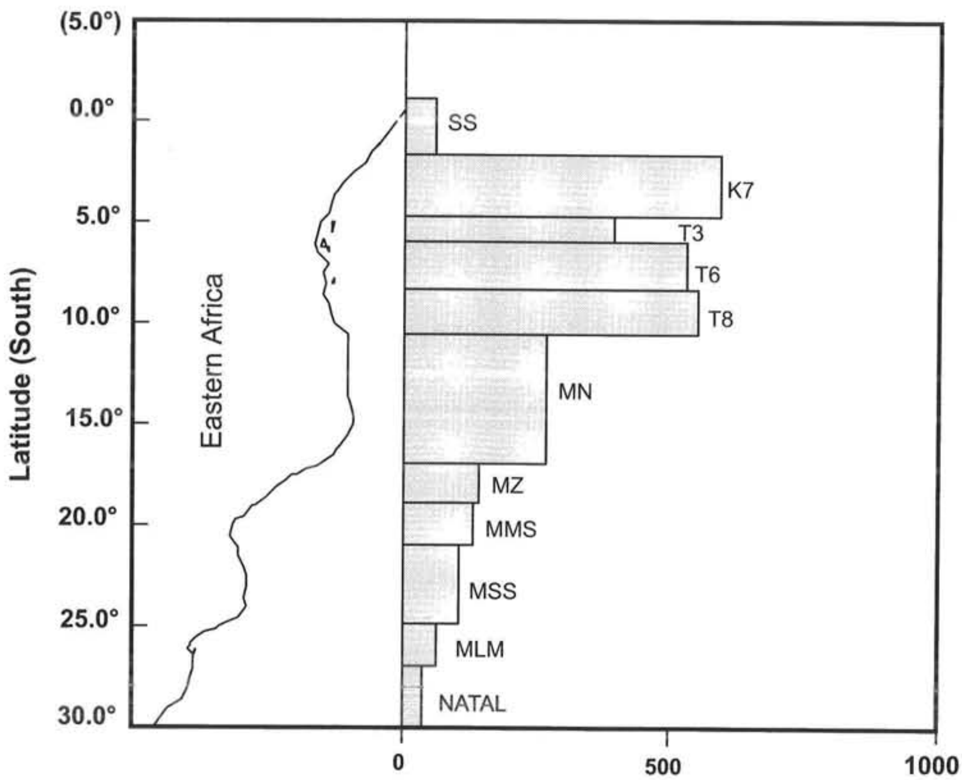


Figure 4.1.4 Number of Swahilian *sensu lato* regional endemic plant species recorded in each geographical division of the Floras.

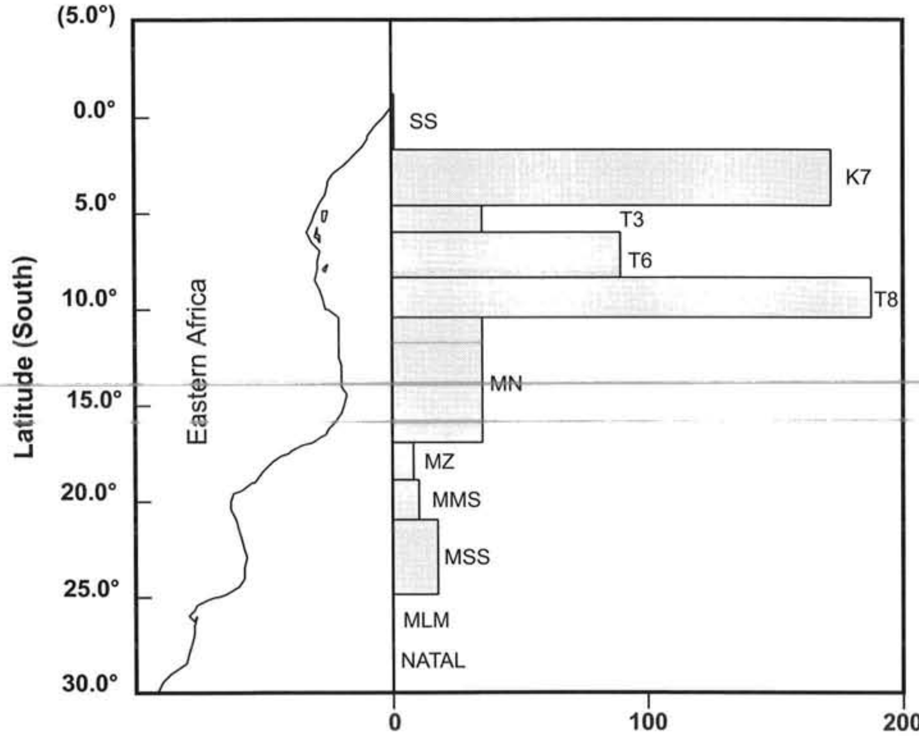


Figure 4.1.5 Number of Swahilian *sensu lato* regional endemic plant species confined to a single geographical division of the Floras.

Comparison with rates of endemism in other African Tropical Forests

A direct comparison of the rate of endemism present in the Coastal Forests against that in other major tropical forest areas in Africa is presented in Table 4.1.4, illustrating that the Coastal Forests are about as rich in forest dependent endemic species as the Eastern Arc Montane forests (*sensu* Lovett, 1990), but contain almost twice as many forest dependent endemic genera, even though Coastal Forests extend to just one-third of the area of the Eastern Arc forests.

Biogeographic affinities

Shared genera

Our analysis of the taxonomic literature has identified 27 genera with disjunct distributions between the Zanzibar-Inhambane regional mosaic *sensu lato*/Coastal Forest belt and other regions (Table 4.1.2), yet of these just two (*Foetidia* and *Fernandoa*) contain more than one species in both areas of their range disjunction. The geographical disjunctions in the remaining genera may be the result of one species reaching a distant location through the process of long-range dispersal (cf. Brenan, 1978 *cit.* Thorne, 1973); in some cases that species has undergone some evolutionary changes and now differs from all the other species in its ancestral range (i.e. is a distinct species), whilst in others the disjunct populations show only sub-specific variation.

Evidence for long-range dispersals are suggested by patterns in the genera that are disjunct between the Coastal Forest belt and the Madagascan/Indian Ocean Island phytochoria. Although Leroy (1978) postulated a former connection between these two areas, ten of the 13 genera that are disjunct between the two regions are genera which have a common species in both areas, such that the observed range disjunctions may be the result of recent long-distance transport across the Mozambique Strait. Of the three remaining disjunct genera, *Foetidia* has winged wind dispersed seeds which suggests a further possibility of a long distance dispersal event, possibly predating that of the monotypic genera and occurring sufficiently long ago to have enabled allopatric speciation to take place.

Table 4.1.4 Comparative floristic endemism in the Guineo-Congolian, Eastern Arc and eastern African Coastal Forests.

Forest type	No. of endemic species	No. of endemic genera	No. of endemic sp. per endemic genus	Extent (km^2)
Guineo-Congolian	6,400[1]	approx. 359[2]	17.8	1,854,000[3]
Eastern Arc	500–600[4]	13[5]	38–46	9,000[4]
Coastal	554[6]	22[6]	25.2	3,193[7]

Sources: [1]Davis *et al.*, 1994; [2]Brenan, 1978 and White, 1993, but see following note; [3]Sayer *et al.*, 1992; [4]Lovett, 1988 and [5]1993, but see note below for [5]; [6]Appendix 3 (this volume); [7]Chapter 3.1 (this volume).

[1] All of the endemic Guineo-Congolian plant species are assumed to be forest dependent, and therefore limited in area to the approximate remaining extent of the Guineo-Congolian forests (from Sayer *et al.*, 1992). White's Guineo-Congolian regional centre of endemism is somewhat larger than this at 2,800,000km^2. Sayer *et al.* (1992) estimate the original extent of moist closed tropical forest in West and Central Africa to have been even greater at 4,384,000km^2, since some of the original forest will have extended into the Guineo-Congolian regional transition zones.

[2] The number of endemic genera in the Guineo-Congolian region are estimated from Brenan's (1978) figure of 1121 genera recorded in tropical African rain forest. Excluding the endemic Coastal Forest and Eastern Arc genera leaves approximately 1050 genera present in the Guineo-Congolian. White (1993) estimates that one quarter of these will be endemic, giving a lower estimate of 263 endemic genera. However, Brenan estimates that 490 genera are endemic to West and Central Africa (which may include non-forest and upland genera), and 492 genera are endemic to tropical African rain forest *sensu lato*. Excluding the endemic eastern outliers and disjunct genera gives an upper estimate of 454 endemic genera. The figure given therefore lies halfway between 263 and 454.

[5]Lovett (1993) cites 16 genera, but of these *Aerisilvaea* is here considered to be a Coastal Forest genus, *Saintpaulia* is here considered to be a shared genus with the Coastal Forests, and *Zimmermannia* is excluded since one species is also found on Madagascar.

[6]Although we estimate elsewhere in this Chapter that 800 species may prove to be strictly forest dependent, we here maintain our actual figure of 554 species, to compare this with the actual (known) number of forest dependent endemic genera.

Ten genera are shared with the Guineo-Congolian phytochorion. Eight of these Zanzibar-Inhambane/Swahilian and Guineo-Congolian disjunct genera have a different species in each phytochorion, suggesting that their present distribution pattern may originate from ancient populations that have been severed and have since diverged to produce the separate species, thereby supporting the hypothesis of a former connection with the Guineo-Congolian forests (e.g. Davis *et al.*, 1994; Hamilton and Faden, 1973; Hamilton, 1982; Axelrod and Raven, 1978; Lovett, 1992; Chapters 2.1 and 2.3). The other two genera which are disjunct between these phytochoria are monotypic, of which *Bosqueiopsis* may warrant the separation of its two disjunct populations to a higher taxonomic classification since it grows to a 35m high tree in the Guineo-Congolian region but is more usually a shrub, or occasionally a small tree to 8m in the Coastal Forest belt.

Further evidence for the postulated former connection between the two lowland forest blocks is provided by the genus *Scorodophloeus,* where *S. fischeri* is a common and often dominant canopy constituent in the Coastal Forests of southern Kenya, Tanzania and northern Mozambique, whilst its Guineo-Congolian relative *S. zenkeri* is only found in the Lower Guinea sub-centre of endemism (*sensu* White, 1979) and not in the intervening areas of lowland forest (Temu, 1990). The disjunction between these species which have heavy seeds of a short viability cannot be due to long distance dispersal, but rather by vicariant allopatric speciation following the extinction of a common ancestor in the intervening area (Hall and Swaine, 1981 p.38). The Coastal Forests and the Guineo-Congolian forests nonetheless do not share any disjunct endemic vascular plant families, and share a low number of disjunct endemic species. Both Brenan (1978) and White (1979) emphasise that the flora of the Guineo-Congolian forests is very distinct from that of the remainder of tropical Africa. Nonetheless, the occurrence of forest genera that are unique to the Guineo-Congolian and Coastal Forest regions does indicate that remnants of the ancient pan-African tropical forest have survived along the eastern African coast (i.e. as Coastal Forest). Climatic changes during the 10–30 million years subsequent to the break-up of that former pan-African forest have undoubtedly led to fluctuations in the extent of the Coastal Forests, but have seemingly failed to eradicate them during this time (Hamilton in Sayer *et al.*

1992, p.22). Only five genera have been identified which are strictly shared with the Eastern Arc mountains (Table 4.1.5), suggesting that phylogenetically ancient floristic similarities with the Guineo-Congolian forests are stronger than with the neighbouring sub-montane and montane forests.

Table 4.1.5 Vascular plant genera that are endemic to and shared by both the Coastal Forests and the Eastern Arc forests.

Genus	Family	Habitat	Habit	Distribution	No. sp.
Buttonia	Scrophulariaceae	F,W,B,Ro	C,S	K4,6,7; T3,6,8; MSS, MLM; E.Zim	3
Oncella	Loranthaceae	F	Paras.	K6,7; T3,6,8; Z	4
Sacleuxia	Asclepiadaceae	F,W,B	C?	K7; T2,3,6	2
Saintpaulia	Gesneriaceae	F	H	K7; T3,6,7	21
Spragueanella	Loranthaceae	F,W,B,T	Paras.	K7; T3,6,8; Maf; Moz; Mal; E.Zim	2

Sources: Brenan and Greenway (1949); Lovett (1993); Mabberley (1987); FTEA (Loranthaceae) (in press); East African Herbarium (Nairobi) LEAPMASTER database.

Shared species

Moll and White (1978, p.564) in a study of 'about' 1000 species of woody plants of their 'Indian Ocean Coastal Belt' (which combines the Zanzibar-Inhambane and the Tongaland-Pondoland phytochoria) found 26% of a sub-sample of 190 tree species (which usually attain >9m height) to occur in the rain forests of the Guineo-Congolian region, but not in the 'typical vegetation of the intervening Zambezian and Somalia-Masai Regions'. However, we consider 'Guineo-Congolian' to be an inappropriate label for these species, since the authors later comment that half of these species do occur 'in small populations in fringing forests or in small islands of forest in other specially favoured sites [in the Zambezian and Somalia-Masai regions]'. Ignoring these species leaves 13% of the larger woody plants having a Coastal Forest/Guineo-Congolian distribution, most of which only occur in the northern part of the Zanzibar-Inhambane regional mosaic [Swahilian region *sensu lato*], i.e. north of Moçambique town (Moll and White, 1978).

Species shared with only one other phytochorion are much fewer than those with the shared 'affinities' as listed by Moll and White (1978). Coastal Forests are thus largely composed of a combination of both widespread and endemic species, with just a few species that are shared only with one other phytochorion (Table 4.1.6, based on an analysis of Clarke, 1995a).

Table 4.1.6 Composition of the Coastal Forest flora.

Species distribution	Number of species	Percentage of total	Forest dependent	Percentage
Swahilian *sensu lato* Near Endemic	343	33.0%	139	59.7%
Swahilian and Zambezian	70	6.7%	14	6.0%
Swahilian and Afromontane	47	4.5%	21	9.0%
Swahilian and Guineo-Congolian	35	3.4%	20	8.6%
Swahilian and Madagascar/Malagasy	30	2.9%	9	3.9%
Swahilian and Tongaland-Pondoland	11	1.1%	6	2.6%
Widespread	511	49.3%	24	10.3%

Source: Combined inventory from 13 Tanzanian Coastal Forests (sample size 1038 species, data in Clarke, 1995a updated with further data from Appendix 3, this volume).

Although the Coastal Forests merge with White's Afromontane domain at the Eastern Arc Mountains, the Afromontane element is usually very poorly represented in the Coastal Forest flora (except in the Coastal/Eastern Arc transition forest as defined in Chapter 1.2), yet is much better represented in the neighbouring (and sub-tropical) Tongaland-Pondoland flora (Moll and White, 1978). 3.7% of the species in Moll and White's sample of 190 tree species from the Zanzibar-Inhambane regional mosaic were found to be common to the Afromontane phytochorion, and these species were often localised to the islands of Zanzibar, Pemba and Mafia. The presence of these species on the Indian Ocean Islands suggests a requirement for a higher dry season rainfall than found elsewhere in the Coastal Forest belt (cf. Chapter 2.3). Links with the montane flora are more prominent on these islands, e.g. the giant heather bush *Phillipia mafiensis* (endemic to Pemba and Mafia) which belongs to a genus that is only found elsewhere on high mountains in the tropics, or in temperate and Arctic regions (Greenway with Rodgers *et al.*, 1988; Beentje, 1990). Other island links to the Afromontane region include *Quassia undulata*, a tree that occurs at sea-level in Ngezi Forest, Pemba Island, but elsewhere does not occur below 800m altitude (Beentje, 1990).

The location of the Coastal Forest belt alongside the Indian Ocean may be responsible for the component of Asian/Pacific and South American genera and species within the Zanzibar-Inhambane regional mosaic/Swahilian region *sensu lato* /Coastal Forest belt flora (Hawthorne, 1993). Some of these species are only known in Africa from one site, e.g. *Chrysophyllum lanceolatum* on Pemba Island. Only a few such species exist, and we believe that the majority, if not all, of these have arrived by some means of long distance dispersal, rather than being relicts of ancient floristic connections.

Discussion

Island Biogeography

The low rates of floristic endemism on the islands of Pemba, Zanzibar and Mafia would appear to contrast with the paradigm that tropical island floras usually contain many endemic genera and taxonomically isolated groups (Cronk, 1997; Gentry, 1986), although these islands do compare with oceanic islands in being rather species poor and may be equally vulnerable to extrinsic (anthropic) disturbance. The virtual absence of endemic plant species confined to these islands is further reflected by relatively low numbers of Zanzibar-Inhambane [Swahilian *sensu lato*] regional endemics, and may indicate the ultimate (long-term) fate of the mainland Coastal Forest flora, for the vegetation of these islands has been intensely modified by human activity for at least 2000 years (Chapter 5.1). Any species which is reduced to a small population on an island is more likely to become extinct compared to a similarly small population of the same species on the mainland, i.e. due to effects of genetic unviability, the Allee effect and stochastic (catastrophic) events combined with the low immigration rate of individuals onto islands (MacArthur and Wilson, 1967). Sufficient time may therefore have elapsed for the long term effect of human disturbance to now be manifest on Pemba, Mafia and Zanzibar Islands, resulting in lower equilibrium levels of regional endemic species richness, following the gradual extinction of other regional endemic species which had been reduced to unviably small populations through anthropic activity.

Like the flora of Pemba, Zanzibar and Mafia Islands, the endemic Coastal Forest flora is now effectively reduced to an archipelago of forested islands in a sea of synanthropic vegetation. Given that the species immigration/emigration and evolution/extinction equilibrium will take much longer to reach the Coastal Forests of the mainland than the islands, their current endemic species richness may not then be sustainable in the long-term, even if all the remaining forest is left intact, since they may contain genetically unviable populations of long-lived species (e.g. trees) which may take a long time to become extinct, as has been observed on St. Helena (Cronk, 1997). The island-like nature of the distribution of the endemic Coastal Forest vascular plant flora is therefore a cause of concern for the long term viability of its rare species.

Endemism

Floristic endemism in the Zanzibar-Inhambane regional mosaic/Swahilian region *sensu lato*/Coastal Forest belt does not appear to be correlated with rainfall, as the peaks of endemism (in the K7 and T8 floral divisions) are subjected to rather different climatic regimes (Chapter 2.3), with the slightly greater concentration of endemic species occurring in the drier of the two areas (the two-month dry season and 1200mm mean annual rainfall in the southern part of K7 contrasting with a six-month dry season and a 900mm mean annual rainfall in coastal T8). Few endemic species are recorded from the islands of Zanzibar, Pemba and Mafia, or from the Zambezi Delta area, even though these areas receive the highest mean annual rainfalls in the Coastal Forest belt (Figure 2.3.1 of Chapter 2.3).

Most of the endemic plant species of the Coastal Forest belt occur between the Tana River in northern Kenya and the Lurio River in northern Mozambique, and the intervening area coincides with (a) the area containing complex layers of marine sedimentary substrate (Figure 2.1.1 of Chapter 2.1; Hawthorne, 1993); (b) the area over which the Inter-Tropical Convergence Zone (ITCZ) passes (Figure 2.3.5 of Chapter 2.3); (c) the area where mean annual coastal temperatures are at least 26°C (Figure 2.3.9 of Chapter 2.3); and (d) the hypothetical eastern extent of the ancient pan-African tropical forest prior to its severance during the Miocene tectonic upheavals (Figure 2.3.15). Any one or more of these factors may determine the existence of each endemic plant species, and attempts to link the presence of all the endemic species to a single factor would be naive, for the high rate of floristic endemism in this area is certainly the result of a combination of the aforementioned factors, and of others, e.g. soils which are derived from the climatic and geological factors (Chapter 2.2), and local climatic stability where vicariant speciation may have followed the fragmentation of an ancestral species during the Pleistocene climatic fluctuations (cf. Fjeldså *et al.*, 1997; Lovett and Friis, 1996; Chapter 2.3). We consider the high rate of floristic endemism in this area to be the result of both deterministic and historic factors, and recognise that the endemic flora may be composed of both palaeoendemics (relict species) as well as neo-endemics (more recently evolved taxa), although the former probably dominates.

Extinctions

The region containing most of the endemic plant species and genera in the Coastal Forest belt coincides with the coastal extent of both the proto-Swahili and of the later Swahili civilisation of 800–1500 AD (maps 2 and 4 in de Vere Allen, 1993). It also matches the linguistic extent of mother-tongue Swahili during the last century (map 7 in Nurse and Spear, 1985), prior to its spread following the formation of nation states. Some of the conditions that have given rise to the large number of endemic species (e.g. fertile soils and monsoon winds) have evidently made the area favourable for human settlement, cultivation and trade, and may therefore indirectly (through encouraging human population growth) contribute towards the destruction of those endemic species. Forest is now reduced to just *c.* 1% of the whole Zanzibar-Inhambane regional mosaic/Swahilian region *sensu lato*, yet contains 70% of the endemic species present in the eastern African coastal zone and 42% (possibly more) have only ever been recorded from this vegetation type. Given that severe disturbance reduces the endemic species component in Coastal Forests (Mwasumbi *et al.*, 1994), more endemic plant species probably formerly occurred in this area, but are now extinct following the introduction of repeated fires and widespread forest clearance by humans (remaining areas of forest may therefore represent anthropic rather than climatic refugia). The endemic species and genera recorded in this region from the botanical collections conducted during the last 200 years may therefore represent a fraction of the former floristic richness of the area. Much more effort is required of the international conservation community to safeguard this heritage if that fraction is not to be reduced very much further.

Summary

The Coastal Forests of eastern Africa are far richer in endemic vascular plant species and genera than had hitherto been realised, and are intermediate in species diversity between the Guineo-Congolian and Eastern Arc forests. Most of the 1356 species and 33 genera at least which are limited to the lowland coastal zone of eastern Africa occur in these forests, even though they extend to only *c.* 1% of the Zanzibar-Inhambane regional mosaic/Swahilian region *sensu lato*. The majority of the endemic species and genera are further restricted to the Kenyan, Tanzanian and northern Mozambique coastal zone. Further botanical surveys and taxonomic studies may reveal yet higher levels of endemism. Ancient phylogenetic links in the vascular plant flora are more pronounced with the Guineo- Congolian forests than with either the forests of Madagascar or with the nearby Eastern Arc

forests. These results support earlier hypotheses that (a) the Coastal Forests were formerly much more extensive, and may even have been the dominant vegetation type in the region, and (b) that the Coastal Forests contain fragments of the eastern part of the former (pre-Miocene) pan-African tropical forest, especially in the north where the higher levels of endemism are recorded. A number of the endemic species may already be present in too low numbers to remain genetically viable in the long term.

Acknowledgements

Many thanks to Alan Rodgers, Ann Robertson, Neil Burgess, Jon Fjeldså, Jon Lovett and William Hawthorne for many detailed and critical comments on this Chapter, and to Quentin Cronk for a helpful discussion on the interpretation of the patterns of endemism on the islands.

References

Axelrod, D.I. and Raven, P.H. (1978). Late Cretaceous and Tertiary vegetation history of Africa. In Werger, M.J.A. (ed.) with assistance of Van Bruggen, A.C. (1978). *Biogeography and Ecology of Southern Africa.* Dr. W. Junk Publishers, The Hague.

Bailey, H. (1994). *An Assessment of the Patterns in the Ecology of Lianas and their Host Trees in Two Different Forest Types in Africa.* Unpublished B.Sc dissertation. University of East Anglia, Norwich.

Beentje, H.J. (1988). Atlas of the rare trees of Kenya. *Utafiti* **1**: 71–120.

Beentje, H.J. (1990). *Botanical Assessment of Ngezi Forest, Pemba.* FINNIDA report to the Commission for Natural Resources, Zanzibar.

Bjørnstad, A. (1976). The vegetation of Ruaha National Park, Tanzania. I. Annotated check-list of the plant species. *Serengeti Research Institute* **215**: 1–61.

Brenan, J.P.M. (1978). Some aspects of the phytogeography of tropical Africa. *Annals Missouri Botanical Garden* **65**: 437–478.

Brenan, J.P.M. and Greenway, P.J. (1949). *Check-list of the Forest Trees and Shrubs of the British Empire. 5 Tanganyika Territory.* Parts 1 and 2. Imperial Forestry Institute, Oxford.

Burgess, N.D. and Muir, C.E. (1994). *Coastal Forests of Eastern Africa: Biodiversity and Conservation.* The Society for Environmental Exploration/ the University of Dar es Salaam, London and Dar es Salaam.

Clarke, G.P. (1995a). *Tanzanian Coastal Forest Research Programme: Checklist of the vascular plants from 13 Coastal Forests in Tanzania.* Frontier-Tanzania Technical Report No. 15. 40pp. The Society for Environmental Exploration/The University of Dar es Salaam, London and Dar es Salaam:

Clarke, G.P. (1995b). *Status Reports for 6 Coastal Forests in Lindi Region, Tanzania.* Frontier-Tanzania Technical Report No. 18.. 63pp. The Society for Environmental Exploration/The University of Dar es Salaam, London and Dar es Salaam.

Clarke, G.P. and Dickinson, A. (1995). *Status Reports for 11 Coastal Forests in Coast Region, Tanzania.* Frontier-Tanzania Technical Report No. 17. 113pp. The Society for Environmental Exploration/The University of Dar es Salaam, London and Dar es Salaam.

Clarke, G.P. and Stubblefield, L.K. (1995). *Status Reports for 7 Coastal Forests in Tanga Region, Tanzania.* Frontier-Tanzania Technical Report No. 16. 67 pp. The Society for Environmental Exploration/The University of Dar es Salaam, London and Dar es Salaam.

Connel, J.H. and Lowman, M.D. (1989). Low-diversity tropical rain forests: some possible mechanisms for their existence. *The American Naturalist* **134**: 88–119.

Connor, E.F. and McCoy, E.D. (1979). The statistics and biology of the species-area relationship. *The American Naturalist* **113**: 791–833.

Cronk, Q.C.B. (1992). Relict floras of Atlantic Islands: patterns assessed. *Biological Journal of the Linnean Society* **46**: 91–103.

Cronk, Q.C.B. (1997). Islands: stability, diversity, conservation. *Biodiversity and Conservation* **6**: 477–495.

Davis, S.D., Heywood, V.H. and Hamilton, A.C. (1994). *Centres of Plant Diversity. A Guide and Strategy for their Conservation. Volume 1 Europe, Africa, Southwest Asia and the Middle East.* WWF and IUCN, Godalming and Cambridge.

de Vere Allen, J. (1993). *Swahili Origins. Swahili Culture and the Shungwaya Phenomenon.* James Currey, E.A.E.P. and Ohio University Press, London, Nairobi and Athens.

Dowsett-Lemaire, F. (1990). The flora and phytogeography of the evergreen forests of Malawi II: Lowland forests. *Bull. Jard. Bot. Nat. Belg. / Bull. Nat. Plantentuin Belg.* **60**: 9–71.

Exell, A.W. and Hayes, A. (1975). Henry Salt and John Forbes. *Kirkia* **1**: 130–137.

Exell, A.W. and Wild, H. *et al.* (1960-). *Flora Zambesiaca.* London: Crown Agents for Overseas Governments and Administrations. Later volumes published in London by the Royal Botanic Gardens, Kew for the Flora Zambesiaca Managing Committee.

Fjeldså, J., Ehrlich, D., Lambin, E. and Prins, E. (1997). Are biodiversity "hotspots" correlated with current ecoclimatic stability? A pilot study using the NOAA-AVHRR remote sensing data. *Biodiversity and Conservation* **6**: 401–423.

Frazier, J.G. (1993). Dry coastal ecosystems of Kenya and Tanzania. Pp.129–150. In van der Maarel, E. (ed.). *Dry Coastal Ecosystems. Africa, America, Asia and Oceania.* Ecosystems of the World **2B**. Elsevier, Amsterdam.

Friis, I. and Vollesen, K. (1989). Notes on the vegetation of southernmost Somalia, with some additions to the flora. *Willdenowia* **18**: 455–477.

Gentry, A.H. (1986). Endemism in tropical versus temperate plant communities. In Soulé, M.E. (ed.) *Conservation Biology.* Sinauer Associates, Sunderland, Massachusetts.

Gentry, A.H. (1991). Distribution and evolution of climbing plants. Pp. 1–42. In Putz, F.E. and Mooney, H.A. (eds.). *The Biology of Vines.* Cambridge University Press, Cambridge.

Gerhardt, K. and Steiner, M. (1986). *An inventory of a Coastal Forest in Kenya at Gedi National Monument, Including a Check-list and a Nature Trail. Report from a Minor Field Study.* 25pp. + appendices. Swedish University of Agricultural Sciences, Uppsala.

Gillet, J.B. (1961). History of the botanical exploration of the area of 'The Flora of Tropical East Africa' (Uganda, Kenya, Tanganyika, Zanzibar). *Comptes Rendus de la IVe Reunion plénière de AETFAT*: 205–229.

Gould, M., Lowe, A.J. and Clarke, G. P. (1994). The Frequency of Termite (Isoptera) Damage to Tree Species in Namakutwa Forest, Tanzania. *Sociobiology* **23**: 189–197.

Greenway, P.J. and Vesey-Fitzgerald, D.F. (1969). The vegetation of Lake Manyara National Park. *Journal of Ecology* **57**: 127–149.

Greenway, P.J. (1969). A check-list of plants recorded in Tsavo National Park, East. *Journal of the East African Natural History Society* **27**: 169–209.

Greenway, P.J. with Rodgers, W.A., Wingfield, R.J. and Mwasumbi, L.B. (1988). The vegetation of Mafia Island, Tanzania. *Kirkia* **13**: 197–238.

Hall, J.B. and Swaine, M.D. (1981). *Distribution and Ecology of Vascular Plants in a Tropical Rain Forest. Forest Vegetation in Ghana.* Dr. W Junk Publishers, The Hague.

Hall, J.B., Rodgers, W.A., Mwasumbi, L.B. and Swai, I. (1982). 'Woody Vegetation on Tanzanian Coral Rag: a Reconnaissance'. Unpublished. Forestry working group of the University of Dar es Salaam, Dar es Salaam.

Hamilton, A.C. and Faden, R.B. (1973). The history of the vegetation. Pp. 188–209. In Lind, M. and Morrison, M.E.S. (eds.). *East African Vegetation.* Longman, London.

Hamilton, A.C. (1982). *Environmental History of East Africa.* Academic Press, London.

Hart, T.B., Hart, J.A. and Murphy, P.G. (1989). Monodominant and species-rich forests of the humid tropics: causes for their co-occurrence. *The American Naturalist* **133**: 613–633.

Hawthorne, W.D. (1984). 'Ecological and Biogeographical Patterns in the Coastal Forests of East Africa'. Unpublished Ph.D Thesis. University of Oxford, Oxford.

Hawthorne, W.D. (1993). East African Coastal Forest botany. Pp. 57–99. In Lovett, J.C. and Wasser, S.K. (eds.). *Biogeography and Ecology of the Rain Forests of Eastern Africa.* Cambridge University Press, Cambridge.

Iversen, S.T. (1988). Conservation of the Usambara Mountains. Botanical Values at the species and phytogeographical level. In Hedberg, I. (ed.) Systematic Botany – a Key Science for tropical research and documentation. *Sym. Bot. Ups.* **XXVIII**: 218–243.

Iversen, S.T. (1991). The Usambara Mountains, NE Tanzania: Phytogeography of the vascular plant flora. *Sym. Bot. Upsaliensis* **XXIX**: 1–234.

Kerner von Marilaun, A. and Hansen, A. (1916). *Pflanzenleben. Dritter Band: Die Pflanzenarten als Floren und Genossenschaften.* Bibliographisches Institut, Leipzig und Wien.

Leroy, J.F. (1978). Composition, origin and affinities of the Madagascan vascular flora. *Annals Missouri Botanical Garden* **65**: 535–589.

Lovett, J.C. and Friis, I. (1996). Patterns of endemism in the woody flora of north-east and east Africa. Pp. 582–601. In L.J.G. van der Maesen *et al.* (eds.). *The Biodiversity of African Plants*. Kluwer Academic Publishers, The Netherlands.

Lovett, J.C. (1988). Endemism and affinities of the Tanzanian montane forest flora. In Goldblatt, P. and Lowry, P.P. (eds.). Proceedings of the eleventh plenary meeting of the Association for the Taxonomic Study of Tropical Africa. *Monographs in Systematic Botany from the Missouri Botanical Garden* **25**: 591–598.

Lovett, J.C. (1990). Classification and status of the Tanzanian forests. *Mitt. Inst. Allg. Bot. Hamburg* Band **23a**: 287–300.

Lovett, J.C. (1992). 'Tanzanian Moist Forests'. Ph.D Thesis. University of Wales, Bangor.

Lovett, J.C. (1993). Eastern Arc Moist Forest Flora. Pp. 33–55. In Lovett, J.C. and Wasser, S.K. (eds.) *Biogeography and Ecology of the Rain Forests of Eastern Africa*. Cambridge University Press, Cambridge.

Lovett, J.C., Bridson, D.M. and Thomas, D.W. (1988). A preliminary list of the moist forest angiosperm flora of Mwanihana forest reserve, Tanzania. *Annals Missouri Botanical Garden* **75**: 874–885.

Lucas, G.L. (1968). Kenya. In Hedberg, I. and Hedberg, O. (eds.) *Conservation of Vegetation in Africa South of the Sahara*. Uppsala: *Acta Phytogeographica Suecica* **54**: 152–163.

Luke, W.R.Q. (1988). New records of rare Kenyan Plants 1. *Utafiti* **1**: 68–70.

Mabberley, D.J. (1987). *The Plant Book*. Cambridge University Press, Cambridge.

MacArthur, R.H. and Wilson, E.O. (1967). *The Theory of Island Biogeography*. 203pp. Princetown University Press, Princetown, NJ.

Madgwick, J. (1988). Riverine forest in the Jubba Valley: A vegetation analysis and comments on forest conservation. *Biogeographia* **XIV**. *The Biogeography of Somalia*, 67–88.

Mbwana, A.H.B., Mtui, C.Y.S. and Mwakamela (1991). *Studies on Floristic Composition of Pugu and Pande Forests*. Unpublished typescript. University of Dar es Salaam, Dar es Salaam.

McIntosh, R.P. (1967). An index of diversity and the relation of certain concepts to diversity. *Ecology* **48**: 392–404.

Medley, K.E. (1992). Patterns of forest diversity along the Tana River, Kenya. *Journal of Tropical Ecology* **8**: 353–371.

Mendonça, F.A. (1961). Botanical collectors in Mozambique. *Comptes Rendus de la IV^{e} Réunion plénière de AETFAT*, pp.205–229.

Milne-Redhead, E. (1955). Distributional ranges of flowering plants in tropical Africa. *Proceedings of the Linnean Society London* **165**: 25–35.

Moll, E.J. and White, F. (1978). The Indian Ocean Coastal Belt. Pp. 563–598. In Werger, M.J.A. (ed.) with assistance of Van Bruggen, A.C. (1978). *Biogeography and Ecology of Southern Africa*. Dr W. Junk Publishers, The Hague.

Moomaw, J.C. (1960). *A Study of the Plant Ecology of the Coast Region of Kenya Colony*. Government Printer, Nairobi.

Muller, T. (1991). 'The rainforests of Zimbabwe'. Unpublished report. National Herbarium, Harare.

Mwasumbi, L.B., Burgess, N.D. and Clarke, G.P. (1994). The vegetation of Pande and Kiono monsoon forests, Tanzania. *Vegetatio* **113**: 71–81.

Nurse, D. and Spear, T. (1985). *The Swahili. Reconstructing the History and Language of an African Society, 800–1500*. University of Pennsylvania Press, Philadelphia.

Peet, R.K. (1974). The measurement of species diversity. *Annual Review of Ecology and Systematics* **5**: 285–307.

Pennington, T.D. (1991). *The Genera of Sapotaceae*. 295pp. Royal Botanic Gardens and New York Botanical Garden, Kew and New York.

Robertson, S.A. and Luke, W. R. Q. (1993). *Kenya Coastal Forests*. WWF, Nairobi.

Robertson, S.A. (1987). 'Preliminary Floristic Survey of Kaya Forests in Coastal Kenya'. Unpublished internal report. National Museums of Kenya, Nairobi.

Rodgers, W.A., Hall, J.B., Mwasumbi, L.B., Griffiths, C.J. and Vollesen, K. (1983). 'The Conservation and Status of Kimboza Forest Reserve, Tanzania'. Unpublished typescript. Forestry Working Group of the University of Dar es Salaam, Dar es Salaam.

Rodgers, W.A., Hall, J.B. and Mwasumbi, L. (1984). 'The Floristics of Three Coastal Forests near Dar es Salaam'. Unpublished typescript. Forestry Working Group of the University of Dar es Salaam, Dar es Salaam.

Rodgers, W.A., Hall, J.B., Mwasumbi, L.B., Swai, I. and Vollesen, K. (1986). 'The Conservation Status and Values of Ngezi Reserve, Pemba Island, Tanzania. Unpublished typescript. Forestry Working Group of the University of Dar es Salaam, Dar es Salaam.

Ruffo, C.K. (1991). 'A Report on Species Identification for Jozani and Ngezi Forest Inventory'. Unpublished report. Tanzania Forestry Research Institute, Lushoto.

Sayer, J.A., Harcourt, C.S. and Collins, N.M. (1992). *The Conservation Atlas of Tropical Forests. Africa.* Macmillan, London.

Schlieben, H.J. (1939). Die forstlichen Vegetationsverhaltnisse Deutsch-Ostafrikas. *Kolonialeforstliche Mitteilungen* **1**: 406–424.

Sheil, D. (1992). Tanzanian Coastal Forests – unique, threatened, and overlooked. *Oryx* **26**: 107–114.

Swynnerton, C.F.M. (1917). Some factors in the replacement of the ancient East African forest by wooded pasture land. *South African Journal of Science* **14**: 493–518.

Temu, R.P.C. (1990). Taxonomy and biogeography of woody plants in the Eastern Arc Mountains, Tanzania: case studies in *Zenkerella, Scorodophloeus* and *Peddiea. Acta Universitatis Upsaliensis Comprehensive Summaries of Uppsala Dissertations from the Faculty of Science* **286**: 1–68.

Thorne, R.F. (1973). Floristic relationships between tropical Africa and tropical America. In Meggers, B.J., Ayensu, E.S. and Duckworth, W.D. (eds.). *Tropical Forest Ecosystems in Africa and South America: A Comparative Review.* Smithsonian Institution, Washington.

Thulin, M. *et al.* (1993-). *Flora of Somalia. Volume 1-.* Royal Botanic Gardens, Kew.

Timberlake, J.R. and Muller, T. (1994). Identifying and describing areas for vegetation conservation in Zimbabwe. *Strelitzia* **1**: 125–139.

Timler, F.K. and Zepernik, B. (1987). German colonial botany. *Ber. Deutsch. Bot. Ges.* 1987 **100**: 143–168.

Turrill, W.B. and Milne-Redhead, E. *et al.* (eds.) (1952-). *The Flora of Tropical East Africa.* A.A. Balkema, Rotterdam.

Verdcourt, B. (1952). Notes from the East African Herbarium. I. *Kew Bulletin* **3**: 353–365.

Verdcourt, B. (1996). *Sanrafaelia* a new genus of Annonaceae from Tanzania. *Garcia de Orta, Ser. Bot., Lisboa* **13**: 43–44.

Vollesen, K. and Bidgood, S. (1992). 'Kew Expedition to Tanzania and Malawi Jan–April 1991'. Unpublished report. Royal Botanic Gardens, Kew.

Vollesen, K. (1980). Annotated Checklist of the Selous Game Reserve. *Opera Botanica* **59**: 1–117.

Vollesen, K. (1992). *Trichaulax* (Acanthaceae: *Justicieae*), a new genus from East Africa. *Kew Bulletin* **47**: 613–616.

Vollesen, K. (1994). Rondo Plateau, Tanzania. Pp. 225–226. In Davis, S.D., Heywood, V.H. and Hamilton, A.C. (eds). *Centres of Plant Diversity. A Guide and Strategy for their Conservation.* WWF and IUCN, Godalming and Cambridge.

Whitaker, R.H. (1960). Vegetation of the Siskiyou Mountains, Oregon and California. *Ecol. Monogr.* **30**: 279–338.

White, F. (1976). The vegetation map of Africa: the history of a completed project. *Boissiera* **24**: 659–666.

White, F. (1979). The Guineo-Congolian Region and its relationships to other phytochoria. *Bull. Jard. Bot. Nat. Belg. / Bull. Nat. Plantentuin Belg.* **49**: 11–55.

White, F. (1983). *The Vegetation of Africa: A Descriptive Memoir to Accompany the UNESCO/AETFAT/UNSO vegetation map of Africa.* 356pp. UNESCO, Paris.

White, F. (1993). The AETFAT chorological classification of Africa: history, methods and applications. *Bull. Jard. Bot. Nat. Belg. Bull. Nat. Plantentuin Belg.* **62**: 225–281.

Whitmore, T.C. (1986). *Tropical Rainforests of the Far East.* 2nd edition. Oxford University Press/ELBS, Oxford.

Whitmore, T.C., Peralta, R. and Brown, K. (1985). Total species count in a Costa Rican tropical rain forest. *Journal of Tropical Ecology* **1**: 375–378.

4.2 Birds

C.O.F. Mlingwa, E.M. Waiyaki, L.A. Bennun and N.D. Burgess

Introduction

It has been known since earlier this century that the Coastal Forests of eastern Africa contain a number of unique bird species that make their avifauna distinct from that of other forest types in the region (e.g. Vincent, 1933 and 1934; Fuggles-Couchman, 1939; Moreau, 1940a, b; 1944 and 1966). The remainder of the avifauna is known to have strong affinities with that of other lowland forest communities in eastern and western Africa (see Moreau, 1966; Diamond and Hamilton, 1980; Dowsett-Lemaire, 1989).

In recent years there has been considerable effort to study the avifauna of all unsurveyed Coastal Forest patches, particularly in Somalia, Kenya and Tanzania. There is now a much better knowledge base from which to discuss in detail the avifauna of this forest type. The survey intensity may even perhaps now rival that in the Eastern Arc Mountains, which have been studied throughout this century (Sclater and Moreau, 1932 and 1933; Moreau, 1966; Stuart and Jensen, 1981 and 1985; Newmark, 1991; Evans *et al.*, 1992 and 1994; Stuart *et al.*, 1993; Dinesen *et al.*, 1993 and 1994; Cordeiro and Kiure, 1995; Svendsen and Hansen, 1995; Fjeldså and Rabøl, 1995).

This Chapter aims to characterise the Coastal Forest avifauna in terms of richness, endemism and threat; identify its biogeographical elements and affinities; and assess its importance, as a whole and for particular sites.

Sources of information and study methods

Data sources

This Chapter draws on field data collected during several research programmes active in eastern Africa since the late 1970s; published information from the period of British colonial rule in the region; and comments from respected regional experts. Museum collections have not been examined and literature from before 1930 (especially German) has not been comprehensively reviewed. Discussion focuses on records from Somalia, Kenya and Tanzania, although records of rare bird species have also been compiled for Coastal Forests in Mozambique (Vincent, 1933 and 1934; Clancey, 1971), Malawi (e.g. Dowsett-Lemaire, 1989) and Zimbabwe (e.g. Irwin, 1994).

Somalia

The small area of Coastal Forest remaining along the Jubba river in Somalia was studied by Madgwick (1988 and 1989) and Wood (1988).

Kenya

Coastal Forests are scattered all along the coastal strip of Kenya. Their ornithology has been investigated in two phases: in the 1970s and early 1980s (Glover, 1969; Anonymous, 1973; Andrews *et al.*, 1975; Marsh *et al.*, 1975; Turner, 1977; Britton and Zimmerman, 1979; van Someren, 1979; Britton *et al.*, 1980; Kelsey and Langton, 1984; Bennun, 1985), and again in the 1990s (Bennun and Waiyaki, 1992a, b; Waiyaki, 1994; Virani, 1994; Waiyaki, 1995; Fanshawe, 1995; Matiku, 1996; Nemeth, 1996; Waiyaki and Bennun, in press; D. A. Turner, *in lit.*; T. Butynski, *in lit.*).

Table 4.2.1 Summary bird species richness in 41 eastern African Coastal Forests, broken into two categories of forest dependence. Survey periods (wet or dry seasons) and relative study effort are indicated.

Forests	Survey period (wet/dry)	Categories FF	F	Total species FF+F	Area (km^2)	Relative study effort
Somalia						
1 = Jubba	D	4	19	23	5	low
Kenya						
2 = Boni	D	5	22	27	20	low
3 = Tana	W/D	12	36	48	20	medium
4 = Dakatcha	D	3	21	24	?	low
5 = Gede	W/D	13	29	42	0.44	high
6 = Sokoke	W/D	21	38	59	370	high
7 = Mtswakara	D	3	17	20	1.2	low
8 = Gandini	D	9	21	30	1.5	low
9 = Teleza	D	5	14	19	1	low
10 = Waa	D	4	12	16	0.2	low
11 = Shimba Hills	D	18	36	54	63	low
12 = Diani/ Jadini	D	12	22	36	0.4	low
13 = Kinondo	W	5	18	23	0.3	low
14 = Timbwa	D	6	17	33	0.2	low
15 = Muhaka	W	11	21	32	1.5	low
16 = Gongoni	W/D	13	23	36	8.2	low
17 = Buda	W/D	13	19	32	5.9	low
18 = Mrima	W	18	29	47	2.5	low
19 = Dzombo	W	12	23	35	3	low
20 = Marenji	W	15	27	42	14	low
Tanzania						
21 = East Usambaras	W/D	28	32	60	25	low
22 = Kilulu	D	7	14	21	1.6	low
23 = Gendagenda	W	16	27	43	28	low
24 = Msubugwe	D	13	29	42	44	low
25 = Kiono/Zaraninge	W/D	17	29	46	20	medium
26 = Pande	D	13	22	35	11	low
27 = Pugu	W/D	26	36	61	10	high
28 = Kazimzumbwi	W/D	17	29	46	24	low
29 = Vikindu	W	10	24	34	10	low
30 = Kisiju	D	4	10	14	2	low
31 = Mchungu	D	9	24	33	2	low
32 = Kiwengoma	W/D	14	25	39	22	low
33 = Litipo	W/D	17	31	48	5	low
34 = Rondo	W/D	17	33	50	18	low
35 = Nyangamara	D	5	19	24	6	low
36 = Chitoa	D	16	18	44	6	low
37 = Pindiro	W/D	14	30	44	10	low
38 = Ngarama	D	16	30	46	7	low
39 = Pemba Island	W/D	4	8	12	15	low
40 = Zanzibar Island	W/D	8	16	24	3	low
41 = Mafia Island	W/D	2	15	17	3	low

Key: Forest dependence categories: **FF**, forest specialist; **F**, forest generalist. Survey period: **W**, wet; **D**, dry. Study effort: **low**, 1–3 visits; **medium**, 4–6 visits; **high**, more than six visits.

Table 4.2.2 Frequency of occurrence of forest specialist (FF) and forest generalist (F) bird species in 41 Coastal Forests in eastern Africa.

FF Species		F Species	
in >50% sites	**in <50% sites**	**in >50% sites**	**in <50% sites**
African Crowned Eagle	Buff-spotted Flufftail	Southern Banded Snake Eagle	Great Sparrowhawk
Eastern Green Tinkerbird	Lemon Dove	African Goshawk	Ayres' Hawk Eagle
African Broadbill	Eastern Bronze-naped Pigeon	Crested Guineafowl	Brown-headed Parrot
Tiny Greenbul	Barred Long-tailed Cuckoo	Tambourine Dove	Livingstone's Turaco
Fischer's Greenbul	Usambara Eagle Owl	African Green Pigeon	Emerald Cuckoo
Red-tailed Ant Thrush	Sokoke Scops Owl	Fischer's Turaco	African Barred Owlet
Black-headed Apalis	Green Barbet	Yellowbill	Pel's Fishing Owl
Crested Flycatcher	African Pitta	African Wood Owl	Fiery-necked Nightjar
Forest Batis	Sokoke Pipit	Böhm's Spinetail	Mottled Spinetail
Plain-backed Sunbird	Stripe-cheeked Greenbul	Narina's Trogon	Silvery-cheeked Hornbill
Olive Sunbird	Yellow-streaked Greenbul	Trumpeter Hornbill	White-eared Barbet
Green-backed Twinspot	Pale-breasted Illadopsis	Yellow-rumped Tinkerbird	Mombasa Woodpecker
	White-chested Alethe	Yellow-bellied Greenbul	Golden-tailed Woodpecker
	East Coast Akalat	Eastern Nicator	Little Greenbul
	Swynnerton's Robin	Fischer's Greenbul	White-starred Robin
	Spotted Ground Thrush	Red-capped Robin Chat	Green-capped Eremomela
	Orange Ground Thrush	Kretschmer's Longbill	Yellow White-eye
	White-winged Apalis	Chestnut-fronted Helmet-Shrike	Four-coloured Bush-Shrike
	Little Yellow Flycatcher	Black-backed Puffback	Square-tailed Drongo
	Reichenow's Batis	Black-bellied Starling	Green-headed Oriole
	Banded Green Sunbird	Collared Sunbird	Uluguru Violet-backed Sunbird
	Clarke's Weaver	Dark-backed Weaver	Amani Sunbird
		Peter's Twinspot	

Species endemism

The following elements of endemism can be recognised:

1. Species endemic to the Coastal Forests (Figure 4.2.2a–h)

These occur only in Coastal Forests in the eastern African coastal region. Five species fall into this group (see Table 4.2.3). One of these, Sokoke Pipit *Anthus sokokensis*, is relatively widespread in the Coastal Forests, but with a patchy and apparently relict distribution. Clarke's Weaver *Ploceus golandi* and Sokoke Scops Owl *Otus ireneae* (Figure 4.2.3) are very restricted in range, known respectively only from Arabuko-Sokoke and Dakatcha, and Arabuko-Sokoke and the East Usambaras. The Little Yellow Flycatcher *Erythrocercus holochlorus* is widespread north of the Rufiji River; Reichenow's Batis *Batis reichenowi* is restricted to forests south of this river.

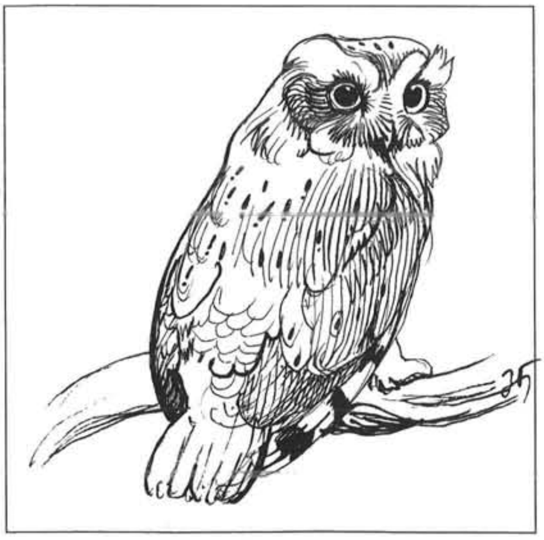


Figure 4.2.3 Vignette of Sokoke Scops Owl by J. Fjeldså

2. Species unique to the Coastal Forests and Eastern Arc forests (Figure 4.2.2i)

Eight species belong to this group (Table 4.2.3) and have breeding populations in both Coastal Forests and Eastern Arc montane forests. The Usambara Eagle Owl and Banded Green Sunbird are considered mainly montane birds, with only a few

Table 4.2.3 Endemic and near-endemic Coastal Forest birds and Pemba endemics. Forest-dependence category, 'rarity score', global threat status (Collar *et al.*, 1994) and regional threat status (Bennun and Njoroge, 1996) are shown. Occurrence in montane forests of the Eastern Arc and in other forest types is indicated.

Species	Forest dependence	Note	Rarity score	Global threat status	Range status	Regional threat status	Eastern Arc	One other forest type
Sokoke Scops Owl	FF	A	4	VU	EBA	VU/RR	.	.
Reichenow's Batis	FF	A[1]	3	VU		(VU)[1]	.	.
Little Yellow Flycatcher	FF	A	2			VU/RR	.	.
Sokoke Pipit	FF	A	2	VU	EBA	VU/RR	.	.
Clarke's Weaver	FF	A	4	VU	EBA	VU/RR	.	.
Southern Banded Snake Eagle	F	B	1	NT		NT	x	x
Fischer's Turaco	F	B	1	NT	EBA	NT/RR	x	.
Eastern Green Tinkerbird	FF	B	1			RR	x	x
Mombasa Woodpecker	F	B	2			RR	x	.
Green-headed Oriole	F	B	3			RR	x	x
Tiny Greenbul	FF	B	1			RR	x	.
Fischer's Greenbul	FF	B	1			RR	x	.
East Coast Akalat	FF	B	2	VU		EN/RR	.	x
Spotted Ground Thrush	FF	B[2]	2	EN		EN/RR	.	x
White-winged Apalis	FF	B[3]	3	VU	EBA	EN	x	x
Kretschmer's Longbill	FF	B	3			RR	x	x
Chestnut-fronted Helmet Shrike	F	B	1			NT	x	x
Uluguru Violet-backed Sunbird	F	B	2			VU/RR	x	.
Amani Sunbird	F	B	4	VU	EBA	VU/RR	x	.
Plain-backed Sunbird	FF	B	1	NT		NT	x	x
Usambara Eagle Owl	FF	C		VU	EBA	VU/RR	x	.
Swynnerton's Robin	FF	C	4	VU	EBA	VU/RR	x	x
White-chested Alethe	FF	C				RR	x	x
Banded Green Sunbird	FF	C		VU	EBA	VU/RR	x	.
Pemba Scops Owl	f	D		NT	EBA	VU/RR	.	.
Pemba Green Pigeon	f	D		NT	EBA	NT/RR	.	.
Pemba White-eye	f	D		NT	EBA	NT/RR	.	.
Pemba Sunbird	f	D		NT	EBA	NT/RR	.	.

Key:

Forest dependence: see text.

Note: A. Coastal Forest endemics; **B**. Characteristic Coastal Forest birds also found in the Eastern Arc forests and/or one other forest type; **C**. Characteristic Eastern Arc birds with some records from Coastal Forest, chiefly at the base of the East Usambara Mountains in Tanzania (see Appendix 4), where the montane Eastern Arc and lowland Coastal Forests are contiguous. **D**. Pemba endemics: these are not confined to forest. [1] Reichenow's Batis is not recognised as a full species by OS-c (1996), nor therefore by Bennun and Njoroge (1996). We treat it as a species that is globally vulnerable, based on Collar *et al.*, (1994). [2] Long-distance migrant that spends both the breeding and non-breeding season in Coastal Forests. [3] May be extinct in Tana River forests.

Rarity score: Not calculated for Pemba species or montane species. **4** = occurs in 1–2 sites; **3** = occurs in 3–6 sites; **2** = occurs in 7–14 sites; **1** = occurs in more than 14 sites (see Table 4.3.5).

Global threat status: EN = Endangered (20% chance of becoming extinct in 20 years); **VU** = Vulnerable (10% chance of becoming extinct in 100 years); **NT** = near-threatened (species very close to Vulnerable). These categories apply either regionally (to East Africa) or globally.

Range status: EBA = restricted-range species, with a world range of less than 50,000 km^2, defining an Endemic Bird Area or secondary area.

Regional threat status: RR = 'Regional responsibility' species, for which the East African countries have a special responsibility (Bennun and Njoroge, 1996). All Coastal Forest endemics are RR species, as are any species with more than 90% of the range or population in East Africa (Kenya, Tanzania, Uganda, Rwanda and Burundi).

records from the Coastal Forests. We do not know how important the Coastal Forests are to them, but the Usambara Eagle Owl *Bubo vosseleri* appears more common in the lowland than the montane East Usambaras (see Evans *et al.*, 1994). The remaining five are characteristic Coastal Forest species.

3. Forest species that have a restricted distribution in the forests of eastern and south-eastern Africa, but are not confined to Coastal Forests and Eastern Arc forests (Figure 4.2.2j)

A total of 11 species occur in this group (Table 4.2.3). They are found in the Coastal Forests and often in the Eastern Arc Mountain forests as well, but also have a (restricted) distribution in other forest types. Swynnerton's Robin and White-chested Alethe are primarily montane birds, also recorded in the lowland East Usambaras; other species are characteristic Coastal Forest birds. Kretschmer's Longbill *Macrosphenus kretschmeri* also occurs on the montane forests of volcanic Mount Kilimanjaro (Britton, 1980); the Spotted Ground Thrush *Zoothera guttata* has a strange relict distribution, known from a handful of sites in southern Sudan, southern Zaïre, Malawi and the eastern coast of South Africa (Bennun, 1985). The remaining species penetrate to a greater or lesser extent to isolated highlands in Zambia, Malawi and Zimbabwe and/or lowland forest in southern Mozambique.

4. Species endemic to Pemba Island, but not tied to forest

The Pemba Scops Owl *Otus pembaensis*, Pemba Green Pigeon *Treron pembaensis*, Pemba White-eye *Zosterops vaughani* and Pemba Sunbird *Nectarinia pembaensis* (sometimes treated as a well-marked sub-species) are restricted to Pemba Island. Today they are not tied to forest, although they may have evolved as forest-dependent birds.

5. Species endemic to the Zanzibar-Inhambane regional mosaic/Swahilian region *sensu lato*, but not tied to forest

Several additional species are endemic or very nearly endemic to the Zanzibar-Inhambane regional mosaic (White, 1983)/Swahilian region *sensu lato* (Chapter 1.2). These comprise the Malindi Pipit *Anthus melindae*, Scaly Babbler *Turdoides squamulatus*, Tana River Cisticola *Cisticola restrictus*, Violet-breasted Sunbird *Nectarinia chalcomelas*, Lesser Seed Cracker *Pyrenestes minor* and Mouse-coloured Sunbird *Nectarinia veroxii*. They do not occur in forest, being birds of grassland, bushland or thicket.

6. Sub-species endemic to the Coastal Forests

Including the forest visitors ('f' species), 12 bird sub-species are endemic to the Coastal Forests and a further 26 sub-species found in the Coastal Forests are endemic or nearly endemic to the Zanzibar-Inhambane regional mosaic/Swahilian region *sensu lato* (Table 4.2.4). Pemba and Zanzibar have several endemic sub-species. There is also evidence of biogeographical segregation at the sub-species level, with races of Dark-backed Weaver (*kersteni*) and Tiny Greenbul (*rabai*) reaching their southern limit at the Rufiji River. Moreover, the *woodwardii* race of Green Barbet is found only in southern Tanzania and Mozambique (Collar and Stuart, 1985).

Northern Coastal Forests endemics

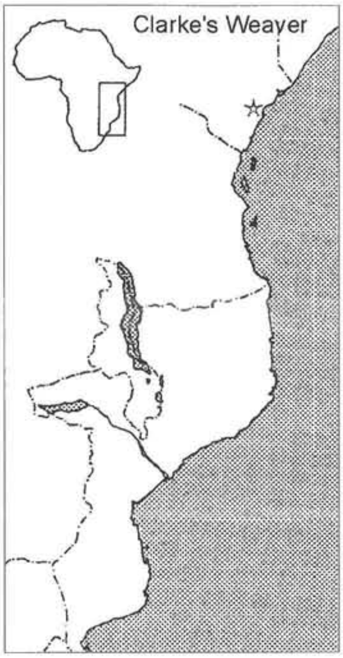


Figure 4.2.2(a) Clarke's Weaver *Ploceus golandi.*

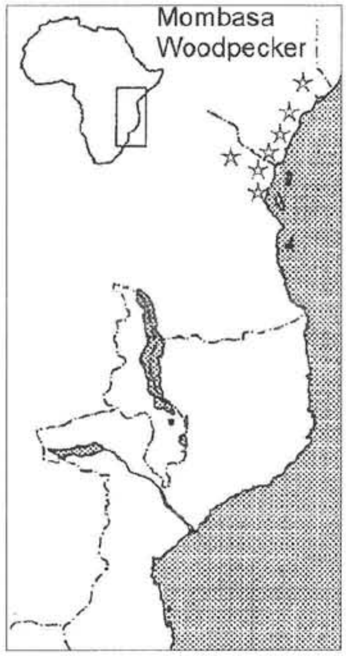


Figure 4.2.2(b) Mombasa Woodpecker *Campethera mombassica.*

Figure 4.2.2(c) Sokoke Pipit *Anthus sokokensis.*

Figure 4.2.2(d) Sokoke Scops Owl *Otus ireneae.*

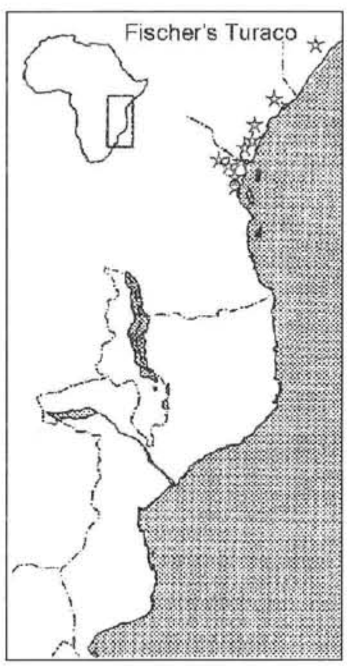


Figure 4.2.2(e) Fischer's Turaco *Tauraco fischeri.*

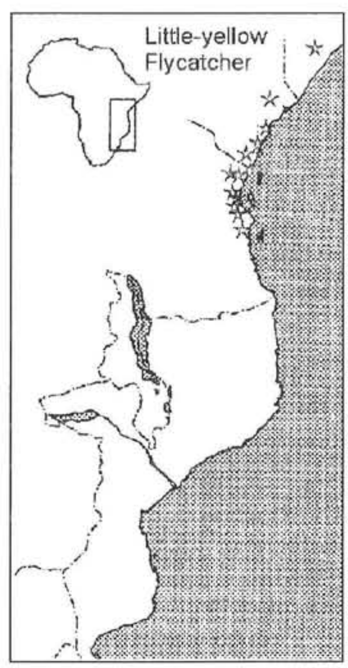


Figure 4.2.2(f) Little Yellow Flycatcher *Erythrocercus holochlorus.*

Figure 4.2.2 (a–f) Distribution patterns of Coastal Forest birds.

Southern Coastal Forests endemics/near endemics

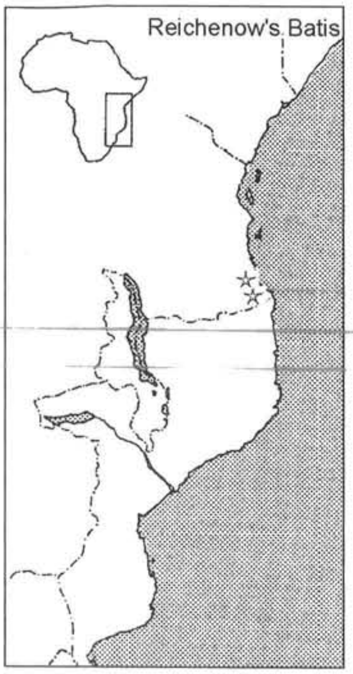


Figure 4.2.2(g) Reichenow's Batis ***Batis reichenowi.***

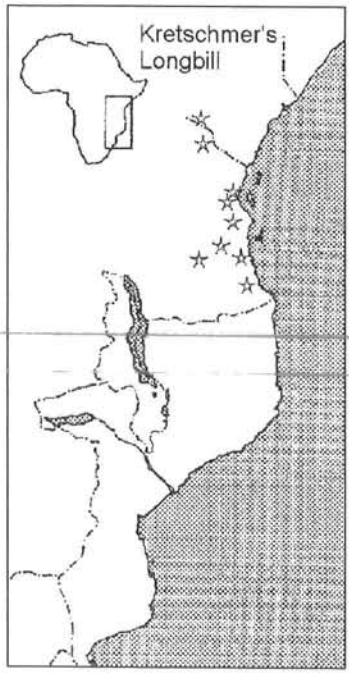


Figure 4.2.2(h) Kretschmer's Longbill ***Macrosphenus kretschmeri.***

Coastal Forest and Eastern Arc

Figure 4.2.2(i) Amani Sunbird ***Anthreptes pallidigaster.***

Coastal Forest to Mozambique

Figure 4.2.2(j) East Coast Akalat ***Sheppardia gunningi.***

Figure 4.2.2 (g–j) Distribution patterns of Coastal Forest birds (cont.)

Table 4.2.4 Endemic sub-species of forest birds in the Coastal Forests of eastern Africa, and the vegetation of the Swahilian *sensu lato* regional centre of endemism (distribution and taxonomy from Mackworth-Praed and Grant, 1952, and updated from Britton, 1980).

Species	Coastal Forest sub-species	Swahilian *sensu lato* sub-species
African Goshawk		*pembaensis* (Pemba only)
Crested Guineafowl		*barbata* (also Eastern Arc and Malawi)
African Green Pigeon		*wakefieldii* (Lamu to Tanzania)
		granti (also somewhat inland of Swahilian *sensu lato* area)
Brown-headed Parrot		*zanzibaricus* (Zanzibar and Pemba only; possibly extinct)
Fischer's Turaco	*zanzibaricus* (Zanzibar only; possibly extinct)	*fischeri*
Green Barbet	*woodwardi*	
Yellow-rumped Tinkerbird		*fischeri*, *pallidus*
African Broadbill		*suahelicus*
Little Greenbul		*zanzibaricus* (Zanzibar only)
Tiny Greenbul	*debilis* (south of the Rufiji to Mozambique)	
	rabai (north of the Rufiji)	
Yellow-streaked Greenbul		*tenuirostris* (also Eastern Arc)
Pale-breasted Illadopsis	*puguensis* (Pugu Hills only)	
East Coast Akalat	*sokokensis*	
Eastern Bearded Scrub Robin		*greenwayi* (Zanzibar and Mafia only)
		erlangeri (Jubba valley only)
Red-tailed Ant Thrush		*rufus* (also Eastern Arc)
Spotted Ground Thrush	*fischeri*	
White-winged Apalis	*chariessa* (Tana River, possibly extinct)	
Kretschmer's Longbill	*griseiceps* (Rufiji to Mozambique)	
	kretschmeri (N. Tanzania to Pugu)	
Grey-backed Cameroptera	*pileata* (Kenya to Mozambique)	
Chestnut-fronted Helmet Shrike		*kirki* (Kenya and Tanzania, including Eastern Arc)
Tropical Boubou		*sublacteus* (and Eastern Arc and thickets etc.).
Four-coloured Bush Shrike		*nigricaudata*
Square-tailed Drongo		*muenzneri*
Black-bellied Starling		*mandanus* (Somalia to Mozambique)
		vaughani (Pemba only)
Olive Sunbird		*olivacia* (Rovuma to Inhambane)
		changamwensis (Somalia to Pangani)
		puguensis (Pangani to Lindi)
Plain-backed Sunbird	*yokanae*	*granti* (Zanzibar and Pemba only)
Dark-backed Weaver		*kersteni* (Somalia to Rufiji)
		stictifrons (Rufiji to Mozambique)

Rarity and extinction threat

The degree of global and regional extinction threat faced by species endemic or near-endemic to the Coastal Forests is shown in Table 4.2.3 (from Collar *et al.*, 1994 and Bennun and Njoroge, 1996; with the addition of Reichenow's Batis). For completeness, Table 4.2.3 includes Eastern Arc birds recorded from Coastal Forests and Pemba endemics. The category 'near-threatened' is defined as Lower Risk but very close to Vulnerable' (Collar *et al.*, 1994). Seven Coastal Forest birds (and three of the montane species that occur in Coastal Forests) are globally threatened; three are near-threatened, as are all the Pemba endemics (because of their restricted distribution). Six Coastal Forest birds are restricted-range species whose ranges define the East African Coastal Forests Endemic Bird Area (EBA: see below). At the regional level, Little Yellow Flycatcher and Uluguru Violet-backed Sunbird are also considered threatened in the Vulnerable category, while White-winged Apalis and East Coast Akalat are considered Endangered (recent data on East Coast Akalat populations may cause this classification to be downgraded to Vulnerable: Nemeth, 1996).

Table 4.2.5 Distribution and rarity scores for endemic and near-endemic Coastal Forest birds in 41 forests in eastern Africa (see Table 4.2.3 for explanation of codes and rarity score calculation).

Species (rarity score)	Status	No. sites	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
Southern Banded Snake Eagle (1)	NT	24	1	.	1	1	1	1	1	1	.	.	1	1	.	.	1	1	1	.	.	.	1	1	1	1	1	1	1	1	.	.	.	1	1	1	.	.	1	.	.	.	.
Fischer's Turaco (1)	NT, EBA	24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sokoke Scops Owl (4)	VU, EBA	2	.	.	.	.	.	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Green Tinkerbird (1)		25	.	.	.	.	1	1	.	1	.	1	1	.	.	1	1	1	1	1	.	1	.	.	1	1	1	1	1	1	.	.	1	1	1	1	.	1	1	1	.	1	.
Mombasa Woodpecker (2)	EBA	13	.	.	2	.	.	2	2	2	2	.	2	2	2	.	.	2	2	2	2	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Green-headed Oriole (3)		6	.	.	.	.	.	3	.	.	.	.	3	.	.	.	.	.	.	3	.	3	3	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.	.	.	.	.	.
Tiny Greenbul (1)		26	.	.	.	.	.	1	.	.	.	.	1	1	.	.	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.	1	1	1	.	.	.
Fischer's Greenbul (1)		28	.	1	1	.	1	1	.	.	.	.	1	1	.	.	1	1	1	1	1	1	1	.	1	1	1	1	1	1	1	1	1	1	1	1	.	1	1	1	.	.	.
East Coast Akalat (2)	VU	10	.	.	2	.	.	2	.	.	.	.	2	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	2	2	.	.	.	.	2	2	.	2	.	.	.	2	.
Spotted Ground Thrush (2)	EN	11	.	.	2	.	2	2	.	2	.	2	2	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	2	2	.	.	.	.	2	2	.	.	.	.	.	.	.
White-winged Apalis (4)	VU, EBA	1	.	.	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Kretschmer's Longbill (3)		7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	2	2	.	2	2	.	.	.	2	.	2	.	.	.	.	.	.	.
Reichenow's Batis (3)	(VU, EBA)	5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	3	.	3	3	3	.	.	.
Little Yellow Flycatcher (2)		19	1	.	1	.	1	1	.	.	1	.	.	1	.	.	1	1	1	1	.	1	1	1	1	1	1	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.
Sokoke Pipit (2)	VU, EBA	11	.	.	.	2	2	2	.	2	.	.	2	.	.	.	.	.	.	.	2	2	.	2	.	.	2	.	2	.	2	.	.	.	.	.	.	.	.	.	.	.	.
Chestnut-fronted Helmet Shrike (1)		24	1	1	1	.	1	1	1	1	.	.	1	.	.	.	.	.	.	1	1	1	.	.	1	1	1	1	1	1	1	.	1	1	1	1	.	.	1	1	.	.	.
Uluguru Violet-backed Sunbird (2)		16	.	.	1	.	1	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	1	.	1	1	1	.	1	1	.	.	.	1	1	1	.	1	1	1	.	.	.
Amani Sunbird (3)	VU, EBA	2	.	.	.	.	.	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Plain-backed Sunbird (1)	NT	21	.	.	1	.	1	1	.	1	.	.	1	1	.	.	.	.	.	1	1	1	1	1	1	1	1	1	.	.	.	.	.	.	1	1	1	1	1	1	.	.	.
Clarke's Weaver (4)	VU, EBA	2	.	.	.	4	.	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Number of species			4	3	11	4	10	16	4	8	3	3	12	7	2	2	6	8	8	10	7	10	11	6	10	10	10	7	11	10	4	2	4	7	10	12	1	7	8	7	0	2	0
Total rarity scores			4	3	17	8	12	31	5	11	4	4	18	8	3	2	6	9	9	14	9	14	19	7	11	11	12	7	15	13	5	2	4	8	14	19	1	10	10	9	0	3	0

Key:
Rarity scores: 4 = Species recorded in 0–2 sites; 3 = Species recorded in 3–6 sites; 2 = Species recorded in 7–14 sites; 1 = Species recorded in >14 sites.
Status: VU = Vulnerable; EN = Endangered; NT = Near-threatened (after Collar *et al.*, 1994; see Table 4.2.3 and text); EBA = restricted-range species with global range <50,000 km^2 (see text).
Forests: 1 = Jubba, 2 = Boni, 3 = Tana, 4 = Dakatcha, 5 = Gede, 6 = Sokoke, 7 = Mtswakara, 8 = Gandini, 9 = Teleza, 10 = Waa, 11 = Shimba, 12 = Diani/Jadini, 13 = Kinondo, 14 = Timbwa, 15 = Muhaka, 16 = Gongoni, 17 = Buda, 18 = Mrima, 19 = Dzombo, 20 = Marenji, 21= East Usambara, 22 = Kilulu, 23 = Gendagenda, 24 = Msubugwe, 25 = Kiono (Zaraninge), 26 = Pande, 27 = Pugu, 28 = Kazimzumbwi, 29 = Vikindu, 30 = Kisiju, 31 = Mchungu, 32 = Kiwengoma, 33 = Litipo, 34 = Rondo, 35 = Nyangamara, 36 = Chitoa, 37 = Pindiro, 38 = Ngarama, 39 = Pemba Island, 40 = Zanzibar Island, 41 = Mafia Island.

2. Intra-African migration

Birds known to undertake seasonal migration within Africa, unrelated to altitude, include the Buff-spotted Flufftail, Yellowbill *Ceuthmochares aureus*, African Pygmy Kingfisher *Ispidina picta*, African Pitta *Pitta angolensis*, Eastern Bearded Scrub Robin *Cercotrichas quadrivirgata*, Red-capped Robin Chat *Cossypha natalensis*, Spotted Ground Thrush, Ashy Flycatcher *Muscicapa caerulescens*, Crested Flycatcher *Trochocercus cyanomelas*, Paradise Flycatcher *Terpsiphone viridis* and Green-backed Twinspot *Mandingoa nitidula*. In most cases very little is known about these movements. Species where the whole population is believed to migrate are the African Pitta and Spotted Ground Thrush (N.E. Baker, pers. comm.); for the remainder the Coastal Forests hold both resident and migratory populations (Baker and Howell, 1988; Baker and Baker, 1992).

The east coast of Africa is undoubtedly also an important flyway for intercontinental migrants (see Harvey and Howell, 1987; Mlingwa, 1992). However, the value of the Coastal Forests to this group of migrants is not well understood, or even established.

Biogeographical affinities

Many birds found in the Coastal Forests have a wide distribution in Africa. A large component occur also in the Guineo-Congolian Forest Region, for example the Square-tailed Drongo *Dicrurus ludwigii*, Red-headed Bluebill *Spermophaga ruficapilla* (East Usambaras only), Little Greenbul *Andropadus virens*, Red-tailed Ant Thrush *Neocossyphus rufus* and Dark-backed Weaver *Ploceus bicolor*. Such species usually show a disjunct distribution, being absent from forests in the volcanic highlands of central Kenya and northern Tanzania and reappearing (often in a form that is sub-specifically distinct) in western Kenya or Uganda. A few species, such as the Collared Sunbird *Anthreptes collaris* and Olive Sunbird *Nectarinia olivacea*, range through the highlands as well. Others, such as Silvery-cheeked Hornbill *Bycanistes brevis* and White-eared Barbet *Stactolaema leucotis* are confined to eastern Africa but occur in both lowland and highland forests. A third broad group ranges across moist woodland in central and southern Africa, where they are essentially thicket or riparian species: examples are Terrestrial Brownbul *Phyllastrephus terrestris*, and Black-throated Wattle-eye *Platysteira peltata*.

Recent studies of bird DNA (Sibley and Ahlquist, 1990) have allowed the relative 'ages' of species to be compared and their patterns of distribution explored (Fjeldså, 1994b; Fjeldså and Lovett, 1997). Such studies show that the Coastal Forest mosaic in general contains species which differentiated millions of years ago. The portion of the avifauna shared with the Guineo-Congolian rain forest is therefore partially a relict from the times when there was a continuous belt of rain forest across equatorial Africa (see Chapters 1.2 and 2.3 for discussion). These ancient links are clearly demonstrated by super-species such as Clarke's and Weyns's Weavers (*Ploceus golandi* and *P. weynsi*), or Sokoke and Cinnamon Scops Owls (*Otus ireneae* and *O. icterorhynchus*) (Britton and Zimmerman, 1979): in each case the Coastal Forest species is a relict form. The few representatives of recently radiating groups contrasts to the nearby montane forests of the Eastern Arc, where there are both old relict species and species which are recently evolved (Fjeldså and Lovett, 1997).

There are also strong species links to other lowland forest types in eastern Africa, particularly those of the lowland Eastern Arc and further south in Malawi (Dowsett-Lemaire, 1989) and Zimbabwe (Irwin, 1994) (transitional rain forest: Chapter 1.2). Lowland forests of Eastern Arc Mountains, such as the East Usambaras, Ulugurus and Udzungwas, have an avifauna which contains many of the species typical of both the Eastern Arc and the Coastal Forests (see Moreau, 1966; Stuart, 1981; Stuart and Jensen, 1985; Stuart *et al.*, 1993; Hipkiss *et al.*, 1993; Evans *et al.*, 1994).

Discussion

Variation in species richness

Several factors are likely to determine the substantial variation in species richness for Coastal Forests.

Forest area: The well-known species-area power relationship, number of species = cA^z where A is area and c and z are constants (see e.g. Rosenzweig, 1995), holds good for Coastal Forests too (Figure 4.2.1). The log-log relationship is clearly linear, although with considerable scatter around the line. For forest-dependent birds the value of z is 0.12, rather low for sites within a single biogeographic province (Rosenzweig, 1995). There may be several reasons for this relatively gentle slope. One contributing factor could be sampling bias: several small forests (such as Gede and Pugu) have been intensively studied, and thus have long species lists, while little is known about some larger sites.

Forest vegetation type and structural composition: In the eastern African Coastal Forests the vegetation is spatially highly heterogeneous, both in terms of assemblages (Hawthorne, 1993; Mwasumbi *et al.*, 1994; Chapter 3.2), and structure (Chapter 3.3; Waiyaki, in prep; Fanshawe, 1995). Both these factors influence the presence or absence of bird species in the Coastal Forests (Bennun, 1985; Fanshawe, 1995; Matiku, 1996; Nemeth, 1996; Waiyaki, 1995; Waiyaki and Bennun, in press). In the very heterogeneous forests of the southern Kenyan coast, Waiyaki (1995) demonstrated that structure was more important than fragment area in determining the composition of understorey bird communities. Among the sites in his study set, relatively tall forests with a shaded understorey lie above the species-area regression line in Figure 4.2.1, while relatively scrubby forests with reduced canopy cover lie below it.

Location within biodiversity 'hot-spot': Three areas of the Coastal Forest belt possess endemic species (see below). The species richness of forests in these areas is also likely to be higher than in others, reflecting past biogeographic processes.

Study effort: In Kenya, the Arabuko-Sokoke forest has a long history of ornithological study (e.g. Ripley, 1966; Turner, 1977; Britton and Zimmerman, 1979; Kelsey and Langton, 1984; Bennun and Waiyaki, 1992b; Fanshawe, 1995). Most other forests have only been investigated for a few weeks at most (e.g. Bennun, 1985; Bennun and Waiyaki, 1992a; Waiyaki, 1995). A similar situation is found in Tanzania where only Pugu forest has been intensively studied (Fuggles-Couchman, 1939; Stuart and van der Willigen, 1979; Howell, 1981; Baker, 1984; Baker and Baker, 1992; N. E. and E. M. Baker, unpublished data; Mlingwa, in press). Most other Tanzanian Coastal Forests have been surveyed for only a few weeks (e.g. Bagger *et al.*, 1989; Faldborg *et al.*, 1991; Burgess *et al.*, 1991b; Mlingwa, 1993; Eriksen *et al.*, 1994; Mlingwa and Burgess, in press; Mlingwa *et al.*, 1993). The full range of survey methods has not been used in all cases – inexperienced teams, unfamiliar with some bird calls, and those not using mist nets, are likely to miss a number of cryptic or secretive species.

Also, many forests have been surveyed at only one time of the year, so that some migratory species may not have been recorded. This is a likely reason why the intra-African migrants breeding in southern Tanzania from January to March, and wintering on the southern Kenya coast between June and October, have been recorded at very few sites in between these two areas (see Appendix 4, this volume). Time of year also affects song in many species, which may make them harder to detect in the non-breeding season.

Species lists in many forests are therefore probably incomplete, especially for secretive, rare or migratory species. Well-surveyed forests again show up strongly above the regression line in Figure 4.2.1.

Patterns of endemism

The eastern African Coastal Forests are one of the centres of endemism for forest birds in Africa (Moreau, 1966; Hamilton, 1976; Diamond and Hamilton, 1980; Collar and Stuart, 1988; ICBP, 1992; Stuart *et al.*, 1993). Part of the Coastal Forest belt has been identified by BirdLife International as one of the world's 221 areas of particular importance for the conservation of endemic birds, due to the presence of species with world ranges of under 50,000km² (ICBP, 1992). This Endemic Bird Area (EBA) lies between the Arabuko-Sokoke forest in Kenya and the forest at the base of the East Usambara Mountains in northern Tanzania. The restricted-range birds that define it are Fischer's Turaco, Sokoke Scops Owl, Sokoke Pipit, White-winged Apalis, Amani Sunbird and Clarke's Weaver, It is important, however, that the conservation importance of Coastal Forests is not considered only forest-by-forest. Adequate conservation measures need to be taken in as many of the Coastal Forests as possible, however small, in order to ensure the preservation of the system's overall biodiversity. Small sites can be very valuable for conservation, for a variety of reasons (e.g. Bennun, 1992). All these forests are under considerable threat – critically in some cases – and their future depends on effective and sustained conservation action (see Chapter 5.4; Howell, 1981; Rodgers and Homewood, 1982; Lovett, 1990; Burgess *et al.*, 1992; Mlingwa *et al.*, 1993; Burgess and Muir, 1994; Bennun, 1995).

Summary

We know enough about the avifauna of eastern Africa's Coastal Forests to describe the diversity, endemism, distribution patterns and seasonal movements of its constituent species:

- The eastern African Coastal Forests contain a distinctive avifauna of great conservation interest. The 139 forest species so far recorded include 85 that are entirely dependent on forest (33 'forest specialists' and 52 'forest generalists'). Five species and eight sub-species are Coastal Forest endemics; eight species also occur in Eastern Arc mountain forests (including two that are primarily montane); and 12 species (including two mainly montane birds) have a restricted distribution in other forests of eastern Africa. These 25 species include all those considered to be globally threatened or with highly restricted ranges ($50,000 km^2$: eight species in each case, excluding montane forms). Pemba Island has its own suite of four endemic species, but these are not confined to forest.
- Many of the endemic species in the Coastal Forests are relict forms, but the endemics on Pemba may have evolved there more recently. Strong avifaunal affinities exist with the Guineo-Congolian forests to the west, indicating an ancient connection, and also with the highland forests of eastern Africa and thicket and riparian forest in central and south-eastern Africa.
- Coastal Forests on the northern half of the East African coast have the most important avifauna, with six endemic or near-endemic species found only between Msubugwe (northern Tanzania) and Tana River (Kenya). However, one endemic, Reichenow's Batis, occurs only in forests south of the Rufiji River.
- The number of species, and of rare species, increase with forest size but are also strongly influenced by forest structure, location and the intensity of study. Many Coastal Forest species are altitudinal or intra-African migrants, although often only part of the population migrates. All sites in this highly fragmented habitat type are important for bird conservation, especially for the migratory species.
- As a set, the most significant forests (selected on the basis of size, the presence of threatened and endemic species, and complementarity) are Tana River, Dakatcha, Arabuko-Sokoke, Shimba Hills, Marenji, the East Usambara lowlands, Pugu/Kazimzumbwi, Rondo and Litipo.

However, there are still sites in Tanzania and Kenya which are essentially unexplored, and only Arabuko-Sokoke, Gede and Pugu have been fully surveyed. The Coastal Forests in Mozambique remain almost completely unknown. Future surveys will doubtless result in revision of the information presented here.

The first research task is therefore basic inventory work in the sites that remain inadequately surveyed. The second task is ecological research on individual species. At a time when pressing conservation problems demand increased action, we need to understand better the populations, movements and ecological needs of threatened species (Stuart *et al.*, 1993). The ecology of most of the Coastal Forest species is very little known at present. A comparative ecological study of the pycnonotids is being undertaken by C.O.F. Mlingwa in the Pugu Hills, and some ecological aspects of the Arabuko-Sokoke avifauna have been described by Fanshawe (1995). There has already been some work on the Spotted Ground Thrush (Bennun, 1985; 1987), the Sokoke Scops Owl (Virani, 1995) and the East Coast Akalat (Matiku, 1996; Nemeth, 1996).

Topics that are high priorities for research include:

- Studying the habitat preferences, populations and breeding strategies of the endemic and/or threatened species, in order to understand their conservation requirements and the likely effects of different types of forest management.
- Determining the ecological effects of forest fragmentation, in order to understand why some species can survive in very small forest patches where others cannot.
- Investigating the seasonal (and other) movements of birds, in order to assess the potential importance of forest fragments as 'stepping-stones' for migrating or dispersing individuals.

Acknowledgements

Charles O.F. Mlingwa would like to thank the following organisations for their logistical and financial support during survey work: Frontier-Tanzania Coastal Forest Research Programme, a joint project of the Society for Environmental Exploration (London) and the Faculty of Science, University of Dar es Salaam (Tanzania), The Royal Society for the Protection of Birds (RSPB–UK), the Wildlife Conservation Society (NYZS–USA), the Wildlife Conservation Society of Tanzania (WCST–TZ) and the Deutscher Akademischer Austauschdienst (DAAD–Germany). COFM and Neil Burgess are very grateful to Neil and Liz Baker for the support, guidance and helpful criticism they have received over the years, and in particular for extensive comments on this Chapter. Alan Tye, Jon Fjeldså, Brindley Best and Thomas Lehmberg also kindly commented on earlier drafts. Edward Waiyaki and Leon Bennun thank the ODA-sponsored Kenya Indigenous Forest Programme (KIFCON) for their support throughout recent survey work in Kenyan Coastal Forests. EMW also wishes to thank the RSPB for financial support of his work in the Kenyan Coastal Forests, and the Coast Forest Conservation Unit (CFCU) of the National Museums of Kenya for their logistical support. The Tanzanian Bird Atlas Project (Liz and Neil Baker) provided considerable input from their unpublished data, for which we are most grateful.

References

Andrews, P., Groves, C. P and Horne, J. E. M. (1975). Ecology of the lower Tana river floodplain (Kenya). *J. E. Afr. Natl. Hist. Soc. and Nat. Museum* **151**: 1–31.

Anonymous (1973). 'Cheyney Expedition (LACM) to Boni Forest'. Unpublished Mimeo held in the National Museums of Kenya Ornithology Department.

Archer, A.L. and Turner, D.A. (1993). Notes on the endemic species and some additional new birds occurring on Pemba Island, Tanzania. *Scopus* **16**: 94–98.

Archer, A.L., Collins, S. and Bampton, I. (1991). Report on a visit to Jozani Forest, Zanzibar. *EANHS Bulletin* **21**: 59–66.

Backhurst, G.C. and Pearson, D.J. (1977). Ethiopian region birds attracted to the lights of Ngulia safari lodge, Kenya. *Scopus* **1**: 98–103.

Bagger, J., Halberg, K and Nnyiti, P.Y. (1989). *Observation of Birds in Rondo and Litipo Forests. Tanzania.* Preliminary report of the Danish-Tanzania ICBP expedition. Institute of Population Biology, University of Copenhagen.

Baker, N.E. (1984). Recent coastal records of the White-starred Forest Robin *Pogonocichla stellata* in Tanzania. *Scopus* **8**: 51–52.

Baker, N.E. (1993). On the racial status of the White-eared Barbet *Stactolaema leucotis* in coastal Tanzania. *Scopus* **16**: 111–113.

Baker, N.E. and Baker, E.M. (1992). Four Afrotropical migrants on the East African coast: evidence for a common origin. *Scopus* **15**: 122–124.

Baker, N.E. and Howell, K.M. (1992). Unusual movements of Afrotropical birds in the Dar es Salaam area, Tanzania. *Proc. Pan-Afr. Orn. Congr. VII:, Nairobi, 1988*: 163–168.

Irwin, M.P.S. (1994). Birds. Pp. 77–91. In Timberlake, J. and Shaw, P. (eds.) *Chirinda Forest: a Visitor's Guide.* Forestry Commission/ODA, Harare.

IUCN (1994). *IUCN Red List Categories.* IUCN, Gland, Switzerland and Cambridge, UK.

Kelsey, M.G. and Langton, T.E.S. (1984). *The Conservation of the Arabuko-Sokoke Forest, Kenya.* ICBP/University of East Anglia: ICBP study report no 4.

Kingdon, J. (1990). *Island Africa.* Collins, London.

Koenders, L. (1993). *Fauna of Pemba Island: a Checklist of Animals Occurring on Pemba Island, Tanzania.* Wildlife Conservation Society of Tanzania: Publication no.1, Dar es Salaam.

Lovett, J.C. (1990). Classification and status of the Tanzanian forests. *Mitt. Inst. Allg. Bot. Hamburg* **23A**: 287–300.

Mackworth-Praed, C.W. and Grant, C.H.B. (1952–1973). *Birds of Eastern and Northeastern (II vols.), West Central and Western Africa (II vols.) and the Southern Third of Africa (II vols.).* Longmans, London.

Madgwick, J. (1988). An ecological study of the remaining areas of riverine forest in the Jubba Valley, southern Somalia. *Br. Ecol. Soc. Bull.* **19(1)**: 19–24.

Madgwick, J. (1989). Somalia's threatened forests. *Oryx* **23**: 84–101.

Marsh, C., Nichols, S. and Parker, D. (1975). *Birds of the Tana River Primate Game Reserve; Species Abundance and Habitat Preferences.* Unpublished Ms., in the library of the East African Natural History Society, Nairobi.

Matiku, P. (1996). Distribution and habitat selection of the East Coast Akalat *Sheppardia gunningi sokokensis* in Arabuko-Sokoke Forest. MPhil thesis, Moi University, Eldoret, Kenya.

Mlingwa, C.O.F. (1991). Further records of the Sokoke Pipit *Anthus sokokensis* from Tanzania. *Scopus* **15**: 57–58.

Mlingwa, C.O.F. (1992). Birds of the main University campus in Dar es Salaam, Tanzania: a ringing study. *Scopus* **16**: 50–54.

Mlingwa, C.O.F. (1993). Vikindu Forest Reserve, Tanzania: a first ornithological survey including a record of the Sokoke Pipit *Anthus sokokensis. Scopus* **16**: 8–13.

Mlingwa, C.O.F. (1996a). A first record of the Stripe-cheeked Greenbul *Andropadus milanjensis* in the Pugu Hills. *Bulletin of the British Ornithological Club* **116**: 63–64.

Mlingwa, C.O.F. (1996b). A note on the rediscovery of the Sokoke Pipit *Anthus sokokensis* in the Pugu Hills, Tanzania. *Bird Conservation International* **6**: 293–294.

Mlingwa, C.O.F. (in press). Birds at Pugu: results obtained during an ecological study of bulbuls (Pycnonotidae). *Tanzania Science Journal.*

Mlingwa, C.O.F., Huxham, M.R. and Burgess, N.D. (1993). The avifauna of Kazimzumbwi Forest Reserve, Tanzania: initial findings. *Scopus* **16**: 81–88.

Mlingwa, C.O.F. and Burgess, N.D. (in press). Avifaunal notes on Gendagenda and Kilulu Hill (Moa), Tanzania. *Scopus.*

Moreau, R.E. (1940a). Contributions to the ornithology of the East African Islands. *Ibis* **(14)4**: 48–91.

Moreau, R.E. (1940b). Distributional notes on East African birds. *Ibis* **(14)4**: 454–463.

Moreau, R.E. (1944). Additions to the avifauna of Mafia Group of Islands. *Ibis* **14(8)**: 33–37.

Moreau, R.E. (1966). *The Bird Faunas of Africa and its Islands.* Academic Press, London.

Mwasumbi, L.B. Burgess, N.D. and Clarke, G.P. (1994). Flora of Pande and Kiono coastal monsoon forests, Tanzania. *Vegetatio* **113**: 71–81.

Nemeth, E. (1996). Distribution, habitat selection and behaviour of the East Coast Akalat *Sheppardia gunningi.* Report to the Project nr. 5443 of the Jubiläumsfonds of the National Bank of Austria. Konrad Lorenz Institute, Vienna.

Newmark, W.D. (1991). Tropical forest fragmentation and the local extinction of understorey birds in the East Usambara Mountains, Tanzania. *Conservation Biology* **5**: 67–78.

Ornithological Sub-committee of the East Africa Natural History Society (1996). *Checklist of the Birds of East Africa.* EANHS, Nairobi.

Pakenham, R.H.W. (1979). *The Birds of Zanzibar and Pemba.* BOU: Checklist No. 2.

Rodgers, W.A. and Homewood, K.M. (1982). The conservation of the East Usambara Mountains, Tanzania: a review of the biological values and land use pressures. *Biological Journal of the Linnean Society of London* **24**: 285–304.

Ripley, S.D. (1966). A notable owlet from Kenya. *Ibis* **108**: 136–137.

Ripley, S.D. and Heinrich, G.H. (1966). Comments on the avifauna of Tanzania, 1. *Postilla* **96**: 1–45.

Ripley, S.D. and Heinrich, G.H. (1969). Comments on the avifauna of Tanzania, 2. *Postilla* **134**: 1–21.

Rosenzweig, M.L. (1995). *Species Diversity in Space and Time.* Cambridge University Press, Cambridge.

Sclater, W.L. and Moreau, R.E. (1932). Taxonomic and field notes on some birds of north-eastern Tanganyika Territory. *Ibis* **(13)2:** 487–522, 656–683.

Sclater, W.L. and Moreau, R.E. (1933). Taxonomic field notes on some birds of north-eastern Tanganyika Territory. *Ibis* **(13)3**: 1–33, 187–219.

Sibley, C.G. and Ahlquist, J.E. (1990). *Phylogeny and Classification of Birds: a Study in Molecular Evolution.* Yale University Press, New Haven-London.

Snow, D.W. (1978). *An Atlas of Speciation in African Non-passerine Birds*. British Museum (Natural History), London.

Stuart, S.N. (1981). A comparison of the avifaunas of seven East African forest islands. *African Journal of Ecology* **19**: 133–151.

Stuart, S.N. and Jensen, F.P. (1981). Further range extensions and other notable records of forest birds from Tanzania. *Scopus* **5**: 106–115.

Stuart, S.N. and Jensen, F.P. (1985). The avifauna of the Uluguru Mountains, Tanzania. *Gerfaut* **75**: 155–187.

Stuart, S.N. and Van der Willigen, T.A. (eds.) (1979). 'Report of the Cambridge Ecological Expedition to Tanzania, 1978'. Unpublished, mimeo.

Stuart, S.N., Jensen, F.P., Brøgger-Jensen, S. and Miller, R.I. (1993). The zoogeography of the montane forest avifauna of eastern Africa. Pp. 203–228. In Lovett, J.C. and Wasser, S.K. (eds.). *Biogeography and Ecology of the Rain Forests of Eastern Africa.* Cambridge University Press, Cambridge.

Svendsen, J.O. and Hansen, L. (eds.) (1995). 'Uluguru Mountains Biodiversity Survey, Tanzania'. Unpublished. Royal Society for the Protection of Birds (UK)/Zoological Museum of the University of Copenhagen (DK).

Turner, D.A. (1977). Status and distribution of East African endemic species. *Scopus* **1**: 2–11.

Van Someren, G.R.C. (1979). *Birds of Gede Historical Site*. Unpublished report for National Museums of Kenya, Ornithology Department.

Vincent, J. (1933 and 1934). The birds of northern Portuguese East Africa. Comprising a list of, and observations on, the collections made during the British Museum Expedition of, 1931–32 – Parts I–1V. *Ibis* **13** (3 and 4): 126–652.

Virani, M. (1994). The ecology of the endangered Sokoke Scops Owl *Otus ireneae.* MPhil thesis. Moi University, Eldoret.

Waiyaki, E.M. (1994). 'A Preliminary Report on Important Sites for Bird Conservation Among Kenya's South Coast Forests'. Unpublished report for the Royal Society for the Protection of Birds, Sandy.

Waiyaki, E.M. (1995). *Effects of Forest Fragmentation, Isolation and Structure on the Richness and Abundance of Bird Communities in Major Coastal Forests of the South Coast, Kenya.* MSc thesis. University of Kent, Canterbury, Kent.

Waiyaki, E.M. and Bennun, L.A. (in press). The avifauna of coastal forests in southern Kenya: status and conservation. *Ostrich (suppl.).*

White, F. (1983). *The Vegetation of Africa*. UNESCO, Paris.

Wood, B. (1988). The bird community of riverine forest in Somalia. *Biogeographica* **14**: 83–89.

4.3. Mammals

N.D. Burgess, D. Kock, A. Cockle, C. FitzGibbon, P. Jenkins and P. Honess

Introduction

Mainland Africa south of the Sahara supports *c.*960 mammal species belonging to 270 genera and 61 families (from Wilson and Reeder, 1993). About one-third of the families are confined to Africa, and most of the others are found in Asia and Eurasia. The high level of continental endemism in the African mammals is a product of a long period of biogeographical isolation from other areas, followed by the closing of the Tethys Sea some 15–18 million years ago which allowed interchange between African and European, Middle Eastern and Asian faunas (Kingdon, 1990; Chapter 2.3).

African mammals have been the subject of many years of intensive study, particularly the East and Southern African species (e.g. Kingdon, 1971–1982; Skinner and Smithers, 1990). However, research has concentrated on larger plains living game and on pest species, hence there are still significant gaps in our knowledge of the taxonomy and distribution of smaller mammals, in particular those which are nocturnal or difficult to detect, such as bats, rodents, shrews and galagos. This is especially true for forest-dwelling species.

Although many of the Coastal Forest mammals are widespread, a few species have been known for many years to be confined to the Coastal Forests, e.g. Ader's Duiker *Cephalophus adersi* from Arabuko-Sokoke forest and various localities on Zanzibar (Pakenham, 1984), and the Golden-rumped Elephant-shrew *Rhynchocyon chrysopygus* from Kenya (FitzGibbon, 1994). In this Chapter we present a detailed assessment of the mammalian fauna of these forests, including the results of recent field collecting, and assess the species-richness, endemism and biogeographical affinities of this fauna. Mammal groups showing the highest levels of endemism and rarity in the Coastal Forests (shrews, bats, galagos, rodents, antelopes and elephant-shrews) are selected for more detailed treatment.

Data Sources

Data presented are mainly from Somalia, Kenya and Tanzania, although records of rare species are also compiled for Mozambique (Dalquest, 1965; Smithers and Lobão Tello, 1976), Malawi (Ansell and Dowsett, 1988), and Zimbabwe (Smithers and Wilson, 1979; Smithers, 1983; Skinner and Smithers, 1990; Cotterill, 1994).

Since the mid 1980s several field programmes have studied the mammal populations of Coastal Forests of Somalia, Kenya and Tanzania (Table 4.3.1). The most comprehensive has been in Tanzania where mammal assemblages of 25 Coastal Forests have been investigated by Frontier-Tanzania. For this study larger mammal species were identified from sight-records, specimens caught by local hunters, local peoples' knowledge of the species living in the area, and footprints and droppings (Dorst and Dandelot, 1972; AWF, 1989). Smaller species were identified from specimens, which were obtained from mist-nets (bats), baited live and snap-traps (rodents and other ground-dwelling species) and large pit-fall traps (shrews and other small species). Specimens were provisionally identified in the field using Kingdon (1971–82) and Meester and Setzer (1971–77), and were then sent to expert taxonomists to confirm the field identifications (Bats and Rodents: Kim Howell and Dieter Kock; Shrews: Paula Jenkins). Tape play-back of known vocalisations was also used to assist the identification of galagos (tape from Simon Bearder, Oxford Brookes University).

Data from unpublished reports (see Table 4.3.1) and the published scientific literature (Table 4.3.2) have also been used where available (see Appendix 5, this volume, 'literature records').

Table 4.3.1 Mammal sampling effort and sampling methods in the Coastal Forests of eastern Africa.

Forests	Study period	Mist-netting (weeks)	Trapping (Trap nights)	Tapes	Interviews	Observation
Jubba Valley	1–3 months	12	100s	no	no	yes
Tana river and delta	1–2 months	–	unknown	no	no	yes
Arabuko-Sokoke	30–50 months	–	1000s	–	yes	yes
Shimba Hills	1–3 months	–	100s	–	yes	yes
East Usambara	6–12 months	24	1000s	yes	yes	yes
Kilulu	1–3 months	5	243	no	no	yes
Tongwe	1–3 months	5	390	no	no	yes
Amboni Caves	1–3 months	3	580	no	no	yes
Msubugwe	3–6 months	0.5	10s	no	no	yes
Gendagenda	3–6 months	20	500	no	no	yes
Mkwaja	1–3 months	5	522	no	yes	yes
Pangani Falls	1–3 months	–	160	no	no	yes
Kiono/Zaraninge	3–6 months	5	522	no	no	yes
Ruvu North	1–3 months	2	20	no	no	yes
Pugu	20–30 months	20+	unknown	no	no	yes
Kazimzumbwi	3–6 months	10	1107	no	no	yes
Ruvu South	13 months	3	604	no	no	yes
Vikindu	1–3 months	0	30	no	no	yes
Kisiju	1–3 months	5	29	no	no	yes
Mchungu	1–3 months	?	500	no	no	yes
Namakutwa/Nyamuete	1–3 months	5	211	no	no	yes
Kiwengoma	6 months	10	1–2000	no	no	yes
Tong'omba	1–3 months	4	224	no	no	yes
Litipo	1–3 months	2	208	no	no	yes
Rondo	3–6 months	1+	6	no	no	yes
Ndimba	<1 month	0.25	0	no	no	yes
Pindiro	1–3 months	–	yes	no	no	yes
Chitoa	1–3 months	1	0	no	no	yes
Ngarama	1–3 months	0	0	no	no	yes
Pemba Island	3–6 months	0	0	no	no	yes
Zanzibar Island	24–36 months	0	0	no	no	yes
Mafia Island	1–3 months	12+	100s	no	no	yes
Kimboza	1–3 months	4	unknown	no	no	yes

Key: – not known

Table 4.3.2 Literature sources on the mammals of the Coastal Forests of eastern Africa.

Country	References
Somalia	Lower Shabeele, Jubba, southern forest – Madgwick *et al.*, 1988; Varty, 1988 and 1990; Varty and Hill, 1988; Ward and Sorrell, 1950; Azzaroli and Simonetta, 1966; Funaioli, 1971.
Kenya	General – Davies and Vanden Berghe, 1994; Aggundey and Schlitter, 1984 and 1986 Tana River and Delta – Groves *et al.*, 1974; Andrews *et al.*, 1975; Arabuko-Sokoke – Thomas, 1984; Kelsey and Langton, 1984; Davies *et al.*, 1992; FitzGibbon, 1994; FitzGibbon *et al.*, 1995; Gedi – Nicoll and Rathbun, 1990; FitzGibbon, 1994; Diani – Moreno-Black and Maples, 1977; Southern Kenya coast – Rodgers *et al.*, 1982; Shimba Hills – Brown, 1964; Bergmans, 1980; Davies *et al.*, 1992.
Tanzania	General – Swynnerton and Hayman, 1951; Rodgers *et al.*, 1982; Eastern Arc forests – Allen and Loveridge, 1927 and 1936; Archer *et al.*, 1991; Hamilton and Bensted-Smith, 1989 Rodgers *et al.*, 1982; Rodgers and Homewood, 1982; Newmark, 1991; Kingdon and Howell, 1993; Hutterer *et al.*, 1991; Coastal Forests – Dobroruka, 1965; Howell, 1979 and 1981; Howell and Jenkins, 1984; Moreau and Pakenham, 1941; Bagger *et al.*, 1989; Cambridge-Tanzania Rainforest Project, 1994; Eriksen *et al.*, 1994; Faldborg *et al.*, 1991.

Table 4.3.3 Mammal diversity in the Coastal Forests in relation to that of the Afrotropical Region (latter assessed from Wilson and Reeder, 1993).

Class – Mammalia	Afrotropical Zoogeographical Region	Coastal Forests
Number of orders	14	12
Number of families	61	30
Number of species	960	158

Species richness

At least 158 species of mammal use the Coastal Forests in Somalia, Kenya and Tanzania (Table 4.3.3, Appendix 5), including most orders and families found in Africa, and approximately 17% of the total species number in the Afrotropical Zoogeographical region (Table 4.3.3). The most diverse mammal groups in the Coastal Forests are bats (58 species), rodents (27+ species), carnivores (19 species), primates (14 species) and shrews (14 species). Species richness is mainly caused by the large numbers of more generalist species in these forests (109 species), rather than by forest dependent species (31 only). Moreover, the diversity of mammals in an individual forest is low, with an average of 24 $\pm$ 12.3 species per forest. The high variance is mainly due to differences in the methods used to sample the fauna. For example, in some forests there has been little or no mist-netting for bats and bat-lists are not available (e.g. in Tana River, Arabuko-Sokoke and Shimba Hills forests in Kenya, and Pindiro, Chitoa, Ngarama, Pemba and Zanzibar in Tanzania).

Mammal species which have been found in more than ten Coastal Forests are *Epomorphorus wahlbergi, Hipposideros ruber, Triaenops persicus, Scotophilus viridis* (bats), *Galagoides zanzibaricus, Otolemur garnetti, Cercopithecus mitis, Chlorocebus aethiops, Colobus angolensis* (primates), *Panthera leo, Panthera pardus* (carnivores), *Loxodonta africana* (elephant), *Potamochoerus larvatus* (bush pig), *Cephalophus natalensis, Neotragus moschatus* (pygmy antelopes), *Heliosciurus rufobrachium, Paraxerus palliatus, Acomys spinosissimus, Beamys hindei, Cricetomys gambianus, Grammomys dolichurus* and *Hystrix* sp. (rodents), *Petrodromus tetradactylus* (Figure 4.3.1) and *Rhynchocyon petersi* (elephant-shrews). This represents a mixture of forest generalist species, non-forest species and true forest species (see Appendix 5, this volume).

Figure 4.3.1 Four-toed elephant-shrew *Petrodromus tetradactylus.*

An assessment of the degree of forest dependence (Appendix 5) shows that 20% (31) of the mammal fauna are forest specialists, compared with 42% (66) which are forest generalists and 37% (61) species which are habitat generalists (or not known). This situation differs markedly from that in the Guineo-Congolian rain forest to the west, where the majority of species in the forest are restricted to this habitat (Happold, 1996), although even in the main African forest block savannah species are also found.

Species endemism and rarity

There are at least 15 mammal species of conservation value in the Coastal Forests, either because they are endemic (min. 3 and max. 14 species) and/or globally rare (11 species). In comparison, there are seven endemic species in the Eastern Arc mountain forests, all of which are threatened or probably so (Tables 4.3.4 and 4.3.5).

Table 4.3.4 Endemic mammal taxa of the Coastal Forests and Eastern Arc mountains, species of restricted or disjunct distribution found in the Coastal Forests, and the degree of threat to these mammal species as attributed by IUCN (Baillie and Groombridge, 1996).

Categories	Species	Threat*	Habitat
Coastal Forest endemic species	4 undescribed species of shrew, ?*Crocidura* spp.	–	Terrestrial
	Pteropus voeltzkowi (Fruit Bat)	CR	Flies outside forest; roosts in trees
	Rhinolophus sp. nov. (Insectivorous Bat)	–	Flies in forest; roosts in caves
	Galago sp. nov. A (Primate: Prosimian)	–	Lives in trees
	Galago sp. nov. B (Primate: Prosimian)	–	Lives in trees
	Cephalophus adersi (Duiker)	EN	Terrestrial
	Graphiurus sp. nov. (Rodent: dormouse)	–	Lives in trees
	Rhynchocyon chrysopygus (Elephant-shrew)	EN	Terrestrial
Eastern Arc endemic species	*Myosorex geata* (Shrew)	EN	Terrestrial
	Sylvisorex howelli (Shrew)	VU	Terrestrial
	Crocidura tansaniana (Shrew)	VU	Terrestrial
	Crocidura telfordi (Shrew)	CR	Terrestrial
	Crocidura desperata (Shrew)	CR	Terrestrial
	Crocidura usambarae (Shrew)	VU	Terrestrial
	Paraxerus vexillarius (Squirrel)	VU	Lives in trees
Coastal Forest and Eastern Arc endemics	*Myonycteris relicta* (Fruit Bat)	VU	Flies in forest; roosts in trees
	Rhynchocyon petersi (Elephant-shrew)	EN	Terrestrial
	Galagoides zanzibaricus (Primate: Prosimian)	–	Lives in trees
	Kerivoula africana (Insectivorous Bat)	–	Flies in forest
CF/EA and a few other East African forests	*Rhinolophus deckenii* (Insectivorous Bat)	–	Flies in forest
	Heliosciurus undulatus (Squirrel)	–	Lives in trees
	Dendrohyrax validus (Tree Hyrax)	VU	Lives in trees
	Beamys hindei (Rodent)	VU	Terrestrial
	Cephalophus spadix (Duiker)	VU	Terrestrial
Endemic species in Tana river forests of Kenya	*Procolobus rufomitratus* (Primate: Cercopithecid)	–	Lives in trees
	Cercocebus galeritus (Primate: Cercopithecid)	–	Lives in trees
	Chalinolobus kenyacola (Insectivorous Bat)	–	Flies in trees
Wider habitat range	*Mops brachypterus* (Bat)	–	Flies in trees
	Rhychocyon cirnei (Elephant-shrew)	VU	Terrestrial
	Taphozous hildegardeae (Insectivorous bat)	VU	Flies in trees
	Otolemur garnettii (Primate: Prosimian)	–	Lives in trees

Key:
* Threat is according to IUCN categories: CR = Critically endangered; EN = Endangered; VU = Vulnerable (in Baillie and Groombridge, 1996);
– Taxa not in Baillie and Groombridge (1996).

Sources: Kingdon and Howell (1993), Burgess and Muir (1994), Frontier-Tanzania data, a review of the literature, and comments from reviewers.

Table 4.3.5 Rates of mammal species endemism in the Coastal Forests and Eastern Arc forest.

Forest type	Forest area	Endemic species	Endemic species/ forest area
Coastal Forests	$3000km^2$	3	10×10^{-4}
		(6)	(20×10^{-4})
		[14]	$[46 \times 10^{-4}]$
Eastern Arc	$9000km^2$	7	8×10^{-4}

Note: Figures without brackets are for described endemic species. Figures in round brackets include Tana River endemics. Figures in square brackets include undescribed species.

a. Coastal Forest endemics

Three mammal species are endemic to the Coastal Forests: Golden-rumped Elephant-shrew *Rhynchocyon chrysopygus*, Ader's Duiker *Cephalophus adersi* and the Pemba Fruit Bat *Pteropus voeltzkowi* (Figure 4.3.2a). A further species, Zanzibar Red Colobus *Colobus kirkii*, is a Coastal Forest endemic if the taxonomy of Corbet and Hill (1991) is accepted. However, here we have followed Wilson and Reeder (1993), where this monkey is regarded as a sub-species of *Procolobus pennantii*. The poorly known bat species *Pipistrellus permixtus* may also be a Coastal Forest endemic, but is only recorded from 'Dar es Salaam'. There is also considerable endemism at the level of sub-species, with 16 mammal sub-species endemic to the islands of Pemba, Zanzibar and Mafia (Kingdon and Howell, 1993), and the *minor* subspecies of the bat *Miniopterus minor* is confined to Coastal Forests on the mainland. Importantly, a number of mammals collected from the Coastal Forests in recent years are potentially new species. These comprise four species of shrew, one species of bat, one or two species of bush-baby, and one species of rodent (see below).

Two species of monkey, *Cercocebus galeritus* and *Procolobus rufomitratus* (Groves *et al.*, 1974), and the bat *Chalinolobus kenyacola* (Peterson, 1982) are endemic to the Tana river forests in Kenya.

b. Coastal Forest and Eastern Arc Mountain endemics

Four species are found only in the Coastal Forests and lower parts of the Eastern Arc mountain forests. These species are the bats *Kerivoula africana* (Figure 4.3.2d) and *Myonycteris relicta* (Figure 4.3.2c), the Black and Rufous Elephant-shrew *Rhynchocyon petersi* and the Zanzibar Galago *Galagoides zanzibaricus*.

c. Rare species found in the Coastal Forests, and of restricted distribution in eastern Africa

The bats *Taphozous hildegardeae* (Figure 4.3.2b) and *Mops brachypterus* (Figure 4.3.2i) and Garnets Galago *Otolemur garnettii* are coastal eastern African endemics, but are also found in habitats other than Coastal Forests. The Lesser Pouched Rat *Beamys hindei* was until recently regarded as one of the rarest rodents in Africa (e.g. Groombridge, 1993). It is now known to be more widely distributed with the sub-species *hindei* being found in a number of forests, mainly Coastal Forests, in Kenya and Tanzania (Hubbard, 1970; Dieterlen, 1979; Christensen, 1987; FitzGibbon *et al.*, 1995), and the sub-species *major* being found in forests of southern Tanzania, Malawi and Zambia (FitzGibbon *et al.*, 1995; Figure 4.3.2f). The Eastern Tree Hyrax *Dendrohyrax validus* is confined to eastern Tanzania and Kenya (including Zanzibar and Pemba), but is also found in the Kilimanjaro mountain forests in addition to several Eastern Arc and Coastal Forests. On Mafia Island in Tanzania there is also a population of the Seychelles Fruit Bat *Pteropus seychellensis* which has a small global population confined to a few Indian Ocean islands. It uses Coastal Forest and thicket as roost sites on the island. The bat species *Rhinolophus deckenii* is also known from a few coastal localities, stretching as far inland as Mt. Kilimanjaro and the Udzungwa Mountains (Figure 4.3.2e).

Biogeographical relationships

Guineo-Congolian forests

The mammal fauna of the Guineo-Congolian forest has been recently summarised by Happold (1996) and patterns in the eastern African mammal faunas by Rodgers *et al.* (1982) and Kingdon and Howell (1993). The Western rain forests have 90–130 species of mammals, of which over 70% are rain forest endemics, compared with only 20% forest endemics in the Coastal Forests. Greatest diversity in the Guineo-Congolian block is seen in the primates, bats, rodents, and forest antelopes. Few of the forest species in the Coastal Forests are also found in the main Guineo-Congolian rain forest block, and all the larger species are lacking. Exceptions in bats are the species *Hipposideros cyclops* (Figure 4.3.2h) and *Rousettus angolensis* (Figure 4.3.2g). The Red Colobus *Procolobus pennantii* is also shared with West African forms, although the distribution in East Africa is highly fragmentary and

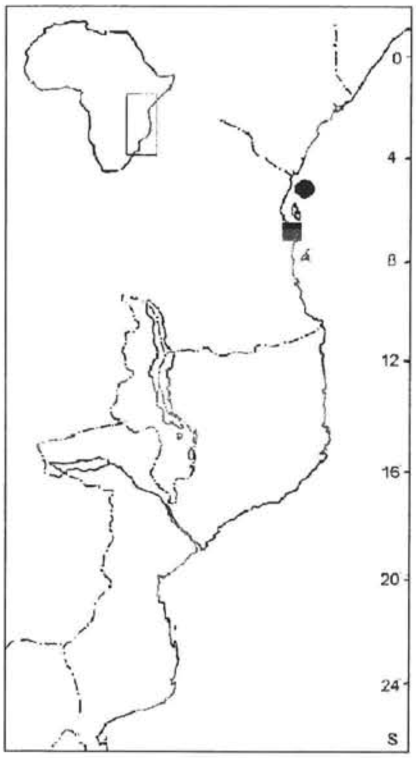


Figure 4.3.2(a) Coastal Forest endemic and near-endemic mammals: *Pteropus voeltzkowi* on Pemba Island (circle), *Pipistrellus permixtus* at Dar es Salaam (square).

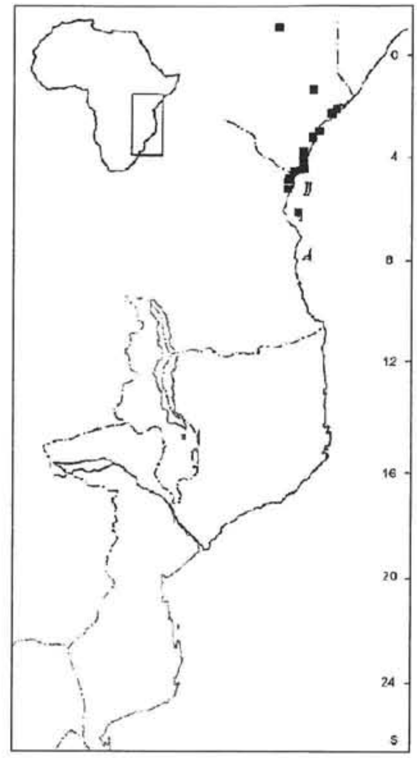


Figure 4.3.2(b) Coastal Forest endemic and near-endemic mammals: *Taphozous hildegardeae*, based on Aggundey and Schlitter (1984) for Kenya, McWilliam (1988a) for Kenya, Kingdon (1974:205) for Zanzibar, Kock (1974) and Frontier-Tanzania Coastal Forest Research Programme records for Tanzania.

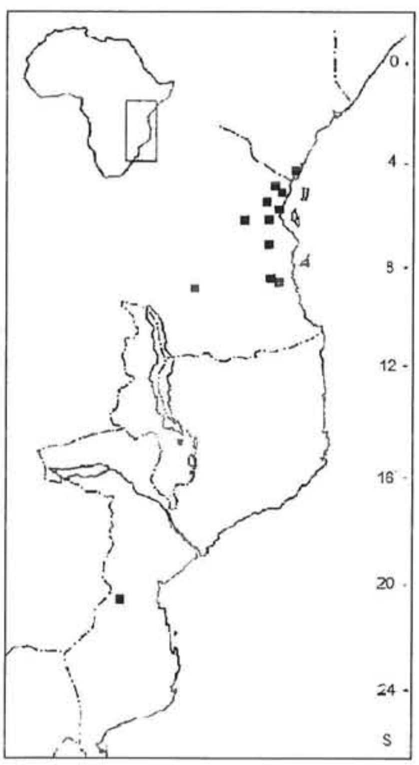


Figure 4.3.2(c) Coastal Forest and Eastern Arc endemic and near- endemic mammals: *Myonycteris relicta*, based on Bergmans (1980) for Kenya Tanzania, Schlitter and McLaren (1981), Frontier-Tanzania and SMF records for Tanzania, and Cotterill (1994) for Zimbabwe.

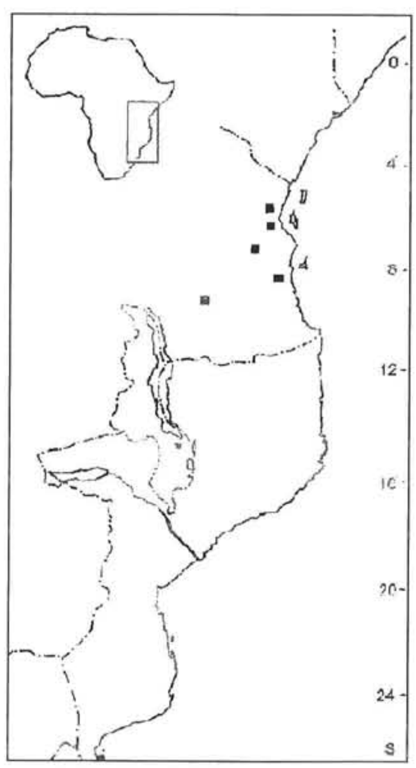


Figure 4.3.2(d) Coastal Forest and Eastern Arc endemic and near-endemic mammals: *Kerivoula africana*, based on Matchie (1895), Rees (1964) and Frontier-Tanzania Coastal Forest Research Programme records.

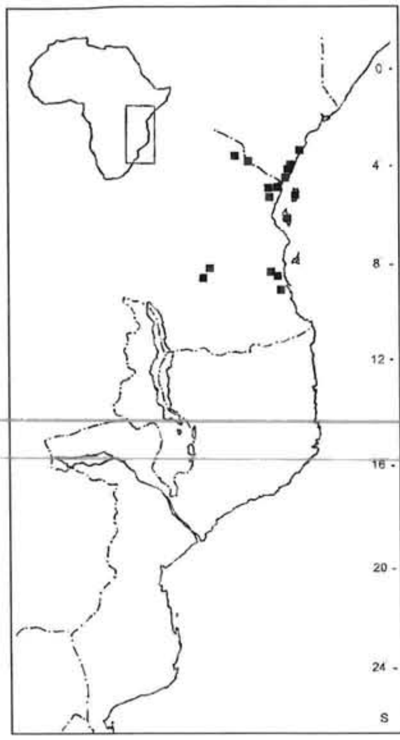


Figure 4.3.2(e) Notable additional mammals in the Coastal Forests: *Rhinolophus deckenii*, based on Aggundey and Schlitter (1984) for Kenya, Rees (1964), Demeter and Topal (1982), Koopman (1982), Pakenham (1984), Frontier- Tanzania and SMF records for Tanzania (but not on wrong or doubtful records in Swynnerton and Hayman (1951) and Child (1965)). Not mapped is an occurrence in Uganda (Bogdanowicz and Owen, 1992).

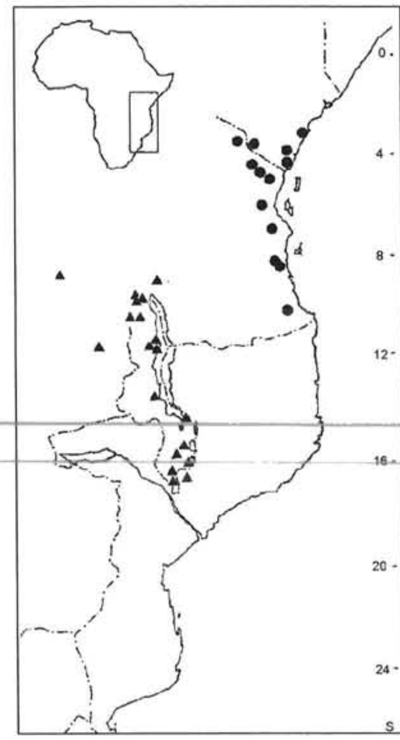


Figure 4.3.2(f) Notable additional mammals in the Coastal Forests: *Beamys hindei* (circles) and *B. major* (triangles), based on Thomas (1909), Hollister (1919), Ansell and Ansell (1973), and FitzGibbon *et al.* (1995) for Kenya, Hubbard (1970), Dieterlen (1979), Christensen (1987) and Frontier- Tanzania and SMF records for Tanzania, Ansell and Dowsett (1988) for Malawi, Ansell and Dowsett (1988) for Zambia, and Hanley and Morris (1962) and Long (1973) for Mozambique.

represented by different subspecies or species depending on the taxonomic viewpoint. Although the species richness of forest mammals in the Coastal Forests is low when compared with the Guineo-Congolian forests, the endemism per unit area of forest is high, indicating that the Coastal Forests may possess the remnants of a fauna which has become extinct further to the west, or that the endemic mammals of the Coastal Forests have evolved in the area.

Eastern Arc

The close affinities between the mammal fauna of the Eastern Arc and the Coastal Forests is seen in their shared importance for smaller mammals such as elephant-shrews, bats, galagos and pouched rats. Indeed, previous studies of eastern African forest mammals have not regarded these forest types as distinct (Rodgers *et al.*, 1982; Kingdon and Howell, 1993). For the elephant-shrews, both forest types are of great importance for the genera *Rhynchocyon* and *Petrodomus*. The Coastal Forests are in fact regarded as the most important area in the world for elephant-shrews, closely followed by the Eastern Arc forests (Nicoll and Rathbun, 1990).

Local differentiation and close relationships are also seen in the bush-babies of the Coastal Forests and Eastern Arc, both of which support unique and highly vulnerable communities, including several probable new species of very local distribution (e.g. Bearder *et al.*, 1994; Kingdon, 1997). In the Coastal Forests, the Rondo Forest Reserve can be singled out for its high diversity of species, including a probable endemic. There are also shared species of bats, such as *Myonycteris relicta*, *Kerivoula africana* and the subspecies *Scotophilus nigrita alvenslebeni* and rodents, such as *Beamys hindei*.

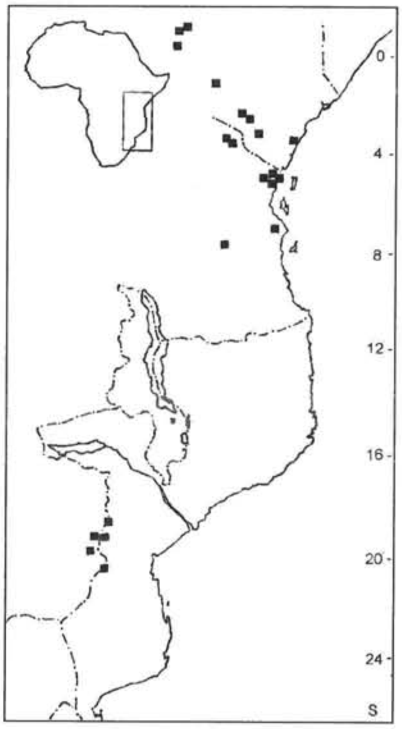


Figure 4.3.2(g) West African species also found in Coastal Forests: *Rousettus (Lissonycteris) angolensis*, based on Aggundey and Schlitter (1984) for Kenya, Swynnerton and Hayman (1951), Kock (1978), Howell (1979), and Frontier-Tanzania and SMF records for Tanzania, Smithers and Lobão Tello (1976) for Mozambique, and Smithers and Wilson (1979) for Zimbabwe.

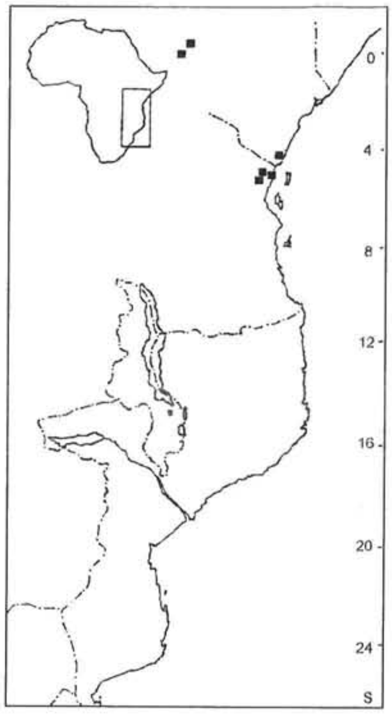


Figure 4.3.2(h) West African species also found in Coastal Forests: *Hipposideros cyclops*, based on Aggundey and Schlitter (1984) and Schlitter *et al.* (1986) for Kenya, and Frontier-Tanzania Coastal Forest Research Programme collections and a sight record (Amboni caves) for Tanzania.

Both forest types have no endemic large mammals, perhaps because the areas of forest are insufficient to permit the persistence of unique large forest mammal species. Many of the mammal groups of most importance in the Coastal Forests and Eastern Arc forests (*Rhynchocyon* and *Beamys* in particular) are regarded by taxonomists as 'primitive' (see Kingdon and Howell, 1993 for discussion), and thus these species are likely to be ancient relicts in these forests.

Focus on key mammal groups in the Coastal Forests

Shrews

The shrew species of East Africa are not well known. This is illustrated by the results of recent collecting in the Coastal Forests of Tanzania. Shrews were recorded from 13 of the 23 forests studied by Frontier-Tanzania. One or two, at most four, shrew species were collected from any locality. *Crocidura hirta* (Peters, 1852) was the most common species, being collected from four separate forests, from Gendagenda in the north to Namakutwa in the south; this reflects the common occurrence of this species throughout Tanzania. Similarly, *C. fuscomurina* (Heuglin, 1865) is widespread in Africa and its collection from two of the Coastal Forests is not surprising. *Crocidura jacksoni* (Thomas, 1904) is known from northern Tanzania, Kenya, Uganda and eastern Zaïre. If correctly attributed to this species, the presence of specimens in Kiwengoma on the Matumbi Hills and Mrora/Mlola Forest on Mafia Island are southern extensions of the known range.

More importantly, there are five different unidentified specimens in the collections from the Tanzanian Coastal Forests, each from separate forests. Four of these are apparently undescribed species. Two of these, one specimen each from Kazimzumbwi and Tong'omba forests, have highly uncertain affinities. The affinities of the other two specimens are discussed below.

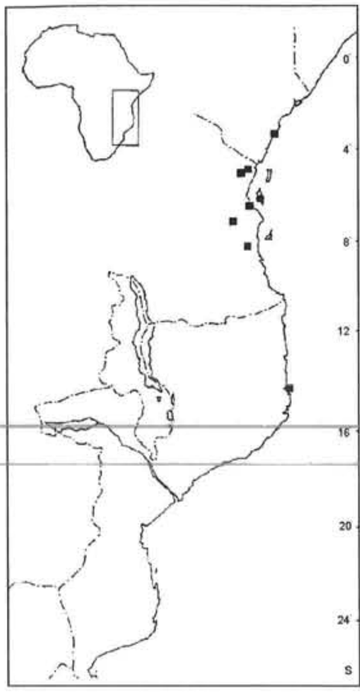


Figure 4.3.2 (i) Rarely recorded species found in the Coastal Forests *Mops brachypterus*, based on Peters (1879) for Kenya, Matchie (1895) for Zanzibar, and Noack (1891), Eisentraut (1958) and Frontier-Tanzania Coastal Forest Research Programme records for Tanzania. An occurrence in Uganda (Freeman, 1981) is outside the mapped area, and *Tadaridia* (*M.*) *leonis*, possibly a junior synonym, is not mapped.

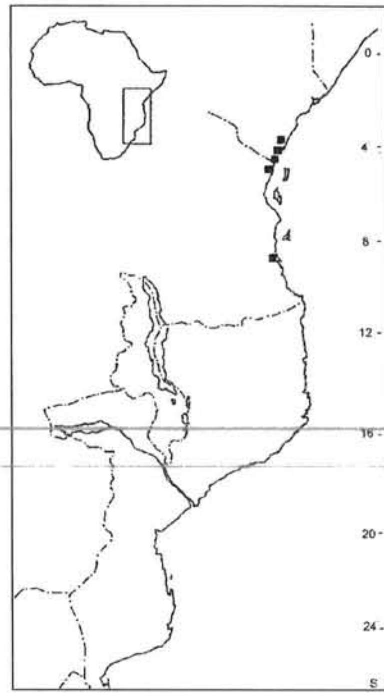


Figure 4.3.2 (j) Rarely recorded species found in the Coastal Forests *Miniopterus minor minor*, based on Aggundey and Schlitter (1984), Uchikwa (1985) and McWilliam (1988b) for Kenya, and Swynnerton and Hayman (1951), Harrison (1959) and Frontier-Tanzania Coastal Forest Research Programme records for Tanzania.

The unidentified specimen from Gendagenda Forest has cranial proportions which indicate a close relationship with members of the subgenus *Afrosorex* (Hutterer, 1986a), yet the pelage is dark and differs considerably from the usually variegated, light coloration characteristic of most members of the subgenus. Most of the species grouped in this subgenus are savannah dwelling, with the exception of the West African *Crocidura. (A.) lamottei* (Heim de Balsac, 1968) which has been recorded both from savannah and forest-savannah boundaries; specimens from the forest-savannah boundaries are darker in colouration than their savannah dwelling counterparts according to Hutterer (1986a). The specimen from Gendagenda differs markedly from the nearest geographical representatives of *Afrosorex*, namely *C. (A.) voi* (Osgood, 1910) – recorded from Kenya, Somalia, Sudan, Ethiopia and Nigeria, and from *C. (A.) parvipes* (Osgood, 1910) – known from a few localities in Tanzania, and several other countries in East, Central and West Africa.

The unidentified specimen from Tongwe Forest is attributable to the *C. monax-C. usambarae* species group. Within this group, *Crocidura usambarae* (Dippenaar, 1980) is thought to be endemic to the Usambara Mountains and is probably closely related to *C. monax*, which is endemic to Mount Kilimanjaro. Specimens attributable to the *monax-usambarae* species group have also been collected from the Uluguru Mountains. The presence of another member of this species group, in Tongwe Coastal Forest not far from the Usambaras, suggests a former link between all these relict forests, as has been suggested previously (Rodgers *et al*., 1982; Kingdon, 1971; Grubb, 1983).

The rates of diversity (generic and species) and endemism in the shrews of the Coastal Forests are lower than in the Eastern Arc mountains. For example, only one shrew genus, *Crocidura*, was collected in the 13 Tanzanian Coastal Forests, with the exception of Kiono Forest, where *Suncus varilla* (Thomas, 1895) was also found. In contrast, three genera, *Crocidura, Myosorex* and *Sylvisorex* are known to occur in the Eastern Arc montane forests. There are no endemic genera in either of these forest types. Moreover, of the eight shrew species recorded from the Usambaras, two, *Crocidura* *tansaniana* (Hutterer, 1986b) and *C. usambarae* (Dippenaar, 1980), are endemic; of the eight species recorded from the Ulugurus, two, *C. telfordi* (Hutterer, 1986b) and *Myosorex geata* (Allen and Loveridge, 1927) and possibly a third (in the *monax-usambarae* group) are endemic, while *Sylvisorex howelli* (Jenkins, 1984) is restricted to the Usambara and Uluguru Mountains.

There is little information on the shrew fauna of the volcanic mountains of East Africa, except Kilimanjaro, from which five species have been recorded. Of these, *C. monax* (Thomas, 1910) and *Myosorex zinki* (Heim de Balsac and Lamotte, 1956) are endemic to that mountain. It seems that the Coastal Forest shrew fauna is intermediate in importance between that of the Eastern Arc Mountains and the more recent volcanic mountains of eastern Africa, such as Kilimanjaro.

Bats

A number of bat species occur in the Coastal Forests which are either endemic to these forests, or known from only a few localities globally (see Figure 4.3.2 for distribution maps of some species in the eastern African coastal area). Records of rare bats in the Coastal Forests are summarised below.

Pteropus voeltzkowi. This species is confined to Pemba Island in Tanzania (Figure 4.3.2a) where it uses Coastal Forest as a roosting habitat. The population has been much reduced by local hunting and now stands at 4600–5500 individuals (Entwistle and Corp, 1997).

Pipistrellus permixtus. This species was described from 'Dar es Salaam' by Aellen (1957) and has not been recorded since. Assuming it is a valid species there must be some considerable doubt about whether it still survives.

Myonycteris relicta. This species was described by Bergmans (1980) using a specimen from the Shimba Hills of southern Kenya, and other specimens from the Usambara Mountains of Tanzania. It has recently been collected from six Coastal Forest localities in Tanzania (Gendagenda, Mkwaja, Zaraninge-Kiono, Ruvu South, Kiwengoma and Tong'omba) and there are literature records from two further Eastern Arc forests; Nguru Mountains (Schlitter and McLaren, 1981), and Udzungwa Mountains (Mickleburgh *et al.*, 1992) (Figure 4.3.2c). The species is also known in the lowland Haroni-Rusitu Coastal Forest in Zimbabwe (Cotterill, 1994).

Taphozous hildegardeae. This species is an East African coast endemic, known from coastal Kenya, NE Tanzania and Zanzibar Island (Figure 4.3.2b).

Rhinolophus deckenii. This species was described by Peters in 1869 from a specimen caught on the 'Sansibarküste' (Zanzibar Coast). There were further records from Ulanga District (Rees, 1964), near Moshi (Demeter and Topal, 1982), Pemba and Zanzibar (Pakenham, 1984; Koopman, 1982), and 'Uganda' (Bogdanowicz and Owen, 1992). Frontier-Tanzania has also collected this bat in two northern Tanzanian Coastal Forests (Kilulu and Tongwe) and Namakutwa, Kiwengoma and Tong'omba forests on the Matumbi Hills in southern Tanzania (Cockle *et al.*, 1998). Wilson and Reeder (1993) also state that this bat is found in Kenya, and there are specimens in the Senckenberg Museum (Germany) from Mawarenje, Kilwa District, southern Tanzania (see Figure 4.3.2e).

Kerivoula africana. This species was described by Dobson 1878 from a single specimen caught on the 'east coast of Africa (Zanzibar)' (Wilson and Reeder, 1993), and there are two other possible old records, from 'Morogoro' (Matschie 1895; Swynnerton and Hayman, 1951), and 'Ulanga District' (Rees, 1964). Frontier-Tanzania has collected specimens from two Coastal Forests in Tanzania, one in the north (Gendagenda) and one in the south (Tong'omba) (see Figure 4.3.2d).

Miniopterus minor and ***Mops brachypterus***. These are two very rarely recorded bats which seem to have a concentration of records in the coastal area of eastern Africa, or within the Coastal Forests themselves. However, both species have records far to the west of the Coastal Forest belt (Wilson and Reeder, 1993). The *minor* subspecies of *M. minor* is confined to coastal eastern Africa (Figure 4.3.2j) and may be a Coastal Forest endemic.

Galagos

Galagos, or bush-babies, are nocturnal prosimians found only in Africa, south of the Sahara and north of the Cape. Criteria for accurate identification of galagos in the field have been greatly modified over the last five years, with a growing appreciation of the importance of species-specific

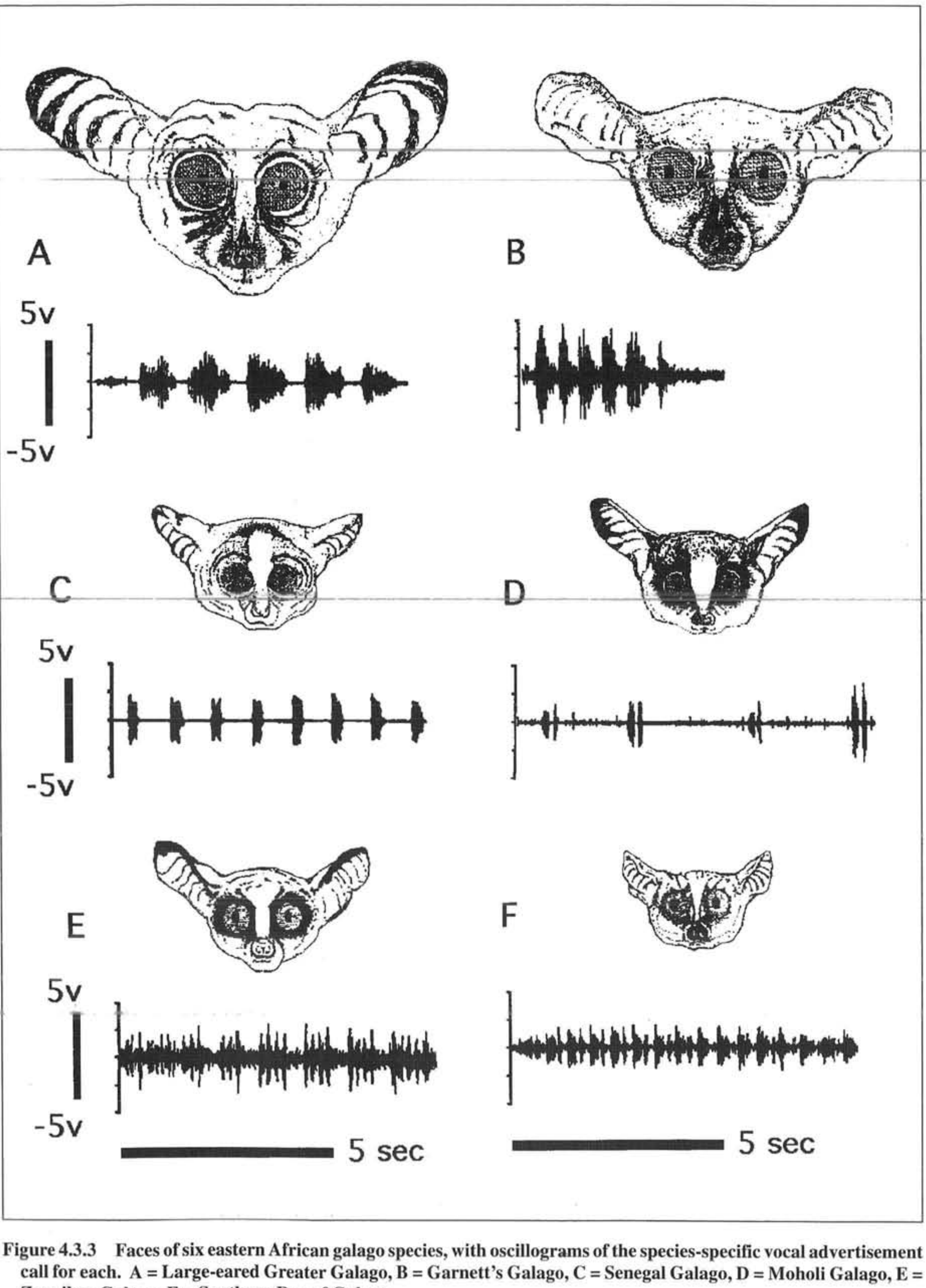


Figure 4.3.3 Faces of six eastern African galago species, with oscillograms of the species-specific vocal advertisement call for each. A = Large-eared Greater Galago, B = Garnett's Galago, C = Senegal Galago, D = Moholi Galago, E = Zanzibar Galago, F = Southern Dwarf Galago.

vocalisations (Bearder *et al.*, 1994; Kingdon, 1997; Figure 4.3.3), which allow morphologically similar species to be separated on the basis of calls. There are at least four species in the Coastal Forests, with the possibility of two or more undescribed species also being present. The Rondo Coastal Forest is of particular importance for its assemblage of galagos.

Garnett's Galago *Otolemur garnettii* is a species of Coastal Forest and other areas with trees in the coastal part of eastern Africa from southern Somalia to SE Tanzania (including Pemba, Zanzibar and Mafia).

Large-Eared Greater Galago *Otolemur crassicaudatus* is a species which typically inhabits wooded savannah, deciduous woodland, tree-crop plantations (e.g. coconut/cashew/mango) and occasionally Coastal Forest edge. A pygmy form of this species, which is of unclear taxonomic status, is reported from Litipo F.R. and the Rondo Plateau in southern Tanzania (Crouse, 1988; Bearder *et al.*, 1994; Figure 4.3.3).

Zanzibar Galago *Galagoides zanzibaricus* is a locally abundant species confined to Coastal Forest and thicket, and to the Eastern Arc forests. The taxonomic status of the form that occurs in southern Tanzania (possibly *G. z. granti*) is under review as substantial differences in vocalisations, behaviour and appearance exist between this and northern forms (Bearder *et al.*, 1994). Another pygmy form, possibly of this species, is also reported from the Rondo Plateau (P. Honess, unpublished).

Southern Dwarf Galago *Galagoides demidoff orinus* is a dwarf galago restricted to montane forest. The sub-species was described from a single specimen from Bagilo, in the Uluguru Mountains (Lawrence and Washburn, 1936). The dwarf galagos collected in southern Tanzania from Newala in 1953, from Rondo in 1956 (Jenkins, 1987) and from Pugu (Kock, *in lit.*) were subsequently assigned to this taxon. Field-work has shown that the southern (particularly Rondo) form is substantially different vocally, behaviourally and in appearance from *G. demidoff* studied elsewhere (Bearder and Honess, unpublished). These differences justify the separation of this form as a new species (Kingdon, 1997; Bearder and Honess, in prep). The true identity of the *G. d. orinus* type specimen also needs to be determined.

Kingdon (1997) reports that of the forms mentioned above as having unclear taxonomic status, a form on the Rondo Plateau, another in the lowlands of the Udzungwa Mountains, and a third in the East Usambaras have specific status. Full descriptions are to be published by Bearder and Honess (in prep.).

Body weights and additional morphological details of described species can be found in Nash *et al.* (1989), and further sonograms of species are presented in Bearder *et al.* (1994).

Rodents

The distribution and ecology of the Lesser-Pouched Rat, *Beamys hindei*, has recently been reviewed (FitzGibbon *et al.*, 1995), showing that the species is not as rare as it was originally thought. It is now known to occur in three Coastal Forests in Kenya and six in Tanzania. Population densities are high in some Coastal Forests, but it appears to be absent from other sites which have been studied using similar methods. The reasons for this patchy distribution are not understood. A probable new species of Dormouse, *Graphiurus* species has also been recorded in the Kazimzumbwi Coastal Forest (Holden, *in lit.*).

Antelopes

One rare and endemic species, Ader's Duiker, occurs in the Coastal Forests. This species has been recorded in the Arabuko-Sokoke forest in Kenya (Davies *et al.*, 1992) and on Zanzibar Island (Pakenham, 1984). Recent investigations in Arabuko-Sokoke forest (Davies *et al.*, 1992) failed to produce definite records of the species, which was last sighted in Arabuko-Sokoke in 1991, but specimens have been recently trapped on Zanzibar and are part of a breeding programme there (Wilson, pers. comm.). Due to the high rates of hunting pressure in both of these areas the future of this species must, however, be of considerable concern.

Elephant-shrews

All 15 species and 33 described forms of the family Macroscelidae are endemic to Africa. Most of them occupy woodland or forest habitats (Corbet, 1971; Nicoll and Rathbun, 1990; Rathbun, 1995), and four species occur in the eastern African Coastal Forests.

The Golden-rumped Elephant-shrew *Rhynchocyon chrysopygus* is endemic to the Coastal Forests (FitzGibbon, 1994). The other two members of the genus *Rhynchocyon*, the Black and Rufous *R. petersi* and the Chequered Elephant-shrew *R. cirnei* also occur in Coastal Forests. While *R. chrysopygus* is only found in a few Kenyan Coastal Forests north of Mombasa, *R. petersi* is distributed more widely. The sub-species *R. p. petersi* is found in the Coastal Forests of Kenya south of Mombasa and in Tanzania, and inland in the Eastern Arc forests. The threatened sub-species, *R. p. adersi*, only occurs on the island of Zanzibar. A sub-species of the Chequered Elephant-shrew *R. cirnei cirnei* is known from the type (and only) specimen from Quelimane in Mozambique, north of the Zambesi River (Nicoll and Rathbun, 1990).

The continued existence of Kenya's northern Coastal Forests, particularly Arabuko-Sokoke, is essential for the conservation of the Golden-rumped Elephant-shrew, while those of Tanzania are important for both sub-species of the Black and Rufous Elephant-shrew. Although these elephant-shrews can exist outside forests, in thicket and dense woodland, they survive at low densities in these non-optimal habitats. For both the Chequered and Four Toed Elephant-shrew, eastern African Coastal Forests comprise a small proportion of their range and are therefore less important. Further conservation recommendations for these species are found in Nicoll and Rathbun (1990) and Rathbun (1995).

Summary

The Coastal Forests of eastern Africa support 31 species of forest dependent mammal, and 109 species of broader habitat tolerance, including typical open country savannah-woodland species. The dominance of non-forest species is probably because the Coastal Forests are small, surrounded by open habitats, and dry for part of the year.

Despite the low number of forest dependent mammals in the Coastal Forests, they support a minimum of three and a maximum of 14 endemic mammal species, of which eight are currently undescribed. The endemism is focused in smaller ground dwelling mammals (shrews, rodents and elephant-shrews), although it is also seen in bats, primates (Tana River and Zanzibar), and antelopes. Rates of endemism are high in the Coastal Forests considering the small forest area, and comparable with those in the Eastern Arc forests. Many of the endemics are in groups considered by taxonomists as primitive, perhaps indicating that these species are ancient relicts of formerly more widespread species.

The Coastal Forest mammal fauna has most in common with that of the Eastern Arc Mountains, with several species endemic to these two forest types. Relationships with the mammal fauna of the main Guineo-Congolian forest further west are much weaker although species such as *Hipposideros cyclops, Rousettus angolensis* and *Procolobus pennantii* are shared. The greatest Guineo-Congolian affinities are found in the lowland forests of the East Usambara Mountains.

The most important Coastal Forests for the conservation of mammal species richness are: Arabuko-Sokoke (44 species), E. Usambara (42), Gendagenda (42), Pugu Hills (42), Jubba Valley (39), Zaraninge/Kiono (39), Mkwaja (37), Tana River (37), Rondo (35), Kiwengoma (31). This list is strongly affected by the size of the forests and the survey effort which has been expended on it. In terms of numbers of endemic and near-endemic mammals in different sites a quite different rank order emerges: Gendagenda (6), Zanzibar (6), E. Usambara (5), Tong'omba (5), Tana River, Pugu Hills, Rondo, Zaraninge/Kiono (4 each), Arabuko-Sokoke, Kilulu, Mkwaja, Ruvu South, Kiwengoma, Litipo, Pindiro (3 each). Again this ordering seems to be biased by collection effort as the best studied forests in Tanzania are ranked higher than might intuitively have been expected.

Acknowledgements

We thank Alan Rodgers (GEF Biodiversity Support Programme for East Africa), Glyn Davies (University College London – UK), Julian Kerbis of the Field Museum of Natural History (Chicago) and Kim Howell (University of Dar es Salaam) for providing comments on this Chapter.

References

Aellen, V. (1957). Les chiroptères Africains du Musée Zoologique de Strasborg. *Revue Suisse Zoologie* **64**: 189–214.

Aggundey, I.R. and Schlitter, D.A. (1984). Annotated checklist of the mammals of Kenya. I. Chiroptera. *Annals Carnegie Museum* **53**: 119–160.

Aggundey, I.R. and Schlitter, D.A. (1986). Annotated checklist of the mammals of Kenya. II. Insectivores and Macroscelidae. *Annals Carnegie Museum* **55**: 325–347.

Allen, G. M. and Loveridge, A. (1927). Mammals from the Uluguru and Usambara Mountains, Tanganyika Territory. *Proceedings of the Boston Society of Natural History* **38**: 413–441.

Allen, G. M. and Loveridge, A. (1936). Scientific results of an expedition to rain forest regions of Eastern Africa. III. Mammals. *Bull. Mus. Comp. Zool. Harvard Coll.* **79**: 29–126.

Andrews, P., Groves, C.P. and Horne J.F.M. (1975). Ecology of the Lower Tana floodplain (Kenya). *Journal of the East African Natural History Society and National Museum* **151**: 1–31.

Ansell, W.F.H and Ansell, P.D.H. (1973). Mammals of the north-eastern montane areas of Zambia. *Puku* **7**: 21–69.

Ansell, W.F.H. and Dowsett, R.J. (1988). *Mammals of Malawi: an Annotated Checklist and Atlas*. Trendrine Press, St. Ives.

Archer, A.L., Collins, S. and Bampton, I. (1991). Report on a visit to Jozani Forest, Zanzibar. *EANHS Bulletin* **21**: 59–66.

AWF (1989). *Wild Lives*. African Wildlife Foundation, Nairobi.

Azzaroli, L. and Simonetta, A.M. (1966). Carnivori della Somalia ex-italiana. *Monitore Zoologico Italiano* **74**: 102–195.

Bagger, J., Halberg, K. and Nnyiti, P.Y. (1989). *Observation of Birds in Rondo and Litipo Forests. Tanzania. Preliminary Report of the Danish-Tanzania ICBP Expedition*. Institute of Population Biology, University of Copenhagen and ICBP Denmark and Tanzania, Copenhagen.

Baillie, J. and Groombridge, B. (eds.) (1996). *The 1996 IUCN Red List of Threatened Animals*. IUCN, Gland, Switzerland and Cambridge, UK and Conservation International, Washington DC, USA.

Bearder, S.K., Honess, P.E. and Ambrose, L. (1994). Species diversity among galagos with special reference to mate recognition. In Altmann, L., Doyle, G.A. and Izard, M.K. (eds.). *Creatures of the Dark: the Nocturnal Prosimians*. Plenum Publishing Co, New York.

Bergmans, W. (1980). A new fruit bat of the Genus *Myonycteris* Matschie 1899, from eastern Kenya and Tanzania (Mammalia, Megachiroptera). *Zoologische Mededelingen* **55:** 170–181.

Bogdanowicz, V. and Owen, R.D. (1992). Phylogenetic analyses of the bat family Rhinolophidae. *Zeitschrift Zool. Syst. Evolut. Forsch.* **30**: 142–160.

Brown, J.C. (1964). Observations on the Elephant shrews (Macroscelidae) of equatorial Africa. *Proceedings of the Zoological Society of London* **143**: 103–119.

Burgess, N.D. and Muir, C. (1994). Coastal Forests of Eastern Africa: Biodiversity and Conservation (unpublished). The Society for Environmental Exploration, London.

Cambridge Tanzania Rainforest Project (1994). 'A Biological and Human Impact Survey of the Lowland Forest, East Usambara Mountains, Tanzania'. BirdLife Study Report No.59. BirdLife International, Cambridge, UK. (unpublished).

Child, G.S. (1965). Some notes on the mammals of Kilimanjaro. *Tanganyika Notes and Records* **64**: 77–90.

Christensen, J.T. (1987). A new record of *Beamys* from Tanzania. *Journal of Mammology* **68**: 858.

Cockle, A., Kock, D., Stubblefield, L.K., Howell, K.M. and Burgess, N.D. (1998). Bat assemblages in Tanzanian Coastal Forests. *Mammalia* **62**: 53–68.

Corbet, G.B. (1971). Family Macroscelididae. Pp. 1–6 In J. Meester and H.W. Setzer (eds.). *The Mammals of Africa: an Identification Manual*. Smithsonian Inst. Press, Washington DC.

Corbet, G.B. and Hill, J.E. (1991). *A World Checklist of Mammalian Species (third edition).* Natural History Museum Publications/Oxford University Press, London and Oxford.

Cotterill, F. (1994). Mammals. Pp. 93–99. In Timberlake, J. and Shaw, P. (eds.). *Chirinda Forest: a Visitors Guide*. Forestry Commission/ODA, Harare.

Crouse, K.E. (1988). 'The Distribution and Taxonomic Status of a Small Tanzanian Galago (Primates: Galagidae)'. Unpublished M.Sc Thesis. Oxford University, Oxford.

Dalquest, W.W. (1965). Mammals from the Save river, Mozambique, with descriptions of two new bats. *Journal of Mammology* **46**: 254–264.

Davies, G. and Van den Berghe, E. (eds.) (1994). *Checklist of the Mammals of East Africa*. East Africa Natural History Society, Nairobi.

Davies, G., Ochiago, O., Kibanya, P. and Kwambai, J. (1992). *Mammal Survey of Arabuko-Sokoke.* KIFCON/NMK Biodiversity Survey Report, Nairobi.

Demeter, A. and Topal, G. (1982). Kittenberger Kalman kelet-Afrikai expediciói és az általa gyüjtött emlösök. *Allatt. Közlem*. **69**: 43–59.

Dieterlen, F. (1979). Der frühestes Fund der afrikanischen kleinen Hamsterratte (*Beamys hindei*) (Cricetomyinae: Cricetidae: Rodentia). *Stuttgarter Beiträge Naturkunde* (A) no. **330**: 1–3.

Dippenaar, N.J. (1980). New species of *Crocidura* from Ethiopia and northern Tanzania (Mammalia: Soricidae). *Annals of the Transvaal Museum* **32**: 125–154.

Dobroruka, L.J. (1965). Zur Verbreitung den "Sansibar-Leoparden", *Panthera pardus adersi* Pocock, 1932. *Zeitschrift für Sägetierkunde* **30**: 144–146.

Dorst, J. and Dandelot, P. (1972). *A Field-guide to the Larger Mammals of Africa*. Collins, London.

Eisentraut, M. (1958). Beitrag zur Chiropterenfauna Ostafrikas. Ergebnisse der Deutschen Zoologischen Ostafrika-Expedition 1951/52 Gruppe Linder, Stuttgart, Nr.28, und Gruppe Knipper, Bremen. *Veröffent. Übersee-Mus. Bremen* **3**: 17–24.

Entwistle, A. and Corp, N. (1997). Status and distribution of the Pemba flying fox *Pteropus voeltzkowi*. *Oryx* **31**: 135–142.

Eriksen, T., Halberg, K., Lehmberg, T. and Petersen, F.S. (1994). *A Survey of Bird Life in Five Coastal Forests of South-eastern Tanzania*. University of Copenhagen/BirdLife Denmark, Copenhagen.

Faldborg, J., Halberg, K., Brammer, F. and Eriksen, T. (1991). *Observations of Birds and Mammals in Six Coastal Forests of Tanzania: a Preliminary Report of the Danish-Tanzanian ICBP Expedition 1990.* Institute of Population Biology, University of Copenhagen and ICBP Danish Section, Copenhagen.

FitzGibbon, C.D. (1994). The distribution and abundance of the golden rumped elephant-shrew *Rhynchocyon chrysopygus* in Kenyan Coastal Forests. *Biological Conservation* **67**: 153–160.

FitzGibbon, C.D., Leirs, H. and Verheyen, W. (1995). Distribution, population dynamics and habitat use of the lesser pouched rat, *Beamys hindei*. *Journal of Zoology, London* **236**: 499–512.

Freeman, P.W. (1981). A multivariate study of the family Molossidae (Mammalia, Chiroptera): morphology, ecology, evolution. *Fieldiana Zool*. **7**: 1–173.

Funaioli, U. (1971). *Guida Breve dei Mammiferi della Somalia*. Instituto Agronomico per l'Otremare. Biblioteca Agaria Tropicale.

Groombridge, B. (ed.) (1993). *1994 IUCN Red List of Threatened Animals*. IUCN/WCMC, Gland, Switzerland and Cambridge, UK.

Groves, C.P., Andrews, P. and Horne, J.M.F. (1974). Tana River Colobus and Mangabey. *Oryx* **12**: 565–575.

Grubb, P. (1983). The biogeographic significance of forest mammals in Eastern Africa. *Annales du Musée Royal de l'Afrique Centrale. Sciences Zoologique* **237**: 75–85.

Hamilton, A.C. and Bensted-Smith, R. (eds.) (1989). *Forest Conservation in the East Usambara Mountains, Tanzania*. IUCN, Gland, Switzerland and Cambridge, UK and Forest Division, Ministry of Lands, Natural Resources and Tourism, United Republic of Tanzania.

Hanley, P. and Morris, B. (1962). Some observations on the pouched rat in Nyasaland. *J. Mamm*. **43**: 238–248.

Happold, D.C.D. (1996). Mammals of the Guinea-Congolian rain forest. Pp. 243–285. In Alexander, I.J., Swaine, M.D. and Watling, R. (eds.). *Essays on the Ecology of the Guinea-Congo Rain Forest. Proceedings of the Royal Society of Edinburgh* **104B**.

Harrison, D.J. (1959). A new subspecies of lesser long-winged bat *Miniopterus minor* Peters, 1867, from the Comoro Islands. *Durban Mus. Novit*. **5**: 191–196.

Heim de Balsac, H. and Lamotte, M. (1956). Evolution et phylogénie des Soricidés Africains. *Mammalia* **20**: 140–167.

Heim de Balsac, H. (1968). Recherches sur la faune des Soricidae de l'ouest Africain (du Ghana au Sénégal). *Mammalia* **32**: 379–418.

Heuglin, T. von (1865). Weitere Einsendungen an die Kaiser Leopold. – Carol. deutsche Akademie des Wissenschaften, mit Zoologischen Notizen aus Afrika. *Novorum Actorum Academiae Caesaree Leopoldino-Carolinae Germanicae Naturae Curiosorum* **32**: 32–36.

Hollister, N. (1919). East African mammals in the United States National Museum, II. Rodentia, Lagomorpha and Tubulidentata. *US Nat. Mus. Bull.* **99**: 1–184.

Howell, K.M. (1979). Natural destruction of kaolin mine bat roosts in Tanzania. *Bat Res. News* **20**: 8.

Howell, K.M. (1981). Pugu Forest Reserve: biological values and development. *African Journal of Ecology* **19**: 73–81.

Howell, K.M. and Jenkins, P. (1984). Records of shrews (Insectivora: Soricidae) from Tanzania. *African Journal of Ecology* **22:** 67–68.

Hubbard, C.A. (1970). A first record of *Beamys* from Tanzania, with observations on its breeding habits in captivity. *Zool. Afr.* **5**: 229–236.

Hutterer, R. (1986a). African shrews allied to *Crocidura fischeri*: taxonomy, distribution and relationships. *Cimbebasia* (A) **8**: 23–35.

Hutterer, R. (1986b). Diagnosen neuer Spitzmäuse aus Tansania (Mammalia: Soricidae). *Bonner Zoologische Beiträge* **37**: 23–33.

Hutterer, R., Jenkins, P.D. and Verheyen, W.N. (1991). A new forest shrew from southern Tanzania. *Oryx* **25**: 165–168.

Jenkins, P.D. (1984). Description of a new species of *Sylvisorex* (Insectivora: Soricidae) from Tanzania. *Bulletin of the British Museum of Natural History, Zoology* **47**: 65–76.

Jenkins, P.D. (1987). *Catalogue of Primates in the British Museum (Natural History). Part IV.* British Museum (Natural History), London.

Kelsey, M.G. and Langton, T.E.S. (1984). *The Conservation of the Arabuko-Sokoke Forest, Kenya.* Report on the Arabuko-Sokoke Forest Expedition, July–August 1983. ICBP, Cambridge.

Kingdon, J. (1971–1982). *East African Mammals, vols. I–IIID.* Academic Press, London.

Kingdon, J. (1990). *Island Africa.* Collins, London.

Kingdon, J. (1997). *The Kingdon Field Guide to African Mammals.* Academic Press, London.

Kingdon, J. and Howell, K.M. (1993). Mammals in the forests of eastern Africa. Pp. 229–242. In Lovett, J.C. and Wasser, S.K. (eds). *Biogeography and Ecology of the Rain Forests of Eastern Africa.* Cambridge University Press, Cambridge.

Kock, D. (1974). Hildegarde's tomb bat *Taphozous hildegardeae* Thomas, 1909 first record from Tanzania. *Bull. E. Afr. Nat. Hist. Soc.* **1974 (5)**: 70–71.

Kock, D. (1978). A new fruit bat of the genus *Rousettus* Gray 1821, from the Comoro Islands, Western Indian Ocean (Mammalia: Chiroptera). Pp. 205–216. In Olembo, R.J., Castelino, J.B. and Mutere, F.A. (eds.). *Proceedings of the Fourth International Bat Research Conference.* National Academy, Nairobi.

Koopman, K.F. (1982). Family Nycteridae, Family Megadermatidae, Family Rhinolophidae. Pp.133–135, 135–136, 136–148. In Honacki, J.H., Kinman, K.E. and Koeppl, J.W. (eds.). *Mammal Species of the World.* Allen Press, Lawrence.

Lawrence, B.V. and Washburn, S.L. (1936). A new eastern race of *Galago demidovii. Occasional Papers Boston Society of Natural History* **8**: 255–266.

Long, R.C. (1973). A list with notes of the mammals of the Nsanje (Port Herald) District, Malawi. *Soc. Malawi J.* **26**: 60–78.

Madgwick, J., Wood, B., Varty, N. and Maunder, M. (1988). *Somalia Research Project: an Ecological Study of the Remaining Areas of Riverine Forest in the Jubba Valley, Southern Somalia.* University College London, London.

Matschie, P. (1895). Die Säugethiere Deutsch-Ost-Afrikas. Pp. i–xxviii, 1–157. In Möbius, E. (ed.): *Deutsch-Ost-Afrika,* **3:** Die Thierwelt Ost-Afrikas und der Nachbargebiete, Wirbelthiere, Teil 1. D. Reimer, Berlin.

McWilliam, A.N. (1988a). The reproductive cycle of male tomb bats, *Taphozous hildegardeae* (Chiroptera: Emballonuridae), in a seasonal environment in the African tropics. *Journal of Zoology* **215**: 433–442.

McWilliam, A.N. (1988b). The reproductive cycle of male long-fingered bats, *Miniopterus minor* (Chiroptera: Vespertilionidae), in a seasonal environment in the African tropics. *Journal of Zoology* **216**: 119–129.

Meester, J. and Setzer, H.W. (eds.) (1971–1977). *The Mammals of Africa: an Identification Manual.* Smithsonian Institution, Washington DC.

Mickleburgh, S.P., Hutson, A.M. and Racey, P.A. (1992). *Old World Fruit Bats: an Action Plan for their Conservation*. IUCN, Gland, Switzerland and Cambridge, UK.

Moreau, R.W. and Pakenham, R.H.M. (1941). The land vertebrates of Pemba, Zanzibar and Mafia: a zoo-geographical study. *Proceedings of the Zoological Society of London, Ser. A.* **110**: 97–128.

Moreno-Black, G. and Maples, W.R. (1977). Differential habitat of four Cercopithecidae in a Kenyan forest. *Folia Primatol.* **27**: 85–107.

Nash, L.T., Bearder, S.K. and Olson, T.R. (1989). Synopsis of galago species characteristics. *International Journal of Primatology* **10**: 57–80.

Newmark, W.D. (1991). Tropical forest fragmentation and the local extinction of understorey birds in the East Usambara Mountains, Tanzania. *Conservation Biology* **5**: 67–78.

Nicoll, M. and Rathbun, G. (1990). *African Insectivora and Elephant-shrews: an Action Plan for their Conservation*. IUCN, Gland, Switzerland and Cambridge, UK.

Noack, Th. (1891). Beiträge zur Kenntnis der Säugetier-Fauna von Ostafrika. *Jahrb. Hamburg. Wiss. Anstalten* **9**: 1–88.

Osgood, W.H. (1910). Further new mammals from British East Africa. *Field Museum of Natural History. Zoological series* **10**: 15–21.

Pakenham, R.H.W. (1984). *The Mammals of Zanzibar and Pemba Islands*. Privately published, Harpenden.

Peters, W.C.H. (1852). *Reise nach Mossambique. I. Säugethiere.* Berlin.

Peters, W.C.H. (1879). Über die von Herrn. Dr. G.A. Fischer auf einer Reise im J. 1878 in Ostafrika, von Mombas bis in das Pokomo-Land und das südliche Galla-Land, unternommenen Reise eingesammelten Säugethiere. *Mber. k. Preuss. Akad. Wiss. Berlin* **1879**: 829–832.

Peterson, R.L. (1982). A new species of *Glauconycteris* from the east coast of Kenya (Chiroptera: Vestpertilionidae). *Canadian Journal of Zoology* **60**: 2521–2525.

Rees, A. (1964). A checklist of the mammals and amphibia of Ulanga District. *Tanganyika Notes and Records* **63**: 1–4.

Rathbun, G.B. (1995). Conservation issues and strategies for elephant-shrews. *Mammal Review* **25**: 79–86.

Robins, C.B., De Vree, F. and Van Cakenberghe, V. (1985). A systematic revision of the African bat genus *Scotophilus* (Vespertilionidae). *Zool. Wetenschappen* **246**: 53–84.

Rodgers, W. A., Owen, C. F. and Homewood, K. M. (1982). Biogeography of East African forest mammals. *Journal of Biogeography* **9**: 41–54.

Rodgers, W.A. and Homewood, K.M. (1982). Species richness and endemism in the Usambara mountain forests, Tanzania. *Biological Journal of the Linnean Society* **18**: 197–242.

Schlitter, D.A. and McLaren, S.B. (1981). An additional record of *Myonycteris relicta* Bergmans 1980, from Tanzania (Mammalia: Chiroptera). *Annals Carnegie Museum* **50**: 385–389.

Schlitter, D.A., Aggundey, I.R., Qumsiyeh, M.B., Nelson, K. and Honeycutt, R.L. (1986). Taxonomic and distributional notes on bats from Kenya. *Annals Carnegie Museum* **55**: 297–302.

Skinner, J. and Smithers, R.H.N. (1990). *Mammals of the Southern African Subregion*. University of Pretoria Press, Pretoria.

Smithers, R.H.N. and Lobão Tello, J.L.P. (1976). *Check-list and Atlas of the Mammals of Moçambique*. Museum Memoir No.8, Trustees of the National Museums and Monuments of Rhodesia, Salisbury, Rhodesia.

Smithers, R.H.N. and Wilson, V.J. (1979). *Check-list and Atlas of the Mammals of Zimbabwe Rhodesia*. Museum Memoir No.9, Trustees of the National Museums and Monuments of Rhodesia, Salisbury, Rhodesia.

Smithers, R.H.N. (1983). *The Mammals of the Southern African Subregion*. University of Pretoria, Pretoria.

Swynnerton, G.H. and Hayman, R.W. (1951). A checklist of the land mammals of the Tanganyika Territory and Zanzibar Protectorate. *Journal of the East African Natural History Society* **20**: 274–392.

Thomas, N.R. (1984). 'Ecological Studies in the Arabuko-Sokoke Forest'. Unpublished PhD thesis.

Thomas, [M. R.] O. (1895). Descriptions of five new African shrews. *Annals and Magazine of Natural History* **16**: 51–56.

Thomas, [M. R.] O. (1904). List of mammals from Mount Kilimanjaro, obtained by Mr Robin Kemp, and presented to the British Museum by Mr C.D.Rudd. *Annals and Magazine of Natural History* **6**: 308–316.

Thomas, [M.R.] O. (1909). New African small mammals in the British Museum collection. *Annals and Magazine of Natural History* **4**: 98–112.

Thomas, [M. R.] O. (1910). On shrews from British East Africa. *Annals and Magazine of Natural History* **14**: 236–241.

Uchikawa, K. (1985). *Calcarmyobia* from the Ethiopian region (Acarina: Myobiidae). *Bull. Brit. Mus. Nat. Hist. (Zool.)* **48**: 45–55.

Varty, N. (1988). Mammals and problems of their conservation in the riverine forests of the Jubba valley, southern Somalia. *Tropical Zoology* **1**: 179–192.

Varty, N. (1990). Ecology of the small mammals of the riverine forests of the Jubba valley, Southern Somalia. *Journal of Tropical Ecology* **6**: 179–189.

Varty, N. and Hill, J.E. (1988). Notes on a collection of bats from the riverine forests of the Jubba valley, southern Somalia including two species new to Somalia. *Mammalia* **52**: 533–540.

Ward, J.N. and Sorell, D.S. (1950). The fauna of Jubaland. *Oryx* **1**: 26–34.

Wass, P. (ed.) (1995). *Kenya's Indigenous Forests: Status, Management and Conservation*. IUCN, Gland, Switzerland and Cambridge, UK and The Overseas Development Administration, London, UK.

Wilson, D.E. and Reeder, D.M. (eds.) (1993). *Mammal Species of the World: a Taxonomic and Geographical Reference*. 2nd edition. Smithsonian Institute, Washington DC.

4.4 Reptiles

D.G. Broadley and K.M. Howell

Introduction

Since the early days of the documentation of East Africa's fauna by zoologists, much of the focus was on the forests and associated faunas of the mountains, especially those of the volcanoes and the older, basement block Eastern Arc Mountains (see Howell, 1993, for a review and bibliography). In contrast, relatively little attention was paid to the many small patches of Coastal Forest and thicket (see Loveridge, 1936; 1942; 1951; 1955 and 1957). Until recently, the only sites for which even preliminary species lists were available were some early records for the Arabuko-Sokoke forest in Kenya (Loveridge, 1936), an area of woodland and thicket at Kibaha (Anfinnsen, 1966), Pugu Forest Reserve near Dar es Salaam (Howell, 1981), Zanzibar and Pemba Islands (Pakenham, 1983) and the forests of southern Malawi (Stevens, 1974).

This Chapter summarises the available data on the reptiles of the Coastal Forests of eastern Africa, and discusses them in terms of species endemism, biogeography and ecology.

Sources of data

Most of the data for Tanzania were provided by the 316 reptile specimens collected by the Frontier-Tanzania Coastal Forest Research Programme between 1989 and 1994. These are catalogued at the Natural History Museum of Zimbabwe and duplicates are deposited in the collection of the Department of Zoology, University of Dar es Salaam. Apart from the new species, the specimens were readily identified using the recently published checklist of the reptiles of Tanzania, with synoptic keys (Broadley and Howell, 1991). A review of the available published literature, a compilation of the unpublished information held by the authors, and written correspondence with S. Spawls and J. Ashe on Kenyan records were also used to complete the assessment of the Coastal Forest reptile fauna (see Appendix 6, this volume, for literature sources).

Reptile fauna of the Coastal Forests

The reptile fauna of 26 Coastal Forests is presented in Appendix 6, this volume. 94 reptile taxa are represented, and 47 of them are confined to forest (50%). Of these, 24 species are endemic to the Coastal Forests, and a further 13 species are otherwise found only in the forests of the Eastern Arc Mountains (Howell, 1993). The list also includes species that occur outside forest, but are found at the forest edge; many of these are fossorial reptile species.

We believe that the number of species endemic to the Coastal Forests could easily increase further. For example, the limbless skink *Scolecoseps acontias* (Werner) is still known only from the meagre description, and the type specimen collected at Dar es Salaam in 1903 that was destroyed during World War II. Moreover, *Typhlops platyrhynchus* Sternfeld 1910 is still known only from the three cotypes from Tanga in Tanzania.

It is also evident that the fossorial herpetofauna of the entire coastline of eastern Africa has been inadequately sampled, as Frontier-Tanzania have discovered six new species in the past five years. The Coastal Forests of Kenya, and northern Mozambique between the Rovuma and Zambezi Rivers, remain unexplored and urgently need investigation as there may be further species remaining to be discovered in those areas.

Further fossorial reptiles could probably be found in many Coastal Forests by demolishing rotten logs and digging beneath logs, and by searching for such species during earth moving operations in the vicinity of forest patches, e.g. trench excavations for pipelines, canals, cables or foundations, road or building construction etc. Many small vertebrates and numerous invertebrates fall into such excavations, which serve as 'giant pitfall traps', and others are exposed or killed by earthmoving equipment and can be collected by somebody following the machines. Recently felled trees are also worth investigating as they may have small vertebrates hiding under loose bark or in cavities in the trunk.

Comparison with other African forests

It is difficult to determine which genera and species are entirely restricted to forest, especially for lizards and amphisbaenians in the Guineo-Congolian forests. Data for snakes are based on Hughes (1983).

In the Coastal Forests, 24 reptile species are believed to be endemic, and another 13 are shared with the montane forests of the Eastern Arc Mountains, which have 26 endemic species and one endemic genus (Howell, 1993). In comparison, there are about 180 endemic species and 20 endemic genera in the lowland forest blocks of West Africa and the Congo Basin. The relative rate of endemism when the number of endemic species is compared with the remaining area of habitat is summarised in Table 4.4.1.

Table 4.4.1 Rates of reptile endemism in the Coastal Forests of eastern Africa in comparison with Eastern Arc and Guineo-Congolian forests.

Forest type	Forest area (km^2)	Number of species	Number of genera	Species per km^2 of forest	Genera per km^2 of forest
Coastal Forests	3,000	24	0	8.0×10^{-3}	–
Eastern Arc	9,000	50	1	5.5×10^{-3}	1.1×10^{-4}
Guineo-Congolian	2,000,000	*c.*180	20	0.9×10^{-4}	0.1×10^{-4}

The rate of endemism in relation to the existing forest area shows the highest level in the Coastal Forests, where species richness is also higher than in the Eastern Arc Mountains, with *c.* 94 species in the former and 78 in the latter.

Biogeographical distribution of key reptile groups

A reptile species with a distribution corresponding almost perfectly with that of the Coastal Forests is the East African Egg-eating Snake *Dasypeltis medici*, which ranges from southern Somalia (Lanza, 1990) to Maputaland in South Africa (Bruton and Haacke, 1980). An even wider distribution is shown by the Green Mamba *Dendroaspis angusticeps*, which has not yet been recorded from southern Somalia, but extends southwards to Pondoland in South Africa, and inland to Kilimanjaro. The Forest Cobra *Naja melanoleuca* occurs throughout the Coastal Forests from southern Somalia to Maputaland, but this species also inhabits forests (and savannah) throughout West and Central Africa.

Geckos

The diurnal dwarf geckos of the genus *Lygodactylus* range throughout Tropical Africa and Madagascar (Pasteur, 1964). Three forest species are known from West Africa and the islands in the Gulf of Guinea, two more occur on the Eastern Arc Mountains and one of these, plus six additional species, occur in the eastern African Coastal Forests (Figure 4.4.1).

Until recently, *L. conradti* was only known from the East Usambara Montane forest, but has now been recorded from the Kambai forest in the lowland East Usambaras, and Kilulu forest further east. *L. uluguruensis* was described from the northern slopes of the Uluguru Mountains (Pasteur, 1964) and has now been found to extend northeast to Tongwe Forest near the East Usambaras. A new species

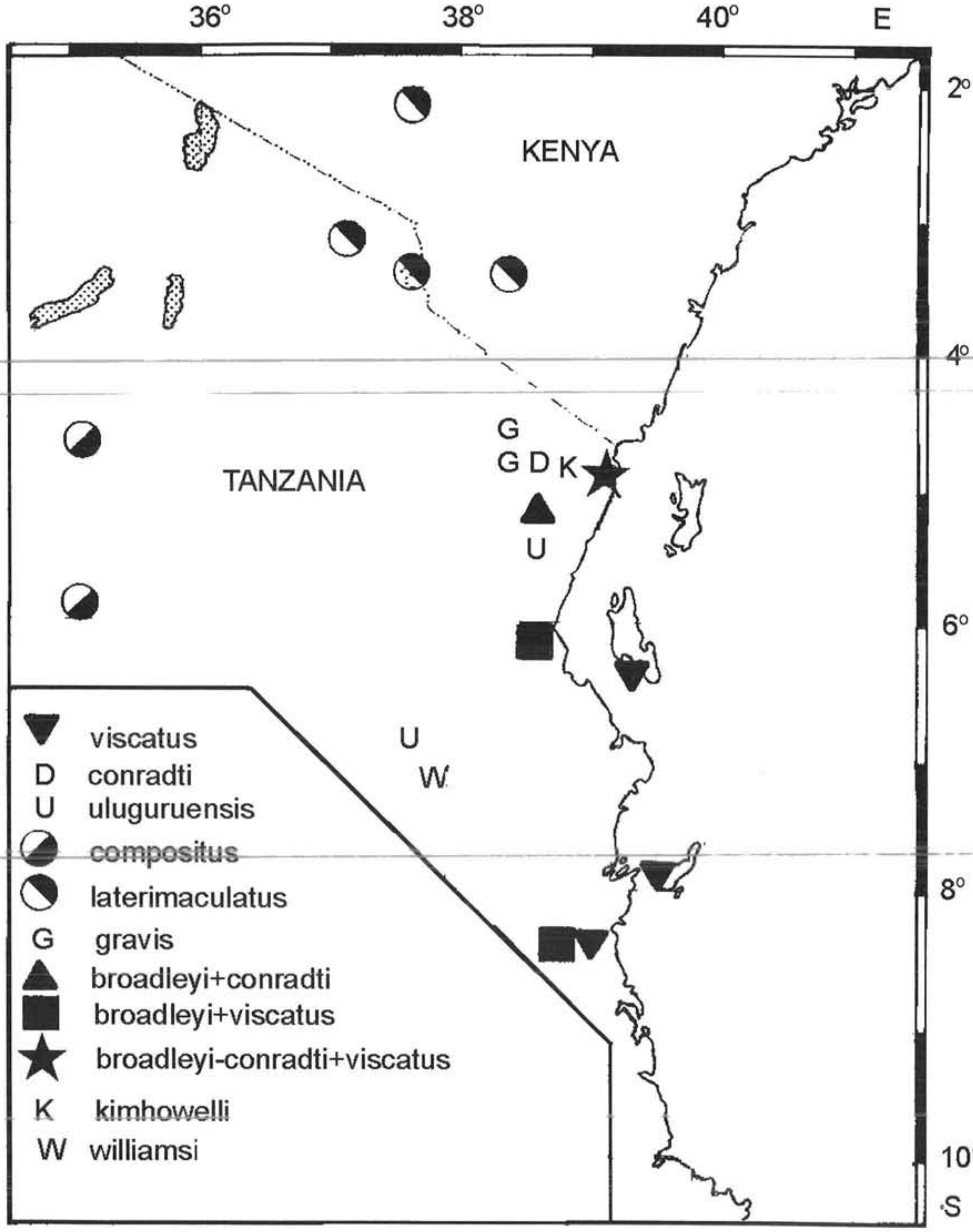


Figure 4.4.1 Distribution patterns of *Lygodactylus* species geckos in eastern African forests.

belonging to the same group, *L. broadleyi* has recently been described (Pasteur, 1995) using material from the Kilulu, Zaraninge and Kiwengoma Forests. *L. howelli* was described from Jozani forest on Zanzibar Island (Pasteur and Broadley, 1988) and has since been recorded from Mafia Island and also from Kilulu, Zaraninge, Kiwengoma, Tong'omba and Namakutwa forests on the mainland. However, Pasteur (1995) has found that this species was described in 1873 from a fossil specimen imbedded in Zanzibar gum copal and its correct name is therefore *L. viscatus* (Vaillant).

Two species belonging to the *L. picturatus* group are only known from single localities, *L. williamsi* from Kimboza Forest and the newly described *L. kimhowelli* from the Amboni Caves Forest (Pasteur, 1995). Another lowland forest species, *L. rex*, is only known from the forests at the foot of Mulanje Mountain in southern Malawi (Broadley, 1963).

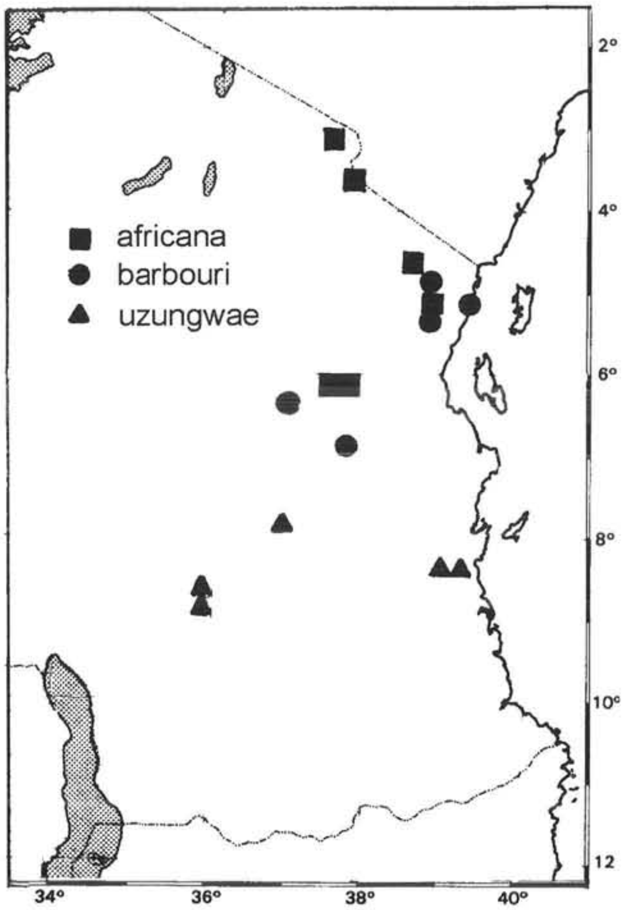


Figure 4.4.2 Distribution patterns of three *Cnemaspis* species geckos in eastern African forests.

The genus *Cnemaspis* occurs in forests of south-east Asia (subgenus *Cnemaspis*) and tropical Africa (subgenus *Ancylodactylus*). Six species occur in West Africa and four more inhabit Central Africa and the Eastern Arc Mountains (Perret, 1986), but the Frontier collections include two species recorded from Coastal Forests for the first time (Figure 4.4.2). *Cnemaspis barbouri* was described by Perret from the Uluguru Mountains in 1986 and has now been recorded from the Amboni Caves and Tongwe forests, which is surprising, as another species *C. africana* inhabits the forests of the nearby Usambara Mountains. *C. uzungwae* was also described in 1986 from a single specimen from the Udzungwa Mountains ('above Sanje'), although five more were subsequently obtained in this area. This species is now also known from the Kiwengoma and Tong'omba Forests, an eastern range extension of 250km.

The forest gecko genus *Urocotyledon* is represented by one species in the Cameroon/Zaïre region, one in the eastern African Coastal Forests and one on the Seychelles.

Chameleons

The forest species of chameleons belong to three genera. West and Central Africa have about 25 species of *Chamaeleo* (*Trioceros*), but only three *Bradypodion* and one *Rhampholeon*. The Eastern Arc Forests have four species of *Bradypodion*, seven *Chamaeleo* (*Trioceros*) and five *Rhampholeon*. The eastern African Coastal Forests have two *Bradypodion*, one *Chamaeleo* (*Ensirostris*), and five Pigmy Chameleons of the genus *Rhampholeon* (e.g. Figure 4.4.3).

Most of the chameleons recorded from the Coastal Forests have wide ranges within that habitat type. *Chamaeleo* (*Ensirostris*) *melleri* has been recorded from Pugu and Kiwengoma Forests, but it has a wide range in forests and savannahs of southern Tanzania, northern Mozambique and southern Malawi. *Rhampholeon k. kerstenii* has a wide distribution in Kenyan Coastal Forests and has recently been collected in Gendagenda Forest in Tanzania. *Rhampholeon brevicaudatus* inhabits the Eastern Arc Mountains and has now been recorded from the Zaraninge, Kazimzumbwi, Ruvu South, Kiwengoma, Tong'omba and Rondo Forests. *R. brachyurus* has been recorded from Kiwengoma Forest and this species has a wide range in gallery forests throughout southern Tanzania, northern Mozambique and southern Malawi. *Bradipodion mlanjense, Rhampholeon chapmani* and *R. platyceps* are restricted to forests in southern Malawi, but the last of these extends into montane forest on Mulanje Mountain.

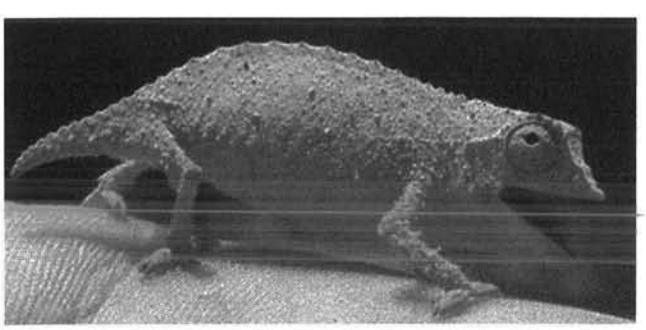


Figure 4.4.3 *Rhampholeon brevicaudatus*, Kimboza Forest, Tanzania. (*Photo: G.P. Clarke*)

Skinks

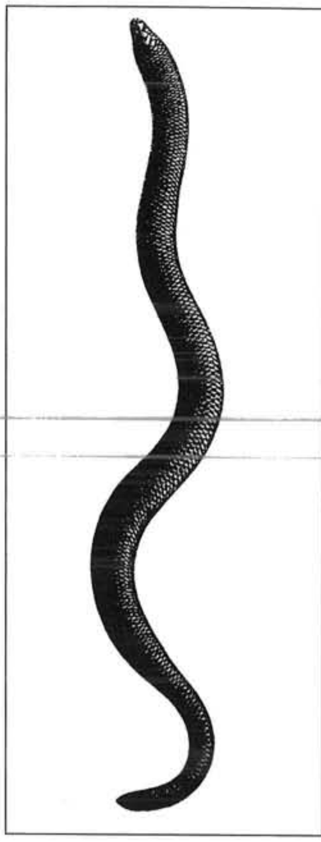


Figure 4.4.4 ***Melanoseps ater*** **(from Boulenger, 1887).**

The primitive fossorial skinks of the subfamily Scincinae are poorly represented in West and Central Africa, with only a single species of the limbless genus *Melanoseps*, whereas the Eastern Arc and Coastal Forests have six (e.g. Figure 4.4.4) and eight species respectively, three of them shared (see Brygoo and Roux-Estève, 1981). Another limbless genus, *Scolecoseps*, is endemic to the eastern African Coastal Mosaic, with a newly described species in Litipo Forest (Broadley, 1995a), *S. acontias* described from Dar es Salaam and *S. boulengeri* on the north Mozambique coast (probably not in forest). Two species of *Scelotes* are endemic to the Bazaruto Archipelago (Broadley, 1990).

In the subfamily Lygosominae, no species appears to be restricted to forest. The more conspicuous forest tree-trunk dwelling skinks of the genus *Mabuya* are represented by two species (four species in West Africa). The Speckle-lipped Skink *M. m. maculilabris* (Figure 4.4.5) has been recorded from many forests, whereas *M. boulengeri* has only been recorded from Tong'omba forest. The former species has an enormous distribution throughout West and Central Africa and south to central Mozambique (with an insular subspecies on Casuarina Island off the north Mozambique coast), whereas the latter species is restricted to south-eastern Tanzania south to central Mozambique and adjacent Zimbabwe (Broadley, 1974). *Lygosoma mafianum* has recently been described from Mafia and Kisiju islands (Broadley, 1994). This is a primitive species with keeled dorsal scales throughout life: *L. lanceolatum*, the most primitive species in the group, was described from coastal thickets on the Bazaruto Archipelago off the south Mozambique coast (Broadley, 1990 and 1992). *Lygosoma afrum* occurs in forest-edge situations on Zanzibar and the mainland, where it is widely distributed (Broadley, 1966). In the Arabuko-Sokoke forest it is sympatric with *L. pembanum* (Loveridge, 1936). In the southern sector of the East African Coastal Mosaic, the genus *Lygosoma* is replaced by smaller fossorial skinks of the genus *Scelotes*, but both genera occur on the Bazaruto Archipelago (Broadley, 1990 and 1992). Another large limbless skink, *Acontias plumbeus*, inhabits the southern Coastal Forests.

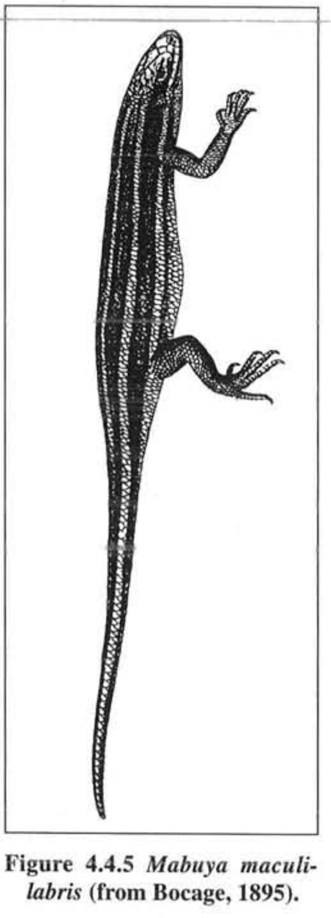


Figure 4.4.5 ***Mabuya maculilabris*** **(from Bocage, 1895).**

Lacertid lizards

Two species of the forest-dwelling lacertid genus *Gastropholis* occur in the eastern African Coastal Forests. The first, *G. vittata* (brown with white dorsolateral stripes), occurs along the coast from Tanga south to Lumbo in Mozambique, with a new record from Mkwaja forest. The second, *G. prasina*, is a handsome emerald green lizard found in the Coastal Forests of southeastern Kenya (e.g. Ashe and Ashe, 1995), and northeastern Tanzania, with a recent record from Zaraninge forest (Arnold, 1989). The other two species of *Gastropholis* occupy an area extending from Liberia to northeastern Zaïre. The arboreal lacertid *Holaspis guentheri laevis*, which has a striking blue tail, occurs in the forests of the Eastern Arc Mountains and south through Malawi to Central Mozambique (Arnold, 1989). There is a sight record from Zaraninge forest. The typical form has a wide range in West Africa and Zaïre.

Worm-lizards, blind-snakes and worm-snakes

Most worm-lizards of the suborder Amphisbaenia inhabit savannahs, but *Chirindia swynnertoni* inhabits Coastal Forests in Mozambique and adjacent Zimbabwe, while *Zygaspis violacea* is found in dune forest of the Bazaruto Archipelago. Three other species have been recorded from Tanzanian Coastal Forests.

The blind-snakes (family Typhlopidae) are again mostly inhabitants of savannahs, but eight species occur in West and Central African forests, two in the Eastern Arc forests and one, *Rhinotyphlops lumbriciformis*, in the Coastal Forests.

Two specimens of a new species of worm-snake (*Leptotyphlops macrops*), with large eyes beneath 'blisters' in the ocular shields (a unique condition in the genus), were collected by Frontier-Tanzania in Mkwaja and Mchungu Forests (see Broadley and Wallach, 1996). A third specimen was collected in Kambai Forest (Cambridge Tanzania Rainforest Project, 1994), and three more from Gede Ruins and the Arabuko-Sokoke Forest were found in the National Museums of Kenya in Nairobi. *Leptotyphlops pembae*, endemic to Pemba Island, is closely related, but has reduced ocular 'blisters'.

Advanced snakes

The primitive snakes of the family Atractaspididae are well represented in the West and Central African forests by the genera *Atractaspis* (8 spp.), *Aparallactus* (3 spp.) and *Polemon* (10 spp.). Only one *Atractaspis* and two *Aparallactus* inhabit the Eastern Arc forests and one of the latter extends into the Coastal Forests. The centipede-eating snake, *Aparallactus werneri*, previously known from the Pare, Usambara, Magrotto and Uluguru Mountains, has now been recorded from the Kazimzumbwi and Kiwengoma forests, the last locality representing a considerable southern range extension. *Aparallactus turneri* is a rare Kenyan endemic recorded from the Arabuko-Sokoke Forest (type locality), Malindi and the coast between the Tana River and Lamu Island. *Aparallactus guentheri* is usually associated with lowland or submontane forest and ranges from the Kenya coast south to eastern Zimbabwe.

The three species of large venomous snakes found in the Coastal Forests have very different distributions. The Forest Cobra *Naja melanoleuca* has an enormous range extending from Senegal to Kenya and then south to Angola and Maputaland (Bruton and Haacke, 1980). The Gaboon Viper *Bitis g. gabonica* (Figure 4.4.6) has a similar range, but is replaced by a subspecies west of the 'Benin gap'. The Eastern Green Mamba *Dendroaspis angusticeps* is an eastern African Coastal Mosaic endemic, ranging from Kenya south to Pondoland at low altitudes.

West and Central Africa has a much richer forest fauna of venomous snakes, including among the Viperidae two species of nightadder (*Causus*), the Nose-horned Viper *Bitis nasicornis* (which reaches the West Usambara Mountains) and four species of arboreal vipers (*Atheris*). The forests of the Eastern Arc have two species of *Atheris* and the endemic genus *Adenorhinos*, but none of these occur in the Coastal Forests. Additional forest dwelling Elapids in West and Central Africa are two tree cobras *(Pseudohaje)*, two water cobras *(Boulengerina)*, the fossorial *Paranaja*, and two species of mamba, with *Dendroaspis jamesoni kaimosae* reaching Kakamega Forest in Kenya and northwestern Tanzania (Roux, 1910). The Eastern Arc Forests have one forest garter snake, *Elapsoidea nigra*.

The non-venomous and back-fanged 'typical snakes' of the family Colubridae are represented in the forests of West and Central Africa by about 50 species, compared with six in the Eastern Arc Forests. Nine have been recorded from the Coastal Forests, three of them shared with the Eastern Arc Forests, including the wolf snake *Lycophidion meleagre*, which has recently been recorded from the Arabuko-Sokoke forest in Kenya. A marsh snake *Natriciteres variegata sylvatica* inhabits the Eastern Arc and Coastal Forests from southern Tanzania to Maputaland; the typical form occurs in West Africa.

A shovel-snouted snake *Prosymna janii* is endemic to the dune forests of Maputaland (South Africa), extending north to the Bazaruto Archipelago (Broadley, 1992). A new banded species (*Prosymna semifasciata*) has recently been found in the Kwamgumi Forest at the base of the East

Usambara Mountains in northeastern Tanzania (Broadley, 1995b); it seems to be most closely related to *P. ornatissima* of the Uluguru Mountains.

A forest representative of the harmless green snake *Philothamnus macrops* was originally described from the Usambara Mountains, but has now been recorded from the Gendagenda, Kiwengoma and Rondo Forests. In southern Mozambique *P. natalensis natalensis* is usually associated with dry Coastal Forests and thicket. Tornier's Cat Snake (*Crotaphopeltis tornieri*) inhabits forests of the Eastern Arc Mountains, extending southwards to the Misuku Hills in the extreme north of Malawi. It has now been collected in the Kiwengoma Forest, a considerable range extension. The poorly known *Dipsadoboa werneri* appears to be more or less restricted to the forests of the East Usambaras (one record from Tanga). The eastern race of the Cross-barred Tree Snake *Dipsadoboa flavida broadleyi* has a typical eastern African Coastal Mosaic distribution, ranging from southern Somalia south to southern Mozambique. It has recently been collected in the Kazimzumbwi Forest. The East African Egg-eater *Dasypeltis medici* has a similar distribution, but extends into Maputaland (Bruton and Haacke, 1980): a specimen was collected on Mafia Island.

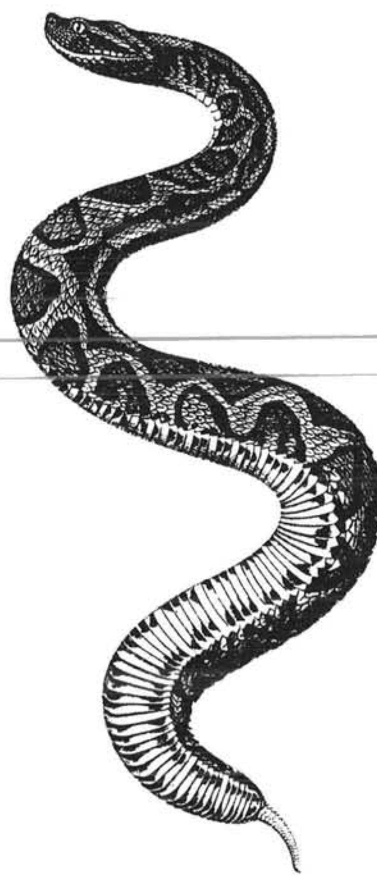


Figure 4.4.6 ***Bitis gabonica*** **(from Dumeril, Bibron and Dumeril, 1854).**

Summary

The endemic (indicated by *) or near-endemic reptile fauna of the Coastal Forests of eastern Africa consists of the following species:

GEKKONIDAE – *Lygodactylus uluguruensis, L. conradti*, L. broadleyi*, L. rex*, L. viscatus*, L. williamsi*, L. kimhowelli*.*

CHAMELEONIDAE –*Bradypodion tenue*, Bradypodion mlanjense*, Rhampholeon platyceps, R. chapmani*, R. brachyurus, R. k. kerstenii.*

SCINCIDAE – *Sepsina tetradactyla*, Scelotes duttoni*, S. insularis*, Melanoseps rondoensis*, Scolecoseps litipoensis*.*

LACERTIDAE – *Holaspis guentheri laevis, Gastropholis prasina*, G. vittata*.*

TYPHLOPIDAE – *Typhlops rondoensis*, Rhinotyphlops lumbriciformis*.*

LEPTOTYPHLOPIDAE –*Leptotyphlops macrops *, L. pembae.*

ATRACTASPIDIDAE – *Aparallactus turneri*.*

ELAPIDAE – *Dendroaspis angusticeps.*

COLUBRIDAE – *Natriciteres variegata sylvatica, Prosymna janii*, Prosymna semifasciata*, Philothamnus macrops*, P. n. natalensis*, Dipsadoboa werneri, Dasypeltis medici.*

It is probable that further exploration would increase this number. The most likely places to yield additional new species are the Coastal Forests of northern Mozambique between the Rovuma and Zambezi Rivers, which are completely unexplored.

The lizards *Lygosoma tanae* and *L. mabuiiformis*, and the snake *Meizodon krameri* are either endemic or nearly endemic to the Tana River area of Kenya. They are probably best regarded as species endemic to the Zanzibar-Inhambane regional mosaic/Swahilian region *sensu lato*, but not necessarily Coastal Forest.

Acknowledgements

We are very grateful to all the participants on Frontier-Tanzania expeditions who collected voucher specimens of reptiles from the Coastal Forests of Tanzania, and thus contributed much of the basic new data for this Chapter.

Valuable comments on the Chapter were received from Jens Rasmussen and Jon Fjeldså (University of Copenhagen), Stephen Spawls (Sandford English Community School, Addis Ababa, Ethiopia), James Ashe (Bio-Ken Snake Farm and Laboratory), Julian Bayliss (Frontier-Tanzania East Usambara Forest Research Programme), and Bob Drewes (California Academy of Sciences).

References

Anfinnsen, M.T. (1966). 'The Snakes of Kibaha'. Unpublished MS.

Arnold, E.N. (1989). Systematics and adaptive radiation of equatorial African lizards assigned to the genera *Adolfus, Bedriagaia, Gastropholis, Holaspis* and *Lacerta*. *Journal of Natural History* **23**: 525–555.

Ashe, J. and Ashe, S. (1995). Some notes on *Gastropholis prasina*. *EANHS Bulletin* **25**: 54–55.

Bocage, J.V. Barboza du (1895). *Herpetologie d'Angola et du Congo.* Imprimerie Nationale, Lisbon.

Boulenger, G.A. (1887). *Catalogue of the Lizards in the British Museum (Natural History).* Second edition. Volume III. Trustees of the BMNH, London.

Broadley, D.G. (1963). Three new lizards from south Nyasaland and Tete. *Annals Magazine of Natural History* **6**: 285–288.

Broadley, D.G. (1966). A review of the *Riopa sundevallii* group (Sauria: Scincidae) in southern Africa. *Arnoldia Rhodesia* **2 (34)**: 1–7.

Broadley, D.G. (1974). Review of the *Mabuya maculilabris* group in southeastern Africa (Sauria: Scincidae). *Arnoldia Rhodesia* **6 (23)**: 1–10.

Broadley, D.G. (1990). The herpetofaunas of the islands off the coast of south Mozambique. *Arnoldia Zimbabwe* **9 (35)**: 469–493.

Broadley, D.G. (1992). Reptiles and amphibians from the Bazaruto Archipelago, Mozambique. *Arnoldia Zimbabwe* **9 (38)**: 539–548.

Broadley, D.G. (1994). A review of *Lygosoma* Hardwicke and Gray 1827 (Reptilia: Scincidae) on the East African coast, with the description of a new species. *Tropical Zoology* **7**: 217–222.

Broadley, D.G. (1995a). A new species of *Scolecoseps* (Reptilia: Scincidae) from southeastern Tanzania. *Amphibia-Reptilia* **16**: 241–244.

Broadley, D.G. (1995b). A new species of *Prosymna* Gray (Serpentes: Colubridae) from Coastal Forest in northeastern Tanzania. *Arnoldia Zimbabwe* **10 (4)**: 29–32.

Broadley, D.G. and Howell, K.M. (1991). A checklist of the reptiles of Tanzania, with synoptic keys. *Syntarsus* **1**: 1–70.

Broadley, D.G. and Wallach, V. (1996). Remarkable new worm snake (Serpentes: Leptotyphlopidae) from the East African Coast. *Copeia* **1996 (1)**: 162–166.

Bruton, M.N. and Haacke, W.D. (1980). The reptiles of Maputaland. In Bruton, M.N. and Cooper, K.H. (eds.). *Studies on the Ecology of Maputaland.* Grahamstown and the Wildlife Society, Rhodes University, Durban.

Brygoo, E.R. and Roux-Estève, R. (1981). Un genre des Lézards Scincinés d'Afrique: *Melanoseps. Bulletin Muséum Nationale Histoire Naturelle de Paris*. Paris. 4e sér, **3**: 1169–1191.

Cambridge Tanzania Rainforest Project (1994). *A Biological and Human Impact Survey of the Lowland Forest, East Usambara Mountains, Tanzania*. BirdLife Study Report No.59. BirdLife International, Cambridge, UK.

Dumeril, A.M.C., Bibron, G. and Dumeril, A. (1854). *Erpetologie générale ou histoire naturelle complète des Reptiles.* Libraire Encyclopédique de Roret, Paris.

Howell, K.M. (1981). Pugu Forest Reserve: biological values and development. *African Journal of Ecology* **19**: 73–82.

Howell, K.M. (1993). Herpetofauna of the eastern African forests. Pp. 173–203. In Lovett, J.C. and Wasser S.K. (eds.). *Biogeography and Ecology of the Rain Forests of Eastern Africa.* Cambridge University Press, Cambridge.

Hughes, B. (1983). African snake faunas. *Bonn Zool. Beitr.* **34**: 311–356.

Lanza, B. (1990). Amphibians and reptiles of the Somali Democratic Republic: checklist and biogeography. *Biogeographia* **14**: 407–465.

Loveridge, A. (1936). Scientific results of an expedition to rain forest regions in eastern Africa. V. Reptiles. *Bulletin Museum of Comparative Zoology, Harvard* No.79: 207–337.

Loveridge, A. (1942). Scientific results of a fourth expedition to forested areas in east and Central Africa. IV. Reptiles. *Bulletin Museum of Comparative Zoology, Harvard* No.91: 237–373.

Loveridge, A. (1951). On reptiles and amphibians from Tanganyika territory collected by C.J.P. Ionides. *Bulletin Museum of Comparative Zoology, Harvard* **106**: 177–204.

Loveridge, A. (1955). On a second collection of reptiles and amphibians taken in Tanganyika Territory by C.J.P. Ionides, Esq. *Journal of the East African Natural History Society* **22**: 168–198.

Loveridge, A. (1957). On a third collection of reptiles taken in Tanganyika by C.J.P. Ionides, Esq. *Tanganyika Notes and Records* **43**: 1–19.

Pakenham, R.H.W. (1983). The reptiles and amphibians of Zanzibar and Pemba Islands, with a note on the freshwater fishes. *Journal of the East African Natural History Society and National Museum* **177**: 1–40.

Pasteur, G. (1964). Recherches sur l'evolution des Lygodactyles, lézards Afro-Malagaches actuels. *Trav. Inst. scient chérif. Sér. zool.* **29**: 1–132.

Pasteur, G. (1995). Biodiversité et reptiles: diagnoses de sept nouvelles espèces fossiles et actuelles du genre de lézards *Lygodactylus* (Sauria, Gekkonidae). *Dumerilia* **2**: 1–21.

Pasteur, G. and Broadley, D.G. (1988). A remote, insular species of the *Lygodactylus somalicus* superspecies (Sauria: Gekkonidae). *Amphibia-Reptilia* **9**: 237–244.

Perret, J.-L. (1986). Révision des espèces africains du genre *Cnemaspis* Strauch, sous-genre *Ancylodactylus* Müller (Lacertilia, Gekkonidae), avec la description de quatre espèces nouvelles. *Revue Suisse Zoologie* **93:** 457–505.

Roux, J. (1910). Reise von Dr Carl in nordlichen zentral-afrikanische Seengebeit. Reptilien und Amphibien. *Ann. Soc. Zool. Suisse* **18**: 95–103.

Stevens, R.A. (1974). An annotated check list of the amphibians and reptiles known to occur in south-eastern Malawi. *Arnoldia Rhodesia* **6 (30)**: 1–22.

4.5 Amphibians

J.C. Poynton

Introduction

A treatment of amphibians found in the eastern African Coastal Forests presupposes some understanding of what constitutes these forests, and what properly defines a 'forest' amphibian species. Hawthorne (1993) has discussed the complexities and arbitrariness inherent in attempts to define 'Eastern African Coastal Forest', while Poynton and Broadley (1991) emphasized that association with forest does not necessarily indicate a direct causal connection between the presence of trees in closed formation and the occurrence of the amphibian species in question. The association may, for example, result from rugged topography that provides both protection for trees and special habitats for tadpoles; while several species that are forest-limited in lowland areas occur in open formations at high altitudes, evidently where the risk of desiccation or other heat damage is reduced.

Difficulties therefore have to be recognized in defining strictly forest dependent or forest-limited amphibian species. The list given in Appendix 7 (this volume) of amphibian species collected from Coastal Forest sites reveals some of these difficulties. Two main points emerge from the list, firstly that collecting has been uneven in Forest Reserve areas and very incomplete, secondly that the majority of species in the collections are known to breed in open situations. Species that appear in collections from Forest Reserves but which are known to breed in open situations (at least below 1500m) are entered in the Appendix as 'f '. Species entered as 'F' are not known to breed in open situations and have at least one record from a Coastal Forest. It will be seen from the high incidence of 'f's' that the majority of species collected from Forest Reserve areas cannot be characterized as strictly 'forest species' in the sense of being dependent on resources that are provided only by a closed-canopy tree association. Some uncertainty nevertheless remains on account of imprecision regarding habitat data attached to most available specimens. Future work needs to concentrate on ways of characterizing habitat and recording the habitat in which specimens are collected, and more especially what kind of habitat is selected by each species for breeding.

High-quality data have recently been presented in the study of Drewes and Altig (1996) on amphibians in the Arabuko-Sokoke Forest area. The precise locality of the main collecting site in relation to forest was given, together with a history of the site and its present habitat structure. It is clear from the data that although the general location of the main site is the Arabuko-Sokoke Forest, the exact location is a quarry only partly surrounded by forest and freely accessible to open-site breeders. Quarries are much favoured by such breeders, and the deafening sound of calling which Drewes and Altig described is typical of quarry sites, whether against forest or out in the open. In closed-canopy forest of the coastal lowlands, such bodies of water typically do not exist (Grandison and Ashe, 1983) and there are no noisy congregations of breeding frogs. Widely-dispersed terrestrial or treehole breeders are the rule. Nearly all the amphibian species listed by Drewes and Altig from their site are therefore given 'f-rating' in Appendix 7. Lists from other Forest Reserves are likely to have a similar background. Other reasons why so many 'f-rated' species appear in the collections from Forest Reserves are considered in the Discussion.

Not surprisingly, there exists a grey area where assignation of species into a 'true forest breeding' category or an 'open habitat breeding' category is not done with much confidence or consistency. Two species are 'f-rated' here but are included by Schiøtz (1976) in a 'farmbush element' of his group of forest amphibians. These are *Hyperolius argus* and *H. tuberilinguis*. Schiøtz records collecting *H. argus* 'in a rather dense savannah' and *H. tuberilinguis* in 'savannah, but mainly on localities with rather dense vegetation'. My experience of these species is similar; they are not true forest breeders.

Rana angolensis breeds in streams or ponds in both open and closed habitats. It is treated here primarily as a 'f-rated' species, pending more data which may show that in low latitudes it tends to be associated more with forest, at least at lower altitudes. It avoids lowland within the tropics (Poynton and Broadley, 1985a) but it has been collected in one Forest Reserve covered in this paper. This presents some difficulties, encountered below.

Data sources

This study is based primarily on material collected by Frontier-Tanzania and deposited in the Natural History Museum, London (NHM), augmented by Tanzanian material already deposited in the NHM, collected mainly by Dr K.M. Howell and associates. Limited Kenyan lowland forest material in the NHM was collected mainly by Miss A.G.C. Grandison. Localities based on NHM material are entered as x in Appendix 7. Some Frontier material which has been retained in Tanzania and identified by Howell is entered in Appendix 7 as +. Some literature records are included, indicated by []. Collections in other European and American museums have not been searched for Coastal Forest records, as it is not expected that many such records exist.

It should be stressed that the forest patches cannot yet be considered well explored from the point of view of the amphibian fauna, and many aspects of the taxonomy of the species involved are still a long way from being settled. Apart from Schiøtz's *The treefrogs of eastern Africa* (1975), the amphibians of the coastal lowlands lack comprehensive taxonomic study. Even among treefrogs there are several outstanding taxonomic problems. The separation of the common species complex *Hyperolius marmoratus* and *viridiflavus* is controversial. The reedfrog *Afrixalus brachycnemis* was apparently misidentified as *A. pygmaeus* by Schiøtz (1975) (Poynton and Broadley, 1987), and the identity of the species named *A. brachycnemis* by him has not yet been properly established. Schiøtz's *A. brachycnemis* is here referred to as *Afrixalus* sp. The taxonomy of the small-sized *Afrixalus* needs reviewing. In other families, the taxonomy of small species of *Arthroleptis* and *Phrynobatrachus* is especially poorly understood. A question mark following a species name in the Appendix indicates that specimens have been assigned to the species only provisionally. The general classification of amphibians follows the revision in Duellman (1993) of Frost's *Amphibian species of the world* (1985).

The Tanzanian forests listed in Appendix 7 are those recognized by the Frontier-Tanzania Coastal Forest Research Programme (Clarke and Stubblefield, 1995; Clarke and Dickinson, 1995; Clarke, 1995) for which amphibian data are available.

The amphibian fauna

Diversity

As data on population densities are lacking, the term 'diversity' in this study has to be limited to taxon richness. The frequency with which each species appears in the localities shown in the Appendix does however give some indication of population density. *Arthroleptis stenodactylus* seems the commonest species. As indicated in Appendix 7, it seems possible to give only about fourteen species 'F-rating'. These are: CAECILIAIDAE *Boulengerula changamwensis* (Shimba Hills); BUFONIDAE *Mertensophryne micranotis* (Shimba Hills, Arabuko-Sokoke, Pugu, Kazimzumbwi, Kiwengoma, Rondo, Jozani); *Stephopaedes loveridgei* (Kiwengoma, Tong'omba, Chitoa, Litipo, Rondo); *Stephopaedes* sp. (Mrora); MICROHYLIDAE *Spelaeophryne methneri* (Rondo); RANIDAE *Phrynobatrachus ukingensis* (?) (Arabuko-Sokoke, Gendagenda, Vikindu, Kiwengoma); ARTHROLEPTIDAE *Arthroleptis affinis* (Pugu, Rondo); *Arthroleptis stenodactylus* (Shimba Hills, Arabuko-Sokoke, Pangani Falls, Gendagenda, Mkwaja, Zaraninge, Ruvu South, Pugu, Kazimzumbwi, Vikindu, Mchungu, Namakutwa, Kiwengoma, Tong'omba, Chitoa, Litipo, Rondo, Mrora); *Arthroleptis xenodactyloides* (Gendagenda, Pugu, Vikindu, Namakutwa, Kiwengoma, Tong'omba, Chitoa, Litipo, Rondo); HYPEROLIIDAE *Leptopelis flavomaculatus* (Gendagenda, Kazimzumbwi, Namakutwa, Kiwengoma, Tong'omba, Jozani); *Afrixalus sylvaticus* (Shimba Hills, Kazimzumbwi); *Afrixalus uluguruensis* (Mkwaja); *Hyperolius mitchelli* (Gendagenda, Kazimzumbwi, Jozani); *Hyperolius rubrovermiculatus* (Shimba Hills).

A specimen of *Scolecomorphus vittatus*, a limbless amphibian, has been collected on a farm near the Vikindu Forest Reserve. This species is fairly common in Eastern Arc collections, and it is not included in the Coastal Forest list until its distribution at lower altitudes is better known.

Few of the species listed above seem limited in range to Coastal Forest. The question of which (if any) may be regarded as Coastal Forest endemics will be considered later.

Comparison with Eastern Arc Forests

Caution is needed in comparing amphibian faunas inhabiting forests of the eastern coastal lowland and montane areas, since some Eastern Arc mountains are far better collected than the Coastal Forests. Comparison is made more difficult by the physiographical complexity underlying the inland forests, and by the near impossibility of drawing a clear line between 'coastal' and 'montane' forests. Taking into account the better collecting and physiographical complexity of montane forests, it may be expected that more species have been found there. Howell (1993) listed some 36 'forest dependent' amphibian species from inland forests, although several of these could be considered marginal rather than true forest species.

The best collected forest in East Africa is on the East Usambara Mountains, which is normally treated as Eastern Arc Forest or transitional Coastal Forest. The East Usambaran fauna may be listed to give the impression of a well-collected East African forest, and to identify by contrast some peculiarities of true Coastal Forest. Species which have not been recorded from Coastal Forests are identified by †; these include species grouped as a 'highforest fauna' by Schiøtz (1976) and amphibians of the 'forested basement mountains' listed later by him (Schiøtz, 1981).

CAECILIAIDAE *Boulengerula boulengeri*† SCOLECOMORPHIDAE *Scolecomorphus vittatus*† BUFONIDAE *Bufo brauni*†, *Nectophrynoides tornieri*† MICROHYLIDAE *Callulina kreffti*†, *Hoplophryne rogersi*†, *Parhoplophryne usambarica*†, *Probreviceps macrodactylus*† RANIDAE *Arthroleptides martiensseni*†, *Phrynobatrachus krefftii*†, *Rana angolensis* ARTHROLEPTIDAE *Arthroleptis affinis, Arthroleptis stenodactylus, Arthroleptis xenodactyloides, Arthroleptis xenodactylus*† HYPEROLIIDAE *Leptopelis barbouri*†, *Leptopelis flavomaculatus, Leptopelis parkeri*†, *Leptopelis uluguruensis*†, *Leptopelis vermiculatus*†, *Afrixalus uluguruensis*, *Hyperolius mitchelli, Hyperolius spinigularis*†, *Hyperolius puncticulatus.*

The treefrog species currently named *Hyperolius puncticulatus* appears to have a distribution from the Eastern Arc to southern Malawi, and is probably not referrable to the species described by Pfeffer from 'Zanzibar' whose type is lost. The problem of name allocation was discussed by Poynton and Broadley (1987), who may have concluded incorrectly that *H. puncticulatus* is not a synonym of the coastal *H. argus*. All the species in this Usambara list could be regarded as associated with forest, although *Rana angolensis* (as currently understood taxonomically) also breeds in open streams (Poynton and Broadley, 1985a). For the purpose of comparing the Usambara fauna with the lowland fauna it could be treated as forest-dwelling. The presence of *Rana angolensis* in the Kiwengoma Forest Reserve is exceptional, but it accords with the extension of the reserve to a relatively high altitude (740m a.s.l.); the species (indeed the whole genus) tends to avoid lowland in the tropics (Poynton and Broadley, 1985a).

The Coastal Forest and East Usambara lists show a high degree of taxonomic turnover. The Dice-Sørensen similarity index gives a convenient measure of turnover (2 x number of taxa common to both areas/sum of totals of taxa from both areas), expressed as a percentage. The value at species level for the two areas is only 32%; for comparison, a value of 27% is obtained when comparing the amphibian fauna from three stations in Cameroon below 750m with the fauna of Mt Manengouba above 1200m (data from Amiet, 1975).

At genus level, the similarity value obtained is 56%, which is not high. Most striking are the differences in the Microhylidae and Bufonidae. The microhylid genera of the Eastern Arc mountains form a characteristic feature of the East African amphibian fauna, as does the speciose bufonid genus *Nectophrynoides*, endemic to Tanzania. But there is no record of them in Coastal Forest, apart from the microhylid *Spelaeophryne* which occurs in southern forested areas and marginally in Coastal Forest. *Bufo brauni* is widespread in northern Tanzanian forests but so far has not been collected in Coastal Forest. On the other hand the Coastal Forest is the distributional centre of the peculiar bufonid genera *Mertensophryne* and *Stephopaedes*. This is a complex situation, and the various Coastal Forest species require individual discussion.

Species associated with Coastal Forests

As noted above, fourteen species are considered in this study to be 'Coastal Forest species', at least to the extent that they are not known to breed in open situations, and have at least one record from a recognized Coastal Forest. These species are considered in turn.

Boulengerula changamwensis

This worm-like amphibian was described by Loveridge (1932) from 'Changamwe, near Mombasa', but no account of the habitat appeared with the description or in subsequent papers. Nussbaum and Hinkel (1994) reported a specimen in the Nairobi Museum from Shimba Hills, southeast Kenya, and also a specimen in the NHM from the Shire Highlands of Malawi, most likely Mount Zomba or Mount Mlanje. Habitat data are lacking for these two specimens. Since caecilians are associated with forest, this species seems likely to occur in Coastal Forest as well as in more inland forests, but whether it should be considered a strictly 'forest' amphibian has to await more data. Also remaining to be determined is whether the distributional gap is only apparent on account of inadequate collecting or inadequate taxonomy, or a real disjunction associated with a current lack of suitable habitat. As long as the Shire Highlands record stands, this species cannot be regarded as a Coastal Forest endemic.

Mertensophryne micranotis

This dwarf toad, whose adults do not exceed 24mm, is currently regarded as belonging to a monotypic genus (Poynton, 1991). It has been found mainly in East African Coastal Forest (Figure 4.5.1), where it shows marked climbing ability. It can be called a 'tree toad' because it mates and lays eggs in treeholes as much as 150cm from the forest floor (Grandison, 1980; Grandison and Ashe, 1983). Egg laying does however also take place in pockets of water on the ground, as in the shells of the giant snail *Achatina* (Grandison, 1980; Grandison and Ashe, 1983). Marginal Coastal Forest records recently gathered by Frontier are Manga, Mtai and Bamba Ridge Forest Reserves in the foothills of the East Usambaras, but older records more decisively rule against this toad being regarded strictly as a Coastal Forest endemic. It was recorded by Loveridge (1925) from Kilosa; a pair was taken *in coitu* by a collector, but unfortunately the exact habitat was not noted. Kilosa lies outside what is conventionally regarded as Coastal Forest, as does Loveridge's later locality for this species, namely Mkangazi, some 1000m a.s.l. on the Uluguru Mountains (Barbour and Loveridge, 1928). The area was described as being 'largely under cultivation with the exception of one or two small clumps of trees; there is no trace of forest.' (Barbour and Loveridge, 1928). Brought in by a young collector, the exact habitat of this specimen was again not noted, but the record suggests that individual *Mertensophryne* can – at least for a time – survive almost total deforestation. As human litter, such as empty cans, may provide pockets of water suitable for breeding, the prospect of survival of these dwarf toads in areas of human settlement need not necessarily be thought to be zero.

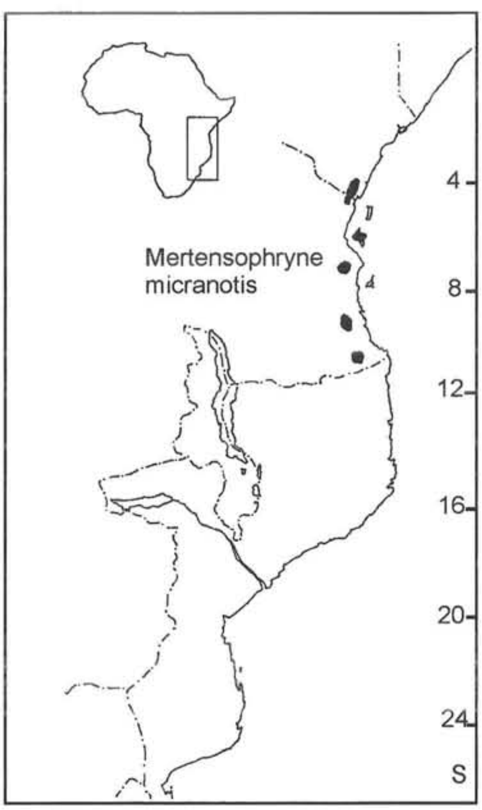


Figure 4.5.1 Distribution pattern of *Mertensophryne micranotis*.

While the Kilosa and Uluguru records could argue against *Mertensophryne* being considered either a strictly forest amphibian or a coastal endemic, there are no current records from the Eastern Arc forests proper, and the Kilosa and Uluguru records may be viewed as representing very marginal inland populations, which might now be extinct. Otherwise, *M. micranotis* has been collected widely in Coastal Forest patches from just south of the Galana River mouth in southeastern Kenya (Grandison and Ashe, 1983) to the Rondo Plateau in southeastern Tanzania (Howell, 1993), and also on Zanzibar and Songo Songo Island.

Stephopaedes spp.

This dwarf toad genus, in which adults do not exceed 45mm (Figure 4.5.3), appears to have three species, one still awaiting description. Its tadpoles are very similar to those of *Mertensophryne* (Figure 4.5.2), but adult features are sufficiently different to suggest two separate genera (Poynton, 1991). *S. anotis* (Figure 4.5.3) occurs in the Chirinda Forest of Zimbabwe and adjoining forest in Mozambique (Channing, 1978 and 1993; Poynton and Broadley, 1988). This is transitional forest from Coastal to Afromontane (White, 1978). *S. loveridgei* (Figure 4.5.4) has been collected in southeastern Tanzania from the Kiwengoma Forest Reserve to the Rondo Plateau and inland to Mahenge (Poynton, 1991). The undescribed species was first collected on Mafia Island (Howell, 1993); specimens of what appears to be the same species have been collected by the Cambridge-Tanzania Rainforest Project 1992–93 from the Kwamgumi Forest Reserve, at the base of the East Usambara Mountains. The Mafia and Kwamgumi populations could represent relicts of a northeastern species undergoing severe range restriction (see Figure 4.5.5). The Kwamgumi fauna includes Eastern Arc species, namely *Bufo brauni*, *Arthroleptides martiensseni*, *Leptopelis parkeri* and *Leptopelis vermiculatus*. This record and the Mahenge record prevents either Tanzanian *Stephopaedes* species from being regarded strictly as a Coastal Forest endemic.

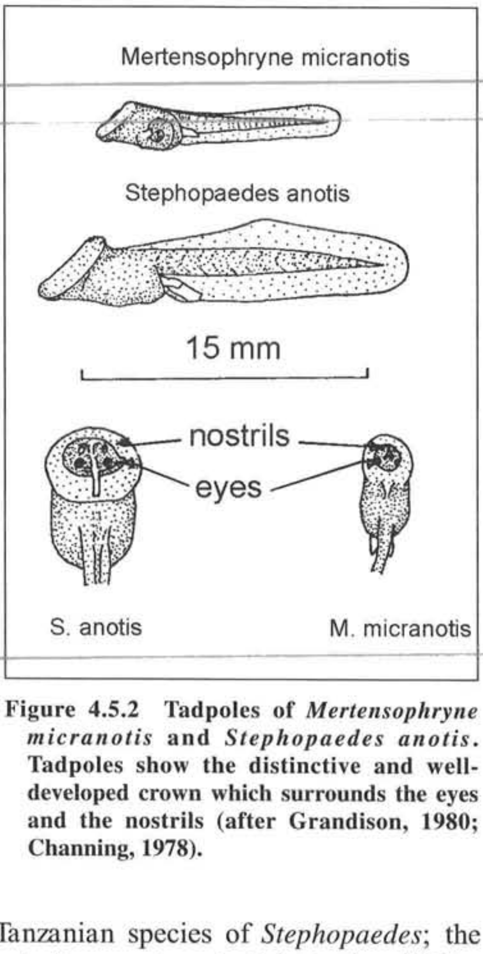


Figure 4.5.2 Tadpoles of *Mertensophryne micranotis* and *Stephopaedes anotis*. Tadpoles show the distinctive and well-developed crown which surrounds the eyes and the nostrils (after Grandison, 1980; Channing, 1978).

Virtually nothing is known about the biology of the Tanzanian species of *Stephopaedes*; the Zimbabwean *S. anotis* lays eggs in pockets of water between buttress roots or held in trunks of fallen trees (Channing, 1978 and 1993; Poynton and Broadley, 1988). Individuals of *Stephopaedes* are larger than those of *Mertensophryne*, and apparently are not tree-climbers.

While *Stephopaedes* cannot be regarded strictly as a Coastal Forest endemic, both *Stephopaedes* and *Mertensophryne* nevertheless are centred in the eastern lowland forest, and give the forest its major taxonomic distinctiveness amongst the Amphibia. The tadpoles of both genera are similar, especially in having a peculiar ridged 'crown'

Figure 4.5.3 Adult *Stephopaedes anotis* (from Boulenger, 1907).

Figure 4.5.4 Adult *Stephopaedes loveridgei* paratype BM 1969. 1493 (from Poynton, 1991).

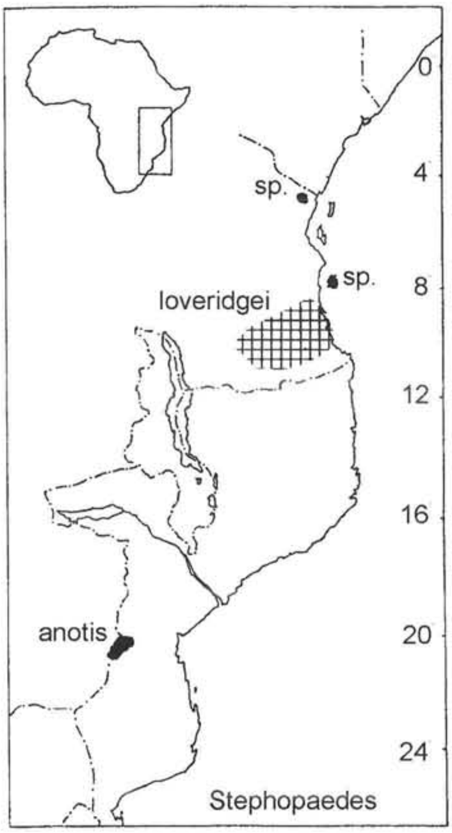


Figure 4.5.5 Distribution pattern of the three known species of *Stephopaedes*.

encircling the nostrils and eyes (Figure 4.5.2), which is evidently an adaptation to life in confined pockets of water (Channing, 1978 and 1993; Grandison, 1980; Grandison and Ashe, 1983). Adults are less similar, but they and, more especially the tadpoles, differ markedly from any other known bufonids; the genera appear to be the remains of a group whose affinities have not been discovered. Their occurrence in the eastern lowland forest is therefore notable, and in need of biogeographical explanation.

An ecological explanation for the survival of these small-sized bufonids in the lowland forests is not far to find. In discussing the biology of *Mertensophryne*, Grandison and Ashe (1983) noted a lack of free-standing or flowing water in the forests where this toad was studied, with the result that 'the only anurans that can survive in such forests need to have a highly specialised breeding strategy.' The *Mertensophryne – Stephopaedes* group provides an example of such a strategy. The species could be regarded as truly forest-dwelling, in that the pockets of water selected for breeding are normally available only in forest. Unfortunately the habitat preference of *S. loveridgei* has not been adequately described, and its breeding biology is unknown. The same is true of the undescribed species of *Stephopaedes*. The Mafia Island specimens were collected from Mrora Forest, described in Clarke and Dickinson (1995) as dry forest. It is some five km from Chunguruma Forest, once a patch of primary evergreen forest which was reported by Greenway *et al.* (1988) to have been 'totally cleared' in the early 1980s. As the biology of this species is not known, it cannot be predicted whether or not it will survive the destruction of forest on the island, but its future must be cause for much concern.

Spelaeophryne methneri

Members of the Microhylidae form a distinctive element of the Eastern Arc forests (Howell, 1993). Two microhylids occur in the Lindi Region of Tanzania (Poynton, 1991); *Spelaeophryne methneri,* which apparently shows association with forest, was collected by Loveridge from Nchingidi, 'the name given to a clearing at the [Rondo] forest edge' at 823m a.s.l. (Loveridge, 1944). This is at the extreme range of what can be called 'Coastal Forest', and its main distribution appears to be southern Eastern Arc. Barbour and Loveridge (1928) recorded it on the Uluguru Mountains from an altitude of about 450m to 900m; similarly, Klemens (pers. comm. 1996) collected it from 350m to 800m in the Udzungwa Mountains National Park. Other records are given in Poynton (1991), to which may be added the Mwanihana Forest Reserve in the Udzungwa Mountains (NHM). Not enough is known of its biology to say how tight its presumed forest association is, but its general range seems more inland than coastal. Large eggs suggest terrestrial deposition, as with the other microhylid found in the area, *Breviceps mossambicus*. This is a savannah species that burrows underground using spade-like metatarsal tubercles (Poynton and Broadley, 1985b).

Arthroleptis spp.

Arthroleptis is a mainly forest-associated genus; in species which have been studied, eggs are laid in forest litter or earth. Development excludes a free tadpole stage. Two widespread species are represented in eastern Coastal Forest localities, *A. stenodactylus* and *A. xenodactyloides* (Figure 4.5.6). *A. stenodactylus* is a particularly widespread and versatile species, occurring in anything from forest to bush clumps, and it is not surprising that it is the commonest amphibian species in Coastal

Forest Reserve collections. Its range extends as far as Angola (Poynton and Broadley, 1985b). *A. xenodactyloides* appears to be limited to forest in more lowland areas, but it is not forest-limited at higher altitudes (Poynton and Broadley, 1985b; 1991). Its appearance on highlands west of Lake Malawi and in eastern Zimbabwe excludes it from being considered only a 'Coastal Forest' species. In fact neither species can be considered to be a 'forest species' in the strictest sense of being found only in closed canopy communities.

A. affinis, known from the Usambara and Udzungwa mountains, is represented in collections from the Rondo Plateau and Pugu Forest Reserve. As with *Spelaeophryne methneri*, its main distribution seems to be inland. It is not yet clear to what extent this species is limited to forest; fairly strongly developed digging metatarsal tubercles suggest an ability to exploit forest edge and bush clumps.

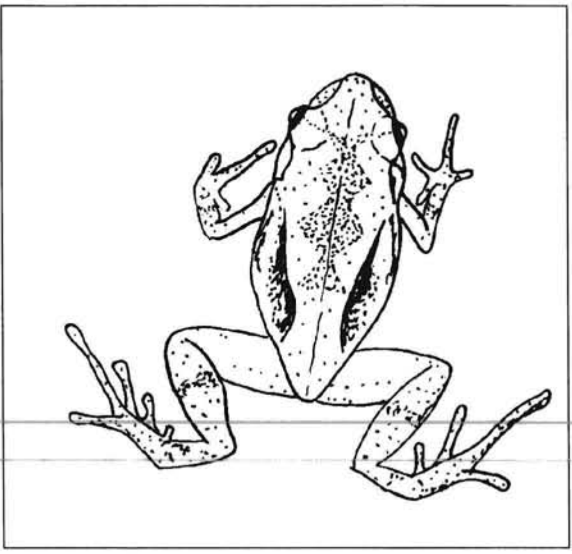


Figure 4.5.6 Adult *Arthroleptis xenodactyloides* (from Stewart, 1967).

Leptopelis flavomaculatus

This large treefrog is characteristic of evergreen forest, mainly in lowland areas from coastal Kenya to Mozambique north of the Save River, but particularly in Malawi it extends far from the coastal region (Poynton and Broadley, 1987). It appears to have a tight association with the presence of trees or shrubs (Poynton and Broadley, 1991).

Afrixalus sylvaticus, Hyperolius rubrovermiculatus, Hyperolius mitchelli and *Afrixalus uluguruensis*

The first two of these treefrogs, discussed by Schiøtz (1975), may be endemic to eastern African Coastal Forest. *A. sylvaticus* was found by Schiøtz breeding in a dense forest locality at Kwale, Shimba Hills, and it appears to be represented by a Frontier-Tanzania specimen from Kazimzumbwi. Schiøtz states that *H. rubrovermiculatus*, also from Shimba Hills, 'has only been collected in connection with forest, possibly in forest clearings'. It seems to be a forest-edge rather than a true forest species, and, as Schiøtz notes, it may be characterized better as a 'farmbush' species. It could perhaps nevertheless be classed as a Coastal Forest endemic, a distinction shared only by *A. sylvaticus*.

H. mitchelli seems to be less tightly associated with true forest. It is replaced in southeastern Kenya by *H. rubrovermiculatus*, with which it appears to be closely related (Schiøtz, 1975). At a stretch it could be included in the list of coastal lowland species, although not an endemic.

Afrixalus uluguruensis, apparently mainly an Eastern Arc species (see Schiøtz, 1975), is represented by a single specimen from Mkwaja forest collected by Frontier-Tanzania.

Discussion

The distribution of the genus *Boulengerula* is instructive. It is currently thought to include five species, which occur in East Africa and western Rwanda; the most closely related genus appears to be *Brasilotyphlus* of South America (Nussbaum and Hinkel, 1994). No close relationship with West African caecilians is indicated. The genera *Mertensophryne* and *Stephopaedes* again indicate the distinctiveness of the East African lowland fauna; *Stephopaedes* enters southern Africa (southeastern Zimbabwe), but neither show any taxonomic link with West African bufonids. This conforms to a general pattern of distinct amphibian faunas in eastern-southern Africa and in western Africa.

According to current taxonomic assessment, 31 genera are centred in eastern-southern Africa and 29 in western Africa, while only 14 genera are common to both. This gives a Dice-Sørensen similarity index value of only 47%. The difference between the herpetofaunas of eastern and western forests has been emphasized by Schiøtz (1976), Clarke (1988) and Howell (1993).

The Frontier collections could suggest a large intrusion into forested areas of species known to breed in open situations. Interpretation is hampered by a lack of precise ecological data. The mosaic nature of the vegetation of the eastern lowlands might have encouraged a catholicity in many species; while breeding in transient open situations, it could be expected that many such species will take refuge in closed situations especially during dry periods. The lowland savannah has a rich amphibian fauna of some 56 species (Poynton, 1990), and diffusion throughout the vegetational mosaic would be facilitated by frequent disturbance events in forest or bush communities, whether natural or anthropogenic.

Conclusion

Allowing for the rather uncertain criteria for defining a 'Coastal Forest amphibian', and further uncertainties regarding their biology and distribution, fourteen species can be regarded as being associated with the eastern African Coastal Forests, and five species may be listed as being limited to this forest or its margins: *Mertensophryne micranotis*, *Stephopaedes loveridgei*, *Stephopaedes* sp., *Afrixalus sylvaticus* and *Hyperolius rubrovermiculatus*. This list may well change as the forests become more fully explored and the biology of the associated species becomes better known. From the point of view of the Amphibia, the dwarf bufonid genera *Mertensophryne* and *Stephopaedes* are of particular interest. An explanation is needed as to why this peculiar division of the Bufonidae occurs here. Answers to this question would probably provide much that is of importance for understanding broader issues of biogeography and evolution in East Africa. It would be a disgraceful loss to science and to Africa if significant areas of Coastal Forest with their peculiar amphibian fauna are not preserved.

Acknowledgements

Most of the work for this paper was carried out in the Natural History Museum, London, supported by a grant from the World Wide Fund for Nature (WWF). I am grateful for the friendly help given by museum staff in the Amphibians and Reptiles Section. Close association with participants in the Frontier-Tanzania Coastal Forest Research Programme has been essential for the completion of this Chapter; the contributions of Neil Burgess, Phil Clarke and Kim Howell are especially acknowledged. Valuable discussions and exchange of information with Bob Drewes, Arne Schiøtz and Michael Klemens are also acknowledged.

References

Amiet, J.-L. (1975). Ecologie et distribution des Amphibians anoures de la région de Nkongsamba (Cameroun). *Ann. Fac. Sci Yaoundé* **20:** 33–107.

Barbour, T. and Loveridge, A. (1928). A comparative study of the herpetological faunae of the Uluguru and Usambara Mountains, Tanganyika Territory. *Mem. Mus. comp. Zool.* **50:** 87–265.

Boulenger, G.A. (1907). Descriptions of a new toad and a new Amphisbaenid from Mashonaland. *Annals and Magazine of Natural History* **20**: 47–49.

Channing, A. (1978). A new bufonid genus (Amphibia: Anura) from Rhodesia. *Herpetologica* **34:** 394–397.

Channing, A. (1993). Observations on the natural history of *Stephopaedes anotis* (Bufonidae). *J. Herpetol.* **27:** 213–214.

Clarke, B.T. (1988). The amphibian fauna of the East African rainforests, including the description of a new species of toad, genus *Nectophrynoides* Noble 1926 (Anura Bufonidae). *Trop. Zool.* **1:** 169–177.

Clarke, G.P. (1995). Coastal forest research programme: Status reports for 6 coastal forests in Lindi Region, Tanzania. *Frontier-Tanzania Technical Report* **18:** i–vi+ 1–63.

Clarke, G.P. and Dickinson, A. (1995). Coastal forest research programme: Status reports for 11 coastal forests in Coast Region, Tanzania. *Frontier-Tanzania Technical Report* **17:** i–vi+ 1–113.

Clarke, G.P. and Stubblefield, L.K. (1995). Coastal forest research programme: Status reports for 7 coastal forests in Tanga Region, Tanzania. *Frontier-Tanzania Technical Report* **16:** i–vi+ 1–67.

Drewes, R.C. and Altig, R. (1996). Anuran egg predation and heterocannibalism in a breeding community of East African frogs. *Tropical Zoology* **9**: 333–347.

Duellman, W.E. (1993). Amphibian species of the world: Additions and corrections. *Univ. Kansas Mus. Nat. Hist. Special Publ.* **21:** 1–372.

Frost, D.R. (ed.) (1985). *Amphibian Species of the World: a Taxonomic and Geographical Reference.* Allen Press and The Association of Systematics Collections, Lawrence.

Grandison, A.G.C. (1980). Aspects of the breeding morphology in *Mertensophryne micranotis* (Anura: Bufonidae): secondary sexual characters, eggs and tadpole. *Bull. Br. Mus. Nat. Hist.* (Zool.) **39:** 299–304.

Grandison, A.G.C. and Ashe, S. (1983). The distribution, behavioural ecology and breeding strategy of the Pygmy Toad, *Mertensophryne micranotis* (Lov.). *Bull. Br. Mus. Nat. Hist.* (Zool.) **45:** 85–93.

Greenway, P.J., Rodgers, W.A., Wingfield, R.J. and Mwasumbi, L.B. (1988). The vegetation of Mafia Island, Tanzania. *Kirkia* **13:** 197–238.

Hawthorne, W.D. (1993). East African Coastal Forest botany. Pp. 57–99. In Lovett, J.C. and Wasser, S.K. (eds.). *Biogeography and Ecology of the Rain Forests of Eastern Africa.* Cambridge University Press, Cambridge.

Howell, K.M. (1993). Herpetofauna of the eastern African forests. Pp. 173–203. In Lovett, J.C. and Wasser, S.K. (eds.). *Biogeography and Ecology of the Rain Forests of Eastern Africa.* Cambridge University Press, Cambridge.

Loveridge, A. (1925). Notes on East African batrachians, collected 1920–1923, with the descriptions of four new species. *Proc. Zool. Soc. Lond.* **1925:** 763–791.

Loveridge, A. (1932). New reptiles and amphibians from Tanganyika Territory and Kenya Colony. *Bull. Mus. comp. Zool.* **72:** 375–387.

Loveridge, A. (1942). Scientific results of a fourth expedition to forested areas in east and central Africa. V. Amphibians. *Bull. Mus. Comp. Zool.* **91:** 377–436.

Loveridge, A. (1944). Scientific results of a fourth expedition to forested areas in east and central Africa. VI. Itinerary and comments. *Bull. Mus. Comp. Zool.* **94:** 189–214.

Nussbaum, R.A. and Hinkel, H. (1994). Revision of East African caecilians of the genera *Afrocaecilia* Taylor and *Boulengerula* Tornier (Amphibia: Gymnophiona: Caeciliaidae). *Copeia* **1994:** 750–760.

Poynton, J.C. (1990). Composition and subtraction patterns of the East African lowland amphibian fauna. Pp. 285–296. In Peters, G. and Hutterer, R. (eds.). *Vertebrates in the Tropics.* Museum Alexander Koenig, Bonn.

Poynton, J.C. (1991). Amphibians of southeastern Tanzania, with special reference to *Stephopaedes* and *Mertensophryne* (Bufonidae). *Bull. Mus. Comp. Zool.* **152:** 451–473.

Poynton, J.C. and Broadley, D.G. (1985a). Amphibia Zambesiaca 2. Ranidae. *Ann. Natal Mus.* **27:** 115–181.

Poynton, J.C. and Broadley, D.G. (1985b). Amphibia Zambesiaca 1. Scolecomorphidae, Pipidae, Microhylidae, Hemisidae, Arthroleptidae. *Ann. Natal Mus.* **26:** 503–553.

Poynton, J.C. and Broadley, D.G. (1987). Amphibia Zambesiaca 3. Rhacophoridae and Hyperoliidae. *Ann. Natal Mus.* **28:** 161–299.

Poynton, J.C. and Broadley, D.G. (1988). Amphibia Zambesiaca 4. Bufonidae. *Ann. Natal Mus.* **29:** 447–490.

Poynton, J.C. and Broadley, D.G. (1991). Amphibia Zambesiaca 5. Zoogeography. *Ann. Natal Mus.* **32:** 221–277.

Schiøtz, A. (1975). *The Treefrogs of Eastern Africa.* Steenstrupia, Copenhagen.

Schiøtz, A. (1976). Zoogeographical patterns in the distribution of East African treefrogs (Anura: Ranidae). *Zool. Afr.* **11:** 335–338.

Schiøtz, A. (1981). The Amphibia in the forested basement hills of Tanzania: a biogeographical indicator group. *Afr. J. Ecol.* **19:** 205–207.

Stewart, M.M. (1967). *Amphibians of Malawi.* State University of New York Press, New York.

White, F. (1978). The Afromontane Region. Pp. 463–513. In Werger, M.J.A. (ed.). *Biogeography and Ecology of Southern Africa.* Dr. W. Junk, The Hague.

4.6 Millipedes

R. L. Hoffman

Introduction

Recent sampling of the diplopod (millipede) faunas in a number of Coastal Forests in eastern Tanzania has revealed a degree of endemism rivalling that already documented for the 'Eastern Arc' block fault mountains of that country (e.g. Hoffman, 1993). Two distinct elements are noted for the coastal regions of eastern Africa: widespread species ranging from Mozambique to Somalia, and endogenous taxa at both the generic and specific levels confined either to small areas north and south of the Rufiji River, most dramatically within small forest isolates in which levels of endemism may exceed 50%.

The large numbers of still undescribed taxa, and the lack of comprehensive revisions of the African diplopod families largely impede any real understanding of either phylogenetic or biogeographic relationships. Two fairly well sampled forests in Tanzania, Gendagenda near Pangani (north of the Rufiji) and Kiwengoma near Kipatimu (south) are compared and analysed in terms of endemism and taxonomic condition (see Figure 4.6.1 for location of sites). Only four species are shared by the two, which have a collective known total of 33 species – 16 of them so far undescribed. Eleven genera (7 + 4 respectively) appear to be undescribed, all strictly endemic to the two forest areas. Three further new genera have been found in the lowland forests of the East Usambaras, and additional new species were reported in the Pugu hills in the 1970s (Howell, 1981).

Past collection of Coastal Forest Millipedes

Despite heroic feats of descriptive taxonomy during the past century, notably by the tireless Count Attems, Africa has remained to the present day a 'Dark Continent' insofar as its millipede fauna is concerned. Although over a thousand species have been described so far from the Afrotropical faunal region, the majority of them are still known only from the original published descriptions (many of which are, themselves, totally uninformative). Moreover, every indication suggests that only a tithe of the actual fauna is yet known, and finally, practically every taxon – at all levels – urgently requires systematic revision.

Another persistent difficulty in analysing distributional patterns, one true for most tropical countries, is that although material collected during the past several decades has often carried some ecological documentation, the same cannot be said for most of the older samples of widespread species. Thus one cannot always be sure whether a given millipede is really confined to lowland forest habitats, for instance, or may occur widely in gallery forests etc. as well.

Under such conditions it would seem both premature and imprudent to attempt any kind of synthesis about distributional phenomena, as it is axiomatic that biogeographic conclusions can be no better than the raw material on which they are based. Yet it can be argued that despite the deficiencies of present knowledge, some areas have been sufficiently well collected that some generalisations can be inferred. Such projections can provide a model to be improved or dismantled by future students of the Diplopoda (if, indeed, any such ever appear in a coming generation). And even fragmentary information may have some value if it gives an insight into the faunistic richness of surviving areas of native forest in the eastern African coastal region.

For purely pragmatic reasons, essentially all of the following remarks relate to the eastern forests in Tanzania, the only country in which anything more than token collecting has been done. Yet even Tanzania was only superficially sampled prior to the early 1970s. In a watershed event, the collection of millipedes incidental to other field research was commenced at Dar es Salaam by K. M. Howell in 1971. This initiative later escalated into a massive operation involving not only Prof. Howell himself, The first Coastal Forest to be adequately sampled was Pugu, near Kisarawe, where millipedes were picked up during the 1970's by K. M. Howell during investigations of the vertebrate faunas (e.g. Howell, 1981). More limited and opportunistic sampling was conducted in some of the smaller forests between Bagamoyo and Tanga by Howell, students, and colleagues and some of this material was later described (e.g. by Hoffman 1977 and 1983; Hoffman and Howell, 1980, 1981 and 1987). The late Norwegian lepidopterist Jan Kielland obtained a number of species (now under study) in the Rondo Forest but no attempts to provide faunal lists have yet been made for any of these localities. Each place has yielded species of uncertain systematic position, requiring revision of the entire genera involved, and until this time-consuming work can be completed no useful end is served by listing species merely as 'Odontopygid, gen. and sp. nov.', for instance. Even the rich 'Frontier' collections have as yet been only partly identified (and none of the new taxa yet named).

Given the limitations mentioned above, as well as the paucity of both geographic and ecological data, any attempt to distinguish smaller patterns of distribution within a given region is an exercise in futility. The difficulty in associating specific organisms with specific habitats compels reliance upon the inferences drawn from distribution. A provisional solution may be reached by considering the last two major patterns sequentially in the sense of widespread coastal elements as opposed to those with apparently very limited ranges.

1. Widespread elements

The lowland fauna contains a number of quite widespread species, many of which were described by Peters (1864) from Mozambique and by Gerstäcker (1873) from specimens from eastern Tanzania. Some examples include the spirostreptid *Archispirostreptus gigas* (Peters) and the odontopygid *Helicochetus dimidiatus* (Peters), both of which range from Mozambique to Kenya but do not extend inland much beyond the 1000m contour. Another spirostreptid, *Otostreptus stylifer* (Peters) occurs from the Zambezi River northward as far as Bagamoyo but no further. It is not uncommon for genera to be represented in the coastal fauna by several closely-related taxa. The range of *Otostreptus* is carried further north into Kenya by *O. gilvitarsus* (Attems) and a closely related unnamed species. *Phaeodesmus* (Paradoxosomatidae) has one member in southeastern Kenya, another on Mafia Island, and a third in Mozambique (these three may be subspecies of one wide ranging form). It is evident that components of this widespread pattern are coextensive with Faunal Area IV as defined above. The implication is clear that in the recent past, suitable habitat was continuously available to allow occupation of, migration along, and speciation within lowland forest. Interestingly, the major east-west rivers seem not to have been effective barriers. Perhaps their lower reaches changed course frequently enough to provide the possibility of 'passive crossing'.

Despite being classified as 'lowland forest' elements, many of these species do extend upward in forested mountains as high as 970m, and coexist with species of group V.

Some of these species are not necessarily dependent on forest. *Archispirostreptus gigas* and the pachybolid *Epibolus pulchripes* are both known from coastal habitats in Kenya where there are trees (parks etc.), but no forest. The present wide distribution of these species does not therefore necessarily indicate a former continuous forest habitat.

2. Southern elements

A substantial number of lowland taxa appear to be centred on Mozambique, and extend into southeastern Tanzania only as far as Lindi. Two of these are gomphodesmids: *Aulodesmus mossambicus* (Peters) and *A. perarmatus* (Hoffman); two others are spirostreptids: *Doratogonus flavifilis armatus* (Attems) and *Plagiotaphrus sulcifer* (Attems); and one is an oxydesmid, *Orodesminus macrolophus* (Attems). Additional species, known so far only from this part of Tanzania, may belong also to this category if they are subsequently collected further south in Mozambique. All of these taxa are large and conspicuous enough to have been taken by Frontier collectors if they occurred north as far, e.g., as Kiwengoma near Kipatimu.

3. Northern elements

The members of this group are largely confined to the coastal region between the Rufiji and Tana Rivers, although sometimes extending westward in northern Tanzania as far as the vicinity of Morogoro (Figure 4.6.1, subregion 3). Included here are several spirostreptids: *Macrolenostreptus brachycerus* (Gerstäcker), *Anastreptus scalatus* (Karsch), *Dendrostreptus macracanthus* (Attems), and *Pseudotibiozus anaulax* (Attems) (as well as several other species not yet placed in the correct genus), and some odontopygids: *Helicochetus gregorii* (Pocock), several species of *Prionopetalum* and of *Callistodontopyge*, and *Xystopyge alluaudi* (Brolemann). Other components include the gomphodesmids *Astrodesmus laxus* (Gerstäcker) and *A. stellifer* (Cook); and the oxydesmids *Rhododesmus mastophorus* (Gerstäcker) and *Orodesminus erectus* (Brolemann). This by no means exhausts the list, and the large number of entries suggests the importance of this faunule in the make-up of the Coastal Forest biota. Some species like *Otostreptus gilvitarsus* (Attems) which are endemic to area 3 (Figure 4.6.1) are clearly terminal components of area I species with affinities to the south.

4. Local endemic elements

Ironically, this group is of greatest biogeographic interest while being least-known because of the recency of its discovery. Present information suggests that the millipede faunules of the isolated lowland forests, especially those south of the Rufiji Delta, contain a very high percentage of strict endemics. Unfortunately, since the taxonomy of most East African millipede taxa is so rudimentary, and so many of the endemic forms still undescribed, it is very difficult to derive a meaningful synthesis of either phylogenetic or geographical affinities, or to discriminate between patterns reflecting local differentiation and relictual distributions and special ecological conditions which permitted taxa of potentially diverse origins to persist in specific places.

A tabulation of the species obtained in two forests (Kiwengoma and Gendagenda – see Figure 4.6.1 for location), which have been reasonably well sampled for at least the larger species, emphasises local diversity and the high number of undescribed endemic taxa more effectively than a written account (Table 4.6.1). These areas are separated by about 200km in a north-south direction, with one major difference between them being a greater vertical relief (up to 740m a.s.l.) and substantially greater forested surface area for Kiwengoma. Such elevation so close to the coast would seem to merit a more appropriate name than the Matumbi 'Hills': 'mountains' would appear more descriptive.

Further material has been collected from more than 20 additional Coastal Forests in Tanzania, but much of that remains to be inspected carefully, let alone described.

In Table 4.6.1, some female specimens identifiable to genus but not species are indicated by the term 'sp.' following the generic name. These are almost certainly undescribed endemics, but not verifiable without male specimens. In some cases, the most appropriate geographical category (I–IV) is not clear and an arbitrary selection indicated by a '?'.

Although the two forests are not particularly distant (200km), their millipede faunas are strikingly different. Of a total of 33 species known from the two forests, only four species are shared, and three of these are widespread from Mozambique to Kenya. Kiwengoma Forest has the greater number of taxa, 21 species as opposed to 16 at Gendagenda. This greater diversity may be a function of greater moisture, since a disparity is noticeable among the species of Polydesmida: eight at Kiwengoma, and only two at Gendagenda (polydesmidans appear to be more partial to moist situations).

The 21 species at Kiwengoma represent 21 genera, seven of which (33%) are undescribed; 10 of the species (49%) are unnamed, a remarkable condition for most groups of animals, but routine for tropical millipedes. The 17 species at Gendagenda represent 15 genera, only four of which (25%) are new. Five of these 17 species (31%) are undescribed, the slightly lower value perhaps reflecting the paucity of polydesmidans.

The lists of millipede species are impressive enough as they stand, being the results of short-term collecting by non-specialists. It must be kept strictly in mind, however, that specialised collecting for

Table 4.6.1 Known millipede faunas of two Coastal Forests of eastern Tanzania.

	Forest		Faunal Group			
Taxa (order, family, genus, species)	**Kiwengoma**	**Gendagenda**	**1**	**2**	**3**	**4**
Order STEMMIULIDA						
FAMILY Stemmiulidae						
1. *Stemmiulus* sp.	x	.	.	.	.	x
Order SPIROBOLIDA						
FAMILY PACHYBOLIDAE						
2. *Epibolus pulchripes* (Gerstäcker)	x	x	x	.	.	.
Order SPIROSTREPTIDA						
FAMILY SPIROSTREPTIDAE						
3. *Macrolenostreptus brachycerus* (Gerstäcker)	x	.	.	x	.	.
4. *Pseudotibiozus cerasopus* (Attems)	.	x	.	.	x	.
5. *Pseudotibiozus* sp. n. 1	.	x	.	.	.	x
6. *Pseudotibiozus* sp. n. 2	.	x	.	.	.	x
7. *Archispirostreptus gigas* (Peters)	x	x	x	.	.	.
8. *Otostreptus stylifer* (Peters)	x	x	x	.	.	.
9. *Calostreptus ?chelys* Cook	.	x	.	.	x	.
10. *Lophostreptus* sp.	x	.	.	.	.	x
11. *Trachystreptine*, gen. and sp. n.	.	x	.	.	.	x
12. Gen. & sp. n.	x	.	.	.	.	x
FAMILY HARPAGOPHORIDAE						
13. *Zinophora* sp.	x	.	.	.	.	x
14. *Apoctenophora* sp.	.	x	.	.	.	?
FAMILY ODONTOPYGIDAE						
15. *Xystopyge robusta* Attems	x	x	.	.	x	.
16. *Plethocrossus octofoveatus* Attems	.	x	.	.	x	.
17. *Helicochetus dimidiatus* (Peters)	x	.	.	x	.	.
18. *Callistodontopyge decora* Hoffman and Howell	.	x	.	.	x	.
19. *Prionopetalum* sp. n.	x	.	.	.	.	x
20. Gen. & sp. n. 1	x	.	.	.	.	x
21. Gen. & sp. n. 2	x	.	.	.	.	x
22. Gen. & sp. n. 3	.	x	.	.	.	x
23. Gen. & sp. n. 4	.	x	.	.	.	x
24. *Lissopyginae*, gen. & sp. n.	.	x	.	.	.	x
Order POLYDESMIDA						
FAMILY PARADOXOSOMATIDAE						
25. Gen. & sp. n. 1	x	.	.	.	.	x
26. Gen. & sp. n. 2	x	.	.	.	.	x
FAMILY OXYDESMIDAE						
27. *Orodesminus macrolophus* (Attems)	x	.	.	x	.	.
28. *Lyodesmus* sp.	x	.	.	.	.	x
29. Gen. & sp. indet., probably new	x	.	.	.	.	x
30. *Rhododesmus mastophorus* (Karsch)	.	x	.	.	x	.
FAMILY GOMPHODESMIDAE						
31. *Astrodesmus laxus* (Gerstäcker)	.	x	.	.	x	.
32. *Erythronassa saucra* Hoffman & Howell	x	.	.	?	.	.
33. *Sphenodesmus* sp. n.	x	.	.	.	.	x
FAMILY CRYPTODESMIDAE						
34. *Thelydesminae*, gen. & sp. n.	x	.	.	.	.	x
Column totals	**21**	**16**	**3**	**3**	**9**	**19**
Species in common	**4**					
New genera	**7**	**4**				
New species	**10**	**5**				

small species and in different seasons may increase the present totals by 100%, if collecting efforts in other regions are any indication.

Data for other lowland forests is less quantified. However, collections from Kwamgumi and Manga forests in the lowlands of the East Usambaras also contain at least three new genera of millipede in collections which total about 18 species. Also, few of the 16 Gendagenda millipedes occur at Pugu Forest, some 100km to the south (which also has endemics – Howell, 1981), and those species found at Kiwengoma are only sparsely represented at Rondo Forest which is a further 150km to the south (and where there are yet more endemics). It is therefore apparent that many of the isolated Coastal Forests have evolved millipede faunas containing species which are strictly endemic, and that further investigation of the millipede fauna of these forests would show detailed patterns of endemism between sites.

The millipedes do not seem, however, to have incurred local speciation such as seen in the oxydesmid genera *Ceratodesmus* in the Usambara Mountains and *Gonepacra* in the Udzungwas. Perhaps this difference is a function of the evolutionary history of the taxa, in which local new genera are not sufficiently old for adaptive radiation to have occurred. The Matumbi uplands, high enough to have escaped inundation in the past, have been sampled so far in the Kiwengoma, Tong'omba, and Namakutwa forests, but so far only material from the first-named has been identified.

Looking further afield for geographic affinities elsewhere is not very rewarding since so many of the lowland forest endemics (particularly small spirostreptids) are still undescribed and belong to families which have not been revised. The isolated faunules may actually contain elements from different sources. For instance, the genus *Stemmiulus*, found at Kiwengoma (and Pugu Forest) appears to be an ancient Pantropical group with relatives in South America, south India, and the East Indies. The African species are most numerous in the Guinean rain forest, but isolated species have been recovered in the Lake Region, Kilimanjaro, and the Eastern Arc Mountain blocks of the Usambaras, Ulugurus and Udzungwas, suggesting that the Tanzanian forms represent faunal group: West African-Congo.

The recently-described oxydesmid *Gonepacra muhulu* (Hoffman, 1990), or a very closely related sibling species, has been found in the Rondo Forest. The millipede was known only from its type locality in the Mahenge highlands, some 300km to the northwest of Rondo. The genus is otherwise confined to the Udzungwa, Uluguru, and Rubeho ranges in the 'Eastern Arc' mountains, and would thus relate to the Group V pattern. Another example of a taxon shared between 'Coastal' and 'Eastern Arc' forests occurs in the oxydesmid genus *Iringius*, of which the species *I. rossi* is represented by the nominate subspecies at the northern end of the Udzungwas, and *I. rossi kisarawensis* at Pugu Forest and on Mafia Island. Otherwise, few millipedes are common to the two forest groups, again reflecting the high degree of endemism in each.

Summary

Present information provides us with only a glimpse of millipede diversity and evolution in the lowland Coastal Forests of eastern Africa. What lies below the level of existing scant samples cannot be imagined, beyond vistas of local endemism far surpassing anything yet recorded for terrestrial vertebrates. It is a matter of exceptional regret that these marvellous enclaves of tropical life are in danger of eventual loss through human activities. It is a similar tragedy that the ongoing decline of interest in – and support of – basic taxonomy is quickly leading to the loss of specialists qualified to facilitate the study of their millipede components even before existing materials can be analysed.

Acknowledgements

All of the material reported in this account was obtained by field parties directed by Frontier-Tanzania, a joint initiative of the University of Dar es Salaam, Tanzania, and the Society for Environmental Exploration, United Kingdom. The samples were subsequently transmitted to me by K. M. Howell (University of Dar es Salaam), to whom I remain under a debt of gratitude for this and many other kindnesses.

Comments on this Chapter were received from Henrik Enghoff (Zoological Museum, University of Copenhagen, Denmark).

References

Gerstäcker, A. (1873). Gliederthiere (Insekten, Arachniden, Myriopoden und Isopoden). *Baron Claus von der Decken's Reisen in Ost-Afrika* **3** (2): 1–542.

Hoffman, R.L. (1977). East African prepodesmid millipeds (Chelodesmidae). *Revue Zoologie Afrique* **91**: 69–82.

Hoffman, R.L. (1983). A new genus of marptodesmine millipeds from Tanzania (Polydesmida: Gomphodesmidae). *Revue Zoologie Afrique* **97**: 618–624.

Hoffman, R.L. (1990). Family Oxydesmidae. Myriapoda 4. In *Das Tierreich, lief.* **107**: 1–515.

Hoffman, R.L. (1993). Biogeography of East African montane forest millipeds. Pp. 103–115. In Lovett, J.C. and Wasser, S.K. (eds.). *Biogeography and Ecology of the Rain Forests of Eastern Africa*. Cambridge University Press, Cambridge.

Hoffman, R.L. and Howell, K.M. (1980). Records and descriptions of East African orodesmid millipeds (Polydesmida: Oxydesmidae). *Revue Zoologie Afrique* **94**: 433–456.

Hoffman, R.L. and Howell, K.M. (1981). A new genus, composed of brightly colored East African species, in the diplopod family Odontopygidae. *Revue Zoologie Afrique* **95**: 687–696.

Hoffman, R.L. and Howell, K.M. (1987). A new genus and species of spectacular gomphodesmid millipeds from eastern Tanzania (Polydesmida: Gomphodesmidae). *Revue Zoologie Afrique* **100**: 473–477.

Howell, K.M. (1981). Pugu Forest Reserve: biological values and development. *African Journal of Ecology* **19**: 73–82.

Peters, W. (1864). Übersicht der im Königl. Zoologischen Museum befindlichen Myriopoden aus der Familie der Polydesmi, so wie Beschreibungen einer neuen Gattung, Trachyiulus, der Juli, und neuer Arten der Gattung Siphonophora. *Monatsberichte der Königl. Akademie der Wissenschaften zu Berlin* **1864**: 531–551.

4.7 Molluscs

B. Verdcourt

Introduction

Snails and slugs are one of the few groups of invertebrates that have been reasonably well studied in the Coastal Forests. This is particularly true for the snails as their hard shell persists for some time after the animal has died which makes it possible to collect large numbers of specimens from favourable areas.

Snails and slugs are sedentary animals incapable of rapid long-distance travel or migration. However, although they are clearly more sedentary than many organisms, their own movement is the main method of migration within favourable habitats. The vast periods of time which have been available for species to move within the forests of Africa when they were more continuous than today, would in fact have given the snails adequate time to migrate between different parts of Africa. For example a snail moving at an average rate of 0.3mm per second could move from Cameroon to Kenya in only 370 years assuming continuous habitat, a straight route and no other activity. Naturally, nothing would have travelled in a straight line moving all the time in one direction, but this shows that snails and slugs are far from totally sedentary.

The Coastal Forests have been isolated from the lowland Congo Basin forests for millions of years (see Chapters 1.2 and 2.3), although there may have been episodes of connections to the north and south periodically since that time. They are also isolated from much of the nearby Eastern Arc forest by altitude, hence it might be expected that there would be endemic snail and slug forms in the Coastal Forests. These might be species recently evolved in the Coastal Forests, or ancient species which have become isolated in these forests but which used to be more widespread. The phylogenetic history of the molluscs is not well enough known to describe these possibilities. Long distance movement may have also occurred in some species, particularly aquatic and semi-aquatic species which can become attached to birds' feet, or even to insects.

It is also no longer possible for snails and slugs to migrate between Coastal Forests because the forests are reduced to fragments and the intermediate terrain is hostile to the point of fatality. This fragmentation of suitable habitat may have also allowed species to evolve recently in isolated tracts of forest, or to become isolated there as they have died out in other places.

The levels of snail endemism within the Coastal Forests as a whole and the patterns of endemism between the different Coastal Forest patches may reflect the situation with other groups of invertebrates. Hence any particularly important forests for snails may be worth investigating in detail for other invertebrate taxa to test if this relationship does really exist.

Mollusc zones in East Africa

In 1950 I proposed a formal zonal classification of the non-marine molluscs of East Africa (Verdcourt, 1951). This classification recognised four zones:

1. mangrove swamps,

2. lowland zone 0–750m,

3. intermediate zone 750–1200m, and

4. upland zone 1200–2100m.

At that time the abundance of molluscs in montane forests up to 3000m was known to me only from literature and I was unaware that a few truly alpine species extended up to 4050m.

This publication stated that the lowland zone was: – 'formerly covered with a drier type of evergreen forest. *Helicidae* are entirely absent but *Pomatiasidae* are abundant. The genera *Ledoulxia* (= *Trochonanina*), *Achatina* and *Tayloria* are abundant. *Urocyclid* slugs are not common. Freshwater species are more common than in the higher zones'.

Much of this remains true today, save that slugs are much more common than I suggested and the statement about freshwater molluscs is only more or less true if the immensely rich Great Lakes and River Nile are excluded.

Other features not mentioned in that publication were the absence in the lowland zone of *Biomphalaria* and *Pisidium* in the fresh water, the virtual absence of Endodontidae *sensu stricto*, *Limicolaria* and many other land genera. The abundance of Streptaxidae and in particular their range of size allowing them to predate the full range of sizes of the prey snail genera is also notable. This size range also characterises populations from the Miocene deposits of West Kenya (Verdcourt, 1963).

Specific diversity

In terms of specific diversity, the coastal regions of East Africa possess only 207 species and subspecies out of over 1230 for the whole of East Africa (Uganda, Kenya and Tanzania) (Verdcourt, 1983), and 61 of those are freshwater, mangrove swamp or littoral species. A list of the coastal species is given as Appendix 8 (this volume). Of these, 125 species occur in the Coastal Forests and bushland vegetation.

Of the 36 operculates (the first 36 species in the list in Appendix 8, this volume) recognised in the coastal regions, 29 are fresh and brackish water species or littoral species and only seven are truly land forms. Land operculates are sparse in the African fauna as a whole compared with the large numbers occurring in tropical Asia and tropical America. The pulmonates comprise 18 brackish water or littoral species (including an *Onchidium*), eight freshwater species and 136 (+ 3 subspp.) land species of which 38 (+ 3 subspp.) are carnivorous Streptaxidae. Only six freshwater bivalves are recorded.

The land pulmonates, apart from the streptaxids, are made up as follows:- Veronicellidae (slugs), 3; Succineidae, 2; Pupillidae, 6; Enidae, 17; Ferussaciidae, 1; Achatinidae and Subulinidae, 37; Endodontidae, 1; *Sitala* , 1; Urocyclidae, 17 shelled species and 11 slugs. Two species described from the Kenya coast are, I am convinced, errors either of identification as to genus or of labelling as to geography – *Helicarion aureofuscus* was described from Baron von der Decken's collection, the locality given being Mombasa, but it belongs to an upland group and has never been recollected; I did not find the type at Berlin. The other is *Halolimnohelix gaziensis* (= *Zingis gaziensis*) described from Gazi. Because a paratype I have examined is undoubtedly a juvenile helicid, I suspect erroneous labelling since no helicids have ever been found on the coast.

Analysis of the species in Appendix 8 shows that the species recorded in the coastal area are unevenly spread across habitat types (Table 4.7.1). Most species in the coastal zone are forest or 'bushland' species (principally coastal thicket), these two categories comprising 60.3% of the total assemblage of snails and slugs from the East African coastal area.

Endemism

Few genera are endemic to the coastal area. These are probably only *Incertihydrobia* (freshwater snail), *Pembatoxon* (slug) and 'genus near *Omphalotropis* (*Assiminea aurifera*)' yet to be described. Only the slug is a forest specialist.

It is possible that some species at present only known from shells and referred to known genera may prove to be generically distinct when animals are available for dissection. However, at least 109 of the species and sub-species are endemic to the coastal region. Of these 86 species are confined to the Coastal Forests, or evergreen thicket vegetation, 79% of the total (Table 4.7.1).

Table 4.7.1 Habitat distribution of the snails and slugs recorded in the East African coastal area.

Habitat type	Number of species	Percentage of total	Number of endemics	Percentage of total
Forest	89	42.90	86	79
Bushland	36	17.39	1	0.9
Freshwater	34	16.40	9	8.3
Mangrove	6	3.00	1	0.9
Brackish Water	18	8.00	0	0
Littoral	4	2.00	0	0
Coastal scrub	5	2.41	1	0.9
Coral/cliffs	2	0.96	1	0.9
Other and Unknown	13	6.20	10	9.2
TOTAL	207		109	

N.B. Species said to be bushland/forest in habitat preference in Appendix 8 have been placed in the forest category here.

Most of the endemic species in the coastal area of East Africa are Coastal Forest species, with only a few being found in the freshwater habitats, and almost none in all other habitat types. Hence there is no doubt that it is the Coastal Forest habitat which has the greatest importance for the conservation of snails in the lowlands of coastal East Africa. However, it is not possible on the currently available information to say which is the most important forest, or even areas of forest, for the conservation of snails and slugs.

Appendix 8 shows that the recent collections by Frontier-Tanzania contain several apparently new species of snail, only one of which has been described – *Gulella matumbiensis* (Figure 4.7.1). Unfortunately, as most genera of snails and slugs need thorough taxonomic revision it would be unacceptable to casually describe new species based on a single or few specimens; also properly prepared material is required for dissection and in many cases this has not been available. The discovery of new species in opportunistic collections by volunteers indicates that more new species remain to be found in these forests. It is also certain that many new species remain to be found using sieving techniques which are scarcely used in East Africa. For example, such techniques in Kakamega Forest, Kenya, have turned up several previously overlooked species including one belonging to a new genus (Tattersfield, 1994). This forest was previously considered to be a fairly well-worked locality in the region.

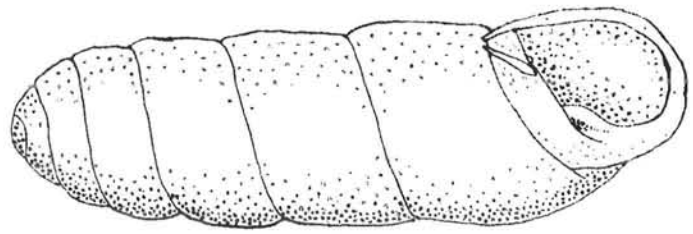


Figure 4.7.1 ***Gulella matumbiensis*, 10mm long.**

The slugs from the Coastal Forests may also prove to be of interest, but so far have not been studied in any detail. Well collected and preserved material is required to determine new species of slugs and their relationship to described species; this is an important consideration for future collections.

However disappointing for collectors, immediate results cannot be expected from collections of snails and slugs. This should not act as a deterrent. Naming tropical invertebrates, save in such well known groups as butterflies, is often a task of immense difficulty and it might well be a century before the group involved is adequately studied. If there is no new material some groups will never be revised and taxonomic understanding will stagnate, hence the importance of undertaking new collections.

Biogeographical affinities

The basic make-up of the non-marine mollusc populations in coastal East Africa has changed very little since the Miocene, perhaps 30 million years ago (Verdcourt, 1963). There is also some evidence that Miocene mollusc populations in the Kavirondo area of Kenya were more similar to the current coastal populations than the present Kavirondo population. Vast geological and climate changes have happened since the Miocene, but as has been discussed before (Chapter 2.3) the coastal area has experienced a relatively stable climate since the Miocene and this may have allowed the mollusc faunas to remain similar.

One element of the present coastal fauna is strictly lowland and extends down through Mozambique and Natal to the NE of Cape Province; *Maizania wahlbergi* is a good example. Other elements have West African affinities: *Ptychotrema sperabile* from the Shimba Hills is an example. However, the majority of the coastal species belong to genera widespread in Africa south of the Sahara, most of which are not known outside of Africa. A few genera have even wider affinities; *Cyathopoma* apart from the Shimoni Caves occurs in India, Ceylon, Japan, Seychelles and Zaïre (Ituri Forest). There is no anatomical proof that all are congeneric.

Gonospira expatriata, if referred to the correct genus, is of great interest; the genus is widespread in the Mascarene Islands (or was). Moreover, van Bruggen (*in lit.*, 1972) says 'I have a specimen from Basutoland (Lesotho), which seems identical to *G. expatriata*'. This may be a relict distribution – although in his opinion the specimens are of different genera, with those in mainland Africa being different from those on the Mascarene Islands. *Gulella gwendolinae* occurs on Aldabra.

Tropidophora extends down to South Africa and to Madagascar (the main centre of distribution), and the Mascarene Islands. Some species in the Coastal Forests which apparently have Indo-Malayan affinities, e.g. *Sitala*, are probably members of undescribed genera which are endemic to the coastal area of Tanzania, and hence are currently wrongly named. Additional genera in the coastal area are Pantropical or even more widely dispersed e.g. *Neritina, Littoraria, Truncatella, Melampus, Lymnaea, Onchidium*, etc. (see Verdcourt, 1972).

Recent quantitative research on the mollusc fauna of seven Coastal Forests in Tanzania has shown that the species makeup of the various forests varies rather little in forests only a few kilometres distance (indicating that such sites may have been formerly joined), but that the fauna varies markedly over a distance of around 100km . The more distant sites share only around 10% of the fauna of other sites and it is suspected that there many species are of extremely local distribution within the Coastal Forest belt (Tattersfield, 1995). Such effects are especially evident in *Gulella* which has a large species radiation in East Africa.

Comparison with the Eastern Arc

The snails and slugs of the mountain forests of eastern Africa have been studied over many years, particularly since about 1890 (e.g. von Martens, 1897; d'Ailly, 1910; Verdcourt in Rodgers and Homewood, 1982). In particular a number of the Eastern Arc Forests (Usambara, Nguru and Uluguru) of Tanzania have been quite well studied. It would be an extensive task to summarise all the literature on the snails and slugs of these forests and determine levels of endemism to compare with the Coastal Forests, but a more detailed analysis has already been prepared for the Usambara Forests of north-eastern Tanzania (Verdcourt in Rodgers and Homewood, 1982). This has shown that of the 115 species (122 taxa, including sub-species), about 55 species (45%) are endemic to this forest block, and no genera.

This level of endemism for a single forest area is much higher than for a single Coastal Forest. This is not surprising as the former has a much larger area of forest, is wetter, does not have the pronounced dry season of the latter, and has great altitudinal variation. In the Coastal Forests the endemic species are spread more widely over a number of smaller forest patches.

It is likely that if the published details on the snail and slug faunas of the Nguru, Uluguru and Udzungwa mountains were considered in addition to that of the Usambaras, then the Eastern Arc

Forests would have higher levels of endemism than the Coastal Forests. However, I do not believe that there would be a great deal of difference in the rates of endemism between the Eastern Arc and the Coastal Forests for snails and slugs, and that both forest types are important for the conservation of these groups.

Moreover, the distinction between the snail and slug fauna of the Coastal Forests and Eastern Arc Forests is not totally clear-cut. Many of the upland forest species also extend into the lowland coastal regions. Species such as *Euonyma magilensis* are found in the East Usambara mountains and the Mkulumuzi cave areas near Tanga, and the Coastal Forests close to Dar es Salaam. Other species have been recently found in the Coastal Forests which were previously thought to be confined to the Usambaras. This is not so surprising as in the past, even earlier in this century, there was extensive connection between the forests of the East Usambaras, and the lowland forests which stretched to the sea near Tanga.

Acknowledgements

I would like to thank Frontier-Tanzania, and especially Kim Howell and Peter Kasigwa of the Department of Zoology at the University of Dar es Salaam for making the material collected under the Frontier-Tanzania Coastal Forest Research Programme available to me. I would also like to thank the various Frontier Research Assistants who painstakingly collected the material and preserved it for future study.

Comments on a draft of this Chapter were received from John Allen (University of Southampton), J. van Goethem (Institut Royal des Sciences de Belgique), and Peter Kasigwa (University of Dar es Salaam in Tanzania).

References

Ailly, A. d' (1910). *Mollusca*. In *Wiss. Ergebn. Schwed. Zool. Exp. Kilimanjaro Sjöstedt* **1: (6).**

Martens, E. von (1897). Beschalte Weichthiere Deutsch-Ost-Afrikas. *Möbius, Deutsch Ost-Afrika 4,* **(1)**: 1–308.

Rodgers, W.A. and Homewood, K.M. (1982). Species richness and endemism in the Usambara Mountain Forests, Tanzania. *Biological Journal of the Linnean Society* **18**: 197–242.

Tattersfield, P. (1994). Patterns of mollusc diversity in Kakamega Forest, Kenya. *Bulletin of the British Ecological Society* **25**: 171–76.

Tattersfield, P. (1995). 'Molluscan Biodiversity of Coastal Forests of Tanzania'. Report on British Ecological Society Small Ecological Project Grant (unpublished).

Verdcourt, B. (1951). Mollusca of NE Tanganyika. *East African Agriculture and Forestry Research Organisation Ann. Rep. for 1950*: 56–57.

Verdcourt, B. (1963). The Miocene non-marine Mollusca of Rusinga Island, Lake Victoria and other localities in Kenya. *Palaeontographica* **121A**: 1–37.

Verdcourt, B. (1972). The zoogeography of the non-marine Mollusca of East Africa. *Journal Conchology* **27**: 291–348.

Verdcourt, B. (1983). A list of the non-marine Mollusca of East Africa (Kenya, Uganda, Tanzania, excluding Lake Malawi). *Achatina* **11**: 200–39.

Forests would have higher levels of endemism than the Coastal Forests. However, I do not believe that there would be a great deal of difference in the rates of endemism between the Eastern Arc and the Coastal Forests for snails and slugs, and that both forest types are important for the conservation of these groups.

Moreover, the distinction between the snail and slug fauna of the Coastal Forests and Eastern Arc Forests is not totally clear-cut. Many of the upland forest species also extend into the lowland coastal regions. Species such as *Euonyma magilensis* are found in the East Usambara mountains and the Mkulumuzi cave areas near Tanga, and the Coastal Forests close to Dar es Salaam. Other species have been recently found in the Coastal Forests which were previously thought to be confined to the Usambaras. This is not so surprising as in the past, even earlier in this century, there was extensive connection between the forests of the East Usambaras, and the lowland forests which stretched to the sea near Tanga.

Acknowledgements

I would like to thank Frontier-Tanzania, and especially Kim Howell and Peter Kasigwa of the Department of Zoology at the University of Dar es Salaam for making the material collected under the Frontier-Tanzania Coastal Forest Research Programme available to me. I would also like to thank the various Frontier Research Assistants who painstakingly collected the material and preserved it for future study.

Comments on a draft of this Chapter were received from John Allen (University of Southampton), J. van Goethem (Institut Royal des Sciences de Belgique), and Peter Kasigwa (University of Dar es Salaam in Tanzania).

References

Ailly, A. d' (1910). *Mollusca*. In *Wiss. Ergebn. Schwed. Zool. Exp. Kilimanjaro Sjöstedt* **1: (6).**

Martens, E. von (1897). Beschalte Weichthiere Deutsch-Ost-Afrikas. *Möbius, Deutsch Ost-Afrika 4,* **(1)**: 1–308.

Rodgers, W.A. and Homewood, K.M. (1982). Species richness and endemism in the Usambara Mountain Forests, Tanzania. *Biological Journal of the Linnean Society* **18**: 197–242.

Tattersfield, P. (1994). Patterns of mollusc diversity in Kakamega Forest, Kenya. *Bulletin of the British Ecological Society* **25**: 171–76.

Tattersfield, P. (1995). 'Molluscan Biodiversity of Coastal Forests of Tanzania'. Report on British Ecological Society Small Ecological Project Grant (unpublished).

Verdcourt, B. (1951). Mollusca of NE Tanganyika. *East African Agriculture and Forestry Research Organisation Ann. Rep. for 1950***:** 56–57.

Verdcourt, B. (1963). The Miocene non-marine Mollusca of Rusinga Island, Lake Victoria and other localities in Kenya. *Palaeontographica* **121A**: 1–37.

Verdcourt, B. (1972). The zoogeography of the non-marine Mollusca of East Africa. *Journal Conchology* **27**: 291–348.

Verdcourt, B. (1983). A list of the non-marine Mollusca of East Africa (Kenya, Uganda, Tanzania, excluding Lake Malawi). *Achatina* **11**: 200–39.

Postscript

Since the above was written I have described *Gulella conoidea* from Frontier-Tanzania material collected in the Kwamgumi/Segoma Forest Reserves (Verdcourt, 1996) and a number of species have been found to descend into the Usambara foothills, e.g. *Pseudoglessula leroyi* (Bgt.) and *Sitala leroyi* (Bgt.). Also, Peter Tattersfield has collected a number of new species in the coastal area, part of 74 species obtained during a recent survey (P. Tattersfield, Report on Percy Sladen Memorial Fund Grant to study molluscan biodiversity of Coastal Forests of Tanzania, 1995).

Verdcourt, B. (1996). A new species of Gulella Pfr. (Gasteropoda Pulmonata, Streptaxidae) from NE. Tanzania *Basteria* **59**: 135–37.

4.8 Butterflies

J. Kielland and N.J. Cordeiro

Introduction

Butterflies (Lepidoptera) are a relatively well studied invertebrate order, especially when compared with most others. In the Afrotropical region of Africa and Arabia there are approximately 3700 species of butterflies (Ackery *et al.*, 1995; Carcasson, 1964 and 1981), which accounts for about 20% of the global total. Of these species about 50% are restricted to forests.

The forest butterflies are most diverse in the Central African forest block, and the greatest number of species are found below the 500–600m altitude band. Eastern Africa has montane forests and lowland forests. Most of the latter are close to the coast and comprise the Coastal Forests discussed here. Both forest types support diverse assemblages of butterflies, and are separated from the main forest block to the west by open habitats which support a lower diversity of butterfly species and have a lower rate of endemism (Larsen, 1991). Defining the areas reaching inland, but which could still be regarded as having a coastal butterfly fauna is extremely difficult. In Kenya the transition from butterflies typical of the Coastal Forests to those of drier areas occurs just inland of the coast, and is quite abrupt. In Tanzania the moist coastal climate stretches much further inland (see Chapter 2.3), and the 'coastal' butterfly fauna similarly ranges further inland. In the south-central part of Tanzania, Coastal Forest elements are found as far inland as the lowland forests in the western part of the Udzungwa range. Further inland is a drier habitat with a typical butterfly fauna which separates the coastal elements from the Guineo-Congolian forest fauna to the west. To the north, some Coastal Forest butterflies are also found as far west as the lowland forests around Mount Kilimanjaro (Cordeiro, in prep.).

This Chapter describes the butterfly fauna of a number of Coastal Forests, particularly those in Tanzania. The coverage of the Coastal Forests is far from complete, largely because many forests have not been studied, but also due to difficulties of obtaining detailed butterfly lists for those forest sites which have been visited by lepidopterists. Comparisons are made here between the Coastal Forest butterflies and montane forest species in eastern Africa, which have been comprehensively described by de Jong and Congdon (1993). In some places, e.g. the foothills of the Usambara, Uluguru, Nguru, Nguu and Udzungwa Mountains, there is a considerable overlap with 'Coastal Forest' elements, but there are also local endemic species, and some montane species may also descend into these adjoining forest areas. Hence such areas tend to be somewhat different to the other sites considered here.

The quality of the information presented is believed to be quite strongly affected by the intensity of collection, which has been very variable in the Coastal Forests, as has the methods used and the skill of the collectors (Table 4.8.1). Results presented here are probably biased towards the larger and more obvious species for most forest sites, as it is those which are typically collected on short-term expeditions.

Sources of information

Some information in this Chapter comes from the country overviews of Kielland (1990) and Larsen (1991), and other published sources (e.g. Van Someren, 1971 and 1972; Sevastopulo, 1973 and 1974; Hecq, 1985; Howarth, 1969; Kielland, 1985 and 1987; Stempffer and Bennett, 1953; Suffert, 1904; Turlin and Chovet, 1987; Grant, 1984; Turlin and Lequeux, 1992; Cordeiro in Evans and Anderson, 1992).

For Kenya, additional unpublished information from Arabuko-Sokoke forest was kindly provided by Torben Larsen and Steve Collins. Much of the data presented for Tanzania is from unpublished collections made by the senior author, supplemented with collection data from Jean-Pierre Lequeux and Kenneth Karumile, the late Terry Grant, the junior author, S.C. Collins, and the Frontier-Tanzania Coastal Forest Research Programme. Most of these collections have been made in the past 10 years.

The many old records from Zanzibar are, unfortunately, unreliable. This is due to two reasons. Firstly, in the past specimens were often given labels referring to the name of the major port that they were shipped from, which was often Zanzibar town (although sometimes Lindi); such specimens may have originated from many different parts of the mainland. Secondly, the sultanate of Zanzibar also formerly included parts of the mainland and hence specimens might also have come from these areas. Recent studies, however, have clarified which species are found in the Coastal Forests of Zanzibar (Collins, 1990; Archer *et al.*, 1991).

Table 4.8.1 Lepidoptera survey effort, methods and expertise in selected Coastal Forests of Kenya and Tanzania.

Site	Effort score	Method codes	Collection expertise score	References/data sources
Arabuko-Sokoke	3	1,2,3,4	1–3	Larsen (1991), T.B. Larsen and S.C. Collins, unpublished data
Shimba Hills	3	1,2,3,4	1–3	Sevastopulo (1973, 1974), Larsen (1991)
East Usambaras (Mtai)	1	1,2,3,4	1–3	Cordeiro in Evans and Anderson (1992)
Other East Usambara sites*	1	4	1–2	Frontier-Tanzania, unpublished data
Gendagenda	1	1,2,3	1	Frontier-Tanzania, unpublished data
Pangani Falls	1	1,2,3	1	Frontier-Tanzania, unpublished data
Kiono/Zaraninge	1	1,2,3,4	1–3	Kielland (1990), J. Kielland and Frontier-Tanzania, unpublished data
Pugu Hills (Pugu and Kazimzumbwi)	3	1,2,3,4	1–3	Grant (1984), Kielland (1990), N.J. Cordeiro, unpublished data, and Frontier-Tanzania, unpublished data (Kazimzumbwi)
Dendene/Kisiju	2	1,2,3,4	1–3	Kielland (1990), J. Kielland and Frontier-Tanzania, unpublished data
Namakutwa	1	1,2,3	1	Frontier-Tanzania, unpublished data
Kiwengoma	1	1,2,3	1	Frontier-Tanzania, unpublished data
Rondo	2	1,2,3,4	1–3	Kielland (1990) and Frontier-Tanzania, unpublished data
Pemba	2	1,2,3,4	1–3	Kielland (1985, 1990)
Zanzibar	2	1,2,3,4	1–3	Archer *et al.* (1991)
Mafia	1	1,2,3	1	Frontier-Tanzania, unpublished data
Kimboza (Ulugurus)	1	1,2,3,4	1–3	Kielland (1990), J. Kielland, unpublished data

Notes:

Effort scores: 1 = collections by one collector over a maximum of three months in one season (wet or dry); 2 = collections over 3–12 months by one or more collectors, spread to include the wet and dry seasons; 3 = collections by many collectors over a number of years and including all seasons.

Method codes: 1 = general netting; 2 = butterfly traps using rotting fruit; 3 = sampling of all habitat types including across the vertical strata; 4 = special emphasis on smaller Hesperids and Lycaenids.

Collection expertise scores: 1 = untrained volunteers; 2 = trained collectors; 3 = regional experts (S.C. Collins, N.J. Cordeiro, T.A. Grant, J. Kielland, T.B. Larsen, D.G. Sevastopulo).

* Three sites for which records are available were recently visited by Frontier-Tanzania. Manga Forest was believed to have been a Coastal Forest whereas Kwamgumi and Magrotto Forests were thought to be transitional Coastal and submontane forests. Only very selective collecting of *Pentila*, *Baliochila*, *Euthecta* and small hesperids was undertaken in these areas (J. Bayliss, *in lit.*).

Data on the forest butterflies of Somalia and Mozambique are probably available in private and museum collections, but apart from the information contained in Pennington (1994) and some new distribution information on species which are thought to be confined to Mozambique, they have not been considered here.

Species diversity and endemism

The total number of forest-associated butterfly species which can be found in the Coastal Forests of eastern Africa as a whole may reach around 400, although not all of these are strictly confined to forests and are seen in dense woodland, thicket and occasionally farmed areas. For Kenya, the figure of 320 species (S.C. Collins, *in lit.* 1997) in the Arabuko-Sokoke Forest is remarkable and bears testament to what intensive collecting in a large forest can produce. The highest numbers of species known from single Coastal Forest sites in Tanzania are 241 species from the Pugu Hills; 228 species at Kimboza (Ulugurus); 178 species at Rondo; 164 species at Mtai (East Usambaras); 127 species from Dendene Forest at Kisiju and 129 species at Kiono/Zaraninge forest. These species totals are certainly correlated with the collecting effort at the various sites, but may also broadly reflect a true sequence of species diversity. Two exceptions may be that the forests in the East Usambaras and Ulugurus, which are very rich, hold both lowland and montane species at low altitudes which increases their species diversity. Two endemic species have also been found in the lowland East Usambara forests in the 1990s, indicating that there is much still to learn from further research in these areas.

Appendix 9 (this volume) presents a sites-by-species list of the butterflies which are regarded as endemic, near-endemic or with strong affinities to Coastal Forests and related vegetation types, for 14 forest groupings in Tanzania and two in Kenya. The table shows that of the 134 (this and subsequent figures include *Aslauga orientalis,* for which habitat data are lacking – Appendix 9) taxa listed, many are restricted or nearly restricted to Coastal Forest vegetation. The strictly dense forest taxa confined to the eastern African Coastal Forests number 75, with a further 17 that mainly range into lowland and Coastal Forests in Malawi, eastern Zimbabwe and northeastern South Africa. Nineteen taxa known from Coastal Forests also occur in adjacent montane forest habitats, whereas five forest and non-forest taxa have broader ranges. Additionally, another 16 of these species inhabit the forest edge, closed- canopy woodland or coastal dune and farmland habitats (although they also occasionally occur in Coastal Forests).

Distribution data in Appendix 9 are grouped into the forests of coastal Kenya, those found between the Kenyan border and just south of the Dendene forest at Kisiju in Tanzania (Figure 4.8.1), those found between Kisiju and the southern part of Tanzania (Figure 4.8.1), and those found on the islands off the coast of Tanzania. A further grouping was made of forests occurring at the base of the Eastern Arc mountains. Apart from the Kenyan records, this division reflects the butterfly faunal zones recognised in Kielland (1990).

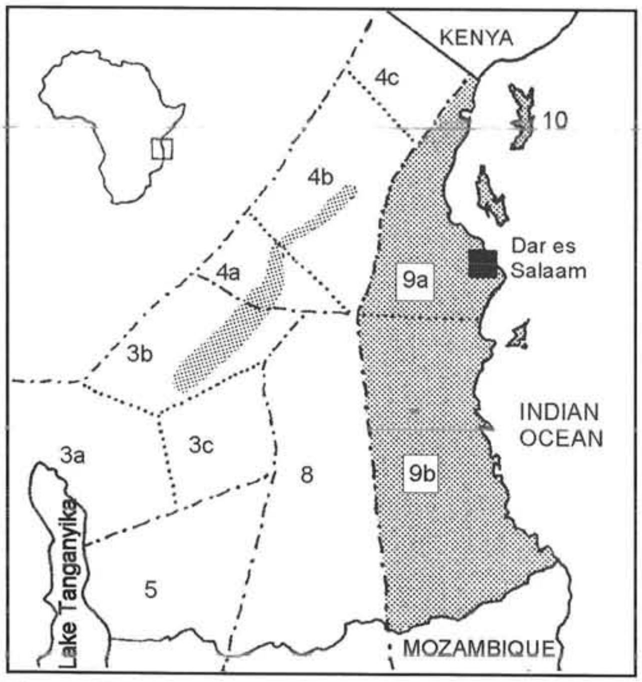


Figure 4.8.1 Butterfly regions of eastern Tanzania (from Kielland, 1990); Coastal Forest Regions are shaded, including an outlier along the base of the Eastern Arc Mountains.

Legend: 9a = Northern coastal zone. This extends into southern Kenya; boundary with next subzone cannot be precisely defined.

9b = Southern coastal zone. This is mapped to the Mozambique border but probably extends into northern Mozambique.

10 = Pemba Island. Other zone numbers are described in Kielland (1990).

However, it must be noted that there are considerable difficulties in accurately defining the Coastal Forest species as some of them range further inland in Tanzania to the lowland forests around the Ulugurus, Ngurus, Nguus, Udzungwas and Kilimanjaro (see Appendix 9), and others have associations with many wooded vegetation types in the coastal area and not strictly Coastal Forest.

Many of the Coastal Forest endemics appear to have close relatives in the equatorial forests of West and Central Africa and mainly occur as one or a few representatives of otherwise large genera, but more detailed phylogenetic analyses are needed to support this conclusion. If there are shared species in these genera then that would tend to support the hypothesis that there have been past contacts between the Central African forest zone and the Coastal Forest. This meeting of forest types could have been through either the Kenyan highlands and into northern Tanzania around the East Usambaras, or through southern Tanzania. Based on the distribution of butterflies there is the clear impression that the contact was never broad based, rather taking the form of 'corridors' (Larsen, 1991, p.63). A striking example of the above postulated contact can be found in *Triclema kimboza*, a lone species representing an otherwise dominant West and Central African genus, known only from Kimboza Forest (Ulugurus), Arabuko-Sokoke Forest and the Shimba Hills. Additionally, *Euptera kinugnana* is the only Coastal Forest representative of an otherwise western rain forest genus. In comparison with these two examples, the majority of the *Baliochila* species are coastal or near-Coastal Forest and woodland inhabitants, but a few species also range inland to western Tanzania and Zaïre.

Apart from those examples of species that indicate a connection between the Central African forests and mainland Coastal Forests, there is also strong evidence of an association between the biota of islands adjacent to the eastern shore of the African continent. This was very briefly explored by Turlin and Lequeux (1992) and Archer *et al.* (1991), who discussed the affinities of the Pemba and Zanzibar butterflies with their continental relatives. Although rates of endemism are slightly higher in Pemba, that being mainly due to an earlier separation from the continent than Zanzibar, several species from both islands probably evolved from the Eastern Arc – Coastal Forest refugia on the mainland (Archer *et al.*, 1991; Turlin and Lequeux, 1992). *Charaxes pembanus* from Pemba and *Charaxes pollux piersoni* from Zanzibar, both island endemics, most likely evolved from parent stock of the highland *Charaxes usambarae* group and *Charaxes pollux*, respectively, both of which occur in the nearby East Usambaras. A similar pattern is also evident in *Abisara zanzibarica* and *Anthene rubrimaculata* ssp. nov. from Zanzibar which have montane relatives in the Eastern Arc Mountains. Another species which indicates, in this case, a Madagascar – eastern Africa connection, is *Acraea cuva*. These examples are just a few that illustrate that forest was probably once more extensive along the eastern coast of Africa, and more connected than now. Further biogeographical comparisons of the island fauna with that of the mainland fauna should be made to clarify the patterns of evolution in the Lepidoptera.

Compared to the many endemic butterfly species of the Coastal Forests, there is little endemism at the genus level. Two genera are endemic to the Coastal Forests and another appears near-endemic. The endemics are *Euthecta* and *Eresinopsides*, of which the latter and to a certain extent also *Euthecta* go inland to the East Usambara and Uluguru Mountains in eastern Tanzania. The near-endemic genus, *Teriomima*, comprises five species that are largely restricted to the Coastal Forests from Kenya to Mozambique whereas a sixth species, *T. zuluana*, occurs in the lowland forests of South Africa.

Comparison with mountain forests in eastern Africa

In terms of diversity the mountain forests of eastern Africa (Ethiopia, Kenya, Uganda and Tanzania) probably support around 1000 species of butterfly. Of these around 177 species (259 taxa = species and subspecies) are restricted to the forests of this area (de Jong and Congdon, 1993).

In the Eastern Arc mountain forests of Tanzania there are probably around 700 species of butterfly, as compared with approximately 400 in the Coastal Forest. This might be expected given the much greater altitudinal variation in the inland Eastern Arc Mountains, and the many different vegetation types which occur. There are also at least 123 fully endemic butterfly taxa (species and subspecies) in the Eastern Arc, many of which are dense forest specialists (de Jong and Congdon, 1993; and see notes in Appendix 9). In comparison, the coastal strip of eastern Africa supports a total of 92 endemic taxa. However, only 75 of these taxa are true endemics of Coastal Forests, with a few representatives extending to lowland forests at the base of the Eastern Arc Mountains; the rest also occur in other habitats in the low country of the coastal area. A further 20 taxa with strong Coastal Forest affinities were excluded from this figure as they also occur at low to sub-montane elevations chiefly in the Eastern Arc Mountains; examples of such taxa are indicated in Table 4.8.2. An indication of the relative importance of the Coastal Forests and the Eastern Arc forests can be found by analysing the fauna in terms of the endemic taxa and genera they support (Table 4.8.3).

Table 4.8.2 Examples of some endemic Eastern Arc montane butterfly species that descend into adjacent lowland forests in Tanzania.

Species	Forest
Catuna sikorana	lowland Usambaras, Ulugurus, Ngurus, etc.
Charaxes pollux mirabilis	Mtai (East Usambaras)
Charaxes usambarae	Mtai
Pseudacraea dolomena usagara	Mtai
Salamis temora virescens	Kimboza (Ulugurus)
Coeliades chalybe	Mtai and Kimboza
Ceratrichia bonga	Mtai, Kwamgumi and Kimboza
Chondrolepis niveicornis	Mtai and Kwamgumi

Table 4.8.3 Comparison between the rates of species and generic endemism in the Coastal Forests and Eastern Arc forests, in relation to area of remaining forest.

Forest type	Forest area (km^2)	Total species	Endemic taxa (spp. and ssp.)	Endemic genera	Endemic taxa/ area	Endemic genera/area
Coastal Forest	3170	*c.*400	75	2	2.4×10^{-2}	6.7×10^{-4}
Eastern Arc	9000	*c.*700	123	0	1.4×10^{-2}	0

***Note*:** The number of Eastern Arc endemic taxa was 123 (de Jong and Congdon, 1993). This figure has since risen considerably but as the senior author had last updated these data (see text) in mid 1995, the junior author chose to exclude the newly described taxa (e.g. see Rydon, 1996; White, 1996) from this figure as he is not sure which of the newly described taxa were included in the previous update.

There remain problems with such analyses (Table 4.8.3) as in both areas there are probably further endemic species to be discovered, taxonomic clarifications may either increase or decrease the number of endemics, and the highly uneven survey coverage may also be important. However, in broad terms it is clear that with the present information the Coastal Forests are of lower relative importance than the Eastern Arc mountain forests for endemic butterfly species. Nevertheless, when the area of forest remaining is considered then the Coastal Forests can be shown to be of similar, if not higher, importance for endemic taxa per unit area of forest than those of the Eastern Arc mountains. In fact the ratio of endemic taxa per unit area for the Coastal Forests to the Eastern Arc mountains is about 1.8 times greater, indicating that on a broad scale more endemics are restricted to the smaller Coastal Forests. We believe that this is important to consider when comparing and contrasting the values of the two forest types for butterfly conservation.

Table 4.8.4 Single site endemism of butterfly taxa in the Coastal Forests of Kenya and Tanzania.

Sites	Endemic species and sub-species*	Total endemic taxa*	Near endemic taxa	Survey effort
Arabuko-Sokoke	0	0	3	High
Shimba Hills	1ssp	1	1	Medium/high
East Usambaras	2sp	2	2**	Low/medium
Kimboza (Ulugurus)	1sp, 1ssp	2	3	Low/medium
Rondo Plateau***	1sp, 3ssp	4	3	Low/medium
Pemba Island	1sp, 8ssp	9	1	High
Zanzibar Island	2sp, 5ssp	7	1	High
Mafia Island	1sp, 1ssp	2	0	Low

***Key*:** sp = species; ssp = subspecies.

***Notes*:**

* It is important to note that a few species considered as Coastal Forest endemics, especially those from the Islands, are not exclusive forest dwellers and are thus recorded from some other habitats.

** One species included in this total, *Hypolimnas antevorta*, also occurs in submontane forest at Amani, East Usambara Mountains.

*** *Baliochila* sp. nov.? and *Euphaedra castanoiedes* ssp. nov.? (see Appendix 9), both of which are probably distinct but undescribed taxa, were not included in the number of total endemics for the Rondo Plateau.

It is also possible to assess the importance of individual forests in terms of the presence of endemic butterfly species. For the Eastern Arc mountains this has already been done by de Jong and Congdon (1993), and has been updated by the senior author in this Chapter. The most important forest areas in terms of endemic butterfly species and subspecies (taxa) in the Eastern Arc are the Usambara Mountains (27 taxa), Udzungwa Mountains (25 taxa), Uluguru Mountains (19 taxa), Nguru, Kanga and Nguu Mountains (19 taxa), and Rubeho and Ukaguru Mountains (nine taxa). There are also a further 24 taxa which are confined to several forests within the Eastern Arc mountains.

In comparison with the best of the Eastern Arc forests, individual Coastal Forests contain few endemic species and subspecies (Table 4.8.4). The highest levels of single-site endemism are found on the islands of Pemba, Zanzibar and Mafia, in the East Usambara and Uluguru lowlands, and on the Rondo Plateau in the south of Tanzania. Some of the East Usambara and Uluguru records include species and subspecies which are mainly found in montane forests but also occur in the lowlands (and *vice versa*).

This low level of single site endemism is probably related to two main factors:

- The Coastal Forests were probably more continuous and species were more widely distributed than at present. The various Eastern Arc Forests have been physically isolated from one another for much longer (see Lovett and Wasser, 1993).

- The butterfly species of the Coastal Forests are ecologically less isolated than those in the Eastern Arc Mountains. In the coastal area butterflies may still be able to move between forests by passing through thicket, woodland and scrub habitats at the same altitude and under similar climatic regimes. In comparison the butterflies in the Eastern Arc Mountains are highly isolated as the next area of montane forest may be tens of kilometres away and travel in between means moving through lower and hotter altitudes. In such areas species are far less likely to move between forests and hence isolated populations are more capable of evolving into separate species.

However, there are also dispersal barriers between and from many of the areas of Coastal Forest supporting endemic taxa. Particularly for the butterflies of Pemba, Zanzibar and Mafia such dispersal means crossing the sea. We do not consider the higher altitudes of the Rondo Plateau to present a serious barrier to dispersal of the butterfly species, as the forest extends to low altitudes at this site. Reasons for the number of endemics at this forest are therefore not known, but concur with levels of endemism in other taxonomic groups.

Discussion and conclusions

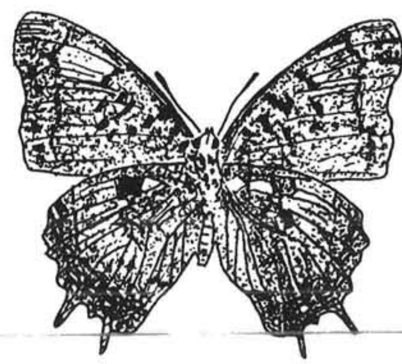


Figure 4.8.2 *Charaxes jahlusa mafiae*, endemic to Mafia Island, Tanzania.

The eastern African Coastal Forests, although not as species rich and as high in endemics as the Eastern Arc Mountains, are comparable in terms of endemic taxa per unit area. They also hold a unique butterfly fauna with many species that are currently known from only one to three sites on a global basis, and at least two genera that are endemic and one believed to be near-endemic to the region. Although these numbers do reflect a significant difference between the two areas, many of the Eastern Arc mountains have received greater attention than the Coastal Forests in the past and it is only recently that much work has been done in the Coastal Forests of, for example, Tanzania. After the recent discoveries of several new species and subspecies in the lowland forests of the East Usambaras and Ulugurus, there is little doubt that further emphasis on the smaller, less conspicuous genera will yield additional new taxa.

To some extent the calculation of numbers of overall species and endemic species in both the Eastern Arc and the Coastal Forests is affected by the current taxonomy of some butterfly genera, especially those in the families Lycaenidae and Hesperiidae. Endemic genera such as *Eresinopsides* and *Euthecta*, although apparently monophyletic, are within a complex group of butterflies and are closely related to the genera *Teriomima* and *Baliochila*. This entire group, comprising the four genera, is greatly in need of revision as many species remain undescribed whilst others (even genera) may be sunk through further study. One must keep this in mind when studying the biogeography of such taxonomically difficult groups in the Coastal Forests and Eastern Arc mountains.

Another great difficulty in the study of organisms as mobile as Lepidoptera is to assign species to strict habitat categories. The current list of Coastal Forest butterflies comprises species that are mainly restricted to lowland forest in the coastal region of eastern Africa. Many species, although generally restricted to Coastal Forest habitats, may occur in adjacent woodland habitats or even montane forests depending on the ecological requirements of the species in question. It is therefore important to note that species categorised as strictly Coastal Forest dwellers in this Chapter may be considered otherwise with further research, and also that the reader should not consider this list to be one that is clearly definitive of the Coastal Forest butterfly fauna.

In conclusion, the Coastal Forest butterfly fauna has considerable biodiversity and conservation value. Forests that require particular conservation attention are the Shimba Hills and Arabuko-Sokoke in Kenya, the patches on the islands off Tanzania, the lowland forests of the East Usambara and Uluguru Mountains and sites such as the Rondo Plateau and Pugu Forest. All of these sites not only show a high species richness but also maintain populations of several unique taxa known only from one or two sites in the world. Other sites, many of which have been less well studied, may prove to produce comparable numbers of endemics in the future. It is therefore imperative to preserve them for their unique butterfly fauna as well as other organisms and to emphasise the need to search for smaller and less conspicuous species in both well studied and poorly studied forest sites in eastern Africa. Although Kenya and Tanzania have clearly made progress in this direction, there is still a further need to train local people in this field as well as to promote additional research in nearby war-torn countries such as Mozambique and Somalia.

Acknowledgements

Frontier-Tanzania are thanked for making available to the senior author the butterflies collected from some Coastal Forests of Tanzania between 1989 and 1995. We thank J. Bayliss of Frontier-Tanzania for sharing his knowledge of some species from the East Usambara lowlands. T.C.E. Congdon in Tanzania, R. de Jong in Belgium, T.B. Larsen in London, and S.C. Collins in Kenya all provided useful comments and additional data that greatly benefited this Chapter and for which we are extremely grateful. Considerable editorial assistance in the completion of this Chapter was provided by Neil Burgess.

Epitaph

This Chapter was posthumously completed by the junior author following the death of the senior author in October 1995 in a car accident. Jan Kielland was travelling in Tanzania on one of his numerous butterfly collection expeditions, on that last occasion to the western section of the country. We hope that this Chapter provides a form of tribute to Jan who devoted most of his life to the study of Tanzania's butterflies. He will be sorely missed. Please note that the junior author shall take responsibility for any discrepancies or errors.

References

D'Abrera, B. (1980). *Butterflies of the Afrotropical Region.* E.W. Classey, Landsdown Editions, Melbourne.

Ackery, P.R., Smith, C.R. and Vane-Wright, R.I. (eds.) (1995). *Carcasson's African Butterflies: an Annotated Catalogue of the Papilionoidea and Hesperioidea of the Afrotropical Region.* CSIRO, Melbourne.

Archer, A.L., Collins, S. and Bampton, I. (1991). Report on a visit to Jozani Forest, Zanzibar. *Bulletin of the East Africa Natural History Society* **21**: 59–66.

Carcasson, R.H. (1964). A preliminary survey of the zoogeography of the African butterflies. *East African Wildlife Journal* **2**: 122–157.

Carcasson, R.H. (1981). *Collins Handguide to the Butterflies of Africa.* Collins, London.

Collins, S.C. (1990). Some new Tanzanian butterflies. In Kielland, J. *Butterflies of Tanzania.* Hill House, Melbourne.

Cottrell, C.B. (1981). The *Aslauga purpurascens* complex of entomophagous butterflies (Lycaenidae). *Systematic Entomology* **6**: 5–45.

Evans, T.D. and Anderson, G.Q.A. (eds.) (1992). *A Wildlife Survey of the East Usambara and Ukaguru Mountains, Tanzania.* ICBP Study Report no.53. ICBP, Cambridge.

de Jong, R. and Congdon, T.C.E. (1993). The montane butterflies of the eastern Afrotropics. Pp. 133–173. In Lovett, J.C. and Wasser, S.K. (eds.). *Biogeography and Ecology of the Rain Forests of Eastern Africa.* Cambridge University Press, Cambridge.

Grant, T.A. (1984). Lowland coastal forest butterflies of Tanzania. *Bulletin of the Amateur Entomological Society* **43** (345): 163–167.

Hamilton, A.C. (1982). *Environmental History of East Africa.* Academic Press, London.

Hecq, J. (1985). Etudes des *Euphaedra* (Nymphalidae afr.), *Euphaedra neophron* Hop. et remarques diverses (Note 26). *Lambillionea* **85**: 1–10.

Howarth, T.G. (1969). Some African Nymphalidae (Lepidoptera). *Proceedings of the Royal Entomological Society of London* **38(B)**: 141–156.

Kielland, J. (1985). A preliminary checklist of the butterflies of Pemba Island, Tanzania. *Arnoldia Zimbabwe* **9**: 267–276.

Kielland, J. (1987). Some new *Rhopalocera* from Eastern Africa (Lepidoptera: Nymphalidae). *Lambillionea* **87**: 38–79.

Kielland, J. (1990). *Butterflies of Tanzania.* Hill House, Melbourne.

Kielland, J. (1994). New taxa of African Lycaenidae (Lepidoptera). *Lambillionea* **94**: 503–506.

Larsen, T.B. (1991). *The Butterflies of Kenya and their Natural History.* Oxford University Press, Oxford.

Libert, M. (1996). Contribution à l'étude des Lycaenidae Africains: révision du genre *Lachnocnema* Trimen, Deuxième partie (1). (Lepidoptera Lycaenidae). *Lambillionea* **96**: 367–386.

Lovett, J.C. and Wasser, S.K. (eds.) (1993). *Biogeography and Ecology of the Rain Forests of Eastern Africa.* Cambridge University Press, Cambridge.

Pennington, K. (1994). *Pennington's Butterflies of Southern Africa.* (eds. Pringle, E.L.C., Henning, G.A. and Ball, J.B.). Struik Winchester, Cape Town.

Rydon, A.H.B. (1996). Notes on some members of *Cymothoe aurivillii* group (Lepidoptera, Nyphalidae). *Lambillionea* **96**: 8–14.

Sevastopulo, D.G. (1973). The butterflies of the Shimba Hills. *Entomologist's Record* **85**: 263–266.

Sevastopulo, D.G. (1974). The butterflies of the Shimba Hills. *Entomologist's Record* **86**: 18–23, 131–136.

Stempffer, H. and Bennett, N.H. (1953). A revision of the Genus *Teriomima* Kirby (Lepidoptera: Lycaenidae). *Bulletin of the British Museum of Natural History (Entomology)* **3**: 79–104.

Suffert, E. (1904). Neue Nymphaliden aus Afrika. *Dt. ent. Z.* **17**: 108–23.

Turlin, B. and Chovet, G. (1987). Description de nouvelles sous-éspèces et d'une forme de *Charaxes* africaine (Lepidoptera: Nymphalidae). *Bulletin Sciences Naturelles* **54**: 5–12.

Turlin, B. and Lequeux, J-P. (1992). Nouveaux Rhopaloceres de Tanzania (Papilionidae, Nymphalidae). *Lambillionea* **92**: 311–321.

van Someren, V.G.L. (1971). Revisional notes on African *Charaxes* (Lepidoptera: Nymphalidae) – Part VII. *Bulletin of the British Museum of Natural History (Entomology)* **26**: 181–226.

van Someren, V.G.L. (1972). Revisional notes on African *Charaxes* (Lepidoptera: Nymphalidae) – Part VIII. *Bulletin of the British Museum of Natural History (Entomology)* **27**: 215–264.

Warren-Gash, H. (1993). Some new records of Lycaenidae from Kenya. *Metamorphosis* **4:** 83–86.

White, R.S. (1996). A new *Charaxes* from the Mwanihana Forest in Tanzania. (Lepidoptera, Nyphalidae). *Lambillionea* **96**: 49–51.

4.9 Global importance and patterns in the distribution of Coastal Forest species

N.D. Burgess

From the preceding Chapters (4.1–4.8) on the flora and fauna of the Coastal Forests, it can be seen that these forests possess large numbers of endemic or threatened species in all the biological groups studied. In this Chapter, a summary of the numbers of endemic species of each major taxonomic group is presented, focussing on the species apparently confined to the Coastal Forests. Moreover, an attempt is also made to assess the main biogeographical patterns in Coastal Forest species, and to define some of the overall priority areas in terms of concentrations of endemic and threatened plants and animals.

Although the focus here is on endemics and rarities, it should be remembered that in most groups these form the minor proportion of the flora and fauna. The remainder is comprised of species which are also recorded in other forest types and woodland/grassland vegetations of eastern Africa, and some may be even more widely distributed in the tropical areas of the world.

Overall species endemism in the Coastal Forests

Numbers of forest endemic species, as a proportion of the total number of forest species in the Coastal Forests, gives one measure of the importance of the Coastal Forests (Table 4.9.1).

Table 4.9.1 Rates of endemism for seven biological groups within the Swahilian *sensu lato* regional centre of endemism, and for forest species found in the eastern African Coastal Forests.

Group	Global total species*	Swahilian region *sensu lato* total sp.	Forest species in Coastal Forests	Number of Swahilian endemics	Number of CF endemics	Percentage Swahilian endemism	Percentage CF endemism
Plants	250,000	4500	c.1500	1366	554	30	37
Birds[1]	9,672	c.300	85	11(15)	5(9)	3.6(5)	5.8(10.5)
Mammals[2]	4,330	c.250	84	7(10)	3(6)	2.8(4)	3.5(7.1)
Reptiles[3]	6,550	–	47	–	24(27)	–	51 (57)
Amphibians	4,000	–	14	–	5	–	36
Molluscs	70,000	c.1200	125	207	86	17	68
Butterflies	20,000	–	400	–	75	–	18.75

Notes:
[1]Figures in parentheses include the species on Pemba Island.
[2]Only the described species are presented here, there may be a further 8 Coastal Forest endemic small mammals when descriptions have been published. Figure in parentheses includes the species in the Tana river forests.
[3]Figure in parentheses includes the species found in the Tana river forests.
*Assessment of global species totals from various chapters in WCMC (1992) and Heywood and Watson (1995). Only the lower number of described species have been used here. For Molluscs the total is for all Molluscs, not just the slugs and snails studied in Chapter 4.7.

The highest rates of endemism are found in invertebrate groups such as the millipedes (perhaps >80%), molluscs (68%, 86 species), and forest butterflies (19%, 75 species). Rates are typically lower in vertebrate groups such as birds (10.5%, nine species) and mammals (7.1%, six species), although they are higher in the forest reptiles (57%, 24 species), and forest amphibians (36%, five species). The vascular plant forest flora is also rich in endemic species (37%, 554 species), and genera (see Chapter 4.1). In total, 786 known species in eight biological groups are strictly endemic to the Coastal

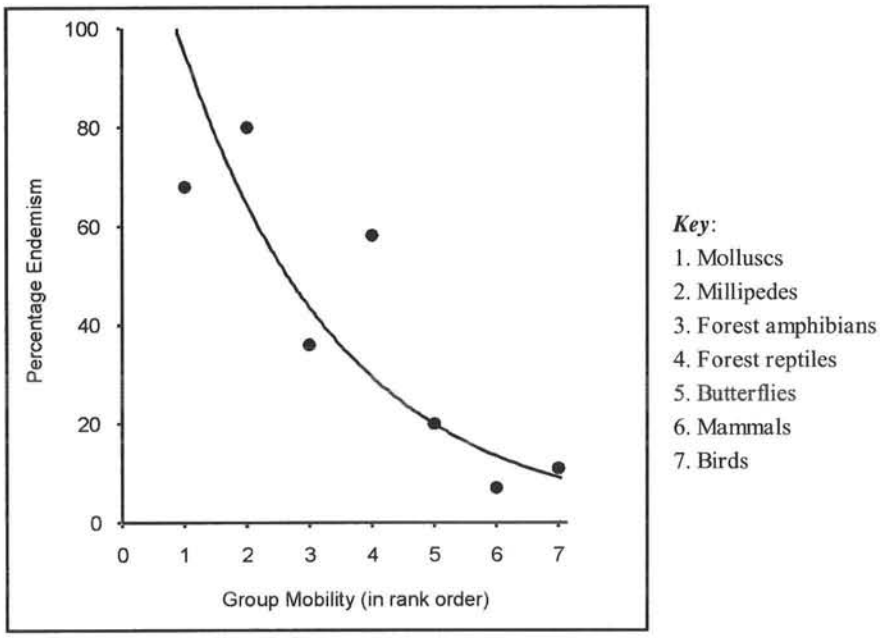


Figure 4.9.1 Relationship between percentage local endemism in the Coastal Forests of eastern Africa and a ranked index of the mobility of the different taxa, derived from data in Table 4.9.1. Assessment of taxa mobility is by the editors.

Forests (776 if Pemba and Tana River endemics are excluded). In comparison, the adjacent Eastern Arc forests contain 827 known endemic species in the same groups (Table 4.9.1). In the Coastal Forests (and the Eastern Arc) the percentage of species endemism is inversely proportional to the mobility of the groups (Figure 4.9.1).

Table 4.9.2 Percentage of global endemic species totals confined to Coastal Forest and Eastern Arc forests of eastern Africa.

Biological group	Global total number of species described in each group	Coastal Forest strict endemics	Percentage of global total unique to Coastal Forests	Eastern Arc strict endemics	Percentage of global total unique to Eastern Arc
Plants	250,000	*c*.554 species	0.226	550 species[a]	0.220
Birds	9,672	5 species	0.051	11 species[b]	0.113
Mammals	4,330	3 species	0.069	4 species[c]	0.092
Reptiles	6,550	24 species	0.370	26 species[d]	0.396
Amphibians	*c*.4,000	5 species	0.125	28 species[e]	0.700
Millipedes	7,000	>20 species	0.280	30+ species[f]	0.430
Molluscs	70,000	86 species	0.123	55 (E.Usambara)[g]	0.078
Butterflies	20,000	75 species	0.375	123 species[h]	0.615
Totals/averages		***c*.776 species**	**0.202**	***c*.827 species**	**0.366**

Sources:
[a] Myers (1988 and1990); Lovett (1993); Chapter 4.1. [b] Tanzanian Biodiversity Database in the Department of Zoology of the University of Dar es Salaam (and Stuart *et al.* (1993); ICBP (1992); Chapter 4.2 and Collar *et al.*, (1994)).
[c] Tanzanian Biodiversity Database (and Kingdon and Howell (1993); Chapter 4.3). [d] Tanzanian Biodiversity Database (and Howell (1993); Chapter 4.4). [e] Tanzanian Biodiversity Database (and Howell (1993); Chapter 4.5). [f] Hoffman (1993); Chapter 4.6. [g] Chapter 4.7. [h] de Jong and Congdon (1993); Chapter 4.8.

As a second measure of the importance of the Coastal Forests for endemic species, total numbers of endemics are compared with described global total numbers of species for each group (Table 4.9.2). Coastal Forest endemics comprise an average of 0.202% of the summed global species totals in the eight groups studied, while the Eastern Arc forests contain an average of 0.366% of all known species in these groups. This may seem low, but represents a far greater concentration than would be expected if the number of endemic species were distributed in proportion to the area of forest. Most sources (e.g. Barnes, 1989; May, 1990; WCMC, 1992; Heywood and Watson, 1995) state that the global species totals presented in Table 4.9.2 are far too low, but this may not change the overall rates of endemism compared with global totals. An assessment of the potential number of endemics in some other invertebrate groups, calculated from the estimated global totals, is presented in Table 4.9.3.

The Eastern Arc Mountains are already considered to be one of the top three areas for species endemism in Africa (Myers, 1988 and 1990; Stuart *et al.*, 1990; ICBP, 1992; WWF and IUCN, 1994). The levels of endemism in the Coastal Forests (Tables 4.9.1–4.9.3) would also rank these forests as one of the top ten priority ecosystems for biodiversity conservation on the continent. Indeed, a recent analysis for the World Bank regarded the Eastern Arc and Coastal Forests as one centre of endemism and ranked this area as the most important for the conservation of endemic species in the whole of tropical Africa (Mittermeier *et al.*, 1998).

An additional assessment of the importance and urgency for conservation action can also be made by considering the area of forest remaining. In the Coastal Forests there are 786 endemic species and when divided by the 3170km^2 of forest remaining gives 0.25 endemic species/km^2 forest. For comparison, when the 827 endemic species in the Eastern Arc mountain forests are divided by the 9000km^2 of forest remaining (Lovett, 1990), this gives 0.092 endemic species/km^2 forest. Hence in terms of the urgency of conservation action to protect endemic species, the Coastal Forests may be a higher priority for attempts to reduce the loss of forest cover, than the Eastern Arc.

Table 4.9.3 Estimated potential numbers of endemic species of Coleoptera, Hymenoptera, Diptera and Arachnida in the Coastal Forests (0.202% average endemism) and the Eastern Arc Mountain forests (0.366% average endemism).

Biological group	Global species totals*	Potential Coastal Forest endemics	Potential Eastern Arc endemics
Coleoptera	404,600	817	1480
Hymenoptera	130,900	268	479
Diptera	120,700	243	441
Arachnida	76,500	153	257

Note:
* Global totals are derived from the estimates of described species presented in WCMC (1992). (Total for all species = *c*1.7 million).

Biogeographical patterns in the Coastal Forests

Biogeographical patterns in the Coastal Forests are complex and still poorly understood. The following major patterns are currently evident:

1. Distribution patterns within the Coastal Forests

a) Endemic or near-endemic species distributed throughout the Coastal Forests

Very few of the Coastal Forest endemic species are distributed throughout the range of these forests. Examples are the trees *Dialium holtzii, Bombax rhodognaphalon, Commiphora zanzibarica* and marginally *Sterculia appendiculata*. This situation is also true for the near-endemics, with only the birds Fischer's Greenbul *Phyllastrephus fischeri*, Green Tinkerbird *Pogoniulus simplex*, Spotted Ground Thrush *Zoothera fischeri* and Tiny Greenbul *Phyllastrephus debilis* having a wide distribution.

b) Northern and southern species

A number of the Coastal Forest species have distinctly 'northern' (Somalia to the Rufiji River in Tanzania) or 'southern' (Rufiji River to Mozambique) distributions. The most important divide is the Rufiji River although this is mainly true at the sub-species level (for birds see Chapter 4.2). Vertebrate species with a northern distribution are the birds Clarke's Weaver *Ploceus golandi*, Sokoke Pipit *Anthus sokokensis,* Sokoke Scops Owl *Otus ireneae,* Little Yellow Flycatcher *Erythrocercus holochlorus*, Fischer's Turaco *Tauraco fischeri* and Mombasa Woodpecker *Campethera mombassica,* and the mammals Golden-rumped Elephant-shrew *Rhynchocynon chrysopygus* (southern Kenya only) and *Taphozous hildegardae*. Vertebrate species with a southern (Tanzanian) distribution are the bird Reichenow's Batis *Batis reichenowi*, the mammal *Galago* sp. nov. and the amphibian *Stephopaedes loveridgei*. There are also many plants found only in the northern, or the southern forests (see Chapter 4.1). In addition there are isolated pockets of a few endemics in the Coastal Forests of Malawi, Zimbabwe and Mozambique.

c) Species with disjunct or scattered distribution patterns

Some of the Coastal Forest endemic and near-endemic species have disjunct or scattered distributions. Examples are the mammals Ader's Duiker *Cephalophus adersi* (Zanzibar and Arabuko-Sokoke) and Lesser Pouched Rat *Beamys hindei* (preferring forests on sandy soils, see FitzGibbon *et al.*, 1995), the birds Sokoke Pipit, Plain-backed Sunbird *Anthreptes reichenowi,* Uluguru Violet-backed Sunbird *Anthreptes neglectus* and the coastal race of the East Coast Akalat *Sheppardia gunningi sokokensis* (various forest patches). The pattern is also found in the amphibians (e.g. *Stephopaedes* sp. nov from Mafia and the East Usambaras, *Mertensophryne micranotis* from various forest patches), several reptiles and plants (Chapters 4.1 and 4.4), and presumably also in other groups. There does not appear to be any recurring pattern in these disjunctions.

d) Smaller scale distributional patterns

Available evidence indicates that the plants and smaller and less mobile invertebrate groups show smaller scale patterns of endemism than are found in the larger species (Figure 4.9.1). For example, in Tanzania there is a 70% difference in the Millipede fauna and a 80% difference in the vascular plant flora from sites separated by only 100km distance (Chapters 4.1 and 4.6). Also, the large number of morphospecies of molluscs which were found by Emberton *et al.* (1997) to be unique to different forested areas implies that there is also substantial local endemism in that group. Similar patterns are reported from the isolated montane blocks of the Eastern Arc (Rodgers and Homewood, 1982; Hoffman, 1993; Scharff, 1993).

2. Relationship of Coastal Forests to the Eastern Arc Forests

There is current debate on whether these forests are best regarded as distinct units, or the lowland and montane equivalents of the same broad forest type (see Chapters 2.1 and 3.4; Lovett, 1993 and 1996). The close relationship is emphasised by the species which are found in both forests, but not elsewhere, and the degree of separation is indicated by the many species uniquely confined to each forest type.

Species found in Coastal Forests and lower altitude portions of the Eastern Arc Forests include the mammals Black and Rufous Elephant-shrew *Rhynchocyon petersi*, the bats *Myonycteris relicta, Kerivoula africana* and *Mops brachypterus*, the Zanzibar Galago *Galagoides zanzibaricus* and the *hindei* ssp. of *Beamys hindei* (also Kilimanjaro area). Birds in this category are Usambara Eagle Owl *Bubo vosseleri*, Fischer's Turaco, Uluguru Violet-backed Sunbird, White-winged Apalis *Apalis chariessa* and Amani Sunbird. The following reptiles also fall in this category *Lygodactylus conradti, L. uluguruensis, Cnemaspis barbouri, C. uzungwae, Rhampholeon brevicaudatus* and *Dipsadoboa werneri*, and the amphibians *Arthroleptis affinis* and *Mertensophryne micranotis*. There are also large numbers of plants shared by the Coastal Forests and lower altitude parts of the Eastern Arc Forests (Chapters 3.4 and 4.1). Altitudinal gradation patterns in plants are complex with different species ranging higher or lower than others such that clear boundaries cannot easily be drawn (Lovett, 1996).

3. Relationship to the West and Central African Guineo-Congolian forests

Some species found in the eastern African Coastal Forests are outliers of much larger populations in the Guineo-Congolian forests to the west, particularly among the forest birds (Chapter 4.2), but much less so among the forest amphibians or reptiles (Chapters 4.4 and 4.5). Other species have outliers of their populations in the Coastal Forests. For example, western African mammalian elements in the Coastal Forests comprise the bats *Rousettus angolensis* and *Hipposideros cyclops,* which both extend marginally to the Coastal Forests around the East Usambaras, but not further north or south. Although the species linkage with the Guineo-Congolian forests is not particularly high, there are often stronger relations at the generic level which supports evidence for an ancient connection between these forests (e.g. discussion in Lovett and Wasser, 1993; Fjeldså, 1994; Fjeldså and Lovett, 1997; Fjeldså *et al.*, 1997; Chapter 4.1). For example, the Sokoke Scops Owl *Otus ireneae* seems to have strong affinities to the West African *O. icterorhynchus*, and the same pattern is seen in Clarke's and Weyns's Weavers (*Ploceus golandi* and *P. weynsi*). There are also a number of plant genera where closely- related sister species are found in the Coastal Forests of eastern Africa and in the lowland forests of West and Central Africa (e.g. Fjeldså and Lovett, 1997; Chapters 3.4 and 4.1).

4. Relationship to other forested areas

In the plants there is some relationship betwen the species found in the Coastal Forests and those of Madagascar (Chapter 4.1). For bryophytes a considerable shared element has been found between the Eastern Arc forests and those of Madagascar (Pócs, 1975), which seems to indicate a shared flora which predates the formation of volcanoes such as Kilimanjaro (as these have a much poorer Madagascan element in their bryophytes). Unfortunately, the degree to which the bryophytes of the Coastal Forests of eastern Africa are shared with Madagascar is not known. There may also be some affinity in the mollusc fauna with that of Madagascar (Emberton *et al.*, 1997).

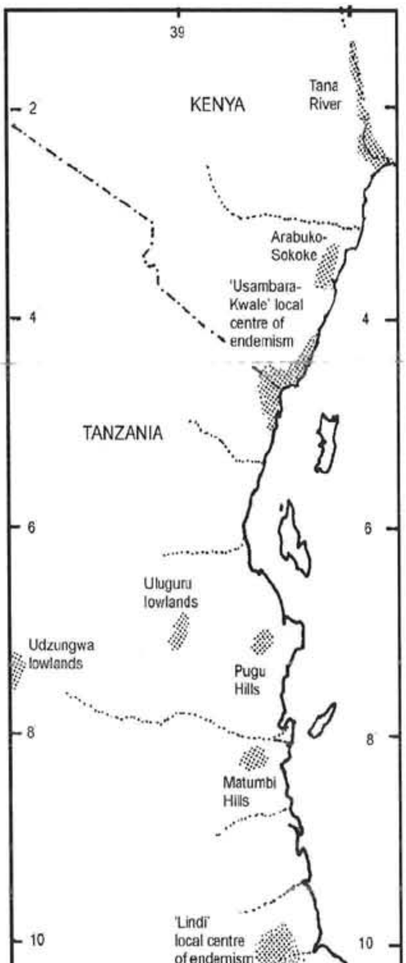


Figure 4.9.2 Sub-centres of endemism within the eastern African Coastal Forests of Kenya and Tanzania.

Sub-centres of endemism within the Coastal Forests

Most Coastal Forests have at least one endemic species. However, there are some areas where species endemism occurs in much higher concentrations than elsewhere. Areas with more than 100 endemic species (not only plants) are here defined as local centres of endemism (*sensu* White, 1993). Less rich areas, where there is at least one endemic vertebrate, or at least 10 endemic plants, or at least two endemic butterflies are here defined as 'minor' centres of endemism. Areas with an even lower concentration of endemism (at least two endemic plant, vertebrate or butterfly taxa), but which are geographically definable, are here described as 'marginal' centres of endemism (Figure 4.9.2).

1. Local centres of endemism

The 'Usambara-Kwale' local centre of endemism (03°20' S, 39°45' E to 05°45' S, 38°30' E)

The 'Usambara-Kwale' local centre of endemism ranges from the Shimba Hills to the southernmost kaya forests in southeast Kenya, and then to the lowland East Usambaras in Tanzania and south to the hills of Tongwe and Gendagenda (Figure 4.9.2). This area encompasses the majority (the southern portion) of the ranges of the six birds characteristic of the Kenyan and Tanzanian Coastal Forests Endemic Bird Area (ICBP, 1992).

The patterns of endemism in this area are complex. Several species are confined to more restricted parts of the area, and there are forest sites which possess high numbers of endemic species in their own right. Further sub-division of the area is probably possible.

For mammals one species found throughout the area is the bat *Taphozous hildegardeae*, and in the more southern part of the area there are *Galago* sp. nov. A in the East Usambaras (Bearder *et al.*, 1994), an undescribed species of bat *Rhinolophus* sp. nov. (East and West Usambaras and Amboni Caves) and two undescribed species of shrews *Crocidura* sp. (Gendagenda and Tongwe).

Several amphibians and reptiles are also endemic or near-endemic to this area. These are the amphibian *Hyperolius rubrovermiculatus*, the reptiles *Gastropholis prasina, Aparallactus turneri* (also Tana River), *Prosymna semifasciata* (lowland Usambaras), *Lygodactylus kimhowellii* (Amboni Caves), *L. conradti* (also E. Usambara Mts.), *Dipsadoboa werneri* (E. Usambaras and Tanga) and *Typhlops platyrhynchus* ('Tanga'). The amphibian *Stephopaedes* sp. nov. A is also near-endemic to the lowland East Usambaras (also Mafia Island).

In terms of plants there are 12 endemic species in the Shimba Hills (*Uvariodendron* sp. 3 of FTEA, *Rinorea* sp. ?nov. of Robertson and Luke (R and L), 1993, *Combretum* sp. ?nov. aff. *apiculatum* of R and L, 1993, *Dalbergia* sp. 1 of R and L, 1993, *Salacia* sp. cf. *elegans*, *Simirestis* sp.1 of R and L, 1993, ?*Strombosiopsis* sp. of R and L, 1993, *Pancovia* sp. aff. *ugandensis* of R and L, 1993, *Synsepalum* sp. cf. *subcordatum* of R and L, 1993, *Pavetta tarennoides*). The lowland forests of the East Usambaras possess one endemic plant genus and 17 endemic species (Rodgers and Homewood, 1982; Hamilton and Bensted-Smith, 1989; Iversen, 1991), and there are further endemics in the Tanga Limestone forests and south to Tongwe (Hawthorne, 1993; Clarke and Stubblefield, 1995; Chapter 4.1).

Several species of butterflies are endemic to this area (Chapter 4.8). These are *Charaxes blanda kenyae, Iolaus maritimus maritimus, Aphnaeus coronae littoralis, Acraea matuapa, Coeliades keithloa* and *Goryra diva*. The many endemic molluscs, spiders and millipedes known from the East Usambaras are presented in Rodgers and Homewood (1982) and Scharff (1993).

The 'Lindi' local centre of endemism (10°2–10' S, 39°10–29' E)

A group of sites in Lindi District (Figure 4.9.3) are of great importance for their assemblages of unique species, even though they have not been particularly well-studied. The most important areas are a number of small (total < 150km^2) forest patches, mainly located on elevated plateaux in the area (see Figure 4.9.3). Endemic vertebrates comprise an undescribed species of Galago *Galago* sp. nov. B (Bearder *et al.*, 1994), one species of bird *Batis reichenowi* (also some other forests in the area), a distinctive sub-species of bird *Stactolaema olivacea* ssp. *hylophona*, three species of reptile in the forests (*Melanoseps rondoensis, Scolecoseps litipoensis, Typhlops rondoensis*) and two other species in the area (*Chirindia rondoensis* and *Chirindia ewerbecki*). The invertebrates have not been well studied, but for the butterflies there are two endemic species. There are also two endemic and two near-endemic plant genera and *c.*60 endemic plant species in Rondo and one near-endemic genus and 16 endemic species in Litipo (Chapter 4.1). Recent discoveries of further new plant species (Vollesen, 1992; Clarke, 1995) indicates that this figure may be even higher, making the area of similar importance for plants to the East Usambara Mountains (compare Rodgers and Homewood, 1982 and K. Vollesen in WWF and IUCN, 1994).

2. Minor centres of endemism

The Tana River (01°20' S , 40°00' E to 02°40' S, 40°40' E)

The lower Tana River in coastal Kenya comprises an area of forest and woodland/grassland. Tana River endemic vertebrates comprise two monkeys *Procolobus rufomitratus* and *Cercocebus galeritus*, one bat *Chalinolobus kenyacola*, two birds, the Tana river Cisticola *Cisticola restricta* (non-forest) and a sub-species of the White-winged Apalis *Apalis chariessa chariessa*, three reptiles

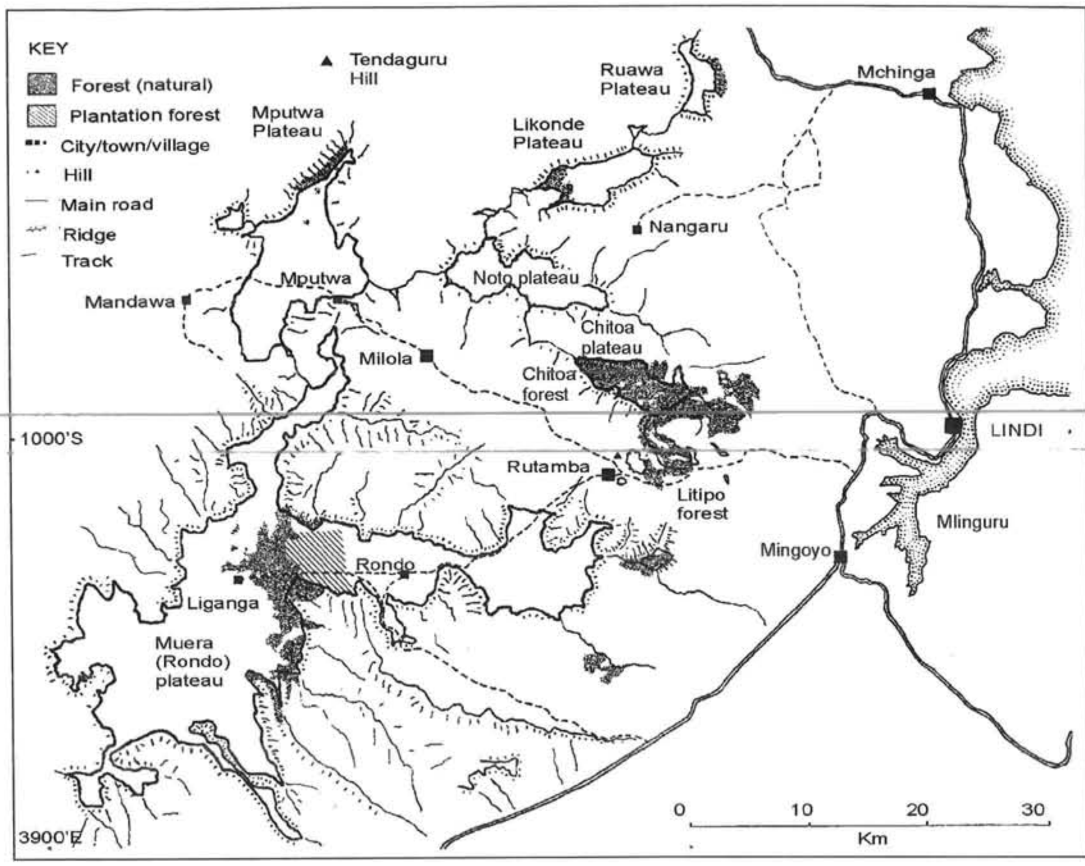


Figure 4.9.3 The Lindi local centre of endemism, showing the main plateau areas and associated forests. Villages and area names known for endemic plants (e.g. Mlinguru) are marked.

Meizodon krameri, Lygosoma tanae and *L. mabuiiformis* (last two also perhaps in southern Somalia). There are also at least four endemic plants (*Dichapetalum* sp.1, *Cynometra lukei, Cyphostemma* sp. nr *bambuseti, Cyphostemma ternatum*).

Arabuko-Sokoke area (03° 20' S, 39° 55' E)

Vertebrate species confined to the Kenyan coast, and centred on Arabuko-Sokoke are the mammal Golden-rumped Elephant-shrew (see FitzGibbon, 1994), and the bird Clarke's Weaver (Chapter 4.2). In terms of plants there are at least four endemic species in the Arabuko-Sokoke forest (*Mildbraedia* sp. A of the Flora of Tropical East Africa (FTEA), *Dichapetalum fadenii, Elachyptera parvifolia, Taxillus wiensii).*

The Pugu Hills (06° 54' S, 39°05' E)

The Pugu Hills are located close to Dar es Salaam in Tanzania and hence have been well-studied over many years (e.g. Howell, 1981). There is forest in both the Pugu and the Kazimzumbwi Forest Reserves and data for these are combined. There are two presently undescribed new species of mammals from the Kazimzumbwi Forest Reserve, a shrew *Crocidura* sp., and a dormouse *Graphiurus* sp. nov. There is also an endemic sub-species of bird, the Pale-breasted Illadopsis *Trichastoma rufipennis puguensis,* the endemic invertebrates presented in Howell (1981), and one endemic plant genus and 12 endemic plant species (Chapter 4.1). Species which may be endemic, but which are very poorly known include the reptile *Scolecoseps acontias* and the bat *Pipistrellus permixtus* (both known only from 'Dar es Salaam').

The Matumbi and Kichi Hills (08° 22' S, 38°56' E)

This area of high land just south of the Rufiji river in Tanzania is rather poorly studied, but has been shown to be important. So far known are an undescribed species of shrew *Crocidura* sp. (in Tong'omba), at least three endemic species of plants, an endemic butterfly, and at least 16 un-described species of millipedes (Kiwengoma).

The Tanzanian offshore islands

The large islands off the coast of Tanzania (Pemba (05° 20' S, 39° 45' E), Zanzibar (06° 00' S, 39° 30' E) and Mafia (07° 50' S, 39° 45' E)) all have their own endemic species, many of which are forest confined or at least associated with the forest cover which probably clothed these islands until a few hundred years ago (e.g. Greenway *et al.*, 1988).

Pemba Island has the highest levels of endemism. There is one endemic mammal, the Pemba Fruit Bat *Pteropus voeltzkowi,* and four endemic birds – Pemba Sunbird *Nectarinia pembae,* Pemba White-eye *Zosterops vaughani*, Pemba Scops Owl *Otus pembaensis* and Pemba Green Pigeon *Treron pembaensis* (Archer and Turner, 1993). There is also one species of endemic butterfly, and four endemic plants, including *Chrysalidocarpus pembanus* (Beentje, 1990).

The other islands have somewhat lower rates of endemism. On Zanzibar there is the *kirkii* sub-species of the Red Colobus Monkey *Procolobus pennantii,* which is regarded by some as a full species (e.g. Corbett and Hill, 1991), and the second population of Ader's Duiker (the other being at Sokoke in Kenya). There are also three endemic butterflies (Archer *et al.*, 1991), and four endemic plants (e.g. *Ipomoea zanzibarica, Acalypha boiviniana, Ardisia* sp. A of FTEA) (also see Beentje, 1990). On Mafia, there is a species of leaf-litter toad *Stephopaedes* sp. nov. which is shared with the East Usambaras, and a species of writhing skink *Lygosoma mafianum* which is also known from Kisiju Island just off the mainland of Tanzania. There is also an endemic butterfly and four endemic plants (including *Spermacoce* sp. D of FTEA). A population of the rare Seychelles Fruit Bat *Pteropus seychellensis* is also found here.

The offshore islands also possess 13 endemic sub-species of mammals (Kingdon and Howell, 1993).

The Uluguru lowlands (06° 59' S, 37° 48' E)

There are a number of forest patches at the base of the Uluguru Mountains. The only one which has been studied is in the Kimboza Forest Reserve, and this site has a number of endemic species. These include the lizard *Lygodactylus williamsi*, the butterflies *Triclema kimboza* and *Celaenorrhinus kimboza*, and two endemic plant genera and 16 endemic plant species (Rodgers *et al.*, 1983).

The Udzungwa lowlands (07° 45' S, 36° 40' E)

The lower altitude forests on the eastern side of the Udzungwa Mountain range possess a number of endemic sub-species (see Stuart *et al.*, 1993; Kingdon and Howell, 1993; Dinesen *et al.*, 1993 and 1994). The precise relationship between these forests and the Coastal Forests described here is not clear, but the forests have greater affinity to Coastal Forests than to Eastern Arc mountain forests, and possess at least 10 species of endemic plants (six in Magombera alone).

3. Marginal areas of endemism

The Bazaruto archipelago (22° S, 36° E)

This area is found to the south of Mozambique and thus is far removed from the core Coastal Forest areas in Kenya and Tanzania. Three endemic species of reptile are known from Bazaruto – *Scelotes duttoni, Scelotes insularis* and *Lygosoma lanceolatum* (Broadley, 1990 and 1992). There are probably other locally endemic species in this area.

Easternmost Malawi and Zimbabwe (16–20° S, 32–35° E)

There are small areas of lowland forest in the eastern margins of Malawi and Zimbabwe which have their strongest affinities to the Coastal Forests (see Chapter 1.2). These lowland forests support several endemics, for example the chameleons *Bradipodion mlanjense, Rhampholeon chapmani* and *R. platyceps* are found only in Malawi. Other species, which are not strictly endemic to the Coastal Forests, have a distribution which includes parts of the Malawi/Zimbabwe/western Mozambique forests, in addition to forests further north. Examples are the bat sub-species *Scotophilus nigrita alvenslebeni* and the *Beamys hindei/major* species complex (FitzGibbon *et al.*, 1995).

Richest sites

The importance of individual Coastal Forests for biodiversity can also be ranked in terms of their species-richness or number of Coastal Forest endemics they possess. This has been done for plants, birds and mammals (Chapters 4.1–4.3), which are the only groups where data are adequate for the task. The ranking of sites depending on their species richness or endemic richness in different taxonomic groups (Table 4.9.4) shows that priority sites often recur in the set of the top ten most important sites, but that the ordering of the importance of the sites varies according to the biological group and to whether richness or endemism is considered as the most important variable. Also, there are a number of sites which appear in only one list. These can generally be ascribed to a much greater level of survey effort at the site (e.g. Gede forest in the birds endemism list), or to the collection of a new species from that site (e.g. Mt. Tongwe in Tanzania).

These lists give some idea of biological priorities in the Coastal Forests, which has an obvious application for targeting conservation efforts. A more statistically robust assessment of overall priorities could be made using computer programmes that are able to select minimum sets of areas through the use of complementarity algorithms (e.g. Vane-Wright *et al.*, 1991; Pressy *et al.*, 1993; Kershaw *et al.*, 1994). An example of this approach, using a database of forest birds of eastern Africa (Figure 4.9.4), shows that for this group all the major and minor areas of endemism outlined earlier in this Chapter have been selected. This further reinforces the critical importance of these areas. Further refinement of the biological (and conservation) priorities could be achieved by more work using such approaches, although there will be problems with uneven survey effort between forests, and the lack of complete species lists for groups other than birds. Although such work is scientifically valid, we believe that the local, minor and marginal areas of endemism outlined in this Chapter, and the sites presented in Table 4.9.4 are already of such great biological importance that they should all receive conservation attention in one way or another.

Summary

Overall rates of species endemism in the different groups in the Coastal Forests vary from 7.1 to 80+%, with the lowest rates in the mammal and bird vertebrates and the highest rates in the invertebrates. Percentage endemism is inversely correlated with generalised mobility of the group concerned, in common with endemism patterns observed in the nearby Eastern Arc forests. The overall rate of endemism for eight groups of animals and plants is 0.202% of the known worldwide species totals for those groups, and for the Eastern Arc this is 0.366%. This rate in the Coastal Forests is *c.*100 times greater than would be expected if the world's species were distributed evenly across the available land surface.

The geographical ranges of most endemic species in the Coastal Forests are small, with single-site endemism being commonplace. There are also several marked concentrations of endemics, which tend to be replicated across taxonomic groups. Two local centres of endemism (with more than 100 endemic species) are found in the Coastal Forests, in southern Kenya and northernmost Tanzania – the 'Kwale' local centre of endemism, and in southern Tanzania – the 'Lindi' local centre of endemism. Seven other more 'minor' centres of endemism exist (with over 10 endemic plants), and are only in Tanzania. 'Marginal' centres of endemism occur at the southern limits of these forests in western Mozambique and easternmost Malawi and Zimbabwe. The relatively low rates of exploration of the flora and fauna of northern Mozambique may account for the lack of evidence of concentrations of endemics in this area.

Comparisons of numbers of species (species-richness) and numbers of Coastal Forest endemic species in individual forest sites shows varying priorities between the groups studied here, although the same 'top' sites generally appear in most lists. Complementarity analyses to define sets of areas which are needed for conservation of biodiversity have not been attempted for most groups because of the patchy nature of collection and the lack of comprehensive species lists for most forests. However, where such an analysis is undertaken for the forest birds of eastern Africa the set of priority areas defined for the Coastal Forests includes all the local and minor centres of endemism described in this Chapter using our simple prioritisation methods.

Table 4.9.4 Ranked priority sites for vascular plants, birds, mammals and reptiles in terms of species richness and species endemism. Note that these are not corrected for forest area.

Rank	Vascular Plants		Birds		Mammals		Reptiles	Amphibians***
	Species richness*	Species endemism**	Species richness*	Species endemism**	Species richness*	Species endemism**	Species endemism**	Species endemism**
1	Shimba Hills (1087)	Rondo (60)	Pugu Hills (62)	Arabuko-Sokoke (16)	Arabuko-Sokoke (44)	Gendagenda (6)	Rondo and Litipo (5)	Shimba Hills
2	Rondo (800 est.)	E. Usambaras (17)	E. Usambaras (60)	Shimba Hills (12)	E. Usambaras (42)	Zanzibar (6)	Kiwengoma (4)	Pugu-Kazimzumbwi
3	Tana River NPR (663+)	Kimboza (16)	Arabuko-Sokoke (59)	Rondo (12)	Gendagenda (42)	E. Usambaras (5)	Arabuko-Sokoke (4)	Rondo
4	Arabuko-Sokoke (511+)	Litipo (16)	Rondo (54)	E. Usambaras (11)	Pugu Hills (42)	Tong'omba (5)	Bazaruto (4)	Mrora (Mafia Island)
5	Gongoni (409+)	Pugu-Kazimzumbwi (12)	Shimba Hills (54)	Pugu Hills (11)	Jubba Valley (39)	Tana river (4)	E. Usambaras (4)	E. Usambaras
6	Kiwengoma (367)	Shimba Hills (12)	Litipo (47)	Tana river (11)	Zaraninge/Kiono (39)	Tongwe (4)	Kilulu (3)	
7	Boni (335+)	Matumbi/Kichi (6)	Mrima (47)	Gede (10)	Mkwaja (37)	Pugu Hills (4)	Zaraninge/Kiono (3)	
8	Zaraninge (288)	Pemba, Zanzibar, Arabuko-Sokoke and Mafia (4 each)	Ngarama (46)	Gongo (10)	Tana river (37)	Rondo (4)	Zanzibar Island (3)	
9	Witu (287)	Pande (3)	Tana River (46)	Gendagenda (10)	Rondo (35)	Zaraninge/Kiono (4)	South Mlanje (3)	
10	Pangani Falls (271)	Noto (3) and Chitoa (3)	Zaraninge/Kiono (46)	Msubugwe (10), Zaraninge/Kiono (10), Litipo (10)	Kiwengoma (31)	Arabuko-Sokoke, Kilulu, Mkwaja, Ruvu South, Kiwengoma, Litipo, Pindiro (3 each)	11 sites with 1 CF endemic species present	

Notes:

* Species richness = the name of the forest site and the number of species recorded (in parentheses). For mammals this figure includes bats, which gives some bias as not all sites have been studied for bats.

** Species endemism = the name of the forest site and the number of Coastal Forest endemic species which have been recorded from it (in parentheses) except for plants where single site endemics only are listed (see Table 4.2.3 for list of bird endemism scores, Table 4.2.5 for birds, Appendix 4 for mammals, Appendix 5 for reptiles and Appendix 6 for amphibians).

*** Sites cannot be ranked for amphibians, but some important sites are listed.

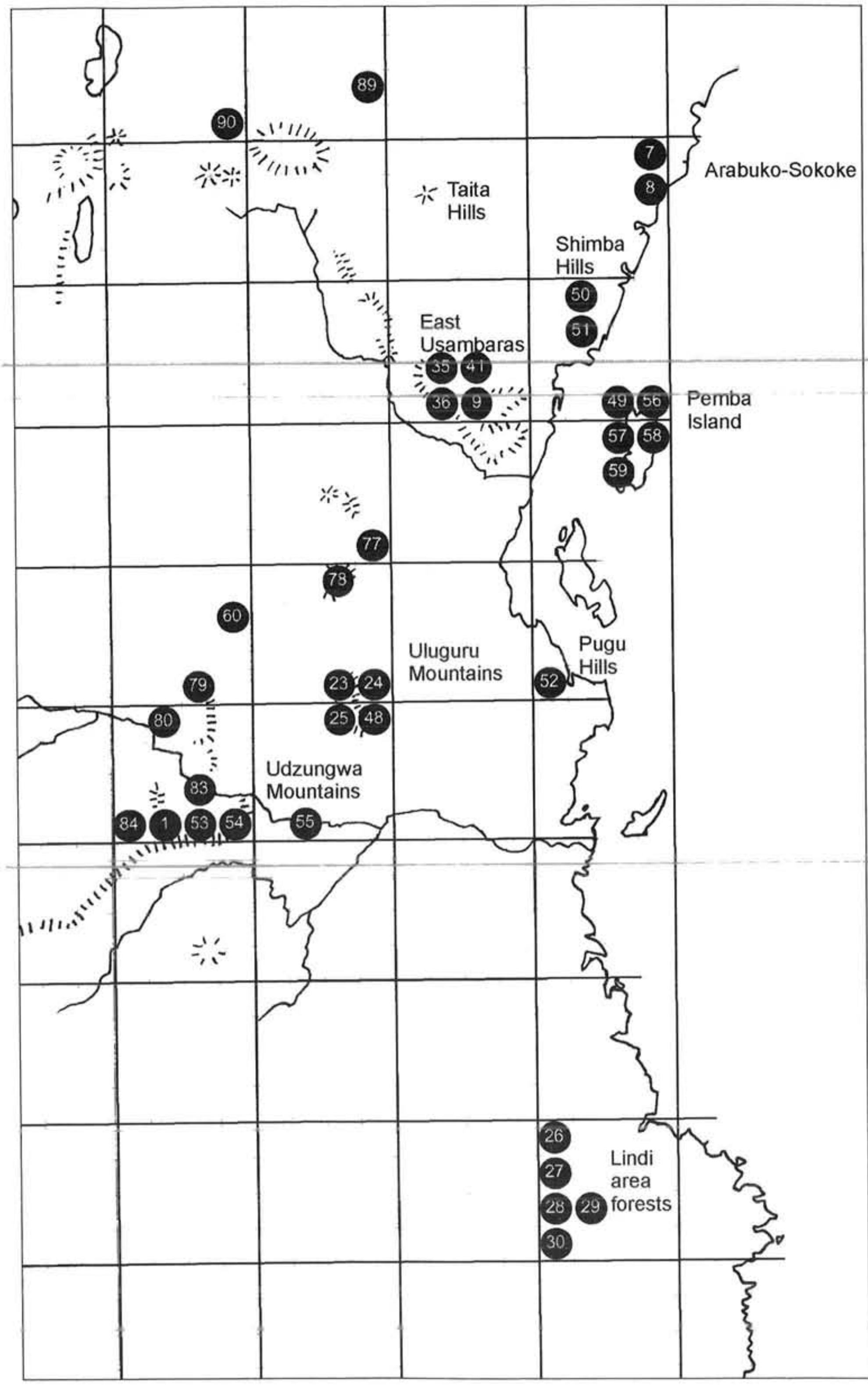


Figure 4.9.4 Part of a minimum set of 0.25 degree squares (represented here as numbered circles) in eastern Africa required to conserve forest birds in five (or less in the case of more restricted species) separate sites. Data are from a provisional distributional database for eastern African bird species, with the database being most accurate for the Coastal and Eastern Arc forests represented here. Numbering within the circles is the rank order of the sites, from a list of 130 irreplaceable and flexible areas. All calculations were performed using WORLDMAP IV, developed by Paul Williams of the Natural History Museum in London. It should be noted that the Taita Hills endemics are here regarded as sub-species, else that site would also be one of the areas represented.

Acknowledgements

Many comments and much useful discussion on this Chapter were provided by Alan Rodgers, Jon Fjeldså and Phil Clarke.

References

Archer, A.L. and Turner, D.A. (1993). Notes on the endemic species and some additional new birds occurring on Pemba island, Tanzania. *Scopus* **16:** 94–98.

Archer, A.L., Collins, S. and Bampton, I. (1991). Report on a visit to Jozani Forest, Zanzibar. *EANHS Bulletin* **21**: 59–66.

Barnes, R.D. (1989). Diversity of organisms: how much do we know? *American Zoologist* **29**: 1075–1084.

Bearder, S.K., Honess, P.E. and Ambrose, L. (1994). Species diversity among galagos with special reference to mate recognition. In Altmann, L., Doyle, G.A. and Izard, M.K. (eds.). *Creatures of the Dark: The Nocturnal Prosimians*. Plenum Publishing Co, New York.

Beentje, H.J. (1990). *Botanical Assessment of Ngezi Forest, Pemba.* Zanzibar: FINNIDA report to the Commission for Natural Resources.

Broadley, D.G. (1990). The herpetofaunas of the islands off the coast of south Mozambique. *Arnoldia Zimbabwe* **35**: 469–493.

Broadley, D.G. (1992). Reptiles and amphibians from the Bazaruto Archipelago, Mozambique. *Arnoldia Zimbabwe* **38**: 539–548.

Clarke, G.P. (1995). *Status Reports for 6 Coastal Forests in Lindi Region, Tanzania.* Frontier-Tanzania Technical Report No. 18. The Society for Environmental Exploration and The University of Dar es Salaam, London and Dar es Salaam.

Clarke, G.P. and Stubblefield, L.K. (1995). 'Status Reports for 7 Coastal Forests in Tanga Region, Tanzania'. Unpublished report: Frontier-Tanzania Technical Report No. 18. The Society for Environmental Exploration, UK/The University of Dar es Salaam, Tanzania.

Collar, N.J., Crosby, M.J. and Stattersfield, A.J. (1994). *Birds to Watch 2: the World List of Threatened Birds.* BirdLife Conservation Series no. 4. BirdLife International, Cambridge.

Corbet, G.B. and Hill, J.E. (1991). *A World Checklist of Mammalian Species (third edition).* Natural History Museum Publications/Oxford University Press, Oxford and London.

de Jong, R. and Congton, T.C.E. (1993). The montane butterflies of the eastern African forests. Pp.133–173. In Lovett, J.C. and Wasser, S.K. (eds.). *Biogeography and Ecology of the Rain Forests of Eastern Africa.* Cambridge University Press, Cambridge.

Dinesen, L., Lehmberg, T., Svendsen, J.O. and Hansen L.A. (1993). Range extensions and other notes on some restricted-range forest birds from West Kilombero in the Udzungwa mountains, Tanzania. *Scopus* **17**: 48–59.

Dinesen, L., Lehmberg, T., Svendsen, J.O., Hansen, L.A. and Fjeldså J. (1994). A new genus and species of perdicine bird (Phasianidae, Perdicini) from Tanzania: a relict form with Indo-Malayan affinities. *Ibis* **136**: 2–11.

Emberton, K.C., Pearce, T.A., Kasigwa, P., Tatterfield, P. and Habibu, Z. (1997). High diversity and regional endemism in land snails of eastern Tanzania. *Biodiversity and Conservation* **6**: 1123–1136.

FitzGibbon, C.D. (1994). The distribution and abundance of the Golden-rumped Elephant-shrew *Rhynchocyon chrysopygus* in Kenyan Coastal Forests. *Biological Conservation* **67:** 153–160.

FitzGibbon, C.D., Leirs, H. and Verheyen, W. (1995). Distribution, population dynamics and habitat choice of the Lesser Pouched Rat, *Beamys hindei* (Rodentia: Cricetomyinae). *Journal of Zoology, London* **236**: 499–512.

Fjeldså, J. (1994). Geographical patterns for relict and young species in African and South America and the dilemma of ranking biodiversity. *Biodiversity and Conservation* **3**: 207–226.

Fjeldså J., Ehrlich D., Lambin E., and Prins E. (1997). Are biodiversity 'hotspots' correlated with current ecological stability? a pilot study using the NOAA-AVHRR remote sensing data. *Biodiversity and Conservation* **6**: 401–423.

Fjeldså, J. and Lovett, J.C. (1997). Geographical patterns of old and young species in African forest biota: the significance of specific montane areas as evolutionary centres. *Biodiversity and Conservation* **6**: 325–347.

Greenway, P.J., Rodgers, W.A., Wingfield, R.J. and Mwasumbi, L.B. (1988). The vegetation of Mafia Island, Tanzania. *Kirkia* **13:** 197–238.

Hamilton, A.C. and Benstead-Smith, R. (eds.) (1989). *Forest Conservation in the East Usambara Mountains, Tanzania.* IUCN, Gland, Switzerland and Cambridge, UK.

Hawthorne, W.D. (1993). East African Coastal Forest botany. Pp. 57–99. In Lovett, J.C. and Wasser, S.K. (eds.). *Biogeography and Ecology of the Rain Forests of Eastern Africa.* Cambridge University Press, Cambridge.

Heywood, V.H. and Watson, R.T. (eds.) (1995). *Global Biodiversity Assessment.* Published for the United Nations Environment Programme by Cambridge University Press, Cambridge.

Hoffman, R.L. (1993). Biogeography of East African montane forest millepedes. Pp. 103–115. In Lovett, J.C. and Wasser, S.K. (eds.). *Biogeography and Ecology of the Rain Forests of Eastern Africa.* Cambridge University Press, Cambridge.

Howell, K.M. (1981). Pugu Forest Reserve: biological values and development. *African Journal of Ecology* **19**: 73–81.

Howell, K.M. (1993). Herpetofauna of the eastern African forests. Pp. 173–201. In Lovett, J.C. and Wasser, S.K. (eds.). *Biogeography and Ecology of the Rain Forests of Eastern Africa.* Cambridge University Press, Cambridge.

ICBP (1992). *Putting Biodiversity on the Map: Priority Areas for Global Conservation.* ICBP, Cambridge.

Iversen, S.T. (1991). The Usambara Mountains, NE Tanzania: phytogeography of the vascular plant flora. *Symbolae Botanicae Upsaliensis* **24**: 1–234.

Kershaw, M., Williams, P.H. and Mace, G.M. (1994). Conservation of Afrotropical antelopes: consequences and efficiency of using different site-selection methods and diversity criteria. *Biodiversity and Conservation* **3**: 354–372.

Kingdon, J. and Howell, K.M. (1993). Mammals of the forests of eastern Africa. Pp. 229–243. In Lovett, J.C. and Wasser, S.K. (eds.). *Biogeography and Ecology of the Rain Forests of Eastern Africa.* Cambridge University Press, Cambridge.

Lovett, J.C. (1993). Eastern Arc moist forest flora. Pp. 33–57. In Lovett, J.C. and Wasser, S.K. (eds.). *Biogeography and Ecology of the Rain Forests of Eastern Africa.* Cambridge University Press, Cambridge.

Lovett, J.C. (1996). Elevational and latitudinal changes in tree associations and diversity in the Eastern Arc mountains of Tanzania. *Journal of Tropical Ecology* **12**: 629–650.

Lovett, J.C. and Wasser, S.K. (1993). *Biogeography and Ecology of the Rain Forests of Eastern Africa.* Cambridge University Press, Cambridge.

May, R.M. (1990). How many species? *Phil. Trans. R. Soc. Lond.* **330B**: 293–304.

Mittermeier, R.A., Myers, N., Thomsen, J.B., da Fonseca, G.A. and Olivieri, S. Biodiversity Hotspots and Major Tropical Wilderness Areas: Approaches to Setting Conservation Priorities. *Conservation Biology* **12(3):** 516–520.

Myers, N. (1988). Threatened biotas: 'hot spots' in tropical forests. *The Environmentalist* **8:** 187–208.

Myers, N. (1990). The biological challenge: extended hot-spots analysis. *The Environmentalist* **10**: 243–256.

Pócs, T. (1975). Affinities between the bryoflora of East Africa and Madagascar. *Biossiera* **24**: 125–128.

Pressy, R.L., Humphries, C.J., Margules, C.R., Vane-Wright, R.I. and Williams, P.H. (1993). Beyond opportunism: key principals for systematic reserve selection. *Trends in Ecology and Evolution* **8**: 124–128.

Robertson, S.A. and Luke, W.R.Q. (1993). *Kenya Coastal Forests: report of the NMK/WWF Coast Forest Survey.* World Wide Fund for Nature, Nairobi.

Rodgers, W.A. and Homewood, K.M. (1982). Species richness and endemism in the Usambara mountains forests, Tanzania. *Biological Journal of the Linnean Society* **18**: 197–242.

Rodgers, W.A., Hall, J.B., Mwasumbi, L.B., Griffiths, C.J. and Vollesen, K. (1983). *The Conservation Values and Status of Kimboza Forest Reserve, Tanzania.* Forest Conservation Working Group, University of Dar es Salaam Forest, Dar es Salaam.

Scharff, N. (1993). The Linyphiid spider fauna (Araneae: Linyphiidae) of mountain forests in the Eastern Arc Mountains. Pp. 115–132. In Lovett, J.C. and Wasser, S.K. (eds.). *Biogeography and Ecology of the Rain Forests of Eastern Africa.* Cambridge University Press, Cambridge.

Stuart, S.N., Adams, R.J. and Jenkins, M.D. (1990). *Biodiversity in Sub-Saharan Africa and its Islands.* Occasional Papers of the IUCN Species Survival Commission No. 6. IUCN, Gland, Switzerland.

Stuart, S.N., Jensen, F.P., Brøgger-Jensen, S. and Miller, R.I. (1993). *The zoogeography of the montane forest avifauna of eastern Africa.* Pp. 203–228. In Lovett, J.C. and Wasser, S.K. (eds.). *Biogeography and Ecology of the Rain Forests of Eastern Africa.* Cambridge University Press, Cambridge.

Vane-Wright, R.I., Humphries, C.J. and Williams, P.H. (1991). What to protect? Systematics and the agony of choice. *Biological Conservation* **55**: 235–254.

Vollesen, K. (1992). *Trichaulax* (Acanthaceae: Justicieae), a new genus from East Africa. *Kew Bulletin* **47**: 613–618.

WCMC (1992). *Global Biodiversity: Status of the Earth's Living Resources.* Chapman and Hall, London.

White, F. (1983). *The Vegetation of Africa*. UNESCO, Paris.

White, F. (1993). The AETFAT chorological classification of Africa: history, methods and applications. *Bull. Jard. Bot. Nat. Belg. Bull. Nat. Plantentuin Belg.* **62**: 225–281.

WWF and IUCN (1994). *Centres of Plant Diversity: A Guide and Strategy for their Conservation. Vol.1. Europe, Africa, SW Asia and the Middle East.* IUCN, Gland, Switzerland and Cambridge, UK.

Section 5

Human and forest interactions

This section summarises the interaction between humanity and the Coastal Forests. In the first Chapter, the history of the influence of the human population on the forest cover of the area is discussed in relation to the changes since hominids first appeared around five million years ago, concentrating on the harnessing of fire by modern humans around 150,000 years ago, on the influence of cultivation, and on the effect of the arrival of the major colonial powers which exploited the area from the 16th century to the 1960s. The following Chapter is devoted to a detailed presentation of the history of modern forestry over the past 100 years when the German, British and Independent governments instigated and maintained systems to demarcate, manage and exploit the forest resources in the area. In the third Chapter, a detailed discussion is presented on the current uses of, threats to, and human attitudes towards these forests. Finally in the last Chapter a summary of recent conservation initiatives in these forests is presented, followed by a discussion of the issues which are involved, and some ways in which they might be tackled.

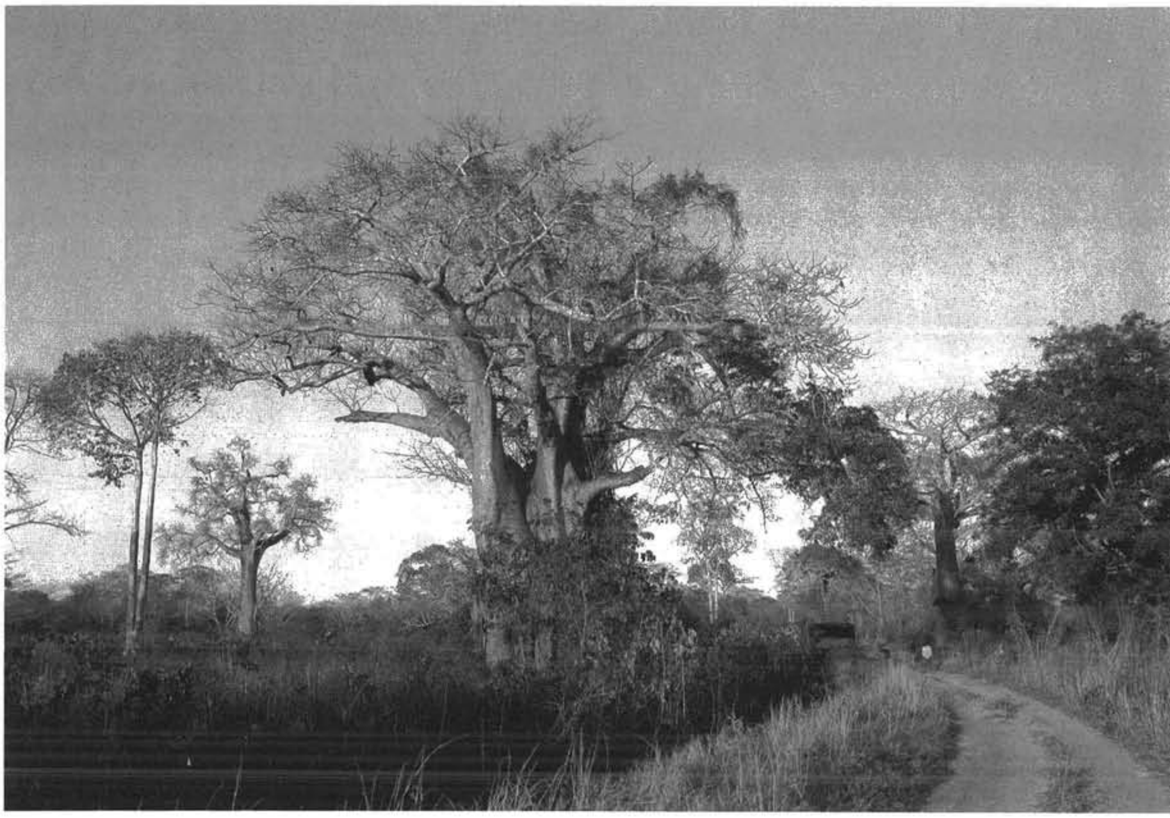


Figure 5 Isolated baobabs *Adansonia digitata* and the forest dependent *Sterculia appendiculata* remaining in cultivated land near Kitomanga, Lindi Region, Tanzania. These species are usually left following forest clearance, due to their soft, spongy wood which does not burn, and also due to the traditional protection usually accorded to them. Baobabs may also have been planted as a traditional crop as they were formerly important for clothing fibres and perhaps also as a staple food source. (*Photo: G.P. Clarke*)

5.1 History of anthropic disturbance

G.P. Clarke and N.J. Karoma

Introduction

Coastal Forests are widely recognised to have been formerly much more extensive (Elton, 1874; Swynnerton, 1917; Troup, 1923; Gray, 1952; Moll and White, 1978; Hall, 1984; Sheil, 1992; Hawthorne, 1993; Chami, 1994). Although global climatic changes (especially the drier periods during the Pleistocene climatic fluctuations) are recognised to have both fragmented and reduced the extent of tropical forest in Africa (e.g. Hamilton, 1989), the severity of these climatic desiccations are not thought to have been sufficient in the eastern African coastal zone to fully account for the amount of Coastal Forest that must have been lost (Chapter 2.3; cf. Dale, 1954), and are even thought to have been greatly exaggerated in tropical lowlands in general (White, 1993). We believe that it is the combination of gradual climatic desiccation together with increasing human activity that accounts for much of the loss of Coastal Forest during recent geological time.[1]

Modern humans (*Homo sapiens*) originated in eastern Africa some 300,000 years ago (although the hominid lineage stretches back at least five million years). At first their limited technological capability and low population had little impact on the Coastal Forests, and the early hunter-gatherers in general had a much lower effect on the presence and condition of the forests than that caused by natural factors such as elephants and climate. Subsequent developments of fire, tools (and more recently of machines) have given humanity an ever greater destructive capability on the forests, which together with advances in crops and medicines have led to an increased population to carry out that destruction. This chapter charts the history of the anthropic disturbance to the Coastal Forests, in chronological order of the main events and discoveries that we believe have brought about the gradual destruction of these forests.

The discovery of fire-making

The creation and use of fire was a major discovery for humanity, and the first tool that could be used to dominate the landscape (Hall, 1984). However, wildfires predate the human genesis as they can be started naturally by lightning, falling stones, volcanic activity etc. (Phillips, 1965; Granger, 1984). There is considerable evidence of natural fires throughout the geological record, with charcoal layers being a common palaeobotanical feature of many strata. There are records of bush fires in eastern Africa from the Plio-Pleistocene (2–5 million years ago) in Ethiopia, which are contemporary with (although not caused by) the earliest hominids (Deschamps, 1984). Hominids learnt to make fire about 1.5 million years ago in the Rift Valley area (Clark and Harris, 1985; Brian, 1993), but are not thought to have used it to create artificial bushfires until 180,000–150,000 years ago (Kielland-Lund, 1988; Hall, 1984). These fires are thought to have been set to drive game animals out of areas of dense vegetation to where they could be more easily hunted.

The use of fire by hunters may have had a great influence on Coastal Forests (cf. Hall, 1984; Hawthorne, 1993). Fires are known to occur (albeit occasionally) in dry forests[2] which may then recover if further fires are excluded (Menaut *et al.,* 1995; Swaine, 1992), but forest will eventually be

[1] Swynnerton (1917) concludes that most of the forest between the Chimanimani Mountains and the sea (i.e. in the lowlands of southern Mozambique) was removed 'especially by, and for long only by, fire'. From his observations of the rate of forest loss due to fire at Chirinda, he calculates from a slightly increased rate of forest loss that the duration of this forest destruction had taken place over 105,000 years, which is in the same order of magnitude as the earliest evidence for bush firing by humans (180,000–150,000 years ago).

[2] Moomaw (1960) notes that 'even the humid rain forest community' of the Kenya coast will burn during the dry season, but comments that the Kenyan Coastal Forests nonetheless do not burn readily.

converted to woodland or grassland if it is repeatedly burnt[3]; conversely many woodlands will revert to forest if fire is excluded (Menaut *et al.*, 1995; Trapnell, 1959; Swaine *et al.*, 1992[4]). We believe that natural bushfires would have originally occurred at a sufficiently low frequency[5] to have enabled Coastal Forest to regenerate once it had been burnt, and that the deliberate creation of additional bushfires by prehistoric hunters tipped the ecological balance such that fire, encroaching into the forest margins, was able over thousands of years to convert large areas of these forests to woodland. Once converted, the woodlands were maintained by the continued regime of regular burning. Coastal Forests have certainly been more widespread in areas that are now woodland, as borne out by discoveries of fossilised Gum Copal (a product of the Coastal Forest tree *Hymenaea verrucosa*[6]) in areas that are now fire-climax woodland (Elton, 1874; Kerner von Marilaun and Hansen, 1916).

Circumstantial evidence for the past role of fire as a cause of forest loss has been unearthed in recent archaeological excavations at Mpara Hill on the Tanzanian coast. Here small pieces of charcoal have been found throughout the later Pleistocene (pre 10,000 BC) artefact bearing deposit (Karoma, 1993a), in an area where fossilised Gum Copal is also found, demonstrating that ancient fires have swept through an area that has also been covered with Gum Copal forest[7]. The base of the

---

[3] Moomaw (1960) considers the *Manilkara-Diospyros* Lowland Dry Forests of the northern Kenya coast to have largely been destroyed by fire, cultivation and grazing, and that the remaining forest at Boni is particularly at risk from fires set by hunters and honey gatherers. The 'Moist Lowland Savanna' (classified as woodland in White, 1983) of coastal Kenya is considered by Moomaw to be secondary fire-destroyed forest.

The elders of Gendagenda village in northern Tanzania describe a forest fire on the northern of the Gendagenda peaks during the last century (Clarke and Stubblefield, 1995). The forest has since been replaced by elephant grass (*Pennisetum purpureum*) which burns on the peak with spectacular ferocity every year (Clarke, pers. obs.). Coastal Forest still exists on the southern peak but in places appears to be in retreat from the annual fires at its edge (Clarke, pers. obs.). Comparable observations of the destruction by fire of large patches of forest, and of the erosion of their boundaries, are recorded by Swynnerton (1917) from Chirinda Forest, Zimbabwe.

Clarke has also observed stages in the conversion of Coastal Forest to woodland/grassland by fire, but this process is believed to be very slow and does not become complete until forest canopy trees that are not affected by fire die a natural death of old age. A good example of this process is taking place at Tongwe Forest where there is a moribund stand of 25–30m high individuals of *Antiaris toxicaria* emerging from a grassland that is regularly burnt (Clarke and Stubblefield, 1995). No regeneration is taking place and no other forest species exist here except further up the slope where the forest edge is in retreat from fire.

[4] The references cited are for fire-exclusion experiments in Zambia and Ghana. To our knowledge no such experiments have been completed in the Coastal Forest belt, although fire plots were constructed in the *Brachystegia* woodlands of the Simbo Forest Reserve, Bagamoyo District, Tanzania (Forest Department, 1948). However a number of examples can be cited of forests that have regenerated following a known history of complete clearance and even cultivation or urbanisation (e.g. around Tongwe Fort, over the graves and house on Kilulu Hill, over the abandoned city of Gede in coastal Kenya (Figure 5.1.3(a) and (b)) and over former villages in the Matumbi Hills that were abandoned after the Ujamaa villagisation programme. Most of these sites are areas where the forest has regenerated under the protection from fire by existing forest, although over the ruins of the former German military HQ on Chole Island (off Mafia Island) dense forest has now developed where there was no forest at the beginning of this century. Bush fires are unknown on Chole Island which is densely cultivated.

Further examples of forest regenerating where fire is excluded can be found throughout coastal Tanzania, where ancient mango trees in small villages (e.g. Nambunjo in Rufiji District) sometimes develop a forest understorey where they are undisturbed from grazing or cultivation, and where the surrounding areas of local cultivation provide the necessary buffer against bush fires.

[5] The great majority of the bushfires observed today in Africa (perhaps 99%) are thought to be started by humans (Granger, 1984; Swynnerton, 1917).

[6] *Hymenaea verrucosa* is limited to the Coastal Forests on the African mainland, but occurs elsewhere on Madagascar and the Mascarene Islands. It grows to a very large, distinctive and commercially important tree, and is very infrequently, if ever, found in fire climax woodland. The species appears therefore to depend on forest conditions to survive (where fire is absent).

[7] Gum Copal trees were noted to be scattered in the Uzaramo area of Tanzania at the end of the last century 'representing what at one time must have been a dense copal forest' (Gray, 1952) but where 'the extent of these ancient forests can now only be estimated by the area of the [digging for semi-fossilised Gum Copal] and by the position of the existing [Gum Copal trees]' (Elton, 1874). The Gum Copal trees had become so rare that the majority of the copal trade at that time was supplied by digging (up to 4ft deep) for the semi-fossilised resin from those ancient forests (Elton, 1874; Gray, 1952 citing notes by Sir John Kirk).

deposit, which is part of a raised beach 100ft above the current sea level, is dated to the last interglacial (about 100,000 BC).

Patterns of floristic endemism in the Coastal Forest belt also suggest that the Coastal Forests are older than the surrounding woodland areas, based on the evidence of endemic plant genera which are thought to represent ancient phylogenetic lineages. Most (91%) of the genera which are restricted to the eastern African coastal zone are found in forest and other fire-excluded habitats (such as thickets and bushland clumps), compared to just 14% that are recorded in the fire climax woodlands and grasslands, even though the fire-excluded habitats account for less than 2% of this area (Chapter 4.1). The comparatively higher proportion (50%) of endemic species occurring in the fire-climax habitats nonetheless suggests that a mosaic of fire climax rangeland and forest must have been present for a long time (i.e. long before the earliest records of forest clearance for agriculture), to enable the necessary speciation to have occurred in the habitats modified by fire (cf. Moreau, 1933; Granger, 1984; Chapter 4.1 for more detailed discussion).

The introduction of crops and cultivation

The earliest humans were nomadic hunter-gatherers who took what they needed from the environment. Just before the end of the last Ice-Age (approx. 10,000 BC) humans discovered that the environment could be altered to support an increased proportion of useful foodplants, or crops (i.e. through the practice of cultivation), thereby enabling an area to support a larger and settled population.

Coastal eastern Africa is known to have been settled continuously since late Pleistocene times, as indicated by recent archaeological finds at the Abu Bakar Hill and Mpirani sites near Mombasa (Kato 1988a, 1988b; Yasukawa 1988) and at several locations in the Kilwa coast area, including Kilwa Kisiwani (Chittick, 1974), Kilwa Masoko (Harding, 1961), Mgongo, Kiuleule, Mpara and Singino Hills (Karoma, 1982 and 1993a). In the Kilwa coast area there are remains of large Stone Age hunter-forager-fishing communities, which have been found on raised former beaches at between 60 and 100ft above the present sea level, suggesting a late Pleistocene date when the sea level was higher (Birch, 1963; Cooke, 1970 and 1974; Alexander, 1969). It was possibly these people who first utilised the abundant Baobab trees along the coast as a food and raw material source, and these may have been intentionally planted to increase their number, thereby possibly becoming the first food crop in eastern Africa (Karoma, 1993b).

The practice of cereal cultivation came later, probably reaching eastern Africa via two routes, from the north or the east via the coast, and later from the interlacustrine region between Lake Victoria and the Western Rift. The arrival of cereal cultivation coincides with a population explosion in areas inland of the coast, where the population had remained sparse until the Early Iron Age (500 BC). The population increase is attributed by some historians to the expansion of the Bantu people from central Africa, based on the evidence of a shared Bantu language that is now adopted throughout eastern and southern Africa. Other historians consider this dispersal to have been limited to language, cereal cultivation and the knowledge of iron-working (Gramly, 1978; Schepatz, 1988), which would have enabled the existing population to expand (see following section). However, irrespective of which school of thought is followed, the start of this Bantu 'dispersal' to other parts of the continent is acknowledged to predate 2000 BC (Maggs in Moll and White, 1978), reaching the Indian Ocean at the Usambara Mountains about 2000 years ago (Schmidt, 1989). The Bantu migration/influence brought the practice of forest clearance and the cultivation of sorghum and millet (Sutton, 1990) to East Africa. There is archaeological evidence of forest clearance and settlement in the lowland forests of the Eastern Arc Mountains during this time (Schmidt, 1989).

A further cereal type (Asian rice) was brought by settlers from Indonesia to coastal areas during the first millennium AD, and contributed to the clearance of forest on Zanzibar and Pemba Islands.

The effect of forest loss due to clearance for cultivation would have been intensified by bushfires, as these prevent cleared land at the edge of forests from regenerating back to forest (Swynnerton, 1917). Even a low population practising shifting cultivation would then have gradually reduced the extent of forest, if these farmers had chosen to clear more forest rather than woodland during their successive cultivation cycles (Hall, 1984). Forest is often cleared in preference to woodland in coastal East Africa (Clarke, pers. obs.; Hall, 1984) as there is no herb layer to remove and forest soils initially tend to be more fertile as they contain a higher organic matter content (which is rapidly lost if the forest is removed) and have not lost nitrogen through volatization by fire (Kiellund-Lund, 1988; Chapter 2.2). In addition, forest contains a greater quantity of woody matter than woodland, so more fertile ash is produced when this is burnt during clearing, thereby improving the yield from the resulting agricultural land for a few years (Hall, 1984; shifting cultivation practice described in Gillman, 1945).

The combined effects of shifting agricultural clearance and bushfires are considered by Hall (1984) to have been a major recent cause of forest loss in southern Africa, especially along the eastern coastal plains.

The development of iron tools

At the time that cereal cultivation was introduced to East Africa, the population density in the lowlands was so low that shifting cultivation cycles would have had a sufficient rotation interval to permit much of the forest (except for the edges of forest blocks exposed to bushfires) to regenerate. Pressure for agricultural land would have been so low that it is likely that some areas (particularly steeply sloping hillsides) would never have been cleared. Evidence from the montane areas of Kilimanjaro, the Pare and Usambara Mountains nonetheless demonstrate a history of intense human pressure, leading to severe soil degradation and loss of much of the lowland forest at the base of these mountains (Schmidt, 1989).

The severity of the deforestation in these areas may be partially attributed to the need for fuelwood for the iron smelting that was carried out here by Early Iron Age people (Schmidt, 1989). Agricultural communities with a knowledge of iron working similar to those of the Usambaras and Kagera have also been found at Mkiu and Limbo in Kisarawe District, 20km from the coast (Schmidt and Karoma, 1987) dating from the first millennium AD (Chami, 1992; Schmidt *et al.*, 1992; Karoma *et al.*, 1988). The large quantities of slag recovered from the 2nd and 3rd levels at Limbo (Chami, 1994) would seem to suggest that the need for fuelwood for iron smelting during the first century AD was already considerable. Iron smelting is also known from Nampula in Mozambique in the second century AD (Chami, 1992; Chami, 1994 citing Sinclair *et al.,* 1993).

A high demand for fuelwood could have had considerable impact on the Coastal Forests, just as it was responsible for the depletion of much of the indigenous tropical forest in Kagera Region during Early Iron Age times, i.e. from 500 BC (Schmidt and Childs, 1985). Early iron working on the coast may therefore have led to a reduction in area and subsequent fragmentation of the Coastal Forests, both from the need for fuelwood for smelting, and from the consequent production of better iron tools that made it easier to clear areas of forest.

Trade and urbanisation on the coast

The earliest writing to mention the East African coast dates back to the first century AD, in which the Greek author of the *Periplus of the Erythraen Sea* records a well established trading entrepot called Rhapta, now interpreted to be either near present day Lamu, or Chakechake on Pemba Island (Horton, 1990). Early Iron Age communities (with characteristic pottery) were already present on the coast by this time, and the eastern African coast (known then to the Greeks as Azania) traded with merchants from the Red Sea and the Roman Empire. Sutton (1990) considers these trade links to have declined after the first century AD until after the advent of Islam at about 800 AD (Dale, 1954), but new finds (Chami, 1993) demonstrate that between the 4th and 10th centuries AD the coast was occupied by a people who are associated with a Triangularly Incised Ware (TIW), and who worked a variety of metals including iron, copper and lead. They also engaged in international trade, expanded in population and occupied the Indian Ocean coastal islands. Later archaeological records, particularly at Kilwa Kisiwani (Chittick, 1974) demonstrate that a sophisticated civilisation developed along the coast in the following centuries (Freeman-Grenville, 1967), especially after the arrival of the Shirazi

Arabs in 900 AD (Moomaw, 1960). Large coastal towns developed (Figure 5.1.1), which together with a thriving local ship-building industry would have created a large demand for termite-resistant timber (which may also have been exported at this time (Moomaw, 1960)). Coastal Forests (and also the mangrove forests) near these settlements would have been exploited to satisfy this demand, and some have given their name to the preferred timber species, e.g. the etymology of 'Mbamba Kofi' (*Afzelia quanzensis*) is derived from the Bamba forest near Kilife (Aldrick, 1990).

The thriving settlements on the coast are known to have traded with the hinterland (as shown by the distribution of finds of Triangularly Incised Ware dating from the 4–11th centuries AD) and were later responsible for organising trade caravans into the interior during the late eighteenth or early nineteenth century (Freeman-Grenville, 1967), coinciding with the beginning of the slave trade.

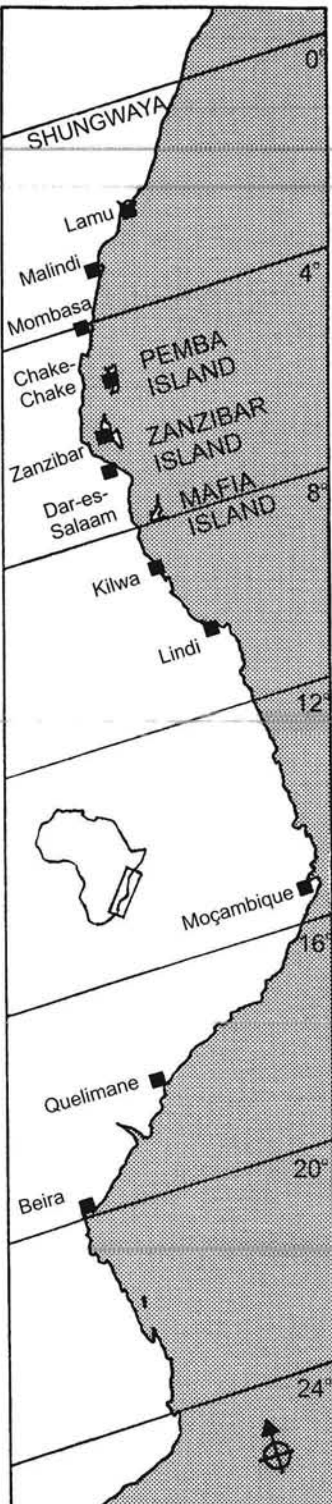


Figure 5.1.1 Main towns on the eastern African coast during the time of Vasco da Gama.

The arrival of the Portuguese

Vasco da Gama's arrival in eastern Africa in 1498 found a prosperous cosmopolitan community living along the coast north of Quelimane (Figure 5.1.1), who were accustomed to trading with merchants from Arabia and India (Strandes, 1899). Over the ensuing centuries, the Portuguese sought to monopolise this trade (Figure 5.1.2), which had the reverse consequence of causing it to collapse, and the coastal area of eastern Africa went into economic decline (see Strandes, 1899 for a full account). Some of the thriving coastal towns were destroyed by the combination of repeated sackings by the Portuguese and the marauding Zimba tribe during the sixteenth century (Strandes, 1899), which may have slowed down the subsequent rate of forest loss in these areas. The Portuguese also began to take slaves, and from the early nineteenth century were joined in this trade by the Arabs.

The direct consequence of the arrival of the Portuguese in eastern Africa was a disruption to a steadily increasing population, which may be expected to have reversed the decline in the extent of the forests (Figure 5.1.3a and b). However, there is evidence that even during the height of slaving activity in eastern Africa the population continued to increase, or was at least stagnant (Kjekshus, 1977). The reason for this is that the arrival of the Portuguese coincided with the discovery of the New World (1492), and of further Portuguese explorations in Asia. These voyages brought the Portuguese into contact with new foodcrops, which they then introduced into eastern Africa (cassava, maize, papaya, cashews and avocadoes from the Americas and mangoes from SE Asia). The new crops enabled the land to support many more people, in an area which had formerly been almost uninhabited inland of the coast (the stretch of land between the Rovuma River and Kilwa had almost no people when the Portuguese Gaspar Bocarro travelled from Tete to Kilwa in 1616 (Gray, 1948)).

There are no written records of the history of the coastal hinterland prior to the middle of the last century, although oral historical accounts of the various tribes currently settled in the Coastal Forest belt indicate that these arrived relatively recently, typically 200–500 years ago, during a period of extensive tribal

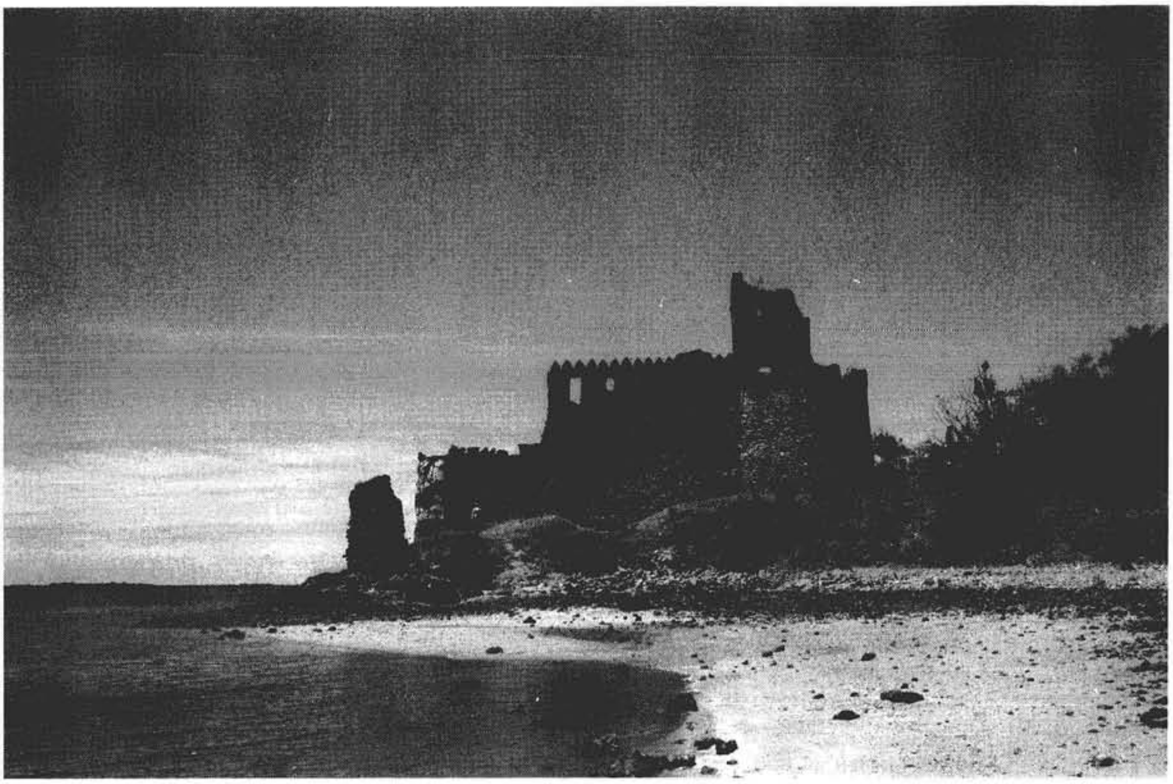


Figure 5.1.2 Portuguese fort at Kilwa Kisiwani, (Tanzania) used as a base to control trade along the eastern African coast. (*Photo: G.P. Clarke*)

Figure 5.1.3a Forest-covered Swahili ruins at Gede near Malindi (Kenya coast), abandoned at about the time of the arrival of the Portuguese. (a) Palace. (*Photo: G.P. Clarke*)

Figure 5.1.3b Forest-covered Swahili ruins at Gede near Malindi (Kenya coast), abandoned at about the time of the arrival of the Portuguese. (b) Mosque. *(Photo: G.P. Clarke)*

movements in eastern and southern Africa. The recent arrival of the tribes in the area may account for the poor knowledge that they have of their local forest plant species (Clarke, pers. obs.), particularly when compared to their excellent knowledge of the woodland species occurring in the areas surrounding the forests. This would indicate that these tribes have a much longer acquaintance with woodland rather than forest areas.

The settlement of the people of the coastal hinterland may be linked with the introduction of new foodcrops by the Portuguese, which would have allowed the population to expand and become settled, but this would have probably also meant an increase in the rate of forest loss in these areas.

Colonialism and plantations

Portuguese interests in eastern Africa were initially limited to the establishment of a number of forts and settlements, from which the coastal trade could be dominated and taxed. The introduction of a colonial-style economy can be ascribed to the Omani Arabs, who first wrested control of the Kenyan and Tanzanian coastal towns and trade from the Portuguese at the end of the seventeenth century, and later introduced cash crop plantations (cloves and cardamom) to Zanzibar and Pemba at the beginning of the nineteenth century. Large tracts of land were cleared for these plantations, such that Pemba Island, which was thickly forested before 1830, now has just a few km^2 of forest left. Coconut plantations were introduced to the mainland coastal areas from the middle of the nineteenth century, and Dar es Salaam, which was formerly covered with Gum Copal [*Hymenaea verrucosa*] forest, (see Figure 5.1.4) was cleared to create a coconut plantation for the Sultan of Zanzibar in the 1870s (Gray, 1952). These plantations were worked with slave labour, which probably caused a redistribution of the eastern African population from the hinterland to the coast and islands, rather than an overall population decline (Kjekshus, 1977).

The arrival of the European powers throughout eastern Africa at the end of the nineteenth century led to the spread of colonialism over the whole of eastern Africa. New cash crops were introduced to the coastal regions, particularly sisal and rubber. The plantations increased the demand for labour which was partially satisfied by the migration of people from inland areas (Kjekshus, 1977). Combined with better diets and healthcare these factors caused a substantial increase in the

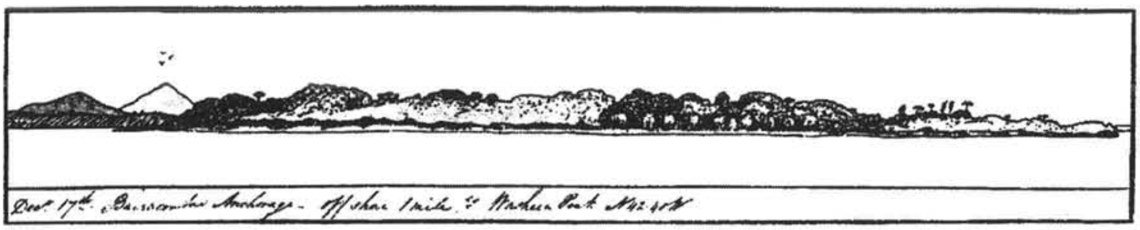


Figure 5.1.4 Dar es Salaam from Oyster Bay in 1822, showing thick (?gum copal) forest on the Msasani Peninsula, as drawn by J.C. Galler, acting pursar on H.M.S. Barracouta (Captain A.E. Vidal). Pugu Hills to background left. Reproduced with permission of the UK Hydrographic Office.

population of coastal areas near the ports, with a corresponding increase in fuelwood, timber and cultivation pressures on the Coastal Forests (Chapter 5.3). Areas close to the large coastal cities have been most affected by the burgeoning human population, and some forests have completely disappeared during the last century, e.g. the Sachsenwald [Mogo] forest near Dar es Salaam and the Amboni forests near Tanga.

Imperial rule and forest management

In spite of the abolition of slavery, the advent of new medicines, plantation crops and industrialisation, the imposition of European imperial rule in eastern Africa, where traditional systems were disrupted and people were evicted from their land, actually caused the overall population to go into decline (Kjekshus, 1977). Colonial wars, as well as the First World War, caused a massive loss of life among the eastern African people, which added to that caused by the rinderpest epidemics and the arrival of jiggers and syphilis. The population decline that followed allowed areas that were formerly cultivated to revert to bush, such that game animals returned and with them the tsetse fly and sleeping sickness, thereby spiralling the population decline into a vicious circle and an eventual population collapse from the 1890s to the 1920s (particularly in the inland areas), which did not recover until the 1960s (Kjekshus, 1977).

This population collapse may have temporarily relieved the pressure on many of the Coastal Forests (except those near the large cities), i.e. through the cessation of salt and local iron production (Kjekshus, 1977), and by the abandonment of plantations on the coast that had formerly fed the slave industry (Moomaw, 1960). In addition, this period coincided with the advent of forest gazettement and management practices, so that for the first time the forests were considered to merit conservation[8], albeit to monopolise timber production and to safeguard water catchments.

Most of the Coastal Forests are now contained within Forest Reserves or National Parks (Chapter 5.2; Burgess and Muir, 1994), so their history over the last 100 years is largely that of the development of the forestry service in eastern Africa. A detailed description of Forestry follows in the next Chapter, focusing on Tanzania.

Summary

The history of the interaction between humans and the Coastal Forests is one of ever increasing disturbance leading to the fragmentation of what must once have been a much more extensive forest along the eastern African seaboard.

The fragmentation process started with the introduction of increased burning, so that bushfires were increased in frequency far above the natural rate and would have gradually reduced the extent of forest over thousands of years. This process was then accelerated by the development of a large

[8] The Mijikenda people of the Kenyan coast have protected many small patches of Coastal Forest as sacred, and similar local protection is also known to occur in Tanzania (Hawthorne, 1993). However, such local protection is usually only afforded very small areas and thus the gazettement of Forest Reserves at the beginning of the 20th century marks the first instances where larger tracts of forest were protected in their entirety.

population along the coast during the first millennium BC, and later in the foothills of the Eastern Arc Mountains where forest was first cleared for cultivation and to fuel iron smelting. Degradation of the forests near the coast would have continued with the development of the Swahili civilisation, but further inland the forests were probably little disturbed (except by fire) until new crops brought by the Portuguese led to an increasing population that was forced to seek more marginal land suitable for cultivation, starting about 500 years ago. The development of cash-crop plantations from the nineteenth century onwards further depleted the extent of the forests in areas with a higher rainfall, such as along the coast, on the islands and later (during European colonisation) at the base of the Eastern Arc mountains.

The Scramble for Africa at the end of the nineteenth century temporarily halted the process of forest loss (except in areas that were converted to plantations, or near the coastal ports), but by this time only tiny fragments of the extensive forests that were formerly present at the base of the Eastern Arc Mountains and along the coast were left for gazettement into Forest Reserves. The majority of the remaining patches of Coastal Forest have now been incorporated into protected areas, but all of the forests are still threatened with total elimination as a consequence of an ever increasing demand for farmland, fuel and timber (Chapters 5.2 and 5.3).

Acknowledgements

The 1992 fieldwork at the Kilwa Coast sites was supported by the Norwegian Agency for International Development (NORAD) through Grant no. TAN 064 under the University of Bergen and the University of Dar es Salaam Co-operation in Archaeology. Comments on this chapter were received from Alan Rodgers and Neil Burgess.

References

Aldrick, J. (1990). The Nineteenth-century carved wooden doors of the East African Coast. *Azania* **XXV**: 2–18.

Alexander, C.S. (1969). Beach ridges in northeastern Tanzania. *The Geographical Review* **59**: 104–122.

Birch, W.R. (1963). Observations on the littoral and coral vegetation of the Kenya coast. *Journal of Ecology* **51**: 603–615.

Brian, C.K. (1993). A taphonomic overview of the Swartkrans fossil assemblages. Pp. 257–264. In Brian, C.K. (ed.). Museum Monograph 8. Swartkrans. *A Cave's Chronicle of Early Man*. Transvaal Museum, Pretoria.

Burgess, N.D. and Muir, C. (1994). *The Coastal Forests of Eastern Africa: Biodiversity and Conservation*. Society for Environmental Exploration/University of Dar es Salaam, London and Dar es Salaam.

Chami, F.A. (1992). Limbo: early iron-working in south-eastern Tanzania. *Azania* **XXVII**: 45–52.

Chami, F.A. (1993). New Chronology for the First Millennium AD Sites on the Coast of Eastern Africa. Mombasa: Paper presented at the Urban Origins Conference in Mombasa, 1993.

Chami, F.A. (1994). *The Tanzanian Coast in the First Millennium AD: an archaeology of the iron-working, farming communities (with microscopic analyses by Anders Lindahl)*. Studies in African Archaeology no.7. 107pp. Societas Archaeologica Upsaliensis, Uppsala.

Chittick, N.H. (1974). *Kilwa: An Islamic Trading City on the East African Coast*. Memoir No. 5. British Institute in Eastern Africa, Nairobi.

Clark, J.D. and Harris, J.W.K. (1985). Fire and its roles in early hominid lifeways. *The African Archaeological Review* **3**: 3–27.

Clarke, G.P. and Stubblefield, L. K. (1995). *Status Reports for 7 Coastal Forests in Tanga Region, Tanzania*. Frontier-Tanzania Technical Report No. 16. The Society for Environmental Exploration/The University of Dar es Salaam, London and Dar es Salaam.

Cooke, H.J. (1970). The cave systems of the Tanga Limestone in north-east Tanzania and the influence of former sea-levels on their formation. *Studies in Speleology* **2**: 69–78. Published by William Pengelly Cave Studies Trust Ltd.

Cooke, H.J. (1974). The coastal geomorphology of Tanga, Tanzania. *Geographical Review* **64**: 515–535.

Dale, I.R. (1954). Forest spread and climatic change in Uganda during the Christian Era. *Empire Forest Review* **33**: 23–29.

Deschamps, R. (1984). Evidence of bushfires during Plio-Pleistocene in Africa (Omo and Sahabi) with the aid of fossil woods. *Palaeoecology of Africa* **16**: 291–294.

Elton, F. (1874) On the copal districts south of Dar-es-Salaam, East African Coast. *Journal of the Royal Geographical Society* **44**: 227–230 + map.

Forest Department (1948). *Annual Report of the Forest Department 1947*. Government Printer, Dar es Salaam.

Freeman-Grenville, G.S.P. (1967). The Coast, 1498–1840. In Oliver, R. and Mathew, G. (eds.) (1967). *History of East Africa the Early Period*. Oxford University Press, Nairobi.

Gillman, H. (1945). Bush fallowing on the Makonde Plateau. *Tanganyika Notes and Records* **19**: 34–44.

Gramly, R.M. (1978). Expansion of Bantu-speakers versus development of Bantu language and African culture *in situ*: an archaeological perspective. *South African Archaeological Bulletin* **XXXIII**: 128.

Granger, J.E. (1984). Fire in Forest. In Booysen, P. de V. and Tainton, N.M. (eds.) *Ecological Effects of Fire*. Springer-Verlag, Berlin.

Gray, Sir J. (1952). Dar es Salaam under the Sultan of Zanzibar. *Tanganyika Notes and Records* **33**: 1–21.

Gray, Sir J. (1948). A journey by land from Tete to Kilwa in 1616. *Tanganyika Notes and Records* **26**: 37–47.

Hall, M. (1984). Man's historical and traditional use of fire in Southern Africa. In Booysen, P. de V. and Tainton, N.M. (eds.). *Ecological Effects of Fire*. Springer-Verlag, Berlin.

Hamilton, A.C. (1989). African Forests. In Leith, H. and Werger, M.J.A. (eds.). *Tropical Rain Forest Ecosystems: Biogeographical and Ecological Studies*. Elsevier, Oxford.

Hamilton, A.C. (1981). The Quaternary history of African forests: its relevance to conservation. *African Journal of Ecology* **19**: 1–6.

Harding, J.R. (1961). Late stone age sites on the Tanganyika Coast. *Man* **61**: 221.

Hawthorne, W.D. (1993). East African Coastal Forest botany. Pp. 57–99. In Lovett, J.C. and Wasser, S.K. (eds.). *Biogeography and Ecology of the Rain Forests of Eastern Africa*. Cambridge University Press, Cambridge.

Horton, M. (1990). The Periplus and East Africa. Review Article. *Azania* **XXV**: 95–99.

Karoma, N.J. (1982). New Evidence of Palaeohistoric Human Activity along the Kilwa Coast, South-eastern Tanzania. Unpublished Mimeograph. Department of History, University of Dar es Salaam, Dar es Salaam.

Karoma, N.J., Schmidt, P.R., La Violett, A., Fawcett, W.B., Mabulla, A., Rutanbanzibwa, L. and Saanane, C. (1988). Archaeological Investigations in the vicinity of Mkiu, Kisarawe District, Coast Region, Tanzania. *Archaeological Contributions of the University of Dar es Salaam*. Occasional Paper no. 1.

Karoma, N.J. (1993a). Later Quaternary Archaeological Occurrences on the Kilwa Coast, Southern Tanzania. Arusha: Paper presented at the International Congress in Honour of Mary Leakey's Outstanding Contribution in Palaeoanthropology.

Karoma, N.J. (1993b). Past and present exploitation of the Baobab tree *Adansonia digitata* in the Kilwa Coast area, southeastern Tanzania: Its implications for prehistory. Arusha: Paper presented at the International Congress in Honour of Mary Leakey's Outstanding Contribution in Palaeoanthropology.

Kato, Y. (1988a). Surface collected implements from three sites around Mombasa. In Omi, G. (ed.). *Mtongwe and Mgonga: Interim Report of the East and Northeast African Prehistory Research Project – 1986*.

Kato, Y. (1988b). A preliminary summary of the Palaeolithic culture development in the Coast Province of Kenya. In Omi, G. (ed.). *Mtongwe and Mgonga: Interim Report of the East and Northeast African Prehistory Research Project – 1986*.

Kerner von Marilaun, A. and Hansen, A. (1916). *Pflanzenleben. Dritter Band: Die Pflanzenarten als Floren und Genossenschaften*. Bibliographisches Institut, Leipzig and Vienna.

Kielland-Lund, J. (1988). Influence of grass fires on African landscape ecology. In Mgeni, A.S.M., Abeli, W.S., Chamshama, S.A.O. and Kokwero, G.S. (eds.) (1988). *Proceedings of a Joint Seminar/workshop on 'Management of Natural Forests of Tanzania' under Sokoine University of Agriculture and Agricultural University of Norway Cooperation*. Sokoine University of Agriculture, Morogoro.

Kjekshus, H.K. (1977). *Ecological Control and Development in East Africa*. Heinemann Educational Books, Nairobi.

Menaut, J-C., Lepage, M. and Abbadie, L. (1995). Savannas, woodlands and dry forests in Africa. In Bullock, S.H., Mooney, H.A. and Medina, E. (eds.). *Seasonally Dry Tropical Forests*. Cambridge University Press, Cambridge.

Moomaw, J.C. (1960). *A Study of the Plant Ecology of the Coastal Region of Kenya Colony, British East Africa*. Government printer, Nairobi.

Moll, E. and White, F. (1978). The Indian Ocean Coastal Belt. Pp. 561–597. In Werger, M.C.H. with assist. of van Bruggen, A.C. (eds.). *Biogeography and Ecology of Southern Africa*. Dr. W. Junk Publishers, The Hague.

Moreau, R.E. (1933). Pleistocene climatic changes and the distribution of life in East Africa. *Journal of Ecology* **XXI**: 415–435.

Phillips, J. (1965). Fire-as master and servant: its influence in the bioclimatic regions of trans-Saharan Africa. *Proc. Tall Timbers Fire Ecology Conf.* **4:** 7–109.

Schepantz, L.A. (1988). Who were the later Pleistocene eastern Africans? *The African Archaeological Review* **6:** 57–72.

Schmidt, P.R. (1989). Early exploitation and settlement in the Usambara Mountains In Hamilton, A.C. (ed.) (1989). *Forest Conservation in the East Usambara Mountains, Tanzania*. IUCN, Gland, Switzerland and Cambridge, UK.

Schmidt, P.R. and Childs, S.T. (1985). 'Innovations and industry during the early Iron Age in east Africa: the km2 and km3 sites of northern Tanzania'. *African Archaeological Review* **3:** 53–94.

Schmidt, P.R. and Karoma, N.J. (1987). 'Preliminary Report: Archaeological Survey of the Western Usambara Mountains, West and South-west of Lushoto, Tanga region and Kilwa, Kilwa Coastal Zone, Lindi Region'. Unpublished report submitted to the Antiquities Unit, Ministry of Culture, Youth and Sports, Tanzania.

Schmidt, P.R., Karoma, N.J., La Violette, A., Fawcett, W.B., Mabulla, A.Z., Rutabanzibwa, L.N. and Saanane, C.M. (1992). *Archaeological investigations in the vicinity of Mkiu, Kiserawe District, Tanzania*. Archaeological Contributions of the University of Dar es Salaam. Occasional Paper No. 1.

Sheil, D. (1992). Tanzanian Coastal Forests – unique, threatened, and overlooked. *Oryx* **26:** 107–114.

Sinclair, P.J.J., Morais, J., Adamowicz, L. and Duarte, R. (1993). A perspective on archaeological research in Mozambique. Pp. 409–31. In Shaw, T., Sinclair, P.J.J., Andah, B.and Okpoko, A. (eds.). *The Archaeology of Africa: food, metals and towns*. Routledge, London.

Strandes, J. (1899). *Die Portugiesenzeit von Deutsch- und Englisch-Ostafrika*. Berlin. Reprinted English translation as *The Portuguese Period in East Africa*. Kenya Literature Bureau, 1961, Nairobi.

Sutton, J.E.G. (1990). *A Thousand Years of East Africa*. British Institute in Eastern Africa, Nairobi.

Swaine, M.D. (1992). Characteristics of dry forest in West Africa and the influence of fire. *Journal of Vegetation Science* **3**: 365–374.

Swaine, M.D., Hawthorne, W.D. and Orgle, T.K. (1992). The effects of fire exclusion on savanna vegetation at Kpong, Ghana. *Biotropica* **24**: 166–172.

Swynnerton, C.F.M. (1917). Some factors in the replacement of the ancient East African forest by wooded pasture land. *South African Journal of Science* **14**: 493–518.

Trapnell, C.G. (1959). Ecological results of woodland burning experiments in Northern Rhodesia. *Journal of Ecology* **47**: 129–168.

Troup, R.S. (1923). Forestry in Kenya Colony. *Empire Forestry Journal* **2**: 46–60.

White, F. (1983). *The Vegetation of Africa*. A Descriptive Memoir to Accompany the UNESCO/ AETFAT/UNSO Vegetation Map of Africa. UNESCO, Paris.

White, F. (1993). Refuge theory, ice-age aridity and the history of tropical biotas: an essay in plant geography. *Fragmenta Floristica et Geobotanica* **2** Pars 2: 385–409.

Yasukawa, T. (1988). Palaeolithic Implements excavated and collected at the Mtongwe site 1986. In Omi, G. (ed.). *Mtongwe and Mgonga. Interim Report of the East and Northeast African Prehistory Research Project – 1986.*

were experimental plantations of Coastal Forest species such as *Milicia excelsa, Afzelia quanzensis* and *Baphia kirkii* (Anon, 1911; Wood, 1966).

During the period of the First World War the lack of effective supervision resulted in considerable forest damage through encroachment by shifting cultivators (Troup, 1940).

British administration (1918 –1961)

The British administered Tanganyika under a League of Nations mandate from the end of the First World War until independence in 1961.

A Department of Forestry headed by a Conservator of Forests was created on the 20th December 1920, the Conservator arrived in January 1921 and the other staff soon followed (Forest Department, 1921). The initial priority of the Department was to introduce a new Forest Ordnance (September, 1921) and to re-proclaim all the German gazetted reserves, which were principally in the coastal mangroves, the Coastal Forests and the Eastern Arc Mountains. The administration then started dealing with problems in reserves which had been reclaimed by local people, instigated protection against illegal cutting, clearing and grazing, and started programmes to resume timber extraction. Forest Reserves were also established in some of the former German estates, especially in the East Usambara Mountains following the seizure of these estates (Rodgers and Homewood, 1982; Hamilton and Mwasha, 1989b). This consolidation phase lasted up to the onset of the Second World War (Grant, 1924; Troup, 1936 and 1940; Parry, 1962; Sangster, 1962; Lundgren, 1975; Hamilton and Mwasha, 1989b; Rodgers, 1993).

The Tanganyikan forestry service was initially modelled on that of India, because Indian forestry had been established on a sound commercial basis during the latter half of the nineteenth century, raising revenue for the government whilst also being able to finance extensive programmes of reafforestation (Troup, 1940). Indian-trained foresters were recruited into the African colonies in the hope that they would be able to achieve the same results. However, it became clear that the lower yield of merchantable timber in the Tanzanian (and Kenyan) forests made it very difficult, if not impossible, to generate sustained revenue surpluses (Troup, 1923; Nicholson, 1931; Brasnett, 1942; Ofcansky, 1984).

Between the First and Second World Wars colonial forest policy was derived from the Imperial Forestry Institute (now Oxford Forestry Institute), and could be summarised as 'the public good was best served through the protection of forests and water resources, even if this meant the displacement of local communities' (McCracken, 1988). Assessments were also made of the potential of indigenous trees and shrubs (e.g. Brenan and Greenway, 1949), and of the value of forests to safeguard water supplies (Hughes, 1949).

In Tanganyika[2] forest exploitation was stepped up during the Second World War to meet the demands of the war, and this intense exploitation continued until the early 1950s (see later). This policy caused considerable damage to the Coastal Forests, especially those of the Rondo Plateau and the Tanga area. However, in 1953 a new forest policy statement for the Forestry Department was issued (Box 5.2.1) which was more orientated towards conservation of forest resources, although not specifically their biodiversity values, and the involvement of local people in management was not sought.

This policy remained in force until early 1998, when it was replaced by one which was more open to involving local people in forest management (see Chapters 5.4 and 5.5).

Throughout the period of British colonial forestry in Tanganyika there was a degree of conflict with the local populations. The local people considered forest conservation which was deemed 'for the public good' to be a restriction of their private rights to gather forest products, cut trees and farm and graze animals in the forest area (Forest Department, 1921–1961).

---

[2] Also in Kenya (Gardner, 1942).

Box 5.2.1 Forest policy statement for the Tanganyikan Forest Department (Forest Department, 1953)

(a) To demarcate and reserve in perpetuity, for the benefit of present and future inhabitants of the country, sufficient forested land or land capable of afforestation to preserve or improve local climates and water supplies, stabilise land which is liable to deterioration, and provide a sustained yield of forest produce of all kinds for internal use and export.

(b) To manage forest estate and all forest growth on public land so as to obtain the best financial returns on capital value and cost of management in so far as such returns are consistent with the primary aims above.

(c) To encourage and assist the practice of forestry by local Government bodies and by private enterprise.

(d) To undertake and promote research and education in all branches of forestry and to build up by example and teaching a real understanding among the people of the country, of the value of forests and forestry to them and their descendants.

Post-colonial period (1961–present)

After independence the protection and exploitation functions of the Forestry Department continued much as before, except that the British officers gradually returned home as Tanzanian nationals were trained to take their places (Hamilton and Mwasha, 1989c; Forest Department, 1962–1970 and 1978; Somi and Nshubemuki, 1980; Holmes, 1995).

A major change in the management of forestry in Tanzania occurred between 1968 and 1972 when the government was decentralised. Following decentralisation, forestry management was undertaken by the Regional and District administrations. The Director of Forestry remained in control of the Forestry Department at central government level, but could only 'advise' on management issues relating to most Forest Reserves (including Coastal Forests). Regional and District Forestry Officers undertook the work in the forests, but were responsible to their local administrations and *not* to the Director of Forests. This change is regarded by senior foresters in Tanzania today as one of the major and continuing problems with the Tanzanian forestry service. Centralised functions, such as data-gathering and planned management declined from this time, and the situation worsened with increasing financial problems in the country, and frequent changes in the location of the Forestry and Beekeeping Division Headquarters in Dar es Salaam. This, however, was not the same in Kenya where the Division remained centralised, but the centralised functions declined nonetheless, due to a general lack of finance.

In 1988, Tanzania prepared a Tropical Forest Action Plan (TFAP) (Bensted-Smith and Msangi, 1989), which built on the existing Forestry Policy and was adopted by the Government of Tanzania in 1992. Its aim was to coordinate aid donor inputs to the forestry sector, but was also an acknowledgement that the major funding for forestry was being provided by foreign multilateral and bilateral aid donors of 'northern' countries (particularly Scandinavia).

The Tanzanian TFAP document generated considerable interest amongst the donor community, and the Coastal Forest options have been taken up by environmental non-governmental organisations (NGOs – including the World Wide Fund for Nature (WWF) and the Wildlife Conservation Society of Tanzania (WCST)), both using their own money and funds provided by other sources (see Chapter 5.4)). The TFAP has probably assisted in channelling funds to the conservation and management of the Coastal Forests, but it is difficult to separate the effect of the TFAP from a surge of environmental awareness in donor countries during the late 1980s and early 1990s.

In the last few years there has been a considerable retrenchment of forestry staff, and a shift from the government/donors as paymaster to the current situation where the Forestry Department is permitted to keep 70% of the revenue it generates through licences, camping fees etc. It is likely that this trend towards self-accounting and self-financing will continue and it remains to be seen what effect this will have on the management of the Tanzanian forests, although in 1996 the Department only collected about 30% of the funds that it needed to finance its programmes. At the same time donor support declined from $22.5 million in 1990–91 to $12.4 million in 1996, and the government's development contribution has fallen from TSh 98 million in 1992/93, to zero in 1995/96.

History of forest protection in Tanzania

Records of the Forestry Department in Tanzania (Forest Department, 1921–1970 and 1978), unpublished reports (Lovett and Pócs, 1993; Eriksen *et al.,* 1993; Clarke, 1995; Clarke and Dickinson, 1995; Clarke and Stubblefield, 1995), and the published documents referenced above have provided the data for this section.

Gazettement of Coastal Forests as Forest Reserves

Tanzanian Forestry Department records state that the majority of Coastal Forest reserves were gazetted during the British period. In fact, we believe that most reserves were originally designated by the Germans and then re-declared by the British (Table 5.2.1). Only a few Forest Reserves have been declared since independence, although renewed programmes of gazettement have been initiated in recent years through partnerships between Forestry Department and foreign aid donors, in some cases regazetting reserves which had been degazetted in the 1970s and 1980s, or where the gazettement process had never been completed.

Table 5.2.1 Gazettement of Forest Reserves containing Coastal Forest in Tanzania, 1891–1995, and in progress.

Period (mainly 10-year blocks)	Numbers of reserves per period	Mean number of reserves per year	Total reserved area (km^2)
1891–1920 (German) (30yrs)	26	0.86	895.74
1921–1930 (British)	1	0.1	910.14
1931–1940 (British)	1	0.1	959.14
1941–1950 (British)	1	0.1	1003.14
1951–1960 (British)	16	1.5	2647.64
1961–1970 (Independent)	3	0.3	2694.64
1971–1980 (Independent)	0	0	2694.64
1981–1990 (Independent)	1	0.1	2706.94
1991–1995 (Independent)	2	0.4	2764.94
In progress (Independent)	7	0	
Total	**51, plus 7 in progress**		**2764.94**

Source: From data in Forest Department 1921–1970, 1978; and G.P. Clarke's analysis of Forest Department records since that time.

Activities of forestry officers through time

The official duties of forestry officers in Tanzania have never significantly changed. These duties include survey and reserve gazettement, production of management plans/working plans, silviculture (controlled burning, natural regeneration, state plantation), and protection (annual boundary marking, protection from encroachment, apprehension of offenders, dealing with problems with animal and fungal pests).

What has changed is the level of finance available to the Forest Department to undertake these tasks. A decline in available funds started in the late 1960s, became serious in 1973 (coinciding with the first oil price shock), and continued to worsen throughout the 1980s and 1990s. This decline in finance is reflected in a reduction in activities and a major fall in written reporting by the Forest Department. Reduced reporting has resulted in increasingly scarce and unreliable statistics on all aspects of Forestry. Current retrenchment also means that there are few staff left in most offices.

A review of records in the Regional and District Forestry offices in Kilwa, Lindi and Tanga Regions show a marked decline in forestry activity after 1968. In some reserves, there have been no management activities for 30 years and the more remote reserves have been visited only rarely. Despite this great decline in forestry activity, Forest Reserve boundaries have generally remained well-respected by local people, sometimes due to the presence of a Forest Guard, but also because the positions of reserve boundaries were known and the local people respect government authority. Our experience, however, suggests that this respect started to break down in the late 1980s, and that this trend is continuing today (e.g. Chapter 5.4).

Wherever there is an externally financed project (see Chapter 5.4), capacity has been increased and in these areas forestry activities and staff morale have been greatly boosted. Also, the re-clearance and marking of the boundaries of a Forest Reserve demonstrate that the Forestry Department still has authority, and this benefit lasts for many years as the boundary remains clear and encroachment can be easily recognised.

Forest exploitation in Tanzania

Timber

There are several timber species in the Coastal Forests, which have long been valued by both indigenous peoples and Arab and European powers (Grant, 1934; Bryce, 1967) as they have the desirable traits of straightness, size, wood density and 'workability' (Table 5.2.2).

Table 5.2.2 Timber species in the Coastal Forests of eastern Africa.

Species	Distribution and habitat
1. Premium timbers suitable for high grade furniture and veneer	
Milicia excelsa	Widespread, f and w
Khaya anthotheca	Widespread, f
Afzelia quanzensis	s-m z-i za, f and w
Brachylaena huillensis	z-i za, f and w
Warburgia stuhlmanii	z-i, f and w
2. Lesser timbers for construction, plywood, flooring, crates, railway sleepers, etc.	
Antiaris toxicaria	Widespread, f
Baphia kirkii	z-i, f
Bombax rhodognaphalon	z-i f and w
Combretum schumannii	z-i &za , f and w
Cordia goetzei	z-i, f
Cordyla africana	z-i za, f
Diospyros mespiliformis	Widespread, f
Manilkara sansibarensis	z-i, f and w
Mimusops fruticosa	z-i mad, f
Newtonia paucijuga	z-i,f
Trichilia emetica	Widespread, f and w
3. Specialist wood for carving	
Dalbergia melanoxylon	Widespread, w
Brachylaena huillensis	s-m z-i, f
Combretum schumannii	z-i za, f and w

Key:
Distribution: z-i = Zanzibar- Inhambane regional mosaic; za = Zambezian regional centre of endemism; mad = Madagascar; s-m = Somalia – Masai regional centre of endemism (after White, 1983).
Habitat: f – forest habitat (includes evergreen thicket); w – woodland habitat.

The relative accessibility of the Coastal Forests meant that they were one of the earliest sources of timber from East Africa. Since the development of Forest Reserves, their most valuable specialist timbers have been the heaviest exploited, and many forests have been exhausted of *Milicia*, *Khaya* and *Brachylaena*. Species of *Hymenaea, Baphia, Afzelia* and *Manilkara* are still common canopy constituents of several Coastal Forests, and *Brachylaena* forms almost pure stands on drier sites which are still inaccessible to logging. These species have been more recently exploited, or are starting to be used now as other species become unavailable.

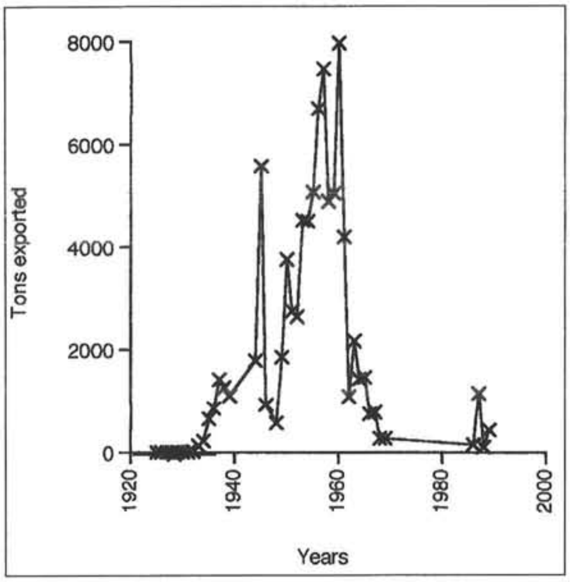


Figure 5.2.1(a) Timber exports: Mvule *Milicia excelsa* from Tanzania, 1925–1989 in tons dry wood (raw data from Forest Department, 1925–1978 and Forest Department, unpublished).

Timber volumes

Data on annual exports of timber are available from the late 19th century through to 1970, as well as for 1977–1978 and 1986–1989. Within the Coastal Forests, it has only been possible to locate detailed logging data for the Rondo forest in Tanzania[3]. However, by selecting species which are found in the Coastal Forests (e.g. Mvule *Milicia excelsa*) an impression of the logging rates in the Coastal Forests can be obtained (Figure 5.2.1a–c). This shows, in particular, how the British colonial Forest Department exploited the high value *Milicia excelsa* and *Khaya anthotheca* timbers between the First and Second World Wars, and especially in the 1950s and early 1960s.

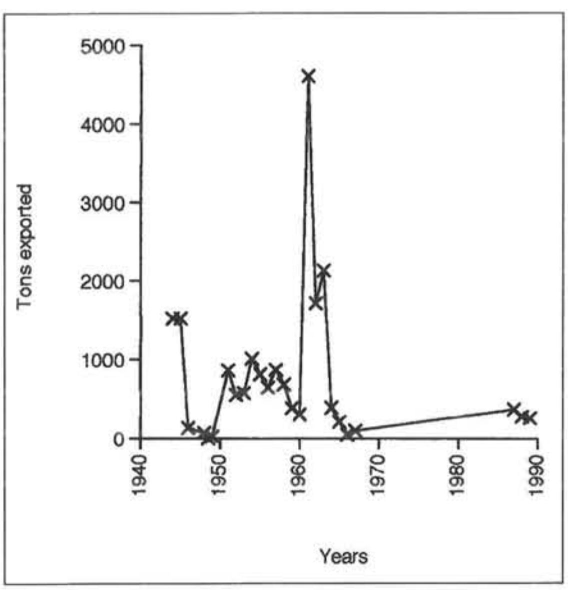


Figure 5.2.1(b) Timber exports: Mkangazi *Khaya anthotheca* 1943–1989 in tons dry wood (raw data from Forest Department, 1925–1978 and Forest Department, unpublished).

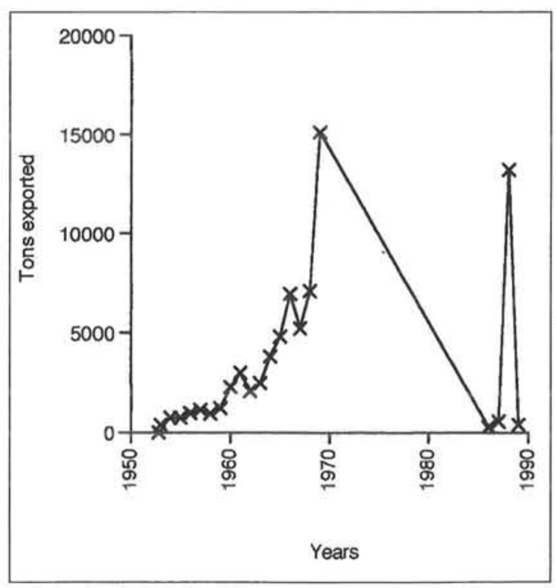


Figure 5.2.1(c) Timber exports: Mhuhu *Brachylaena huillensis* 1951–1989 in tons dry wood (raw data from Forest Department, 1925–1978 and Forest Department, unpublished).

3 Even the large scale and large budget KIFCON programme in Kenya was unable to compile these data for coastal Kenya (Wass, 1995).

The bulk of the *Milicia* exports during the late 1940s and 1950s came from the Rondo Plateau. The low volumes of both *Milicia* and *Khaya* harvested since Independence reflect the commercial scarcity of large trees, and more recently because timber trees have been extracted illegally by private operators (often using pit-sawing techniques). The majority of this timber has been used in Tanzania and is not thus recorded as an export. With the decline in availability of *Milicia* and *Khaya,* exploitation of *Brachylaena huillensis* became more important, with large volumes of this species being exported through the 1960s, 70s and 80s (although the data are sporadic in later years). Information from Kenya indicates that in recent years *Brachylaena* has become very scarce and exploitation is now focused on *Afzelia quanzensis, Brachystegia spiciformis* and *Manilkara sansibarensis* (Wass, 1995). This continues a trend over the past 50 years, where alternative timber species (of generally poorer quality) are substituted for preferred species as these become commercially extinct in the Coastal Forests (and elsewhere).

Data on the annual production of timber between 1951 and 1990, based on information recorded on exploitation licences, is also available in Tanzania (Figure 5.2.2). This data is useful for comparison with export figures (Figure 5.2.1) as the licences issued will be for both timber being exported and for timber used in the Tanzanian market, thus they may show a better picture of the exploitation of timber in the country's forests. Data presented (Figure 5.2.2) show the exploitation of different timber species over time. There is a decline in licence records from 1972, corresponding with the decentralisation of the government and a decline in reporting. There is also an apparent decline in the volume of timber harvested over time. This may be real, but it is difficult to determine because of (a) reduced centralised reporting following decentralisation, and (b) increased illegal pit-sawing as the management authority of the Forestry Department has declined.

During the colonial era, logging within Forest Reserves was carried out primarily by European- and Indian-owned companies that operated on long concessions using mechanised harvesting where possible (e.g. Steele Brothers in Rondo, Taj Mohammed in Morogoro, Sikh Sawmills in Tanga Region). At that time, pit-sawing was used strictly as a salvaging operation to remove what the concessionaires left behind. Quality hardwood timber from Tanzania was exported to markets in the UK, France, Germany, USA, with small quantities to a number of other countries and for use within

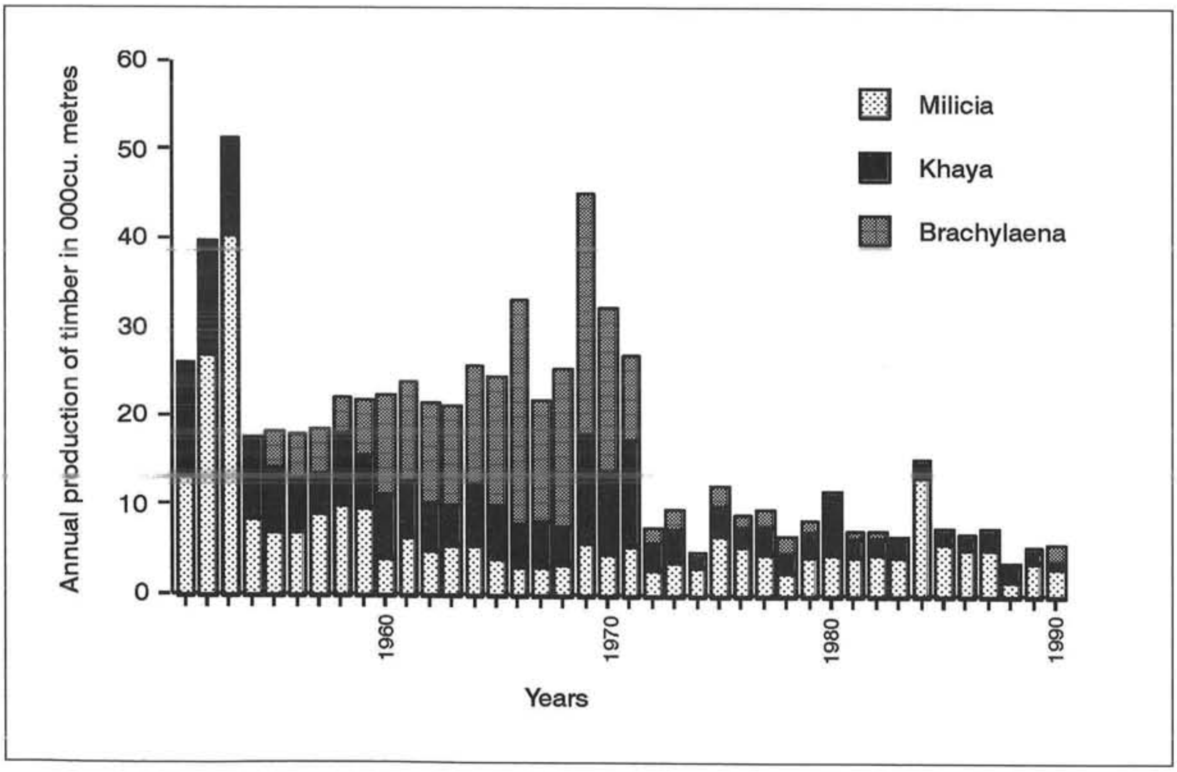


Figure 5.2.2 Annual production of timber in Tanzania 1951–1990, based on fee paying production, in 000cu. metres (from Bureau of Statistics, 1993).

Tanzania. The number of concessionaires has declined with time, and the last operating in the Coastal Forests were in Rondo (until 1984/85) and Sikh Sawmills in Kwamgumi and other lowland forests of the East Usambaras (until *c.* 1990). Timber exploitation from the Coastal Forests has increasingly been undertaken by small-scale operators using chain-saws or (much more commonly) pit-sawing teams, often operating illegally.

Table 5.2.3 Logging volumes and number of logs harvested from the Rondo Plateau, Tanzania, 1949–1960.

Year	Tree Species				Notes
	Mvule (*Milicia excelsa*)		Mninga (*Pterocarpus angolensis*)[A]		
	Cu. tons	No. logs ¼ girth	Cu. tons	No. logs ¼ girth	
1949–1951	3800	–	–	–	
1950	3545	–	–	–	1772 mvule trees
1951	–	–	–	–	sawn timber production started
1952	3600	–	–	–	average of 1.4 cubic tons/ tree and 4.5-6.0 cubic tons per acre
1953	4750	863,000	1000	228,000	
1954	4210	751,442	1070	237,442	
1955	4329*	779,350	817**	183,750	48,200 other logs, 7460 cu tons of all species
1956	3660*	658,750	992**	223,280	8060 cubic tons of all species
1957	5350*	963,000	1769**	398,080	9730 cubic tons of all species
1958	3910*	703,750	1697**	381,900	9990 cubic tons of all species
1959	4234*	762,064	2257**	507,936	8445 cubic tons of all species
1960	–	–	–	–	logging of mvule stopped
Total	**41,388***	**5,481,356**	**9602****	**2,160,388**	**62,115 cubic tons (all species)**

Notes: [A]Mninga (*Pterocarpus angolensis*) occurs outside forest in fire climax woodland.
* based on an average conversion rate of 180 1/4 girth logs/cu. ton.
** based on an average conversion rate of 225 1/4 girth logs/cu. ton.

The Rondo Plateau is the only Coastal Forest site where detailed logging data are available. A total of eight million cubic feet of mvule (*Milicia excelsa*) was reported to be present on the plateau in 1945 (Forest Department, 1946), making it the largest single concentration of this species in East Africa. The area was intensively logged by the Steele Brothers (Tanganyika Forest Ltd.) from 1949–1960 (Table 5.2.3) and periodically since then by the Tanzania Wood Industry Corporation (TWICO) (last in 1984–85). Because of the difficulties of opening up the Rondo Plateau, the government agreed that felling was to be completed over a 15-year period, which was not on the basis of sustained yield, although the Steel Brothers did plant extensive areas of *Milicia* on land that they had logged. The scale of the logging operation caused much comment at the time (e.g. Forest Department, 1951), and the fact that it was not carried out on the basis of sustained yield is typical of forest operations elsewhere in Africa (Poore, 1989).

The current timber resource in the Coastal Forests is very small (e.g. for Kenya, see Wass, 1995). It is generally not viable for commercial operators with mechanical machinery, but can still be exploited on a tree-by tree basis by local operators who use pit-sawing techniques. Most of this exploitation will be for the local furniture-making and construction markets, although some may also be exported.

Pit-sawing

Pit-sawing is conducted by teams of 2–4 people who are able to reach most parts of a forest to exploit selected trees. Once they have cut the tree, it is lifted onto a platform (made from 3–4 smaller and lower value trees), sawn into planks and carried out of the forest manually. Harvesting costs per plank are low, and for the best timbers represent less than 5% of the final market value. Until 1993 licences were available for pit-sawing in the Coastal Forests, but the prices were unrealistically low, and even then were often not obtained. In 1993 the Director of Forestry issued a decree to ban pit-sawing in Tanzanian Forest Reserves, to prevent the practice of further depleting stocks of timber trees. The rate of pit-sawing has certainly declined in some areas, e.g. the East Usambara lowland forests and Kilombero area, but there is no quantification of the reduction and pit-sawing continues in all areas (Cambridge-Tanzania Rain Forest Project, 1994; Woodcock, 1995; Fjeldså, pers. comm.).

Typically, the main beneficiaries of pit-sawing are the businessmen who arrange the transportation (have their own lorries) as well as the final sale of the timber, often to Dar es Salaam in Tanzania, or Kenya. The highly skilled pit-sawing crews are often from outside the Coastal Forest belt (often from Iringa Region), and stay in the forest for the work period only. In this case little or no benefit accrues to the local communities, or the local forestry service. Our experience from the lowland East Usambaras is that pit-sawyers can be unpopular with the local people, although the main reasons are not clear – be they a sense of income lost, a distrust of outsiders, or perhaps the loss of hunting opportunities. However, this is not always the case as in the Pugu Hills near Dar es Salaam the pit-sawing teams are locally derived and the money they make from this activity goes directly back to the villages they come from.

Pit-sawn timber obtained from the Coastal Forests has a high value in local terms (Table 5.2.4), especially considering that the monthly salaries for forestry workers when these surveys were undertaken were $30–50 per month.

Table 5.2.4 Example prices of timber trees and wood in 1991 and 1992.

Species	Year	Value		Units used	Data source
		TSh	USD ($)		
Milicia excelsa (Mvule)	1991	–	425	m^3 timber	Clarke, unpublished
Afzelia quanzensis (Mkomba)	1991	1,000	–	12'x1'x1" plank	Clarke, unpublished
Pterocarpus angolensis (Mninga)	1991	–	450	m^3 timber	Clarke, unpublished
Milicia excelsa (Mvule)	1992	300,000	665	Tree	Woodcock, 1995
Afzelia quanzensis (Mbambakofi)	1992	180,000	400	Tree	Woodcock, 1995
Newtonia buchananii (Mnyasa)	1992	150,000	335	Tree	Woodcock, 1995

Note: * US Dollar prices for 1991 were assessed as 350TSh = $1.00, and for 1992 as 450TSh = $1.00.

Management capability

The Tanzanian Forestry Department started from a very small number of staff at the end of the 19th century, and the numbers of professional foresters employed increased steadily since then (Figure 5.2.3). There was also a gradual increase in 'support' staff through time (drivers, typists, cleaners etc.). Moreover, a large and variable number of people were employed on a more casual basis to provide labour. Over the 17 years from 1951–1968 there was an average casual labour-force of 1604 people/year. Prison labour was also used in several areas.

During the German and British administrations the senior jobs were held by Colonial Officers. In 1953 there were 58 British staff employed in the Tanganyikan Forestry Service. After independence many of these officers departed for Britain, and increased emphasis was placed on training Tanzanians to fill the senior posts. A few British foresters continued to serve in the Tanzanian Forestry Department throughout the 1960s, and were gradually replaced as Tanzanians returned from training abroad. However, the Forestry Department has continued to be assisted by overseas volunteers and technical advisors, particularly from Scandinavia, Britain, Canada and America. Over time there have been changes in the emphasis of these agencies, from trying to promote commercial production forestry along the models developed in their own countries (e.g. Finland – see Pöyry, 1979; Moyo and Kowero, 1987), to the current emphasis on trying to ensure the involvement of local people in the management of the forests.

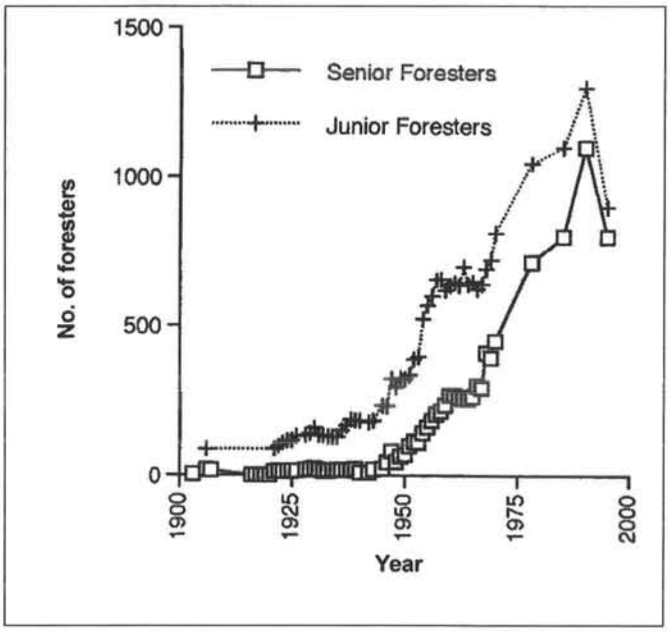


Figure 5.2.3 Numbers of senior foresters (Professional, Senior Technical and Junior Technical grades) and junior foresters (Forest Guards and Patrolmen grades) in the Tanzanian Forestry Department between 1903 and 1978 (from Colonial German records; Forest Department, 1920–1978), and estimated for 1985, 1990 and 1995.

We have not been able to locate detailed data on the numbers of forestry employees between 1978 and 1996. However, approximate numbers can be calculated from the known increase in the number of civil servants (e.g. Bureau of Statistics, 1993), assuming that forestry employee numbers increased in a similar way to other government sectors. Such an assessment indicates that the number of forestry employees probably doubled between 1978 and 1984 (to approx. 3400 staff), and probably doubled again by 1992 (to approx. 6800 staff). In 1992 the total number of government employees was around 500,000 (increased from 174,000 in 1980, 107,000 in 1976 and 105,062 in 1973). Since 1992, the number of government employees has been declining due to the conditions imposed by the World Bank/ IMF Structural Adjustment Programme. Between 1992 and 1994, 88,399 government staff were laid off and this process has continued. In the first phases of retrenchment only older and support staff were affected, but the current phase (1996/7) is removing trained foresters, and leaving the District and Regional Offices with few people to do the necessary jobs. Assuming that Forestry has lost an average number of staff, the current total number of forestry personnel is probably in the region of 5000.

Finances

The income and expenditure of the Forestry Department between 1922 and 1978 can be compiled from Forestry Department annual reports (Figure 5.2.4; Figure 5.2.5). Due to changes in the location of the Tanzanian Forestry Department headquarters, records have become scattered and we have not been able to locate centrally compiled statistics for the late 1970s and 1980s, although information is available for the 1990s (Tables 5.2.5 and 5.2.6).

After the establishment of the British colonial forestry service in 1920, the first operational profit was made in 1928. Profitability was reversed in the 1930s as the world underwent a severe recession, leading to a fall in demand for wood products. From the end of the Second World War until 1952, the Forestry Department made considerable profits, reflecting intense (and unsustainable) forest exploitation by the British administration, partially in an attempt to repay war debts. If the official financial figures are taken at face value the Forestry Department has made a loss every year since 1953.

Table 5.2.5 1990/91–1995/96 annual recurrent budget for the Tanzanian Forestry Sector (data from Forestry Department, Dar es Salaam).

Financial year	Budget TSh x 1000	US dollar rate	US dollar total
1990/91	143,583.9	1$ = TSh 180	797,688
1991/92	271,585.6	1$ = TSh 230	1,180,806
1992/93	304,315.1	1$ = TSh 350	869,471
1993/94	432,978.3	1$ = TSh 480	902,038
1994/95	612,876.0	1$ = TSh 520	1,180,530
1995/96	545,908.0	1$ = TSh 550	992,560

Table 5.2.6 1991/92–1995/96 annual infrastructural development and investment budget of the Tanzanian Forestry Sector (in TSh x 1000) (data from Forestry Department, Dar es Salaam).

Year	Local TSh x 1000	Foreign TSh x 1000	Total TSh x 1000	US dollar rate	Local in US dollar total	Foreign in US dollar total
1991/92	98,340	915,100	1,013,440	$1=TSh230	427,500	3,979,690
1992/93	161,289	2,617,935	2,779,224	$1=TSh350	460,820	7,479,810
1993/94	91,600	1,291,022	1,382,622	$1=TSh480	190,830	2,689,620
1994/95	45,700	2,441,554	2,487,254	$1=TSh520	87,884	4,695,260
1995/96	51,485	2,039,871	2,091,356	$1=TSh550	93,600	3,708,850

Note: 'Local'and 'foreign' denote the source of finance used for infrastructural development and investment.

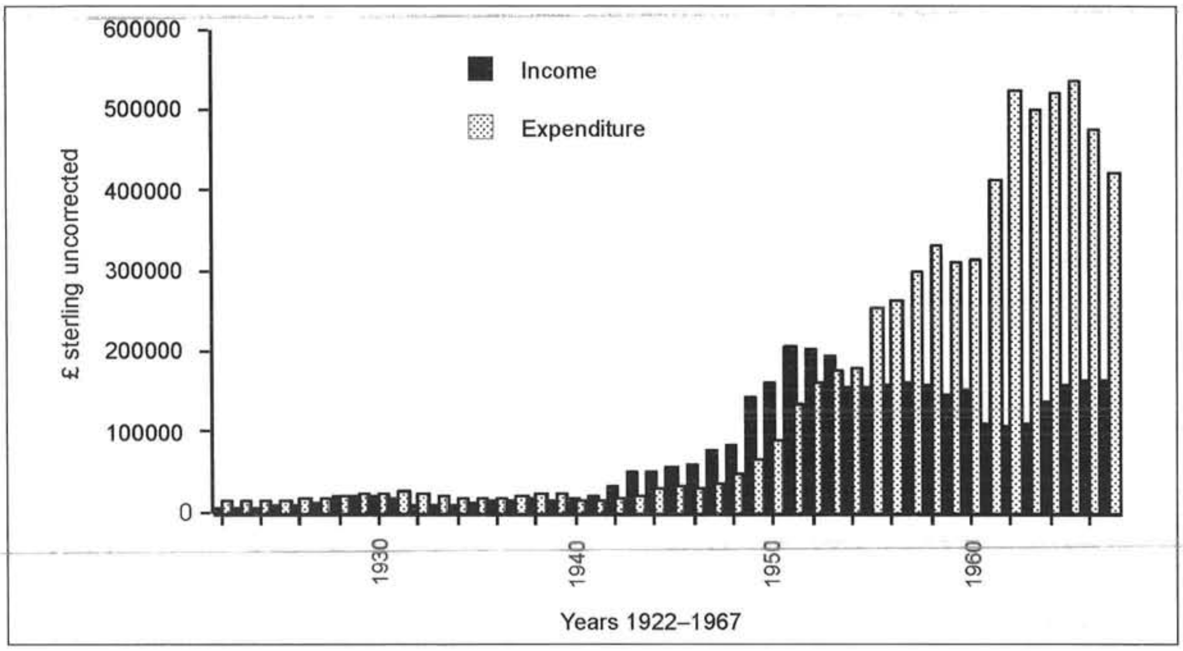


Figure 5.2.4 Income and expenditure of the Tanzanian Forest Department, 1922–1967 (as £ Sterling per year, uncorrected for inflation, devaluation etc.) (from Forest Department, 1922–1967).

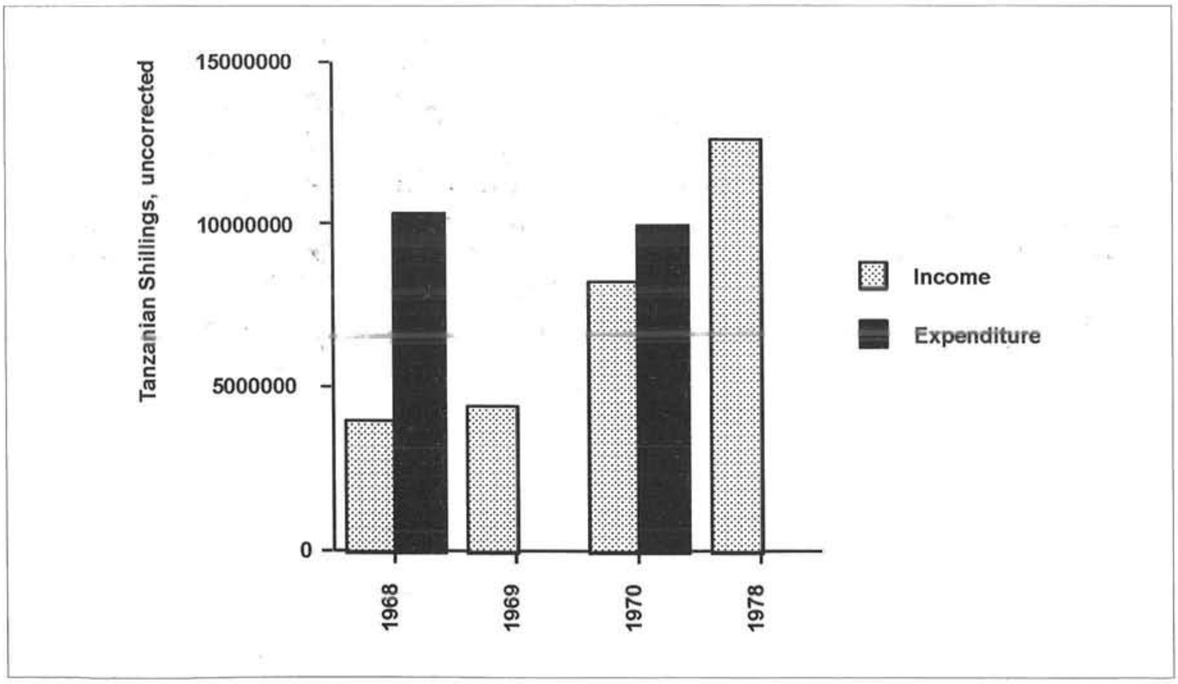


Figure 5.2.5 Income and expenditure of the Tanzanian Forest Department, 1968-1978 (in uncorrected Tanzanian Shillings) (from Forest Department, 1968–1978).

In recent years almost all of the annual recurrent budget has been used to pay staff salaries, with almost no money available for operational activities. Even the money available for salaries has been insufficient to provide a living wage. Assessments of the real value of the average monthly forester's wage showed that in 1986 this wage was worth less than 18% of its 1975 value, and that it covered about 25% of the required expenses of a typical household (World Bank, 1991). Wages have fallen further in real value terms since then, and civil servants are all obliged to have alternative means of earning money (Bagachwa *et al.*, 1994).

In the early 1990s funds from the Tanzanian government for capital investment in forestry were low, and most of this money came from foreign donors (Table 5.2.6). The quantity of externally supplied funds has, however, varied dramatically between years as projects have come and gone, and thus it is not easy to plan investment based on aid projects. Since 1994 the Forestry Department has been allowed to retain 70% of its recurrent revenue for running operational plans (Mariki, 1996), and the government has gradually ceased providing any development funding. Currently the Department is raising approximately 30% of its needs through this mechanism, and new ways of raising money are being considered (Katigula, 1996), as well as ways to improve the collection mechanisms (at least 50% of the money collected is believed not to reach the correct bank accounts – Mariki, 1996). At this time of major changes in the way that forestry is financed, the foreign donors have also been reducing their support, citing economic recession, fatigue in donating and their perception of a low capacity to manage 'affairs' in the Forestry Department (Mariki, 1996). Donor funding fell from $22.5 million in 1990/91 to $12.4 million in 1995/96, and the proportion used in consultancies rather than direct support increased. However, the amount of externally provided funding for Coastal Forest work with the Forestry Department has remained stable, or even increased over this period.

Plantations

Early German afforestation efforts are summarised in Stuhlmann (1902), and the British approach to plantation forestry is outlined in Honoré (1962). East African forests were assessed to produce too little timber annually to meet the demands of the population. The policy was thus to strip the productive forest areas of all marketable produce, firstly as timber and poles, and subsequently as firewood and charcoal. Once this had been completed, the land was then to be completely cleared and plantations established. Plantation forestry in the Coastal Forests was continued after independence, with plantations being established into the 1980s when a lack of funds stopped these efforts (Figure 5.2.6).

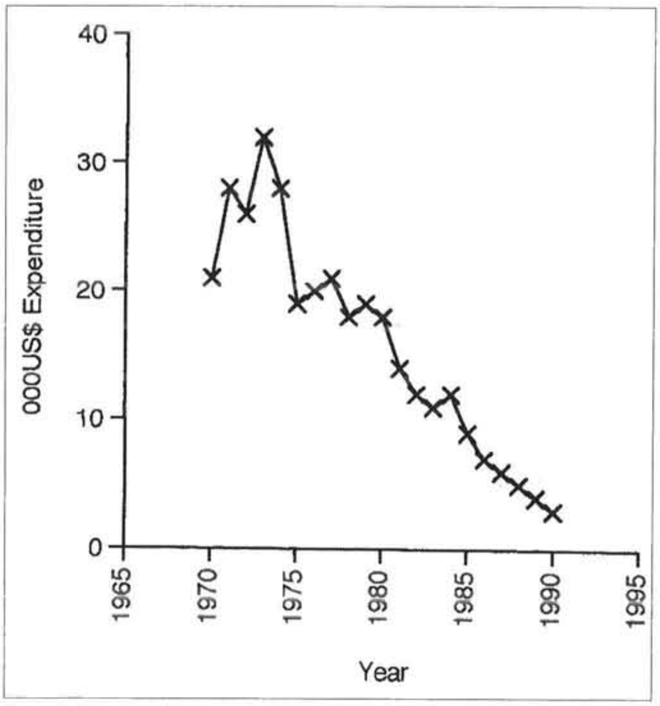


Figure 5.2.6 Expenditure on plantation forestry in Tanzania from 1970–1990 (from Bagachwa *et al.*, 1994).

Three types of plantations have been established in Tanzanian Coastal Forests; softwood and hardwood species for timber, fast-growing species which could produce fuelwood and building poles, and a mixture of species for the reafforestation of degraded areas within reserves. The largest timber plantation in a Coastal Forest was in the natural forest of the Rondo Plateau in southern Tanzania. Hardwood planting (especially of *Milicia excelsa*) established 1100ha of forest between 1953 and 1958, when the emphasis was shifted back to natural regeneration. Softwood planting continued until the 1980s (see Procter, 1968; Eriksen *et al.*, 1993; Clarke, 1995), by which time over 1700ha of *Pinus* species had been established. In the mid-1980s these efforts were abandoned as the infrastructure of this remote area declined too much to continue the work. Other plantations of timber species have been established, for example, in the Arabuko-Sokoke forest in Kenya, the lowland East Usambaras, Pugu Hills, Ruvu North and Vikindu. Teak *Tectonia grandis*, *Eucalyptus* species, and other trees such as *Grevillea robusta* have all been used in these plantations.

Plantations of fuel-wood and pole-producing species (mainly *Senna siamea*) have also been established within areas of Coastal Forest near to major towns. For example, plantations were set up during the 1950s within Vikindu, Pugu and Kazimzumbwi Forest Reserves near Dar es Salaam, and Bassi, Kolekole and Steinbruch Forest Reserves near Tanga. Harvesting was originally undertaken by contractors to supply the urban market with cooking fuel, but the deteriorating economic situation led to the collapse of this system.

Discussion and conclusions

The situation in other eastern African countries possessing Coastal Forests will have differed in detail from that of Tanzania which is presented above, but we believe that the same broad trends are seen, particularly in Kenya which has been well-documented elsewhere (Anderson and Grove, 1988; Ofcansky, 1984; Brasnett, 1942; Gardner, 1942; Honoré, 1962; Logie, 1962; Nicholson, 1931; Hutchins, 1907; 1909; Wass, 1995). The exceptions would be Mozambique and Somalia where there have been few forestry operations during the prolonged civil disturbances.

As discussed in Anderson and Grove (1988) the problems with forestry management in eastern Africa (as elsewhere) have often been a conflict of interests between a) local people who wished to continue to utilise the forest resources (including turning it to agricultural land), b) commercial companies that wished to exploit the forests for profit without external interference, and c) the Forest Department who sought to 'police' the exploitation of the forest for the 'public good' and in order to make a financial return, whilst also sustaining the forest resource. Political considerations have influenced the ability of the Forestry Department to manage the resource. In general, periods when forest conservation is more popular (e.g. during the late 1980s) tend to increase their influence, whereas periods when local people's rights or financial considerations are paramount, tend to reduce their influence and power. The financial means of the government also has a major bearing on whether the Forestry Department will be able to do its traditional job. In the past few years the Forestry Departments of eastern Africa have been debating the role and approaches to management and there is considerable interest in more 'participatory' methods of forest management, with foresters and the local community working together to conserve the resource for the benefit of both (Toledo, 1994–1996), and also in increasing sources of income from the forests (Katigula, 1996). In Tanzania the forest policy operating until early 1998 was still that of the colonial administration and participatory management could not fit easily within that framework. However this is changing and, as is indicated in Chapter 5.5, there is now a new Forest Policy and a number of projects in the Coastal Forests experimenting with the participatory approach to forest management. The need to make money from the forests in Tanzania may, however, influence the ways in which participatory management can be implemented.

One of the problems with writing this chapter was that data were relatively easy to compile from the late 19th century through to 1970 (and 1978) by using the Annual Reports of the Forest Department, but for the late 1970s to late 1980s data were far harder to obtain and come from a number of scattered sources. Despite considerable efforts, we were not able to obtain complete information for this period. Since the late 1980s data compilation functions have been strengthened at the Forestry Department Headquarters in Dar es Salaam, and we were able to locate more information for this period.

Despite the problems with obtaining a complete set of data, we believe that the generalised sequence of events in Tanzania can be discerned, and that this seems similar to that in other countries which possess Coastal Forests. The general trends can be summarised as follows:

- An establishment and initial exploitation phase when the colonial governments set up Forestry Departments to locate areas of forests, map them, gazette them as Forest Reserves, enumerate their timber resources and start/manage a programme of systematic exploitation. At this time the Forest Reserves were established primarily for the exploitation of their timber resources, a policy which was continued until the 1990s.

- The 1930s, when the global economic decline reduced the markets for timber products and Forestry Departments had considerable economic problems.
- The Second World War to early 1950s, when timber resources were heavily exploited to supply the demands of the war and to finance debts immediately following the war.
- The later 1950s to early independence period when Forestry Departments pursued both exploitation and conservation policies within their forestry estates, at a time when there was adequate funding for the work.
- The early 1970s onwards, when the oil price shocks and a worsening economic situation in eastern African nations was reflected in declining financial resources, salary levels and work within the Forestry Departments. Data compilation and quality also declined dramatically from this period.
- The later 1970s onwards, when aid donors started to provide funds for forestry work. By the 1980s funds available from government typically covered meagre salaries and little more. In many Coastal Forests forestry work largely ceased during this time, with exploitation becoming less well controlled.
- The late 1980s and early 1990s, when there was considerable aid financing, but forestry policy was still very much based on the colonial laws and foresters were often viewed as policemen protecting the forests from use by others. However, during this period considerable progress in forestry work was made. It was more widely recognised that the Forest Reserves of Tanzania contain a very significant biodiversity resource, and the provision of funds to the Forestry Department to maintain these forests for the species that they contain became increasingly common (particularly by national and international conservation NGOs).
- The later 1990s when the aid funding is falling, a proportion of the Forestry staff have been retrenched (made redundant), and the Department is being encouraged both to seek ways to increase its revenue and involve the local people in participatory forest management programmes. A new 1998 forest policy allows 'participatory' management of the forests for the first time and several projects are starting to experiment with this agenda. However, the authority of the Department is being challenged by powerful local people and institutions, and some areas of forest have been claimed by local people for farmland.

The current situation in Tanzania at least is well summarised in Chapter 5.4 where the pertinent question is asked 'who controls the forest resources of Tanzania?' The resolution of this question will be of major importance to the future of all forests in Tanzania. Recent news of the proposed degazettement of a large portion of the Arabuko-Sokoke forest in Kenya for farmland (Fanshawe, pers. com.) indicates that the same question is also relevant there, and that there are considerable challenges ahead if the Forest Reserves are to be maintained as one of the major ways to achieve the conservation of the Coastal Forests of eastern Africa.

Acknowledgements

We would like to thank Sarah Woodward and Phil Clarke for assisting in the compilation of data on Forest Reserves in coastal Tanzania. The library of the Forestry Department at the Ivory Rooms on the Pugu Road in Dar es Salaam, and the library of the University of Dar es Salaam also helped to locate information from Forestry Department files, and other historical documents. Comments on this chapter were received from Phil Clarke, Alan Rodgers, Jon Lovett and Peter Gibbon.

References

Anderson, D. and Grove, R. (1988). *Conservation in Africa, People, Policies and Practices*. Cambridge University Press, Cambridge.

Anon (1902). Forestry in German East Africa. *Indian Forester* **1902**: 372–374.

Anon (1911). Sonderbericht der Forstverwaltung von Deutsch-Ostafrika für das Jahr 1909. *Berichte Über Land und Forstwirtschaft in Deutsch-Ostafrika* **3**: 289–320.

Bagachwa, M., Shechambo, F., Sosovele, H., Kulindwa, K., Naho, A. and Cromwell, E. (1994). *Structural Adjustment and Sustainable Development in Tanzania*. Overseas Development Institute and WWF, London.

Bensted-Smith, R. and Msangi, T.H. (1989). *Tanzania Forestry Action Plan*. United Republic of Tanzania, Dar es Salaam.

Brasnett, N.V. (1942). Finance and the Colonial Forest Service. *Empire Forestry Journal* **21**: 7–11.

Brenan, J.P.M. and Greenway, P. (1949). *Check-list of the Forest Trees and Shrubs in the British Empire No.5: Tanganyika Territory. Part II.* Imperial Forestry Institute, Oxford.

Bryce, J.M. (1967). *The Commercial Timbers of Tanzania*. Tanzania Forest Division Booklet, Utilisation Section, Morogoro.

Bureau of Statistics (1993). *Selected Statistical Series: 1951–1990*. President's Office, Bureau of Statistics, Dar es Salaam.

Cambridge Tanzania Rainforest Project (1994). *A Biological and Human Impact Survey of the Lowland Forest, East Usambara Mountains, Tanzania*. BirdLife Study Report No.59. BirdLife International, Cambridge.

Clarke, G.P. (1995). *Status Reports for 6 Coastal Forests in Lindi Region, Tanzania*. Frontier-Tanzania Coastal Forest Research Programme, Technical Report No.18, Dar es Salaam.

Clarke, G.P. and Dickinson, A. (1995). *Status Reports for 11 Coastal Forests in Coast Region, Tanzania*. Frontier-Tanzania Coastal Forest Research Programme, Technical Report No.17, Dar es Salaam.

Clarke, G.P. and Stubblefield, L.K. (1995). *Status Reports for 7 Coastal Forests in Tanga Region, Tanzania*. Frontier-Tanzania Coastal Forest Research Programme, Technical Report No.16, Dar es Salaam.

Eriksen, T., Halberg, K. and Petersen, F.S. (1993). *A Proposal for a Conservation Initiative for Rondo, Litipo, and Chitoa, Lindi District, Tanzania*. University of Copenhagen/BirdLife International, Copenhagen.

Forest Department (1921–1970, 1978). *Annual Reports of the Tanzanian Forestry Department (1921–1970, 1978)*. Government Printer, Dar es Salaam.

Gardner, H.M. (1942). Kenya forests and the War. *Empire Forestry Journal* **21**: 45–47.

Grant, D.K.S. (1924). Forestry in Tanganyika. *Empire Forestry Journal* **3**: 33–38.

Grant, D.K.S. (1934). *Some Local Timbers*. Tanganyika Forestry Department Booklet, Government Printer, Dar es Salaam.

Graß, A. (1904). *Forststatistik für die Waldungen des Rufijideltas, angefangen im Jahre 1902*. German Colonial Administration.

Hamilton, A.C. and Mwasha, I.V. (1989a). History of resource utilisation and management: under German rule. Pp. 39–40. In Hamilton, A.C. and Bensted-Smith, R. (eds.) (1989). *Forest Conservation in the East Usambara Mountains, Tanzania*. IUCN, Gland, Switzerland and Cambridge, UK and Forest Department of Tanzania.

Hamilton, A.C. and Mwasha, I.V. (1989b). History of resource utilisation and management: under the British. Pp. 41–43. In Hamilton, A.C. and Bensted-Smith, R. (eds.) (1989). *Forest Conservation in the East Usambara Mountains, Tanzania*. IUCN, Gland, Switzerland and Cambridge, UK and Forest Department of Tanzania.

Hamilton, A.C. and Mwasha, I.V. (1989c). History of resource utilisation and management: after independence. Pp. 45–56. In Hamilton, A.C. and Bensted-Smith, R. (eds.) (1989). *Forest Conservation in the East Usambara Mountains, Tanzania*. IUCN, Gland, Switzerland and Cambridge, UK and Forest Department of Tanzania

Hermansen, J.E., Benedict, F., Corneliussen, T., Horfsted, J. and Venvik, H. (1985). *Catchment Forestry in Tanzania: Status and Management*. Institute for Environmental Analysis, Bo.

Holmes, J. (1995). *Natural Forest Hand-book for Tanzania. Vols I and II*. Sokoine University of Agriculture, Morogoro.

Honoré, E.J. (1962). Forestry in Kenya. Pp. 117–122. In Russell, E.W. (ed.). *The Natural Resources of East Africa*. Hawkins/East Africa Literature Bureau, London and Nairobi.

Hughes, J.F. (1949). Forest and water supplies in East Africa. *Empire Forestry Journal* **28**: 314–323.

Hutchins, D.E. (1907). *Report on the Forests of Kenya*. HMSO, London.

Hutchins, D.E. (1909). *Report on the Forests of British East Africa*. HMSO, London.

Katigula, M.I.L. (1996). Forgotten revenue sources in Catchment Forests. Pp. 24–26. In *Forestry is Wealth, vol. 2 (3* and *4*). Newsletter of the Forest and Beekeeping Divison, Dar es Salaam, Tanzania.

Logie, K.P.W. (1962). *Forestry in Kenya: A Historical Account of the Development of Forest Management in the Colony.* Government printer, Nairobi.

Lovett, J.C (1992). *Main report of the Udzungwa Forest Management Project Identification Mission. Pp. 108 plus 16 technical annexes.* Forest and Beekeeping Division, Ministry of Tourism, Natural Resources and Environment, and DANIDA. Dar es Salaam.

Lovett, J.C. and Pócs, T. (1993). *An Assessment of the Condition of the Catchment Forest Reserves.*Catchment Forestry Project, Forest and Beekeeping Division, Ministry of Lands, Natural Resources and Forestry, Dar es Salaam.

Lundgren, B. (ed.) (1975). *Land Use in Kenya and Tanzania.* Royal College of Forestry, Stockholm.

Mariki, S.W.L. (1996). Effective revenue collection: the lifeline for the Forestry Sector. Pp. 27–28. In *Forestry is Wealth, vol. 2* (*3 and 4*). Newsletter of the Forest and Beekeeping Divison, Dar es Salaam, Tanzania.

McCracken, J. (1988). Conservation priorities and local communities. In Anderson, D. and Grove, R. (eds.). *Conservation in Africa – Peoples, Policies and Practice.* Cambridge University Press, Cambridge.

Moyo, C.L. and Kowero, G.S. (1987). Some observations on sawn hardwood exports from Tanzania. *Forest Ecology and Management* **18**: 153–160

Nicholson, J.H. (1931). *The Future of Forestry in Kenya.* Government Printer, Nairobi.

Ofcansky, T.P. (1984). Kenya forestry under British colonial administration, 1895–1963. *Journal of Forest History* **28**: 136–143.

Parry, M.S. (1962). Progress in the protection of stream-source areas in Tanganyika. *East African Agricultural and Forestry Journal* **27**: 104–106.

Poore. D. (1989). *No Timber Without Trees: Sustainability in the Tropical Forest.* Earthscan, London.

Pöyry, J. (1979). *Wood Industries Development Programme in Tanzania.* Annex: Domestic and Export Market Prospects for Mechanical Wood Products. Finnida, Helsinki.

Procter, J. (1968). Tree growth on trial plots on the Rondo plateau. *Tanzanian Silvicultural Research Notes* **5**: 1–6.

Rodgers, W.A. and Homewood, K.M. (1982). Species richness and endemism in the Usambara mountain forests, Tanzania. *Biological Journal of the Linnean Society* **18**: 197–242.

Rodgers, W.A. (1975). Past Wandingo settlements in the eastern Selous Game Reserve. *Tanzania Notes and Records* **77/78:** 210–26.

Rodgers, W.A. (1993). The Conservation of the forest resources of eastern Africa: past influences, present practices and future needs. Pp. 283–331 In Lovett, J.C. and Wasser, S. (eds.). *Biogeography and Ecology of the Rain Forests of Eastern Africa.* Cambridge University Press, Cambridge.

Sangster, R.G. (1962). Forestry in Tanganyika. Pp. 123–125 In Russell, E.W. (ed.). *The Natural Resources of East Africa.* Hawkins/East Africa Literature Bureau, London and Nairobi.

Schabel, H.G. (1990). Tanganyika Forestry Under German Colonial Administration, 1891–1919. *Forest and Conservation History* **34**: 130–141.

Somi, F.G.R. and Nshubemuki, L. (1980). An Annotated List of Research Reports Issued by the Silvicultural Research Station from 1951 – Jan 1980. *Tanzania Silviculture Technical Note* (new series) No. **35**.

Stuhlmann, F. (1902). Übersicht über Land-und Forstwirtschaft in Deutsch-Ostafrika in *Berichtsjahre* vom 1 Juli 1900 bis 30 June 1901. Pp. 1–23. Carl Winter's Universtätsbuchhandlung, Heidelberg.

Toledo (1994–1996). Forestry is Wealth. *Newsletter of the Forest and Beekeeping Divison.* Dar es Salaam, Tanzania.

Troup, R.S. (1923). Forestry in Kenya Colony. *Empire Forestry Journal* **2**: 46–60.

Troup, R.S. (1936). *Report on Forestry in Tanganyika.* Government Printer, Dar es Salaam.

Troup, R.S. (1940). *Colonial Forest Administration.* Oxford University Press, Oxford.

Wass, P. (ed.) (1995). *Kenya's Indigenous Forests: Status, Management and Conservation.* IUCN, Gland, Switzerland and Cambridge, UK and The Overseas Development Administration, London.

White, F. (1983). *The Vegetation of Africa.* A Descriptive Memoir to Accompany the UNESCO/AETFAT/UNSO Vegetation Map of Africa. UNESCO, Paris.

Wood, P.J. (1966). A guide to some German Forestry Plantations in Tanga Region. *Tanzanian Notes and Records* **66**: 203–206.

Woodcock, K. (1995). *Socio-economics of some Lowland Forests at the Base of the East Usambara Mountains, Tanzania.* Frontier-Tanzania Tropical Forest Research Programme, Society for Environmental Exploration/University of Dar es Salaam, London and Dar es Salaam.

World Bank (1991). *Tanzania Economic Report: Towards Sustainable Development in the 1990s.* World Bank Report No. 9352-TA, vol.II. Washington DC.

5.3 Non-timber uses, threats and local attitudes

N.D. Burgess, P. Matthews, Y. Evers and K. Woodcock

Introduction

The Coastal Forests are used for many purposes in addition to the production of timber. These uses often have a long history, sometimes extending back over thousands of years (see Chapter 5.1). The use of the forest varies from non-destructive, such as the limited gathering of medicines from 'sacred forests', to wholesale clearance of the forest to convert the land to agriculture.

Although Coastal Forests appear to be resistant to considerable use, there is a threshold beyond which the use becomes a threat to the continued existence of the forest. Forests close to coastal towns, where the population is increasing rapidly (up to 10% per annum; World Bank, 1992), are especially threatened. In a region with an average population increase of 2.5–3.5% per annum (World Bank, 1992) the demand for additional farmland, building materials and fuel-wood is also increasing every year. The way the local people think about the Coastal Forests is also an important factor in what happens to them. Recent studies in the Coastal Forests have tried to assess the attitudes of the local people towards various Coastal Forest areas (Mogaka, 1992; Evers, 1994; Msonganzila *et al.*, 1994; Lagerstedt, 1994; Woodcock, 1995).

This Chapter summarises the non-timber uses of the Coastal Forests, assesses which are the greatest threats to the forests' future, and outlines the results of studies which have investigated what people think about these forests.

Uses of Coastal Forests

The relative frequency of a number of uses in the Coastal Forests of Kenya and Tanzania has been recently assessed (Figure 5.3.1 – Burgess and Muir, 1994). The most frequently reported uses of these forests (>50 forests) were pole collection for the construction of houses, pit-sawing to produce timber for house construction and furniture-making, religious (spiritual) sanctity and ceremonies, the gathering of medicinal plants and the clearance of the forest to grow crops (agriculture). Further uses (not presented on Figure 5.3.1) include the collection of edible plants and honey from the forests, conversion of Coastal Forest into plantations of exotic trees (e.g. pines and eucalyptus), mining, and building of hotels and other large developments (mainly for tourism in Kenya).

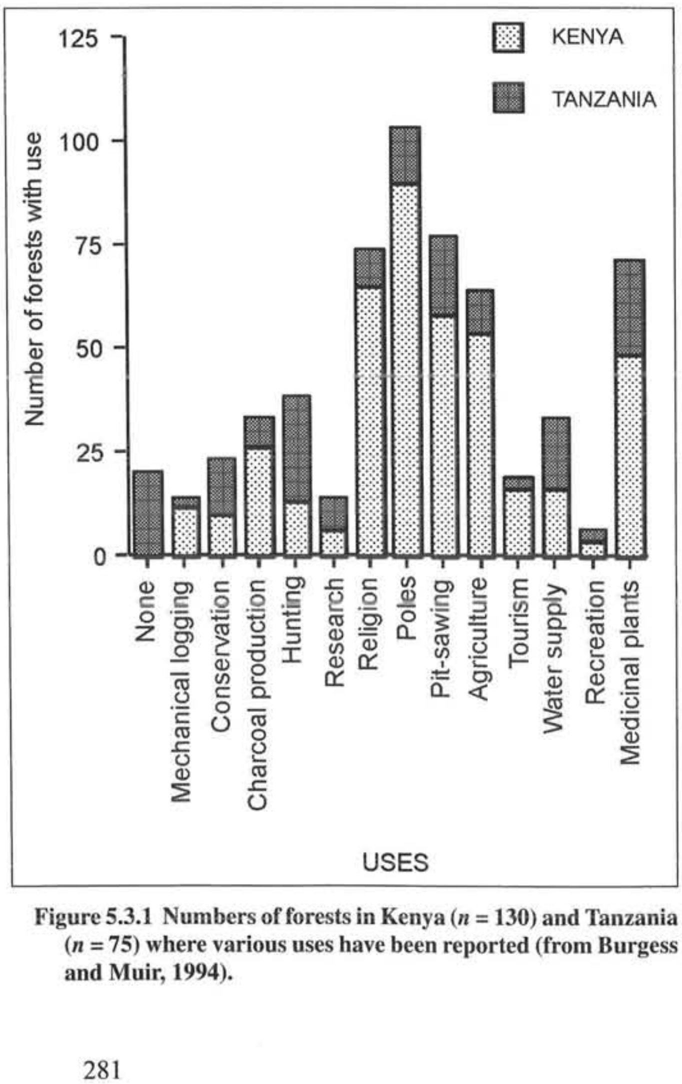


Figure 5.3.1 Numbers of forests in Kenya (n = 130) and Tanzania (n = 75) where various uses have been reported (from Burgess and Muir, 1994).

Wood products

Eastern Africa's Coastal Forests have been exploited for hardwood timber for at least the past 100 years (see Chapter 5.2), and have provided a source of building

Table 5.3.1 Natural and man-made disturbance of three Coastal Forest sites in Tanzania, 1993–1994. Data were gathered using a series of 250m long transects (30 metres apart). All standing or cut trees (>10cm DBH) and shrubs/saplings (>10cm DBH) 2.5m either side of the transect line were measured (data from Frontier-Tanzania).

Sites and transects	Total measured	Standing stems <10cm DBH	Standing stems ≥10cm DBH	Cut stems <10cm DBH	Cut stems ≥10cm DBH	Total natural falls
Gendagenda in northern Tanzania (1993)						
Transect 1	498	328	85	40	1	44
Transect 2	479	259	100	95	1	24
Transect 3	417	274	63	61	0	19
Transect 4	429	316	59	39	0	15
Transect 5	490	317	81	81	0	11
Transect 6	485	314	74	30	4	63
Transect 7	403	274	69	18	0	42
Transect 8	522	346	105	11	3	57
Transect 9	402	221	83	38	3	57
Transect 10	309	215	51	4	0	39
Mean and (mean %)	443	286 (64.5)	77 (17.5)	42 (14.6)	1.2 (0.3)	19 (4.3)
Litipo in southern Tanzania (1994)						
Transect 1	451	336	11	67	6	31
Transect 2	490	425	40	10	10	5
Transect 3	428	357	40	17	8	6
Transect 4	928	801	41	60	10	16
Transect 5	608	480	44	49	16	19
Transect 6	658	539	67	28	3	21
Mean and (mean %)	594	489 (82.3)	40 (7)	38 (6.8)	9 (1.6)	13 (2.3)
Kimboza in lowland Ulugurus (1994)						
Transect 1	443	322	59	49	5	8
Transect 2	815	680	49	70	2	14
Transect 3	984	744	54	161	1	24
Mean and (mean %)	747	582 (78)	54 (7.2)	93 (12)	2.6(0.34)	15.3 (2)

poles and cooking fuel for much longer. They continue to be an important source of these commodities despite dwindling stocks in many forests.

Poles

Coastal Forests are an important source of house construction poles for local people (Hall and Rodgers, 1986; Cambridge-Tanzania Rainforest Project, 1994; Woodcock, 1995). Poles are collected in two size classes, ones which are *c.*2cm in diameter and *c.*2.5m long, and others which are 10–15cm in diameter and 2.5–3m long. The former are used for withies in the house walls, and the latter are used for vertical poles and roof beams.

Good pole species are well-known to local people. Forest species are often selected because they are straight and have durable and relatively termite-proof timber, although the best poles of all come from mangrove trees. Roughly 300 poles are needed for an average-sized rural house, which lasts between three and ten years. At most 10% of the poles can be re-used, thus the demand for poles is considerable (Cambridge-Tanzania Rain Forest Project, 1994).

Coastal Forest species used as poles vary somewhat in different forests, presumably according to availability (Mogaka, 1992; Cambridge-Tanzania Rain Forest Project, 1994; Lagerstedt, 1994; Woodcock, 1995). The Coastal Forest canopy trees *Scorodophloeus fischeri* and *Cynometra webberi* are widely exploited where they occur. Other species which produce good poles are *Vepris* *eugeniifolia, Hymenocardia ulmoides, Pouteria alnifolia, Dialium holtzii, Manilkara sansibarensis, Diospyros squarrosa, D. verrucosa, D. mespiliformis, Drypetes parvifolia, Greenwayodendron suaveolens, Pachystela msolo, Psidium guajava, Markhamia hildebrandtii, M. zanzibarica, Lecaniodiscus fraxinifolius, Baphia kirkii, Brachylaena huillensis, Millettia dura* and *M. bussei*.

Information on levels of pole cutting has been obtained from a number of Coastal Forests in Tanzania (Table 5.3.1). Pole cutting rates in these forests were in all cases above 7%, and in some cases over 16% of available poles. This information augments previous studies on pole cutting in Pande, Pugu and Kimboza (Hall and Rodgers, 1986). Comparison of the data from the 1990s with those of Hall and Rodgers (1986) indicate that rates of pole cutting may have decreased. For example, maximum cutting rates in Kimboza at the base of the Ulugurus were 44% in Hall and Rodgers (1986) and 16% in 1994. Pole cutting is concentrated in the areas closest to human populations, for example on the forest margin, close to villages and farms and alongside access routes through the forest (Figure 5.3.2; Hall and Rodgers, 1986). Pole cutting may even, in the long term, change the species composition of a forest, as preferred species are selectively removed.

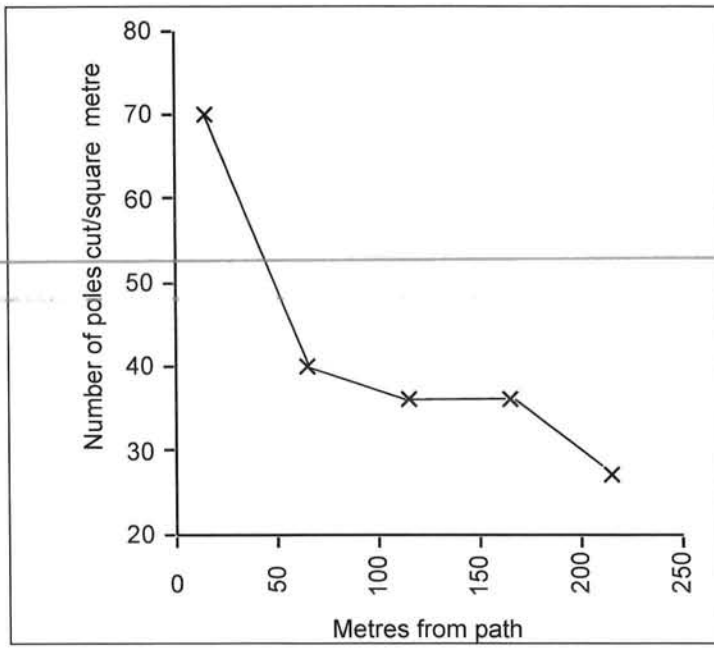


Figure 5.3.2 Pole cutting intensity on increasing distance from a path in Gendagenda Forest, Tanzania (from data collected by P. Smith, Frontier-Tanzania).

Fuelwood

Wood is the major fuel-source for rural people in eastern Africa and makes up over 90% of their energy consumption (e.g. DANIDA, 1989). There are various estimates for fuelwood consumption in Tanzania (e.g. Ongara, 1991; Kimaryo, 1982), but the only estimate from the Coastal Forests is 332–572kg per person/annum in the East Usambara lowlands (Cambridge-Tanzania Rain Forest Project, 1994). Dead wood makes up the bulk of the fuelwood gathered. Live trees are rarely cut, except in areas of very high demand (Figure 5.3.3), although the branch wood of trees felled for their timber is often collected.

Women collect fuelwood and they are generally highly knowledgeable about which species they prefer, selecting features such as high calorific value, little smoke, ease of recognition etc. Preferred fuelwood species from the Coastal Forests are *Pavetta stenosepala, Brachylaena huillensis, Combretum schumanii, Markhamia hildebrandtii, M. zanzibarica, Annona senegalensis, Hymenocardia ulmoides, Loranthus hildebrandtii, Lecaniodiscus fraxinifolius, Grewia goetzeana, Manilkara sulcata, Milletia* spp., *Newtonia paucijuga, Cynometra webberi* and *Sorindeia madagascariensis*.

Charcoal

Some Coastal Forests have been heavily used for the production of charcoal (Figure 5.3.3(d) and (e)) which is the preferred cooking fuel in urban areas (Anderson and Holm, 1990; Ongara, 1991). Coastal Forest trees, shrubs and lianas with dense wood make good, slow-burning charcoal. Species selected preferentially are *Vitex zanzibarica, Dialium holtzii, Markhamia zanzibarica, Baphia kirkii, Cynometra webberi, Brachylaena huillensis* and *Milletia* spp, although where exploitation is intense, all woody species are cut. The charcoal is produced using the pit burning technique, which takes

Figure 5.3.3(a) Forest disturbance in Tanzania; farming underneath dead forest canopy (killed by burning cut shrubs at the base of the trees) in Kiono/Zaraninge forest, 1989. *(Photo: N.D. Burgess)*

Figure 5.3.3(b) Forest disturbance in Tanzania; farming beneath dead canopy trees at Kisiju forest, 1989. *(Photo: N.D. Burgess)*

Figure 5.3.3(c) Forest disturbance in Tanzania; cut tree, Pande forest, 1989. (*Photo: N.D. Burgess*)

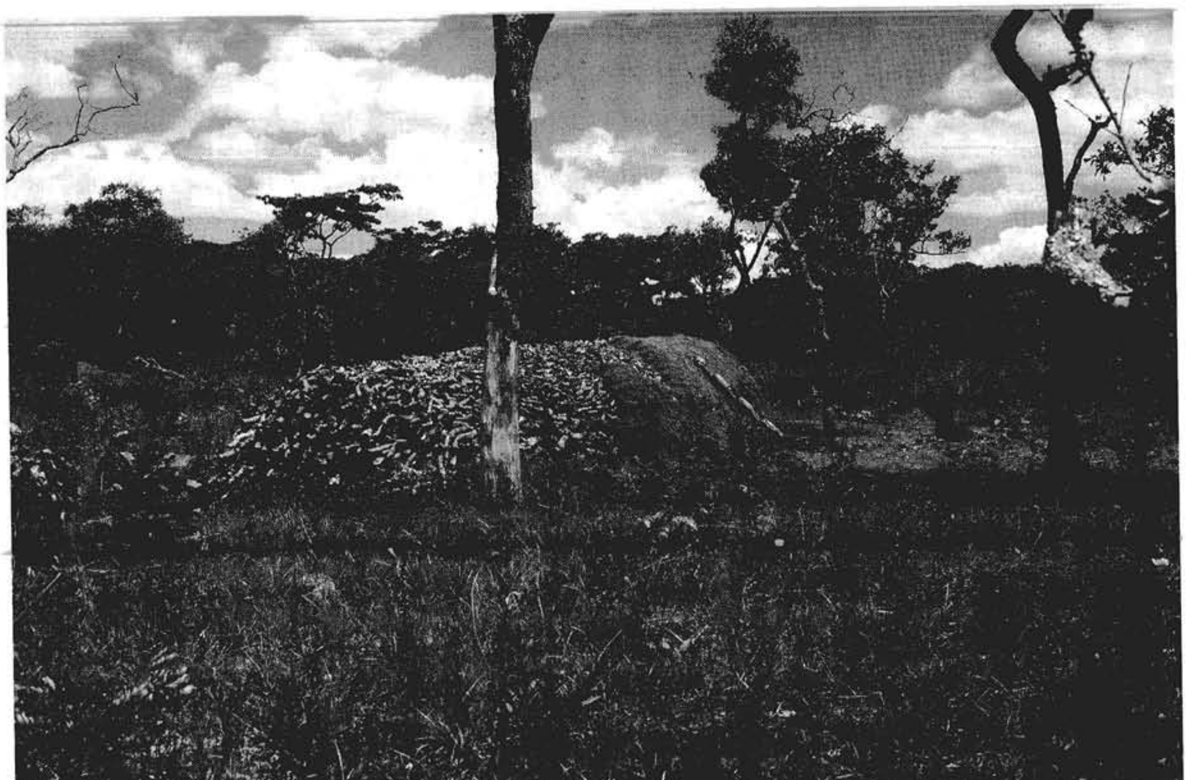


Figure 5.3.3(d) Forest disturbance in Tanzania; charcoal pit in the process of being constructed in Miombo woodland area near forest, Kiwengoma forest area, 1990. (*Photo: S. Davies*)

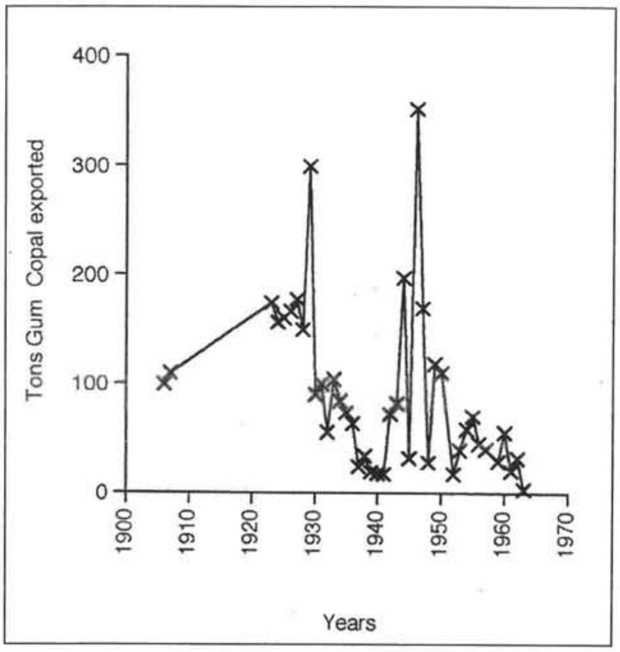


Figure 5.3.4 Fluctuations in the quantity (tons) of Gum Copal exported from Tanzania between 1903 and 1964. (Data from Forest Department, 1920–1964.) Trade effectively ceased in 1964.

and incense (Rodgers, 1992; Figure 5.3.4). Pieces of semi-fossilised resin excavated from around a tree or from former forest sites were most valued, giving copal which produced a very hard varnish (Howes, 1949). Today, with the availability of synthetic resins, use of *Hymenaea* gum is almost exclusively confined to rural communities.

Medicinal plants

Between 70 and 80% of the population of Africa is believed to rely on traditional medicine (mostly plants) as their primary source of healthcare (Cunningham, 1993). Medicinal plants are widely used in eastern Africa (Kokwaro, 1976; Hedberg *et al.*, 1982; 1983a,b; Croom, 1983; Fleuret, 1986; Akerele *et al.*, 1991; Johnson, 1992; Mshigeni *et al.*, 1994), as they are elsewhere in Southern Africa (e.g. Cunningham, 1991), and West Africa (e.g. Falconer, 1991; Leach, 1994). In the early 1980s it was estimated that there were 30,000–40,000 traditional healers in Tanzania, in comparison with about 600 western-trained doctors, most of whom were working in hospitals in big cities (Hedberg *et al.*, 1982). Plants from the Coastal Forests have continued to form a significant proportion of the medicine available to surrounding populations (Kokwaro, 1976; Hedberg *et al.,* 1982; 1983a,b; Madgwick *et al,* 1988; Mogaka, 1992; Cambridge-Tanzania Rainforest Project 1994; Evers, 1994; Matthews, 1994; Woodcock, 1995).

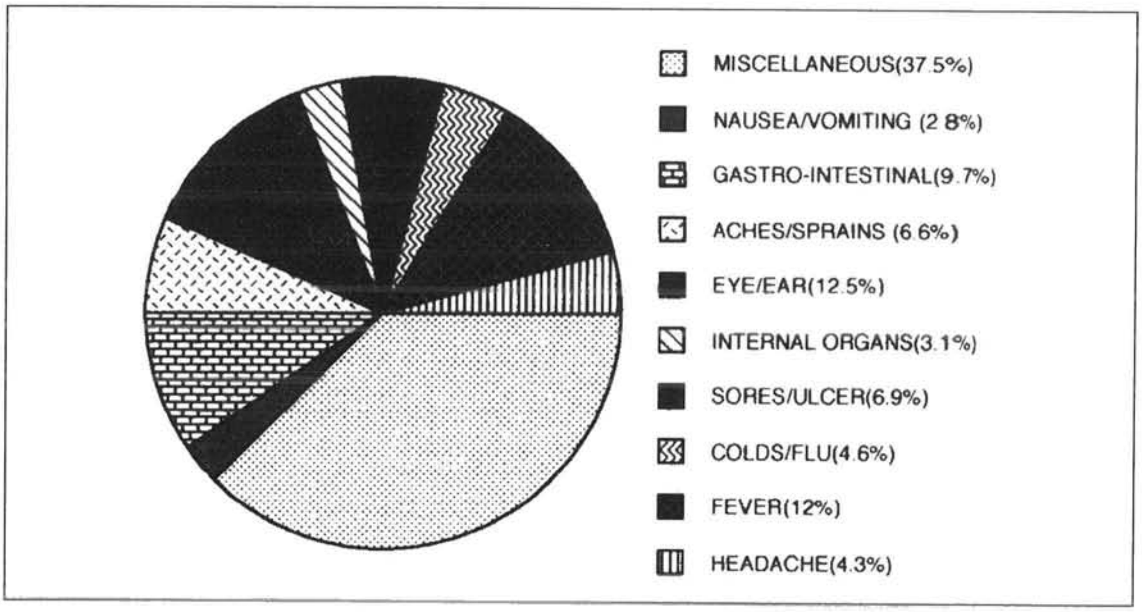


Figure 5.3.5 Pie chart of major ailments treated by Coastal Forest plants from five Coastal Forests, Tanzania (from Matthews, 1994).

Table 5.3.2 Examples of medicinal uses of selected Coastal Forest plants.

Species	Local name	Use
Sorindeia madagascariensis	–	Roots used against malaria, hookworm and haemorrhoids. Stem bark for treatment of syphilitic sores.
Monanthotaxis fornicata	–	Bark burnt and used against mental diseases. Powdered leaves are used against snake bites.
Anchomanes abbreviatus	likupu (mat)	Leaves used to treat boils.
Chassalia umbraticola	lupembesi (mat) npembesi (mat)	Leaf infusion used to treat fever.
Clausena anisata	mjaviali (zig) mingaoka (mat)	Wazigua use for rashes (root infusion). Wamatumbi use for lethargy (leaf juice rubbed on face).
Combretum pentagonum	mpurupuru (mat)	Root used for toothache.
Dichrostachys cinerea	mkunguti (mat)	Infusion of leaves for fever.
Erythrococca trichogyne	nakayemba (mat)	Leaf sap used to treat earache.
Hugonia castaneifolia	mambaato (mat) ngachawa (mat)	Root powder applied to snakebite.
Olyra latifolia	kilai (mat)	Infusion of leaves used to treat swollen spleen.
Paullinia pinnata	utumbu wa ndembo(mat)	Root infusion used as cough linctus.
Suregada zanzibariensis	mwiya (mat)	Infusion of leaves for fever.
Triclisia sacleuxii	ukumbuya (mat) ukumbuza (mat)	Root infusion used to treat hernia.
Uvaria species	–	Roots and leaves used for epilepsy, malaria treatment, lunacy.
Vismia orientalis	mtuno (mat)	Bark applied to itching and nettle rash.

Notes: mat = Kimatumbi language (Kiwengoma Forest, Tanzania).
zig = Kizigua language (Gendagenda and Zaraninge Forests, Tanzania).

Further detail on the uses and methods of preparation of many of these species is found in Hedberg *et al.* (1982; 1983a,b).

Medicinal plant collections in the Matumbi Hills, Gendagenda, Zaraninge, Kazimzumbwi and Ruvu South Coastal Forests (Matthews, 1994), supplemented by information from local traditional medicine practitioners, demonstrated that of the 2500 fertile plant specimens collected, 367 species were used for a total of 507 medicinal applications (Figure 5.3.5). Gastro-intestinal disorders (including diarrhoea), fever (including malaria) and eye and ear problems had the greatest number of treatments. Many medicines comprise cold or hot infusions taken orally, although external application is more common for wounds and ulcers (e.g. Table 5.3.2). Bathing in infusions is occasionally practised (Matthews, 1994). The use of medicinal plants has also been assessed in the Pugu Hills (Evers, 1994) and the East Usambaras (Woodcock, 1995).

The extent to which local populations rely on medicinal plants from the Coastal Forests of Tanzania seems to vary according to a number of factors:

- ***Accessibility of the forest.*** In areas close to Coastal Forests, medicines are collected from the forest, but also from forest-derived thicket and woodland. In the Pugu Hills, only 4.3% of the households said they used species from within the Forest Reserve (Evers, 1994). Village 'bushlands' were apparently a more important source of medicines, as they were in the East Usambaras (Woodcock, 1995). However, these results could be due to the reluctance of the interviewed people to state that they obtain products from the Forest Reserve as this was an illegal activity for which they could be punished. Some herbalists have responded to restricted access to the forest by domesticating plants near their homes. In areas away from Coastal Forests people collect medicines from woodland/grassland vegetations.
- ***Proximity of modern pharmacies, clinics or hospitals.*** Where available, modern medicine tends to be preferred to traditional medicine for major illnesses, but the traditional herbal remedies are still used to treat minor ailments. The use of medicinal plants remains strong in remote areas containing Coastal Forest, but people who have lived in towns for some time tend to rely more on 'modern' medicine (Evers, 1994). This trend is exacerbated by the loss of the traditional herbalist knowledge that is passed orally from one generation to another. There is often collaboration between the herbalists and modern nurses in remote villages.

- ***Period of residence of tribal group in the area.*** Ethnobotanic knowledge appears to reflect the length of residence of the people in a particular area. Our experience is that only the people with a long association with forests, such as the Wadigo, Wasambaa and Wamatumbi people in Tanzania have a high level of perceived wisdom on plant names and medicinal applications. In other areas knowledge seemed much poorer.

Some plants used for medicine in the Coastal Forest belt are also used in other areas, although most are not forest species. The herbs *Commelina* spp. yield a well known eye treatment also used by the Wasambaa and Chagga (Von Reis and Lipp, 1982; Chhabra *et al.*, 1989). Stem sap of the herb *Gonatopus boivinii*, used by the Wamatumbi for earache, is also used for this purpose elsewhere. Leaves of the riverine herb *Dissotis rotundifolia*, used in the Matumbi area to treat bilharzia, are also used by the Wadigo people (Kokwaro, 1976). The root of the climber *Artabotrys modestus*, used by the Wamatumbi for stomach ache, is reportedly also used for this purpose by the Wadigo (Kokwaro, 1976).

Leaf and root infusions of *Strychnos* spp. are also used in both northern and southern coastal areas for the treatment of stomach ache (Matthews, 1994). Sedges *Cyperus* spp. are also commonly used for the treatment of indigestion. The leaves of the climbing herb *Gloriosa superba* are used by both the Wazigua and Wamatumbi to treat insect bites and swelling. The climber *Adenia gummifera*, and bark from *Psychotria* spp. shrubs, were recorded as being used to treat snakebite, as in other areas (Kokwaro, 1976).

Medicinal compounds in Coastal Forest plants

A literature review has revealed that a number of Coastal Forest species are already known to contain bioactive agents (Table 5.3.3), or may do (Table 5.3.4). Potentially important species are *Uvaria acuminata*, which contains anti-tumour agents (Jolad *et al.*, 1985) and other Coastal Forest endemic and near endemic *Uvaria* species which have anti-malarial action (Nkunya *et al.*, 1990). Another important species is *Rauvolfia mombasiana*, the roots of which contain over 100 physiologically active alkaloids, including reserpine which is used as a sedative in the treatment of mental illness, and ajmaline which is used to treat arrhythmic heartbeat (Sofowara, 1982). Further collections of potential medicinal plants have also been made in the Tanzanian Coastal Forests (Figure 5.3.3(g)).

Edible plants

Tropical forests are known to provide food to local people in many areas (e.g. Scoones *et al.*, 1992; Falconer, 1990; 1991; Myers, 1988). Coastal Forests also contain plants which are eaten (Tables 5.3.5 and 5.3.6), and indigenous knowledge of wild edible plants is high in some areas.

For example, in the East Usambara lowlands some species are actively exploited locally and are highly palatable (notably members of the plant family Annonaceae), but others are only gathered during times of hardship and some are regarded as 'poor-mans food' (Woodcock, 1995). Knowledge of which plants are edible is passed on from mothers to their daughters, and all households regularly use wild edible plants in their diet. 25 different varieties were named in the Magrotto Hill Forest Reserve area (Woodcock, 1995), nine from forest and 16 from shambas (cultivation) and bushland. In Kenya, 60% of the people living adjacent to the Arabuko-Sokoke forest use it routinely for fruit collection, mainly for personal consumption (Mogaka, 1992; Wass, 1995).

Edible mushrooms

In the East Usambara lowlands and probably other areas, edible mushrooms are gathered by many households, from forest, bushland and farmland. As with other resources a greater number of species were utilised from farmland than from forest (Woodcock, 1995). Collection is seasonal, and can be undertaken by either women or men, generally as a minor activity associated with other work (Härkönen *et al.* 1995).

Table 5.3.3 Coastal Forest plant species containing biologically active compounds.

Species	Active agents/actions	Information Source
Species confined to Zanzibar – Inhambane regional mosaic/Swahalian region *sensu lato*		
Uvaria lucida lucida and *U. pandensis*	Extracts show *in vitro* activity against multidrug resistant strains of *falciparum* malaria parasites	Nkunya *et al.* (1990)
Rauvolfia mombasiana	Contains reserpine and deserpidine. Root extract produces hypotension and counteracts effects of adrenaline	Chhabra *et al.* (1987)
Warburgia stuhlmannii	Contains compounds with strong anti feedant and molluscicidal properties	Chhabra *et al.* (1987)
More widespread species with close relatives in the Coastal Forests		
Phyllanthus welwitschianus (Coastal Forest sister species = *P. harrisii, P. schliebenii, P. wingfieldii*)	*Phyllanthus* species reduce or eliminate hepatitis B virus antigen *in vitro* and *in vivo*	Unander and Blumberg (1991)
Uvaria acuminata (Coastal Forest sister species = *U. faulknerae, U. pandensis* and various others (see Appendix 3))	Uvaricin and desacetyluvaricin show *in vivo* antitumour action, also antibacterial action shown by leaf and root	Chhabra *et al.* (1987)
Vernonia cinerea (Coastal Forest sister species = *V. zanzibarensis*)	Contains vernonin, a hypotensive	Oliver-Bever (1986)
More widespread species		
Annona senegalensis	Bark and rootbark contain diterpenes. Extracts show antimicrobial and antitumour activity *in vitro*	Chhabra *et al.* (1987)
Antiaris toxicaria	Small doses of dried latex may be stimulant to heart and circulation. Very toxic in high doses	Oliver-Bever (1986)
Capparis separia	Roots contain alkaloids and anthracene glycosides	Chhabra *et al.* (1987)
Dioscorea dumetorum	Tubers contain alkaloids with central nervous system stimulating properties	Chhabra *et al.* (1989)
Dracaena deremensis	Shows antimicrobial activity	Chhabra and Uiso (1991)
Gloriosa superba	Contains colchicine, an anti-inflammatory agent	Sofowara (1982)
Momordica foetida	Contains charantin and foetidin which lowers blood sugar levels of fasting rats	Chhabra *et al.* (1989)
Ocimum gratissimum	Contains thymol and has antimicrobial action. Ilium relaxant *in vitro*. Shown empirically to be an ant repellant	Sofowara (1982)
Parquetina nigrescens	Contains aglycones – cardiotonic action	Oliver-Bever (1986)
Paullinia pinnata	Contains a cardiotonic flavotannin and a saponin with antimicrobial action	Oliver-Bever (1986)
Scadoxus multiflorus	Bulb contains alkaloids lycorine, chlidanthine, haemanthidine, hippeastrine and haemultine	Chhabra *et al.* (1987)
Schizozygia coffaeoides	Roots, twigs, leaves and bark contain alkaloids	Chhabra *et al.* (1987)
Strophanthus petersianus	Contains sormentogenin, used in cortisone manufacture	Chhabra *et al.* (1987)
Strychnos lucens	Contain strychnine, powerful poison	Chhabra *et al.* (1987)
Strychnos panganiensis	Stimulant (but highly toxic)	Chhabra *et al.* (1987)
Terminalia sambesiaca	Stembark shows antibacterial activity	Chhabra *et al.* (1989)

Table 5.3.4 Coastal Forest species potentially containing biologically active compounds.

Species	Possible active agents and actions	Source
Zanzibar – Inhambane regional mosaic/Swahilian region *sensu lato* endemics		
Diospyros verrucosa	Rootbark of *D. usambarensis* has fungicidal and molluscicidal properties	Chhabra *et al.* (1989)
Maerua holstii	*M. angolensis* stem-bark contains alkaloids, coumarin and steroids. Bark of this and *M. kirkii* show antibacterial activity	Chhabra *et al.* (1989)
Maytenus mossambicensis	*M. buchananii* contains maytensine, an anti-tumour agent *M. senegalensis* extract shows antimicrobial activity *M. ilicitifolia* rootbark extract shows cytotoxic activity	 Chhabra and Uiso (1991) Itokawa *et al.* (1991)
Thylachium densiflorum	*T. africanum* roots contain alkaloids L-stachydrine and hydroxy-3-stachydrine	
More widespread species		
Bridelia atroviridis	*B. ferruginea* has been very effective in the treatment of diabetics	Sofowara (1982)
Bridelia cathartica		
Combretum pentagonum	*C. microanthum* stem contains antimicrobial agents. Also anthemlintic	Sofowara (1982)
Holarrhena pubescens	*H. febrifuga* bark and leaves contain steroidal alkaloids. Bark of this species also contains conessine, an amoebocide	Chhabra *et al.* (1987)
Lannea schweinfurthii	*L. schimpera* and *L. stuhlmannii* have antibacterial activity	Chhabra *et al.* (1987)
Mallotus oppositifolius	*M. japonicus* pericarps contain mallojaponin, an anti-tumour promoter	Arisawa *et al.* (1991)
Momordica foetida	*M. dioica* extract antimalarial against *Plasmodium berghei*	Misra *et al.* (1989)
Zanthoxylum holtzianum	*Z. zanthoxyloides* contains alkaloids and benzoic acid derivatives – has antimicrobial action	Sofowara (1982)

Table 5.3.5 Some Coastal Forest plants with edible fruit.

Scientific name	Local name**
Allophyllus pervillei	mulalati (zig)
Ancylobothrys petersiana	kituwe (zig)
Annona senegalensis	mtopetope (mat)
Antidesma venosum	muyembayemba (zig)
Asteranthe asterias	
Asystasia gangetica	komba (zig)
Canthium bibracteatum	mpulya (zig)
Canthium mombazense	msonzo (zar)
Carpolobia goetzii	mzuki (zig)
Cissus rotundifolia	vlanga (zig)
Commiphora lindensis	pingi (zar)
Cola microcarpa	mtomokwe (zig)
Cucumis melo	utongo (zig)
Dictylophleba lucida	kimbaruka (mat); kinoe (zar)
Diospyros verrucosa	ujamitu (zig)
Grewia conocarpa	mkole (zig)
Grewia holstii	msofu (zar)
Grewia microcarpa	mkole (zig)
Jasminum meyeri - johannis	mblumbulamundi (zig)
Kraussia kirkii	mkadilowa (zig)
Landolphia kirkii	bungu (zar)
Manilkara sulcata	mchejimtunda (zig)
Manilkara sansibarensis	mkwichimbi (mat)
Meyna tetraphylla	mgola (zig)
Monanthotaxis buchananii	msenzele (zig)
Pachystela brevipes	mgerezi (zar)
Paropsia braunii	moyomoyo (zar)
Phyllanthus nummulariifolius	mpilipili (mat)
Pseudocalyx heterochondros	buku (zar)
Pyrostria bibracteata	mkonge mwitu (zar)
Rinorea spp.	mkoko (zig)
Rytigynia bugoyensis	kipela (zig)
Saba comorensis	ngombe (mat)
Salacia madagascariensis	mbwiku (zig)
Sorindeia madagascariensis	
Strychnos madagascariensis	mtonga mtonga (zig)
Tamarindus indica	ukwaju (mat)
Thespesia danis	mkangala (zig)
Uvaria acuminata	msofusofu (zig)
Uvaria kirkii	msofu (zig)
Uvaria leptocladon	sofu mwitu (zar)
Uvaria pandensis *	kisemvule (zig)
Uvariodendron sp.* ?	lukunde (zig)
Vangueria madagascariensis	mwelu (mat)
Vigna vexillata	mankamba (zig)
Xylotheca tettensis	msekaseka (zar)

***Note*:**

* Zanzibar – Inhambane/Swahilian near endemics found only in forests.

** From local herbalists in their own language: zig – Kizigua, mat – Kimatumbi, zar – Kizaramo

Table 5.3.6 Some plants found in Coastal Forests which have edible leaves or roots.

Scientific name	Local names*
Aerva lanata	bwache (zig)
Ageratum conozoides	gugudulu (zig)
Buchnera hispida	pombomaji (zig)
Cucurbita moschata	
Grewia lepidopetala	mnanga (zig)
Ipomoea sp.	pwapwa (zig); longwe (zig)
Memecylon amaniense	kilumbu (zig)
Oldenlandia johnstonii	kipulwe (zig)
Oliverella hildebrandtii	mkwambe (zig)
Pilea sp. ?	bambiko (zig)
Siphonochilus aethiopicus	manjano (zig)
Tacca leontopetaloides	uwana (zar)
Tamarindus indica	ukwaju (zig)
Teclea sp.	kidenka (zig)
Vernonia aemulans	sunga (zig)
Vernonia cinerea	

Note: * From herbalists in their own language: zig - Kizigua, mat - Kimatumbi, zar - Kizaramo

Miscellaneous uses of Coastal Forest plants

The smoke from the bark of *Caloncoba welwitschii* ('mwabu') and *Xylotheca tettensis* ('linemiambopo') are used in the Matumbi area to sedate bees prior to collecting honey from wild nests. *Dichapetalum stuhlmannii* ('nkichi' in Kimatumbi) is used to produce a tranquilizer for buffaloes (and kills cattle).

Mosquito repellents are made from leaf infusions of *Tetracera boiviniana* and *Keetia zanzibarica*. Stem pieces of the herb *Psilotrichum scleranthum* ('kijafuno' in Zigua) and the liana *Strychnos angolensis* ('tonga') are used as toothbrushes and the roots of *Dichapetalum mossambicense* and *Clerodendrum incisum* are boiled to produce mouthwashes. Bark from the 'mdaa' tree – *Diospyros zombensis* – is used by the Wamatumbi male as a tongue colourant to make him more attractive to women. The roots of this tree are also an aphrodisiac. Roots of the shade-bearing herb *Drimiopsis botryoides* ('nakatumba' in Kimatumbi) are ground and used for tattooing. Shampoos and soaps are produced from the sedge *Kyllinga cartilaginea* and from the leaves of *Ludwigia jussiaeoides* and *Rhynchosia* sp.. The Landolphia rubber creeper, *Landolphia kirkii* ('mpila' in Kiswahili), is used on a small scale for making footballs, snare trip wires and various other items. Its sap was formerly collected as a tax during the German administration of Tanzania (Rodgers, 1993).

Glue can be derived from the root of *Gardenia transvenulosa* and from the latex of *Ficus sycomorus*, *Garcinia livingstonei* and *Maytenus* sp. The bark of the tree *Vismia orientalis* ('mtuno' in Zigua) is used to produce an orange – yellow dye for woven reed mats.

Grass species that frequently occur in more open or disturbed areas, such as *Paspalum glumaceum* and *Sporobolus pyramidalis* are used as roof thatch. Twigs of *Combretum apiculatum* are reportedly used in basket weaving and twigs of *Scorodophloeus fischeri* and *Uvaria* spp. seedlings can be made into a strong twine for binding. Many other liane and vine species are suitable for use as rope. A review by Kabuye (1988) suggests that Coastal Forest species are not important for basket-making, which is supported by our experience.

Nitrogen-fixing plants are also found in the Coastal Forests, for example *Tamarindus indica* ('mkwaju' in Kiswahili), *Entada pursaetha* ('mkuluma' in Kimatumbi) and *Trichilia emetica* ('nukulio' in Kimatumbi), which is also reported to reduce pests when grown alongside crops. *Thunbergia alata*, a herb occurring at forest margins is reportedly planted with dry rice in the

Matumbi area and is said to increase yields. Other species with agricultural value are lianas and climbers used to form a dense live fence. *Hewittia malabarica*, *Smilax anceps* and *Tylophora* sp. were all reportedly used for this purpose in Kisarawe District, Tanzania.

Genetic resources

Some of the plant species found within the Coastal Forests could represent important genotypes of commercial crops. The most important of these may be *Coffea* spp. Some 11 species of coffee (out of a global total of 90 species) are found only in the Coastal Forests and some of these are caffeine-free varieties not yet exploited for these properties (Charrier and Berthaud, 1990). Also of potential interest are wild vanilla and wild yams, although extensive processing may be needed to reduce the natural toxicity of the latter.

Bush-meat

In many Coastal Forests the wild animals are hunted to provide meat for local populations. This hunting is either undertaken by men within the forest, or undertaken by all members of the family with the main aim of reducing animal damage to crops.

In Tanzanian forests, the most frequently hunted species are Red Duiker *Cephalophus natalensis*, Suni *Neotragus moschatus*, Bushbuck *Tragelaphus scriptus*, elephant-shrews – *Petrodromus* and *Rhynchocyon* species, Porcupine *Hystrix* spp. and Bush Pigs *Potamochoerus larvatus*. However, a wide range of species are hunted throughout the range of the Coastal Forests. Details for the Arabuko-Sokoke forest in Kenya are provided by FitzGibbon *et al.* (1995).

The most common hunting methods are the laying of snares (often using bent saplings or metal wire), other traps, the use of bows and arrows, tracking with dogs, and occasionally shooting. A case study in the East Usambara lowlands in Tanzania shows that the communities do not generally depend on hunted animals as a source of protein, and bushmeat is either perceived as an occasional luxury or, by the younger generation, as 'old fashioned poor-mans food' (Woodcock, 1995). However, in other areas, bush-meat may have a high value to local communities, either through money saved by not buying meat at market, or through income gained by selling the meat to others. For example, around 60% of households living adjacent to the Arabuko-Sokoke Forest in Kenya hunt there regularly, and in 1991 about 350kg meat/km^2 forest was harvested, with an estimated value of KShs 1,306,000 per annum (*c.*\$35,000) (FitzGibbon *et al.*, 1995). In the coastal area hunting also takes place in the grassland/woodland areas outside the forest in the dry season. The fires used to drive the animals and allow their capture may encroach into the forests themselves.

In many coastal areas, local communities also hunt Bush Pigs, Sykes Monkey *Cercopithecus mitis*, Vervet Monkey *Chlorocebus aethiops* and Yellow Baboon *Papio hamadryas* because they raid crops grown near the forest. In most of the Muslim areas the pigs' meat is not eaten, although it may be sold to other people. The monkeys are also not generally eaten, although this varies with locality and the Black and White Colobus *Colobus angolensis* has been exterminated by hunting from the Pugu Hills near Dar es Salaam.

In some forests (e.g. Rondo) small children may hunt birds for food, for entertainment, and occasionally to sell into the wild bird trade (Bhatia, *in lit.*). This practice may also occur elsewhere in the coastal area.

Wild honey

The importance of Coastal Forests for honey collection varies greatly. In the Arabuko-Sokoke forest, 30–40% of people collect honey from the forest, mostly during the time of peak production in May and June (Mogaka, 1992). However, the practice is uncommon in the East Usambara lowlands (Woodcock, 1995). In general the forests are less important for the collection of wild honey than areas of *Brachystegia* woodland. In most Coastal Forests, honey collection is opportunistic from naturally occurring hives and the honey is consumed by the collector's family or traded for other goods.

Traditional spiritual value

Some Coastal Forests occupy sites of traditional spiritual value. The best known are the 'Kaya' forests of southern Kenya (Spear, 1978). However, such values are also found elsewhere in the coastal area. For example, historical studies of the coastal Wazaramo people in Tanzania reveal that one of their cultural myths tells of Mwene Mbaga 'owner of the forest' to whom all trees belonged (Knappert, 1987). Discussions about the ritual or cultural uses of the forest are often a taboo subject, probably due to pressures to abandon traditional beliefs by both Muslim and Christian religious groups (Evers, 1994). However, interviews with forest guards confirmed that sacred groves containing grave sites are still visited within the Pugu Forest (Evers, 1994), and that large trees are still retained 'for the spirits to live in' (Frössling, *in lit*). A small burial grove near Pugu Forest also still has local sanctity and is the only known location for the endemic genus and species *Stephanostemma stenocarpum* (Apocynaceae) (Burgess *et al.*, 1992). Such beliefs about forests and trees are thought to be widespread in the Coastal Forests area.

Land

Historically the conversion of Coastal Forest to farmland has been the main use of this resource. When first cleared, forest land is relatively fertile and produces good crops for 2–3 seasons (see Figure 5.3.3). The state of the forest prior to its clearance, be it rich in timber species, biodiversity or other values is of little relevance to the people wishing to utilise the forest to realise its agricultural land value. However, valuable timber trees are often cut prior to clearance, and species which are important to the people (fruits, timbers and poles) are retained during agricultural conversion as a 'stock' of building materials and food (Evers, 1994; Woodcock, 1995).

A similar situation occurs where the mineral interest of a forested area is high. Existing values of the forest are unlikely to be higher than the value of the material to be mined. Mining activities are taking place near the Pugu Forest Reserve in Tanzania and in Mrima Hill in Kenya.

Attitudes to forest conservation

The attitudes of people towards the Coastal Forests are important to understand if effective conservation is to be achieved. The essence of the problem – conflicting viewpoints – is outlined here, with some examples of how resources are used, and what people living around some Coastal Forests think about them. Assessing the reliability of these data is complex, as it is derived from replies to questions posed by a researcher, who is always likely to be seen either as a threat, or a potential saviour – neither being an ideal basis from which to collect objective information.

Conflicting viewpoints

One of the most important aspects of human attitudes to Coastal Forests is the variation in perception of the 'worth' of a forest by different sectors of the community in eastern Africa, leading to conflicts over potential land use options. Three main viewpoints can be identified (from Rodgers, 1993):

- At one end of the spectrum is the local farmer living on the forest margin, who sees the forest as the family's source of land, food and fuel (either now or for future generations).
- At another end is the local government, who see forest as a source of employment and revenue through the exploitation of products such as timber.
- In contrast with this, international and local conservation organisations see the forests as important gene pools (biodiversity areas) and environmental buffer zones of value to the country/world. The national forestry authorities also have similar perspectives in that they see the forests in terms of their water catchment and timber values for the country.

These different perspectives and views are of fundamental significance to the conservation of forest resources in the area. Indeed, in the Coastal Forests, where there are no water catchment values of national importance, and few remaining timber resources through which the Forestry Department or local government could create local employment, there is a strong potential conflict between the conservationists who wish to protect the forests for their biodiversity values, and the local people who wish to use the forests to survive.

Comparative value of resources

A recent review (IIED, 1994) argues that the critical question of how to promote conservation of natural resources as a long-term strategy by local people is influenced by the perceived comparative value of these resources. The three main factors identified by IIED (1994) are: the distribution and characteristics of the natural resources; the value of the natural resources in terms of local income and its distribution; and the socio-economic, political and cultural institutions of local stakeholders and their relationship to higher level structures (IIED, 1994).

Hence, if the value of the standing forest is perceived to be low compared to alternative uses such as agriculture or clear-felling for charcoal production, then the interest in conserving forest resources is likely to be limited. This is particularly true of more accessible areas near urban market centres, where the differentiation within communities tends to be high and in-migration creates greater pressure on resources (for example, Pugu, Pande and Kazimzumbwi Forest Reserves in Tanzania). Where the political, legislative and administrative frameworks are weak there is also a greater threat from illegal exploitation.

On the other hand, in more marginal areas with greater dependence on the resources for livelihood strategies, the local value of the resources will be high. This is likely to apply to those forests located in more remote areas, such as southern Tanzania. Strong linkages within communities, more equitable access rights and income distribution, are also found to be important factors for successful community conservation.

Case studies of local perceptions

The results of several recent participatory studies with villages adjacent to Coastal Forests in Tanzania and Kenya (Mogaka, 1992; Evers, 1994; Lagerstedt, 1994; Woodcock, 1995) give an indication of the generally negative perceptions of local people towards protected Coastal Forests at the present time. Their main concerns related to forests focus around current constraints to agricultural production and improving their income levels. Some examples from these studies are given on the following pages:

Box 5.3.1 Pugu Kajiungeni/Pugu Forest Reserve (Evers, 1994)

In this study, the men's perception of the forest was generally a resentment at being excluded from the reserve by the Forest Department. There was also frustration with a lack of directly communicated information about changes in forest regulations. Commercial use of the forest by outsiders has continued, however, as evidenced by trucks of charcoal, and by other forest products passing through the village, and this was perceived as having a negative impact on the forest. It was felt that timber restrictions should be better enforced, although it is possible that at least some of the local men are employed by the contractors.

It was strongly stated that there should be some flexibility in the regulations to allow for subsistence use of the forest, such as harvesting of fuelwood and poles. Many mentioned the problem of land scarcity, declining soil fertility, and the need for improved technology or access to the fertile land under forest in the future. However, large scale deforestation was seen as negative and examples were given from Dodoma Region where deforestation was believed to have affected the rainfall.

Women's perceptions focused on the need for access to fuelwood as the most important forest product, particularly given its increasing scarcity in the village area. Another problem was the declining availability of building poles which now forces people to substitute inferior species, such as cashewnut tree poles.

Youth in the village focused almost entirely on the problem of access to land, rather than perceptions of benefits from the forest *per se*. All the available land within the village boundaries has already been allocated to individuals by the village government. Many expressed a desire for economic independence by requesting a piece of the parental land, or trying to earn income through small businesses or skilled labour, such as becoming a mechanic.

Other informants felt that the relatively high earnings which could be made from pole harvesting and charcoal production created incentives to exploit these resources. Such activities are easier to get involved in when compared with other small businesses which require skills training, capital, loans and equipment.

Box 5.3.2 Homboza and Vigama Villages/Kazimzumbwi Forest Reserve
(Msonganzila *et al.*, 1994; Lagerstedt, 1994; Mwamfupe, 1997).

The attitudes to forests in the Vigama Village close to Kazimzumbwi Forest Reserve vary depending on the people who are responding to questions (Table 5.3.7).

The men's main concern focused on the decline in soil fertility and increasing unreliability of the rains in the last twenty years. Increasing degradation outside the reserves was seen as the result of the mixing of cultures and the loss of traditional systems of managing the environment. Again, large-scale deforestation was seen as negative, particularly as the forest was regarded as providing better rainfall and important resources such as timber. The sudden eviction from the forest in the late 1950s, and the continuing enforcement of exclusion by the Forest Department, was still, however, resented.

Women also mentioned declining soil fertility and the lack of water sources. Crop-raiding pests from the forest (such as monkeys and bush pigs) were found to have serious impacts on harvest levels. While fuelwood was not seen as a problem by women in these villages, the negative effects of over-exploitation of trees was understood. However, the cash income derived from harvesting trees was seen as critical to their livelihoods.

Youth again emphasised the need to earn cash, mostly through the sale of agricultural products. There was also a feeling of resentment that the Forest Department claimed all the rights and derived all the benefits from 'trees that God and their grandparents had planted'.

In a more recent study of this forest (and Pugu) by Mwamfupe (1997) (Table 5.3.8) it has been more clearly shown that in this particular forest, it is the woody resources which are the most highly valued by the local people. Environmental services are ranked much lower in importance. With an increasing population in the area, a huge market in Dar es Salaam, and these attitudes held by the local people, the difficulties experienced in the conservation of these forests (see Chapters 5.4 and 5.5) can be readily understood.

Table 5.3.7 Ranked perceived value of products from Kazimzumbwi Forest Reserve, by men, young men, and women.

Rank	Men	Young men	Women
1	To hunt animals for food	Timber	Firewood
2	Charcoal	Charcoal	Charcoal
3	Building materials	Building poles	Building poles
4	Medicines	Firewood	Ropes
5	Firewood	Honey	Withies
6	Honey	To hunt animals for food	–
7	Land for farming	–	–

Table 5.3.8 Percentage of villagers valuing different attributes of Pugu and Kazimzumbwi Forests, based on field survey in 1996 (from Mwamfupe, 1997).

	Important	Neither important nor unimportant	Unimportant	Rank
Source of fuelwood	40	8	2	1
Charcoal production	32	12	6	2
Source of timber	28	14	8	3
Crop cultivation	22	19	9	4
Logging	28	12	10	5
Cultural significance	17	22	11	6
Water catchment	14	20	16	7
Medicinal value	8	30	12	8
Environmental value	8	28	14	9
Honey harvesting	12	18	20	10

5.3.3 Manga Forest Reserve and Magoroto Hill – East Usambaras (Woodcock, 1995).

Villagers living around Manga Forest Reserve and Magrotto Hill in the East Usambaras see the public forest as a resource for their day-to-day subsistence; for agricultural land, building poles, timber, firewood, weaving materials, ropes, vegetables and medicine. On Magrotto Hill they were also keen to be able to cultivate cardamom within the forest and suggested this as a way whereby the forest could be conserved whilst also providing them with an income.

In both areas villagers were well-aware of the restrictions placed on the use of Forest Reserves, and who officially controlled them. Some villagers admitted to 'stealing' into the Reserves to obtain building poles, saying that they had no choice, since all good quality materials had been used up in the public forest. Villagers feared that they could be caught by forest guards, taken to the police, asked many questions and possibly given a fine. Another major complaint was that the forest guards, by protecting the forest, also protect the crop pests which live in the forest, such as bush pigs and monkeys, which farmers spend a great deal of time protecting their crops from.

In general the villagers could see the advantage of conserving forests for water catchment, to prevent soil erosion and perhaps for future subsistence uses. However, most felt that due to the low availability of agricultural land, timber and building poles, if the forests are not guarded, villagers would have no alternative but to cut the forest down.

Summary

The Coastal Forests are heavily used by both local populations and outsiders to provide woody (non-timber) and non-woody products for people.

In many cases these uses are so intensive that they threaten the continued existence of the forests. The five most destructive uses (in descending order) are: conversion to agriculture, cutting to produce charcoal, timber logging, pole cutting and fuelwood gathering.

The Coastal Forests most heavily used are those closest to major centres of human population (e.g. close to Dar es Salaam), or in areas of expanding human populations and economic activity (e.g. coastal Kenya). Those least used are located in remote areas of low human population and poor transport infrastructure (e.g. southern Tanzania).

The authorities in charge of the conservation and management of the Coastal Forests (Forestry Departments and elders in charge of 'sacred groves') are both beset with the problems of declining ability to protect the forests under their control. In some Forest Reserves there has been no official presence for many years and hence the local people believe that the government has given the reserve up. Mainstream religions and 'westernisation' have reduced the authority of the elders.

The local people living around Coastal Forests have various perceptions of its importance or value to them. In many cases there was a general appreciation that the forests were useful in helping to guarantee rainfall, but there was also resentment that 'traditional' lands were under the control and management of the Forestry Department and that any 'benefits' did not come back to the local populations. In many villages the need for further land either now or in the future was an over-riding concern, and the need to earn money was identified as a very important consideration by the younger people. These needs would be in conflict both with sustainable forest management and forest conservation.

All in all the future of the Coastal Forests does not look very secure. They are threatened by the surrounding populations and their life-sustaining activities. They are already small and often damaged by previous/existing intensive exploitation activities. The power of those who protect them has been eroded considerably in the past decade. They could easily be written off by national government planners or local people, and left to gradually disappear. An outline of what is being done, and could be done, to prevent this happening is presented in the last Chapter.

Acknowledgements

The Zaraninge and Matumbi ethnobotanical collections were conducted by Doug Sheil and the late Cassandra Clunies-Ross with assistance from Frontier volunteers. The Gendagenda, Ruvu South and Kazimzumbwi collections were conducted by Phil Clarke with assistance from Frontier volunteers. Local herbalist advisors were Abdullah Abdu Mbonde of Kiwengoma village, Rufiji District for the Matumbi collection, Hamisi Matullo of Mbwewe village, Bagamoyo District for Zaraninge forest, Asha Salim for the Gendagenda collection and Mohammed Jinga for the Ruvu and Kazimzumbwi collections.

Identifications of medicinal plants collected in Tanzania were by Leonard Mwasumbi and Frank Mbago of the Herbarium, University of Dar es Salaam, and by Dr Kaj Vollesen of the Herbarium, Royal Botanic Gardens, Kew.

Comments on this Chapter were received from Phil Clarke, Alan Rodgers of the GEF/FAO Biodiversity Support Project for East Africa, Peter Gibbon of the Centre for Development Research (Copenhagen), Eva Lagerstedt and Johan Frössling of the Wildlife Conservation Society of Tanzania Coastal Forest Project (Pugu Hills, Tanzania), and Andrew Perkin of the Kambai Forest Conservation Project (East Usambaras, Tanzania).

References

Akerele, O., Heywood, V. and Synge, H. (eds.) (1991). *The Conservation of Medicinal Plants*. Cambridge University Press, Cambridge.

Anderson, M. and Holm, H. (1990). *The Energy Market in Dar es Salaam: a Minor Field Study*. Working paper, International Rural Development Centre, Swedish University of Agricultural Sciences, Uppsala.

Arisawa, M., Fujita, A., Morita, N., Okuyama, T. and Nishino, H. (1991). Inhibition of tumor-promoter-enhanced 3H-choline incorporation into cellular phospholipids by phloroglucinol derivatives from *Mallotus japonicus*. *Journal of Natural Products* **54**: 1409–1412.

Burgess, N.D., Mwasumbi, L.B., Hawthorne, W.D., Dickinson A. and Doggett, R.A. (1992). Preliminary assessment of the distribution, status and biological importance of Coastal Forests in Tanzania. *Biological Conservation* **62**: 205–218.

Burgess, N.D. and Muir, C. (eds.) (1994). *The Coastal Forests of Eastern Africa: Biodiversity and Conservation*. The Society for Environmental Exploration and the University of Dar es Salaam, London and Dar es Salaam.

Cambridge Tanzania Rainforest Project (1994). *A Biological and Human Impact Survey of the Lowland Forest, East Usambara Mountains, Tanzania*. BirdLife Study Report No.**59**. BirdLife International, Cambridge.

Charrier, A. and Berthaud, J. (1990). Use and value of genetic resources of *Coffea* for breeding and their long-term conservation. *Mitt. Inst. Allg. Bot. Hamburg* **23A**: 53–64.

Chhabra, S.C., Mahunnah, R.L.A. and Mshiu, E.N. (1987). Plants used in traditional medicine in eastern Tanzania. I. Pteridophytes and Angiosperms (Acanthaceae to Canellaceae). *Journal of Ethnopharmacology* **21:** 253–277.

Chhabra, S.C., Mahunnah, R.L.A. and Mshiu, E.N. (1989). Plants used in traditional medicine in eastern Tanzania. II. Angiosperms (Capparidaceae to Ebenaceae). *Journal of Ethnopharmacology* **25:** 339–359.

Chhabra, S.C. and Uiso F.C. (1991). Antibacterial activity of some Tanzanian plants used in traditional medicine. *Fitioterapia* **62:** 499–503.

Clarke, G.P. (in press). Digo kayas in northern Tanzania. *Azania*.

Croom, E.M. (1983). Documenting and evaluating herbal remedies. *Economic Botany* **37**: 13–27.

Cunningham, A.B. (1991). Development of a conservation policy on commercially exploited medicinal plants: a case study from southern Africa. In Aketele, O., Heywood, V. and Synge, H. (eds.). *Conservation of Medicinal Plants*. Cambridge University Press, Cambridge.

Cunningham, A.B. (1993). *African Medicinal Plants: Setting Priorities at the Interface Between Conservation and Primary Healthcare.* People and Plants working paper (March). WWF, Paris.

DANIDA (1989). *Environmental Profile: Tanzania*. Ministry of Foreign Affairs, Copenhagen.

Evers, Y.D. (1994). *Subsistence Strategies and Wild Resource Utilisation: Pugu Forest Reserve, Tanzania.* MSc Thesis. Department of Anthropology, University College, London.

Falconer, J. (1990). 'Hungry season' food from the forests. *Unasylva* **41**: 14–19.

Falconer, J. (1991). *The Major Significance of Minor Forest Products: the Local Use and Value of Forests in the West African Humid Zone*. FAO, Rome.

FitzGibbon, C.D., Mogaka, H. and Fanshawe, J.H. (1995). Subsistence hunting in Arabuko-Sokoke Forest, Kenya and its effects on mammal populations. *Conservation Biology* **9**: 1116–1126.

Fleuret, A. (1986). Dietary and therapeutic uses of fruit in three Taita communities. In Etkin, N. L. (ed). *Plants in Indigenous Medicine and Diet: Biobehavioural Approaches*. Redgrave, New York.

Forest Department (1921–1970, 1978). *Annual Reports of the Tanzanian Forestry Department (1921–1970, 1978)*. Government Printer, Dar es Salaam.

Hall, J.B. and Rodgers, W.A. (1986). Pole cutting pressure in Tanzanian forest. *Forest Ecology and Management* **14**: 133–140.

Härkönen, M., Saarimäki, T. and Mwasumbi, L.B. (1995). Edible mushrooms of Tanzania. *Karstenia* **35** suppl.: 1–92.

Hedberg, I., Hedberg, O., Madati, P.J., Mshigeni, K.E., Mshiu, E.N. and Samuelsson, G. (1982). Inventory of plants used in traditional medicine in Tanzania. I. Plants of the families Acanthaceae – Cucurbitaceae. *Journal of Ethnopharmacology* **6**: 29–60.

Hedberg, I., Hedberg, O., Madati, P.J., Mshigeni, K.E., Mshiu, E.N. and Samuelsson, G. (1983a). Inventory of plants used in traditional medicine in Tanzania. II. Plants of the families Dilleniaceae – Opilliaceae. *Journal of Ethnopharmacology* **9**: 105–128.

Hedberg, I., Hedberg, O., Madati, P.J., Mshigeni, K.E., Mshiu, E.N. and Samuelsson, G. (1983b). Inventory of plants used in traditional medicine in Tanzania. III. Plants of the families Papilionaceae – Vitaceae. *Journal of Ethnopharmacology* **9**: 237–260.

Howes, F.N. (1949). *Vegetable Gums and Resins*. Plant Science Books, Massachusetts.

ICRAF (1992). *A Selection of Useful Trees and Shrubs for Kenya: Notes on their Identification, Propagation and Management for use by Farming and Pastoral Communities*. International Centre for Research in Agroforestry, Nairobi.

IIED (1994). *Whose Eden: An Overview of Community Approaches to Wildlife Management*. IIED, London.

Itokawa, H., Shirota, O., Ikuta, H., Morita, H., Takeya, K. and Iitaka, Y. (1991). Triterpenes from *Maytenus illicifolia*. *Phytochemistry* **30**: 3713–3716.

Johnson, J.A. (1992). Tropical forest biodiversity and its value to the pharmaceutical industry. *Scottish Forestry* **46**: 189–193.

Jolad, S.D., Hoffmann, J.J., Cole, J.R., Barry, C.E., Bates, R.B., Linz, G.S. and Konig, W.A. (1985). Desacetyluvaricin from *Uvaria acuminata*, configuration of uvaricin at C-36. *Journal of Natural Products* **48**: 644–645.

Kabuye, C.H.S. (1988). East African plants used in basketry. *Monogr. Syst. Bot. Missouri Bot. Gard.* **25**: 351–361.

Kimaryo, B.T. (1982). Yield and quality of charcoal from lesser known tree species in Tanzania. In *Wood Energy in East Africa*. International Development Research Centre Manuscript Report, Montreal, Canada.

Knappert, J. (1987). *East Africa: Kenya, Uganda and Tanzania*. Vikas Publishing, New Delhi.

Kokwaro, J. (1976). *Medicinal Plants of East Africa*. East African Literature Bureau, Nairobi.

Lagerstedt, E. (1994). *Views, Needs, Uses and Problems Connected with the Forest in Kazimzumbwi Village, Tanzania*. WCST, Dar es Salaam.

Leach, M. (1994). *Rainforest Relations: Gender and Resource Use Among the Mende of Gola, Sierra Leone*. Edinburgh University Press, Edinburgh.

Madgwick, F.J., Wood, B., Varty, N. and Maunder, M. (1988). *Somalia Research Project Report – an Ecological Study of the Remaining Areas of Riverine Forest in the Jubba Valley, Southern Somalia*. University College London, London.

Matthews, P. (1994). *Medicinal Plants of the Tanzanian Coastal Forests: a List of Species with Local Names and Applications*. The Society for Environmental Exploration/University of Dar es Salaam, London and Dar es Salaam.

Mbuya, L.P., Msanga, H.P., Ruffo, C.K. Birnie, A. and Tengas, B. (1994). *Useful Trees and Shrubs for Tanzania: Identification, Propagation and Management for Agricultural and Pastoral Communities.* Regional Soil Conservation Unit (RSCU) and Swedish International Development Authority, Dar es Salaam and Nairobi.

Misra, P., Pal, N.L., Guru, P.Y., Katiyar, J.C. and Tandon, J.S. (1991). Antimalarial activity of traditional plants against eythrocytic stages of *Plasmodium berghei*. *International Journal of Pharmacognosy* **29:** 19–23.

Mogaka, H.R. (1992). *Local Utilisation of Arabuko-Sokoke Forest Reserve.* Socio-economic report (report No.6). Kenya Indigenous Forest Conservation Project, Nairobi.

Monela, G.C., O'Kiting'ati, A. and Kiwele, P.M. (1993). Socio-economic aspects of charcoal consumption and environmental consequences along the Dar es Salaam – Morogoro highway, Tanzania. *Forest Ecology and Management* **58**: 249–258.

Mshigeni, K.E., Nkunya, M.H.H., Fupi, V., Mahunnah, R.L.A. and Mshiu, E.N. (eds.) (1994). *Traditional Medicinal Plants: Proceedings of an International Conference.* Dar es Salaam University Press, Dar es Salaam.

Msonganzila, C., Lagerstedt, E. and Frössling, J. (1994). *A Participatory Exercise on Biodiversity and Environmental Issues.* GEF Project Report (UNO/RAF/006/GEF), Dar es Salaam.

Mwamfupe, D.G. (1997). *PCIP Report on Pugu and Kazimzumbwi Forest Reserves: a report submitted to WWF Tanzania.* WWF, Dar es Salaam.

Myers, N. (1988). Tropical forests: much more than stocks of wood. *Journal of Tropical Ecology* **4**: 209–221.

Nkunya, M.H.H., Weenen, H., Bray, D.H., Mgani, Q.A. and Mwasumbi, L.B. (1990). Antimalarial activity of Tanzanian plants and their active constituents: the genus *Uvaria*. *Planta Medica* Paper 24/490 930 Biological Activities.

Oliver-Bever, B.E.P. (1986). *Medicinal Plants in Tropical West Africa.* Cambridge University Press, Cambridge.

Ongara, O. (1991). *Forestry Action Plan for Coast Region 1990–2007.* Regional Development Director's Office, Kibaha, Tanzania.

Rodgers, W.A. (1992). History of the Gum Copal trade in Tanganyika. *Tanzania Notes and Records.* Unpublished manuscript.

Rodgers, W.A. (1993). The conservation of the forest resources of eastern Africa: past influences, present practices and future needs. Pp. 283–331 In Lovett, J.C. and Wasser, S. (eds.) (1993). *Biogeography and Ecology of the Rain Forests of Eastern Africa.* Cambridge University Press, Cambridge.

Scoones, I., Melnyk, M. and Pretty, M. (1992). *Hidden Harvest: Wild Foods and Agricultural Systems.* IIED, WWF, SIDA, London.

Sofowara, A. (1982). *Medicinal Plants and Traditional Medicine in Africa.* Wiley, London.

Spear, T. (1978). *The Kaya Complex: a History of the Mijikenda Peoples of Kenya to 1900.* Longmans, Nairobi.

Unander, D.W. and Blumberg, B.S. (1991). In vitro activity of *Phyllanthus* (Euphorbiaceae) species against the DNA polymerase of hepatitis viruses: effects of growing environment and inter- and intra-specific differences. *Economic Botany* **45**: 225–242.

Von Reis, S. and Lipp, F.J. (1982). *New Plant Sources for Drugs and Foods from the New York Botanical Garden Herbarium.* Harvard University Press, Harvard.

Wass, P. (ed.) (1995). *Kenya's Indigenous Forests: Status, Management and Conservation.* IUCN, Gland, Switzerland and Cambridge, UK and The Overseas Development Administration (ODA), London.

Woodcock, K. (1995). *Indigenous knowledge and forest use: two case studies from the East Usambaras, Tanzania.* East Usambara Catchment Forest Technical Paper No.22. Forest and Beekeeping Division and Finnish Forest and Park Service, Dar es Salaam and Vantaa.

World Bank (1992). *The World Bank Development Report.* World Bank, Washington DC.

5.4. Coastal forest conservation problems

W.A. Rodgers and N.D. Burgess

Introduction

Recently there has been considerable interest in the conservation of biodiversity, both at a global level (e.g. WCED, 1987; Wilson, 1988; Reid and Miller, 1989; McNeely *et al.*, 1990; WCMC, 1992 etc.) and within developing countries (e.g. Rodgers, 1998; Government of Tanzania, 1998). Tropical forests have been identified as one of the most important ecosystems for biodiversity conservation. These include the Coastal Forests of eastern Africa (e.g. ICBP, 1992; Burgess *et al.*, 1998; Olson and Dinerstein, 1998; Mittermeier *et al.*, 1998; Stattersfield *et al.*, 1998).

Earlier chapters have summarised both the biological values of the Coastal Forests (Chapter 4.9) and the intense use of these forests by humans over many years (Chapters 5.1 and 5.3). This Chapter reviews the main issues facing forest conservation.

The majority of the Coastal Forests are gazetted as Forest Reserves, and are controlled by government forestry departments (Chapter 5.2). Conservation is therefore closely linked with the future capacity and policies of these departments.

Although modern forest policy (e.g. Government of Tanzania, 1998) has made a significant shift towards the involvement of local communities in the management of forest resources, including Forest Reserves, it is likely that real participation will take time to develop. Tanzania's draft Forest Act, for example, appears to exclude collaborative management for national reserves (Government of Tanzania, 1999). The need to increase the focus on people is emphasised throughout this Chapter.

The introduction (Chapter 1.1) stated that Coastal Forests share most of the conservation problems associated with forest conservation in the tropics. The forests were summarised as follows:

- small fragmented patches, most less than 500ha in size;
- surrounded by relatively impoverished rural communities with a high and growing demand for forest resources;
- individually distinctive, with a significant level of local forest endemism, and a great variety of different vegetation communities;
- lacking the national level "hard" resources, such as timber or water catchment values, that would allow species biodiversity values to be incorporated in their continuation; and
- under-protected by government agencies at present.

Problems facing conservationists

These facts have meant that conservationists have been unable to do the following:

- devise a realistic core and buffer zone strategy, where the forest edge can be used to provide resources to local people, and the centre can be maintained as an inviolate refuge. Patches of only a few hundred hectares don't provide enough space for buffer zones to satisfy the demands of many villagers.
- convince rural people about the concept of conservation, based on essential water catchment values, or convince national or district governments (because of the obvious large-scale commercial timber value).
- decide which of the 150 forest patches are essential for biodiversity conservation, and which have high or medium priority. It has also not been determined which criteria should be used to make such decisions.

The first two of these conservation issues are explored in this Chapter within a set of broader problem headings, including those which are increasingly referred to as the underlying or "root" causes of biodiversity and forest loss. Root causes are the deeper symptoms (e.g. population increase, inadequate tenure, etc.) of loss, rather than the surface signs of loss, such as excessive logging, non-sustainable collection of fuelwood and other natural products, fire and encroachment. Root cause analysis asks the questions: "Why is there excessive logging?" and "Why is there increasing encroachment?" Ideally conservation initiatives should address both the deeper causes and the surface signs. This Chapter suggests that, at the present time, they are not doing either.

The third issue, developing priorities for conservation, is also discussed, drawing on data from earlier chapters in the book.

Forest loss is not unique to the Coastal Forest ecosystems or to Africa. Tropical forest loss continues to increase worldwide, the immediate cause being clearance for cultivation. Rodgers (1997a), reviewing patterns of tropical forest loss, concluded that there was little likelihood of this loss diminishing in the near future. Population growth, lack of alternative employment and need for arable land, as well as the need for woody biomass, are the root causes of the use and conversion of forested land. This conversion starts with non-protected areas; eventually pressure builds up to encroach on and then degazette reserved lands (see IUCN, 1996, for a case history in Kenya).

Tanzania has long had policies to maintain forest cover for the good of its people. However, the fact that the government's own figures suggest an annual forest loss of 400,000 ha, indicates that these policies are not working. Why is this so? Are they inadequate? Are they inadequately implemented? Or are once adequate forest policies failing because of new pressures from other sectors (e.g. agriculture, industry) or from population growth? There is a need for more sophisticated levels of policy analysis (Rodgers, 1997b; Rodgers *et al.*, 1999).

Conservation priorities

There are three conservation priorities in the region:

- Developing a protected area (PA) network that reserves priority resources and allows adequate site-based resource management. In Tanzania this has been at the level of reserve status; there are no National Parks for Coastal Forests, and only one forest park (Udzungwa) in the country. In Kenya, Shimba Hills is a park with forest values, although it was established for large mammal conservation; Tana and part of Arabuko-Sokoke forests have National Reserve status.
- Persuading local communities and government stakeholders to accept these protected areas, by showing that real benefits outweigh costs, and by using the resources inside (where permitted) and outside the PAs in sustainable ways.
- Developing alternative resources and incomes for people around these PAs to reduce the demand for forest resources.

The failure to act on these priorities has led to four main problem areas in Coastal Forest conservation:

- an inadequate protected area network, with individual PAs that are poorly managed;
- increasing human populations practising shifting cultivation and using resources in a way which is not sustainable;
- a breakdown of traditional forest protection practices, and unwillingness on the part of local people to adopt conservation concepts; and
- insufficient management input by government authorities, caused by the low priority and lack of funding for forestry, and lack of leadership.

An inadequate protected area network

The patches of remnant forest that exist as government Forest Reserve are the survivors of a larger extent of forest and thicket along eastern Africa's coastal plains and hills. If it wasn't for their reserve status many of these remnants — with the exception of those forests considered sacred by the local people – would have been cleared for cultivation this century. The protection system brings some benefit, therefore, but still has many serious inadequacies.

- Several forests are still not protected (e.g. Kisiju/Dendene and Kiwengoma south of Dar es Salaam, coral rag forest in Zanzibar and Pemba; the timber-rich *(Brachylaena)* forest thickets in northern Tanzania, etc.). There have been plans to reserve them for years but, due to the lack of government will, it does not happen.
- Reserve status is often inadequate for the long-term conservation of important resources. Earlier chapters discussed the pattern of clearing reserved natural forest in colonial times, both for plantations (since all useful timber had been extracted from the natural forest) and for agricultural development. Degazettement was, and is, achieved with the stroke of a Minister's pen. In Kenya, degazettement has brought frequent encroachment of Nairobi City Forest and Karura Forest. This loss is heightened during election periods (see IUCN, 1996). There is a growing feeling that Kenya's natural forests should be placed under the jurisdiction of the Wildlife Service to prevent such Ministerial excision. (Box 5.4.1 highlights the recent loss of Coastal Forest resources in East Africa). National Park status provides much greater security, in that degazettement must be carried out by Act of Parliament.
- Forest Reserves are "managed" by forest departments, but these departments rarely have the resources to undertake the task and Coastal Forests are often a low priority to them. Structural Adjustment Programmes in Tanzania have led to many districts laying off most forest guards in the past years. This was done with little regard for, or commitment to, the concept of resource conservation.

As yet there is little real capability to involve local people in management, despite the new Forest Policy in Tanzania (1998) that permits real empowerment and ownership. Expertise, funding and legislation are still needed to make the policy operational.

This book is largely about the biological diversity of forests. Such diversity is dependent on maintaining the complexity of the forests' natural woody cover. Maintaining such cover, therefore, should be the ultimate goal of forest management. Utilisation can be permitted if there is sufficient regeneration, and if forest integrity – in terms of species variation, structure and light regimes – is maintained. Management success must be measured against these objectives.

Forestry departments, by tradition, have been resource use agencies. Management was governed by production targets, not conservation of species or plant communities. Where there were no official production targets, then management satisfied local demands. Wildlife departments have been obsessed with preventing all extractive use and have developed huge staffs to eliminate poaching. The silviculture practices of clearing climbers and figs *(Ficus* spp.), and of felling non-commercial species for the sake of uniformity, dominated the forest management practices of government departments in much of the region (see Rodgers, 1995).

Forestry was traditionally concerned with valuable timber and, on a large scale, water catchment capability. The harvesting of fuelwood, poles, honey and duikers was not seen as a problem and was tacitly accepted while staffing levels remained low. As populations increased and resources became scarce, however, the pressure on reserves rose rapidly. Moreover, governments were becoming financially impoverished, and staffing levels were frozen or even reduced. The wildlife sector was more responsive to change, with input from economists, sociologists and biologists from outside the profession. Forestry, however, remained the domain of foresters. Acceptance of new ideas, such as community involvement, took longer.

Box 5.4.1 Destruction of Coastal Forests

a. Tanzania

Kisiju (also known as Dendene)

This is perhaps the last surviving patch of gum copal (*Hymenaea*) forest along the Tanzanian coast. Some 200 hectares, with closed canopy and black and white Colobus monkeys, it is rapidly being cleared for cassava. Coast Region Forestry started the gazettement process with GEF funding in 1994, but activities have ceased.

Vikindu

Vikindu is a closed evergreen Coastal Forest Reserve just south of Dar es Salaam, partially cleared by the British colonial government for a fuelwood reserve (using exotic *Senna*). Although the edges and valleys were left intact, the Dar es Salaam Regional Forest Officer allowed encroachment of the forest for settlement.

Mafia Island

Tall evergreen forest was cleared recently for coconut estate expansion. A part of the coral rag forest is now in the Marine National Park, but plans to gazette the rest as Forest Reserve have stalled.

Pugu/Kazimzumbwi

This area still faces severe encroachment (see details in chapter 5.5).

Pande

Once a Forest Reserve just north of Dar es Salaam, with several valuable plant and bird species, it was degazetted and declared a "private zoo'. This failed and the area was subsequently subject to extremely high levels of collection of charcoal and poles. It was regazetted as a Game Reserve, but no resources were alloted for management. High levels of charcoal cutting continue, mainly by the Tanzanian army.

Rondo Plateau

Described by Kew Gardens botanists as the "richest plant site in Africa's Coastal Forests', this Lindi Region Forest Reserve was largely felled by the British for commercial softwood plantations and some mvule (*Milicia excelsa*). The periphery remains as good forest, and the new mvule understorey has importance for rare birds, although there is little management input.

b. Kenya

Arabuko-Sokoke

This area provides important habitat for several species of rare birds and mammals and is under threat from land clearance and acquisition (see details in chapter 5.5).

The Kayas

These are sacred forests of the coastal people, not gazetted in forest law, although some patches are National Monuments. They are vulnerable to commercial exploitation and encroachment when traditional leadership breaks down.

Chale/Diani

Good coral rag forest and thicket have been taken over by developers. Communities have been bought out, despite ecotourism opportunities.

It is important to stress that these problems are not unique to Tanzania. In other parts of the world deforestation has led to the fragmentation of once continuous forest cover. Caldecott (1998), quoting Norman Myers, states: "A rough guide is that a tropical forest reserve should be 500km^2 or more, if most native species are to survive". This is not the case on Hainan Island in China. There is 4 per cent forest cover remaining, but it is in 19 small discrete fragments. But even there, with only one patch larger than 212km^2 and nine patches only about 20km^2, the situation is better than on the East African coast.

Caldecott describes this area in China and others in the Philippines as "sites where fragmentation is so far advanced that forest conservation projects have to link people and their resource constraints to ecological principle''. He believes that in parts of the Philippines, forest conservation is best addressed on a large scale through work undertaken within IUCN Category V (Protected Landscapes), rather than individually dealing with the small remaining forest patches. Such an approach may offer a suitable model for the conservation of the smaller forest patches along the eastern African coast.

Increasing population pressure, shifting cultivation and unsustainable resource use

Historical research on East Africa documented a considerable decline in human populations from late in the 1800s to the 1920s, due to colonial impact, disease, cattle rinderpest, and World War I (Kjekshus, 1977). Since then the human population has continued to rise, with the increase averaging 2.3–3.8 per cent yearly in the last decades (see Table 5.4.1; Vooren and Sayer, 1992). As most people in eastern Africa are cultivators, the demand on land and on natural resources (such as building materials, timber, fuelwood and grazing to obtain animal proteins) has increased substantially.

Rates of agricultural growth in the region have declined since the 1960s, especially in Mozambique, which experienced a decrease in production (Vooren and Sayer, 1992). Declines have been due to many causes, including lack of incentive, increased central planning, drought and war. Food intake (measured in calories) has declined, agricultural plot sizes have fallen, and forests have been lost. Even if the agricultural and population targets set out in Table 5.4.1 were achieved, the standards of living would remain low for most people. Population growth means that there will be twice as many subsistence farmers by 2020 as there were in 1995. Unlike the drier countries of Somalia and Kenya, Tanzania and Mozambique still have suitable land for agriculture, although some of it would have to come from the remaining Coastal Forests.

Coastal agriculture is inefficient. Much is short-term shifting cultivation (four to eight years) concentrating on food crops like cassava, maize and valley-bottom rice. As rotation times decrease declining yields lead to increased pressure on forest areas. Agricultural extension support has also declined in the past decade.

Non-sustainable use affects forest products as well as land. In Tanzania, fuelwood use projections estimate some 22 million cubic m at the household level, compared to a sustainable yield of 13 million m^3 (an additional five million goes to industry). This demand is likely to reach 52 million m^3 by the year 2020. Much of this will come from the clearing of forest and woodland (when calculating harvest sustainability, however, it should be noted that most woodland and many tree species will regrow from stump). Most fuelwood goes to supply the needs of urban centres such as Dar es Salaam and Tanga, even Mombasa, which has a severe impact on Coastal Forest resources.

Although concern about fuelwood use in Tanzania extends back to the 1970s (see e.g. Leach and Mearns, Beyond the Woodfuel Crisis, Earthscan 1987), some of the predictions made then were based on flawed data. The data was predicated on the assumption that cut forest does not regenerate; in addition, it was based on traditional forest inventories, which do not take into account branch wood (up to 50 per cent of the wood volume available for fuel) or on-farm woody biomass resources (live fences, scattered trees).

Hall and Rodgers (1986) drew attention to high levels of polewood cutting in lowland forests, an issue later commented on by other workers in and around Pugu Forest (see further data in Chapter 5.3). There is no tradition of sustainable harvesting of poles from within private sector interests, communities or from the forest service. Over time uncontrolled pole harvesting eliminates the young trees of forest canopy species.

Uncontrolled fires are another long-term threat to the Coastal Forests. Fire can penetrate into a forest and destroy part of it, especially at the end of the dry season when the leaf-litter on the forest floor dries out. The threat is particularly intense during the period prior to cultivation, when fires are set to burn weeds and clear fields. Before the 1960s fire was prevented from entering the Forest Reserves by controlled burning of the grassland at the margin of the forests (see Forestry Department Annual Reports), but this practice ceased due to a lack of funds.

Table 5.4.1 Food consumption, agriculture, population and the environment in eastern Africa (from Vooren and Sayer, 1992).

	Eastern African Countries			
	Somalia	**Kenya**	**Tanzania**	**Mozambique**
Agricultural production growth rates (per cent per annum)				
1965–1973	no data	6.2	3.1	no data
1980–1988	3.9	3.3	4.0	(0.8)
1990–2020 (target)	3.0	4.0	4.0	4.0
Population growth rate (per cent per annum)				
1965–1973	2.6	3.4	3.2	2.3
1980–1988	2.9	3.8	3.5	2.7
1990–2020 (target)	3.0	1.9	2.3	2.3
Per capita calorie consumption per day				
1965	1824	2289	1832	1979
1988	1749	2060	2192	1595
2010 (target)	2200	2400	2400	2200
Percentage of population who are food insecure				
1980/81	50	37	35	49
2020 (target)	15	10	10	20
Reforestation rates per annum (per cent)				
1980s	(0.1)	(1.7)	(0.3)	(0.8)
1990–2020 (target)	1.5	1.5	1.5	1.5
Per capita arable land area (ha)				
1965	0.3	0.2	0.3	0.3
1987	0.2	0.1	0.2	0.2
Percentage of total land under crops				
1987	1	4	6	4
2020 (minimum target)	2	4	10	7
Percentage wilderness area to total area				
Present %	24	25	10	9
Minimum target %	22	25	10	9

***Note*:** Numbers in brackets denote negative values.

Limited awareness of conservation issues locally and nationally

Breakdown of traditional forest protection practices

Small areas of forest have traditionally been conserved as sacred places all along the eastern African coast, most notably in southern Kenya (see Spear, 1978; Robertson, 1987 re: the Kaya Forests). Small sacred groves, usually ancestor worship sites, are also found in coastal Tanzania. These areas have been protected by traditional customs, but are now threatened by inmigration of people who do not owe allegiance to traditional authorities, and by the increasing influence of Islam and Christianity. Experience from Kenya suggests that if traditions are lost or unduly weakened, then the forests are cleared for farmland and construction.

There has been little research into traditional forms of resource management, including forest and fuelwood resources. Most traditional conservation practices follow from perceptions of scarcity (hunting rules), practicality (no felling along springs) or ethics (no hunting of nursing females). Traditional custom did regulate land use, and governed the use of resources that were perceived to be scarce.

Negative views of the values of forest conservation

Although there may be many scientific and broad societal reasons for conserving the Coastal Forests (see Section 4), these generally have limited relevance for those engaged in subsistence agriculture and forest use. Forest conservation must be presented in more practical terms, stressing existing and potential benefits to local people (Emerton, 1998).

Local communities suffer the direct and indirect costs of forest conservation, such as crop damage by forest animals and lost agricultural opportunities. Households living adjacent to Arabuko-Sokoke forest, for example, are estimated to lose between half and three-quarters of the crops they grow to damage by elephants, baboons, monkeys and bush pigs. For the majority of the local inhabitants, these problems outweigh any of the potential benefits of conserving the forest. Where the forest is located within a Forest Reserve people also feel that the land has been appropriated by the government for its own ends. There is often an antagonism towards the management authorities as being those who are "preventing" access to needed resources, especially if the authorities are also involved in harvesting the resource (particularly if this use is thought to be illicit).

There is, therefore, a gulf between those who want to save or sustainably manage the forests,and those who live close by them and who need to be persuaded of the benefits of conservation.Experience in the Coastal Forests indicates that at best the local inhabitants regard their forest as avaluable resource to be utilised. At worst, they see the forests as a stock of unclaimed farmland, or a wild area harbouring animals that damage crops. In a study of the East Usambara lowland forests (Woodcock, 1997) farmers were found to have divided feelings about Forest Reserves. On the one hand, they felt that it was necessary for the government to protect the reserves; otherwise, all forest would be converted to agricultural land and it would then be difficult to obtain poles or firewood.

Some also commented on water catchment values. On the other hand, people regretted that they would be unable to use the forest as land for future generations. Most farmers could see no solution to these conflicting viewpoints; their biggest problem was where to obtain "fresh" agricultural land for themselves and their children.

Changing patterns and priorities in conservation

The present conservation pattern in eastern Africa stems from past colonial practice, and is embodied in natural resource laws in the wildlife, forestry, and water sectors. These laws stipulate a centralised control of reservation, and proscribe most resource use by local people. Any incentive to conserve was removed by alienating local communities from resource ownership. Even the use of valued trees *(Milicia)* on private land was controlled; a government permit was needed to fell it, transport it, or sell it.

New concepts about conserving forests have not yet taken hold with decision-makers; it is only in the last five years that African forest conservationists have begun to push for more local participation in management, decision-making, and benefit sharing. (It should be noted, however, that only four years ago, Tanzania added several tree species to the reserved trees order, including bamboo.) This push for broader participation has arisen from an increasing realisation that command and control under a central authority does not work. In Tanzania these changes are given official sanction by the new Forest Policy (1998), and the advent of Joint Forest Management devolution and initiatives on the ground. In Kenya progressive policy processes (a Forest Master Plan and Draft Forest Policy) have been stalled for some time.

Now that the emphasis of conservation programmes is shifting towards the involvement of the local people, a new problem has arisen. Most conservation or development organisations and individuals come with their own perceptions of problem-solving. These perceptions are rarely derived from an understanding of the historical, social and financial constraints of the local area and people. Moreover, ideas that are used to design conservation programmes vary between conservation (or development) organisations, and between staff within those organisations. Such a variation in approaches and policies can cause confusion in national forestry departments as well as local villages.

Addressing some of the major problems of Coastal Forest conservation – such as agricultural encroachment, illegal charcoal production and logging, and corruption – can be an extremely sensitive political issue; this is illustrated by the Jozani Forest Project in Zanzibar (see Box 5.5.4). Many conservation/development organisations shy away from tackling these issues for fear of offending national governments or local populations, or finding themselves in opposition to powerful vested interests. In some cases donor country sentiments prohibit certain conservation actions, such as relocating encroachers; in Uganda, for example, the issue of Kibale Forest squatters meant a cessation of EU funding.

Lack of money, poor governance and lack of management input by government

As most Coastal Forests are gazetted Forest Reserves, the capacity of government forestry departments to manage them, and their attitudes and policies, are critical to the prospects for forest conservation.

For most of its history the Forestry Service of Tanzania has not generated sufficient income from issuing felling licences for timber and other mechanisms to cover its own costs (see Chapter 5.2). The only time it generated more income than it spent was during intense and unsustainable timber exploitation (especially during the British colonial period just after World War II). Although its calculations fail to take into consideration the values of the forest products extracted on licence from the forest, or other values such as water supply, climatic stabilization and prevention of erosion, etc., it has been this perception of a deficit which has influenced government funding of forestry activities.

This was discussed extensively within the Tanzania Forest Action Plan process (see Government of Tanzania, 1992; Rodgers, 1993). During that process it was stressed that forestry's contribution to GDP was much greater than just direct earnings of fees and royalties. It was suggested that if fuelwood support to the energy sector, and agricultural and water support were included, then the proportion of GDP would exceed 6 per cent. Recent Food and Agricultural Organization (FAO) statistics have suggested that a realistic figure would actually be around 20 per cent of GDP.

In Tanzania, the Forest and Beekeeping Division, in its role as the guardian of a large share of the country's biodiversity, is the logical recipient of biodiversity conservation funding from external donors. Such support will need to be provided over the long term if it is to succeed fully. Novel ways to provide long-term support at a moderate level are required, and establishing such mechanisms is a challenge to all conservationists. As of mid-1999 the Forest and Beekeeping Division in Tanzania did not have an office with responsibility for Coastal Forests, or a section responsible for conservation.

Low priority attached to forestry in government

Within government, the highest priority (in terms of recurrent and development expenditures) is typically given to departments concerned with education, health and infrastructure works such as roads, electricity and communications. Much lower levels of funding are allocated to forestry departments. With the declining economic fortunes of eastern African countries since the 1970s, the proportion of funds available to forestry has declined even further. By the mid 1980s, when even core forest areas (plantations, major catchment forests) were poorly funded, there was little more than salary money available. This remains true today, despite the retrenchment of significant numbers of staff and the saving of their salary payments. Indeed, recent statistics for the forest sector funding in Tanzania indicate a donor to government ratio of 19 to 1.

The decline in funds for forestry departments

Over the past 20 years national funds available for forestry have declined, and they continue to fall in most countries with Coastal Forests. In Tanzania and Kenya in the 1960s, the typical District Forestry Officer was equipped with a vehicle, a house and equipment to do the job, and was paid at a level where he could maintain a professional standard of living for himself and his family. Forest Assistants had access to some form of transport (a bicycle), equipment, field clothes, a machete, and a uniform and beret as symbols of authority.

Now these officers are without transport and have little equipment. More importantly, salaries in Tanzania do not cover a family's average monthly expenditures, forcing people to find alternative sources of income. Howard (1992) showed that by 1990 the salary purchasing power of a forest guard in Uganda had declined to one per cent of 1960 levels. In many areas, actual payment of the salary may be delayed for months. It is no longer possible for staff to carry out regular patrols in the forests, supervise any harvesting or silviculture operations (if there are any), meet with representatives of local populations to resolve disputes – or in some places even to go to the forests at all.

In Tanzania decentralisation led to an incremental reduction in supervision. Without regular visits from senior forestry officials, there is little incentive for people at the lower levels of the forestry service to carry out their jobs. In some cases there may be pressure on the forest guards living in the community not to convict local offenders, or to take payoffs to turn a blind eye to offences (Rodgers *et al.*, 1983).

One of the reasons for a decline in available funds is the poor rate of revenue collection. Recent analyses (e.g. FRMP, 1997; Cobb, 1998) show that the Tanzanian government has been able to collect less than five per cent of the timber and produce royalties due. Revenue retention schemes could be an incentive for greater collection, but the schism between central and district ownership has prevented them from being implemented.

Poor governance

Governance refers to the pattern of institutional administration, including issues of democracy in decision-making, financial probity (or corruption) and style of leadership. Forestry in eastern Africa has long been subject to misappropriation of funds, poor collection of royalties, etc. Indeed, the Director of Forestry and Beekeeping in Tanzania recently described corruption by officers of his division as the single most important factor leading to illegal harvesting of forest products. He drew attention to the report from Tabora Region (FRMP, 1997) citing royalty collection as averaging between 0.9 and 1.5 per cent of expected payments (Statement at Eastern Arc Conference, December 1997). To a great extent these problems are understandable; wages are extremely poor, there is little field level or management supervision, and valuable natural resources are easily exploited. More systematic exploitation of forest resources by people in authority is also thought to occur (although not so frequently in the Coastal Forests as elsewhere, since these forests do not have much high-value timber remaining).

In addition to the illegal exploitation of timber resources, control over charcoal and pole production and the issuing of rights to farm within reserves are also believed to provide a considerable underground income. All these factors can lead to corrupt practices; once started they become part of a *laissez-faire* attitude towards forest resources.

The forestry sector in all three East African countries is undergoing or will undergo major institutional change. Issues being discussed include decentralisation, a move to self-financing agencies or authorities instead of civil-service departments (as in Tanzania and Uganda, respectively), passing plantations to the private sector, and devolving some responsibility for natural forest conservation to National Park organisations. In theory, the governance system would then alter significantly, with greater local empowerment and accountability. But while this process is underway – with new legislation, new staffing levels and new reporting systems – capacity is weakened rather than strengthened. Forestry capacity is at a low ebb in the eastern Africa region; further declines may have serious consequences for forest and biodiversity conservation.

Limited suitability of some forms of donor assistance

Project time scales

Conservation of the Coastal Forests will be a long-term task, but most donor funding and national projects are generally short-term, typically lasting three to five years. This limits long-term planning by forestry departments and other stakeholders, and can reduce the chances of involvement by local populations. Short-term projects are much less likely to tackle conservation problems effectively, although they can be useful in certain situations, such as providing boundary demarcation to prevent encroachment. Short-term projects can also create a project-dependence culture, however, where nothing happens unless a project provides the finances. Short-term projects may cause confusion in local populations who see a stream of such projects (or worse, studies) in different areas with different approaches.

Project finances

Most donors have a far greater financial capability than the groups with whom they are working. A typical budget for a three-year project is one million US dollars, compared to a typical three-year district forestry operational budget in Tanzania (including salaries) of a few thousand US dollars. There is a 'boom and bust' pattern as projects come and go. Also, projects typically pay higher salaries than governments. Although this can induce essential people to leave government, better project salaries do allow staff to concentrate on the job without having to earn money or farm to survive. Today in the Coastal Forest countries project financing is almost the only basis for forestry departments to work, or to incorporate new ideas into forestry management.

The efficiency of the modern project approach to conservation, when applied to working with communities, has been questioned (e.g. Kiss, 1999). The short-term, result-oriented and often externally driven agendas of projects limit communities' capacity and abilities to address longer-term issues of land reform and land use. Although greater emphasis on tenure, access, and financial inducements (incentives and disincentives) to achieve behaviour change is seen as critical, to date the short-term project approach remains dominant.

Project intervention periods

The length of project support is a critical issue. A three-year project will only allow a conservation process to start, except for dealing with some of the more immediate problems such as marking a forest boundary. This is particularly true in cases where there is a shift from direct control by the Forestry Department to more participation by the communities. INGOs, NGOs or CBOs can mediate such a shift. This could take 10–15 years, with a monitoring role continuing after that. Funding mechanisms need to be developed that allow for this long-term involvement, including ways to share benefits and revenues derived from the forest. Such longer-term interventions, linked to the presence of forest in an area, should also increase the local communities' perceived value of the forest.

Kiss (1999) stressed that short-term projects are often driven by short-term goals, and often ignore the longer-term goal of changing behaviours to allow conservation principles to be incorporated into land-use planning. In 30–50 years there should be a major change in attitudes to forests and to integrating them into the land ownership pattern as a valued and respected part of the landscape. There is also hope for a decrease in forest destruction and overuse, and even for attempts to enlarge targeted forest areas. Only time will tell if the appropriate changes can be made, and, if they can, whether they work or lead to over-exploitation by the communities and clearance of the forests for farming land.

Conclusions

This Chapter has outlined the main problems facing conservation in the eastern African Coastal Forests. Forests have been fragmented to a point where traditional forest reserves may not provide adequate protection of biodiversity. In other parts of the world an approach is being advocated which more fully involves the local communities in forest management and land use. Government departments – which have traditionally held responsibility for the management of these forests – are changing, and further major changes are likely in the near future. What these changes mean for forest conservation in the area is not yet known, but a paradigm shift in forest conservation planning and implementation in the region may occur. External financing has become an essential part of conserving forest resources and their biodiversity. More of this will be needed, but longer-term planning that allows sufficient time to fully engage the local communities is also required. This cannot be accomplished using three-year projects, but longer-term alternatives and the required financial mechanisms do not yet exist in the region.

The situation on the ground is serious and is exacerbated by an apparent lack of concern about Coastal Forests within forest agencies. All is not lost, however; there is both the need and the capability for successful conservation intervention. Chapter 5.5 suggests ways in which this can be achieved.

Acknowledgements

We thank Phil Clarke, Peter Gibbon, Johan Frössling, Kerry Woodcock, Alex Hipkiss, Andrew Perkin and Simon Rietbergen for comments on this Chapter. The Chapter has also benefited from the input of a large number of people who have attended various forest conservation workshops in eastern Africa and Tanzania in particular. They are too numerous to list here, but include members of the government Forestry and Beekeeping Division, researchers, conservationists and donors.

References

Burgess, N.D., Clarke, G.P. and Rodgers, W.A. (1998). Coastal Forests of eastern Africa: status, species endemism and its possible causes. *Biological Journal of the Linnean Society* 64: 337–367.

Caldecott, J. (1998). *Designing Conservation Projects.* Cambridge University Press, Cambridge, UK.

Cobb, D. (1998). *Report for the East Usambara Forest Catchment Project.*

Emerton, L. (1998). *Community Conservation in Africa: the Nature of Benefits and the Benefits of Nature: why Wildlife Conservation has not Economically Benefitted Communities in Afric*a. ESRC Paper 9. University of Manchester, UK.

FRMP (1997) *Forest Resources Management Project*. Progress Report for 1996. World Bank and Tanzania Forest and Beekeeping Division, Dar es Salaam.

Government of Tanzania (1998). *National Forest Policy*. Ministry of Natural Resources and Tourism, Dar es Salaam.

Government of Tanzania (1999). *Draft Forest Bill*. Ministry of Natural Resources and Tourism, Dar es Salaam.

Government of Tanzania (1992). *The Tanzania Forest Action Plan*. Division of Forestry and Beekeeping, Dar es Salaam.

Hall, J.B. and Rodgers, W.A. (1986). Pole cutting pressures in Tanzanian forests. *Journal of Forest Ecology and Management* 14: 133–140.

Howard, P. (1992). *Nature Conservation in Uganda's Tropical Forest Reserves*. IUCN Tropical Forest Series. IUCN, Gland, Switzerland and Cambridge, UK.

ICBP (1992). *Putting Biodiversity on the Map: Priority Areas for Global Conservation*. ICBP, Cambridge.

IUCN (1996). *Forest Cover and Forest Reserves in Kenya: Policy and Practice*. IUCN Eastern Africa Regional Office, Nairobi.

Kiss, A. (1999). *Making Community Based Conservation Work*. Paper Presented at Society for Conservation Biology Meeting Annual Meeting, June 1999, USA.

Kjekshus, H.K. (1977). *Ecological Control and Development in East Africa*. Second Edition. Heinemann Educational Books, Nairobi.

McNeely, J.A., Miller, K., Reid, W., Mittermeier, R. and Werner, T. (1990). *Conserving the World's Biodiversity*. IUCN/WRI/CI/WWF(USA)/World Bank, Gland, Switzerland and Washington DC.

Mittermeier, R.A., Myers, N., Thomsen, J.B., da Fonseca, G.A.B. and Olivieri, S. (1998). Global biodiversity hotspots and major tropical wilderness areas. *Conservation Biology* 12: 516–520.

Olson, D. and Dinerstein, E. (1998). The Global 200: a representation approach to conserving the Earth's most biologically valuable ecoregions. *Conservation Biology* 12: 502–515.

Reid, W.V. and Miller, K.R. (1989). *Keeping Options Alive: the Scientific Basis for Conserving Biodiversity*. World Resources Institute, New York.

Robertson, S.A. (1987). *Preliminary Floristic Survey of Kaya Forests in Coastal Kenya*. Unpublished Report. National Museums of Kenya, Nairobi.

Rodgers, W.A. (1993). The conservation of the forest resources of eastern Africa: past influences, present practices and future needs. Pp. 283–331. In Lovett, J.C. and Wasser, S. (eds.). *Biogeography and Ecology of the Rain Forests of Eastern Africa*. Cambridge University Press, Cambridge, UK.

Rodgers, W.A. (1995). *The Conservation of Forest Resources in East Africa: The Approaches of Forest and Wildlife Sectors Compared*. In Workshop on Conservation of African Biodiversity. National Museums of Kenya, Nairobi.

Rodgers, W.A. (1997a). *Global Patterns of Loss of Forest Biodiversity*. Vol 2. Eleventh World Forest Congress, Anatalya, Turkey. FAO, Rome.

Rodgers, W.A. (1997b). The Role of NGOs in Facilitating Community Participation in Forest Conservation: Institutions and Forest Policy Reform in Tanzania. Pp. 291–304. In *African Forest Policy Forum*. Vol II. World Bank, Africa Region Policy Group, Washington DC.

Rodgers, W.A. (1998). *Mainstreaming Biodiversity Issues into Forest Policy and Programmes in Tanzania*. Proceedings of Workshop on Biodiversity Policies, November 1997. ACTS, Nairobi.

Rodgers, W.A. and Muheto, R.N. (1994). *The Protected Area System of Tanzania: Report of Workshop Proceedings*. FAO Field Project Document. Dar es Salaam.

Rodgers, W.A., Hall, J.B., Mwasumbi, L.B., Griffiths, C.J. and Vollesen, K. (1983). *The Biological Values and Threats in Kimboza Forest Reserve, Morogoro Region*. Tanzania Forest Conservation Group, Dar es Salaam.

Spear, T. (1978). *The Kaya Complex: a History of the Mijikenda Peoples of Kenya to 1900*. Longmans, Nairobi.

Stattersfield, A.J., Crosby, M.J., Long, A.J. and Wege, D.C. (1998). Endemic Bird Areas of the World: priorities for biodiversity conservation. *BirdLife Conservation Series* no.7, Cambridge.

Vooren, F. and Sayer, J. (1992). Population, environment and agriculture. Pp. 49–55. In Sayer, J.A. and Collins, M. (eds.). *Tropical Forest Atlas for Africa*. IUCN/WCMC, Cambridge, UK.

WCED (World Commission on Environment and Development) (1987). *Our Common Future*. Oxford University Press, Oxford.

WCMC (1992). *Global Biodiversity: Status of the Earth's living Resources*. Chapman and Hall, London.

Wells, M.P. (1994). *Community-based Forestry and Biodiversity Projects have promised more than they have delivered: Why is this and what can be done?* Paper for the International Symposium on Rain Forest Management in Asia, Oslo, March 23–26, 1994. Centre for Development and the Environment, Oslo.

Wilson, E.O. (ed.) (1988). *Biodiversity*. National Academy Press, Washington DC.

Woodcock, K. (1997). *Kambai Forest Conservation Project in the East Usambaras, Tanzania: experiences from field-work and studies, 1994–1996*. Tanzania Forest Conservation Group, Dar es Salaam.

5.5 Taking conservation action[1]

W.A. Rodgers and N.D. Burgess

Chapter 5.4 describes the threats facing the Coastal Forests of eastern Africa, including the severity of these threats and the difficulties of seeking sustainable solutions for long-term conservation of small forest patches. There are a number of potential ways forward, which are discussed in this Chapter.

Several types of conservation initiatives are being considered for Coastal Forests by governments, their conservation partners and local communities. This Chapter describes these initiatives, using case studies where appropriate. Priority sites for Coastal Forest conservation are reviewed and recommendations are made for actions to be tested and implemented over the coming years.

There are two critical themes for successful conservation. These are:

- focusing on the most important sites (priority sites) for conservation action; and
- undertaking actions that reduce the primary threats to the long-term survival of these sites.

Focusing on priority sites for conservation

In general the most important Coastal Forest sites are those with high levels of biodiversity (using species richness and degree of endemism as a measurement). The conservation literature has many methods to determine levels of priority using hard quantitative data. Several methods focus on "complementarity" as an approach, where the site with the highest number of species is used as a starting point. Thereafter the site that adds the highest number of new species is chosen, and so on until all species are represented. This allows the determination of the minimum number of sites needed to include all taxa, for example. This can be done for each taxonomic group separately, or all combined. Chapter 4.2 showed that all presently known forest bird species in the Coastal Forests could be represented by having a minimum of six Protected Areas (PAs). However, the lack of comparable data for other taxonomic groups, such as plants, precludes the use of this approach.

In this Chapter we use a simpler approach, focusing on sites with high levels of animal and plant species endemism. The number of endemic taxa thus defines the level of priority. Rondo Forest Reserve (FR), for example, has many more such species than Pande FR. From this general statement, two sets of data can be generated. One list (Table 5.5.1) is based on the size of remaining forest; larger sites give greater chances of population viability (only sites larger than 400 ha were used).

The second list (Table 5.5.2) is based on the immediacy and magnitude of threat. Threats include non-reserved status, unchecked deforestation, and encroachment. Small forest size increases the level of conservation concern in terms of population viability and perturbation impacts. This would include sites of less than 400ha.

---

1 The original material for this Chapter was edited and reorganised by the IUCN Forest Programme in Gland, Switzerland.

Table 5.5.1 High-priority sites for long-term conservation

Site	Status	a	b	Notes
Kenya				
Arabuko-Sokoke	NR, FR	> 4	1	EU Project support via BirdLife
Shimba Hills	NP	>12	0	GTZ Project support
Tana River Forests	NR	> 4	7	GEF Project support
Tanzania				
Lowland East Usambara *, Tanga	FR, O	>20	3–4	4 x FINNIDA, 3+ not supported
Rondo (not plantation), Lindi	FR	>50	4	Minor WCST/ IUCN Holland
Pugu, Coast Region	FR	12	2	WCST with SSNC support
Matumbi-Kiwengoma, Coast-Lindi	O	>3	2	DfID via WWF Tanzania
Kiono-Zaraninge, Coast Region	O	>2	0	DfID via WWF Tanzania
Litipo, Lindi Region	FR	>16	1	Minor WCST/IUCN Holland
Pemba Island (including Ngezi)	FR	>4	5	No support
Zanzibar Island (including Jozani)	FR	>4	1	CARE-Tanzania
Kimboza, Morogoro Region	FR	17	1	NORAD via Catchment Forestry
Gendagenda, Tanga Region	FR	4	1	No support
Others				
Mozambique, Bazaruto, **		?	3	
Malawi, S Mulanje, Nkhata Bay		?	3	
Zimbabwe, Haroni-Rusitu		?	0	

Key: **a:** Plant endemics **b:** Vertebrate endemics

Notes: * These lowland forest areas would include: Kambai, Segoma, Manga and Kwagumi FRs managed by the East Usambara Catchment Forest Project and Mzimbazi, Magogo and North Bombo FRs which fall outside such project support. There is also some ungazetted closed forest north of the East Usambara Mts.

** Mozambique also includes parts of the Macondes Plateau, although details are not available.

Some of the sites in this table are already within National Parks or National Reserves, and thus have a high level of protection. Exceptions requiring additional strong protection in our opinion are: the remaining area of the Arabuko-Sokoke forest, the remaining forest on the Tana River in Kenya, the open forests around the East Usambaras, Pugu, Kiwengoma, Ngezi on Pemba Island and the Rondo/Litipo forest areas in Tanzania.

Table 5.5.2 Coastal Forest sites in danger

Site	Area and status	Plant endemics	Notes
Kenya			
Mrima Hill	FR, 600ha?	10?	Small, very rich botanically.
Several 'Kayas'	M	10	Uncertain management authority.
Diani, Chale Island	O	?	Coral rag forest, not reserved.
Tanzania			
Pande, Dar es Salaam Region	GR, 1100ha	3	GR status but no input at all.
Kazimzumbwi, Coast Region	FR, 1400ha	12 in Pugu	Still facing severe encroachment.
Kisiju /Dendene	O, 200ha	Gum copal	NOT gazetted, 5 years trying!
Amboni Gorge	O, 200ha	2?	Rapid degradation, African Violet values.

Key: FR = Forest Reserve; GR = Game Reserve; M = Monument; O = open land.

Box 5.5.1 Protecting Coastal Forests

The strongest set of practical guidelines comes from Wild *et al.* (1999) writing about Coastal Forests in Tanzania. Part of their report is summarised here.

Protection of forests from agricultural clearance, settlement, timber and woodcutting and fire is essential. This protection must include a high level of community involvement and even leadership. Communities must gain clear benefits if they are going to be involved, and some level of community use or benefit sharing will be necessary. Efforts should concentrate on establishing what constitutes wise use.

Boundary demarcation is crucial for proper management but conservation boundaries should not be drawn so closely around the forests that subsequent changes in land use leaves them isolated from each other or from adjoining habitats.

Improving the conservation status of the forests is important but it is crucial that this be done in a way that **strengthens local communities' stake** in management. "Village Forest Reserve" is the preferred status for future forest reserves, while community participation in local and central government reserves should be increased and formalised. Additionally, communities must gain clear tenure and rights (as well as responsibilities, i.e. for protection).

While there has been a concerted effort to gain information about the forests through biological inventory, this should be broadened to include other knowledge, especially about the use of the forest and of individual species.

Governance was seen as a major problem in all communities, with complaints about both village government and forest authorities. Lack of information about appropriate forest, wildlife and village government policies and legislation meant villagers felt helpless in assessing the procedures being followed.

Timber revenue was a contentious issue. Community members claimed that, while they were exhorted to conserve the forest, their villages received no benefit from timber licences. Land tenure and forest use issues were also cited as problematic, with government staff telling villagers that the forests belonged to the community but not allowing communities to use them.

Crop damage by forest animals was a problem faced by adjacent farmers; villagers did not see forest clearance as an appropriate solution to this problem.

The Coastal Forests need **greater recognition of their global values** at district, ward and village levels. They also need adequate protection, appropriate use and effective management.

Communities, on the other hand, need improved livelihood opportunities, access to basic services, and clear rights and responsibilities for managing and benefiting from forests in their areas. Forests also play a role in generating income for the districts.

While several of these needs appear to be in conflict, it may be possible to reconcile them, given appropriate approaches and inputs. This will, however, require a concerted long-term effort. A number of factors will influence this:

- some communities are protecting certain forests for cultural reasons. Although these initiatives often receive little official government support, they should be recognized and supported;
- communities do value the forests. Many villagers living close to the forests depend on them for a number of reasons. While the value of these goods and services in comparison to alternative sources is difficult to measure, villagers valued the forests because of them;
- certain individuals living in close proximity to the forests have an intimate knowledge of them, the species within them and their uses and values. This is a critical body of knowledge for future forest management;
- collection of indigenous knowledge and linking it to scientific knowledge will lead to very thorough information upon which to base management;
- decentralizing government services to the district level provides the opportunities to increase accountability;
- conservation and development projects already exist in most districts; and as sustainable forest management is now a goal of sustainable development and biodiversity conservation, it will be possible to mobilise the support of non-conservation organisations, such as development NGOs and religious groups.

Cont.

Box 5.5.1 Protecting Coastal Forests (cont.)

A holistic approach to planning must be taken so as integrate the Coastal Forests. Village land-use plans are part of national policy; this is preferable to planning only for Coastal Forests.

Promoting community-based management is essential:

- effective Joint Forest Management arrangements between communities and government must be established, with the support of civil institutions (i.e. CBOs, NGOs and INGOs).Effective JFM must be put in place if the Coastal Forests are to survive intact;
- strengthen communities to play their most effective role in managing the Coastal Forests; and
- facilitate government departments (especially forestry at the district and national level) and appropriate NGOs to support communities while strengthening their own forest management activities (the serious shortage of forestry staff and experienced NGOs at the district level is a constraint to this, however).

Income generation (appropriate and sustainable forest and non-forest enterprises) also needs to be developed. To support this it is important to provide interim financial assistance.

- as well as sustainable forest management, the potential for forest product certification for forests and woodlands should be explored.
- forest and non-forest income generation activities will need to be promoted, especially beekeeping and appropriate forest harvesting.
- some kind of financial intervention will be necessary to stimulate appropriate income generating activities and to channel conservation funds to the village level while ensuring accountability.

Integrating conservation and development

There are many viewpoints, often conflicting, on optimal approaches to conserving natural resources in developing countries. Several recent publications deal with the issue (e.g. Sayer, 1991; Hannah, 1992; IIED, 1994; Pimbert and Pretty, 1995; Fisher, 1995; Hackel, 1999; Rodgers *et al.*, in press). The approaches can be grouped into three broad categories:

- the **"social-anthropological"** approach, where indigenous peoples are allowed to continue their practices in harmony with their local environment and are actively involved in the protection of natural resources (and by implication, biodiversity);
- the **"hard-line protectionist"** command and control approach, where people are excluded from a defined area and suffer penalties if they break the rules. This is based on a wilderness concept, where a pristine ecosystem is maintained free of people;
- a more recent **"progressive"** conservationist approach, where the integrity of the protected area (National Park, Forest Reserve, sacred grove or whatever) is maintained through local people's involvement in management, including self-regulation. Theoretically the people derive enough benefit from the area to support such control.

The hard-line protectionist approach has been difficult to maintain as pressures grow and governments can no longer finance such control. There is much recent literature on the progressive approach for forest conservation. There are few direct examples of successful long-term project interventions, however (see Rodgers, 1993; Fisher, 1995; Caldecott, 1998). Experience in Asia with Joint Forest Management has largely focused on rehabilitating degraded forest land, and involves much extractive use of usufruct resources. There are few examples involving forests with globally significant biodiversity. Most experience in Africa relates to wildlife projects (MacKinnon *et al.*, 1986; McCracken, 1987; Hannah, 1992; Pimbert and Pretty, 1995; Leader-Williams *et al.*, 1996). There are few forestry examples (see Wiley, 1997 and Rodgers, 1998 for beginnings in Tanzania). Hackel (1999) points out the difficulties of using this approach with poverty-stricken people.

The potential link between development benefit and conservation status has led to a series of Integrated Conservation and Development Projects (ICDPs) around the world. Their implementation over the last ten years has led to a number of "lessons learned" reviews. Hannah (1992) summarised the experiences of early ICDP projects in Africa, and further relevant information is found in Sayer (1991), Fisher (1995) and Caldecott (1998).

The most successful of the progressive people-centred conservation projects are long-term and have a relatively low but sustained financial input. In contrast, high levels of funding and short-term time lines cannot achieve a long-term sustainable situation. Short-term projects can be very effective in solving immediate problems, such as infrastructure development, boundary encroachment and reserve gazettement, and they provide an immense boost to morale in underfunded and largely inactive government departments. Kiss (1999) describes the limitations of short-term, donor-driven project initiatives, which seek solutions that necessitate major changes in the use of the land and resources by a large number of people.

It is essential to have an adequate protection component in forest conservation projects. In all successful projects reviewed in Hannah (1992) this was an important aspect. More recent reviews (Sanjayan *et al.*, 1997; Wiley, 1997) showed that it is a mistake to assume that providing improved development will lead to improved conservation within ICDPs. ICDPs should focus on development only if this is a suitable means to achieve conservation. Even if this is the case, development efforts need to be complemented either through continued government controls (where these can be made effective), or through locally enforced regulatory mechanisms, or a combination of these. A true joint management approach is effective, if it is attainable.

Successful projects were often undertaken by local community groups with financing provided by tourism initiatives. In theory, pit-sawing, collection of building materials and fuel from Coastal Forests can bring shared benefits, but in practice these are harvested illegally at unsustainable rates in most forests. There are few, if any, high-value resources left to provide incentives. There would therefore need to be effective law enforcement before the sharing of the values from these resources could provide a viable conservation system. Preliminary assessment of collaborative forest management initiatives in Lushoto showed that villagers continued to have a great interest in short-term extraction benefits, rather than investing in longer-term conservation responsibility. The scale of benefit is unlikely to be a sufficient incentive to bring about change when resources are freely available.

Integrating local communities into the management process

Integrating local people into the management of forest resources is seen as an essential step in eastern Africa, particularly in the case of small areas such as the Coastal Forests. In many places such integration has only recently begun and appropriate methodologies and control mechanisms are still being formulated. In Tanzania at least, the strong need for this integration follows from the huge reduction in the staffing levels of the Forestry Department. There has been no increase in the salaries or operational capacity of the remaining staff except where projects are providing support.

Restoring local control of forest management

Most conservationists agree that restoring some level of rights to utilise forest products to local communities could empower them – either alone, or jointly with public sector forestry agencies – to manage the resources better than could such agencies by themselves (see Fisher, 1995; Wiley, 1999 for review). Communities with a long-term interest in the forest should be better guardians than more remote government institutions.

There is no long-term project experience of people-orientated conservation in the forests of eastern Africa; no projects using this approach are more than five years old. Nevertheless, such an approach may offer hope for the conservation of some small Coastal Forests with a close link to local people. There are promising examples of projects following the people-based model from elsewhere in Africa (e.g. Hannah, 1992), in India (Gadgil, 1992) and in Nepal (see Fisher, 1995). However, other projects have failed to deliver as much as their potential suggested (Wells, 1994; Pimbert and Pretty, 1995).

Very few projects have assessed their results objectively to determine if the approach is more successful than earlier methods (Fisher, 1995).

One approach is Community Forest Management (CFM) or Joint Forest Management (JFM), which is now embodied in the 1998 National Forest Policy for Tanzania (although the Draft Forest Bill that would implement the policy makes little mention of CFM/JFM, apart from references to "village forests"). In the CFM/JFM approach government and local communities, generally with the support of a third party (a community-based organisation or non-governmental organisation), develop a set of agreements and rules for the management of the forest resource. These rules can be given legal authority. They include information on who can collect what, what is not allowed, who has the authority to prevent certain activities occurring, and how revenues can be shared locally (Wiley, 1997).

Supporting land-use planning initiatives

For some parts of the eastern African coast, land use plans have been developed, either by central or village government authorities. At the village level the boundaries of different land attributes and needs are well known, as are the boundaries of different farmers' land. Village forests may be incorporated into such a system, and there may be privately owned areas of trees. In all parts of eastern Africa, private ownership of land is increasing and will almost certainly continue to grow. Collective ownership and government ownership of large amounts of land is declining markedly. In Tanzania, a new land bill has paved the way for this to happen, and created the possibility of land speculation. Under such a scenario it is strongly desirable to develop land-use plans at the relevant level for forest conservation.

Box 5.5.2 Involving Local Communities

A practical set of recommendations for involving local communities in the management of the Coastal Forests has recently been proposed by Wild *et al.* (1999):

Stage One: Provisional Community Management

- communities local to, and wanting to manage, a particular forest with the District Authorities are registered; this could be initiated by either of the parties.
- village government is issued with a letter authorising provisional management powers and bylaws, including powers to patrol, arrest, collect fees and identify the boundary.
- villages (with support from forest officers and NGO staff) draft a provisional harvesting plan, which is reviewed, amended and then approved by the District Forest Office.

Stage Two: Full Planning and Implementation of Community Management

- district government staff and communities enter into a participatory planning exercise which results in a village land use plan, a village forest plan, species vulnerability assessments and village bylaws, which include forest revenue collection methodology.
- forest and village boundaries are demarcated and full implementation of the plan starts.
- village receives title deeds for the forest.
- joint monitoring of the management process is in place.

This two-stage process will quickly allow communities to become involved in forest management, and should prevent communities from over-harvesting their forests. The detailed planning process will attempt to solve some of the more difficult management issues. This can be tackled as time and resources allow, but will not preclude communities becoming quickly involved in the basic management process.

Increasing forest income and resources

In Kenya the Arabuko-Sokoke forest is visited by tourists from local beach hotels, which helps generate income. In Tanzania the number of tourists visiting Jozani forest on Zanzibar is increasing rapidly; small numbers visit a nature trail in the Coastal Forests of the Pugu Hills near Dar es Salaam. This site also attracts local schools and provides a modest source of revenue. Details of a revenue-sharing scheme are now being worked out between the Forestry Department, the local communities and WCST.

It should be possible to increase the numbers of tourists visiting some of the more favourably located Coastal Forests in both Kenya and Tanzania, thereby increasing their value both to the government and to the local populations. However, the political situation in Somalia means that no tourists visit the forests there, and the number visiting Coastal Forests in Mozambique is also probably very low.

Fiscal measures

In 1996 the government implemented a Retention Scheme, which permitted the Tanzanian Forestry Service to increase its income, and to retain part of that income. The income can then be reinvested in forestry as the department sees fit. This has promoted some rethinking of possible ways to make money from Forest Reserves. There are several ideas under discussion (e.g. Katigula, 1996), which include the following:

Camping fees. Some forests, mainly in the East Usambara Mountains, attract small numbers of ecotourists. Budget ecotourists may be encouraged to visit more areas if simple camping facilities were provided. Modest entry fees could generate some income. The Amani Nature Reserve in the East Usambaras provides one example of an attempt to raise money in this way.

Water fees. As most drinking and industrial water comes from forests there is the possibility that the Forestry Department could charge user organisations for providing it. Such a scheme could provide a major source of income to the Forestry Department, and would allow forested areas to "pay their way" within the Tanzanian government system. However, such water provision values are generally not associated with the lowland Coastal Forests and thus such a system would not contribute directly to their conservation.

Biodiversity fees. A further possibility not considered by Katigula is that of obtaining regular funding from the world's governments for conserving a known proportion of the world's biodiversity.

If the Coastal Forests have 0.202 per cent of the world's species confined within their 3000-square-km area, then arguably they should receive this proportion of the funding available for biodiversity conservation. Such funding would make a very significant difference to the conservation of these small and isolated forested areas. If a suitable trust fund mechanism and set of trust-worthy partners were found, activities could continue into the distant future.

Alternatives to destructive forest use

Alternative sources of timber, poles and fuelwood could take the pressure off the Coastal Forests to provide these resources. For local populations in the coastal area, on-farm planting and woodlots of fast-growing exotics, such as teak, *Eucalyptus*, *Grevillea*, *Casuarina* and *Senna (Cassia)* can theoretically provide sufficient fuelwood and timber, which can be used or sold for cash. Fuelwood can also be obtained by pollarding scattered trees in farm fields or coppicing live fences. Farmers are often reluctant to plant trees solely as a source of fuelwood (because of its low value) although they do use lops and tops of trees planted for polewood.

Where projects have started nurseries and provided seedlings, local farmers have responded. The Kambai Forest Conservation project, for example, provided 90,000 seedlings over two years to farmers who have planted on farm for timber and building poles. In this area, farmers see tree growing as a way to increase income and believe that it goes hand-in-hand with attempts to intensify agriculture. The same pattern has been found in Arabuko-Sokoke (see below) and by the WWF project in coastal Tanzania (see below), where established nurseries were welcomed by many local people.

Land availability remains a major concern, however, since trees take up space that could be used for crops. There is no space for buffer-zone planting within the small reserves themselves. It can be difficult to encourage people to invest in trees when fuel and poles are still freely available from the reserves. A further difficulty is encouraging local people to continue planting once external funding is removed.

Reducing the need to use forest land for agriculture

The main threat to the Coastal Forests is population expansion. With the number of people in eastern Africa projected to double by 2020, the potential of this threat alone to eliminate the last Coastal Forests cannot be underestimated. Of course demographic patterns and population movements cannot always be predicted; the rural population of the Tanzanian coast may move to the cities in search of wealth, or a portion of the town people may move back to their ancestral villages. If current trends are accepted, however, then local communities need help to grow more food on their available land, and to reduce the pressure to encroach on and clear forest areas. Many standard development interventions are appropriate, so long as they do not encourage clearing the forest and replacing it with more areas of subsistence agriculture. There may be an opportunity to develop more cash-based agricultural systems that require smaller areas of land.

Slash and burn agriculture

It is now recognised that many agricultural systems are rich in biodiversity (including crop diversity) and can be stable and sustainable. Agro-ecological research should investigate the typical coastal system of cashew cultivation with slash and burn agriculture.

An evaluation of the impact of slash and burn agriculture on the Coastal Forest and woodland habitats should be carried out, with realistic recommendations for agricultural staff and village management. Slash and burn agriculture is widely seen as destructive due to the uncontrolled burning of forest resources. Burning is deeply ingrained into the local consciousness for practical and cultural reasons (individuals gain status if the fire they start burns a large area, so there is competition to burn the greatest area). Fires are also started for a number of other reasons. A detailed evaluation of this issue is warranted given the following points:

- positive re-evaluation of the maintenance of biodiversity and agricultural sustainability under certain slash and burn regimes, particularly those with long rotations and which have a forest cover for most of the time;
- an emerging understanding of the beneficial role of fire in some ecosystems;
- the destructive nature of fire in closed canopy forests;
- the deeply ingrained history of slash and burn agriculture in local communities;
- the practical reasons for burning, such as control of rodents and insects; and
- the current lack of convincing advice to farmers not to burn.

Developing partnerships

Governments do not have the resources to manage Coastal Forest resources alone; the past policy of command and control by a central agency is no longer adequate. Governments have to seek partnerships in forest management with local people, CBOs/NGOs (as intermediaries to reach the people more effectively), the private sector, and donor organisations.

Command and control

Much recent literature discusses the failure of command and control (C&C) policies, and the need to move to a new system of community resource management. Unfortunately, the literature suggests that these two possibilities are the only tenable positions that can be adopted. This is a gross over-simplification of the facts. Further, the contention that C&C is failing is an overstatement.

Most reserves are still there; most resources are intact; most people respect the boundaries. Command and control is needed but it cannot be imposed from the outside without local support.

Any regulatory system, be it external or internal, operates by rules. Who has access to what? What are the exploitation limits? These rules are the "commands". If the commands are to be followed then there has to be a "control" system. In traditional society, community management — as in most forms of traditional management — had command and control systems (albeit more benign than government's rule of law), but also made use of social ostracism as a powerful force. In cases where communities are heterogeneous, with outsiders forming powerful elites, such self-regulation fails (e.g. Coast Region Tanzania, see below). What has failed is the central authority's command and control system that excluded local people from its governance. Change is needed, not necessarily in the system itself, but in its application. People must be involved in planning, implementing and monitoring the system.

Box 5.5.3 Community Participation in Tanzania

This information is a statement by the Principal Secretary, Ministry of Natural Resources and Tourism, Dar es Salaam, at the NGO Environment Workshop, July 1996 (updated by the National Forest Policy, 1998).

"It is the responsibility of the Ministry of Natural Resources and Tourism to conserve natural resources and to promote sustainable use of these resources; and to take actions required to curb uncontrolled forest and wildlife resource degradation. In the forestry sector these actions include:

- developing and putting in place appropriate policies and legislation that guide and rationalise the conservation of these resources and their wise and sustainable use. The Ministry has reviewed the Forest Policy. Revised legislation to suit current needs, especially the involvement of communities in management of their resources, will follow.
- developing institutional capacities to manage these resources through effective institutional coordination and collaboration.
- most importantly, creation of awareness among the people on the importance of owning and managing their own trees, if not forests.

All these initiatives have reached and involved the communities.

In the 1998 National Forestry Policy there are two policy statements which are important here:

Policy statement (3): To enable participation of all stakeholders in forest management and conservation, joint management agreements, with appropriate user rights and benefits, will be established. The agreement will be between the central government, specialised executive agencies, private sector or local governments, as appropriate in each case, and organised local communities or other organisations of people living adjacent to the forest.

Policy statement (5): To enable sustainable management of forests on public lands, clear ownership for all forests and trees on those lands will be defined. The allocation of forests and their management responsibility to villages, private individuals or to the government will be promoted. Central, local and village governments may demarcate and establish new forest reserves.

Conclusion: The Natural Resources Sector has a new outlook to policy formulation. The outlook is people-centred, environmentally conscious and involves sustainable use of resources.

We are looking forward to serving a motivated and empowered population."

Box 5.5.4 Jozani Forest, Zanzibar

Jozani Forest is the largest remaining stand of near-natural forest on Zanzibar (Unguja). Its conservation values include a wide range of coastal vegetation as well as several rare and endemic species. At the heart of the protected area is a groundwater forest, which is flanked on either side by dry coastal forest, thicket and grassland. Extensive mangrove forests lie at either end and to the north is an area of salt marsh with populations of wading birds and a large variety of seaweed. The forest has many plant and animal species of restricted distribution, such as the Zanzibar Red Colobus (endemic to Zanzibar) and Ader's Duiker.

The coral rag area was settled early. Farming there has involved low-potential, rotational shifting agriculture, where trees are cut, wood products are sold, the remains are burnt and crops planted in crevices between the rocks. Most trees re-sprout and the plot is left to regenerate for 100 years or more. Over time human populations have increased in the area, and much of the forest has been cut and degraded for fuelwood, building poles, and lime burning. Most people are dependent on wood-cutting and fishing.

The Jozani groundwater forest has been logged for timber since the 1940s, and was made a Forest Reserve in the early 1960s. The Forest Department planted areas with indigenous and exotic species until the late 1980s, when there was increased pressure to change its status to that of a conservation forest. In the face of considerable local antagonism, the reserve area was extended by presidential decree in 1983 to include farms and villages as well as areas of coral rag forest. Timber harvesting in the forest stopped in 1990; since then, the area has been managed as a conservation forest. The Government of Zanzibar asked the Government of Austria to help develop the forest as a protected area. In 1995 the Jozani Chwaka Bay Conservation Project was started, as a partnership between the Commission for Natural Resources (Forestry Sector) and CARE Tanzania.

Several approaches have been used to engage the communities in conservation activities. These included collaborative management, tourist revenue sharing, community institution building, conservation education, community tourism and alternative income generation, funding community infrastructure development, and participatory problem analysis and planning. Implementing these activities required considerable training and strengthening of the Commission's forestry staff.

The relationship with the community has become a positive one, particularly with community leaders and elders. The following has been achieved:

- Conservation Committees have been established in each village;
- an umbrella Advisory Committee is working effectively at the community level;
- a tourist site in community mangroves earns $1,000 per month for community development;
- the Ministry of Finance approved 30 per cent (about $1,600/month) retention of tourist revenues by the Commission for Natural Resources (under this plan, which has already begun, the Commission retained 18 per cent of this for management costs and gave 12 per cent to the Advisory Committee for community development—a Cabinet Paper increased the retention rate to 80 per cent, with half used for management costs and half for the communities);
- simple tourist facilities have been constructed and local guides have been recruited and trained;
- Conservation Committees have received training in financial monitoring;
- there have been 20 small community infrastructure projects implemented, including school and health centre improvements, well repairs and road grading (these are planned, implemented and monitored by the Advisory Committee with support from forestry);
- the PA boundary has been negotiated with communities and the gazette documents have been submitted to the Ministry as part of the proposal for the area to be a national park (past errors will be rectified by the degazetting of villages and farmland);
- forest guards have been locally recruited and patrolling has become more effective;
- there are fewer cases of reserve rules being broken, and better enforcement of community arrests;
- one community has developed a plan for its own "Sehia" (community) forest;
- the Advisory Committee is becoming a legally recognised body;

Cont.

Box 5.5.4 Jozani Forest, Zanzibar (cont.)

- the Advisory Committee has temporarily expelled one community that complied with illegal harvesting; and
- three closed hunting seasons have been implemented, with the police temporarily impounding shotguns.

While much has been achieved in a relatively short period, there are many outstanding problems. Foremost is the fact that communities remain as dependent as ever on forest products. Also, collaborative management is seen by the most dependent communities as another type of law enforcement, and is resisted. The pressure to harvest resources from within the reserve is still high. The Red Colobus monkeys have become habituated to humans. The new protected area has yet to be gazetted, and community and protected area processes are at a delicate stage.

While progress has been made, it is fragile. Many of the initiatives need consolidation, and must become an everyday part of institutional operations. Mechanisms need to be found to provide longer-term funding. It is crucially important to develop alternative income-generating activities, or a stable situation will never be accomplished and the pressure to harvest will remain. The project has carried out studies to address this issue and community alternative income-generation will be an important activity in the future.

The role of NGOs

Experience from elsewhere suggests that community-based organisations (CBOs) and non-governmental organisations (NGOs) can play a major role in developing community participation in resource management. In India, NGOs have actively fostered Joint Forest Management initiatives at the national level (Ford Foundation, Society for the Promotion of Wasteland Development), and at state and grassroots levels (over 900 active NGOs).

In eastern Africa is it perhaps too early to tell if the same models will apply. The NGO movement in Tanzania is still relatively young; very few NGOs are older than ten years. The situation is different in Kenya and Zimbabwe. Although the involvement of NGOs has not yet reduced or prevented deforestation, they are having an impact; they are testing methodologies, raising awareness and showing what can be done. More NGOs and more time are needed to fully test the potential, however. In eastern Africa more CBOs are needed, as well as capacity-building programmes to assist their development (these are missing from Tanzania as compared to Kenya and Uganda). In addition, there is a long-standing need to reduce NGOs' transaction costs related to donors' administrative requirements. And there is still a tendency to opportunism – the "briefcase NGO" tapping donor funds – which needs to be eliminated.

The role of Donors

Donors active in eastern Africa include the bilateral governmental aid agencies of western European countries (especially Scandinavia and Germany) and multilateral agencies such as the World Bank, various United Nations bodies, the Global Environment Facility and the European Union. The larger international non-governmental organisations (INGOs) provide funds in a similar way, although they typically focus on NGO partners in the recipient countries. Over the past 20 years, there have been many donor support programmes to Forestry Departments in eastern Africa.

These programmes have provided considerable levels of funding for forestry activities of one kind or another. The Coastal Forests have benefitted from these activities, especially over the past ten years. Some of the relevant projects are outlined below. In Kenya, four major projects seek to conserve Coastal Forests:

- the WWF/NMK Coast Forest Conservation Unit focusing on sacred forests;
- the BirdLife International Arabuko-Sokoke forest conservation project;
- the GEF Tana River Forest conservation project; and

- German (GTZ) support for the Shimba Hills forests and Kwale District Forests. This project was terminated in 1998 when the expatriate adviser was murdered. It is still uncertain if the project will re-open.

In Tanzania there have been five initiatives (mostly small) to conserve Coastal Forests:

- the Tanzania Forest Conservation Group, working with the Kambai Forest Conservation Programme in the lowland East Usambaras;
- the FINNIDA East Usambara Catchment Forestry project in Tanga Region;
- the WCST project (with past BirdLife and GEF funding, and current Swedish Society for Nature Conservation funding) in Pugu/Kazimzumbwi FRs (see above) and Lindi Region, with later funding from EU, BirdLife and the Netherlands Committee for IUCN;
- the WWF/DfID Coastal Forest conservation project in forests in the Coast Region (see above);
- CARE Tanzania's project, with funding from Austria and the Commission for Natural Resources for Jozani FR, Zanzibar (see below). Three further inputs are planned. These are DANIDA support for woodlands (and potentially forests) in Lindi Region, NORAD support (via CARE and NGOs) for forests near Dar es Salaam, and GEF for the Coastal Forests of Kenya, Zanzibar and mainland Tanzania.

Conservation of the Arabuko-Sokoke forest in Kenya

This project was a partnership with the British Overseas Development Administration (now DfID), BirdLife International, the Kenyan Forest Department, the Kenyan Wildlife Service and the European Union. Work focused on biodiversity and resource conservation in the forest. There were two phases, separated by a near cessation of activities.

The first project phase was funded by the British Overseas Development Administration (ODA), through the Kenyan Indigenous Forest Conservation Programme (KIFCON). This phase began in June 1991 and included one Coastal Forest: Arabuko-Sokoke near Malindi. Arabuko-Sokoke was chosen because it is a very important forest for rare/endemic birds (e.g. Sokoke Scops Owl, Sokoke Pipit, Amani Sunbird, Clarke's Weaver) and mammals (e.g. Ader's Duiker and Golden-rumped Elephant-shrew).

A programme of multi-disciplinary surveys was set up to gather information on: a) the threats to biodiversity in different sections of the forest; b) wood volumes (timber, poles, fuelwood etc.); and c) the use of the forest by rural communities and commercial enterprises. This information filled gaps in knowledge, and was supplemented with data on birds and plants.

A zoning plan was proposed to ensure that representative areas of the four main tree groups (mixed/*Afzelia* forest, *Brachystegia* woodland, *Cynometra* forest and *Cynometra* thicket) were included in protection zones where no forest products could be extracted. This was intended to reduce the chances of plant and animal extinctions and to allow time for biological systems to renew themselves naturally. The plan also encouraged non-extractive use of the protection zones through tourism, education and research activities. The remainder of the Forest Reserve was proposed as a utilisation zone available for extractive use on a sustainable basis.

Fuelwood, pole-wood and *Brachylaena* fuelwood/carving wood are all needed by rural communities, and seasonal pools are important sources of water for forest-adjacent villagers. Development of on-farm tree planting initiatives was a major component of an active conservation phase in the Sokoke forest; this was thought to represent the best way to reduce pressure on the remaining forest resources. A five-year funding package was proposed to support strengthening of the Forestry Department, and to develop joint management of the Forest Reserve by the Forestry Department and Kenya Wildlife Service with the support of BirdLife International and local populations, and with funding from British ODA. This proposal was supported locally and at ODA headquarters, but in the final stages the British government withdrew funding from the project, apparently because of concern about the Kenya government's political commitment to forest conservation.

The detailed surveys, proposal writing and plan development raised considerable expectations in the local communities and the Forestry Department, although they were not realised at that time. Subsequently a new application was prepared and accepted by the European Union DGVIII budget line for the conservation of Tropical Forests.

A large number of activities were outlined within the framework of the new five-year project proposal. These included the development and implementation of a forest management plan, including zoning and an evaluation of fencing the reserve to reduce elephant damage. Various rural development options were also suggested, such as improving water supplies, enhancing tree planting initiatives, and licensing and regulation of the sustainable use of forest products (e.g. beekeeping and butterfly farming). Income generation from the forest will also be enhanced through promoting tourist visits to the reserve. Awareness will be raised through a conservation education programme in schools involving the Wildlife Clubs of Kenya. The impact of the project, including its effect on forest biodiversity, will also be evaluated.

Detailed planning and limited project activities began in 1996. Further project activities began to be implemented in 1997. The Kipepeo butterfly farm, a related GEF project in the area, has assisted local communities through contracting them to raise butterfly pupae for export to Europe and the United States, and by providing them with improved concrete water tanks. Such local successes indicate that other approaches, such as an increase in tourism, would also benefit the forest and the well-being of the local populations. However, the two major threats to all forests in eastern Africa – land clearance for local agriculture, and lower land values for retention as forest – both continued to pose a threat to Arabuko-Sokoke.

In the first phase, a local MP proposed that ten per cent of the Forest Reserve, the main areas of *Brachystegia* forest and the best habitat for the endemic Clarke's Weaver and the very rare Sokoke Pipit be degazetted for settlement by local people. This was averted after a visit by Kenya's President, Daniel Arap Moi, who told the local people in a public meeting that the forest should be preserved for future generations of Kenyans and to help protect the local water supply.

In the second phase, explorations of the Kenyan coastal area have revealed the presence of titanium-rich soils at several locations, including the south of the Arabuko-Sokoke reserve. The ore deposits may extend under the forested land of the reserve. Although no actions have yet been taken the presence of this very valuable deposit may influence future land use in the area.

The proponents of forest conservation must continue to provide the arguments to ensure that the Sokoke forest remains, and that its undeniable biological richness survives into the future, while also providing clear and tangible benefits to the local communities and the country.

Conservation of the Pugu Hills in Tanzania

The Wildlife Conservation Society of Tanzania (WCST), an NGO, attempted sustainable conservation initiatives with government and villagers on the edge of a fragmented Coastal Forest found within Pugu (2200ha) and Kazimzumbwi Forest Reserves (3500ha) near Dar es Salaam. WCST began the project in 1991 in cooperation with the World Wide Fund for Nature (WWF). The two NGOs held monthly management planning meetings with Government Forestry.

Concern grew over continued illegal encroachment for cultivation in Kazimzumbwi FR by people from a local village. Charcoal production escalated, from the illegal clearing and elsewhere in the forest. WCST raised the issue with government at many levels from 1993 to 1996, but without success.

Local villages are heterogeneous, and include wealthy people from the adjacent city of Dar es Salaam. Years of neglecting reserve boundaries (typical of all Tanzanian Forest Reserves) meant that people were able to ignore them. Villagers complain of land shortages; the forest provides better farmland than drier empty land to the south. There is money to be made from supplying charcoal to the city. Vacillation on the part of the authorities and inadequate levying of fines suggested that encroachment would not be stopped. In addition, the villagers had a persuasive leader, M. Mtitimkavu, who openly advocated encroachment.

Conservation activity hinged on empowering the weak forest department of Coast Region to deal with the powerful villagers of Dar es Salaam Region. The role of the Central Government Forest Division was unclear: did it have an operational mandate or was it just an advisory body?

Although the forests in question were Central Government Reserves they were managed by the Districts on behalf of the Central Government, with no guidelines governing such management.

Policies on land allocation, Central versus District responsibility, court jurisdiction, fines, concepts of sustainable fuel supply, etc. were all vague and inadequate.

WCST took on several roles:

- channelling donor funds for conservation and education to District levels; implementing conservation by convening planning meetings with villagers, training field staff, demarcating boundaries, planting village nurseries, etc.;
- acting as an information organisation, by issuing press releases and news-sheets;
- becoming an advocacy organisation, openly pushing government to seek a solution as normal policing and extension methodologies failed; and
- bringing together Central and District administrations with villagers and the press.

During this period, WCST changed its emphasis from benign policing efforts like providing sympathetic guards, to helping with simple alternatives such as planting tree seedlings. Because conservation of natural resources is part of politics and overall land-use practices, it is also a factor in whether people make money or don't make money. Conservation thus had to deal with corruption and deceit at several levels.

Conservation also has to function within a large and complex bureaucracy. There are many institutional players and there is a three-way split in forestry decision-making processes. Although the Forestry Directorate is the policy and advisory body, actual implementation is the responsibility of District Foresters, who report to the district, not the directorate. District forestry is supervised by Regional Officers, who approve budgets etc. (Note: as of July 1996, Tanzania reduced the power of regions, which take on a reduced advisory role with little natural resources expertise.)

An added difficulty is that Coast Region staff operate in Dar es Salaam Region. When Coast Region forest guards impound the bicycles of illegal charcoal transporters, the Dar es Salaam District authorities facilitate their release. The Coastal Forests are too small to permit a realistic buffer zone that can provide sufficient resources to enough people. On the Dar es Salaam side land is in short supply and there is a demand for degazettement for cultivation (and eventually for high-value plots). The presence of the capital city provides an ever-increasing demand for charcoal and charcoal manufacture provides an income for the landless poor, especially youth.

In the past few years, WCST has done the following to raise the conservation issues at the political level:

- a 1994 seminar for MPs chaired by the Minister for Natural Resources on the importance of Coastal Forests. The MPs were interested, but the NGO had no follow-up programme and interest died;
- involving the Minister and local MPs in January 1995. The Deputy Minister visited the site with the District Commissioners and MPs. Although statements were made in villages about stopping deforestation within the reserve, an election was approaching, and no action was taken; and
- writing an editorial in the society's magazine, criticising the lack of control over forests in the country.

This led to a national workshop entitled "Putting Environment on the National Agenda", organised by the NGOs. The President participated and made a strong statement on the environment, which was designed to be the foundation of future conservation effort.

The Vice-President visited the area and dictated that villagers stop encroachment. The area was re-notified as a Forest Reserve in the gazette, however, the energy died down after this visit. No responsibility for follow-up was set out and cultivation started up again.

In 1998 the people appealed to State House and the President's Office asked the Permanent Commission of Enquiry to report. This they did, ruling in favour of conservation. Encroachers were again evicted. A year later, however, agitation began afresh.

The way forward involves political will. Conservation will not be achieved through local policing efforts alone. Senior District and Central Government leaders (politicians and officials) must be convinced that the forest has significant value and that its destruction will not be tolerated. This in itself involves political decisions:

- does Tanzania want these forests, or should they be converted to city plots?
- which institution should translate that decision into practice?

Conservation would require better policing, coupled with agricultural extension support for local people and an alternative fuelwood supply for Dar es Salaam. Dar es Salaam city growth should be controlled, and urban policy must be linked to forest policy. Guidelines on the responsibility of District and Central forest functions are needed. Does the Director have an overall monitoring function? How will that work? How do neighbouring districts and regions cooperate? The society has considered a management planning process for these reserves, but fundamental questions have not been answered:

- how does forestry develop a management plan that involves people in the districts?
- who approves the plan, and what will be the legislative status will the plan's provisions?
- how does a management plan link with sustainable development plans for neighbouring villages?

There seems to be a need for much larger rural development inputs, perhaps involving experienced international agencies such as CARE, World Vision etc. NGOs have provided help. In spite of continuing pressures there are signs of success, in that the new District leadership accepted the need to restore law and order as a precursor to further inputs to extension support. The new Director of Forestry agreed that the area was a serious test case of national conservation interest, and is taking measures to reverse past damage. It is unlikely that any of this would have happened without WCST's involvement.

Conservation efforts in five Tanzanian forests

This WWF project concentrates on five forests in the Coast Region. Funded by the British Government (DFID) and WWF-UK, it started in 1992 and will continue until at least 2001. The project assists conservation through a combination of protection and development of sustainable alternatives to the currently overused forest resources. Major goals are:

- to ensure government institutional capacity to manage key forests in Coast Region; and
- to ensure that local communities are involved in forest management, and to help them develop alternatives outside the forest that will provide for their fuelwood needs and to improve their agricultural production.

The principal target is to increase the local capacity of the Forestry Department to undertake forest management and protection work in the target Coastal Forests. The project encourages forest staff to develop approaches to ensure that the communities are fully involved in developing and implementing actions that will minimise pressure on existing Coastal Forests.

Project activities for local people include developing agroforestry and extension schemes around Coastal Forests reserves, socio-economic surveys to better understand what the local people need from the area, and establishing local groups who have an interest in managing the natural resources around their village. Protection activities have also begun. These include building houses for forest guards, marking boundaries, gazetting Kiono/Zaraninge Forest Reserve (a process not completed during the colonial era), and resurveying and mapping Kiwengoma and Namakutwa-Nyamuete forests.

Progress has been made in involving the local people in the management of the forest. Nevertheless, the legal restriction on the use of the forest by local people is a major challenge for any participatory project within Tanzanian forests. This restriction means that conservation projects cannot easily establish systems where local people have legal access to the benefits from forests.

Providing alternatives outside the forest is therefore seen as particularly important. This has concentrated on planting trees (for fruit, building materials, fuel and timber) and trying to improve agriculture in areas where the soils are poor and shifting cultivation is the normal practice.

It is too early to tell whether involving local communities in the management of these Coastal Forests will work in the longer term and provide a more satisfactory solution than the protection approach used by the Forest Department in the past. The signs are encouraging, however.

Lessons learned

Supporting government activities

A number of projects in the Coastal Forests help the Forest and Beekeeping Division in Tanzania and the Forest Department in Kenya manage the existing Forest Reserves and the gazettement of new reserves. These projects seek ways by which the traditional and valued protection function of the Forestry Sector can be integrated with concepts of Joint Forest Management. In some cases this could result in handing back smaller Forest Reserves to the local communities as Village Forests.

The concept of forest protection is still central to such initiatives, however, and the ways in which this protection will function in the future (either through government, government/people partnerships or within the village structure) are still inadequately tested. This issue has been discussed by Wild *et al.* (1999) where the need for protection as well as community involvement and benefits was advocated.

The recent programmes of Civil Service Reform and Structural Adjustment have greatly reduced forestry's field capacity. In Tanzania staff numbers have been reduced by more than half; in some places only individual foresters remain. Supporting forestry in places where there are few or no staff requires rethinking. In some places projects have used their funds to re-employ the staff taken off the government payroll. This is necessarily a short-term solution but it keeps staff skills available and prevents wholesale forest degradation until programmes can be put in place that focus more on local communities. The loss of forestry capacity in Tanzania is less severe in the Catchment Forest Reserves, which have nationally important water catchment functions, and most severe at district levels, where most staff have been retrenched.

All levels of government (national, regional, district, ward) also need to be aware that they have a global responsibility under the Convention on Biological Diversity. They also need income to support their activities. The ways in which forests contribute directly or indirectly to the economy of the country as a whole, and the area surrounding the forest, needs careful consideration.

People and conservation

In Tanzania the crucial importance of involving local people was first stressed in 1996. Perhaps surprisingly for a country with a long history of decentralisation and active socialism, there was no strong foundation of community participation in resource management. Most resources were firmly entrenched in government control. Decentralisation created further layers of government bureaucracy at regional, district, and village levels, rather than bringing decision-making closer to the people. In Kenya, the principle of participation was avoided in 1994 when the Ministry of Environment and Natural Resources closed the UK-funded KIFCON project, which espoused participatory conservation methods.

In some places the local communities still exercise a high level of control over remaining forest resources. Examples are the burial grove forests which are scattered throughout coastal eastern Africa (as elsewhere on the continent) and the Kaya forests of coastal Kenya and northern Tanzania.

These latter resources have cultural significance based on past refuge functions (Spear, 1978). The value of traditional forms of protection in these cases is inadequately known as they are not publicised by the local communities and are generally very small.

Traditional approaches can have problems, as illustrated by some of the Kaya Coastal Forests in Kenya. These sacred sites have a close link to local populations, but are being cleared by younger local people and immigrants to provide agricultural and development land. The hunger for land has overcome the value of the forest resources to the local population.

Conclusions

The Coastal Forests (together with the Eastern Arc forests) are ranked among the top 25 forest sites in the world for conservation. The two critical themes for successful conservation are focusing on the highest priority sites for conservation action; and taking actions to reduce the threats to their long-term survival. The highest priority Coastal Forest sites are those with high biodiversity levels. The need to integrate development and conservation has been recognized. The most successful of these initiatives are long-term and have a comparatively low but consistent financing. It is essential to involve local people in the management of the Coastal Forests. This involves rights to use resources, to regulate their use, to develop land-use plans and to realize income from forest resources. Such efforts must go hand in hand with initiatives to find alternatives to destructive forest use.

Governments must develop partnerships with donors, NGOs and individuals in order to manage the Coastal Forests. They need to move away from strict regulatory regimes and initiate more community-based systems of management that take into account the true values and costs associated with the Coastal Forests. They must demonstrate political will to tackle the difficult and contentious issues that arise from resource use.

The start to successful conservation is the increased awareness within governments of the importance of these forests and of their responsibility set out in the Convention on Biological Diversity. It is also necessary to recognise the responsibility of the world community (via their ratification of CBD) to supporting such protection.

Such awareness must underpin bureaucratic initiatives and ideally should link with conservation awareness and planning in other sectors of district and central government. In Tanzania, for example, the National Forest Policy allows forests of strategic importance (in terms of catchment, biodiversity and essential national level resources) to be brought under national – as opposed to district – control. Relevant status should be sought for Coastal Forest Reserves.

Such policies should provide the lead for the development of comprehensive conservation and management strategies, which can form the basis for implementation. Forest Divisions should take the responsibility for this, but should work in collaboration with other sectoral and local community partners.

The strategy should address three key issues (with acknowledgement to the Eastern Arc Mountains Conference of December, 1997): empowering community conservation and joint resource management initiatives through community institution building. Such activities should contain forest protection functions and mechanisms whereby all partners in the agreement (government and village) can be punished if they break the agreement; providing support for alternative incomes and livelihoods for people adjacent to these forests; and resource conservation itself, including (where possible) rehabilitation of degraded land and restoration of forested corridors. Conservation could include boundary marking, zoning (where feasible), starting ecotourism ventures, etc.

Acknowledgements

We thank Rob Wild, Phil Clarke, Peter Gibbon, Johan Frössling, Kerry Woodcock, Alex Hipkiss and Andrew Perkin for comments on this Chapter. Additional information was provided by Peter Sumbi of the WWF-Tanzania Coastal Forest Project, John Fanshawe of the BirdLife Arabuko-Sokoke Project, Rob Wild from CARE-Jozani, and the Chapter authors.

References

Caldecott, J. (1998). *Designing Conservation Projects*. Cambridge University Press, Cambridge, UK.

Fisher, R.J. (1995). *Collaborative Management of Forests for Conservation and Development*. Issues in Forest Conservation Series. IUCN and WWF, Gland.

Gadgil, M. (1992). Conserving biodiversity as if people matter: a case study from India. *Ambio* **21**: 226–270.

Hannah, L. (1992). *African People, African Parks: an Evaluation of Development Initiatives as a Means of Improving Protected Area Conservation in Africa*. Conservation International, Washington DC.

Hackel, J.D. (1999). Community Conservation and the future of Africa's wildlife. *Conservation Biology* **13**: 726-734.

IIED (1994). *Whose Eden: an Overview of Community Approaches to Wildlife Management*. IIED, London.

Katigula, M.I.L. (1996). Forgotten Revenue Sources in Catchment Forests. Pp. 24–26. In *Forestry is Wealth*, vol. 2 (3 and 4). Newsletter of the Forest and Beekeeping Divison, Dar es Salaam, Tanzania.

Kiss, A. (1999). Making Community Based Conservation work. Paper presented at Society for Conservation Biology Annual Meeting, June 1999.

Leader-Williams, N., Kayera, J.A. and Overton, G.L. (1996). *Community-based Conservation in Tanzania*. IUCN, Gland, Switzerland and Cambridge, UK.

MacKinnon, J.K., MacKinnon, G., Child, G. and Thorsell, J. (eds.) (1986). *Managing Protected Areas in the Tropics*. IUCN, Gland, Switzerland and Cambridge, UK.

McCracken, J. (1987). Conservation priorities and local communities. In Anderson, D. and Grove, R. (eds.). *Conservation in Africa – Peoples, Policies and Practice*. Cambridge University Press, Cambridge.

Pimbert, M.C. and Pretty, J.M. (1995). *Parks, People and Professionals: putting 'Participation' into Protected Area Management*. UNRISD Discussion Paper DP57. Geneva.

Rodgers, W.A. (1993). The Conservation of the forest resources of eastern Africa: past influences, present practices and future needs. Pp. 283–331. In Lovett, J.C. and Wasser, S. (eds.). *Biogeography and Ecology of the Rain Forests of Eastern Africa*. Cambridge University Press, Cambridge.

Rodgers, W.A. (1998). *Mainstreaming Biodiversity Issues into Forest Policy and Programmes in Tanzania*. Proceedings of Workshop on Biodiversity Policies, November 1997. ACTS, Nairobi.

Rodgers, W.A., Hartley, D. and Bashir S.B. (In press). Community Approaches to Conservation. In Saberwal, V. (ed.). *Conservation of Protected Areas in India*. OUP, New Delhi.

Sayer, J.A. (1991). *Rainforest Buffer Zones: Guidelines for Protected Area Managers*. IUCN, Gland, Switzerland and Cambridge, UK.

Sanjayan, M., Shen, S. and Jansen, M. (1997). *Experiences with Integrated Conservation and Development projects in Asia.* World Bank Technical Pages 388. World Bank, Washington, DC.

Spear, T. (1978). *The Kaya Complex: a History of the Mijikenda Peoples of Kenya to 1900*. Longmans, Nairobi.

Wells, M.P. (1994). Community-based Forestry and Biodiversity Projects have promised more than they have delivered: Why is this and what can be done? Paper for the International Symposium on Rain Forest Management in Asia, Oslo, March 23–26, 1994. Centre for Development and the Environment, Oslo.

Wild, R., Makota, V., Haule, E. and Maximillan, J. (1999). *Site Based Needs for Conservation of Coastal Forest Biodiversity*. NEMC and CARE, Dar es Salaam.

Wiley, L. (1997). Community based natural forest management in Tanzania: The case of Duru-Haitemba and Mgori Forests. Pp. 305–322. In *Africa Forest Policy Forum*. Volume II. World Bank, Africa Region Environment Group. Washington DC.

Appendices

A1. Eastern African Coastal *Brachystegia* Forest, Arabuko-Sokoke Forest Reserve, Kenya. Photo taken in March 1997, at the end of a prolonged period of drought. Main tree species are *Brachystegia spiciformis* over a smaller stratum of *Julbernardia magnistipulata*. (*Photo: G. P. Clarke*)

A2. Legume-dominated eastern African Coastal Dry Forest, Mlungui Hill, Tanga Region, Tanzania. Main tree species *Scorodophloeus fischeri* and *Cynometra webberi* with smaller *Dracaena usambarensis*. (*Photo: G. P. Clarke*)

A3. Legume-dominated eastern African Coastal Dry Forest, Ruawa Forest Reserve, Lindi Region, Tanzania. Main tree species *Scorodophloeus fischeri* and *Craibia zimmermannii* with smaller *Euphorbia nyikae*. (*Photo: G. P. Clarke*)

Appendix 1 Location and status of Coastal Forests in eastern Africa

	Province/ region	District	Grid location	Altitude (m)	Quoted area (km²)	Min. Forest area (km²)	Status
SOMALIA							
Shoonto	Southern	Bu'aale–Fanoole	0104N 4236E	0–20	3	?	FR
Barako Madow	Southern	Bu'aale–Fanoole	0108N 4236E	0–20	1	?	FR
Boni	Southern	?	?	?	? large	?	?
TOTAL: **3 sites**						***c.* 2**	
KENYA							
Boni NR	North-eastern	Garissa	0120S 4120E	50	1358	?100	NR
Boni prop FR	Coast	Lamu	0140S 4051E	0–100	184.66	?100	Proposed FR
Dodori NR	Coast	Lamu	0143S 4056E	0–20	877	?20	NR, 1976
Lunghi prop FR	Coast	Lamu	0144S 4045E	0–20	95.17	?80	Proposed FR
Mvundeni Village	Coast	Lamu	0150S 4120E	5	[0.1]	[0.1]	In Marine NR
Ashuweni Village and Tombs	Coast	Lamu	0151S 4120E	15	[0.1]	[0.1]	NM in Marine NR
Witu FR	Coast	Lamu	0222S 4030E	10–20	39.37	14	FR, order 454:1962
Witu FR extension	Coast	Lamu	0223S 4031E	20	[c. 1]	[0.9]	FR
Kiponozi Ruins NM and Wells	Coast	Lamu	0224S 4045E	5	[0.1]	[0.1]	NM
Famau Ruins and Famau Hill	Coast	Lamu	0226S 4043E	57	[0.1]	[0.1]	NM
Kiunga Marine NR	Coast	Lamu	0230S 4045E	< 100	c. 300	?	Marine NR
Ras Tenewi area	Coast	Lamu, Tana River	0229S 4040E	0–60	105	?20	None
Bura gallery forests (incl. Nanigi and Chewele)	Coast	Tana River	0105S 3955E	60	1	1	None
Wayu I, Wayu II, Wayu III and Kokani forests	Coast	Tana River	?	?	1120 ?	?100	Proposed FR
Mbia	Coast	Tana River	0137S 4006E	45	1	1	None
Tana River Primate NR	Coast	Tana River	0143S 4003E	30–50	171	11	NR, 1975
Lower Tana forests (30 + patches)	Coast	Tana River	0210S 4010E	10–30	?	10	None
Mlango ya Simba Bridge	Coast	Tana River	0215S 4021E	11	[0.1]	[0.1]	None
Kanwe Mayi forest fragments (5–7 patches)	Coast	Tana River	0227S 4028E	10	1	1	None
Rain Tree forest	Coast	Tana River	0230S 4020E	5	[1]	[1]	None
Tana Delta	Coast	Tana River	0230S 4020E	?	3400	20	None

	Province/ region	District	Grid location	Altitude (m)	Quoted area (km²)	Min. forest area (km²)	Status
KENYA (cont.)							
Shaka Ruins NM	Coast	Tana River	0232S 4034E	5	[0.1]	[0.1]	NM
Ras ya Wanawali Sabaa Tombs NM	Coast	Tana River	0233S 4037E	15	[0.1]	[0.1]	NM
Dakawachu Hill	Coast	Malindi	0241S 3937E	227	0.1	0.1	None
North Kilifi Brachystegia woodlands (4 sites)	Coast	Malindi	0250S 3950E	50–100	500	?	None
Dakabuko Hill	Coast	Malindi	0253S 3938E	356	5	5	None
Werune Cliffs	Coast	Malindi	0256S 3952E	80–100	1	?	None
Ras Ngomeni dune forest and woodland	Coast	Malindi	0258S 4008E	50	< 1	1	None
Devil's / Hell's Kitchen	Coast	Malindi	0301S 3957E	45–80	1	1	None
Kaya Bore	Coast	Malindi	0303S 3953E	115	c. 0.5	0.4	None
Ulaya Nyari at Bore	Coast	Malindi	0303S 3953E	45–100	[?]	[?]	None
Kaya Singwaya	Coast	Malindi	0306E 3951E	60	0.1	0.1	None
Kaya Kirimani	Coast	Malindi	0307S 3951E	50	1	0.25	None
Kayas Dagamura and Kilulu	Coast	Malindi	0307S 3955E	45	1	1	None
Kaya Bura	Coast	Malindi	0308S 3956E	45	1	0.5	None
Lower Sabaki Wetlands (various sites)	Coast	Malindi	0311S 3953E	30	0.1	0.1	None
Kaya Bate	Coast	Malindi	0311S 3955E	30	0.25	0.25	None
Nyari at Jilore	Coast	Malindi	0311S 3956E	30–105	1	1	None
Mangea Hill	Coast	Malindi	0315S 3943E	10–520	35	35	Proposed FR and NR
Malindi Point Sacred Grove	Coast	Malindi	0317S 4007E	10	0.2	0.2	None
Gede Ruins	Coast	Malindi	0318S 4000E	15	0.35	0.35	NM
Pangayambo Caves Sacred Grove	Coast	Malindi	0319S 4002E	15	< 0.1	0.05	None
Arabuko-Sokoke FR, NR and NP	Coast	Kilifi and Malindi	0320S 3955E	0–210	417.64	370	FR, 1943; NP, 1990
Kibongo Hill	Coast	Kilifi	0315S 4006E	20	0.1	0.1	None
Nyari within Arabuko-Sokoke	Coast	Kilifi	0320S 3951E	90–140	[?]	[?]	FR
Kaya Kidzini	Coast	Kilifi	?	?			None
Rare River Gorge	Coast	Kilifi	0327S 3945E	120	0.1	0.1	None
Nyari S.W. of Arabuko-Sokoke	Coast	Kilifi	0330S 3948E	100–170	0.1	0.1	None
Kambe Rocks Sacred Grove	Coast	Kilifi	0332S 3939E	90	0.25	0.25	None
Mulungu Mawe and Bikisaga Sacred Grove	Coast	Kilifi	0333S 3937E	165	< 0.1	0.05	None
Njora River Gorge	Coast	Kilifi	0334S 3943E	75	0.1	0.1	None

	Province/ region	District	Grid location	Altitude (m)	Quoted area (km^2)	Min. forest area (km^2)	Status
KENYA (cont.)							
North of Jaribuni forest patch	Coast	Kilifi	0335S 3944E	120	0.1	0.1	None
Nyari at Mjibu	Coast	Kilifi	0335S 3948E	120	0.01	0.01	None
Mnarani	Coast	Kilifi	0338S 3950E	20	0.01	0.01	NM
Kaya Starehe	Coast	Kilifi	0339S 3941E	210	0.01	0.01	None
Ndzovuni River Gorge	Coast	Kilifi	0339S 3943E	100	0.01	0.01	None
Vyambani cliffs	Coast	Kilifi	0339S 3944E	100–170	0.01	0.01	None
Kaya Kivara	Coast	Kilifi	0341S 3941E	324	1.5	1.5	None
Dzitsoni Caves	Coast	Kilifi	0342S 3944E	120	0.1	0.1	None
Cha Simba Sacred Grove	Coast	Kilifi	0344S 3941E	200	0.2	0.2	None
Kaya Fungo / Giriama	Coast	Kilifi	0347S 3930E	180	c. 1	0.9	None
Kaya Chonyi/Achonyi FR	Coast	Kilifi	0347S 3940E	210	2	2	FR
Mwarakaya Sacred Grove	Coast	Kilifi	0347S 3941E	120	0.25	0.25	None
Kaya Vuga	Coast	Kilifi	0348S 3940E	210	[?]	[?]	In FR
Vipingo Caves Sacred Grove	Coast	Kilifi	0348S 3949E	15	0.1	0.1	None
Kaya Koyeni	Coast	Kilifi	0349S 3940E	210	[0.5]	[0.5]	None
Kaya Mudzimuvia	Coast	Kilifi	035?S 393?E	?	[0.1]	[0.1]	None
Kaya Jibana FR	Coast	Kilifi	0350S 3940E	308	1.5	1.5	FR
Kaya Tsolokero	Coast	Kilifi	0350S 3944E	135	0.25	0.25	None
Kaya Kambe / Mbwaka Kaya and FR	Coast	Kilifi	0351S 3938E	180	0.75	0.6	57ha (75%) is FR
Pangani Rocks Sacred Grove	Coast	Kilifi	0351S 3940E	75	0.5	0.5	None
Kaya Ribe (incl. K. Ribe FR)	Coast	Kilifi	0353S 3937E	105	1	1	36ha (33%) is FR
Kombeni River Gorge	Coast	Kilifi	0354S 3935E	150	0.1	0.1	None
Kaya Fimboni	Coast	Kilifi	0355S 3935E	150	[1.5]	[1.5]	None
Kaya Bomu	Coast	Kilifi	0356S 3935E	210	[3]	[3]	None
Mtwapa Creek north bank	Coast	Kilifi	0356S 3942E	30	1	?	None
Mtwapa NM	Coast	Kilifi	0356S 3945E	10	0.05	0.05	NM
Jumba la Mtwana NM	Coast	Kilifi	0356S 3946E	0–10	0.1	0.1	NM
Kaya Mwidzimwiru	Coast	Kilifi	0357S 3934E	255	[1]	[1]	None
Kaya Kauma	Coast	Kilifi	0357S 3944E	120	1	1	None
Kaya Chilulu	Coast	Kilifi	?	?	?	?	None
Kaya Kinangoni	Coast	Kilifi	?	?	?	?	None
Kaya Madunguni	Coast	Kilifi	?	?	0.1	0.1	None

	Province/ region	District	Grid location	Altitude (m)	Quoted area (km^2)	Min. forest area (km^2)	Status
KENYA (cont.)							
Kaya Maiowe	Coast	Kilifi	?	?	0.1	0.1	None
Kaya Rabai	Coast	Kilifi	035?S 393?E	?	> 5.6	5.6	None
Kirima Cha Mpepe Sacred Grove	Coast	Kilifi	?	?	0.1	0.1	None
Nguu Tatu hill	Coast	Mombasa	0358S 3940E	15–75	0.01	0.01	None
Kaya Shonda	Coast	Mombasa	0406S 3938E	30	0.1	0.1	NM
Kaya Pungu / Mvuakani	Coast	Mombasa	0407S 3938E	?	?	?	None
Kaya Mlele	Coast	Mombasa	040?S 393?E	?	?	?	None
Similani Caves Sacred Grove	Coast	Mombasa	0408S 3938E	5	0.1	0.1	NM
Taru and Kilisa Hills	Coast	Kwale	0345S 3906E	500	c. 17	16	None
Mariakani west forests (Kumbulu and Gobwe)	Coast	Kwale	0352S 3921E	320	1		None
Mwache FR	Coast	Kwale	0400S 3932E	20–120	4.17	2.85	FR
Kaya Gandini / Takawa / Duruma	Coast	Kwale	0401S 3930E	140–200	1.5	1.5	NM
Kaya Mtswakara	Coast	Kwale	0401S 3931E	20–140	1.2	1.2	None
Kaya Chonyi (Jivani)	Coast	Kwale	0403S 3931E	50	1.5	1.5	None
Maluganji FR	Coast	Kwale	0404S 3926E	30–300	17.15	14	FR
Kaya Mtai / Mtae NM	Coast	Kwale	0406S 3927E	300	[?]	[?]	NM in FR
Kaya Ngyorani	Coast	Kwale	0406S 3930E	?	0	0	None
Kaya Chitanze / Kitsantse forest	Coast	Kwale	0407S 3928E	280	c. 0.3	0.25	None
Kaya Lunguma	Coast	Kwale	0407S 3931E	100	1.5	1.5	None
Kaya Bombo NM	Coast	Kwale	0407S 3934E	90	< 0.1	0.05	NM
Kaya Kiteje NM	Coast	Kwale	0407S 3934E	20	c. 0.2	0.15	NM
Kaya Teleza / Dugumura Hill SG	Coast	Kwale	0408S 3930E	255	1	1	None
Kaya Miyani	Coast	Kwale	0409S 3926E	400	c. 0.25	0.2	None
Kaya Kwale / Digo NM	Coast	Kwale	0410S 3926E	390	[?]	[?]	NM in NR
Kaya Waa NM	Coast	Kwale	0411S 3936E	15	c. 0.2	0.15	NM
Shimba Hills NR	Coast	Kwale	0415S 3920E	100–448	192.6	63	NR, 1968
Simkumbe forest patch	Coast	Kwale	0415S 3930E	?	?	?	None
Kaya Tiwi NM	Coast	Kwale	0415S 3935E	5	< 0.1	0.05	NM
Mwamungu forest patch	Coast	Kwale	0416S 3932E	?	?	?	None
Mkongani North FR	Coast	Kwale	0416S 3918E	100–200	11.13	[11]	FR: order 406, 1956

	Province/ region	District	Grid location	Altitude (m)	Quoted area (km^2)	Min. forest area (km^2)	Status
KENYA (cont.)							
Kaya Diani NM	Coast	Kwale	0416S 3935E	15	0.2	0.2	NM
Mkongani West FR	Coast	Kwale	0417S 3916E	100–200	13.66	[13]	FR: order 406, 1956
Kaya Ukunda NM	Coast	Kwale	0418S 3933E	20	0.2	0.2	NM
Kaya Muhaka / Kambe / Mwadabara NM	Coast	Kwale	0419S 3931E	45	1.5	1.5	NM
Diani / Jadini Forest	Coast	Kwale	0419S 3933E	10	c. 0.85	0.8	None
Mwereni Brachystegia woodland	Coast	Kwale	0420S 3911E	150	c. 1.5	1.4	None
Kaya Dzombo NM	Coast	Kwale	0423S 3912E	462	[?]	[?]	NM in FR
Kaya Galu/Ganzoni NM	Coast	Kwale	0423S 3950E	5	0.1	0.1	NM
Kaya Ngalaani/Kinondo NM	Coast	Kwale	0423S 3932E	5	0.3	0.3	NM
Gongoni FR	Coast	Kwale	0424S 3928E	10–70	8.24	6.35	FR: order 44, 1932
Jombo FR	Coast	Kwale	0426S 3912E	100–520	9.07	2.92	FR: order 102, 1941
Buda Mafisini FR	Coast	Kwale	0426S 3923E	70–80	6.68	6	FR: order 44, 1932
Kaya Chale / Chale Island SG NM	Coast	Kwale	0426S 3931E	6	0.5	0.5	NM
Kaya Mrima / Mrima Hill SG NM	Coast	Kwale	0427S 3915E	285	[?]	[?]	In FR
Mrima FR	Coast	Kwale	0428S 3915E	80–300	3.77	2.9	FR: order 304, 1961
Kaya Msambweni	Coast	Kwale	0428S 3929E	?	?	?	None
Marenji FR	Coast	Kwale	0429S 3912E	30–160	15.29	15	FR: order 50, 1967
Palm woodland, Ramisi (3 patches)	Coast	Kwale	0433S 3918E	15	10	10	None
Kaya Sega NM	Coast	Kwale	0433S 3906E	60	0.5	0.5	NM
Chuna gallery forest	Coast	Kwale	0433S 3908E	40	1	1	None
Gonja FR	Coast	Kwale	0434S 3907E	30–90	8.42	6	FR: order 304, 1961
Kaya Gonja/Mwalewa NM	Coast	Kwale	0434S 3907E	75	[?]	[?]	NM in FR
Miongoni gallery forest	Coast	Kwale	0436S 3901E	20	c. 0.8	0.7	None
Shimoni forest	Coast	Kwale	0437S 3921E	20	c. 6	4	None
Kaya Jego NM	Coast	Kwale	0438S 3911E	10	> 0.1	0.11	NM
Shimoni Cave Sacred Grove NM	Coast	Kwale	0438S 3922E	5	< 0.1	0.05	NM
Kaya Bogowa NM	Coast	Kwale	0439S 3923E	5	< 0.1	0.05	NM
Lunga Lunga gallery forest	Coast	Kwale	043?S 390?E	40	1	1	None
Kilibasi hill	Coast	Kwale, Taita Taveta	0357S 3857E	400–900	4	4	None
Kitovu	Coast	Taita, Taveta	0326S 3736E	700	< 1	0.5	None
TOTAL: **145 sites**						**660.89**	

	Province/ region	District	Grid location	Altitude (m)	Quoted area (km^2)	Min. forest area (km^2)	Status
TANZANIA							
Ras Kiuyu	Pemba Is. N.	?	0452S 3950E	?		2.1	None
Msitu Mkuu	Pemba Is. N.	?	0455S 3940E	?		1.3	None
Ngezi	Pemba Is. N.	Micheweni	0455S 3942E	20	14.4	7.5	FR: 1923?
Kojani Island	Pemba Is. N.	Wete	0509S 3952E	10–20		3	None
Mgelema	Pemba Is. S.	Mkoani	0519S 3942E	90		0.45	None
Jambangombe	Pemba Is. S.	Mkoani	0519S 3942E	90		0.45	None
Horohoro	Tanga	Muheza	0437S 3905E	80		0.8	None
Kilulu Hill ("Moa")	Tanga	Muheza	0446S 3907E	200–267		0.16	None
Mafi Hill	Tanga	Korogwe	0453S 3810E	600–1480	45.08	10	None
Mtapwa	Tanga	Muheza	0455S 3853E	140		4	None
Kwamgumi	Tanga	Muheza	0457S 3842E	180–1000	11.5	10	FR: 1955
Kambai Public Lands	Tanga	Muheza	0458S 3842E	160–200		11	None
Segoma	Tanga	Muheza	0458S 3843E	180–1000	11.68	11	FR: 1955
Kambai FR	Tanga	Muheza	0500S 3842E	180–800	10.46	8	FR: 1994
Manga	Tanga	Muheza	?	200–800	8.6	7.6	FR: 1955
Marimba	Tanga	Muheza	0502S 3845E	180–300	8	5	FR: German
Amboni Caves and Mkulumuzi Gorge	Tanga	Tanga Municipal	0505S 3902E	0–80		3.5	None
Yambe Island	Tanga	Tanga Municipal	0506S 3910E	0–10		2	None
Tongwe	Tanga	Muheza	0518S 3844E	220–648	12	3	FR: German and 1956
Pangani Falls	Tanga	Muheza	0521S 3840E	20–160		1	None
Kwani	Tanga	Muheza	0521S 3841E	0–200	25	10	FR: German
Mlungui	Tanga	Muheza	?	?		2	None
Kwasumba	Tanga	Handeni	?	?	29	28	FR: German
Mtunguru	Tanga	Handeni	0536S 3805E	580–760		29.32	FR: German
Mbuzini	Tanga	Handeni	0538S 3800E	?		0.5	None
Kwasumba	Tanga	Handeni	0539S 3803E	580–640	29	28	FR
Gendagenda (South and North)	Tanga	Handeni and Pangani	0533S 3838E	80–545	28	28	FR: German
Handeni Hill	Tanga	Handeni	0527S 3830E	790–1040	5.4	6.77	FR: German
Mgambo	Tanga	Handeni	0532S 3838E	300	20?	20	FR: German
Msubugwe	Tanga	Pangani	0532S 3845E	80–120	44.08	44	FR: 1947

	Province/ region	District	Grid location	Altitude (m)	Quoted area (km^2)	Min. forest area (km^2)	Status
TANZANIA (cont.)							
Mkwaja	Tanga	Pangani	0552S 3847E	0–100		10	GR
Jozani / Unguju	Zanzibar Island	?	0615S 3924E	< 20	5	3	FR
Muyuni	Zanzibar Island	?	0620S 3925E	?		10	None
Magotwe	Morogoro	Morogoro	0602S 3739E	400–700		7.09	None
Pagale Hill	Morogoro	Morogoro	0610S 3750E	300–500	32	32	FR: 1959
Kilandiwe Hill	Morogoro	Morogoro	0622S 3744E	400–657		2	None, private ranch
Msavula Hill	Morogoro	Morogoro	0627S 3745E	400–765		1.5	None, private ranch
Dindili	Morogoro	Morogoro	0639S 3757E	350–800	10	3	FR: 1953
Kitulang'alo	Morogoro	Morogoro	0639S 3757E	350–774	26.38	30	FR: 1955
Ruvu	Morogoro	Morogoro	0653S 3750E	200–480	31	30	FR: 1955
Kimboza	Morogoro	Morogoro	0701S 3748E	200–540	4	4	FR: German
Mselezi	Morogoro	Ulanga	0846S 0852E	560–890	7.71	7.71	FR: Catchment
Pande	Dar es Salaam	Kinondoni	0642S 3905E	100–200	12.3	11	GR: 1988
Gongolamboto	Dar es Salaam	Ukonga	0655S 3910E	100	0.01	0.01	graveyard
Kiono / Zaraninge	Coast	Bagamoyo	0608S 3838E	100–300		20	None
Ruvu North	Coast	Kibaha	0633S 3855E	40–140	405	2	FR: 1959/67
Bagala	Coast	Kibaha	?	?		10	None
Ruvu South	Coast	Kisarawe and Kibaha	0658S 3900E	120–260	350	20	FR: 1958/79
Pugu	Coast	Kisarawe	0654S 3905E	100–305	22	10	FR: German
Vikindu	Coast	Kisarawe	0659S 3917E	40–80	18	5	FR: German
Kazimzumbwi	Coast	Kisarawe	0700S 3903E	120–280	49	23.5	FR: German
Kisiju / Dendene	Coast	Kisarawe	0721S 3920E	0–20		2	None
Mrora (Mlola)	Coast	Mafia	0753S 3951E	0–20		3	NP: Mafia, 1995
Kilindoni	Coast	Mafia	0755S 3940E	0–20	0.01	0.01	None
Mchungu/Kikale	Coast	Rufiji	0740S 3917E	0–15	10	2	FR: German
Namakutwa-Nyamuete	Coast	Rufiji	0817S 3903E	150–380	46.34	12	FR: German
Kiwengoma	Coast	Rufiji	0822S 3856E	250–740	33	22	Proposed FR
Kichi Hills	Coast	Rufiji	?	?		20	None
Kitope Hill	Lindi	Kilwa	?	?	34	6	FR: German
Tong'omba	Lindi	Kilwa	0825S 3901E	150–540	25.1	11	FR: German
Nangoma	Lindi	Kilwa	0827S 3853E	500	0.01	0.01	None

	Province/ region	District	Grid location	Altitude (m)	Quoted area (km²)	Min. forest area (km²)	Status
TANZANIA (cont.)							
Mbinga	Lindi	Kilwa	0831S 3850E	1600–1950	18.6	1	FR: German
Mitundumbea	Lindi	Kilwa	0910S 3916E	500–650	85.5	3	FR: 1957
Ngarama North and South	Lindi	Kilwa	0922S 3920E	45–480	417	10	FR: 1955/57
Pindiro / Bwatabwata	Lindi	Kilwa	0930S 3916E	100–300	117.8	5	FR: German
Rungo	Lindi	Kilwa	0930S 3900E	?	226		FR: 1956
Ndimba	Lindi	Lindi	0935S 3937E	75–150	26.8	5	FR: German
Matapwa	Lindi	Lindi	0942S 3917E	?	165	?	FR: German
Ruawa	Lindi	Lindi	0944S 3933E	150–460	29.5	?	FR: German
Kiwawa plateau	Lindi	Lindi	0946S 3916E	?	?	c.1	None
Likonde plateau	Lindi	Lindi	0948S 3927E	?	?	c.1	None
Noto plateau	Lindi	Lindi	0952S 3922E	?	?	c.10	None
Chitoa	Lindi	Lindi	0957S 3927E	240–420	7.72	6	FR: German
Litipo	Lindi	Lindi	1002S 3929E	180–270	9.96	4	FR: German
Rondo	Lindi	Lindi	1010S 3910E	465–885	140	25	FR: German
Nyangamara	Lindi	Lindi	1023S 3935E	?	9.2	5	None
Namikupula	Lindi	Lindi	1052S 3955E	?			None
Sudi	Lindi	Lindi	?	0–20	?	c. 8	None
Chilangala	Mtwara	Newala	1033S 3908E	?	6	c.1	FR: 1963
Mahuta	Mtwara	Newala	1052S 3955E	?	15		FR: 1961
Ziwani	Mtwara	Mtwara rural	1021S 3915E	50		7.7	FR: Prot. and Catch.
Mtuli / Hinju	Mtwara	Mtwara rural	1033S 3947E	274		3	None
Mtiniko / Mnivata	Mtwara	Mtwara rural	1034S 3956E	182		17	None
TOTAL: **83 sites**						**707.98**	
MOZAMBIQUE							
Nangade	Cabo Delgado	Nangade	1110S 3970E	?	> 100	100	None
Negomano	Cabo Delgado	Nagomano	1148S 3853E	?	> 100	100	None
Mueda	Cabo Delgado	Mueda	1170S 3950E	?	> 100	100	None
Nairoto	Cabo Delgado	Nairoto	1255S 3907E	?	> 100	100	None
Namapa	Nampula	Namapa	1375S 3975E	?	> 100	100	None
Baikopinda	Nampula	Memba	1413S 4042E	100–200	190	100	FR

	Province/ region	District	Grid location	Altitude (m)	Quoted area (km²)	Min. forest area (km²)	Status
MOZAMBIQUE (cont.)							
Mecuburi	Nampula	Mecuburi	1433S 3900E	300–500	2300	800	FR
Matibane	Nampula	Nakala	1436S 4048E	100–200	199	100	FR
Muecate	Nampula	Muecate	1500S 3950E	?	> 100	100	none
Inhamitanga	Manica e Sofala	Cheringoma	1815S 3515E	100	8	8	Proposed FR
Amatongas	Manica e Sofala	Gondola	1910S 3345E	400	5	5	None
Serra Mocuta (Mavita)	Manica e Sofala	Manica	1928S 3308E	700	2	2	?
Dondo	Manica e Sofala	Dondo	1937S 3445E	50	1	1	Chiefs' burial ground
Dombe	Manica e Sofala	Manica	1958S 3323E	200	5	5	None
Chinhongue forest, Benguera Is.	Inhambane	?	2151S 3525E	2–15	20	10	N P
Mabote	Inhambane	Mabote	2230S 3430E	0	> 100	100	Proposed FR
Bazaruto	Inhambane	Bazaruto	?	0	< 100	50	NP
Inhaca Island Dune Forest	Maputo	Maputo	2600S 3259E	10–40	9	9	Terrestrial Reserve
TOTAL: **18 sites**						**1790**	
MALAWI							
S. Mulanje forests	Southern	Mulanje	1600S 3539E	c. 800	2	2	?
Ruo Gorge	Southern	Mulanje	1600S 3539E	800	[2]	[2]	Private
Malawi Hills (part of Matandwe FR)	Southern	Nsanje	1656S 3590E	900	4	4	FR
TOTAL: **3 sites**						**8**	
ZIMBABWE							
Chitema River	Manicaland	Nyanga	1823S 3254E	700	0.1	0.1	In Nyanga NP
Rumbise Hill	Manicaland	Nyanga	1823S 3256E	780	0.15	0.15	Sacred Forest
Pungwe Bridge	Manicaland	Nyanga	18S 32E	?	0.09	0.09	?
Lower Pungwe Valley	Manicaland	Nyanga	18S 32E	?			?
Makurupini	Manicaland	Chimanimani	2002S 3301E	300–350	1.7	1.7	In Chimanimani NP
Haroni Botanic Reserve	Manicaland	Chimanimani	2002S 3301E	300–350	0.04	0.04	Botanic Reserve
Rusitu Botanic Reserve	Manicaland	Chimanimani	2002S 3301E	300–350	0.8	0.8	Botanic Reserve
TOTAL: **7 sites**						**2.88**	
TOTAL: 259 SITES						**3172 km²**	

Appendix 2 Dominant and common tree species recorded in the Coastal Forests

Table 1 Tree species recorded in literature as dominant or common in legume-dominated eastern African Coastal Dry Forest.

	Dominant species	
Afzelia quanzensis[(T2), T3, MZ1]	*Cynometra longipedicellata*[T3]	*Hymenaea verrucosa*[T1, T3, T4, MF1, MZ1]
Albizia adianthifolia[T3, MZ1]	*Cynometra* sp. A of FTEA[FTEA]	*Hymenocardia ulmoides*[(T2), (T3), T15]
Albizia petersiana[T3]	*Cynometra* sp. B of FTEA[FTEA]	*Julbernardia magnistipulata*[(K2), T2, T4]
Baphia kirkii[T1, (T2), T4, (MF1)]	*Cynometra* sp.[T15]	*Millettia eetveldeana*[T3]
Baphia macrocalyx[T15, MZ1]	*Cynometra suaheliensis*[T1]	*Millettia stuhlmannii*[MZ1]
Berlinia orientalis[T3]	*Cynometra webberi*[K4, K5, K6, K11, T1, T2, T3]	*Newtonia buchananii*[MZ1]
Bussea eggelingii[T3]	*Dialium holtzii*[T1, T3, T4, (MF1)]	*Paramacrolobium coeruleum*[K2]
Craibia zimmermannii[T1, T3, (T4)]	*Dialium mossambicensis*[MZ1]	*Scorodophloeus fischeri*[T1, T2, T3, T4]
Cynometra brachyrrachis[T2]	*Erythrina sacleuxii*[T3]	*Xylia africana*[Clarke, pers. obs.]
Cynometra filifera[T3]	*Erythrophleum suaveolens*[K10, MZ1]	
Cynometra greenwayi[K1]	*Guibourtia schliebenii*[T15, MZ1]	
	Common species	
Albizia glaberrima[K2, MF1]	*Drypetes arguta*[T1]	*Millettia* sp.[T1]
Albizia gummifera[MF1]	*Drypetes natalensis*[T1]	*Nesogordonia holtzii*[MZ1]
Angylocalyx braunii[T1]	*Ekebergia capensis*[MZ1]	*Oldfieldia somalensis*[T1]
Brachylaena huillensis[K4, K5, K6, T2]	*Euphorbia* sp.[T3]	*Olea woodiana*[K10]
Brachylaena rotundata[MZ1]	*Ficus tremula*[T1]	*Pteleopsis myrtifolia*[MZ1]
Cola mossambicensis[MZ1]	*Garcinia buchananii*[T1]	*Ricinodendron heudelottii*[T3]
Cola sp.[T2]	*Grewia conocarpa*[MZ1]	*Rinorea angustifolia*[T3]
Craibia sp.[T2]	*Khaya anthotheca*[MZ1]	*Sorindeia madagascariensis*[T1, MF1]
Croton jatrophoides[T2]	*Manilkara sansibarensis*[T1, T2, MF1]	*Strychnos henningsii*[T3]
Diospyros spp.[MF1]	*Manilkara sulcata*[K5, K6, K11, T1, T2, T3, T4]	*Strychnos* sp.[K5, K6]
Diospyros verrucosa[T1]	*Markhamia obtusifolia*[T1]	*Synsepalum brevipes*[K2, MZ1]

Table 2 Tree species recorded in literature as dominant or common in mixed eastern African Coastal Dry Forest.

	Dominant species	
Acacia polyacantha[MZ1]	*Commiphora serrata*[T8, T14]	*Garcinia buchananii*[T1]
Adansonia digitata[(K5), T2, MZ1]	*Cordyla africana*[(K1), (K4), T8, MZ1]	*Garcinia livingstonei*[(K1), MZ1]
Afzelia quanzensis[K1, K2, (K4), K10, K11, (T1), (T2), (T6), T8, T11, MZ1]	*Craibia brevicaudata*[K1, T2]	*Grewia* sp.[Z1]
Albizia adianthifolia[(K1), T3, T5, T8, Z1, MZ1]	*Croton jatrophoides*[T2]	*Haplocoelopsis africana*[(K1), T1]
Albizia glaberrima[K1, (K4), Z1]	*Croton* spp.[MZ1]	*Haplocoelum inopleum*[(K6), Z1]
Albizia gummifera[(K4), Z1]	*Croton sylvaticus*[(K1), K10, (T1), (P1), (Z1)]	*Hirtella zanzibarica*[(K1), (K4), MZ1]
Albizia petersiana[T3, T5, T8]	*Cussonia zimmermannii*[(K1), (K4), K8, (T3), T8, T14, Z1]	*Hymenaea verrucosa*[K1, (K4), (K5), (K6), K11, (T1), (MZ1)]
Albizia versicolor[(K4), MZ1]	*Dalbergia boehmii*[T8]	*Hymenocardia ulmoides*[(T3), T14]
Alchornea laxiflora[T1]	*Dialium holtzii*[(K1), T1, T3]	*Inhambanella henriquesii*[MZ1]
Angylocalyx braunii[(K1), T1]	*Dialium mossambicense*[MZ1]	*Julbernardia magnistipulata*[K1, K10, K11, (T2)]
Anthocleista grandiflora[MZ1]	*Dialium orientale*[(K1), K4, K11, T8, T9]	*Khaya anthotheca*[T11, MZ1]
Antiaris toxicaria[K1, (K4), K5, K8, T1, (P1)]	*Dichapetalum stuhlmannii*[T1, (T3)]	*Lannea antiscorbutica*[T5, T8]
Antidesma membranaceum[T8]	*Diospyros consolatae*[T1, (T2), Z1]	*Lannea schweinfurthii*[K1, T1, T9, Z1]
Balanites maughamii[(T2), MZ1]	*Diospyros greenwayi*[K10, T7]	*Lecaniodiscus fraxinifolius*[K1, K8, T2, T7]
Balanites wilsoniana[K1, (K4)]	*Diospyros kabuyeana*[K1, (T2)]	*Lettowianthus stellatus*[T1, T8]
Bersama abyssinica[T8, MZ1]	*Diospyros mespiliformis*[K1, T9]	*Macaranga* sp.[MZ1]
Bombax rhodognaphalon[(K1), K4, (T3), T1, T5, T8, (P1), MZ1]	*Diospyros squarrosa*[K1, K10]	*Macphersonia gracilis*[Z1]
Brachylaena huillensis[(K4), K11, T1, T4]	*Diospyros verrucosa*[T1, (T3)]	*Mallotus oppositifolius*[(K5), Z1]
Brachylaena rotundata[MZ1]	*Dracaena deremensis*[T7]	*Manilkara discolor*[(K1), K2, T1, (T3), T4, T7, T8,]
Brachystegia spiciformis[(K2), K11, T8]	*Dracaena reflexa*[MZ1]	*Manilkara sansibarensis*[K1, K4, (K5), K6, K11, T1, Z1]
Bridelia atroviridis[T8]	*Drypetes arguta*[T1]	*Manilkara sulcata*[(K1), (K4), T1, T2, T5, T8, Z1]
Bussea eggelingii[T3]	*Drypetes natalensis*[K1, T8, T9, Z1]	*Markhamia zanzibarica*[K2, (K6), K11]
Casearia gladiiformis[T8, (Z1)]	*Drypetes reticulata*[K1, K6]	*Mascarenhasia arborescens*[K2]
Cassipourea euryoides[(K4), K5, (K6), K10]	*Ekebergia capensis*[MZ1]	*Memecylon* sp.[K4]
Celtis gomphophylla[T8]	*Erythrophleum suaveolens*[K1, (K4), (K10), (P1), MZ1]	*Milicia excelsa*[K1, (K4), (K5), K8, T14, (P1), MZ1]
Chrysophyllum gorungosanum[MZ1]	*Fagaropsis angolensis*[T8]	*Millettia eetveldiana*[T3, T5, T8]
Cleistanthus schlecteri[T5]	*Fernandoa magnifica*[K1, K10]	*Millettia stuhlmannii*[MZ1]
Cleistanthus sp. nov aff. *michelsonii*[T3]	*Ficus* spp.[(K4), T8, MZ1]	*Mimusops obtusifolia*[K1, (K4), Z1]
Cola clavata[(T1), T3]	*Ficus sur*[Z1]	*Monanthotaxis fornicata*[K11]
Combretum schumannii[K1, (K4), K5, K8, K11, T2]	*Flacourtia indica*[T8]	*Monodora grandidieri*[Z1]
Commiphora fulvotomentosa[T8]	*Funtumia africana*[T8]	*Mystroxylon aethiopicum*[MZ1]

Table 2 Tree species recorded in literature as dominant or common in mixed eastern African Coastal Dry Forest (cont.).

	Dominant species (cont.)	
Nesogordonia holtzii[(K1), K4, K11, T5, MZ1]	*Sterculia quinqueloba*[MZ1]	*Tricalysia ruandensis*[T8]
Newtonia buchananii[T8, MZ1]	*Sterculia schliebenii*[(T4), MZ1]	*Trichilia emetica*[K1, (K4), K8]
Newtonia paucijuga[K1, (K4), K5]	*Sterculia* sp.[MZ1]	*Trilepesium madagascariensis*[(K1), T3]
Olax obtusifolia[(K1), K5, T8]	*Strychnos henningsii*[T2, (T3)]	*Trimeria grandifolia*[k10]
Parinari curatellifolia[MZ1]	*Suregada zanzibariensis*[T8]	*Turraea holstii*[T8]
Parinari excelsa[T8, MZ1]	*Synsepalum brevipes*[(K1), (K4), K10, (P1), MZ1]	*Turraea robusta*[T8]
Peltophorum africanum[MZ1]	*Syzygium cordatum*[K10]	*Turraea wakefieldii*[K1]
Pseudobersama mossambicensis[(K1), T8]	*Syzygium cumini*[Z1]	*Vismia orientalis*[(T1), T8]
Pteleopsis apetala[T8]	*Syzygium guineense*[(K4), MZ1]	*Vitex mossambicensis*[T8]
Pteleopsis myrtifolia[T5, T8, T14, MZ1]	*Tabernaemontana pachysiphon*[(K1), (T3), T8]	*Vitex schliebenii*[T14]
Pterocarpus tinctorius[T8]	*Tabernaemontana ventricosa*[(T3), T8]	*Vitex zanzibarensis*[T8]
Quassia undulata[(K1), P1]	*Tamarindus indica*[K1, (K4), Z1]	*Xylia africana*[(T3), T8, MZ1]
Rapanea melanophloeos[Z1]	*Tapura fischeri*[T8]	*Xylia torreana*[MZ1]
Ricinodendron heudelottii[(K1), (K4), T1, T3, T7, T8, T14]	*Tarenna drummondii*[T1]	*Xylopia africana*[MZ1]
Schefflerodendron usambarense[T1]	*Teclea trichocarpa*[T7]	*Xylopia parviflora*[(K1), K10, T8]
Schrebera trichoclada[T8]	*Terminalia boivinii*[(K1), K11, (T1), Z1]	*Zanthoxylum chalybeum*[K1, T14, (K5)]
Scorodophloeus fischeri[(K1), (T1), T2, (T3)]	*Terminalia kilimandscharica*[(K5), K8, K11]	*Zanthoxylum deremense*[T8, (K5)]
Sideroxylon inerme[K1, (K5), T1]	*Terminalia sambesiaca*[(K1), K4, K11, T8, T9]	*Zanthoxylum holtzianum*[(K1), T3, Z1]
Sorindeia madagascariensis[K1, (K4), K8, T2, T7, T8, Z1]	*Tetrapleura tetraptera*[T8]	*Ziziphus pubescens*[T7]
Sterculia appendiculata[(K1), (K4), K5, (T2), T11, MZ1]	*Trema orientalis*[MZ1]	
	Common species	
Acacia robusta[K1, K5]	*Celtis africana*[T2, MZ1]	*Commiphora eminii*[K1]
Adansonia digitata[K1, K8, T4]	*Celtis mildbraedii*[K1, K5]	*Commiphora pteleifolia*[T6]
Aristogeitona monophylla[K1]	*Celtis philippensis*[K1]	*Commiphora zanzibarica*[K1]
Bauhinia tomentosa[T1]	*Cleistanthus* sp.[K1, T3]	*Croton pseudopulchellus*[K4, K6]
Blighia unijugata[K1]	*Coffea zanguebariae*[T6]	*Cynometra* sp. aff. *webberi*[MZ1]
Brachylaena discolor[MZ1]	*Cola mossambicensis*[MZ1]	*Cynometra suaheliensis*[K1]
Carpodiptera africana[K1, K6]	*Cola* spp.[K1, T2]	*Cynometra webberi*[K4, T3]
Cassia abbreviata[K1]	*Combretum paniculatum*[MZ1]	*Dalbergia* sp.[T2]

Table 2 Tree species recorded in literature as dominant or common in mixed eastern African Coastal Dry Forest (cont.).

Common species (cont.)

Dialium schlecteri[MZ1]	*Harungana madagascariensis*[MZ1]	*Oldfieldia somalensis*[K1, K4, T1]
Diospyros abyssinica[K1, K4]	*Homalium abdessammadii*[K4]	*Pancovia holtzii*[T2]
Diospyros bussei[T2]	*Hugonia orientalis*[MZ1]	*Pandanus rabaiensis*[Z1]
Diospyros quiloensis[T3]	*Hunteria zeylanica*[K1, K5]	*Paramacrolobium coeruleum*[K1, K4, K5]
Dobera loranthifolia[K1, K4, K5]	*Keetia venosa*[MZ1]	*Parkia filicoidea*[K1, K4]
Drypetes sp.[T2]	*Kigelia africana*[K1, K4]	*Pleuristyla africana*[K1]
Drypetes usambarica[K1]	*Lannea welwitschii*[K1, K5]	*Polyalthia stuhlmannii*[K6]
Elaeis guineensis[P1]	*Lepisanthes senegalensis*[K1, T3]	*Pouteria alnifolia*[K1]
Erythrina sacleuxii[K1, K4, K8, T4]	*Leptactina platyphylla*[T1]	*Psydrax schimperiana*[K4]
Erythroxylon emarginatum[K5]	*Lonchocarpus bussei*[K4]	*Pteleopsis tetraptera*[K1]
Euphorbia candelabrum[T6]	*Lovoa swynnertonii*[K1, K5]	*Rawsonia lucida*[Z1]
Euphorbia nyikae[K2]	*Ludia mauritiana*[T2, K6]	*Stadmannia oppositifolia*[Z1]
Ficus lutea[Z1]	*Macaranga capensis*[K1]	*Sterculia africana*[T1]
Ficus sycomorus[Z1]	*Macaranga kilimandscharica*[K4]	*Strychnos mitis*[K1]
Ficus tremula[T1]	*Majidea zanguebarica*[K4]	*Strychnos* sp.[K6]
Flueggea virosa[T3]	*Margaritaria discoides*[T4]	*Tabernaemontana elegans*[K1, K2, K4]
Glenniea africana[K4]	*Markhamia obtusifolia*[T1, MZ1]	*Tarenna nigrescens*[T1]
Gossypioides kirkii[MZ1]	*Maytenus mossambicensis*[Z1]	*Teclea simplicifolia*[T3]
Grandidiera boivinii[T6]	*Maytenus senegalensis*[K1]	*Uapaca guineensis*[P1]
Grewia conocarpa[T1, T3]	*Maytenus undata*[K6]	*Vepris eugeniifolia*[K1]
Guibourtia schliebenii[T3, MZ1]	*Mimusops bagshawei*[K4]	*Vitex doniana*[K1]
Gyrocarpus americanus[K1]	*Morus mesozygia*[MZ1]	*Vitex ferruginea*[K1]
Haplocoelum sp.[T1]	*Mostuea microphylla*[T1]	*Xylotheca tettensis*[T1]
		Zahna golungensis[K1]

Table 3 Tree species recorded in literature as dominant/common in mixed eastern African Coastal Scrub Forest.

Acacia adenocalyx[T1]
Acacia brevispica[T13]
Acacia sp.[K4]
Afzelia quanzensis[S1, K4, K5, T12, T13]
Albizia adianthifolia[MZ1]
Albizia anthelmintica[K4, T13]
Albizia petersiana[T13]
Albizia versicolor[T1]
Alchornea laxiflora[T14]
Allophylus rubifolius[T13]
Aporrhiza paniculata[T1]
Baphia kirkii[T3]
Baphia macrocalyx[T3]
Bombax rhodognaphalon[T3, T5, T10, T12]
Boscia salicifolia[MZ1]
Bourreria petiolaris[K4]
Brachylaena huillensis[K4, K5, T13]
Brachylaena sp.[MZ1]
Caloncoba welwitschii[T1, T5, T14]
Canthium setiflorum[T13]
Carissa edulis[T13]
Cassipourea euryoides[S1, K4]
Cleistanthus schlecteri[T5]
Cola microcarpa[T5]
Combretum apiculatum[T1, MZ1]
Combretum collinum[MZ1]
Combretum hereroense[MZ1]
Combretum illairii[K4, T1]
Combretum molle[MZ1]
Combretum pisoniiflorum[MZ1]
Combretum schumannii[T2, K4, K5]
Combretum sp.[K4]
Combretum zeyheri[MZ1]
Commiphora serrata[T5]
Commiphora spp.[K4, T13]
Cordyla africana[T12, MZ1]
Craibia brevicaudata[S1]
Croton megalocarpoides[S1]
Croton pseudopulchellus[K4, T5]
Cussonia zimmermannii[T5]
Cynometra lukei[T5]
Dalbergia nitidula[T13]
Dalbergia vacciniifolia[K4]
Dialium orientale[S1]
Dielsothamnus divaricatus[T3]
Diospyros bussei[S1]
Diospyros consolatae[K4, K5]
Diospyros mespiliformis[K4]
Diospyros sp.[K4]
Diospyros verrucosa[T1]
Diospyros zombensis[T1]
Dobera loranthifolia[K4, T2]
Drypetes arguta[T1]
Drypetes reticulata[T5]
Erythrina sacleuxii[T5]
Erythroxylum emarginatum[T1]
Euclea natalensis[K4]
Euphorbia sp.[K4, T13]
Euphorbia tirucalli[K4]
Fernandoa magnifica[MZ1]
Ficus sp.[K4]
Garcinia livingstonei[T1]
Gardenia transvenulosa[T1]
Givotia gosai[S1]
Grevea eggelingii[T5]
Grewia conocarpa[T1, T3, T5]
Grewia holstii[T1, T2]
Grewia sp.[K4, T13]
Grewia villosa[K4]
Gyrocarpus americanus[T5]
Haplocoelum inopleum[S1, T13]
Haplocoelum sp.[T1]
Harrisonia abyssinica[T13]
Heinsia crinita[T1]
Hymenaea verrucosa[T3, T12]
Hymenocardia ulmoides[T1, T3, T5]
Julbernardia magnistipulata[K4]
Keetia zanzibarica[T1]
Lannea antiscorbutica[T5]
Lecaniodiscus fraxinifolius[T2]
Maerua kirkii[T13]
Manilkara discolor[K5, T5]
Manilkara mochisia[K4, K5]
Manilkara sansibarensis[K5]
Manilkara sulcata[K4, T3, T5, T13]
Markhamia acuminata[MZ1]
Markhamia obtusifolia[MZ1]
Memecylon sansibaricum[T5]
Milicia excelsa[T10, T14, MZ1]
Millettia punctulata[T3]
Millettia stuhlmannii[T5, MZ1]
Millettia usaramensis[S1]
Mystroxylon aethiopicum[T1]
Newtonia erlangeri[S1]
Ochna pseudoprocera[T5]
Olax pentandra[T14]

Table 3 Tree species recorded in literature as dominant/common in mixed eastern African Coastal Scrub Forest (cont.).

Oldfieldia somalensis[S1, K4, K5]	*Salacia leptoclada*[T5]	*Thespesia danis*[K4]
Olea europaea[K5]	*Salacia madagascariensis*[T1, T5]	*Thylachium africanum*[T13]
Orphrypetalum odoratum[T5]	*Scorodophloeus fischeri*[T3]	*Toddaliopsis sansibarensis*[T5]
Oxyanthus zanguebaricus[T1]	*Sorindeia madagascariensis*[T1]	*Turraea nilotica*[MZ1]
Parinari curatellifolia[P1]	*Spirostachys africana*[T13]	*Uapaca sansibarica*[P1]
Parinari sp.[T10]	*Spirostachys venenifera*[S1]	*Vitellariopsis kirkii*[K4]
Polyalthia tanganyikensis[T5]	*Strychnos henningsii*[T2, T5]	*Vitex amboniensis*[MZ1]
Psorospermum febrifugum[T1]	*Strychnos innocua*[T13]	*Vitex doniana*[MZ1]
Pteleopsis apetala[T1]	*Strychnos* spp.[T1, T12, MZ1]	*Vitex payos*[MZ1]
Pteleopsis myrtifolia[T3, T5, MZ1]	*Suregada zanzibarensis*[S1, K4, T5, T13]	*Vitex schliebenii*[S1]
Rawsonia sp.[T10]	*Syzygium cordatum*[P1]	*Vitex* sp.[T10]
Rhaphanistrocarpus boivinii[K4]	*Syzygium guineense*[K4]	*Vitex zanzibarensis*[T5]
Rinorea ilicifolia[T5]	*Tabernaemontana elegans*[S1, MZ1]	*Xylotheca tettensis*[T5]
Ritchiea capparoides[T1]	*Tabernaemontana* sp.[K4]	*Zanthoxylum chalybeum*[T13]
Rothmannia manganjae[T1]	*Teclea simplicifolia*[T5, T13]	*Zanthoxylum holtzianum*[S1, T1, T5]
Rourea coccinea[T1]	*Terminalia prunioides*[K4, K5]	
Salacia erecta[T1]	*Terminalia sambesiaca*[T5]	

Table 4 Tree species recorded in literature as dominant/common in maritime eastern African Coastal Scrub Forest.

Adansonia digitata[K4, K8, T7, MF1]	*Erythroxylum platyclados*[MZ1]	*Markhamia zanzibarica*[MF1]
Afzelia quanzensis[MZ1, P1]	*Euclea racemosa*[Z1, MF1]	*Maytenus mossambicensis*[Z1]
Allophylus pervillei[K8]	*Eugenia* sp. nov. (Jozani only)[Z1]	*Memecylon sansibaricum*[T1]
Antiaris toxicaria[P1]	*Euphorbia bussei*[T11]	*Millettia usaramensis*[K8]
Baphia macrocalyx[MZ1]	*Euphorbia nyikae*[T7, Z1]	*Mimosa busseana*[MZ1]
Bombax rhodognaphalon[MZ1]	*Euphorbia* sp.[MZ1]	*Mimusops caffra*[MZ1]
Bridelia micrantha[Z1]	*Euphorbia tirucalli*[T7, Z1]	*Mimusops obtusifolia*[Z1, MF1]
Canavalia gladiata[MZ1]	*Ficus* sp.[Z1, MZ1]	*Monodora grandidieri*[Z1]
Cardiogyne africana[MZ1]	*Ficus sur*[Z1]	*Mystroxylon aethiopicum*[T7, Z1]
Carissa bispinosa[MZ1]	*Flacourtia indica*[MF1]	*Olea woodiana*[P1]
Carpodiptera africana[K4, K8]	*Flueggea virosa*[Z1],	*Ozoroa insignis* ssp. *reticulata*[MZ1]
Combretum constrictum[MZ1]	*Gossypioides kirkii*[MZ1]	*Ozoroa obovata*[Z1, MF1]
Combretum pisoniiflorum[MZ1]	*Grandidiera boivinii*[Z1]	*Pandanus kirkii*[Z1]
Combretum schumannii[K4]	*Grewia conocarpa*[MZ1]	*Pemphis acidula*[Z1]
Combretum xanthothyrsum[MZ1]	*Grewia glandulosa*[Z1, MF1, MZ1]	*Phillippia mafiensis*[P1, MF1]
Commiphora pteleifolia[T7]	*Grewia holstii*[Z1]	*Platysepalum inopinatum*[MZ1]
Commiphora zimmermannii[Z1]	*Grewia plagiophylla*[K8]	*Polysphaeria parvifolia*[Z1]
Cremaspora triflora[MF1]	*Grewia vaughaniae*[K8]	*Pseudopropsis euryphylla*[MZ1]
Croton pseudopulchellus[Z1]	*Guettarda speciosa*[Z1]	*Psydrax schimperiana*[Z1]
Cussonia zimmermannii[K4, P1]	*Guibourtia schliebenii*[MZ1]	*Pterocarpus angolensis*[MZ1]
Cynometra sp.[MZ1]	*Haplocoelum inopleum*[K8, Z1]	*Pycnocoma litoralis*[K8]
Dialium mossambicense[MZ1]	*Haplocoelum trigonocarpum*[T7]	*Rapanea melanophloeos*[Z1]
Dialium orientale[K4]	*Harrisonia abyssinica*[MF1]	*Ricinodendron heudelottii*[MF1]
Dichrostachys cinerea[MF1, MZ1]	*Hugonia elliptica*[MZ1]	*Salacia madagascariensis*[MZ1]
Diospyros consolatae[T1, T7, Z1, P1, MF1]	*Lannea schweinfurthii*[K4, T1, Z1]	*Salvadora persica*[K8]
Diospyros mespiliformis[MF1]	*Lonchocarpus bussei*[K4]	*Sclerocarya birrea*[Z1]
Diospyros natalensis[Z1]	*Ludia mauritiana*[MF1]	*Sideroxylon inerme*[K8, T7, T11, Z1, MF1, MZ1]
Dodonaea viscosa[T11]	*Macphersonia gracilis*[Z1]	*Sorindeia madagascariensis*[P1]
Drypetes natalensis[Z1]	*Mallotus oppositifolius*[Z1, MF1]	*Sphaerocoryne gracilis*[MF1]
Elaeodendron schlecterianum[T7]	*Manilkara discolor*[MZ1]	*Sterculia africana*[K4, T7]
Elaeodendron schweinfurthianum[T11]	*Manilkara sansibarensis*[MF1]	*Sterculia schliebenii*[MZ1]
Encephalartos hildebrandtii[T7, Z1]	*Manilkara sulcata*[T7, T11, Z1, MF1]	*Strychnos angolensis*[Z1]

Table 4 Tree species recorded in literature as dominant/common in maritime eastern African Coastal Scrub Forest (cont.).

Suregada zanzibariensis[Z1]	*Tamarindus indica*[T7, P1]	*Xylopia parviflora*[MZ1]
Synaptolepis kirkii[Z1]	*Terminalia boivinii*[Z1, P1]	*Zanthoxylum chalybeum*[K4, K8]
Syzygium cordatum[MF1]	*Toddalia asiatica*[MZ1]	*Zanthoxylum* sp.[K4, K8]
Tabernaemontana elegans[K8]	*Uapaca sansibarica*[MF1]	

Table 5 Tree species recorded in literature as dominant or common in mixed eastern African Coastal/Afromontane Transitional Forest.

	Dominant species	
Alchornea laxiflora[K2]	*Erythrophleum suaveolens*[T5]	*Pseudobersama mossambicensis*[K2, T5]
Anthocleista grandiflora[T5]	*Fernandoa magnifica*[K2, (MA2)]	*Pteleopsis myrtifolia*[MZ1]
Antiaris toxicaria[K2, T1, (T2), T6]	*Ficus* spp.[T1, T6, MZ1]	*Quassia undulata*[K2]
Bequaertiodendron natalense[T1, (T2)]	*Funtumia africana*[T1]	*Rauvolfia mombasiana*[K2, T1]
Blighia unijugata[MZ1]	*Haplocoelopsis africana*[K2]	*Ricinodendron heudelottii*[T1]
Bombax rhodognaphalon[K2, T1, (T2), (MA2)]	*Isoberlinia scheffleri*[(T2), T5]	*Rinorea arborea*[K2]
Brachylaena rotundata[MZ1]	*Khaya anthotheca*[T6, MZ1, (MA1), (MA2)]	*Scorodophloeus fischeri*[T1]
Calycosiphonia spathicalyx[T5]	*Lannea antiscorbutica*[T1]	*Sorindeia madagascariensis*[(K2), T1, (T2), T5]
Cavacoa aurea[MA1, (MA2)]	*Leptaulus holstii*[T6]	*Sterculia appendiculata*[T1, (T2), T6]
Celtis philippensis[(K2), T6]	*Manilkara discolor*[MA1]	*Synsepalum brevipes*[T5, MZ1]
Cordyla africana[T1]	*Melanodiscus oblongus*[MZ1]	*Synsepalum msolo*[T2]
Craterispermum schweinfurthii[T5]	*Milicia excelsa*[T1, T6, MA2]	*Tabernaemontana pachysiphon*[K2, (T2)]
Cussonia zimmermannii[T1]	*Millettia stuhlmannii*[MZ1]	*Tabernaemontana ventricosa*[T6, MA1]
Dialium holtzii[T1, T5, T6]	*Mussaenda monticola*[T6]	*Tarenna drummondii*[K2]
Diospyros abyssinica[K2]	*Newtonia buchananii*[MZ1, MA1, (MA2)]	*Tessmannia* sp.[T1]
Diospyros greenwayi[K2]	*Newtonia paucijuga*[K2, T1]	*Tetrapleura tetraptera*[T5]
Diospyros kabuyeana[K2, T1]	*Ochna holstii*[T5]	*Treculia africana*[T5]
Diospyros verrucosa[T1]	*Pandanus rabaiensis*[T1, T2]	*Trichilia emetica*[K2]
Drypetes natalensis[T1, (T6), (MA1)]	*Parkia filicoidea*[T1, (T2), T5, T6]	*Uvariodendron gorgonis*[T1, (T6)]
Drypetes reticulata[MA1, (MA2)]	*Pavetta tarennoides*[K2]	*Vitex doniana*[T5]
Ekebergia capensis[MZ1]	*Polyalthia verdcourtii*[T5]	*Xylopia parviflora*[(K2), T5]
Elaeis guineensis[T6]	*Pouteria alnifolia*[K2]	*Zahna golungensis*[K2, MZ1, (MA1)]
Ellipanthus hemandradenioides[K2]	*Pouteria pseudoracemosa*[T1, (T2), T6]	

Table 5 Tree species recorded in literature as dominant or common in mixed eastern African Coastal/Afromontane Transitional Forest (cont.).

Common species		
Albizia glaberrima[K2]	*Erythrina sacleuxii*[T2]	*Nesogordonia holtzii*[K2]
Albizia gummifera[T6]	*Ficus exasperata*[MA2]	*Olacaceae* gen. indet. (Shimba Hills only)[K2]
Allophylus pervillei[K2, T6]	*Ficus lutea*[MA1]	*Olax obtusifolia*[K2]
Allophylus zimmermannianus[K2]	*Garcinia livingstonei*[T6]	*Oxyanthus pyriformis*[K2]
Artabotrys modestus[K2]	*Grandidiera boivinii*[T6]	*Paramacrolobium coeruleum*[K2]
Barringtonia racemosa[T2]	*Heinsia diervilleoides* (Shimba Hills only)[K2]	*Pavetta sansibarica*[K2]
Bersama abyssinica[K2]	*Hunteria zeylanica*[K2]	*Pterocarpus mildbraedii*[T2]
Burttdavya nyassica[MA1, MA2]	*Hymenaea verrucosa*[K2]	*Rawsonia lucida*[K2, MA1]
Caesalpinia volkensii[K1]	*Ixora narcissodora*[K2]	*Rinorea ilicifolia*[K2]
Celtis gomphophylla[MA1]	*Julbernardia magnistipulata*[K2]	*Rothmannia manganjae*[MA1]
Celtis mildbraedii[K2]	*Lagynias pallidiflora*[K2]	*Strychnos mellodora*[K2]
Cola mossambicensis[MA1, MA2]	*Lecaniodiscus fraxinifolius*[K2, T2, MA1]	*Terminalia sambesiaca*[T2]
Cola octoboloides[K2]	*Leptactina platyphylla*[K2]	*Tetracera litoralis*[K2]
Cola scheffleri[T2]	*Leptonychia usambarensis*[K2, T6]	*Tricalysia microphylla*[K2]
Combretum schumannii[K2]	*Lovoa swynnertonii*[K2]	*Tricalysia pallens*[K2]
Croton sylvaticus[K2]	*Macphersonia hildebrandtii*[T2]	*Trilepesium madagascariensis*[MA1, MA2]
Didymosalpinx norae[K2]	*Majidea zanguebarica*[K2]	
Drypetes usambarica[T2]	*Mimusops aedificatoria*[K2]	

Table 6 Tree species recorded in literature as dominant or common in eastern African Coastal Riverine/Groundwater Forest.

Dominant species

Acacia elatior[K12]
Acacia robusta[K3, T5]
Afzelia quanzensis[S2, T1]
Alangium salviifolium[(K3), T5]
Albizia sp.[S1, T10]
Anthocleista grandiflora[T5]
Antiaris toxicaria[T1, T2]
Antidesma venosum[S2, (K3), T1)]
Aporrhiza paniculata[K1, K2]
Balanites wilsoniana[T5]
Baphia kirkii[T5]
Barringtonia racemosa[K3, K8, K9, T1, (T2)]
Bombax rhodognaphalon[(T2), T14]
Borassus sp.[T10]
Breonadia microcephala[(K2), T5]
Bridelia micrantha[(T1), T6, T14]
Burrtdavya nyassica[T1, (T2), T5, (MA2)]
Camptolepis ramiflora[S2]
Celtis philippensis[(K7), T5, T14]
Cola clavata[K7, T5]
Cola discoglypremnophylla[(T3), T5]
Cola sp.[S1, (T2)]
Combretum imberbe[T5]
Cordia goetzei[S1, (K3), T5]
Dalbergia lactea[T6]
Deinbollia borbonica[S1]
Diospyros bussei[S2]
Diospyros ferrea[T5]
Diospyros greenwayi[S1]
Diospyros kabuyeana[(T1), T5]
Diospyros mespiliformis[(K3), K12, T5]
Diospyros natalensis[T5]
Diospyros spp.[K7]
Drypetes natalensis[(T2), T14]
Erythrophleum suaveolens[T5, (MA2)]
Ficus bussei[T5]
Ficus scassellattii[S2, (K3), (T2)]
Ficus spp.[T10]
Ficus sycomorus[S2, K12, (T2), T10]
Garcinia livingstonei[S2, (K3), K7, K12, T14]
Gyrocarpus americanus[k7]
Harrisonia abyssinica[S2]
Hirtella zanzibarica[T5]
Homalium abdessammadii[T5]
Hunteria zeylanica[S2]
Hymenaea verrucosa[T1]
Hyphaene compressa[S2, (K3)]
Khaya anthotheca[T1, (T2), T3, T5, T9, T10, T14, MA2]
Kigelia africana[S2, T3, T5]
Lawsonia inermis[S2]
Lecaniodiscus fraxinifolius[S2, K12]
Lepisanthes senegalensis[T5]
Lonchocarpus capassa[T5]
Memecylon sansibaricum[S1]
Milicia excelsa[T1, (T2), T10, T14, (MA2)]
Mimusops obtusifolia[S1, S2, (K3), T5]
Mimusops riparia[(T3), T5]
Newtonia buchananii[(T3), MA2]
Newtonia erlangeri[S2]
Parinari excelsa[T5]
Parkia filicoidea[S1, K1, T1, (T2), T5, T6, T10]
Phoenix reclinata[K3, T5]
Piliostigma thonningii[T5]
Populus ilicifolia[K12]
Pouteria alnifolia[T1, (T3)]
Pterocarpus tinctorius[T1, T5]
Rauvolfia caffra[T5]
Rawsonia lucida[S1]
Rinorea elliptica[S1, T5]
Sorindeia madagascariensis[(K3), K7, (K9), K12, (T1), (T2), T5, T14]
Spirostachys venenifera[(K3), K12]
Sterculia appendiculata[(K7), K12, (T1), (T2), (T3), T5, T10, (MA2)]
Sterculia schliebenii[T10]
Strychnos madagascariensis[T5]
Suregada zanzibariensis[T5]
Synsepalum brevipes[K2, K7, T6]
Synsepalum msolo[(K3), K9]
Syzygium cumini[T6]
Syzygium guineense[K2, T5]
Terminalia brevipes[(K3), K12]
Terminalia sambesiaca[(T2), T14, T5]
Thespesia danis[S2]
Trichilia emetica[S2, K1, (K3), (T3), T5]
Uapaca sp.[T1]
Uvariodendron kirkii[T5]
Xylopia parviflora[T5]
Xylotheca tettensis[T5]

Table 6 Tree species recorded in literature as dominant or common in eastern African Coastal Riverine/Groundwater Forest (cont.).

	Common species	
Acacia elatior[K3]	*Ficus sansibarica*[T2]	*Pavetta sphaerobotrys*[K3]
Albizia versicolor[T2]	*Ficus sur*[T3]	*Pouteria alnifolia*[T3]
Baphia sp.[T3]	*Ficus tremula*[T3]	*Rauvolfia mombasiana*[T2]
Breonadia salicia[T2]	*Ficus vallis-choudae*[T2]	*Ricinodendron heudelottii*[T1]
Celtis africana[T2]	*Mascarenhasia arborescens*[T2]	*Scorodophloeus fischeri*[T1, T2]
Craibia zimmermannii[T2]	*Millettia bussei*[T3]	*Sesbania sesban*[T2]
Dialium holtzii[T1]	*Oxyanthus pyriformis*[T2]	*Strychnos henningsii*[T2]
Dichapetalum stuhlmannii[T3]	*Oxystigma msoo*[K7]	*Tabernaemontana ventricosa*[T2]
Diospyros abyssinica[K3]	*Pancovia golungensis*[T2]	
Drypetes arguta[T3]	*Pandanus rabaiensis*[T2]	

Table 7 Tree species recorded in literature as dominant/common in eastern African Coastal Swamp Forest.

Anthocleista grandiflora[Z1, P1]	*Ficus natalensis*[Z1]	*Typhonodorum lindleyanum*[T11, P1]
Barringtonia racemosa[T1, P1]	*Ficus sur*[Z1]	*Vitex doniana*[Z1, Z2]
**Calophyllum inophyllum*[Z1, Z2,]	*Ficus sycomorus*[Z1]	*Voacanga thouarsii*[T11]
Celtis zenkeri[T5]	*Hyphaene compressa*[T5]	
Combretum imberbe[T5]	*Lonchocarpus capassa*[T5]	
Cussonia zimmermannii[T1]	*Pandanus rabaiensis*[T1, T11, Z1]	
Elaeis guineensis[T11, Z1, Z2]	*Raphia farinifera*[T11, P1]	
Eugenia sp.[Z2]	*Raphia* sp.[T1, P1]	
Ficus lutea[Z1]	*Sorindeia madagascariensis*[T1, T5]	

Table 8 Tree species recorded in literature as dominant or common in eastern African Coastal *Brachystegia* Forest.

	Dominant species	
Brachystegia microphylla[T1, T3, T5]	*Faurea saligna*[T3]	
Brachystegia spiciformis[K4, K5, K6, K11]	*Haplocoelum inopleum*[K6]	
	Common species	
Afzelia quanzensis[K5]	*Dobera loranthifolia*[K4]	*Margaritaria discoidea*[K6]
Baikiaea ghesquiereana[T1, T3]	*Grewia conocarpa*[T1]	*Polyalthia stuhlmannii*[K6]
Cassipourea euryoides[K6]	*Hymenaea verrucosa*[K5, T1, T3]	*Sclerocarya birrea*[K5]
Croton pseudopulchellus[T1]	*Julbernardia magnistipulata*[K4, K5, K11]	*Strychnos* sp.[K6]
Croton sylvaticus[T1, T3]	*Lannea schweinfurthii*[K4]	*Xylopia arenaria*[K6]
Diospyros kabuyeana[T3]	*Manilkara sansibarensis*[K4]	

Key to Tables 1–8:

S1 = Friis, I. and Vollesen, K. (1989). Notes on the vegetation of southernmost Somalia, with some additions to the flora. *Willdenowia* **18**: 455–477.

S2 = Madgwick, F.J. (1988). Riverine forest in the Jubba Valley: vegetation analysis and comments on forest conservation. *The Biogeography of Somalia, Biogeographia* **14**: 67–88.

K1 = Robertson, pers. obs. from Kenyan Coastal Forests.

K2 = Schmidt, R. (1991). Ecology of a tropical lowland rain forest. *Dissertationes Botanicæ* **179**: 1–213.

K3 = Medley, K. (1992). Patterns of forest diversity along the Tana River, Kenya. *Journal of Tropical Ecology* **8**: 353–371.

K4 = Dale, I.R. (1939). *The woody vegetation of the Coast Province in Kenya.* Imperial Forestry Institute Paper No.**18**: 1–38.

K5 = Moomaw, J.C. (1960). *A Study of the Plant Ecology of the Coast Region of Kenya Colony, British East Africa.* Government Printer, Nairobi.

K6 = Wairungu, S., Awimbo, J. and Kigomo, B. (1993). An ecological study of the Nature reserve within the Arabuko-Sokoke Forest Reserve. In Robertson, S.A. and Luke, W.R.Q. (eds.). *Kenya Coastal Forests: report of the NMK/WWF Coast Forest Survey.* World Wide Fund for Nature, Nairobi.

K7 = Andrews, P., Groves, C.P. and Horne J.F.M. (1975). Ecology of the Lower Tana floodplain (Kenya). *Journal of the East African Natural History Society and National Museum* **151**: 1–31.

K8 = Birch, W.R. (1963). Observations on the littoral and coral vegetation of the Kenya coast. *Journal of Ecology* **51**: 603–615.

K9 = Medley, K.E. (1990). Forest ecology and conservation in the Tana River National Primate Reserve, Kenya. Unpublished PhD thesis. Michigan State University, Michigan.

K10 = Blackett, H.L. (1994a). Forest Inventory Report No. 4. Shimba Hills, Mkongani North and Mkongani West. KIFCON, Nairobi.

K11 = Blackett, H.L. (1994b). Forest Inventory Report No. 2. Arabuko-Sokoke. KIFCON, Nairobi.

K12 = Hughes, F.M.R. (1990). The influence of flooding regimes on forest distribution and composition in the Tana river floodplain, Kenya. *Journal of Applied Ecology* **27**: 475–491.

T1 = Clarke, G.P. and Dickinson, A. (1995). *Status Reports for 11 Coastal Forests in Coast Region, Tanzania.* Frontier-Tanzania Technical Report No. 17. The Society for Environmental Exploration, London and The University of Dar es Salaam, Dar es Salaam.

Key to Tables 1–8: (cont.)

T2 = Clarke, G.P. and Stubblefield, L.K. (1995). *Status Reports for 7 Coastal Forests in Tanga Region, Tanzania.* Frontier-Tanzania Technical Report No. 16. The Society for Environmental Exploration, London and The University of Dar es Salaam, Dar es Salaam.

T3 = Clarke, G.P. (1995). *Status Reports for 6 Coastal Forests in Lindi Region, Tanzania.* Frontier-Tanzania Technical Report No. 18. The Society for Environmental Exploration, London and The University of Dar es Salaam, Dar es Salaam.

T4 = Hawthorne, W.D. (1993). East African coastal forest botany. Pp.57–99. In Lovett, J.C. and Wasser, S.K. (eds.). *Biogeography and Ecology of the Rain Forests of eastern Africa.* Cambridge University Press, Cambridge.

T5 = Vollesen, K. (1980). Annotated check-list of the vascular plants of the Selous Game Reserve, Tanzania. *Opera Botanica* **59**: 1–117.

T6 = Pócs, T. (1976). Vegetation mapping in the Uluguru Mountains (Tanzania, East Africa). *Boissiera* **24**: 477–498 + map.

T7 = Hall, J.B., Rodgers, W.A., Mwasumbi, L.B. and Swai, I. (1982). Woody vegetation on Tanzanian Coral Rag: a Reconnaissance. Unpublished. Forestry working group of the University of Dar es Salaam, Dar es Salaam.

T8 = Bidgood, S. and Vollesen, K. (1992). *Bauhinia loeseneriana* reinstated, with notes on the forests of the Rondo Plateau, SE Tanzania. *Kew Bulletin* **47**: 759–764.

T9 = Vollesen, K. and Bidgood, S. (1992). 'Kew Expedition to Tanzania and Malawi Jan–April 1991'. Unpublished report. Royal Botanic Gardens, Kew.

T10 = Schlieben, H.J. (1939). Die forstlichen Vegetationsverhaltnisse Deutsch-Ostafrikas. *Kolonialeforstliche Mitteilungen* **1**: 406–424.

T11 = Greenway, P.J. (1973). A classification of the vegetation of East Africa. *Kirkia* **9**: 1–68.

T12 = Busse, W. (1902). Forschungsreise durch den Sudlichen Teil von Deutsch-Ost Afrika. *Beiheft zum Tropenpflanzer* **6**: 93–119.

T13 = Welch, J.R. (1960). Observations on deciduous woodland in the eastern Province of Tanganyika. *Journal of Ecology* **58**: 557–573.

T14 = Eriksen, T., Halberg, K., Lehmberg, T. and Schoubo Petersen, F. (1994). *A Survey of Bird Life in Five Coastal Forests of South-eastern Tanzania, 1993.* Zoological Institute and BirdLife International, Copenhagen.

T15 = Gillman, H. (1945). Bush fallowing on the Makonde Plateau. *Tanganyika Notes and Records* **19**: 34–44.

Z1 = Beentje, H.J. (1990a). *A Reconnaissance Survey of Zanzibar forests and Coastal Thicket.* Zanzibar Environmental Study Series No. 7. Commission for Lands and Environment, Zanzibar.

P1 = Beentje, H.J. (1990b). *Botanical assessment of Ngezi Forest, Pemba.* Zanzibar Environmental Study Series No. 8. Commission for Lands and Environment, Zanzibar.

Z2 = Robins, R.J. (1976). The composition of the Jozani forest, Zanzibar. *Botanical Journal of the Linnean Society* **72**: 223–234.

MF1 = Greenway, P.J. with Rodgers, W.A., Wingfield, R.J. and Mwasumbi, L.B. (1988). The vegetation of Mafia Island, Tanzania. *Kirkia* **13**: 197–238.

MZ1 = Wild, H. and Grandvaux Barbosa L.A. (1967). *Vegetation map of the Flora Zambesiaca area.* Descriptive memoir: 71pp. M.V.O. Collins (Pvt.) Ltd, Salisbury [Harare].

MA1 = Dowsett-Lemaire, F. (1990). The flora and phytogeography of the evergreen forests of Malawi II: Lowland forests. *Bull. Jard. Bot. Nat. Belg./Bull. Nat. Plantentuin Belg.* **60**: 9–71.

MA2 = Chapman, J.D. and White, F. (1970). *The Evergreen Forests of Malawi.* Commonwealth Forestry Institute, Oxford.

***Notes*:**

Dominant species here defined as species cited in literature as being dominant, or species accounting for 25% of all individuals ≥ 10cm DBH (diameter at breast height) in vegetation plots.
Common species here defined as species cited in literature as being common, or species accounting for 10% to 25% of all individuals ≥ 10cm DBH.
For species listed as dominant, references in parentheses indicate cases where the same species has been recorded as common.
Species names have been revised where necessary, and may not then be the same as cited in the literature.
* Beentje (1990a) considers that most of the *Calophyllum inophyllum* in Jozani forest (Zanzibar) is planted.

Appendix 3 Endemic plants of the Swahilian Regional Centre of Endemism *sensu lato* (including Coastal Forests)

Family	Species	Habitat	Habit	Distribution	Data sources	Notes
Acanthaceae	*Adhatoda* sp. nov. (Mwasumbi 12420)	F	?	T6 endemic	Rodgers *et al.*, 1983	Kimboza endemic
Acanthaceae	*Asystasia linearis* S. Moore	G	H	T6, 8;	Op. Bot. 1980; EA	
Acanthaceae	*Asystasia* sp. nov. aff. *decipiens* (Luke 1650)	T	H	K7; T3,8	R and L; Voll. and Bid., 1992; Notes	?Rare, less than 5 locs.?
Acanthaceae	*Asystasia* sp. nov. I (Rodgers 2512)	F	?	T6 endemic	Rodgers *et al.*, 1983	Kimboza endemic
Acanthaceae	*Asystasia* sp. nov. II (Mwasumbi 12358)	F	H	T6 endemic	Rodgers *et al.*, 1983; Kew	Kimboza endemic
Acanthaceae	*Asystasiella africana* S. Moore	F	S, H	K7; T3, 6	R and L; Iv. 1991; Kew Bull. **47**, 613–617; Kew	Rare in Kenya
Acanthaceae	*Barleria holstii* Lindau	F, B, T	H	T3, 6, 8	Iv. 1991; Op. Bot. 1980; Clarke 1995 and coll.	
Acanthaceae	*Barleria marginata* Oliv.	W, G	H	T8;	Op. Bot. 1980	Rare, 3 locs. only
Acanthaceae	*Barleria repens* Nees	F	H	K4, 7; T6, 8; Maf	R and L; Greenw. 1988; EA	Rare in Kenya
Acanthaceae	*Barleria setigera* Rendle	B, T	S	K7; T6, 8	R and L; KTSL; EA	
Acanthaceae	*Barleria* sp. ?nov. (Clarke 11)	F	C	T8 endemic	Kew	Rondo endemic
Acanthaceae	*Barleria* sp. nov. aff. B. *spinisepala* E.A. Bruce	W	S	T8 endemic	Op. Bot. 1980	Selous endemic
Acanthaceae	*Barleria* sp. nr. *amaniensis* Lindau (R and L 2636)	F	C	K7;	R and L; Haw. 1993	
Acanthaceae	*Barleria usambarica* Lindau	F?	H	K7; T6, 8	R and L; Op. Bot. 1980	Rare in Kenya
Acanthaceae	*Barleria whytei* S. Moore	F, Ro	H	K7; Maf	R and L; Kew	2 locs. only?
Acanthaceae	*Blepharis affinis* Lindau	F, W, B, G	H	T6, 8;	Op. Bot. 1980; Clarke 1995; EA	
Acanthaceae	*Blepharis* sp. nr. *pratensis* S. Moore (Luke 3064)	Shore	H	K7 endemic	R and L; Robertson, coll. notes	Rare, less than 5 locs.
Acanthaceae	*Chlamydacanthus lindavianus* H. Winkler	F	S, H	K7; T3	R and L; Iversen 1991; Clarke 1995; EA	3 locs. in Kenya
Acanthaceae	*Crabbea longipes* Mildbr.	F	H	T8 endemic	Voll. and Bid. 1992; Notes	
Acanthaceae	*Crossandra pungens* Lindau	F, W, T, Sw	H	K7; T3, 6	R and L; Kew Bull. **45**, 530	
Acanthaceae	*Crossandra pyrophila* Vollesen	W	H	MN, MZ, MMS; C.Mal, S.Mal	Kew Bull. **45**, 133–135	
Acanthaceae	*Dicliptera mossambicensis* Klotzsch	F, T, Wa	H	K7; T6; Zam; Zim; Moz	Op. Bot. 1980; Clarke 1995; EA	
Acanthaceae	*Dicliptera olitoria* Mildbr.	W	H	T6 endemic	Op. Bot. 1980	Selous endemic
Acanthaceae	*Dicliptera* sp. (Archibold 2048)	F	H	K7; T3	R and L; Robertson, coll. notes	Rare in Kenya
Acanthaceae	*Dicliptera* sp. (Schlieben 4170)	F	H	K7; T6	R and L; Robertson, coll. notes	Rare, less than 5 locs., 1 K7
Acanthaceae	*Dicliptera* sp. ?nov. (= Schlieben 3999)	?	H	T6;	Op. Bot. 1980	
Acanthaceae	*Dicliptera* sp. ?nov. aff. *D. umbellata* (Vahl) Juss.	F	H	T8 endemic	Op. Bot. 1980	Selous endemic
Acanthaceae	*Dicliptera* sp. not matched at Kew (Frontier 3075)	F	H	T6 endemic	Frontier coll.	Namakutwa-Nyamuete endemic
Acanthaceae	*Ecbolium amplexicaule* S. Moore	F, B, T, G, Wa	H, S	K1, 7; T3, 6, 8; Z; Maf; MN	R and L; Iversen 1991; KB **44**, 662–664; EA	
Acanthaceae	*Ecbolium hastatum* Vollesen	B	H	MSS endemic	KB **43**, 643	Rare, 2 locs. only
Acanthaceae	*Elytraria minor* Dokosi	F	H	K7;	R and L; Haw. 1993	
Acanthaceae	genus ?nov. (Luke 2945)	F	H	K7 endemic	R and L	Rare, 2 locs. only
Acanthaceae	*Isoglossa anisophylla* Brummitt	F, Wa	H	T3 endemic	Kew Bulletin **40**, 788–790	Rare, less than 5 locs.
Acanthaceae	*Justicia brevipila* Hedren	B	S	K7 endemic	Kew Bull. **43**, 356–357	
Acanthaceae	*Justicia engleriana* Lindau	F	S	T3 endemic?	Haw. 1993; B and G, 1949	= *Adhatoda engleriana*
Acanthaceae	*Justicia fittonoides* S. Moore	F, T, Ro	H	K7; T6, 8	R and L; Clarke 1995; EA; Haw. 1993	Rare in Kenya

Family	Species	Habitat	Habit	Distribution	Data sources	Notes
Acanthaceae	*Justicia inaequiifolia* Brummit	F, B, Ro	S	K7; T3, 6; Maf.	R and L; Iversen 1991; Kew Bull. **45**,	
Acanthaceae	*Justicia migeodii* (S. Moore) V.A.W. Graham	W, T	S, H	T8 endemic	Voll. and Bid. 1992; Notes; EA; Kew	
Acanthaceae	*Justicia sansibariensis* Lindau	T	S, H	T3, 5, 6; Maf;	Greenway 1988; Clarke 1995; EA	
Acanthaceae	*Justicia* sp. ?nov. (L and R 614)	F	H	K7 endemic	R and L; Robertson, coll. notes	Mangea endemic?
Acanthaceae	*Justicia* sp. ?nov. aff. *J. nuttii* C.B. Clarke	W	H	T6, 8	Op. Bot. 1980	
Acanthaceae	*Justicia* sp. ?nov. aff. *J. uncinulata* Oliv. not matched	W, G	H	T8 endemic	Op. Bot. 1980	Selous endemic
Acanthaceae	*Justicia* sp. aff. *fittonioides* S. Moore (R and L 5985)	F	H	K7 endemic	R and L; Robertson, coll. notes	3 locs. only
Acanthaceae	*Justicia* sp. near *striata* (Klotzsch) Bullock	F	H	K7 endemic	R and L; Robertson, coll. notes	?Rare
Acanthaceae	*Justicia* sp. nov. (Verdcourt 211)	F	H?	T3;	Iv. 1991	
Acanthaceae	*Justicia* sp. nov. sect *Betonica* (D and H 2289)	F	H	K7; T3	R and L; Robertson, coll. notes	?Rare, less than 5 locs?
Acanthaceae	*Justicia* sp. sect *Rostellularia* (L and R 2770)	F	H	K7 endemic	R and L; Robertson, coll. notes	?Rare, less than 5 locs.
Acanthaceae	*Justicia stachytarphetoides* C.B. Clarke	F, T	S	K7; T6, 8	R and L; Op. Bot. 1980	Rare in Kenya?
Acanthaceae	*Lankesteria alba* Lindau	F	H	K7; T3	R and L; Iversen 1991; Clarke 1995	
Acanthaceae	*Lepidagathis plantaginea* Mildbr.	BW	H	T6, 7, 8	Voll. and Bid. 1992; Notes; EA	
Acanthaceae	*Megalochlamys tanaensis* Vollesen	F	H	K7 endemic	R and L; KB **44**, 637–639	Tana River endemic
Acanthaceae	*Phaulopsis gediensis* M. Manktelow	F	H	K7; T3, 6	R and L; Manktelow 1996	
Acanthaceae	*Phaulopsis pulchella* M. Manktelow	F, T	H	P; Z	Manktelow 1996	Islands endemic
Acanthaceae	*Ruellia* sp. 3 (Luke *et al.* 3375)	F	S, H	K7 endemic	R and L; Robertson, coll. notes	Shimba Hills endemic?
Acanthaceae	*Ruellia* sp. nov.	F	S	T6 endemic	UDSM; Kew	Pande endemic
Acanthaceae	*Rungia* sp. nov. (Faulkner 4076)	F	H	K7; T3	R and L; Robertson, coll. notes	1 loc. in Kenya
Acanthaceae	*Sclerochiton boivinii* (Baillon) C.B. Clarke	F	S	K7; T3	Kew Bull. **46**, 1–50.	
Acanthaceae	*Sclerochiton coeruleus* (Lindau) S. Moore	F	S	MN; MZ; MMS, MSS, MLM; E.Zim	Kew Bull. **46**, 1–50.	
Acanthaceae	*Sclerochiton insignis* (Mildbr.) Vollesen	F	T, S	T6, 8	Kew Bull. **46**, 1–50.	Rare, 2 locs. only
Acanthaceae	*Sclerochiton kirkii* (T. Anderson) C.B. Clarke	F, W	T, S	T8; MN, MZ, MMS; S.Mal; E. Zim; S.Zim	Kew Bull. **46**, 1–50.	
Acanthaceae	*Sclerochiton tanzaniensis* Vollesen	F	S	T6, 8	Kew Bull. **46**, 1–50.	
Acanthaceae	*Streptosiphon hirsutus* Mildbr.	F	S	T8 endemic	Frontier coll.; KB **49**, 401–407	Rare, 2 locs. only
Acanthaceae	*Thunbergia heterochondrous* (Mildbr.) Napper	F	C, H	T6, 8	Clarke 1995	
Acanthaceae	*Thunbergia kirkii* Hook.f.	F, W	S, H	K7; T3	R and L; KTSL; Iversen 1991	
Acanthaceae	*Thunbergia stelligera* Lindau	F	C	K7; T8	R and L; EA	Rare in Kenya
Acanthaceae	*Trichaulax mwasumbii* Vollesen	F	H	K7; T3, 6	R and L; Kew Bull. **47**, 613–617	Rare in Kenya
Aloaceae	*Aloe boscawenii* Christian	B	S	T3 endemic	FTEA	Rare, 1 loc. only
Aloaceae	*Aloe classenii* Reynolds	B, Ro	H	K7 endemic	FTEA; R and L	Rare, less than 5 locs.
Aloaceae	*Aloe dorotheae* A. Berger	F, G, Ro	H	T3 endemic	FTEA; Iversen 1991	?Rare, less than 5 locs ?
Aloaceae	*Aloe killifiensis* Christian	Ro	H	K7 endemic	FTEA; R and L	Rare, less than 5 locs.
Aloaceae	*Aloe rabaiensis* Rendle	B	S	S.Som; K4, 7; T2, 3	FTEA; FSom	
Aloaceae	*Aloe lateritia* forma vel. sp. nov. aff. (Bid. *et al.* 1978)	BW, T	H	T8 endemic ?	Voll. and Bid. 1992; Notes	
Aloaceae	*Aloe leachii* Reynolds	W	H	T6 endemic	FTEA; Op. Bot. 1980	Rare, 2 locs. only
Aloaceae	*Aloe massawana* Reynolds	B, T	H	K7; T3, 6; Z; Maf; Moz	FTEA; R and L; Greenway 1988	Isolated pop. in Eritrea
Aloaceae	*Aloe penduliflora* Bak.	Ro	S	K7 endemic	FTEA; R and L	Rare, less than 5 locs.
Amaranthaceae	*Achyropsis gracilis* C.C. Townsend	F	H	T3; MN, MZ, MLM	FTEA, FZ	Rare, 4 locs. only
Amaranthaceae	*Celosia hastata* Lopr.	F	H	K7; T3, 6	R and L; FTEA	

Family	Species	Habitat	Habit	Distribution	Data sources	Notes
Amaranthaceae	*Celosia nervosa* Townsend	F	H	MN, MSS, MLM	FZ	
Amaranthaceae	*Celosia pandurata* Baker	F	H	MZ, MT, MMS	FZ	
Amaranthaceae	*Celosia pantentiloba* C.C. Townsend	F, T	H	T8 endemic	FTEA; Clarke coll.	Rare, 2 locs. only
Amaranthaceae	*Cyathula braunii* Schinz.	F	H	T8 endemic	FTEA; Clarke coll.	Rondo endemic
Amaranthaceae	*Cyathula* sp. aff. *braunii* Schinz (L. *et al.* 3328)	F	H	K7 endemic?	R and L	Rare, less than 5 locs.
Amaranthaceae	*Hermbstaedtia gregoryi* C.B.Clarke	Dunes	H	K7 endemic	R and L; FTEA	Rare, less than 5 locs.
Amaranthaceae	*Psilotrichum cyathuloides* Suesseng. and Launert	F, W	H	K7; T3, 6, 8	R and L; FTEA; Op. Bot. 1980	
Amaranthaceae	*Psilotrichum fallax* C.C. Townsend	F	H	K7; T3	FTEA; R and L; UDSM herb.	Rare, less than 5 locs.
Amaranthaceae	*Psilotrichum vollesenii* C.C.Townsend	F, T	H	T8 end.	FTEA; Voll. and Bid., 1992	Rare, 2 locs. only
Amaryllidaceae	*Crinum stuhlmannii* Bak.	W, G	H	K7; T2, 3, 6, 8; Moz	R and L; FTEA	Rare in Kenya
Amaryllidaceae	*Crinum subcernuum* Bak.	G	H	T6; Moz	FTEA	Also in Namibia ?
Anacardiaceae	*Lannea* sp. C of FZ	?	?	MN endemic	FZ	Rare, 1 loc. only
Anacardiaceae	*Lannea* sp. D of FZ	?	?	MN endemic	FZ	Rare, 1 loc. only
Anacardiaceae	*Ozoroa obovata* (Oliv.) R. and A. Fernanades	F, W, B, T	T, S	K7; T3, 6, 8; Z; Maf; MN, MZ, MMS, MSS, MLM, MT; S.Zim	FZ; FTEA; Op. Bot. 1980; Bntj.; Greenw.	Extends into Natal
Ancistrocladaceae	*Ancistrocladus robertsoniorum* Leonard	F	L	K7 endemic	R and L; FTEA	Shimba Hills and 1 nearby loc
Annonaceae	?genus indet. (Ismail and Ndangalasi s.n.)	F	S?	T6 endemic	UDSM herb.	Pugu endemic
Annonaceae	?genus indet. of FTEA (Semsei 810)	F	T	T6 endemic	Rodgers *et al.*, 1983	Kimboza endemic
Annonaceae	*Artabotrys modestus* Diels	F, B, W, T, G	L, S	K7; T3, 8	R and L; KTSL; FTEA	
Annonaceae	*Artabotrys* sp. 1 (M and Gl 443)	F	L	K7 endemic	R and L; KTSL	Shimba Hills endemic?
Annonaceae	*Asteranthe asterias* (S. Moore) Engl. and Diels	F, BW, B	T, S	K7; T3, 6; Z	R and L; KTSL; FTEA	
Annonaceae	*Asteranthe lutea* Vollesen	F, T	S	T6, 8; Z	Bot. Notiser **133**, 53–62; Fro. coll.	Rare, 3 locs. only
Annonaceae	*Asteranthe* sp. nov. (Bidgood *et al.* 1552)	F	T	T8 endemic	Voll. and Bid., 1992; Notes	Rondo endemic
Annonaceae	*Dielsothamnus divaricatus* (Diels). R.E. Fries	F, BW	T, S	T8; MN, MZ, C.Mal	FTEA; FZ	Extends into central Malawi
Annonaceae	*Hexalobus mossambicensis* N. Robson	F?	T, S	MN endemic	FZ	?Rare, less than 5 locs?
Annonaceae	*Isolona cauliflora* Verdc.	F	T, S	K7; T3	R and L; FTEA; Beentje 1988	2 locs. Kenya
Annonaceae	*Lettowianthus* sp. of FTEA	F	T	K7; T3	FTEA	
Annonaceae	*Lettowianthus stellatus* Diels	F	T	K7; T6, 8; Maf	R and L; FTEA; Greenway 1988	Rare in Kenya
Annonaceae	*Mkilua fragans* Verdc.	F	T, S	K7; T3, 6, 8; Z; P	R and L; FTEA; Voll. and Bid. 1992; UDSM	
Annonaceae	*Monanthotaxis faulknerae* Verdc.	F, BW	S	K7; T3	FTEA; R and L; UDSM herb.; KTSL	Rare, less than 5 locs.
Annonaceae	*Monanthotaxis fornicata* (Baill.) Verdc.	F, BW, B, T	T, S	S.Som; K7; T3, 6; Z; Maf	R and L; FTEA; Friis and Voll.; Greenw. 1988	
Annonaceae	*Monanthotaxis* sp. ?nov. (Bidgood *et al.* 1402)	F	S	T8 endemic	Voll. and Bid., 1992; Notes	Rondo endemic
Annonaceae	*Monanthotaxis tricantha* (Diels) Verdc.	F	S	T8 endemic	FTEA	Lake Lutamba/Litipo endemic
Annonaceae	*Monanthotaxis tricocarpa* (Engl. and Diels) Verdc.	F	L, S	K7; T3, 6; Z; Maf; MZ, MMS; Mal?	R and L; FTEA; FZ; Greenway 1988	= *Popowia trichocarpa*
Annonaceae	*Monodora grandidieri* Baill.	F, B, T	T, S	S.Som; K7; T3, 6, 8; MN; C.Mal	FTEA; FZ	Extends into central Malawi
Annonaceae	*Monodora minor* Engl. and Diels	F, W, BW, B	T, S	T6, 8	FTEA	
Annonaceae	*Monodora* sp. A of FTEA	F	T	T8 endemic	FTEA	Rondo endemic
Annonaceae	*Ophrypetalum odoratum* Diels	F	T, S	K7; T3, 6, 8	R and L; Bot. Not.**133**, 53–62; FTEA; per obs.	
Annonaceae	*Polyalthia mossambicensis* Vollesen	F	?	MZ	Bot. Notiser **133**, 403–404.	
Annonaceae	*Polyalthia* sp.of FTEA	F	T	T6 endemic	FTEA	Magombera endemic
Annonaceae	*Polyalthia stuhlmannii* (Engl.) Verdc.	F, BW	S	K7; T3, 6	R and L; FTEA; KTSL	

Family	Species	Habitat	Habit	Distribution	Data sources	Notes
Annonaceae	*Polyalthia tanganyikensis* Vollesen	F, T	S	T8 endemic	Bot. Notiser **133**, 53–62.	Selous and Kichi Hills endemic
Annonaceae	*Polyalthia verdcourtii* Vollesen	F	T	T8 endemic	Bot. Notiser **133**, 53–62.	Magombera forest endemic
Annonaceae	*Polyceratocarpus* sp. ?nov. (Luke 1621)	F	T	K7 endemic	R and L	2 locs, Shimba hills area
Annonaceae	*Popowia chasei* N. Robson	F	L, S	E.Zim, S.Zim; S.Mal, MMS	FZ	Now *Monanthotaxis*?
Annonaceae	*Sanrafaelia ruffonammari* Verdc.	F	S	T3 endemic	Verdcourt 1996	E. Usambaras endemic (Kwangumi)
Annonaceae	*Sphaerocoryne gracilis* (Engl. and Diels) Verdc.	F, W, B	T, L, S	K7; T3, 6, 8; Moz	R and L; KTSL; Iversen 1991	= *Melodorum gracilis*
Annonaceae	*Toussaintia orientalis* Verdc.	F	T, C, S	K7; T6	R and L; FTEA	Rare, 3 locs. only
Annonaceae	*Uvaria acuminata* Oliv.	F	T, S, L	S.Som; K7; T3, 6, 8; Z; P; Moz?	R and L; FZ; KTSL; FTEA; Friis and Voll.	May be in Mozambique
Annonaceae	*Uvaria decidua* Diels	F	S	T8 endemic	FTEA; Voll. and Bid., 1992	Rare, 2 locs. only
Annonaceae	*Uvaria denhardtiana* Engl.	B, T	S	S.Som; K7	FTEA	
Annonaceae	*Uvaria faulknerae* Verdc.	F, W, B	T, L	K7; T3, 8	R and L; FTEA; Op. Bot. 1980	Rare, less than 5 locs.
Annonaceae	*Uvaria kirkii* Hook. f.	F, BW, B, T, G	S	K7; T3, 6, 8; Z; P; Maf; MN	R and L; FTEA; FZ; Greenw. 1988	Rare in Kenya
Annonaceae	*Uvaria lungonyana* Vollesen	F, T	S	T8 endemic	Bot. Notiser **133**, 53–62; Op. Bot. 1980	Selous endemic
Annonaceae	*Uvaria pandensis* Verdc.	F	L	T6 endemic	Frontier coll.; Kew Bulletin **43**, 99–105	Rare, less than 5 locs.
Annonaceae	*Uvaria* sp. ?nov., not matched at Kew (Frontier 3486)	F	C	T3 endemic	Frontier coll.	Pangani Falls endemic
Annonaceae	*Uvaria* sp. B of FTEA	F	C, S	T3; P	FTEA; Beentje 1990	?Rare, less than 5 locs ?
Annonaceae	*Uvaria* sp. nov. A (Mwasumbi 12532)	F	S	T3, 6; P	UDSM Herb.	Rare, less than 5 locs.
Annonaceae	*Uvaria* sp. nov. B (Mwasumbi 13858)	F	?	T6 endemic	UDSM Herb.; Mwas. *et al.*, 1994.	Rare, 2 locs. only
Annonaceae	*Uvariodendron gorgonis* Verdc.	F	T	K7; T3, 6	R and L; FTEA; Iv. 1991	Rare, less than 5 locs.
Annonaceae	*Uvariodendron kirkii* Verdc.	F, B	T, S	K7; T3, 6, 8; Z; P	R and L; FTEA; Op. Bot. 1980	
Annonaceae	*Uvariodendron* sp. ?nov. 2 (Hawthorne 1420B)	F	T	K7; T	R and L	Rare, less than 5 locs.
Annonaceae	*Uvariodendron* sp. nov. 1 (Luke 1654)	F	T	K7 endemic	R and L	Dzombo endemic
Annonaceae	*Uvariodendron* sp. nov. 3 (Luke 2929)	F	T	K7 endemic	R and L	Shimba Hills endemic?
Annonaceae	*Uvariodendron* sp. of FZ	F	T, S	MMS endemic	FZ	Rare, 1 loc. only
Annonaceae	*Xylopia arenaria* Engl.	F, BW, B	T, S	K7; T6	R and L; FTEA	
Annonaceae	*Xylopia collina* Diels / *Xylopia latipetala* Verdc.	F, W, T	T, S	T8; MN	FTEA; FZ; Voll. and Bid. 1992	Considered same species in Voll. and Bid.
Annonaceae	*Xylopia* sp. A of FTEA	F	T	T8 endemic	FTEA	Sudi endemic
Annonaceae	*Xylopia* sp. B of FTEA	F	T	T6 endemic	FTEA; UDSM herb.	Rare, 2 locs. only
Annonaceae	*Xylopia* sp., not matched	F	?	T6 endemic	Hawthorne, 1984	Kisiju endemic
Annonaceae	*Xylopia torrei* N. Robson	F	S	MSS endemic	FZ	Rare, 3 locs. only
Apocynaceae	*Ancylobothrys tayloris* (Stapf) Pichon	F	L	K7; T6, 8; S.Mal; MN	R and L; FZ; Kew	Rare in Kenya
Apocynaceae	*Callichilia orientalis* S. Moore	F	S	S.Som; MMS, MSS	FZ; Kew	
Apocynaceae	*Carissa praetermissa* Kupicha	F, W	S	MZ, MSS	FZ	?Rare, less than 5 locs?
Apocynaceae	*Landolphia watsoniana* Roxb.	F	L	K7; T3, 6	R and L; Iversen 1991; Kew	Rare in Kenya
Apocynaceae	*Pleioceras orientale* Vollesen	F, T	T	T8; MZ, MMS	FZ; Bot. Tidskr. **75**, 55–62	
Apocynaceae	*Rauvolfia mombasiana* Stapf	F, W, B, T, Ro	T, S	K7; T3, 6, 8; P; Z; MN, MZ, MMS	FZ; Clarke 1995; KTSL; Kew; Bntje 1990	
Apocynaceae	*Stephanostemma stenocarpum* K. Schum	F	S	T6 endemic	Clarke 1995; Dis. Pl. Af. **30**, 1000; Haw. 1993	Rare, 1 loc. only
Apocynaceae	*Strophanthus hypoleucos* Stapf	W, Ro	S	T8; MN, MZ	FZ; Kew; Dis. Pl. Af. **26**, 876	
Apocynaceae	*Strophanthus zimmermannianus* Monach.	F	L, S	K7; T3, 6; P	Iv. 1991; Kew; Bntje 1990; Dis. Pl. Af. **26**, 892	2 locs. in Kenya
Apocynaceae	*Tabernaemontana elegans* Stapf	F, Dune	T, S	S.Som; K7; T3,6,8; S.Mal; MN,MZ,MMS,MSS, MLM; E.Zim	R and L; FZ; Op. Bot. 1980; Kew; Leeuw. 1991	Extends into Natal and Transvaal
Araceae	*Amorphophallus goetzei* (Engl.) N.E. Br.	F, W	H	T4, 6, 8; Z; Moz; Mal	FTEA	

Family	Species	Habitat	Habit	Distribution	Data sources	Notes
Araceae	*Amorphophallus maximus* (Engl.) N.E. Br.	F, W, B	H	Som; K7; T8	FTEA	Iso. pop. in T1, perhaps a mistake?
Araceae	*Amorphophallus* sp. cf. *stuhlmannii* (Engl.) Engl. and Gehrm.	F	H	K7;	R and L	Rare in Kenya?
Araceae	*Amorphophallus stuhlmannii* (Engl.) Engl. and Gehrm.	F	H	T3, 6	FTEA	
Araceae	*Anchomanes abbreviatus* Engl.	F	H	K7; T3, 6, 8	R and L; FTEA	
Araceae	*Callopsis volkensii* Engl.	F	H	K7; T3, 6	R and L; FTEA	Possibly also in the Cameroons
Araceae	*Culcasia orientalis* Mayo	F	H	K7; T3, 6, 8; Z; P	R and L; FTEA	
Araceae	*Gonatopus clavatus* Mayo	W	H	T8; Moz; Mal	FTEA	
Araceae	*Gonatopus marattioides* (Peter) Bogner	F, W	H	K7; T3	R and L; FTEA	
Araceae	*Gonatopus petiolulatus* (Peter) Bogner	F, BW	H	K7; T3, 6, 8; Moz	R and L; FTEA	
Araceae	*Stylochiton bogneri* Mayo	F	H	K7; T3	R and L; FTEA	
Araceae	*Stylochiton crassipathus* Bogner	F, W	H	K7; T3, 8	FTEA	
Araceae	*Stylochiton euryphyllus* Mildbr.	BW, B	H	T8 endemic	FTEA	
Araceae	*Stylochiton milneanus* Mayo	W	H	T3, 6	FTEA	
Araceae	*Stylochiton salamicus* N.E. Br.	F, W	H	K7; T3, 6, 8; Z	FTEA	
Araceae	*Stylochiton* sp. cf. *milneanus* Mayo (RandL 6104)	F	H	K7 endemic	R and L	Rare, less than 5 locs.
Araceae	*Zamioculcas zamiifolia* (Lodd.) Engl.	F, W, G, B, T, Ro	H	K1, 7; T3, 6; Z; P; Maf; Moz; Mal; Zim	FTEA; Greenway 1988	Extends into Natal
Araliaceae	*Cussonia arenicola* Strey	W	S	MSS, MLM	FZ	Extends into Natal
Araliaceae	*Cussonia zimmermannii* Harms	F, W	T	K7; T3, 6, 8; P; ?Z; Maf; MN	R and L; FTEA; FZ; Bntje 1990; Grnw. 1988	
Arecaceae	*Chrysalidocarpus pembanus* H.E. Moore	F	T	P endemic	FTEA	Ngezi endemic
Asclepiadaceae	*Brachystelma* sp. aff. *B. prostratum* E.A. Bruce	W	H	T8 endemic	Op. Bot. 1980	Selous endemic
Asclepiadaceae	*Ceropegia brevirostris* P.R.O. Bally and D.V. Field	F, B	C	T3, 6	KB **36**, 448–449	
Asclepiadaceae	*Ceropegia cyrtoidea* Werderm.	F?	C	T8 endemic	Kew Bull. **36**, 449–450	Litipo endemic ? ' 45 km W of Lindi'
Asclepiadaceae	*Ceropegia distincta* N.E. Br.	B, Ro	C	Z endemic	KB **36**, 441–443	
Asclepiadaceae	*Ceropegia* sp. 1 (Archer 428)	?	C	K7 endemic	R and L	Rare, less than 5 locs.
Asclepiadaceae	*Ceropegia* sp. 2 (Archer 481)	?	C	K7 endemic	R and L	Rare, less than 5 locs.
Asclepiadaceae	*Ceropegia* sp. 3 (Luke 3309)	F	C	K7 endemic?	R and L	Rare, 1 loc. only
Asclepiadaceae	*Ceropegia* sp. ?nov. (Bid. *et al.* 2061)	F, T, Ro	C	T8 endemic	Voll. and Bid. 1992; Notes	
Asclepiadaceae	*Ceropegia* sp. ?nov. aff. *brevirostris* (Bid. *et al.* 1449)	T	C	T8 endemic	Voll. and Bid., 1992; Notes	Rondo endemic
Asclepiadaceae	*Ceropegia sp.* ?nov. aff. *denticulata* (Bid. *et al.* 1466)	F	C	T8 endemic	Voll. and Bid., 1992; Notes	Rondo endemic
Asclepiadaceae	*Ceropegia* sp. ?nov. aff. *meyeri-johannis* (B. *et al.* 1608)	F	C	T8 endemic	Voll. and Bid., 1992; Notes	Rondo endemic
Asclepiadaceae	*Ceropegia* sp. aff. *racemosa* N.E. Br. (Archer 402)	F	C	K7 endemic	R and L	Shimba Hills endemic?
Asclepiadaceae	*Cryptolepis apiculata* K. Schum.	F, B	C	K7; T3; E.Zim	Kew Bull. **10**, 280	
Asclepiadaceae	*Cryptolepis hypoglauca* K. Schum.	F, T	L, C	K7; T3, 8; Z	R and L; Op. Bot. 1980; Kew Bull. **10**, 279	
Asclepiadaceae	*Cryptolepis obtusa* N.E. Br.	?	?	T6; MZ, MSS	Kew Bull. **10**, 283	Extends into the Transvaal
Asclepiadaceae	*Cryptolepis* sp nov. aff. *C. sanguinolenta* (Lindl.)Schltr	T	C	T8 endemic	Op. Bot. 1980	Selous endemic
Asclepiadaceae	*Dregea faulknerae* Bullock	F	H	T3 endemic	Kew Bull. **11**, 520–521	?Rare, 1 loc. only?
Asclepiadaceae	*Dregea* sp. aff. *crinita* (Oliv.) Bullock (Luke 3123)	?	C	K7 endemic	R and L; Kew	Shimba Hills endemic
Asclepiadaceae	*Gongronema* sp. nov. (Bidgood *et al.* 1435)	T	C	T8 endemic	Voll. and Bid., 1992; Notes	Rondo endemic
Asclepiadaceae	*Gongronema taylorii* (Schltr. and Rendle) Bullock	F	C	K7; T8; MMS; S.Zim	Kew Bull. **15**, 201–202	

Family	Species	Habitat	Habit	Distribution	Data sources	Notes
Asclepiadaceae	*Huernia archeri* Leach	F, Ro	H	K7 endemic	R and L	2 locs. only in Kenya
Asclepiadaceae	*Huernia erectiloba* Leach and Lavranos	G	H	MN endemic	Kirkia **3**, 38–40	
Asclepiadaceae	*Raphionacme* sp. (R and L 6167)	F, T	C?	K7 endemic?	R and L; Robertson, coll. notes	?Rare, less than 5 locs?
Asclepiadaceae	*Raphionacme* sp. 1 (EAH 11541)	G	C?	K7 endemic?	R and L; Robertson, coll. notes	?Rare, less than 5 locs?
Asclepiadaceae	*Raphionacme* sp. cf. *jurensis* N.E. Br. (Archer 520)	Wa	C?	K7 endemic	R and L; Robertson, coll. notes	3 locs. in Kenya
Asclepiadaceae	*Sarcostemma resiliens* Adams and Holland	B	H	K7 endemic	R and L; Adams and Holland 1978	
Asclepiadaceae	*Secamone delagoensis* Schlecter	F	C	MSS; MLM	Kew Bull. **47**, 457–458	Extends into Natal
Asclepiadaceae	*Secamone gracilis* N.E. Br.	F	C	K7; T3	R and L; Kew Bull. **47**, 442–443	Rare, less than 5 locs.
Asclepiadaceae	*Secamone retusa* N.E. Br.	F	C	K7; T3; Z; P; Maf; MN; MZ	Kew Bull. **47**, 442–444	
Asclepiadaceae	*Secamone* sp. nov. aff. *delagoensis* (Bid. *et al.* 1518)	F	C	T8 endemic	Voll. and Bid., 1992; Notes	Rondo endemic
Asclepiadaceae	*Tylophora anomala* N.E. Br.	F	C	T8?; MZ	Kew Bull. **9**, 584	Extends into Natal
Asclepiadaceae	*Tylophora apiculata* K. Schum.	F	S	T3, 6	Kew Bull. **9**, 580	
Asclepiadaceae	*Tylophora* sp. ?nov (R and L 5308)	F	C	K7 endemic	R and L	Rare, less than 5 locs.
Asclepiadaceae	*Tylophora* sp. ?nov. (Eggeling 6421)	F	C	T8 endemic	Voll. and Bid., 1992; Notes	Rondo endemic
Asclepiadaceae	*Tylophora* sp. aff. *tenuipedunculata* K. Schum.	F	C	K7 endemic?	R and L	?Rare, less than 5 locs?
Asclepiadaceae	*Tylophora stenoloba* (K. Schum.) N.E. Br.	F, T	C	K7; T3, 8; Z; P; MN	R and L; Op. Bot. 1980; Kew Bull. **9**, 581	1 loc. in Kenya
Asteraceae	*Achyrothalamus marginatus* O. Hoffm.	F, W, B, T	?	K7; T3;	Iv. 1991; R and L	
Asteraceae	*Aspilia* sp. not matched (Harris 5368)	F	H	T6 endemic	UDSM herb.	Pugu endemic
Asteraceae	*Bothriocline moramballae* (Oliv. and Hiern) O. Hoffm.	F	H	MN, MZ	FZ	?Rare, less than 5 locs?
Asteraceae	*Bothriocline steetziana* Wild and G.V. Pope	W, Ro	S, H	MN, MZ	FZ	?Rare, less than 5 locs?
Asteraceae	*Emilia kilwensis* C. Jeffrey	W	H?	T8 endemic	Kew Bull. **41**, 916	
Asteraceae	*Emilia* sp. not matched	W	H	T8 endemic	Op. Bot. 1980	Selous endemic
Asteraceae	*Erythrocephalum* sp. nov. not matched	W	H	T8 endemic	Op. Bot. 1980	Selous endemic
Asteraceae	*Ethulia angustifolia* DC	G, Wa	H	K7; T2, 3, 6; Z; P	KB **43**, 179–180; FTEA in prep.	
Asteraceae	*Ethulia faulknerae* C. Jeffrey	B	H	K7; Z	KB **43**, 268–269	
Asteraceae	*Ethulia paucifructa* M.G. Gilbert	G, Cult.	H	T6, 8; MN	FZ; Kew Bull. **43**, 181	
Asteraceae	*Grauanthus linearifolius* (O. Hoffm.) Fayed	F, G	H	K7; T6	R and L; FTEA in prep.	Rare in Kenya
Asteraceae	*Gutenbergia pembensis* S. Moore	F	H	K7; T3	R and L; Kew Bull. **43**, 253	
Asteraceae	*Gynura colorata* F.G. Davies	F, Ro	H	K7; T3	R and L; Iversen 1991; KB **33**, 340–341	Rare in Kenya
Asteraceae	*Hystricophora macrophylla* Mattf.	F	?	T8 endemic	Kew Bull. **43**, 249	Rondo endemic
Asteraceae	*Microglossa hildebrandtii* O. Hoffm.	F, B, Wa	S, H	K7; T3, 6	R and L; FTEA in prep.	
Asteraceae	*Pluchea sordida* (Vatke) Oliv. and Hiern	F, Swamp	H	K4, 7; T2, 3, 6, 8; Z; P	FTEA in prep.	
Asteraceae	*Sphaeranthus spathulatus* Peter	Swamp, Cu	H	T3, 6, 8; Z	FTEA in prep.	
Asteraceae	*Vernonia acuminatissima* S. Moore	?	?	T6; MMS; Zim	Kew Bull. **43**, 247	
Asteraceae	*Vernonia hildebrandtii* Vatke	?	?	K1, 2, 7; T3, 6; Z	KB **43**, 215	
Asteraceae	*Vernonia homilantha* S. Moore	B, T	S	S.Som; K7	R and L; KTSL; Kew Bull. **43**, 222	
Asteraceae	*Vernonia inhacensis* G.V. Pope	F	C, S	MSS, MLM	FZ	
Asteraceae	*Vernonia mikumiensis* C. Jeffrey	G	?	T6 endemic	KB **43**, 223	
Asteraceae	*Vernonia rhodanthoidea* Muschler	F?, Dune	?	T6, 8; Maf	KB **41**, 42; KB **43**, 243	
Asteraceae	*Vernonia stuhlmannii* O. Hoffm.	F, T, W	S, H	T3, 5, 6, 8	Kew Bull. **43**, 216; B and G, 1949; Op. Bot. 1980	
Asteraceae	*Vernonia uncinata* Oliv. and Hiern forma vel. sp. aff.	F	H	K7 endemic	R and L	?Rare, less than 5 locs?

Family	Species	Habitat	Habit	Distribution	Data sources	Notes
Asteraceae	*Vernonia vollesenii* C. Jeffrey	G	?	T8 endemic	KB **43**, 222–223	Selous endemic
Asteraceae	*Vernonia zanzibarensis* Loes.	F, B, T	S	K7; T3, 6, 8; Z; P	R and L; KTSL; Op. Bot. '80; KB **43**, 215	
Balanitaceae	*Balanites wilsoniana* Dawe and Sprague	F, T	T	K6, 7; T3, 6, 8	R and L; KTSL; Op. Bot. 1980; EA	Also in Uganda ??
Balsaminaceae	*Impatiens cinnabarina* Grey-Wilson	F	H	T6 endemic	Kew Bull. **33**, 4.	Kimboza endemic
Begoniaceae	*Begonia wakefieldii* Gilg.	F, W, G	H	T3, 8	Iv. 1991; EA	
Bignoniaceae	*Dolichandrone alba* (Sim) Sprague	F, W, T	T, S	MSS, MLM	FZ	
Bignoniaceae	*Fernandoa lutea* (Verdc.) Bidgood	F	T	T8 endemic	Kew Bull. **49**, 383	Rondo endemic
Bignoniaceae	*Fernandoa magnifica* Seem.	F, T	T	K7; T3, 6, 8; E.Zim; S.Mal; MN, MZ, MMS	FZ; Kew Bull. **49**, 385	
Bombaceae	*Bombax mossambicensis* A. Robyns	F?	T	MN, MZ	FZ	
Bombaceae	*Bombax rhodognaphalon* Engl.	F, W, G, B, T	T	K7; T3, 6, 8; P; MN, MZ, MMS; S.Mal	R and L; FZ; FTEA; D-Lm.	
Boraginaceae	*Bourreria nemoralis* (Guerke) Thulin	F, W, B, T, Wa	T,S	K7; T3, 6, 8; MN, MSS	R and L; FTEA; FZ	
Boraginaceae	*Commiphora fulvotomentosa* Engl.	F, W, Ro	T	T6, 8; Moz	FTEA; not in Palgrave	
Boraginaceae	*Commiphora lindensis* Engl.	T	T, S	S.Som; K4, 7; T3, 6, 8; Z	FTEA	
Boraginaceae	*Commiphora* sp. A of FTEA	B	T	K7 endemic	FTEA	
Boraginaceae	*Cordia faulknerae* Verdc.	F, B, T	S	S.Som; K7; T3, 6, 8	R and L; FTEA	
Boraginaceae	*Cordia fissistyla* Vollesen	T	S	T8 endemic	FTEA	Selous endemic
Boraginaceae	*Cordia peteri* Verdc.	F	T, S	T3 endemic	FTEA	E. Usambara endemic
Boraginaceae	*Cordia* sp. B of FTEA	W	S	K7 endemic	R and L; FTEA	Rare, less than 5 locs.
Boraginaceae	*Cordia* sp. C of FTEA	T	S	T8 endemic	FTEA	Lindi Creek endemic
Boraginaceae	*Cordia* sp. D of FTEA	BW	S	T8 endemic	FTEA; Voll. and Bid. 1992	Rare, 2 locs. only
Boraginaceae	*Cordia* sp. D of FTEA	T	S	T8 endemic	Voll. and Bid. 1992; Notes	
Boraginaceae	*Cordia* sp. E of FTEA	F	T	T8 endemic	Voll. and Bid. 1992; Notes	
Boraginaceae	*Cordia stuhlmannii* Guerke	T	T, S	MZ, MMS	FZ	
Boraginaceae	*Cordia torrei* S.Martins	F, W	S	K7; T3; MN	R and L; FZ; FTEA	Rare in Kenya
Boraginaceae	*Cordia trichocladophylla* Verdc.	F	S	T8 endemic	FTEA	Mlinguru endemic
Boraginaceae	*Ehretia bakeri* Britten	F, B, T	T, S	K7; T2, 3, 6, 8; P	FTEA	Extends inland
Boraginaceae	*Ehretia glandulosissima* Verdc.	F	T	T8 endemic	FTEA	Rondo endemic
Boraginaceae	*Heliotropium gorinii* Chiov.	Shore	H	S.Som; K7	R and L; FTEA	
Burseraceae	*Commiphora madagascariensis* Jacq.	F, W, T	T, S	T6, 8; MN, MZ	FTEA; FZ; Op. Bot. 1980	FZ says widespread
Burseraceae	*Commiphora mombassensis* Engl.	F, T	T, S	T8; MN	FTEA; Op. Bot. 1980	
Burseraceae	*Commiphora serrata* Engl.	F, W, T	T, S	T6, 8; MN, MZ, MMS	FZ; FTEA	
Burseraceae	*Commiphora uluguruensis* Engl.	F	S	T6 endemic	FTEA	Tununguo endemic
Burseraceae	*Commiphora zanzibarica* (Baill.) Engl.	F, T	T	K7; T6, 8; MN, MZ, MT, MMS, MLM; E.Zim	R and L; FZ; FTEA	Extends into Natal and Transvaal
Buxaceae	*Buxus obtusifolia* (Milbr.) Hutch.	F	S	K7; T3, 6, 8	R and L; FTEA	
Buxaceae	*Notobuxus cordata* A.R.-Sm. (Mwasumbi 2505)	F	S	T3, 6	Kew Bull **36**, 39–41; KB **40**, 88	Rare, less than 5 locs.
Canellaceae	*Warburgia stuhlmannii* Engl.	F, W	T	K7; T3	R and L; FTEA	
Canellaceae	*Warburgia elongata* Verdc.	F	T, S	T6 endemic	FTEA	Vikindu endemic
Capparaceae	*Cadaba carneo-viridis* Gilg. and Bened.	B, G	S	K7; T3, 6, 8	FTEA	
Capparaceae	*Cleome bororensis* (Klotzsch) Oliv.	?	H	T8; MZ, MMS, MLM	FZ; Voll. and Bid. 1992	
Capparaceae	*Cleome stricta* (Klotzsch) R.A. Graham	Shore	H	S.Som; K7; T6, 8; Z; Maf; MN, MMS, MSS, MLM	FTEA; FZ; Greenway 1988	
Capparaceae	*Maerua acuminata* Oliv.	F, B	S	T8 endemic	FTEA; Voll. and Bid. 1992	Rare, 3 locs. only

Family	Species	Habitat	Habit	Distribution	Data sources	Notes
Capparaceae	*Maerua andradae* Wild	W	S, H	MN endemic	FZ	
Capparaceae	*Maerua brunnescens* Wild	W, T	S	MZ, MMS, MSS, MLM	FZ	
Capparaceae	*Maerua holstii* Pax	F, W	C, S	K7; T3, 6, 8	FTEA; KTSL	
Capparaceae	*Maerua scandens* (Klotzsch) Gilg	BW	S, C	MZ, MSS	FZ	
Capparaceae	*Maerua schliebenii* C.Gilg	F, W	S	T8; MN	FTEA; Voll. and Bid., 1992; FZ	Rare, 3 locs. only
Capparaceae	*Thilachium alboviolaceum* Gilg	F	S	T6 endemic	FTEA	Tununguo endemic
Capparaceae	*Thilachium densiflorum* Gilg and Bened.	F	T, S	T6 endemic	FTEA; UDSM Herb.	
Capparaceae	*Thilachium macrophyllum* Gilg	W, B	S	T6 endemic	FTEA	?Rare, less than 5 locs ?
Capparaceae	*Thilachium paradoxum* Gilg	B	S	T ?6, 8	FTEA	?Rare, less than 5 locs ?
Capparaceae	*Thilachium roseomaculatum* Y.B. Harv. and Vollesen	F	H	K7 endemic	R and L; Kew Bull. **50**(1), 155–160.	Rare, less than 5 locs.
Caryophyllaceae	*Polycarpaea grahamii* Turrill	Shore	H	K7 endemic	FTEA	
Celastraceae	*Elaeodendron fruticosum* N. Robson	W, T	S	MSS endemic	FZ	
Celastraceae	*Elaeodendron schweinfurthianum* (Loes.) Loes.	F, B	T, S	S.Som; K7; T3, 6, 8; Z; Maf	FTEA; Greenway 1988	
Celastraceae	*Hippocratea* sp. ?nov. aff. *graciliflora* (Bid. *et al.* 1688)	T	C	T8 endemic	Voll. and Bid., 1992; Notes	Rondo endemic
Celastraceae	*Maytenus conferta* Masinde	F, B, T	T,S	K7; T3	FTEA	
Celastraceae	*Pristimera longipetiolata* (Oliv.) N. Halle	F, T	S	K7; M; Zim	R and L; FTEA	Extends into the Transvaal
Celastraceae	*Salacia* sp. cf. *elegans* Oliv. (Scheffler 46)	F	S?	K7 endemic?	R and L	?Rare, less than 5 locs.
Celastraceae	*Salacia* sp. cf. *erecta* (G. Don) Walp. (Birch 62/222)	F	S?	K7 endemic	R and L	
Celastraceae	*Salacia stuhlmanniana* Loes.	F, BW, T	T, L, S	S.Som; K4,7; T3, 6, 7, 8; Z; MN, MZ, MMS	FZ; KTSL; FTEA	
Celastraceae	*Simirestis* sp. 1 (L and R 2819)	F	C	K7 endemic	R and L; Robertson, coll. notes	Shimba Hills endemic?
Chenopodiaceae	*Arthrocnemum fruticosum* Moq.	Shore	H	T3, 6	FTEA	Recorded as a doubtful species
Chenopodiaceae	*Salsola* sp. A of FZ	Shore	H	MSS endemic	FZ	
Chenopodiaceae	*Sorcocornia mossambicensis* Brenan	Shore	H	MSS endemic	FZ	
Clusiaceae	*Garcinia acutifolia* N.Robson	F	T, S	T6; MN	FTEA; FZ	
Clusiaceae	*Garcinia bifasciculata* N.Robson	F	T, S	T6 endemic	FTEA	Kimboza endemic
Clusiaceae	*Garcinia* sp. aff. *volkensii* Engl.	F	T	K7 endemic	R and L; Robertson, coll. notes	?Rare, less than 5 locs?
Clusiaceae	*Vismia orientalis* Engl.	F, B	T, S	K7; T3, 6, 8; MN	R and L; FTEA	
Clusiaceae	*Vismia pauciflora* Milne-Redhead	F, B, T	T, S	T8 endemic	FTEA; Op. Bot. 1980	Rondo endemic
Combretaceae	*Combretum andradae* Exell and Garcia	T, B, W	C, S	T8; MN	FTEA; FZ	
Combretaceae	*Combretum butyrosum* (Bertol.f.) Tul.	F, T, W	C, S	K7; T6, 8; MSS	R and L; FTEA; FZ	?Rare in Kenya
Combretaceae	*Combretum caudatisepalum* Exell and Garcia	W, T	S	MN endemic	FZ	Rare, less than 5 locs.
Combretaceae	*Combretum chionanthoides* Engl. and Diels	F, T	T, S	K7; T3, 6	R and L; FTEA; Op. Bot. 1980	
Combretaceae	*Combretum exalatum* Engl.	B	S	S.Som; K4, 7; T3, 6	Iv. 1991; EA	
Combretaceae	*Combretum harrisii* Wickens	F,T	T, S	T6 endemic	Kew Bull. **31**:154; FTEA; UDSM herb.	
Combretaceae	*Combretum illairii* Engl.	F, BW, B	C, S	K1, 7; T3, 6, 8; Z; Maf; MN	FTEA; R and L; FZ; Greenway 1988	
Combretaceae	*Combretum lasiocarpum* Engl. and Diels	W, B	S	MN, MT, MMS	FZ	
Combretaceae	*Combretum lindense* Exell and Mildbr.	B	C, S	T8 endemic	FTEA	Makonde Plateau endemic
Combretaceae	*Combretum pisoniiflorum* (Klotzsch) Engl.	F, BW, T	S	T3, 6; MN, MT, MMS, MSS; S.Mal	FTEA; FZ	
Combretaceae	*Combretum* sp. ?nov. aff. *apiculatum* Sond. (L & R 2686)	F	L	K7 endemic?	R and L	Shimba Hills endemic?
Combretaceae	*Combretum* sp. aff. *tenuipetiolatum* Wickens (L & R 2289)	F	T	K7 endemic?	R and L; Robertson, coll. notes	Rabai endemic?
Combretaceae	*Combretum* sp. B of FTEA	F	T	T3 endemic	FTEA	E. Usambara endemic

Family	Species	Habitat	Habit	Distribution	Data sources	Notes
Combretaceae	*Combretum* sp. nov. (Bid. *et al.* 1869)	F	C	T8 endemic	Voll. and Bid. 1992; Notes	
Combretaceae	*Combretum stocksii* Sprague	F	S	MN endemic	FZ	
Combretaceae	*Combretum tenuipetiolatum* Wickens	F	T	K7; T3	R and L; FTEA	2 x Kenya, and 1 other loc?
Combretaceae	*Combretum xanthothyrsum* Engl. and Diels	F, B, T	L, S	T3, 6, 8; MN	FTEA; FZ	
Combretaceae	*Pteleopsis apetala* Vollesen	F, T	T	T6, 8	Fr. coll.; B and V 1992; NJB **1**: 329–332	Rare, 3 locs. only
Combretaceae	*Pteleopsis barbosae* Exell	W, B	T	MN endemic	FZ	?Rare, less than 5 locs?
Combretaceae	*Pteleopsis tetraptera* Wickens	F, W, B	T	K7; T3	R and L; FTEA	
Combretaceae	*Quisqualis littorea* (Engl.) Exell	F, B	S	Som; K7; T3, 6	R and L; FTEA	
Combretaceae	*Terminalia bagamoyoana* Engl.	?	T	T6 endemic	FTEA	Rare, 1 loc. only
Combretaceae	*Terminalia* sp. ?nov. Not matched	G	T	T8 endemic	Op. Bot. 1980	Selous endemic
Combretaceae	*Terminalia* sp. aff. *spinosa* Engl. (Luke *et al.* TPR766)	F	T	K7 endemic	R and L; Robertson, coll. notes	
Commelinaceae	*Aneilema calceolus* Brenan	F	H	K7; T3	R and L; EA; Faden	Rare, less than 5 locs.
Commelinaceae	*Aneilema clarkei* Rendle	F, W, T	H	K7; T6; P	R and L; EA; Faden	
Commelinaceae	*Aneilema lamuense* Faden	Shore, dunes	H	S.Som; K7	R and L; Faden; FSom	Rare, 2 locs. only
Commelinaceae	*Aneilema succulentum* Faden	F, B, T	H	K7 endemic	Faden	
Commelinaceae	*Aneilema tanaense* Faden	B, T	H	K7 endemic	Faden	
Commelinaceae	*Aneilema taylorii* C.B. Clarke	F	H	K7; T3	R and L; EA; Faden	Rare in Kenya
Commelinaceae	*Commelina* sp. aff. *bracteosa* Hassk. (R and L 6018)	F	H	K7 endemic	R and L	?Rare, less than 5 locs?
Commelinaceae	*Commelina* sp. aff. *erecta* L. (K *et al.* TPR638)	F	H	K7 endemic	R and L	?Rare, less than 5 locs?
Commelinaceae	*Cyanotis* sp. 1 (Rawlins 455)	F?	H	K7 endemic	R and L	Rare, less than 5 locs.
Commelinaceae	*Murdannia axillaris* Brenan	F	H	K7; P	R and L; Beentje 1990; EA	Rare in Kenya
Commelinaceae	*Murdannia* sp. (L and R 2615)	F	H	K7 endemic	R and L	Arabuko-Sokoke endemic?
Connaraceae	*Agelaea setulosa* Schellenb.	F, W	L, S	K7; T3; Z	FTEA	
Connaraceae	*Cnestis calocarpa* Gilg	B?	S?	T6 endemic	FTEA	Rare, 2 locs. only
Connaraceae	*Cnestis confertiflora* Gilg	F, B	T, S	T6; P	FTEA	
Connaraceae	*Cnestis polyphylla* Lan.	F	L	K7 endemic	R and L; Not in FTEA; KTSL	Rare, 2 locs. only
Connaraceae	*Connarus* sp. nov. (Rodgers record)	F	L	P endemic	Beentje 1990	Ngezi endemic
Connaraceae	*Connarus* sp. nov. aff. *C. vrydaghii* Troupin	F	C, S	T6 endemic	Op. Bot. 1980	Selous endemic
Connaraceae	*Connarus* sp. of FTEA	F	L	K7 endemic	FTEA	
Connaraceae	*Ellipanthus hemandradenioides* Brenan	F	T	K7; T8	R and L; FTEA; Bid. and Voll. 1992	
Connaraceae	*Rourea coccinea* (Thonn.) Benth.	F, W, B, T	T, S	K7; T3, 6, 8; MN	R and L; FTEA; FZ; Op. Bot. 1980	= *Byrsocarpus boivinianus*
Connaraceae	*Vismianthus punctatus* Mildbr.	F, B, T	S	T8 endemic	FTEA; Op. Bot. 1980	Rare, 2 locs. only
Convolvulaceae	*Astripomoea* sp. A of FTEA	G?	S	T6 endemic	FTEA	Mtibwa endemic
Convolvulaceae	*Bonamia mossambicensis* (Klotzsch) Hall. f.	F, W, B, T, G	C	T6, 8; MN, MZ, MMS, MSS	FTEA; FZ	
Convolvulaceae	*Convulvulus jefferyi* Verdc.	F, G, Shore	H	K7; T3	R and L; Kew Bull. **37**, 463; FTEA	Rare, less than 5 locs.
Convolvulaceae	*Ipomoea albivenia* (Lindl.) Sweet	B	C, S	K1, 7; MSS?	R and L; FTEA	Rare in Kenya
Convolvulaceae	*Ipomoea consimilis* Schulze-Menz	F, B	C	T8; MMS	FTEA; FZ	Rare, 2 locs. only
Convolvulaceae	*Ipomoea ephemera* Verdc.	B	H	MN, MZ	FZ	?Rare, less than 5 locs?
Convolvulaceae	*Ipomoea ficifolia* Lindl.	W, B, G	H	S.Som; K1, 4 7; T2, 3, 5, 6; Z; MSS, MLM	FZ; FTEA; EA	Extends into South Africa
Convolvulaceae	*Ipomoea flavivillosa* Schulze-Menz	F, B	S	T8 endemic	FTEA	Rondo endemic
Convolvulaceae	*Ipomoea garckeana* Vatke	B, T, G	H	S.Som; K7	FTEA	

Family	Species	Habitat	Habit	Distribution	Data sources	Notes
Convolvulaceae	*Ipomoea irwinae* Verdc.	F, B, G	H	K7; T3, 6, 8	R and L; FTEA	
Convolvulaceae	*Ipomoea kilwaensis* Pilger	G	H	T8 endemic	FTEA	Selous endemic
Convolvulaceae	*Ipomoea simonsiana* Rendle	B	H	T6; Moz; Mal; Zim	FTEA	
Convolvulaceae	*Ipomoea* sp. B of FTEA	F	H	T8 endemic	FTEA	Rondo endemic
Convolvulaceae	*Ipomoea* sp. D of FTEA	F	C	T8 endemic	FTEA	Rondo endemic
Convolvulaceae	*Ipomoea* sp. nr *urbaniana* (Damner) Hall. f. (Luke 2918)	F	C	K7;	R and L; Robertson, coll. notes	Rare in Kenya
Convolvulaceae	*Ipomoea stellaris* Bak.	F?	H	T8 endemic	FTEA	
Convolvulaceae	*Ipomoea ticcopa* Verdc.	G	H	K7; T6, 8; MMS	R and L; FTEA; FZ	2 locs. in Kenya?
Convolvulaceae	*Ipomoea trinervia* Schulze-Menz	G	H	T8; Mal	FTEA	
Convolvulaceae	*Ipomoea zanzibarica* Verdc.	F	L	Z endemic	FTEA	Pangaju and Ufufuma endemics
Convolvulaceae	*Merremia* sp. C of FTEA	W	H	K7 endemic	FTEA	
Convolvulaceae	*Strictocardia lutambensis* (Sculz-Menz.) Verdc.	F	C	T6, 8	FTEA	Rare, 3 locs. only
Convolvulaceae	*Strictocardia macalusoi* (Mattei) Verdc.	Shore	C	S.Som; K7	R and L; FTEA	Rare in Kenya
Convolvulaceae	*Strictocardia* sp. nov., vel gen. aff.	T	H	T8 endemic	Op. Bot. 1980	Selous endemic
Convolvulaceae	*Turbina longiflora* Verdc.	W	C, H	MN, MSS, MLM	FZ	
Crassulaceae	*Kalanchoe ballyi* Cuf.	W	H	K7 endemic	R and L; FTEA	Rare, less than 5 locs.
Crassulaceae	*Kalanchoe fadeniorum* Raadts	T	H	K7 endemic	R and L; FTEA	Rare, less than 5 locs.
Crassulaceae	*Kalanchoe obtusa* Engl.	F	H	K7; T3, 6	R and L; FTEA	
Crassulaceae	*Kalanchoe* sp. ?nov. aff. *bipartita* Chiov. (Landal. 423)	F?	H	K7 endemic	R and L	Tana River endemic
Crassulaceae	*Kalanchoe* sp. B of FTEA	T	H	T8 endemic	FTEA	Selous endemic
Crassulaceae	*Kelanchoe fernandesii* R.-Hamet	F	H	MN endemic	FZ	Rare, 1 loc. only
Crassulaceae	*Kelanchoe hametiorum* R.-Hamet	Ro	H	MN, MZ	FZ	
Cucurbitaceae	?*Coccinia* sp. (Simpson 42)	?	C	K7 endemic?	R and L; Robertson, coll. notes	?Rare, less than 5 locs.
Cucurbitaceae	?*Coccinia* sp. cf. *trilobata* (Cogn.) C. Jeffrey (Si. 383)	F?	C	K7 endemic	R and L; Robertson, coll. notes	?Rare in Kenya?
Cucurbitaceae	*Coccinia fernandesiana* C. Jeffrey	F, W, T	C, H	T8; MN, MZ	FZ; FTEA; Op. Bot. 1980	= *C. senensis*
Cucurbitaceae	*Coccinia grandiflora* Cogn.	F	C	K7; T3, 6, 8; MMS; C.Mal; E.Zim	R and L; FZ; FTEA	
Cucurbitaceae	*Coccinia senensis* (Klotzsch) Cogn.	W, T	C	T8; Moz inc. MMS	FTEA	
Cucurbitaceae	*Coccinia* sp. B of FTEA	F	C	K7; T6	FTEA; R and L	Rare in Kenya
Cucurbitaceae	*Coccinia* sp. E of FTEA	F	C	K1?; K7	R and L; FTEA	1 loc. in Kenya
Cucurbitaceae	*Coccinia subglabra* C. Jeffrey	F	H	MN endemic	FZ	?Rare, less than 5 locs?
Cucurbitaceae	*Corallocarpus ellipticus* Chiov.	B	C	S.Som; K7	R and L; FTEA	
Cucurbitaceae	*Corallocarpus* sp. B of FTEA	B	H	T3 endemic	FTEA	Rare, less than 5 locs.
Cucurbitaceae	*Cucumella aetheocarpa* C. Jeffrey	F, Ro	H	T8; MN	FTEA; FZ	Rare, less than 5 locs.
Cucurbitaceae	*Diplocyclos leiocarpus* (Gilg.) C. Jeffrey	F	C	T8 endemic	FTEA	Rondo endemic
Cucurbitaceae	*Diplocyclos tenuis* (Klotzsch) C. Jeffrey	F, B, T	C	K7; T3, 6; MN, MZ, MMS, MSS, MLM	R and L; FTEA; FZ	On Inhaca Island
Cucurbitaceae	*Eureiandra fasciculata* (Cogn) C. Jeffrey	F, W	C	T6, 8; Moz; Mal; Zim inc. MT	FTEA	
Cucurbitaceae	*Eureiandra* sp. A of FTEA	F, B	C	K7; T3, 6	R and L; FTEA	
Cucurbitaceae	*Eureiandra* sp. A of FZ	?	H	MSS endemic	FZ	Rare, 1 loc. only
Cucurbitaceae	*Gerrardanthus grandiflorus* Cogn.	F	H	K7; T3	R and L; FTEA	?Rare in Kenya
Cucurbitaceae	*Kedrostis heterophylla* A. Zimm.	F	C	K7; T3, 6	R and L; FTEA	Possibly also in Madagascar
Cucurbitaceae	*Kedrostis leloja* (J.F. Gmel) C. Jeffrey	F, B, W	C, H	S; K7; T3, 6, 8	FTEA	Extends into Arabia

Family	Species	Habitat	Habit	Distribution	Data sources	Notes
Cucurbitaceae	*Momordica glabra* A. Zimm.	F	C	T3; Z	FTEA	?Rare, less than 5 locs ?
Cucurbitaceae	*Momordica henriquesii* Cogn.	F, BW	C, H	T8; MN	FZ; KB **30**, 475–476; Op. Bot. 1980	
Cucurbitaceae	*Momordica leiocarpa* Gilg.	F	C	K7; T3	R and L; FTEA	?Rare in Kenya
Cucurbitaceae	*Momordica peteri* A. Zimm.	F	C	K7; T3, 6	R and L; FTEA	
Cucurbitaceae	*Momordica pycnantha* Harms	F	C	T8 endemic	FTEA	Lake Lutamba/Litipo endemic
Cucurbitaceae	*Momordica* sp. A of FZ	BW	H	MN endemic	FZ	Rare, less than 5 locs.
Cucurbitaceae	*Momordica* sp. B of FTEA	B	C	S.Som; K7	FTEA	
Cucurbitaceae	*Momordica* sp. cf. *henriquesii* Cogn. (L and R 2830)	F	C	K7;	R and L; Robertson, coll. notes	
Cucurbitaceae	*Momordica* sp. nov. aff. *glabra* (Bidgood *et al.* 1376)	F	C	T8 endemic	Voll. and Bid. 1992; Notes	Rondo endemic
Cucurbitaceae	*Oreosyce* sp. A of FTEA	S?	C	K7 endemic	FTEA	
Cucurbitaceae	*Peponium leucanthum* (Gilg.) Cogn.	F	C	T8 endemic	FTEA; Frontier coll.	Rare, 2 locs. only
Cucurbitaceae	*Peponium pageanum* C. Jeffrey	F, W	H	T8; MN, MZ, MMS, MSS	FZ; Not in FTEA; KB **30**, 492–493	
Cucurbitaceae	*Peponium* sp. A of FTEA	F, W	H	T8; Moz	FTEA	
Cucurbitaceae	*Telfairia pedata* (Sims) Hook.	F	L	T3, 6, 7, 8; MN, MSS, MLM	FZ; FTEA	Now cultivated
Cucurbitaceae	*Zehneria parvifolia* (Cogn.) J.H. Ross	F	H	MMS, MLM	FZ	Extends into Natal
Cucurbitaceae	*Zehneria* sp. aff. *minutiflora* (Cogn.) C. Jeffrey	?	C	K7 endemic	R and L; Robertson, coll. notes	?Rare, less than 5 locs?
Cyperaceae	*Bulbostylis afroorientalis* (K. Lye) R. Haines	G	Sedge	K7 endemic	R and L; SREA	Rare, less than 5 locs.
Cyperaceae	*Bulbostylis contexta* (Nees) Bodard	W	Sedge	K7; T8; E.Zim	R and L; Op. Bot. 1980; SREA; Drum.	
Cyperaceae	*Bulbostylis densecaespitosa* (K. Lye) R. Haines	?	Sedge	K7 endemic	R and L; SREA	Rare, less than 5 locs.
Cyperaceae	*Bulbostylis* sp. 1 (Moore 6)	?	Sedge	K7 endemic?	R and L	
Cyperaceae	*Cyperus afrodunensis* K. Lye	Dunes, Shore	Sedge	S.Som; K7	R and L; SREA; FSom	Rare, less than 5 locs.
Cyperaceae	*Cyperus boreobellus* K. Lye	Ro	Sedge	K7 endemic	R and L; SREA	Rare, less than 5 locs.
Cyperaceae	*Cyperus frerei* C.B. Cl.	Shore	Sedge	K7 endemic	R and L; SREA	
Cyperaceae	*Cyperus grandis* C.B. Cl.	Sw	Sedge	K7; T6; Z	R and L; SREA	
Cyperaceae	*Cyperus holstii* Kuk.	G	Sedge	K7; T3;	R and L; SREA	
Cyperaceae	*Cyperus kwaleensis* K. Lye	Ro	Sedge	K7 endemic	R and L; SREA	Rare, less than 5 locs.
Cyperaceae	*Cyperus microumbellatus* K. Lye	Sw	Sedge	K7 endemic	R and L; SREA	Shimba Hills endemic?
Cyperaceae	*Cyperus* sp. aff. *cuspidatus* H.B.K.	?	Sedge	K7 endemic	R and L	Rare in Kenya
Cyperaceae	*Cyperus* sp. near *giolii* Chiov.	?	Sedge	K7 endemic	R and L	
Cyperaceae	*Cyperus*, not matched at Kew (Frontier 458)	Sw	Sedge	T6 endemic	Frontier coll.	Zaraninge endemic
Cyperaceae	*Kyllinga cartilaginea* K. Schum.	F, G, Sw	Sedge	K7; T3, 6; Z; Maf	R and L; Greenw. *et al.* 1988; Kew; SREA	
Cyperaceae	*Kyllinga* sp. nr. *bulbosa* P. Beauv.	?	Sedge	K7 endemic	R and L	Mangea endemic?
Cyperaceae	*Mariscus phillipsiae* Chiov.	B, G, Shore	Sedge	K1, 7	R and L; Kew	
Cyperaceae	*Mariscus* sp. 1 nr *diurensis* (Boeck) C.B. Clarke	?	Sedge	K7 endemic?	R and L	
Cyperaceae	*Mariscus* sp. 2 nr *diurensis* (Boeck) C.B. Clarke	?	Sedge	K7 endemic?	R and L	
Cyperaceae	*Mariscus* sp. C (Kabuye *et al.* TPR403)	?	Sedge	K7;	R and L	Rare in Coastal Kenya
Cyperaceae	*Mariscus* sp. nr *macropus* (Boeck) CB. Cl. (EAH 14647)	?	Sedge	K7 endemic?	R and L	
Cyperaceae	*Pycreus* hildebrandtii C.B. Clarke	B, Sw	Sedge	K7; T3; Z; P	R and L; SREA; Kew	
Cyperaceae	*Pycreus* sp. 1 (Kabuye *et al.* TPR745)	?	Sedge	K7 endemic?	R and L	
Cyperaceae	*Pycreus* sp., not matched at Kew (Frontier 1860)	?	Sedge	T6 endemic	Frontier coll.	Kazimzumbwi endemic
Cyperaceae	*Queenslandiella* sp. aff. *hyalina* (Vahl)Bullock (Ku 7269)	?	Sedge	K7;	R and L	

Family	Species	Habitat	Habit	Distribution	Data sources	Notes
Dichapetalaceae	*Dichapetalum* sp. 2 (R *et al.* MDE255)	F	S	K7 endemic	R and L; Robertson, coll. notes	Dzombo endemic?
Dichapetalaceae	*Dichapetalum arenarium* Breteler	F, B	L, S	K7; T3, 6; Z; Maf	R and L; FTEA; Greenway 1988	
Dichapetalaceae	*Dichapetalum barbosae* Torre	F, W, B	L, S	T8; MN, MZ, MMS	FTEA; FZ	
Dichapetalaceae	*Dichapetalum braunii* Engl. and Krause	F, W, T	L, S	T8 endemic	FTEA	Rare, less than 5 locs.
Dichapetalaceae	*Dichapetalum deflexum* (Klotzsch) Engl.	B	S	T8; MN, MSS	FZ; FTEA; KB **45**, 721–723	
Dichapetalaceae	*Dichapetalum edule* Engl.	F, T	L, S	T8; MN	FTEA; FZ	
Dichapetalaceae	*Dichapetalum fadenii* Breteler	F	C	K7 endemic	R and L; FTEA	Mangea and 1 other loc.
Dichapetalaceae	*Dichapetalum fructuosum* Hiern	F	L, S	K7 endemic	Kew Bull. **45**, 721–723; KTSL	
Dichapetalaceae	*Dichapetalum lindicum* Breteler	W?	C	T8 endemic	Kew Bull. **45**, 721–723	
Dichapetalaceae	*Dichapetalum macrocarpum* N. Krause	BW, B, T	S	T8; MN	FTEA; FZ	
Dichapetalaceae	*Dichapetalum mendoncae* Torre	W	C, S	MSS endemic	FZ	
Dichapetalaceae	*Dichapetalum mossambicensis* (Klotzsch) Engl.	F, B	L, S	K7; T3, 6, 8; MMS; MN	R and L; FTEA; FZ	= *D. aureoniteus*
Dichapetalaceae	*Dichapetalum* sp. 1 (L and R 1235B)	F	S	K7 endemic	R and L; Robertson, coll. notes	Tana River endemic?
Dichapetalaceae	*Dichapetalum zambesianum* Torre	W	S	MN, MZ	FZ	
Dilleniaceae	*Tetracera boiviniana* Baill.	W, T	T, S	K7; T3, 6, 8; MN, MZ	R and L; FTEA; FZ	
Dilleniaceae	*Tetracera litoralis* Gilg.	F	C, S	K7; T6; P; Maf	R and L; FTEA; Greenway 1988	
Dilleniaceae	*Tetracera* sp. ?nov. aff. *littoralis* (Bidgood *et al.* 1347)	T	S	T8 endemic	Voll. and Bid., 1992; Notes	Rondo endemic
Dipterocarpaceae	*Monotes lutambensis* Verdc.	F	T	T8 endemic	FTEA	Lake Lutamba/Litipo endemic
Ebenaceae	*Diospyros amaniensis* Guerke	F	S	K7; T3, 6, 7	R and L; White 1988; FTEA in press	Rare in Kenya
Ebenaceae	*Diospyros anitae* F. White	BW	H	T8; MN	FZ; Voll. and Bid. 1992; FTEA in press	Rare, 1 loc. only
Ebenaceae	*Diospyros bussei* Guerke	F, W, B, T	T	S.Som; K1, 4, 7; T3, 6, 8	R and L; White 1988; FTEA in press	Isolated pop. on Shabelle river
Ebenaceae	*Diospyros capricornuta* F.White	F	T, S	T6, 8	White 1988; UDSM herb; FTEA in press	Rare, 2 locs. only
Ebenaceae	*Diospyros consolatae* Chiov.	F, W, B, T, Ro	T, S	K4, 7; T3, 6, 8; Z; P; Maf; MN, MZ	FZ; White 1988; FTEA in press	
Ebenaceae	*Diospyros engleri* Guerke	F	S	T6 endemic	FTEA in press	Pugu endemic. Poss. extinct
Ebenaceae	*Diospyros greenwayi* F. White	F	T	S.Som; K7; T3, 6; Maf	R and L; White 1988; FTEA in press	
Ebenaceae	*Diospyros inhacaensis* F. White	F	T, S	MSS, MLM	White 1988	Extends into Natal
Ebenaceae	*Diospyros kabuyeana* F. White	F	T, S	K7; T3, 6, 7, 8	R and L; White 1988; FTEA in press	= *D. brucei*
Ebenaceae	*Diospyros loureiriana* G. Don	F, W	T, S	K7; T3, 6, 8; MN, MZ, MT, MMS, MSS; E.Zim, S.Zim	FTEA in press; FZ	= *D. usambarensis* and *Royenna macrocalyx*
Ebenaceae	*Diospyros mafiensis* F. White	F, Mg	T, S	T6, 8; Maf; MN	FZ; White 1988; FTEA in press	
Ebenaceae	*Diospyros magogoana* F.White	F	T, S	T8 endemic	White, 1988; FTEA in press	Rondo endemic
Ebenaceae	*Diospyros rotundifolia* Hiern	T	T, S	MSS, MLM	White 1988	Extends into Natal
Ebenaceae	*Diospyros shimbaensis* F. White	F	T	K7; T6; Maf	R and L; White 1988; FTEA in press	Rare, less than 5 locs.
Ebenaceae	*Diospyros* sp. 2 of FZ	F	T	E.Zim; MMS	FZ	
Ebenaceae	*Diospyros troupinii* F. White vel. sp. nov. aff.	F	T	T6 endemic	Op. Bot. 1980	Selous endemic
Ebenaceae	*Diospyros truncatifolia* A.N. Caveney	Ro	T, S	T8?; S.Mal; MN	FZ; Not in White 1988	?Rare, less than 5 locs?
Ebenaceae	*Diospyros usaramensis* Guerke	W	T, S	T6 endemic	FTEA in press	Extinct ?
Ebenaceae	*Diospyros verrucosa* Hiern	F, W, T	T, S	T6, 8; MN, MZ, MMS	FZ; Op. Bot. 1980; FTEA in press	
Ericaceae	*Philippia mafiensis* Engl.	B	T, S	P; Maf	Beentje 1990	Mafia and Pemba endemic
Eriocaulaceae	*Eriocaulon ciliipetalum* H.Hess	Sw	H	T6; Maf	Greenway 1988; FTEA in prep.	
Eriocaulaceae	*Eriocaulon infaustum* N.E. Br.	Sw	H	MMS endemic	FZ in press	Rice fields !

Family	Species	Habitat	Habit	Distribution	Data sources	Notes
Eriocaulaceae	*Eriocaulon selousii* S.M. Phillips	W	H	T6; S.Mal	FTEA in press; FZ in press	
Eriocaulaceae	*Eriocaulon strictum* Milne-Redh.	Sw	H	Maf endemic	FTEA in press	Kilindoni endemic
Erythroxylaceae	*Nectaropetalum acuminatum* Verdc.	F	T	T3 endemic	FTEA	East Usambara endemic
Erythroxylaceae	*Nectaropetalum carvalhoi* Engl.	F	S	MN endemic	FZ; FTEA	Rare, 1 loc. only
Erythroxylaceae	*Nectaropetalum kaessneri* Engl.	F, T, Wa	T, S	K1, 7; T3, 6, 8	R and L; FTEA	
Erythroxylaceae	*Nectaropetalum zuluense* (Schonl.) Corbishley	F, B	S	T3	FTEA	Isolated pop. in Natal
Euphorbiaceae	*Acalypha boiviniana* Baill.	?	T, S	T3, 6 or Z	FTEA	Only known from 1 collection
Euphorbiaceae	*Acalypha bussei* Hutch.	F	S	K7; T8	R and L; FTEA	Rare in Kenya
Euphorbiaceae	*Acalypha echinus* Pax and K. Hoffm.	F	S	K7; T3, 6	R and L; FTEA	
Euphorbiaceae	*Acalypha engleri* Pax	F, B	S	K7; T3, 6, 8; Z; Maf	R and L; FTEA; Greenway 1988	
Euphorbiaceae	*Acalypha gillmanii* A.R.-Sm.	F, T	S	T6, 8	FTEA	Rare, 3 locs. Only
Euphorbiaceae	*Acalypha* sp. A of FTEA	F	S	T8 endemic	FTEA	Lake Lutamba/Litipo endemic
Euphorbiaceae	*Aerisilvaea sylvestris* A.R.-Sm.	F	T	T6 endemic	Kew Bull. **45**, 147–156	Kimboza endemic
Euphorbiaceae	*Argomuellera basicordata* A.R.-Sm.	F	S	T3 endemic	FTEA	E. Usambara endemic
Euphorbiaceae	*Argomuellera* sp. nov. (Luke and Robertson 193)	F	S	K7 endemic	R and L	Rare, 2 locs. only
Euphorbiaceae	*Aristogeitona magnistipulata* A.R.-Sm.	F	S	T6 endemic	Kew Bull. **51**, 799–801	Pugu endemic
Euphorbiaceae	*Aristogeitona monophylla* Airy Shaw	F, T	T, S	K7; T3, 6	R and L; FTEA; Kew Bull. **50**(4), 809.	
Euphorbiaceae	*Cavacoa aurea* (Cavaco) J. Leon	F	T, S	K7; MZ, MMS, MLM; S.Mal	R and L; FTEA; KB **35**, 764; FZ in press; D-Lm.	Extends into Natal
Euphorbiaceae	*Cleistanthus schlecteri* (Pax) Hutch.	F, B	T, S	K7; T3, 6, 8; MN, MZ, MMS, MSS, MLM; S.Mal; E.Zim	FTEA; FZ in press	Extends into Natal
Euphorbiaceae	*Cleistanthus* sp. nov. 1 (Bidgood *et al.* 1515)	F	S	T8 endemic	Voll. and Bid., 1992; Notes	Rondo endemic
Euphorbiaceae	*Cleistanthus* sp. nov. aff. *michelsonii* J. Leon	F	T	K7; T8	R and L; Voll. and Bid., 1992	Rare, less than 5 locs.
Euphorbiaceae	*Croton aceroides* A. Radcl.-Sm.	F	T	MSS endemic	Kew Bull. **45**, 555–560	
Euphorbiaceae	*Croton inhambanensis* A. Radcl.-Sm.	W, Wa	T	MSS endemic	Kew Bull. **45**, 555–560	
Euphorbiaceae	*Croton jatrophoides* Pax.	F	T	T3, 6	FTEA; Hawth., 1984; UDSM herb.	Rare, less than 5 locs.
Euphorbiaceae	*Croton kilwae* A.R.-Sm.	F	S	T8; MN	FTEA	
Euphorbiaceae	*Croton megalocarpoides* Friis and Gilbert	F, T	T, S	S.Som; K1, 7; T6, 8; MN	R and L; KB **50**, 810; FTEA; FZ in press	Rare, less than 5 locs.
Euphorbiaceae	*Croton steenkampianus* Gerstener	T	S	T6; MSS; MLM	FTEA; FZ in press	Extends into Natal and Transvaal
Euphorbiaceae	*Croton talaeporos* A.R. Smith	B, W	T	S.Som; K7	KB **27**, 507; FTEA	
Euphorbiaceae	*Drypetes sclerophylla* Mildbr.	F, W, T	T	T8 endemic	FTEA	Selous endemic
Euphorbiaceae	*Erythrococca berberidea* Prain	F	T, S	T6; Moz	FTEA	Extends into Natal
Euphorbiaceae	*Erythrococca kirkii* (Muell. Arg.) Prain	F, B, T	S	K7; T1, 3, 6, 8; ?Z; P; Moz	FTEA; not in Palgrave	Isolated record from T1
Euphorbiaceae	*Erythrococca pentagyna* A.R.-Sm.	F	S	K7 endemic	R and L; FTEA	= *E.* sp. C of FTEA
Euphorbiaceae	*Erythrococca pubescens* A.R.-Sm.	B	S	K7 endemic	FTEA	
Euphorbiaceae	*Erythrococca* sp. C of FTEA	S	S	K7 endemic	FTEA	
Euphorbiaceae	*Erythrococca usambarica* Prain	F	S	K7; T3, 6, 8	R and L; Kew Bull. **50**, 812; FTEA	Rare in Kenya
Euphorbiaceae	*Euphorbia ambroseae* Leach	F, W, T	T	MT, MZ, MMS, MSS, S.Mal	Kirkia **10**, 391–398	
Euphorbiaceae	*Euphorbia handeniensis* S. Carter	F, Ro	S	T3 endemic	KB **40**, 822–823; FTEA	
Euphorbiaceae	*Euphorbia kassneri* Pax	B, G	S	K7 endemic	R and L; FTEA	
Euphorbiaceae	*Euphorbia kilwana* N.E. Br.	G	H	T3, 6, 8	FTEA	
Euphorbiaceae	*Euphorbia lividiflora* Leach	W, T	T	MN, ?MZ, MMS	Kirkia **4**, 21–2	

Family	Species	Habitat	Habit	Distribution	Data sources	Notes
Euphorbiaceae	*Euphorbia nyikae* Pax	F, W	T	K7; T3, 6, 8; Z; P; Maf	R and L; FTEA; Greenway 1988	
Euphorbiaceae	*Euphorbia selousiana* S. Carter	W	H	T8 endemic	KB **42**, 369–370	Rare, 2 locs. only
Euphorbiaceae	*Euphorbia tanaensis* Bally	F	T	K7 endemic	R and L; FTEA; Beentje 1988	Witu endemic
Euphorbiaceae	*Euphorbia taruensis* S. Carter	Ro	H	K7 endemic	R and L; FTEA	Rare, 2 locs. only
Euphorbiaceae	*Euphorbia wakefieldii* N.E. Br.	F, B, Ro	T, S	K7 endemic	R and L; FTEA; Beentje 1988	
Euphorbiaceae	*Jatropha campestris* S.Moore	W	H	T8; Moz; Zim	FTEA; Op. Bot	
Euphorbiaceae	*Jatropha crinita* Muell. Arg.	Shore?	S	Z endemic?	FTEA	
Euphorbiaceae	*Jatropha scaposa* Radcl.-Sm.	W	H	MN, MMS, MLM	Kew Bull. **46**, 151–152	
Euphorbiaceae	*Jatropha stuhlmannii* Pax	B, G	H	C.Som, S.Som; K1, 7; T3, 6, 8	FTEA	
Euphorbiaceae	*Jatropha subaequiloba* Radcl.-Sm.	W, Sw	H	MSS	Kew Bull. **46**, 154–156	
Euphorbiaceae	*Micrococca scariosa* Prain	F, T	T, S	K7; T3, 6; Z	R and L; Beentje, 1988; FTEA	Rare in Kenya
Euphorbiaceae	*Mildbraedia carpinifolia* (Pax) Hutch.	F	T, S	K7; T3, 6, 8; Z; MN, MZ, MMS	R and L; FTEA; FZ in press	Isolated pop. in T4
Euphorbiaceae	*Mildbraedia* sp. A of FTEA	F?	T	K7 endemic	R and L; FTEA	
Euphorbiaceae	*Monadenium crispum* N.E. Br.	F	H	T3 endemic	FTEA	Rare, less than 5 locs.
Euphorbiaceae	*Monadenium torrei* Leach	W, Ro	S	T8; MN	FTEA	Rare in Tanzania
Euphorbiaceae	*Oldfieldia somalensis* (Chiov.) Milne-Redh.	F, W	T	S.Som; K7; T3, 6, 8; MZ	R and L; FTEA; Kew Bull. **51**, 304	
Euphorbiaceae	*Omphalea mansfeldiana* Mildbr.	F, T	C	T6, 8	Op. Bot. 1980	Rare, 3 locs. only
Euphorbiaceae	*Paranecepsia alchorneifolia* A.R.-Sm.	F, T, Ro	T, S	T6; MN	FTEA	
Euphorbiaceae	*Petalodiscus fadenii* (A.R.-Sm.) A. R.-Sm.	F, Ro	T, S	K7 endemic	R and L; FTEA	= *Savia fadenii* in FTEA
Euphorbiaceae	*Phyllanthus frazieri* A.R.-Sm.	W, G	H	T3, 8	FTEA	
Euphorbiaceae	*Phyllanthus harrisii* A.R.-Sm.	F, SW	H	K7; T6; Z	R and L; FTEA	Rare in Kenya
Euphorbiaceae	*Phyllanthus kaessneri* Hutch.	F, W, B, T	S	K7; T3, 6	FTEA	Extends into Zambia
Euphorbiaceae	*Phyllanthus mendoncae* J.F. Brunel ex Radcl.-Sm.	G	H	MSS endemic	Kew Bull. **51**, 315	Rare, 1 loc. only
Euphorbiaceae	*Phyllanthus rhizomatosus* A.R.-Sm.	F, W	H	T6 endemic	Frontier coll.; FTEA	Rare, 2 locs. only
Euphorbiaceae	*Phyllanthus schliebenii* A.R.-Sm.	F	S	T8 endemic	FTEA	Lake Lutamba/Litipo endemic
Euphorbiaceae	*Phyllanthus somalensis* Hutch.	B, T, Sw	S	S.Som; K1, 7	FTEA	
Euphorbiaceae	*Phyllanthus wingfieldii* A.R.-Sm.	F, T	S	T3, 6	FTEA	
Euphorbiaceae	*Pycnocoma littoralis* Pax	F	T, S	K7; T3, 6	R and L; FTEA	
Euphorbiaceae	*Sapium armatum* Pax and Hoffm.	F, W, T	T	T6, 8; MN; Zim	FTEA	
Euphorbiaceae	*Sapium* sp. of FTEA A.R.-Sm.	F	L	T6 endemic	FTEA	Pande endemic
Euphorbiaceae	*Sapium trilochulare* Pax and K. Hoffm.	F, W	T, S	K7; T6, 8	FTEA; Voll. and Bid, 1992; R and L	Rare, less than 5 locs.
Euphorbiaceae	*Synadenium pereskiifolium* (Baill.) Guill.	F, W	S	K7; T3, 6, 8; P	R and L; FTEA; Beentje 1990	
Euphorbiaceae	*Tetrorchidium ulugurense* Verdc.	F	T, S	T6 endemic	FTEA	Rare, 3 locs. only
Euphorbiaceae	*Thecacoris usambarensis* Verdc.	F, Ro	T, S	K7; T3	R and L; FTEA; Beentje 1988	Rare in Kenya
Euphorbiaceae	*Tragia acalyphoides* A.R.-Sm.	F	H	T6 endemic	FTEA	Pugu/ Kaz. endemic
Euphorbiaceae	*Tragia glabrescens* Pax	B, T	H	K7; T3, 8	R and L; FTEA; Op. Bot. 1980	?Rare, less than 5 locs?
Euphorbiaceae	*Tragia pogostemonoides* A.R.-Sm.	?	S	T6 endemic	FTEA	Rare, 1 loc. only
Euphorbiaceae	*Tragia* sp. ?nov. aff. *okanyua* (Bid. *et al.* 2060)	F, T, Ro	C	T8 endemic	Voll. and Bid. 1992; Notes	
Euphorbiaceae	*Tragia* sp. nov. A of Kew	T	H	T8 endemic	Op. Bot. 1980	Selous endemic
Fabaceae (Caes.)	*Baikiaea ghesquiereana* J.Leon	F	T	T6, 8	FTEA; Fronter coll.	Matumbi Hills endemic
Fabaceae (Caes.)	*Bauhinia mombassae* Vatke	F	S	K7 endemic	R and L; FTEA	Rare, less than 5 locs.

Family	Species	Habitat	Habit	Distribution	Data sources	Notes
Fabaceae (Caes.)	*Berlinia orientalis* Brenan	F, T	T	T8; MN	FTEA; Gomes e Sousa 1966	
Fabaceae (Caes.)	*Bussea eggelingii* Verdc.	F	T, S	T8 endemic	FTEA	Rondo endemic
Fabaceae (Caes.)	*Cassia afrofistula* Brenan	F, B	T, S	K1, 7; T3, 6, 8; Z; P; Maf; Moz	R and L; FTEA; Greenway 1988; not in Palgrave	
Fabaceae (Caes.)	*Cassia burtii* Bak. f.	W, T	T, S	T6, 8; Moz	FTEA; not in Palgrave	
Fabaceae (Caes.)	*Cassia exilis* Vatke	G	H	T3, 6; Z	FTEA	
Fabaceae (Caes.)	*Cassia zambesiaca* Oliv.	G, Cult.	H	K7; T3, 6, 8; Maf; Moz; Zim	FTEA; Greenway 1988	
Fabaceae (Caes.)	*Cynometra brachyrrachis* Harms	F	T	T3 endemic	FTEA; Frontier coll.	Rare, less than 5 locs.
Fabaceae (Caes.)	*Cynometra engleri* Harms	F	T	T3 endemic	FTEA	E. Usambara endemic
Fabaceae (Caes.)	*Cynometra filifera* Harms	F	T	T8 endemic	FTEA; Clarke 1995a	Rare, 2 locs. only
Fabaceae (Caes.)	*Cynometra gillmanii* Harms	F	T	T8 endemic	FTEA	Rare, 1 loc. only
Fabaceae (Caes.)	*Cynometra greenwayi* Brenan	F	T	K7 endemic	R and L; FTEA	Rare, less than 5 locs.
Fabaceae (Caes.)	*Cynometra longipedicellata* Harms	F	T	T3, ?6, ?8	FTEA; Clarke 1995a	Extends to Amani ?
Fabaceae (Caes.)	*Cynometra lukei* Beentje	F	T	K7; T6	R and L; UDSM Herb.	Rare, less than 5 locs.
Fabaceae (Caes.)	*Cynometra* sp. A of FTEA	F	T	T3, 6	Rodgers *et al.*, 1983; FTEA	Rare, less than 5 locs.
Fabaceae (Caes.)	*Cynometra* sp. B of FTEA	F	T	T3 endemic	FTEA	E. Usambara endemic
Fabaceae (Caes.)	*Cynometra* sp. cfr. *C. alexandri* C.H. Wright	T	T	T6 endemic	Op. Bot. 1980	Selous endemic
Fabaceae (Caes.)	*Cynometra* sp., not in FTEA (Rodgers 2586)	F	T	T6 endemic	Rodgers *et al.*, 1983; UDSM Herb.	Kimboza endemic
Fabaceae (Caes.)	*Cynometra* sp., not matched at Kew (Frontier 3433)	F	T	T3 endemic	Frontier coll.	Pangani Falls endemic
Fabaceae (Caes.)	*Cynometra suaheliensis* (Taub.) Bak.f.	F, B	T, S	K7; T3, 6	R and L; FTEA; Mwas. *et al.*, 1994	
Fabaceae (Caes.)	*Cynometra ulugurensis* Harms	F	T	T6 endemic	FTEA	Kimboza endemic
Fabaceae (Caes.)	*Cynometra webberi* Bak.f	F	T	K7; T3, 6, 8	R and L; FTEA; Frontier coll.	
Fabaceae (Caes.)	*Dialium holtzii* Harms	F, W	T	K7; T3, 6, 7, 8; Maf; MN	R and L; FTEA; FZ in prep.; Greenw. 1988	
Fabaceae (Caes.)	*Dialium orientale* Bak.f.	F, B	S	S.Som; K7; T3	R and L; FTEA; KB **36**, 140–141	
Fabaceae (Caes.)	*Gigasiphon macrosiphon* (Harms) Brenan	F	T	K7; T8	R and L; FTEA; Beentje, 1988	Rare, less than 5 locs.
Fabaceae (Caes.)	*Guibourtia schliebenii* (Harms) J. Leon	F	T	T6, 8; Moz	FTEA; not in Palgrave	
Fabaceae (Caes.)	*Julbernardia magnistipulata* (Harms) Troupin	F, BW, B	T	K7; T3	R and L; FTEA	
Fabaceae (Caes.)	*Oxystigma msoo* Harms	F	T	K7; T2, 3	R and L; FTEA; Beentje 1988	Rare; Iso. pop. in Rau forest, Moshi
Fabaceae (Caes.)	*Scorodophloeus fischeri* Harms	F	T	K7; T3, 6, 8; Z; MN	R and L; FTEA; Temu 1990	
Fabaceae (Caes.)	*Stuhlmannia moavi* Taub.	F	T	K7; T3, 8	FTEA; Kew Bull. **51**, 377–379	= *Caesalpinia insolita* and *C. dalei*
Fabaceae (Caes.)	*Tessmania* sp. nov. (Rodgers 2499)	F	T	T6 endemic	Rodgers *et al.*, 1983	Kimboza endemic
Fabaceae (Caes.)	*Tessmannia densiflora* Harms	F	T	T6 endemic	FTEA; Frontier coll.	Matumbi Hills endemic
Fabaceae (Caes.)	*Tessmannia martiniana* Harms	F	T	T6 endemic	FTEA; UDSM herb.	Rare, less than 5 locs.
Fabaceae (Caes.)	*Zenkerella egregia* J.Leon	F	T, S	T3, 6	Rodg. *et al.* 1983; Kapuya 1994; FTEA	Rare, less than 5 locs.
Fabaceae (Mim.)	*Acacia adenocalyx* Brenan and Exell	F, B, T, Wa	T, S	K7; T3, 6, 8; MN; MMS	R and L; FTEA; FZ	
Fabaceae (Mim.)	*Acacia delagoensis* Harms	W	T	MN, MZ, MT, MMS, MSS; E.Zim	FZ; Gomes e Sousa 1966	Extends into Transvaal
Fabaceae (Mim.)	*Acacia forbesii* Benth.	B, T	T	T8; Moz	FTEA; not in Palgrave	Extends into Natal and Transvaal
Fabaceae (Mim.)	*Acacia kraussiana* Meisn. ex Benth.	F, W, B, T	S	MSS, MLM	FZ	Extends into Natal
Fabaceae (Mim.)	*Acacia latistipulata* Harms	F, W, B	S	T6, 8; MN	FTEA; FZ	
Fabaceae (Mim.)	*Acacia* sp. A of FTEA	G	S	K7 endemic	R and L; KTSL; FTEA	Rare, 1 loc. only?
Fabaceae (Mim.)	*Acacia taylorii* Brenan and Exell.	F, B, T	S	T6, 8	FTEA; Op. Bot. 1980	Rare, 1 loc. only

Family	Species	Habitat	Habit	Distribution	Data sources	Notes
Fabaceae (Mim.)	*Acacia tephrodermis* Brenan	F, T	L, C, S	T6 endemic	KB **32**, 549–550	Rare, 3 locs. only ? or poss. Bana end.
Fabaceae (Mim.)	*Acacia torrei* Brenan	G	S	MMS endemic	FZ	
Fabaceae (Mim.)	*Adenopodia rotundifolia* (Harms) Brenan	B	T, S	S.Som; T3	KB **41**, 79–80	
Fabaceae (Mim.)	*Adenopodia schlecteri* (Harms) Brenan	T	S	MSS, MLM	KB **41**, 78–79	
Fabaceae (Mim.)	*Albizia forbesii* Benth.	F, T, W	T	T8; MN, MZ, MSS, MLM; E.Zim, S.Zim	FTEA; Gomes e Sousa 1966; FZ in press	Extends to Transvaal, Natal and Zululand
Fabaceae (Mim.)	*Entada mossambicensis* Torre	F?	S	MN endemic	FZ	?Rare, less than 5 locs?
Fabaceae (Mim.)	*Entada* sp. of FTEA	Sw	S	P; T8	FTEA	
Fabaceae (Mim.)	*Entada stuhlmannii* (Taub.) Harms	W, B, T	C	T6, 8; MN; MZ	FZ; FTEA	
Fabaceae (Mim.)	*Mimosa busseana* Harms	B	S	T8; MN	FTEA; FZ	
Fabaceae (Mim.)	*Newtonia erlangeri* (Harms) Brenan	F, W, B, T	T	Som; K7; T6	R and L; FTEA	
Fabaceae (Mim.)	*Newtonia paucijuga* (Harms) Brenan	F	T	K7; T3, 6, 8	R and L; FTEA	
Fabaceae (Mim.)	*Pseudopropsis euryphylla* Harms	F, T	T, S	K7; T6, 8; MN	R and L; FTEA; FZ	
Fabaceae (Mim.)	*Xylia africana* Harms	F, W	T	T6, 8	FTEA	
Fabaceae (Mim.)	*Xylia mendoncae* Torre	BW	T	MSS endemic	FZ	?Rare, less than 5 locs?
Fabaceae (Mim.)	*Xylia schliebenii* Harms	F	T	T8 endemic	FTEA	Mlinguru endemic
Fabaceae (Pap.)	*Abrus* sp. A of FTEA	F, G	H	K7 endemic	R and L; FTEA	Shimba Hills endemic
Fabaceae (Pap.)	*Aeschynomene mossambicensis* Verdc.	W, Ro	H	T8; MN, MZ	KB **27**, 437–439	
Fabaceae (Pap.)	*Aeschynomene nematopoda* Harms	W, G	H	T6, 8; MN	FTEA; Kirkia **9**, 411	
Fabaceae (Pap.)	*Aeschynomene* sp. B of FTEA	F, Wa	H	K7 endemic	R and L; FTEA	Rare, less than 5 locs.
Fabaceae (Pap.)	*Aeschynomene* sp. B of Kirkia	Wa ?	H	MMS endemic	Kirkia **9**, 359–556	Rare, 1 loc. only
Fabaceae (Pap.)	*Aeschynomene* sp. cf. *brevifolia* Poir. (L and R 2483)	F	H	K7 endemic?	R and L; Robertson, coll. notes	Known from 1 loc. only?
Fabaceae (Pap.)	*Angylocalyx braunii* Harms	F	T	K7; T3, 6	R and L; FTEA	
Fabaceae (Pap.)	*Baphia kirkii* Baker	F, T, W	T	T3, 6; Maf; MSS	KB **40**, 327–329; Greenway 1988	
Fabaceae (Pap.)	*Baphia macrocalyx* Harms	F, W, B, T	T	T8; MN	FTEA	
Fabaceae (Pap.)	*Baphia pauloi* Brummitt	F	T	T6 endemic	Kew Bull. **40**, 357	Kimboza endemic
Fabaceae (Pap.)	*Baphia puguensis* Brummitt	F	T, S	T6 endemic	FTEA; Frontier coll.; KB **40**, 361–362	Rare, 3 locs. only
Fabaceae (Pap.)	*Baphia semseiana* Brummitt	F, T, B, W	T	T6, 8?	KB **40**, 318–319	
Fabaceae (Pap.)	*Bauhinia loeseneriana* Harms	F	T	T8 endemic	Bidgood and Vollesen, 1992	Rare, less than 5 locs.
Fabaceae (Pap.)	*Crotalaria emarginata* Benth.	F, G, Sw	H	K7; T3, 6; P	R and L; FTEA	
Fabaceae (Pap.)	*Crotalaria grata* Polhill	B, G, Wa	H	K7 endemic	R and L; FTEA	Rare, less than 5 locs.
Fabaceae (Pap.)	*Crotalaria kirkii* Bak.	W, G, Cult.	H	K7; T3, 6, 8; Mal	FTEA	
Fabaceae (Pap.)	*Crotalaria malindiensis* Polhill	BW, B, G	H	K7 endemic	R and L; FTEA	Rare, less than 5 locs.
Fabaceae (Pap.)	*Crotalaria misella* Polhill, ined.	W	H	T6;	Op. Bot. 1980	Rare, 2 locs. only
Fabaceae (Pap.)	*Crotalaria patula* Polhill.	B, G, T	H	K7; T3	FTEA	
Fabaceae (Pap.)	*Crotalaria pterocalyx* Harms	W, T	H	T6, 8	FTEA	
Fabaceae (Pap.)	*Crotalaria rhynchocarpa* Polhill	B, Shore	H	K7 endemic	R and L; FTEA	
Fabaceae (Pap.)	*Crotalaria schliebenii* Polhill	W	H	T6, 8; MN	Op. Bot. 1980; FTEA	Rare, 2 locs. only
Fabaceae (Pap.)	*Dalbergia acariiantha* Harms	W, T	T, S	T6, 8; Z	FTEA; UDSM herb.; Op. Bot. 1980	Rare, less than 5 locs.
Fabaceae (Pap.)	*Dalbergia* sp. 1	F	S	K7 endemic?	R and L; Robertson, coll. notes	?Rare, less than 5 locs?

Family	Species	Habitat	Habit	Distribution	Data sources	Notes
Fabaceae (Pap.)	*Dalbergia vacciniifolia* Vatke	F, B, T, Wa	T, S	K7; T3, 6; Z	R and L; FTEA	
Fabaceae (Pap.)	*Desmodium* sp. ?nov. aff. *D. triflorum* (L.) DC	F, W	H	T6 endemic	Op. Bot. 1980	Selous endemic
Fabaceae (Pap.)	*Dolichos ungoniensis* Harms	G	H	T8 endemic	FTEA	?Rare, less than 5 locs ?
Fabaceae (Pap.)	*Erythrina sacleuxii* Hua	F	T	K7; T3, 6, 8; Z; P	R and L; FTEA	
Fabaceae (Pap.)	*Erythrina schliebenii* Harms	F	T	T8 endemic	FTEA	Lake Lutamba/Litipo endemic
Fabaceae (Pap.)	*Galactia argentifolia* S. Moore	G	H	K1, 7; T3, 6	R and L; FTEA	Rare in coastal Kenya
Fabaceae (Pap.)	gen indet. (Miombo Research Centre 4860)	W	T	T8 endemic	Op. Bot. 1980	Selous endemic
Fabaceae (Pap.)	*Indigofera concinna* Bak.	Cult.	H	T6, 8; Moz	FTEA; Op. Bot. 1980	
Fabaceae (Pap.)	*Indigofera fulgens* Bak.	T	S	T8; Moz	FTEA	
Fabaceae (Pap.)	*Indigofera kuntzei* Harms	G	H	T8; Moz	FTEA	
Fabaceae (Pap.)	*Indigofera longimucronata* Bak.f.	F, Wa	H	S.Som; K7; T3	R and L; FTEA; Friis and Voll.	
Fabaceae (Pap.)	*Indigofera malindiensis* Gillet	W, Shore	H	K4, 7	R and L; FTEA	
Fabaceae (Pap.)	*Indigofera* sp. cf. *bussei* Harms (R and L 5537)	F?	H	K7 endemic?	R and L	?Rare, less than 5 locs?
Fabaceae (Pap.)	*Indigofera* sp. nov., not matched	W	H	T6 endemic	Op. Bot. 1980	Selous endemic
Fabaceae (Pap.)	*Indigofera* sp., not matched (Bid. *et al.* 1985)	Wa	H	T8 endemic	Voll. and Bid. 1992; Notes	
Fabaceae (Pap.)	*Indigofera* sp., not matched (Bid. *et al.* 2017)	W, Ro	H	T8 endemic	Voll. and Bid. 1992; Notes	
Fabaceae (Pap.)	*Indigofera wituensis* Bak.f.	G	H	K7; T3, 6; P	R and L; FTEA	Iso. pop. in N. Nigeria
Fabaceae (Pap.)	*Indigofera zanzibarica* Gillett	G?	H	K7; T3, 6; P	R and L; FTEA	
Fabaceae (Pap.)	*Millettia elongatistyla* Gillett	F	T	T6 endemic	FTEA	?Rare, less than 5 locs.
Fabaceae (Pap.)	*Millettia eriocarpa* Dunn	F	T	T8 endemic	FTEA	Rare, 4 locs. only
Fabaceae (Pap.)	*Millettia lasiantha* Dunn.	F	L	K7; T3, 6, 8; Moz; Mal	FTEA	
Fabaceae (Pap.)	*Millettia puguensis* Gillett	F	L	T6 endemic	FTEA	Pugu/Kaz. endemic
Fabaceae (Pap.)	*Millettia schliebenii* Harms	F	T	T8 endemic	FTEA	Rare, less than 5 locs.
Fabaceae (Pap.)	*Millettia* sp. cf. *lasiantha* Dunn (R *et al.* MDE341)	F	L	K7 endemic?	R and L; Robertson, coll. notes	?Rare, less than 5 locs?
Fabaceae (Pap.)	*Ormocarpum schliebenii* Harms	F, B, T	S	T8; MN	FTEA; Kirkia **9**, 363	
Fabaceae (Pap.)	*Ormocarpum* sp. nov. not matched	F	S	T8 endemic	Op. Bot. 1980	Selous endemic
Fabaceae (Pap.)	*Ormocarpum* sp. of Kirkia	T	S	MZ endemic	Kirkia **9**, 359–556	Rare, 1 loc. only
Fabaceae (Pap.)	*Rhynchosia braunii* Harms	?	H	T6 endemic	FTEA	Matumbi Hills endemic ?
Fabaceae (Pap.)	*Rhynchosia calobotrya* Harms	F	H	T8 endemic	FTEA	Lake Lutamba/Litipo endemic
Fabaceae (Pap.)	*Rhynchosia holtzii* Harms	F	C	T6 endemic	FTEA	Pugu endemic
Fabaceae (Pap.)	*Rhynchosia* sp. cf. *hirta* (Andr.) Meikle and Verdc.	F	C	K7 endemic	R and L; Robertson, coll. notes	?Rare, less than 5 locs?
Fabaceae (Pap.)	*Sesbania hirtistyla* Gillett	G, Wa, Sw	H	K7; T3, 6, 8; Z	R and L; FTEA	Rare in Kenya
Fabaceae (Pap.)	*Sesbania speciosa* Taub.	Sw	H	K7; T3, 6	R and L; FTEA	Rare in Kenya
Fabaceae (Pap.)	*Sophora inhambanensis* Klotzsch	Shore	S	K7; T3, 6; MZ, MSS, MLM	R and L; FTEA; Kirkia **5**, 259–270	Extends into Natal
Fabaceae (Pap.)	*Tephrosia* sp. nov. aff. *T. pumila* (Lam.) Pers.	W	H	T8 endemic	Op. Bot. 1980	Selous endemic
Fabaceae (Pap.)	*Teramnus* sp. cf. *micans* (Bak.) Baf. f. (Faden 77/425)	F	C	K7 endemic	R and L; Robertson, coll. notes	Rare, less than 5 locs.
Flacourtiaceae	*Buchnerodendron lasiocalyx* (Oliv.) Gilg	BW, W, B	S	T6, 8; MN, MZ	FTEA; FZ; Dis. Pl. Af. **9**, 267	
Flacourtiaceae	*Dovyalis hispidula* Wild.	F, BW, T	T, S	K7; T3, 6, 7, MN, MMS; S.Zim	FTEA; FZ	
Flacourtiaceae	*Dovyalis* sp. A of FTEA	F	T	K7 endemic	R and L; FTEA	?Rare, less than 5 locs.
Flacourtiaceae	*Grandidiera boivinii* Jaub.	F	T, S	S.Som; K7; T3, 6, 8; Z; MMS	R and L; FZ; FTEA; Friis and Voll.	
Flacourtiaceae	*Homalium elegantulum* Sleumer	F	S	T8 endemic	FTEA	Noto endemic

Family	Species	Habitat	Habit	Distribution	Data sources	Notes
Flacourtiaceae	*Lindackeria somalensis* Chiov.	W, B, G	T, S	S.Som; K7	Friis 1991; KTSL	
Flacourtiaceae	*Xylotheca tettensis* (Klotzsch) Gilg	F, W, B	T, S	K7; T3, 6, 8; Z; Maf; N.Mal, S.Mal; MN, MZ, MMS, MT	R and L; FZ; FTEA; Greenway 1988	Extends into northern Malawi
Gentianaceae	*Faroa involucrata* (Klotzsch) Knoblauch	Ro	H	MN, MZ	FZ	
Gentianaceae	*Faroa richardsiae* P. Taylor	?	H	T8 endemic	Dis. Pl. Af. **7**, 191	Rare, 1 loc. only
Gesneriaceae	*Saintpaulia diplotricha* B.L. Burtt	F, Ro, Sw	H	T3 endemic	Iv. 1991; EA; Johansson	
Gesneriaceae	*Saintpaulia intermedia* Burtt	F, Ro	H	T3 endemic	Haw. 1993; Johansson	
Gesneriaceae	*Saintpaulia ionantha* H. Wendl.	F, Ro	H	T3, 6, 8	Haw. 1993; Johansson	
Gesneriaceae	*Saintpaulia rupicola* B.L. Burtt	F	H	K7 endemic	R and L	Rare, less than 5 locs.
Gesneriaceae	*Saintpaulia* sp. nov. 1 (R and L 5126)	F	H	K7 endemic	R and L	Rare, 1 loc. only
Gesneriaceae	*Saintpaulia* sp. nov. 2 (Robertson 5462)	F	H	K7 endemic	R and L	Rare, 1 loc. only
Gesneriaceae	*Saintpaulia tongwensis* B.L.Burtt	F	H	T3 endemic	Frontier coll.; Kapuya, 1995;	Rare, 3 locs. only
Gesneriaceae	*Streptocarpus kimbozensis* B.L.Burtt	F	H	T6 endemic	Rodgers *et al.*, 1983	Kimboza endemic
Hydnoraceae	*Hydnora africana* Thunb. ?	Shore ?	Paras.	K7 endemic ?	R and L; EA; Robertson, notes	
Hydrocharitaceae	*Ottelia somalensis* Chiov.	Water	H	Som; T6; Z	FTEA	
Hydrophyllaceae	*Hydrolea sansibarica* Gilg	Sw	H	K7; T3, 6, 8; Z	R and L; FTEA	2 locs. in Kenya
Hydrostachyaceae	*Hydrostachys angustisecta* Engl.	F	H (aqua.)	T6, 7; Moz	FTEA	
Icacinaceae	*Iodes usambarensis* Sleumer	F	L	K7; T3	R and L; FTEA	Rare in Kenya
Iridaceae	*Aristea gerrardii* Weimarck	?	H	MZ, MLM	FZ	Extends into Natal
Iridaceae	*Gladiolus decoratus* Baker	F, W, Ro	H	T8; Z; S.Mal; MN, MZ, MMS	FZ; Op. Bot. 1980	
Iridaceae	*Tritonia moggii* Oberm.	W, Coast	H	MSS, MLM	FZ	
Labiatae	*Achyrospermum zanzibaricus* S.Moore	F, G, Ro	S or H?	T3 endemic?	Iv. 1991; Not in Kew	
Labiatae	*Aeollanthus ukamensis* forma vel. sp. aff.	F, T, Ro	H	T8 endemic	Voll. and Bid. 1992; Notes; EA	
Labiatae	*Aeollanthus zanzibaricus* S. Moore	F, G, Ro	S	Som; K7; T2, 3, 6, 7	R and L; Iversen 1991; EA; B and G 1949	
Labiatae	*Becium* sp. ?nov. (= Tanner 4183)	G	H	T8;	Op. Bot. 1980	
Labiatae	*Endostemon albus* A.J. Paton, Harley and M.M. Harley	W, G	H	K7; T3, 6, 8; MN	Kew Bull. **49**(4), 673–716.	
Labiatae	*Endostemon wakefieldii* (Bak.) Ashby	W, BW	H	K7; T6, 8	R and L; KB **49**, 673–716; Op. Bot. 1980	
Labiatae	*Leucas* sp. nov. aff. *milanjiana* (Bid. *et al.* 1826)	BW	H	T8 endemic	Voll. and Bid. 1992; Notes	
Labiatae	*Ocimum fischeri* Guerke	Wa, Ro	H	K4, 7; T3	Kew Bull. **47**, 428–429; EA; Kew	
Labiatae	*Ocimum* sp. aff. *forskolei* Benth. (Jeffery K208)	?	H	K7 endemic	R and L	?Rare, less than 5 locs?
Labiatae	*Ocimum usaramense* Guerke	F, B, T, G	H?	T3, ?6;	Iv. 1991; Not in Kew	Misspelt as *usambarensis* in Iv.1991
Labiatae	*Plectranthus prostratus* Guerke vel. sp. aff.	F?, G, Ro	H	K7; T3	R and L; Iversen 1991; Kew	?Rare, less than 5 locs?
Labiatae	*Plectranthus* sp. 1 (Luke 3400)	F	H	K7 endemic?	R and L	?Rare, less than 5 locs?
Labiatae	*Plectranthus* sp. aff. *longipes* Bak. (Rawlins 933)	F	H	K7 endemic	R and L; Robertson, coll. notes	?Rare, less than 5 locs?
Labiatae	*Plectranthus* sp. nov. (Greenway 5218)	Shore	H	Maf;	Greenway 1988	
Labiatae	*Plectranthus* sp. nov. (MRC 305 etc.)	W	H	T8 endemic	Op. Bot. 1980	Selous endemic
Lecythidaceae	*Foetidia africana* Verdc.	F, T	T	T6 endemic	KB **40**, 635–636	
Liliaceae (Antheri.)	*Anthericum* sp. aff. *warneckei* Engl. (Luke 3025)	?	H	K7 endemic	R and L	?Rare, less than 5 locs?
Liliaceae (Antheri.)	*Anthericum* sp. ?nov. (Bid. *et al.* 1953)	BW, T	H	T8 endemic	Voll. and Bid. 1992; Notes	
Liliaceae (Antheri.)	*Chlorophytum holstii* Engl.	F	H	K7;	R and L	?Rare, less than 5 locs?
Liliaceae (Antheri.)	*Chlorophytum* sp. cf. *comosum* (Thunb.) Jacq.	?	H	K7 endemic	R and L	Rare, less than 5 locs.

Family	Species	Habitat	Habit	Distribution	Data sources	Notes
Liliaceae (Antheri.)	*Chlorophytum* sp. not matched at Kew (Frontier 811)	F	H	T6 endemic	Frontier coll.	Kiwengoma endemic
Liliaceae (Antheri.)	*Chlorophytum* sp. nr. *laxum* R.Br. (L and R 2030)	?	H	K7;	R and L	Rare, less than 5 locs.
Liliaceae (Aspara.)	*Asparagus humilis* Engl.	W	H	K7; T6, 7, 8; Maf	R and L; Op. Bot. 1980; Greenway 1988; EA	Rare in Kenya
Liliaceae (Dracae.)	*Sanseviera arborescens* Thunb.	F, W, B, T	H	K7; T3	Iv. 1991; EA	
Liliaceae (Dracae.)	*Sanseviera bagamoyensis* N.E. Br.	F, Ro	H	T3, 6	EA	
Liliaceae (Dracae.)	*Sanseviera kirkii* Bak.	F, B, T	H	K7; T3; Z	R and L; Iversen 1991; EA	
Liliaceae (Dracae.)	*Sanseviera* sp. cf. *conspicua* N.E. Br. (Adams 114)	F	H	K7 endemic	R and L	?Rare, less than 5 locs?
Liliaceae (Dracae.)	*Sanseviera* sp. nr. *conspicua* N.E. Br. (L and R 1866)	F?	H	K7 endemic	R and L	?Rare, less than 5 locs?
Liliaceae (Dracae.)	*Sanseviera* sp. nr. *raffillii* N.E. Br. (L and R 1865)	F?	H	K7 endemic	R and L	?Rare, less than 5 locs?
Liliaceae (Dracae.)	*Sanseviera volkensii* Guerke	B, T	H	S.Som; K7; T3, 8	Iv. 1991; Frontier coll.; FSOM	
Linaceae	*Hugonia castaneifolia* Engl.	F, B, T	T, L, S	K7; T3, 6, 8; Z	R and L; FTEA; Op. Bot. 1980	
Linaceae	*Hugonia elliptica* N. Robson	?	S	MZ endemic	FZ	Rare, 1 loc. only
Linaceae	*Hugonia grandiflora* N. Robson	F	L, S	T8; MN	FTEA; FZ	?Rare, less than 5 locs?
Loganiaceae	*Mostuea microphylla* Gilg.	F, B, T	L, S	S.Som; K7; T6, 8; MN	R and L; FZ; FTEA; Op. Bot. 1980	Isolated population in Zaire ?
Loganiaceae	*Mostuea rubrinervis* Engl.	F	S	K7; T3, 6	FTEA	
Loganiaceae	*Mostuea* sp. A of FTEA	F	S	T8 endemic	FTEA	Rondo endemic
Loganiaceae	*Mostuea* sp. B of FTEA	F	S	T8 endemic	FTEA	Rondo endemic
Loganiaceae	*Mostuea* sp. C of FTEA	F	S	T3 endemic	FTEA	?Rare, less than 5 locs?
Loganiaceae	*Strychnos cerasifera* Gilg.	?	S	T6 endemic?	FTEA	
Loganiaceae	*Strychnos myrtoides* Gilg. and Busse	W	T	T8; Moz	FTEA; not in Palgrave	
Loganiaceae	*Strychnos panganensis* Gilg.	F, B	C, S	K7; T3, 6, 8; MN, ?MSS	Kew Bull. **11**, 154–155; B and G, 1949	
Loganiaceae	*Strychnos* sp. ?nov. aff. *scheffleri* (Bidgood *et al.* 1521)	F	C	T8 endemic	Voll. and Bid., 1992; Notes	Rondo endemic
Loganiaceae	*Strychnos xylophylla* Gilg.	F	T, S	K7; T3, 6	R and L; FTEA	1 loc. in Kenya
Loranthaceae	*Erianthemum ambiguum* (Engl.) Wiens and Polh.	F	Paras.	K7; T3, 6	R and L; B and G, 1949	Rare in Kenya
Loranthaceae	*Erianthemum curvirameum* (Engl.) Wiens and Polh.	B?	Paras.	K7; T3, 6; Maf	R and L; B and G, 1949	
Loranthaceae	*Erianthemum* sp. 1	F	Paras.	K7 endemic	R and L	Rare, less than 5 locs.
Loranthaceae	*Erianthemum* sp. cf. *alveatum* (Sprague) Danser	?	Paras.	K7 endemic?	R and L	?Rare, less than 5 locs?
Loranthaceae	*Erianthemum* sp. nov. Not matched at Kew	W	Paras.	T8 endemic	Op. Bot. 1980	Selous endemic
Loranthaceae	*Oncella ambigua* (Engl.) v. Tiegh.	B, T	Paras.	K7; T3, 6	Iv. 1991; EA	
Loranthaceae	*Oncella curviramea* (Engl.) v. Tieg.	F, B?	Paras.	K6; T3, 6, 8; Maf	EA; B and G, 1949	
Loranthaceae	*Oncella schliebeniana* Balle ined.	F	Paras.	T8 endemic	EA; FTEA in press	Litipo and Makonde Plateau endemic
Loranthaceae	*Oncocalyx rhamnifolius* (Engl.) Tieghem	F?	Paras.	K7; T3, 6, 8	R and L; B and G, 1949	
Loranthaceae	*Spragueanella rhamnifolia* (Engl.) Balle	F, W, B, T	Paras.	K7; T3, 6, 8; Maf	Clarke 1995; Grnw. 1988; Op. Bot. '80; EA	
Loranthaceae	*Tapinanthus longipes* (Bak. and Sprague) Polhill & Wiens	F	Paras.	T6 endemic	UDSM Herb.; Frontier coll.	Rare, 2 locs. only
Loranthaceae	*Tapinanthus* sp. 1 (Luke 3106)	F	Paras.	K7 endemic?	R and L	?Rare, less than 5 locs?
Loranthaceae	*Taxillus wiensi* Balle	F	Paras.	K7 endemic	R and L	Arabuko-Sokoke endemic
Lythraceae	*Ammannia elata* Fernandes	Sw	H	MZ endemic	FZ	Rare, less than 5 locs.
Lythraceae	*Hionanthera graminea* Fernandes and Diniz	Sw	H	MN endemic	FZ	Rare, less than 5 locs.
Lythraceae	*Hionanthera mossambicensis* Fernandes and Diniz	Sw	H	MN endemic	FZ	Rare, less than 5 locs.
Lythraceae	*Hionanthera torrei* Fernandes and Diniz	Rocks	H	MN endemic	FZ	Rare, less than 5 locs.
Lythraceae	*Nesaea aurita* Koehne	W, G, Sw	H	T6, 8	FTEA	

Family	Species	Habitat	Habit	Distribution	Data sources	Notes
Lythraceae	*Nesaea linearis* Hiern	G, Sw	H	T6, 8; MN, MZ, MMS	FZ; FTEA	
Lythraceae	*Nesaea maxima* Koehne	G	H	T6, 8	FTEA	
Lythraceae	*Nesaea moggii* Fernandes	Sw	H	MN endemic	FZ	Rare, less than 5 locs.
Lythraceae	*Nesaea pedicellata* Hiern	F, Sw	H	K7; T3, 6; Z; Maf	R and L; FTEA; Greenway 1988	2 locs. in Kenya
Lythraceae	*Nesaea pedroi* Fernandes and Diniz	Sw	H	MN endemic	FZ	?Rare, less than 5 locs?
Lythraceae	*Nesaea pygmaea* Fernandes and Diniz	Ro	H	MN endemic	FZ	
Lythraceae	*Nesaea ramosa* Fernandes	F, B, G	H	MSS endemic	FZ	
Lythraceae	*Nesaea spathulata* Fernandes	B	H	MMS endemic	FZ	Rare, less than 5 locs.
Lythraceae	*Nesaea stuhlmannii* Koehne	W, G	H	K7; T3	FTEA	
Lythraceae	*Rotala juniperina* Fernandes	F	H	S.Mal endemic	FZ	Likabula forest endemic
Malphigiaceae	*Acridocarpus chloropterus* Oliv.	F, T	C, S	T6, 8; MN, MZ; S.Mal	FTEA; FZ	
Malphigiaceae	*Acridocarpus pauciglandulosus* Launert	F	C, S	T6, 8	FTEA	Rare, 3 locs. only
Malphigiaceae	*Acridocarpus scheffleri* Engl.	F	C	T3 endemic	FTEA	East Usambara endemic
Malphigiaceae	*Acridocarpus zanzibaricus* A. Juss	F, W, B	S	Som; K1, 7; T3, 6; Z; P	FTEA	
Malphigiaceae	*Triaspis mozambica* A. Juss	F, B, T	C	K1, 7; T2, 3, 6; MLM	FZ; KTSL; Op. Bot. 1980; Iv. 1991	
Malphigiaceae	*Triaspis schliebenii* A.Ernst	F	C	T8 endemic	FTEA	Lake Lutamba/Litipo endemic
Malphigiaceae	*Triaspis suffulta* Launert	B	C	MSS endemic	FZ	
Malphigiaceae	*Tristellateia africana* S.Moore	F, W, B, T	C	K7; T3, 6, 8; MN, MSS	R and L; FTEA; FZ	
Malvaceae	*Abutilon* sp. ?nov.	F	S	T8 endemic	Op. Bot. 1980	Selous endemic
Malvaceae	*Abutilon* sp. nov. aff. *A. galpinii* Meese	F	H	T8 endemic	Op. Bot. 1980	Selous endemic
Malvaceae	*Cienfugosia hildebrandtii* Garcke	F, W, G	S, H	K7; T3; MMS, MSS, MLM	R and L; FZ; EA	Extends into South Africa
Malvaceae	*Gossypoides kirkii* (Mast.) J.B. Hutch	F, B, T	C, S	S.Som; K7; T3, 6, 7, 8; P; Maf; MN, MZ, MMS, MSS	R and L; FZ; Iv. 1991; Op. Bot.; Friis and V.; EA	Extends into Natal
Malvaceae	*Hibiscus altissimus* Hornby	F?	C	K7; T3, 6; MN, MZ, MMS, MSS, MLM; E.Zim	FZ; EA; Drum.	Extends into Natal and Transvaal
Malvaceae	*Hibiscus faulknerae* Vollesen	F	S	K7; T3, 6, 8	Kew Bull. **35**(2), 373–376.	
Malvaceae	*Hibiscus migeodii* Exell	F, W, G	H	T6, 8; Z?; MN, MZ, MMS, MSS; N.Mal	FZ; Op. Bot. 1980	
Malvaceae	*Hibiscus platycalyx* Mast.	F	S	T8; MN, MZ; ?S. Mal.	Kew Bull. **35**(2), 373–376.	
Malvaceae	*Hibiscus schizopetalus* Hook.f.	F	S	K7; T3, 6, 8	R and L; FZ; EA	Rare in Kenya
Malvaceae	*Hibiscus* sp. aff. *physaloides* Guill. and Perr.	T	H	T8 endemic	Op. Bot. 1980	Selous endemic
Malvaceae	*Hibiscus* sp. aff. *rostellatus* Guill. and Perr. (L and R 1666)	F	C	K7 endemic	R and L; KTSL	
Malvaceae	*Hibiscus* sp. nov. aff. *engleri* (Bid. *et al.* 1899)	W, Ro	H	T8 endemic	Voll. and Bid. 1992; Notes	
Malvaceae	*Sida chrysantha* Ulbr.	W	H	K7; T8; Z	Op. Bot. 1980	
Malvaceae	*Sida* sp. aff. *ovata* Forssk. (L and R 2535)	T	H	K7 endemic	R and L; Robertson, coll. notes	?Rare, less than 5 locs?
Malvaceae	*Sida tanaensis* Vollesen	B	S	K1, 7	KB **41**, 95	
Malvaceae	*Thespesia danis* Oliv.	F	T	K7; T2, 3	Haw. 1993	
Malvaceae	*Thespesiopsis mossambicensis* Exell and Hillcoat	F?	T, S	MN endemic	FZ	?Rare, less than 5 locs?
Malvaceae	*Urena* sp. cf. *sinuata* L. (Archibold 1231, Luke 2195)	F	H	K7; T3	R and L; Robertson, coll. notes	1 loc. in Kenya
Melastomaceae	*Cincinnobotrys pulchella* (Brenan) Jac.-Fel.	T	H	T8 endemic	Voll. and Bid. 1992; Notes; FTEA	Rondo endemic = *Primularia pulchella*
Melastomaceae	*Dissotis angustifolia* A. and R. Fernandes	G?	S	MN endemic	FZ	
Melastomaceae	*Lijndenia fragans* (A. and R. Fernandes) Borhidi	F	T, S	K7 endemic	R and L; FTEA; Op. Bot. 1993, 149–151	= *Memecylon fragans*

Family	Species	Habitat	Habit	Distribution	Data sources	Notes
Melastomaceae	*Memecylon insulare* A. and R. Fernandes	F?	S	MSS endemic	FZ	Island endemic
Melastomaceae	*Memecylon magnifoliatum* A. and R. Fernandes	F	S	T6 endemic	Op. Bot. 1980	Selous endemic
Melastomaceae	*Memecylon sessilicarpum* A. and R. Fernandes	F	T, S	MN endemic	FZ	Rare, less than 5 locs.
Melastomaceae	*Memecylon sousae* A. and R. Fernandes	F, B, T	S	T8; MSS, MLM	FZ; Op. Bot. 1980	Inhaca island
Melastomaceae	*Memecylon* sp. aff. *mouririifolium* Brenan	F	S	K7 endemic	R and L	?Rare, less than 5 locs?
Melastomaceae	*Memecylon* sp. B of FZ	F	S	MSS endemic	FZ	Madanda Forest endemic
Melastomaceae	*Memecylon* sp. C of FTEA	F	S	T6 endemic	FTEA	Rare, less than 5 locs.
Melastomaceae	*Memecylon* sp. C of FZ	?	S?	MN endemic	FZ	Rare, less than 5 locs.
Melastomaceae	*Memecylon* sp. D of FZ	Shore	S?	MN endemic	FZ	Rare, less than 5 locs.
Melastomaceae	*Memecylon* sp. E of FZ	F?	S?	S.Mal endemic	FZ	Ruo Gorge endemic
Melastomaceae	*Memecylon* sp. nov. (Bidgood *et al.* 1338)	F	S	T8 endemic	Voll. and Bid., 1992; Notes	Rondo endemic
Melastomaceae	*Memecylon* sp. nov. (Clarke 56)	F	T	T8 endemic	Kew	Chitoa endemic
Melastomaceae	*Memecylon torrei* A. and R. Fernandes	F?	S	MN endemic	FZ	?Rare, less than 5 locs?
Melastomaceae	*Memecylon verruculosum* Brenan	F	S	K7; T3	R and L; FTEA	Rare in Kenya
Melastomaceae	*Tristemma acuminatum* A. and R. Fernandes	F	H	T3; MN	FZ	
Melastomaceae	*Tristemma schliebenii* Markgraf.	Sw	S	T6; Maf	UDSM; Frontier coll.; Greenway 1988	Rare, less than 5 locs.
Melastomaceae	*Warneckea amaniense* Gilg.	F	T, S	K7; T3, 6	R and L; Iv. 1991; FTEA; Op. Bot. 1993, 149–151	
Melastomaceae	*Warneckea hedbergorum* Borhidi	F	S	T3 endemic	Op. Bot. **121**, 149–151	E. Usambara endemic
Melastomaceae	*Warneckea mouririifolium* Borhidi	F	S	K7; T3	R and L; FTEA; Op. Bot. (1993), 149–151	= *Memecylon mouririifolium*
Melastomaceae	*Warneckea sansibarica* (Taub.) Jacq. -Fel.	F, T, Ro	T, S	K7; T3, 6, 8; Z; S.Mal; MZ, MT	R and L; FZ; FTEA; Op. Bot. (1993), 149	Isolated coll. N. Zambia = *M. Zanz.*
Meliaceae	*Pseudobersama mossambicensis* (Sim) Verdc.	F	T	K7; T3, 6, 8; MMS, MSS, MLM	R and L; FZ; FTEA	Extends into Natal
Meliaceae	*Trichilia capitata* Klotzsch	W, T	T, S	MN, MZ, MT, MMS, MSS; N.Zim; S.Mal	FZ	
Meliaceae	*Trichilia* sp. nov. aff. *lovettii* Cheek (Clarke 55)	F	T	T8 endemic	Kew	Chitoa endemic
Meliaceae	*Turraea kimbozensis* Cheek	F	T	T6 endemic	Kew Bull. **44**, 465–468; FTEA	Kimboza endemic
Meliaceae	*Turraea wakefieldii* Oliv.	F	T, S	Som; K7; T3, 6, 8; MSS, MLM	FZ; FTEA	
Menispermaceae	*Albertisia undulata* (Hiern) Forman	F	L, S	K7; T8	R and L; KTSL; Op. Bot. 1980	Dzombo is only Kenyan loc.
Menispermaceae	*Anisocycla blepharosepala* Diels	F	C	T3, 8; Moz (south); Zim	KB **36**, 217–218	
Menispermaceae	*Cissampelos hirta* Klotzsch	?	L	MMS, MSS, MLM	FZ	
Menispermaceae	*Cissampelos nigrescens* Diels	F	L	K7; T3, 6, 8	R and L; FTEA	Rare in Kenya
Menispermaceae	*Epinetum delagoense* (N.E. Br.) Diels	Shore	L, S	MMS, MSS, MLM	FZ	Extends into Natal
Menispermaceae	*Tinospora mossambicensis* Engl.	F	L	T8; Moz (unknown)	FTEA; FZ	Rare, 1 loc. only in Moz.
Menispermaceae	*Tinospora oblongifolia* (Engl.) Troupin	F, B	L	K7; T3, 6; Z; P	R and L; KTSL; FTEA; Bntje '90'; Clrke '95	
Menispermaceae	*Tinospora* sp. nov. aff. *tenera* (Bidgood *et al.* 1392)	F	C	T8 endemic	Voll. and Bid. 1992; Notes	Rondo endemic
Montiniaceae	*Grevea eggelingii* Milne-Redh.	F, BW, T	T, S	K7; T3, 6, 8; MN	FZ; FTEA; KB **51**, 771–773	
Moraceae	*Dorstenia goetzei* Engl.	F	H	K7; T3, 6	R and L; FZ; FTEA	Rare in Kenya
Moraceae	*Dorstenia* sp. aff. *goetzei* Engl. (L and R 2045)	F	H	K7 endemic	R and L	Rare, less than 5 locs.
Moraceae	*Dorstenia tayloriana* Rendle	F	H	K7; T3, 6; P; MZ	R and L; FZ; FTEA; Beentje 1990	Isolated record from T3
Moraceae	*Dorstenia warneckei* Engl.	F	H	K7; T3, 6	R and L; FTEA	
Moraceae	*Dorstenia zambesiaca* Hijman	F	H	MMS endemic	FZ	
Moraceae	*Ficus faulkneriana* C.C. Berg	F, B, G	T	K7; T3	R and L; FTEA	Rare, less than 5 locs.
Moraceae	*Ficus muelleriana* C.C. Berg	F?	S	MMS endemic	FZ	Rare, 2 locs. only

Family	Species	Habitat	Habit	Distribution	Data sources	Notes
Musaceae	*Ensete* sp. nov. near *proboscideum*	F	T	P endemic	Beentje 1990	Ngezi endemic
Myrsinaceae	*Ardisia* sp. A of FTEA	?	T, S ?	Z endemic	FTEA	Rare, little known about species
Myrtaceae	*Eugenia* sp. Taxon D of KTSL	F	T, S	K7 endemic	R and L; KTSL	
Myrtaceae	*Eugenia* sp. (Graham 2314) = Taxon F of KTSL	F, T	T, S	K7 endemic?	R and L; KTSL	?Rare, less than 5 locs?
Myrtaceae	*Eugenia* sp. 1 of FZ	F	T	MMS endemic	FZ	Haroni-Makurupini endemic
Myrtaceae	*Eugenia* sp. nov. (Vaughan 1676)	?	S	P; Z	Beentje 1990	Islands endemic
Myrtaceae	*Eugenia* sp. Taxon C of KTSL near *E. malangensis*	F, Ro	S	K7 endemic	R and L; KTSL	?Rare, less than 5 locs?
Myrtaceae	*Eugenia* sp. Taxon E of KTSL (Luke 2153)	F, T	S	K7 endemic	R and L; KTSL	Rare, less than 5 locs.
Nesogenaceae	*Nesogenes africanus* G. Taylor	F	H	K7; T6, 8	FTEA; R and L	Rare in Kenya
Nyctaginaceae	*Boerhavia* sp. A of FTEA	Shore	H	K7 endemic	R and L; FTEA	?Rare, less than 5 locs.
Ochnaceae	*Ochna angustata* N.Robson	W, T	T, S	MN, MZ, MMS	FZ	
Ochnaceae	*Ochna barbosae* N. Robson	?	T, S	MSS; E.Zim, S.Zim	FZ	
Ochnaceae	*Ochna beirensis* N.Robson	B, T	T, S	MMS endemic	FZ	
Ochnaceae	*Ochna holtzii* Gilg	F, W, T	S	K7; T6, 8; Maf;	R and L; KTSL; Op. Bot.; Grnw. '88; Clrk '95	
Ochnaceae	*Ochna kirkii* Oliv.	F, T	T, S	K7; T3, 6, 8; P; MN; MZ	FZ; KTSL; Op. Bot. 1980; Iv. 1991; EA	Also in Madagascar ?
Ochnaceae	*Ochna mossambicensis* Klotzsch	F, W, BW, B	T, S	K7; T3, 6, 8; Z; Maf; MN, MZ, MMS; S.Zim; E.Zim	R and L; FZ; Op. Bot.; Iv. 1991; Grnw. '88; EA	
Ochnaceae	*Ochna pseudoprocera* Sleumer	F, T	T, S	T3, 6, 8	FZ; Op. Bot. 1980; EA	Rare, 3 locs. only
Ochnaceae	*Ochna* sp. ?nov. aff. *holstii* (Bid. *et al.* 1661)	F	S	T8 endemic	Voll. and Bid. 1992; Notes	Rondo endemic
Ochnaceae	*Ochna* sp. nov (Luke 2419)	F	S	K7; T8	R and L; Clarke coll.	
Ochnaceae	*Ochna* sp. nov. (Greenway 5085)	?	?	Maf;	Greenway 1988	
Ochnaceae	*Ochna* sp. nov. aff. *O. kirkii* Oliv.	F	S	T6, 8	Op. Bot. 1980	Selous endemic
Ochnaceae	*Ochna* sp. nov. aff. *O. macrocalyx*	F	S	T8 endemic	Op. Bot. 1980	Selous endemic
Ochnaceae	*Ochna thomasiana* Engl. and Gilg	F, W, B	T, S	K7; T3, 6; P	R and L; KTSL; Op. Bot.; Beentje 1990; EA	
Ochnaceae	*Ouratea lutambensis* Sleumer	F	S	T8 endemic	Voll. and Bid. 1992; Notes	Rondo endemic
Ochnaceae	*Ouratea sacleuxii* (van Tiegh.) Beentje	F	T, S	K7; T3	R and L; KTSL; Beentje 1988	= *Cercanthemum sacleuxii*
Olacaceae	?*Strombosiopsis* sp. (L and R 2725)	F	T	K7 endemic	R and L	Shimba Hills endemic, = gen. Indet of Schmidt, 1991
Olacaceae	*Olax pentandra* Sleumer	F, T	T, S	T6, 8	FTEA; Frontier coll.; Op. Bot. 1980	Rare, 3 locs. only
Oleaceae	*Jasminum ellipticum* Knobl.	F, B	S	T8 endemic	FTEA	Rare, 2 locs. only
Oleaceae	*Jasminum grahamii* Turrill	B	C	K7 endemic	FTEA	
Oleaceae	*Jasminum* sp. A of FTEA	T	C	MZ endemic	FZ	Rare, 1 loc. only
Oleaceae	*Jasminum* sp. cf. *ellipticum* Knobl.	F	C	K7 endemic	R and L; Robertson, coll. notes	?Rare in Kenya
Oleaceae	*Jasminum tomentosum* Knobl.	B	C	K7; T3, 6, 8; Moz	FTEA	
Opiliaceae	*Pentarhopalopilia umbellulata* (Baill.) Hiopko	F, W, B	C, S	K7; T3, 6; Z; MN, MZ	R and L; FTEA; FZ	
Orchidaceae	*Aerangis alcicornis* (Reichb. f.) Garay	T	E	T6, 8; MZ; S.Mal	FTEA; KB **34**, 308–309	
Orchidaceae	*Aerangis kirkii* (Reichb.f.) Schltr.	F, B	E	K1, 7; T2, 3, 6; Z; P; MZ; MMS; MSS; MLM	KB **34**, 267–271	Isolated pop. on Kilimanjaro
Orchidaceae	*Angraecum teres* Summerh.	F	E	K7; T3	R and L; FTEA	Rare, less than 5 locs. Extends to Amani
Orchidaceae	*Bonatea rabaiensis* (Rendle) Rolfe	F, B	H	K7; T3	R and L; FTEA	Rare in Kenya
Orchidaceae	*Bulbophyllum ballii* P.J. Cribb	F	E	E.Zim endemic	FZ	Haroni and Mutzingazi endemic
Orchidaceae	*Cynorchis* sp. cf. *kirkii* Rolfe	F	H	K7 endemic	R and L; Robertson, coll. notes	Rare, less than 5 locs.

Family	Species	Habitat	Habit	Distribution	Data sources	Notes
Orchidaceae	*Disparis mozambicensis* Schltr.	B?	H	MMS endemic	FZ	Rare, 1 loc. only
Orchidaceae	*Eulophia serrata* Cribb	B	H	K7 endemic	R and L; FTEA	Rare, less than 5 locs.
Orchidaceae	*Habenaria mosambicensis* Schltr.	?	H	MMS endemic	FZ	Rare, 1 loc. only
Orchidaceae	*Habenaria plectromaniaca* Reichb. f.	F, Sw	H	K7; T3, 6, 8	R and L; FTEA	1 unconfirmed record Congo
Orchidaceae	*Habenaria vilosa* Rolfe	?	H	T6 endemic	FTEA	Rare, little known about species
Orchidaceae	*Liparis hemipilioides* Schltr.	F	H	MMS endemic	FZ	Dondo endemic
Orchidaceae	*Microcoelia ?exilis* Lindl. (EAH 11,268)	F	E	K7 endemic	R and L; Robertson, coll. notes	
Orchidaceae	*Microcoelia obovata* Summerh.	F, W, G	E	K4, 7; T3; MN	Dis. Pl. Af. **39**, 1291; FTEA	
Orchidaceae	*Microcoelia smithii* (Rolfe) Summerh.	F	E	K7; T3, 6	R and L; FTEA	Rare in Kenya
Orchidaceae	*Microcoelia* sp. nr. *obovata* Summerh. (L and R 2680)	F	E	K7 endemic	R and L; Robertson, coll. notes	Rare, less than 5 locs.
Orchidaceae	*Oeceoclades zanzibarica* (Summerh.) Garay and Taylor	F	H	K7; T6; Z; P	R and L; FTEA	Rare in Kenya
Orchidaceae	*Polystachya* sp. cf. *disiformis* Cribb (Luke 2933)	F	E	K7 endemic	R and L; Robertson, coll. notes	?Rare, less than 5 locs?
Orchidaceae	*Solenangis wakefieldii* (Rolfe) Cribb and J. Stewart	B	E	K7; T3, 6; Z	FTEA	
Orchidaceae	*Vanilla roscheri* Rchb.f.	F, B, G, Ro, Mg	C	K4, 7; T3, 6; Z; P; Maf; MMS, MSS, MLM	FZ; FTEA; Greenway 1988	Extends into RSA
Pandanaceae	*Pandanus kirkii* Rendle	Shore	T	K7; T3, 6: P; Z;	R and L; FTEA	
Pandanaceae	*Pandanus rabaiensis* Rendle	F, Sw	T	K7; T3, 6, 7; Z; P	R and L; FTEA	
Passifloraceae	*Adenia dolichosiphon* Harms	BW, B	H	T6, 8; MN, MZ	FTEA; FZ	
Passifloraceae	*Adenia kirkii* (Mast.) Engl.	F, G	C	K7; T2, 3, 6, 8; Z; P; Maf	FTEA; Greenway 1988	
Passifloraceae	*Adenia lindiensis* Harms	F, B	C	K7; T3, 6, 8	R and L; FTEA	Rare in Kenya
Passifloraceae	*Adenia mossambicensis* de Wilde	Ro	C	MN endemic	FZ	Rare, less than 5 locs.s
Passifloraceae	*Adenia panduriformis* Engl.	W, B	C	T8; Moz; Zim	FTEA	Extends into Zambia
Passifloraceae	*Adenia schliebenii* Harms	F, B, T	C	T6, 8; MN	Frontier coll.; FZ; FTEA	Rare, 3 locs. only
Passifloraceae	*Adenia* sp. (Jeffrey K569)	F	C	K7 endemic?	R and L; Robertson, coll. notes	?Rare, less than 5 locs?
Passifloraceae	*Adenia* sp. ?nov. (Clarke 37)	F	C	T8 endemic	Kew	Rondo endemic
Passifloraceae	*Adenia* sp. cf. *kirkii* (Mast.) Engl. (R and L 6048)	F	C	K7 endemic?	R and L; Robertson, coll. notes	?Rare, less than 5 locs?
Passifloraceae	*Adenia* sp. nr. *panduriformis* Engl. (R and L 5524)	F	C	K7 endemic	R and L; Robertson, coll. notes	Rare, less than 5 locs.
Passifloraceae	*Adenia zambesiensis* R. and A. Fernandes	F	C	MZ endemic	FZ	Rare, less than 5 locs.
Passifloraceae	*Basananthe zanzibarica* (Mast.) de Wilde	F, B	C	K7; T6; Z	R and L; FTEA	
Passifloraceae	*Paropsia braunii* Gilg.	F, T	T, S	T6, 8; MN, MZ, MMS	FTEA; FZ	
Passifloraceae	*Schlechterina mitostemmatoides* Harms	F, B	L, S	K7; T3, 6, 8; Z; MN, MZ, MMS, MSS, MLM	R and L; FTEA	Extends into northern Natal
Plumbaginaceae	*Plumbago ciliata* Wilmot-Dear	F	H	T8 endemic	Kew Bull. **31**, 848–849; FTEA	Rondo endemic
Plumbaginaceae	*Plumbago stenophylla* Wilmot-Dear	F	S, H	K7 endemic	R and L; FTEA	Rare, less than 5 locs
Poaceae	*Andropogon heterantherus* Stapf	T	Grass	K7; T3, 6	R and L; FTEA	Rare, only 5 locs.
Poaceae	*Aristida leptura* Cope	W	Grass	S.Som; T8	Kew Bull. **47**, 277; Op. Bot.	= *A. funiculata* in Op. Bot.
Poaceae	*Baptorachis foliacea* (Clayton) Clayton	?	Grass	MN endemic	FZ	Rare, 1 loc. only
Poaceae	*Brachiaria lindiensis* (Pilg.) W.D. Clayton	F	Grass	K7; T6, 8	FTEA; R and L	Rare, less than 5 locs.
Poaceae	*Cenchrus mitis* Anderss.	B	Grass	K7; T3, 6; Z; Maf; MN	FTEA; FZ; Greenway 1988	
Poaceae	*Coelorachis lepidura* Stapf	Sw	Grass	K7; T3, 6; P; Moz	R and L; FTEA	Rare in Kenya
Poaceae	*Dactyloctenium australe* Steud.	F	Grass	K7; T3	R and L; FTEA	Extends into Natal
Poaceae	*Dactyloctenium geminatum* Hack.	B, Shore	Grass	K7; T3, 6; Z; Maf; Moz	R and L; FTEA; Greenway 1988	Extends into Natal
Poaceae	*Digitaria argyrotricha* (Andersson) Chiov.	B, Shore	Grass	K7; T3, 6; Z; P; Maf; MN, MZ, MSS, MLM	FZ; FTEA; Greenway 1988	Introduced into Ghana

Family	Species	Habitat	Habit	Distribution	Data sources	Notes
Poaceae	*Dignathia gracilis* Stapf	B	Grass	Som; K7; T3; Moz	R and L; FTEA	
Poaceae	*Digitaria gymnostachys* Pilg.	F, W	Grass	T6, 8; MN, MSS, MLM	FTEA; FZ	Extends into the Transvaal
Poaceae	*Digitaria megasthenes* P. Goetghebeur	W, Ro	Grass	MN, MZ	FZ	
Poaceae	*Eleusine semisterilis* S.M. Phillips	G	Grass	K7 endemic	R and L; FTEA	Rare, less than 5 locs.
Poaceae	*Eragrostis muerensis* Pilg	W	Grass	T8 endemic?	FTEA	Rondo and poss. 1 Zambia site
Poaceae	*Eragrostis perbella* K. Schum.	B	Grass	SS; K7; T3, 6, 8; Z	R and L; FTEA	
Poaceae	*Eragrostis* sp. ?nov., not in FTEA (Frontier 1702)	G	Grass	T6 endemic	Frontier coll.	Kazimzumbwi endemic
Poaceae	*Eragrostis* sp. A (Greenway 9259)	G?	Grass	K7 endemic	R and L; FTEA	Rare, less than 5 locs.
Poaceae	*Erichloa parvispiculata* C.E. Hubbard	B	Grass	K7; T3, 6, 8; Z; P; Maf; Moz	R and L; FTEA; Greenway 1988	
Poaceae	*Erichloa rovumensis* (Pilger) Clayton	Ro	Grass	T6, 8; MN, MZ	FZ; FTEA	
Poaceae	*Erichloa stapfiana* W.D. Clayton	Sw	Grass	K7; T3, 5, 6; MN, MZ, MMS, MSS, MLM; S.Mal	FTEA; FZ	Extends into South Africa
Poaceae	*Farrago racemosa* W.D. Clayton	Ro	Grass	T8 endemic	FTEA	?Rare, less than 5 locs ?
Poaceae	*Holcolemna inaequale* W.D. Clayton	B	Grass	K7; T6	R and L; FTEA	Rare in Kenya
Poaceae	*Humbertochloa greenwayi* C.E. Hubbard	F	Grass	T6 endemic	FTEA	Pugu endemic
Poaceae	*Hylebates chlorochloe* (K. Schum.) Napper	F, B	Grass	K7; T3, 6, 7	R and L; FZ; FTEA	Rare in Kenya
Poaceae	*Hyparrhenia exarmata* (Stapf) Stapf	W	Grass	K; T6	Op. Bot. 1980	Rare, 2 locs. only
Poaceae	*Panicum laticomum* Nees	F	Grass	K7; T3, 7, 8; P; E.Zim, S.Zim; S.Mal; MN, MMS	FZ; FTEA; Beentje 1990	Extends into Natal
Poaceae	*Panicum mlahiense* Renvoize	F	Grass	T6 endemic	Op. Bot. 1980	Selous endemic
Poaceae	*Panicum peteri* Pilg.	F, W	Grass	T6, 8; MMS; E.Zim	FTEA; FZ	Isolated pop. in Chimanimani
Poaceae	*Panicum pleianthum* Peter	F	Grass	K7; T3, 6, 8; MMS, MSS	R and L; FTEA; FZ	
Poaceae	*Panicum* sp. nov. (Bid. *et al.* 2024)	BW	Grass	T8 endemic	Voll. and Bid. 1992; Notes	
Poaceae	*Panicum subflabellatum* Stapf	Dunes	Grass	T6; P; Maf; MMS, MSS, MLM	FZ; FTEA; Beentje 1990; Greenw. 1988	Extends into Natal
Poaceae	*Panicum vollesenii* Renv.	F	Grass	T8 endemic	FTEA	Selous endemic
Poaceae	*Urochloa rudis* Stapf.	B	Grass	SS; K7; T3, 6; Z	R and L; FTEA	Rare in Kenya
Polygalaceae	*Carpolobia* sp. aff. *goetzei* Guerke (L and R 2191)	F	H	K7 endemic	R and L	Mangea Hill endemic
Polygalaceae	*Polygala goetzei* Guerke	W, B, T	H	T6, 8; MN; MMS	FZ; Op. Bot. 1980 [KTSL, Greenw. '88]	Extends into Zambia (1 loc.)
Polygalaceae	*Polygala limae* Exell	?	H	MN endemic	FZ	Rare, 1 loc. only
Polygalaceae	*Polygala sadebeckiana* Guerke	W, Wa	S, H	T8; S.Mal; MZ	FZ; Op. Bot. 1980	
Polygalaceae	*Polygala senensis* Klotzsch	W, G	S, H	T6; S. Mal; MMS; MLM	FZ; Op. Bot. 1980	
Polygalaceae	*Polygala* sp. nr. *liniflora* Boj. (Luke 2943)	F	H	K7 endemic	R and L	Kinondo endemic?
Polygonacaee	*Oxygonum leptopus* Mildbr.	W	H	T6 endemic	Op. Bot. 1980	Selous endemic
Polygonaceae	*Oxygonum subfastigiatum* R. Grah.	G	H	T8 endemic	FTEA	Rare, 1 loc. only
Portulacaceae	*Portulaca* sp. aff. *foliosa* Ker-Gawl. (L and R 2224)	F, Ro	H	K7 endemic	R and L; Robertson, coll. notes	?Rare, less than 5 locs.
Ranunculaceae	*Clematis sigensis* Engl.	F	C	K7; T3	R and L; FTEA; KTSL	Rare in Kenya.
Ranunculaceae	*Clematis viridiflora* Berthol.	F, W	L, C	Z; S.Mal; MZ, MT, MMS, MSS, MLM; E.Zim	Beentje, 1980; FZ; Drum.	
Rhamnaceae	*Lasiodiscus ferrugineus* Verdc.	F	T, S	K7 endemic	FTEA	
Rhamnaceae	*Lasiodiscus holtzii* Engl.	F	S	T6 endemic	FTEA	Pugu endemic
Rhamnaceae	*Lasiodiscus usambarensis* Engl.	F	T	T3, ?8; E.Zim	FZ	
Rhamnaceae	*Ziziphus robertsoniana* Beentje	F	T	K7 endemic	R and L; KB **51**, 197–199	Dzombo and 2 other locs.
Rhizophoraceae	*Cassipourea euryoides* Alston	F, B, W. Ro	T, S	S.Som; K7; T6; MN, MZ, MMS; E.Zim	R and L; FTEA; FZ; Friis and Voll.	
Rhizophoraceae	*Cassipourea mossambicensis* (Von Brehm.) Alston	F, W, T, G	S	MN, MSS, MLM	FZ	Extends into Natal

Family	Species	Habitat	Habit	Distribution	Data sources	Notes
Rhizophoraceae	*Cassipourea obovata* Alston	?	T	MN endemic	FZ	Rare, less than 5 locs.
Rosaceae (Chryso.)	*Maranthes goetzeniana* (Engl.) Prance	F	T	T3, 6; E.Zim; MZ, MMS	FZ; FTEA	= *Parinari goetzeniana* Also afromontane ?
Rubiaceae	?genus unknown tribe VANGUERIEAE of FZ ined.	F	S	MZ endemic	FZ ined.	Milange endemic (Sabelua to Mongoe)
Rubiaceae	?genus nov. tribe VANGUERIEAE of FTEA	F	?	T8 endemic	FTEA	Rondo endemic
Rubiaceae	*Aidia* sp. of FTEA	F	T, L, S	K7; T3, 6;	Mwasumbi *et al.* (1994); R and L; FTEA	Rare, less than 5 locs.
Rubiaceae	*Aoranthe penduliflora* (K. Schum.) Somers	F	T, S	T3, 6, 8	FTEA	Extends up to Amani
Rubiaceae	*Borreria pedicellata* K. Schum	Cliff	H	K7 endemic	R and L; FTEA	Rare, less than 5 locs.
Rubiaceae	*Buchnera namuliensis* Skan	Sw	H	MZ, MMS	FZ	Rare, 2 locs. only
Rubiaceae	*Burttdavya nyasica* Hoyle	F	T	T3, 6, 8; Z; MN, MZ, MT, MMS; S.Mal	FTEA; Ruffo 1991; FZ ined.	
Rubiaceae	*Canthium impressinervum* Bridson	F, B, T	T, S	T8 endemic	FTEA	Rare, less than 5 locs.
Rubiaceae	*Canthium kilifiensis* Bridson	F, BW	T, S	K7 endemic	R and L; FTEA	
Rubiaceae	*Canthium mombazense* Baill.	F, W, B, T	T, S	S.Som; K7; T3, 6, 8; MN	KTSL; FZ ined.	
Rubiaceae	*Canthium ngonii* Bridson	F, W	T, S	MMS; E.Zim	Kew Bull. **47**, 371	
Rubiaceae	*Canthium peteri* Bridson	F, T	S	K7; T3, 6, 8	R and L; FTEA; Frontier coll.	?Rare, less than 5 locs?
Rubiaceae	*Canthium racemulosum* Moore	F, W	T, S	T8; MN, MMS, MSS; S.Mal; E.Zim	FTEA; FZ ined.	
Rubiaceae	*Canthium rondoense* Bridson	F	T, S	T8 endemic	Kew Bulletin **47**,3; FTEA	Rondo endemic
Rubiaceae	*Canthium setiflorum* Hiern	F, T	S	K7; T3, 6; MN, MZ, MT, MSS, MLM; S.Mal; N, E and S Zim	R and L; FTEA; FZ	Extends into Natal and Transvaal
Rubiaceae	*Canthium* sp. A of FTEA	B	S	T8 endemic	FTEA	Selous endemic
Rubiaceae	*Canthium vollesenii* Bridson	F, T	T, S	T6, 8	FTEA	Selous endemic
Rubiaceae	*Catunaregam pygmaea* Vollesen	W	H	T8 endemic	FTEA	Selous endemic
Rubiaceae	*Chassalia longibba* Borhidi and Verdc.	F	S	T3 endemic	FTEA	E. Usambara endemic = *C. Zimmermanni*
Rubiaceae	*Chassalia* sp. aff. *abrupta* (Semsei 680, Bid. *et al.* 1367)	F	S	T8 endemic	Voll. and Bid., 1992; Notes	Rondo endemic
Rubiaceae	*Chassalia* sp. C of FTEA	?	S	T6 endemic	FTEA	Rare, 2 locs. only
Rubiaceae	*Chassalia umbraticola* Vatke	F, W, B	S, H	K7; T3, 6, 8; Z; P; Maf; MN	R and L; FTEA; FZ; Greenway 1988	
Rubiaceae	*Chazaliella* sp. aff. *abrupta*, not matched (B. *et al.* 1704)	F	S	T8 endemic	Vollesen and Bidgood, 1992; Notes	Lake Lutamba/Litipo endemic
Rubiaceae	*Cladoceras subcapitatum* (K Schum.and K Krause)Bremek	F, B	S	K7; T3, 6; Maf	R and L; FTEA	2 locs. in Kenya
Rubiaceae	*Coffea costatifructa* Bridson	F, T	T, S	T6, 8; Maf	Kew Bulletin **49**, 331–342	Rare, 2 locs. only = *C.* sp F of FTEA
Rubiaceae	*Coffea kimbozensis* Bridson	F	S	T6 endemic	Kew Bull. **49**: 331–342	Kimboza endemic
Rubiaceae	*Coffea pocsii* Bridson	F	T	T6 endemic	Kew Bull. **49**, 336–338	Kitulang'alo endemic
Rubiaceae	*Coffea pseudozanguebariae* Bridson	F, B	T, S	K7; T3, 6; Z	R and L; FTEA	
Rubiaceae	*Coffea racemosa* Lour.	F, B, W	S	MMS, MSS, MLM; E.Zim, S.Zim	FZ ined.	Extends into Natal
Rubiaceae	*Coffea schliebenii* Bridson	F	S	T8 endemic	Kew Bulletin **49**, 331	Rare, 2 locs. only
Rubiaceae	*Coffea sessiliflora* Bridson	F	S	K7; T6	R and L; FTEA	
Rubiaceae	*Coffea* sp. A of FZ ined.	T	S	S.Mal endemic	FZ ined.	Rare, 1 loc. only
Rubiaceae	*Coffea* sp. cf. *sessiliflora* Bridson (L and R 2506)	F?	S?	K7 endemic	R and L	?Rare, less than 5 locs?
Rubiaceae	*Coffea* sp. J of FTEA	T	S	T8 endemic	FTEA	Selous endemic
Rubiaceae	*Coffea zanguebariae* Lour.	T	T, S	T8; MN, MSS; N.Zim	FTEA; FZ ined.	

Family	Species	Habitat	Habit	Distribution	Data sources	Notes
Rubiaceae	*Cuviera migeodii* Verdc.	G	S	T8 endemic	FTEA	Tendaguru endemic
Rubiaceae	*Cuviera schliebenii* Verdc.	F	T, S	T8; MN, MZ	FTEA; FZ ined.	Rare, 2 locs. only
Rubiaceae	*Cuviera semseii* Verdc.	F, W, T	T, S	T8; MN; S. Mal	FTEA; FZ ined.	
Rubiaceae	*Cuviera tomentosa* Verdc.	F, W	T, S	T8; MN	FTEA; FZ ined.	
Rubiaceae	*Didymosalpinx norae* (Swynnerton) Keay	F	T, S	K7; T3, 6, 8; MMS; E.Zim	FTEA; Goldsmith 1976; FZ ined.	
Rubiaceae	*Didymosalpinx* sp. A of FTEA	F	S	T8 endemic	FTEA	Lake Lutamba/Litipo endemic
Rubiaceae	*Diodia aulacosperma* Schum.	B, G, Shore	H	S.Som; K7; T3; Z	FTEA	
Rubiaceae	*Fadogia vollesenii* Verdc.	W	H	T8 endemic	FTEA	Selous endemic
Rubiaceae	*Gardenia posoquerioides* S. Moore	F, W	T, S	K7; T6; E.Zim	FTEA	Isolated population in Chirinda
Rubiaceae	*Gardenia transvenulosa* Verdc.	F, W, B	T, S	K7; T3, 6, 8	R and L; FTEA	
Rubiaceae	*Grumilea rufescens* K.Krause	F	S	T6 endemic	FTEA	Pugu endemic
Rubiaceae	*Heinsia bussei* Verdc.	F, W	T, S	T8 endemic	FTEA	Rare, less than 5 locs.
Rubiaceae	*Heinsia zanzibarica* (Bojer) Verdc.	F	T, S	K7; T3, 6, 8; Z; MN	R and L; FTEA; FZ ined.	
Rubiaceae	*Hyperacanthus microphyllus* (K. Schum.) Bridson	F, B, Ro	S	MN, MMS, MSS, MLM; E.Zim	FZ ined.	Extends into Natal
Rubiaceae	*Ixora narcissodora* K.Schum.	F, W, T	T, S	K7; T3, 6, 7, 8; Z; P; MN, MZ, MMS, MSS; S. Mal; E.Zim	FTEA; FZ ined.	Iso. pop. in Zambia?
Rubiaceae	*Ixora* sp. nov. aff. *narcissodora* (Bidgood *et al.* 1377)	F	T	T8 endemic	Voll. and Bid. 1992; Notes	Rondo endemic
Rubiaceae	*Ixora tanzaniensis* Bridson	F	S	T6 endemic	FTEA	?Rare, less than 5 locs ?
Rubiaceae	*Keetia lukei* Bridson	F	S	K7 endemic	Kew Bull. **49**, 803–807; R and L (as K. sp. nov)	Rare, 3 locs. only
Rubiaceae	*Keetia purpurascens* (Bullock) Bridson	Rivers	T, S	T6, 8	FTEA	
Rubiaceae	*Keetia* sp. nov. (Clarke 14)	F	T	T8 endemic	Kew	Rondo endemic
Rubiaceae	*Kohautia obtusiloba* (Hiern) Bremek.	G, Sw	H	K7; T3, 6; ?Moz	R and L; FTEA; FZ	May be in Mozambique
Rubiaceae	*Kraussia kirkii* (Hook.f.) Bullock	F, B, W	S	K7; T3, 6, 8; Maf	R and L; FTEA; Greenway 1988	
Rubiaceae	*Kraussia speciosa* Bullock	F	T, S	K7; T3, 6; P	R and L; FTEA; Beentje 1990	
Rubiaceae	*Lagynias monteiroi* (Oliv.) Bridson ined.	F	S	MLM, MSS	FZ ined.	
Rubiaceae	*Lagynias pallidiflora* Bullock	F, T	T, S	K7; T3, 6; P	R and L; FTEA	Rare in Kenya
Rubiaceae	*Lamprothamnus zanguebaricus* Hiern	F, W, B, T	T, S	Som; K1, 7; T3, 6, 8; Maf	R and L; FTEA; Greenway 1988	
Rubiaceae	*Leptactina delagoensis* Schum.	F	T, S	T8; MN, MZ, MMS, MSS, MLM; C.Mal; E.Zim, S.Zim	FTEA; FZ ined.	
Rubiaceae	*Leptactina oxyloba* K.Schum.	T, G	S	T6, 8	FTEA, Frontier coll.	Rare, less than 5 locs.
Rubiaceae	*Leptactina papyrophloea* Verdc.	F	T, S	T8 endemic	FTEA	Rondo endemic
Rubiaceae	*Leptactina* sp. A of FTEA	F	S	T6 endemic	FTEA	Pande endemic
Rubiaceae	*Mitriostigma greenwayi* Bridson	F	S	K7 endemic	R and L; FTEA	Rare, less than 5 locs.
Rubiaceae	*Multidentia castaneae* (Robyns) Bridson and Verdc.	F	T, S	T6 endemic	FTEA	Rare, less than 5 locs.
Rubiaceae	*Multidentia exserta* Bridson	F, T	T, S	T8; Moz; Zim	FTEA; not in Palgrave	
Rubiaceae	*Multidentia kingupirensis* Bridson	T	S	T8 endemic	FTEA	Selous endemic
Rubiaceae	*Multidentia sclerocarpa* (K. Schum.) Bridson	F	T, S	K7; T3	R and L; FTEA	Rare, less than 5 locs.
Rubiaceae	*Mussaenda monticola* Krause	F	T, S	K7; T6, 7, 8	R and L; FTEA	Extends up to Kilombero Scarp
Rubiaceae	*Oldenlandia aegialodes* Bremek.	B?	H	Maf endemic	FTEA	Mafia Island endemic
Rubiaceae	*Oldenlandia borrerioides* Verdc.	B	H	K7 endemic	R and L; FTEA	Rare, less than 5 locs.
Rubiaceae	*Oldenlandia patula* Bremek.	W	H	T8 endemic	FTEA	Tendaguru endemic

Family	Species	Habitat	Habit	Distribution	Data sources	Notes
Rubiaceae	*Oldenlandia richardsonioides* (K. Schum.) Verdc.	B	H	K7; S.Som	FTEA	
Rubiaceae	*Oldenlandia* sp. ?nov. (Bid. *et al.* 2022)	BW, Ro	H	T8 endemic	Voll. and Bid. 1992; Notes	
Rubiaceae	*Oldenlandia* sp. B of FZ	W?, Ro	H	MN endemic	FZ	Rare, 1 loc. only
Rubiaceae	*Oldenlandia verrucitesta* Verdc.	Ro	H	MZ endemic	FZ	Rare, 1 loc. only
Rubiaceae	*Otiophora lanceolata* Verdc.	F?	S	E.Zim; MMS	FZ	?Rare, less than 5 locs?
Rubiaceae	*Oxyanthus* sp. A of FTEA	F	T	T6, 8	FTEA; Fr. coll.; Voll. and Bid., 1992	Rare, less than 5 locs.
Rubiaceae	*Oxyanthus* sp. nov. (Bid. *et al.* 1789)	T	S	T8 endemic	Voll. and Bid. 1992; Notes	
Rubiaceae	*Oxyanthus* sp., not matched (Bidgood *et al.* 1383)	F	S	T8 endemic	Voll. and Bid. 1992; Notes	Rondo endemic
Rubiaceae	*Oxyanthus zanguebaricus* (Hiern) Bridson	F	T, S	S.Som; K7; T3, 6, 8; ?Moz	R and L; FTEA	
Rubiaceae	*Pachystigma* sp. B of FZ ined.	F	S	MSS endemic	FZ ined.	Rare, 1 loc. only
Rubiaceae	*Pavetta catophylla* K. Schum.	F?	S?	MSS, MLM	FZ in prep.	
Rubiaceae	*Pavetta crebrifolia* Hiern	F, B	S	S.Som; K7; T3, 6; Maf; MN	R and L; FTEA; Friis and Voll.; Greenw. '88; FZ ined.	
Rubiaceae	*Pavetta decumbens* Schum and Krause	W, T	S	T6, 8; MN, MZ, MSS	FTEA; FZ ined.	
Rubiaceae	*Pavetta fascifolia* Bremek.	T	S	T6, 8; MN	FTEA; FZ ined.	
Rubiaceae	*Pavetta gerstneri* Bremek.	?	T, S	Z; Maf; MSS, MLM	FTEA; Greenway 1988; FZ ined.	Extends into Natal
Rubiaceae	*Pavetta gracillima* S. Moore	F?	S?	MSS, MLM	FZ in prep.	
Rubiaceae	*Pavetta incana* Klotzsch	F?	S?	MMS endemic	FZ in prep.	
Rubiaceae	*Pavetta klotzschiana* K. Schum.	F?	S?	Moz	FZ in prep.	
Rubiaceae	*Pavetta lanceolata* ined.	F?	S?	MSS, MLM	FZ in prep.	
Rubiaceae	*Pavetta lindina* Bremek.	F	S	T8 endemic	FTEA	Rondo endemic
Rubiaceae	*Pavetta linearifolia* Bremek.	F, B, T	T, S	K7; T3, 6	R and L; FTEA	Rare in Kenya
Rubiaceae	*Pavetta lutambensis* Bremek.	F, W	S	T6, 8; MN	FTEA; FZ ined.	
Rubiaceae	*Pavetta macrosepala* Hiern	T	T, S	T6, 8; MN	FTEA	
Rubiaceae	*Pavetta mocambicensis* Bremek	?	?	MN endemic ?	FTEA	Ibo Islands endemic
Rubiaceae	*Pavetta pseudo-albicaulis* Bridson	F, T	S	T8; MN	FTEA; FZ ined.	
Rubiaceae	*Pavetta pumilla* N.E. Br.	F?	S?	MSS endemic	FZ in prep.	
Rubiaceae	*Pavetta revoluta* Hochst	F?	S?	MSS, MLM	FZ in prep.	
Rubiaceae	*Pavetta sansibarica* K. Schum.	F, B	S	K7; T3; Z	R and L; FTEA	Rare in Kenya
Rubiaceae	*Pavetta schliebenii* Bremek.	F	S	T8 endemic	FTEA	Lake Lutamba/Litipo endemic
Rubiaceae	*Pavetta* sp. (coll. de Konig *et al.*)	F?	S?	Moz	FZ in prep.	Rare, 1 loc. only
Rubiaceae	*Pavetta* sp. nov. (Bid. *et al.* 2065)	F, T, Ro	S	T8 endemic	Voll. and Bid. 1992; Notes	
Rubiaceae	*Pavetta* sp. nov. (Bidgood *et al.* 1342)	F	S	T8 endemic	Voll. and Bid. 1992; Frontier coll.; Notes	Rare, 2 locs. only
Rubiaceae	*Pavetta* sp. nov. not matched at Kew (Frontier 668)	F	S	T6 endemic	Frontier coll.	Kiwengoma endemic
Rubiaceae	*Pavetta sphaerobotrys* K. Schum	F	T, S	S.Som; K7; T3, 6	FTEA	
Rubiaceae	*Pavetta stenosepala* K.Schum.	F, T, B	S	K7; T3, 6, 7; Z; Maf	R and L; FTEA	
Rubiaceae	*Pavetta tarennoides* S. Moore	F	S	K7 endemic	R and L; FTEA	Rare, less than 5 locs.
Rubiaceae	*Pavetta tendaguruensis* Bremek.	F, G	T, S	T8; MN	FTEA; FZ ined.	Rare, 4 locs. only
Rubiaceae	*Pavetta uniflora* Bremek.	F, W, B	T, S	S.Som; K7; T3, 6, 8; MMS, MSS	R and L; FTEA; FZ ined.	
Rubiaceae	*Pentas* sp. aff. bussei not matched (Bidgood *et al.* 1573)	T	C	T8 endemic	Voll. and Bid., 1992; Notes	Rondo endemic
Rubiaceae	*Phellocalyx vollesenii* Bridson	W, T	T, S	T8; MN; S.Mal	FTEA; Dis. Pl. Af. **21**, 723; FZ ined.	
Rubiaceae	*Polysphaeria braunii* Krause	F	S	T3, 6, 8	FTEA	

Family	Species	Habitat	Habit	Distribution	Data sources	Notes
Rubiaceae	*Polysphaeria* sp. A of FTEA (Frontier 3039)	F?, B	S	T3, 6/8	FTEA; Frontier coll.	Rare, 3 locs. only
Rubiaceae	*Polysphaeria* sp. B of FTEA	F	T	T3 endemic	FTEA	E. Usambaras endemic (Kwamtili)
Rubiaceae	*Pseudomussaenda mozambicensis* Verdc.	Ro	S	MN endemic	FZ ined.	Rare, 1 loc. only
Rubiaceae	*Pseudomussaenda* sp. nov. (L and R 1517)	F	S	K7 endemic	R and L; KTSL; Not in FTEA	Boni endemic
Rubiaceae	*Psilanthus semseii* Bridson	F	S	T6 endemic	FTEA	Magombera/Selous endemic
Rubiaceae	*Psilanthus* sp. A of FTEA	W	S	T6 endemic	FTEA	Rare, 1 loc. only
Rubiaceae	*Psychotria amboniana* K. Schum.	F	S	K7; T3, 6; ?MN, MSS, MLM	R and L; FTEA; FZ	
Rubiaceae	*Psychotria holtzii* (K. Schum.) Petit	F	S	K7; T3, 6; P; Maf	R and L; FTEA; Beentje '90; Greenw. '88	
Rubiaceae	*Psychotria leucopoda* Petit	F	S	K7; T3, 6; Z	R and L; FTEA	Rare in Kenya
Rubiaceae	*Psychotria* sp. A of FZ	F	S	S.Mal endemic	FZ	Ruo Gorge endemic
Rubiaceae	*Psychotria* sp. B of FZ	Dunes	S	MSS endemic	FZ	Inhambane endemic
Rubiaceae	*Psychotria* sp. J of FTEA	F	S	T8 endemic	FTEA	Lake Lutamba/Litipo endemic
Rubiaceae	*Psychotria* sp. nov. (Bidgood *et al.* 1585)	F	S	T8 endemic	Voll. and Bid. 1992; Notes	Rondo endemic
Rubiaceae	*Psydrax faulknerae* Bridson	F, W, B, T	T, S	K7; T3, 6, 8	R and L; FTEA	
Rubiaceae	*Psydrax kaessneri* (S. Moore) Bridson	F, T	S	SS; K7; T3, 6, 8; P; MN	R and L; FTEA; Beentje 1990; FZ ined.	Rare in Kenya
Rubiaceae	*Psydrax kibuwae* Bridson	F	T	T3 endemic	FTEA	East Usambara endemic (Kiwanda)
Rubiaceae	*Psydrax locuples* (K. Schum.) Bridson	W, Ro, Dune	S	MSS, MLM	FZ ined.	Extends into Natal
Rubiaceae	*Psydrax micans* (Bullock) Bridson	F, T	T, S	T6, 8; MN, MZ, MMS	FTEA; FZ ined.	
Rubiaceae	*Psydrax moggii* Bridson	F, Sw	T, S	MN, MMS, MSS, MLM	FZ ined.	
Rubiaceae	*Psydrax polhillii* Bridson	W, T	S	K1, 7	FTEA	
Rubiaceae	*Psydrax recurvifolia* (Bullock) Bridson	F, Sw	S	K7; T6; P	R and L; FTEA	Rare in Kenya
Rubiaceae	*Psydrax robertsoniae* Bridson	F, T	T, S	K7 endemic	R and L; FTEA	Rare, 2 locs. only
Rubiaceae	*Psydrax shuguriensis* Bridson	Rocks	S	T8 endemic	FTEA	Rare, 1 loc. only
Rubiaceae	*Psydrax* sp. A of FTEA	T	S	K7 endemic	R and L; FTEA	Rare, less than 5 locs.
Rubiaceae	*Psydrax* sp. B of FTEA	F	S	T3 endemic	FTEA	E. Usambara endemic (Longuza)
Rubiaceae	*Pyrostria hystrix* (Bremek.) Bridson	W	T, S	MSS, MLM	FZ ined.	Extends into S. Africa and Swaziland
Rubiaceae	*Pyrostria* sp. A of FZ ined.	F	S	MZ endemic	FZ ined.	Manganja endemic
Rubiaceae	*Pyrostria* sp. B of FTEA	F	S	T3 endemic	FTEA	E. Usambara endemic (Longuza)
Rubiaceae	*Pyrostria* sp. D of FTEA	F	S	T8 endemic	FTEA	Rondo endemic
Rubiaceae	*Rothmannia macrosiphon* (Engl.) Bridson	F	T, S	K7; T3, 6, 8	R and L; FTEA	
Rubiaceae	*Rothmannia ravae* (Chiov.) Bridson	F, T	T, S	SS; K7; T3, 6, 8	R and L; FTEA	
Rubiaceae	*Rytigynia binata* (Schum.) Robyns	F, B, T	T, S	T6; 8	FTEA; Rodgers *et al.*, 1983	Rare, 3 locs. only
Rubiaceae	*Rytigynia celastroides* (Baillon) Verdc.	F, T, Sw	T, S	T6, 8; Z; MN, MZ, MSS, MLM	FTEA; FZ in prep.	Extends into Natal
Rubiaceae	*Rytigynia decussata* (K. Schum.) Robyns	F, W, T, G	S	K7; T3, 6, 8; MN, MZ, MMS	R and L; FTEA; FZ ined.	Rare in Kenya
Rubiaceae	*Rytigynia longipedicellata* Verdc.	F	T	T8 endemic	FTEA (*Rytigynia* sp. C)	Rondo endemic
Rubiaceae	*Rytigynia mrimaensis* Verdc.	F	S	K7 endemic	R and L; FTEA	
Rubiaceae	*Rytigynia parvifolia* Verdc.	F, B, G	S	S.Som; K7	R and L; FTEA	
Rubiaceae	*Rytigynia pergracilis* Verdc.	F	S	T6, 8	FTEA; Frontier coll.	Rare, less than 5 locs.
Rubiaceae	*Rytigynia* sp. B of FZ ined.	Ro	S	MZ endemic	FZ ined.	
Rubiaceae	*Rytigynia* sp. C of FZ ined.	W	S	MN endemic	FZ ined.	

Family	Species	Habitat	Habit	Distribution	Data sources	Notes
Rubiaceae	*Rytigynia* sp. E of FZ ined.	F	S	MMS endemic	FZ ined.	
Rubiaceae	*Rytigynia* sp. I of FTEA	F	S	K7 endemic	R and L; FTEA	Rare, less than 5 locs.
Rubiaceae	*Rytigynia* sp. intermed. *parvifolia* et *celastroides*	F	S?	K7;	R and L	
Rubiaceae	*Rytigynia* sp. K of FTEA	W	H	T8 endemic	FTEA	Rare, 1 loc. only
Rubiaceae	*Rytigynia* sp. L of FTEA	F	T	K7 endemic	R and L; FTEA	Rare, less than 5 locs.
Rubiaceae	*Rytigynia* sp. nr. *umbellulata* (Bid. *et al.* 2032)	F	S	T8 endemic	Voll. and Bid. 1992; Notes	
Rubiaceae	*Spermacoce kirkii* (Hiern) Verdc.	Shore	H	MMS, MSS	FZ	
Rubiaceae	*Spermacoce schlecteri* K. Schum	F, T	H	MN, MZ, MMS, MSS	FZ	
Rubiaceae	*Spermacoce* sp. 1 (Robertson 3784)	Shore	H	K7 endemic?	R and L; Robertson, coll. notes	?Rare, less than 5 locs?
Rubiaceae	*Spermacoce* sp. aff. *filituba* (K. Schum.) Verdc.	G	H	K7 endemic	R and L; Robertson, coll. notes	Rare, less than 5 locs.
Rubiaceae	*Spermacoce* sp. B of FTEA	F	H	K7 endemic	R and L; FTEA	Rare, less than 5 locs.
Rubiaceae	*Spermacoce* sp. cf. *tenuior* L. (Luke *et al.* TPR535)	F?	H	K7 endemic	R and L; Robertson, coll. notes	Rare, less than 5 locs.
Rubiaceae	*Spermacoce* sp. D of FTEA	Shore	H	Maf endemic	FTEA	Mafia endemic
Rubiaceae	*Tapiphyllum schliebenii* Verdc.	F	T	T8 endemic	FTEA	Lake Lutamba/Litipo endemic
Rubiaceae	*Tarenna drummondii* Bridson	F, W	T, S	K7; T3, 6	R and L; FTEA	
Rubiaceae	*Tarenna littoralis* (Hiern) Bridson	B	T, S	K7; T3, 6; Z; Maf; Moz; Zim	FTEA; Greenway 1988	Extends into Natal
Rubiaceae	*Tarenna* sp. A of FTEA	F	S	T8 endemic	FTEA	Rare, 2 locs. only
Rubiaceae	*Triainolepis sancta* Verdc.	W, T	S	MSS endemic	FZ	Bazaruto Island endemic
Rubiaceae	*Tricalysia acidophylla* Robbrecht	F, W	T, S	T3, 6	Rodgers *et al.*, 1983; FTEA	Rare, less than 5 locs.
Rubiaceae	*Tricalysia allocalyx* Robbrecht	F, T	S	T6 endemic	FTEA; Mwasumbi *et al.*, 1994	Rare, 3 locs. only
Rubiaceae	*Tricalysia bridsoniana* Robbrecht	F	S	K7; T6	R and L; FTEA	Rare, less than 5 locs.
Rubiaceae	*Tricalysia delagoensis* Schinz	F	T	S.Mal; MZ, MMS, MSS, MLM	Dowsett-Lemaire, 1990; Dis. Pl. Af. **32**, 1067	Extends into Natal
Rubiaceae	*Tricalysia elegans* Robbrecht	F	S	T3 endemic	FTEA	Tanga Limestone endemic
Rubiaceae	*Tricalysia jasminiflora* (Klotzsch) Benth. and Hook. f.	?	?	MZ, MMS, MSS; S. Mal; E.Zim, S.Zim	Dis. Pl. Af. **32**, 1071–1073	
Rubiaceae	*Tricalysia microphylla* Hiern	F	S	K7; T3, 6; Z	R and L; FTEA	
Rubiaceae	*Tricalysia pedicellata* Robbrecht	F	T, S	T6 endemic	FTEA	
Rubiaceae	*Tricalysia schliebenii* Robbrecht	F, W	T, S	T8 endemic	FTEA	
Rubiaceae	*Tricalysia somaliensis* Robbrecht	W	S	S.Som endemic	Friis and Voll.; Dis. Pl. Af. **28**, 937	
Rubiaceae	*Tricalysia sonderana* Hiern	F, W, B	T, S	MN, MZ, MMS, MSS, MLM	Dis. Pl. Af. **16**, 538; Palgrave	Extends into Natal
Rubiaceae	*Tricalysia* sp. 1 (Luke 1611)	F	S	K7 endemic	R and L; Robertson, coll. notes	Mangea endemic?
Rubiaceae	*Tricalysia* sp. ?nov. aff. *delagoensis* (Bid. *et al.* 1452)	T	S	T8 endemic	Voll. and Bid. 1992; Notes	Rondo endemic
Rubiaceae	*Tricalysia* sp. ?nov. aff. *pedicellata* (Bidgood *et al.* 1461)	F	T	T8 endemic	Voll. and Bid., 1992; Notes	Rondo endemic
Rubiaceae	*Tricalysia* sp. F of FTEA	T	S	T8 endemic	FTEA	Rare, 2 locs. only
Rubiaceae	*Tricalysia* sp. G of FTEA	F	S	T8 endemic	FTEA	Lake Lutamba/Litipo endemic
Rubiaceae	*Tricalysia* sp. H of FTEA	F	S	T3 endemic	FTEA	East Usambara endemic (Maramba)
Rubiaceae	*Tricalysia* sp. not matched (Bid. *et al.* 1788)	T	S	T8 endemic	Voll. and Bid. 1992; Notes	
Rubiaceae	*Tricalysia* sp. nov. not matched at Kew (Frontier 634)	F	S	T6 endemic	Frontier coll.	Kiwengoma endemic
Rubiaceae	*Vangueria* sp. A of FTEA	F	T	P endemic	FTEA	Ngezi endemic
Rubiaceae	*Vangueria* sp. nov., vel. gen. aff.	W	S	T8 endemic	Op. Bot. 1980	Selous endemic
Rutaceae	*Diphasia* sp. A of FTEA	F	T	K7 endemic	R and L; FTEA	Rare, less than 5 locs.
Rutaceae	*Teclea crenulata* (Engl.) Engl.	?	?	MZ endemic	FZ	Rare, 1 loc. only

Family	Species	Habitat	Habit	Distribution	Data sources	Notes
Rutaceae	*Teclea* sp. (M and G 1102)	F	T, S	K7 endemic?	R and L; Robertson, notes	
Rutaceae	*Teclea* sp. aff. *simplicifolia* (Ngaza 537)	F	T	K7; T3	R and L	Rare, less than 5 locs.
Rutaceae	*Teclea* sp. cf. *trichocarpa* (Engl.) Engl. (Joanna 8896)	F	T, S	K7 endemic	R and L	Rare, less than 5 locs.
Rutaceae	*Teclea* sp. nov. (L and R 1539)	F	T	K7;	R and L; Robertson, coll. notes	
Rutaceae	*Vepris allenii* Verdoorn	T	T	T; MN	FZ	
Rutaceae	*Vepris morogoroensis* (Kokwaro) W. Mziray	F	S?	T6, 8	KB **32**, 785–787; Voll. and Bid. 92; Mziray 1992	= *Diphasia morogorensis*
Rutaceae	*Vepris sansibarensis* (Engl.) W. Mziray	F, T	T, S	K7; T3, 6, 8	R and L; FTEA; Mziray 1992	= *Toddaliopsis sansibarensis*
Rutaceae	*Vepris schliebenii* Mildbr.	F	S	T8 endemic	FTEA	Mlinguru endemic
Rutaceae	*Vepris* sp. near *stolzii* Verdoorn	F	T	K7 endemic	R and L	Rare, less than 5 locs, 1 K7
Rutaceae	*Vepris* sp., not matched (Clarke 52)	F	T	T8 endemic	Kew	Chitoa endemic
Rutaceae	*Zanthoxylum holtzianum* (Engl.) Waterm.	F, W, B, T	T, S	S.Som; K7; T3, 6, 8; P; MN	R and L; FTEA; FZ	= *Fagara holtziana*
Rutaceae	*Zanthoxylum lindense* (Engl.) Kokwaro	F, W, B	T, S	T8; Maf	FTEA; Greenway 1988	Rare, 2 locs. only
Rutaceae	*Zanthoxylum paracanthum* (Mildbr.) Kokwaro	F, B	L, S	K7; T5, 6	R and L; FTEA	Extends to Mpwapwa
Salicaceae	*Populus ilicifolia* (Engl.) Rouleau	F	T	K7 endemic	FTEA; Medley, 1992	
Salvadoraceae	*Dobera loranthifolia* (Warb.) Harms	F, W, G, T	T	S.Som; K1, 4, 7; T3, 6, 8; MN, MZ	FZ; FTEA	
Sapindaceae	*Allophylus bussei* Gilg.	F	S?	T8 endemic	FZ	Rondo endemic
Sapindaceae	*Allophylus mossambicensis* Exell.	F	S	MSS endemic	FZ	
Sapindaceae	*Allophylus* sp. ?nov. (Schlieben 5895)	F	S	T8 endemic	Voll. and Bid. 1992; Notes	Rondo endemic
Sapindaceae	*Allophylus* sp. ?nov. (Semsei 622)	F	T	T8 endemic	Voll. and Bid. 1992; Notes	Rondo endemic
Sapindaceae	*Allophylus* sp. nov. (sp. nov. 2 of Kew)	T	S	T8;	Op. Bot. 1980	
Sapindaceae	*Allophylus zimmermannianus* F.G. Davies ined.	F	T, S	K7; T3, 8	R and L; Bntje 1988; UDSM; KTSL; Kew	Rare, less than 5 locs.
Sapindaceae	*Chytranthus obliquinervis* Engl.	F	T	K7; T3	R and L; KTSL; Iversen 1991; Kew	
Sapindaceae	*Chytranthus prieurianus* Baill.	F	T, S	K7; T6, 8; Z	R and L; KTSL; Op. Bot. 1980; Kew	Rare in Kenya
Sapindaceae	*Deinbollia oblongifolia* (E. Mey) Radlk.	T	S	MZ, MSS, MLM	FZ	Extends into Natal
Sapindaceae	*Haplocoelum inopleum* Radlk.	F, B, T	T, S	S.Som; K7; T3, 6, 8; P	R and L; KTSL; KB **36**, 141; Op. Bot. '80	
Sapindaceae	*Pancovia holtzii* Radlk.	F, T	T, S	T3, 6, ?7; Maf	FTEA in press; Greenway 1988	
Sapindaceae	*Pancovia* sp. aff. *ugandensis* F.G. Davies ined.	F	S	K7 endemic	R and L; Robertson, coll. notes	Shimba Hills endemic
Sapindaceae	*Pancovia* sp. nov., not matched at Kew (Frontier 413)	F	T	T6 endemic	Frontier coll.	Zaraninge endemic
Sapotaceae	*Inhambanella henriquesii* (Engl. and Warb.) Dubard	F	T	K7; T6; P; MN, MZ, MMS, MSS, MLM; S.Mal; E.Zim	FTEA; FZ; Beentje 1990	Extends into Natal
Sapotaceae	*Manilkara sansibarensis* (Engl.) Dubard	F, W, B	T	K7; T3, 6; Z; P; Maf; MN	R and L; FTEA; FZ; Greenway 1988	
Sapotaceae	*Manilkara sulcata* (Engl.) Dubard	F, W, B, T	T	S.Som; K1, 4, 7; T3, 6; Z; P; Maf	R and L; FTEA; KB **40**, 396–397; Grnw. '88	
Sapotaceae	*Mimusops acutifolia* Mildbr.	F	T, S	T8 endemic	FTEA	Rare, 2 locs. only
Sapotaceae	*Mimusops penduliflora* Engl.	F	T	T6 endemic	FTEA	Rare, 1 loc. only
Sapotaceae	*Mimusops schliebenii* Mildbr. and Schulze	T	T	T6, 8	Op. Bot. 1980	
Sapotaceae	*Mimusops somalensis* Chiov.	F, W, B	T	S.Som; K7; T3, 8	R and L; FTEA; KTSL; KB **40**, 397–398	= *M. schliebenii*
Sapotaceae	*Pouteria pseudo-racemosa* (J.H. Hemsl.) Pennington	F	T	T3, 6	FTEA; Pennington 1991	= *Aningeria pseudoracemosa*
Sapotaceae	*Synsepalum kassneri* (Engl.) Pennington	F	S	K7; T6, 8; MMS; E.Zim	Rodg. *et al.*, 1983; FZ; FTEA; R and L	= *Afrosersalisia kassneri*
Sapotaceae	*Synsepalum subverticillata* (E.A. Bruce) Pennington	F, W, B	T, S	K7 endemic	R and L; KTSL	= *Pachystela*. Rare, less than 5 locs.
Sapotaceae	*Synsepalum Taxon* A of KTSL	F	T	K7 endemic	R and L; KTSL	?Rare, less than 5 locs?
Sapotaceae	*Vitellariopsis kirkii* (Bak.) Dubard	F, B	T, S	K7; T3, 6, 8	R and L; FTEA	

Family	Species	Habitat	Habit	Distribution	Data sources	Notes
Scrophulariaceae	*Alectra* sp. aff. *picta* (Hiern) Hemsl.	G	H	K7; T6	R and L; Robertson, coll. notes	?Rare in Kenya?
Scrophulariaceae	*Buttonia natalensis* McKen ex Benth.	F, W, B, Ro	C, S	K1, 4, 7; T3, 6, 8; E.Zim; MSS, MLM	FZ; Iversen 1980; EA; UDSM	
Scrophulariaceae	*Harveya* sp., not matched at Kew (Frontier 3035)	?	E	T3 endemic	Frontier coll.	Rare, 1 loc. only
Scrophulariaceae	*Lindernia longicarpa* Eb. Fisch. and Hepper	W, Ro	H	T3 endemic	Kew Bull. **46**, 529–533	
Scrophulariaceae	*Lindernia* sp. not matched at Kew (Luke 2899)	Sw	H	K7 endemic	R and L	Rare, less than 5 locs.
Scrophulariaceae	*Lindernia* sp. nov. aff. *L. insularis* Skan	W	H	T6, 8;	Op. Bot. 1980	
Scrophulariaceae	*Lindernia subreniformis* Philcox	Sw	H	K7; T8; Z; MZ	FZ; R and L	
Scrophulariaceae	*Lindernia zanzibarica* Eb. Fisch. and Hepper	Sw, Wa	H	T6; Z	Kew Bull. **46**, 529–533	
Scrophulariaceae	*Striga diversifolia* P. Lima	?	H	MN endemic	FZ	Rare, 1 loc. only
Scrophulariaceae	*Striga pubiflora* Klotzsch	W	H	K7; T6, 8; Z; Maf; C.Mal; MN, MZ, MMS, MSS	R and L; FZ; Op. Bot. '80; Greenw. 1988; EA	Rare in Kenya
Simaroubaceae	*Quassia undulata* (Guill. and Perr.) D.Dietr.	F	T	K7; T3; P	R and L; KTSL; Iv. 1991; Beentje 1988	= *Odyendea zimmermannii*
Solanaceae	*Solanum* sp. cf *monotanthum* Damer (Robertson 3776)	Shore	H	K7;	R and L; Robertson, coll. notes	
Solanaceae	*Solanum* sp. I (Rawlins 226)	F	H	K7 endemic	R and L; Robertson, notes	Rare, less than 5 locs.
Sterculiaceae	*Byttneria fadenii* Dorr. ined.	F	T, S	K7;	R and L; KTSL	
Sterculiaceae	*Byttneria fruticosa* K. Schum	F	T	T3 endemic	Haw. 1993; Not in KTSL Clarke 1995	E. Usambara endemic
Sterculiaceae	*Cola clavata* Mast. sp. 1 of Op. Bot. 1980	F, T	T	T6, 8; MZ	R and L; FZ; KTSL; Op. Bot. 1980; UDSM	
Sterculiaceae	*Cola clavata* Mast. sp. 2 of Op. Bot. 1980	F, T	T	K7; T; Z	R and L; FZ; KTSL; Op. Bot. 1980; Beentje 1990	
Sterculiaceae	*Cola discoglypremnophylla* Brenan and Jones	F	T, S	T8; MN	FZ; Op. Bot. 1980; KB **11**, 141–152	?Rare less than 5 locs?
Sterculiaceae	*Cola microcarpa* Brenan	F	T	T6 endemic	Kew Bull. **11**, 147–148	Uluguru lowland endemic
Sterculiaceae	*Cola minor* Brenan	F, T	T	K7 endemic	R and L; KTSL; KB **11**, 149	
Sterculiaceae	*Cola mossambicensis* Wild.	F	T	MZ, MMS, S.Mal	FZ	
Sterculiaceae	*Cola octoloboides* Brenan	F, Ro	T, S	K7 endemic	R and L; KTSL; KB **33**, 283–286	2 locs. only inc. Dzombo
Sterculiaceae	*Cola porphyrantha* Brenan	F	T	K7 endemic	R and L; KTSL; KB **40**, 85–87	Rare, less than 5 locs.
Sterculiaceae	*Cola scheffleri* K.Schum.	F	T	T3, 6, 8	Kew Bull. **11**, 143	
Sterculiaceae	*Cola stelecantha* Brenan	F	T, S	T6, 8	Rodg. *et al.* '83; V and B '92; KB **11**, 143	Rare, less than 5 locs.
Sterculiaceae	*Cola uloloma* Brenan	F	T	K7; T3, 6	R and L; KTSL; UDSM; KB **11**, 150–151	
Sterculiaceae	*Dombeya lastii* K.Schum.	W	S	MZ endemic	Dis. Pl. Af. **38**, 1265; FZ; Seyani	
Sterculiaceae	*Dombeya leachii* Wild	W	S	MN endemic	Dis. Pl. Af. **38**, 1264; Not in FZ; Seyani	
Sterculiaceae	*Dombeya taylorii* Bak.f.	F, W, B	T, S	S.Som; K7; T3, 6	R and L; KTSL; Iv. 1991; Friis and Voll.; EA	
Sterculiaceae	*Hermannia exappendiculata* (Mast.) K. Schum.	W, B, T	H	K7; T3, 6	Clarke 1995; B and G, 1949	
Sterculiaceae	*Hermannia micropetala* Harv.	?	S, H	MMS, MSS, MLM	FZ	
Sterculiaceae	*Hildegardia migeodii* (Exel) Kosterm.	W	S	T6, 8; MMS	FZ; EA; B and G, 1949	=*Erythropsis migeodii*
Sterculiaceae	*Mansonia diatomanthera* Brenan	F	T	T3 endemic	Kew Bull. **8**, 89–90; B and G, 1949	
Sterculiaceae	*Melhania* sp. ?nov. (Faden 74)	Shore	H	K7 endemic	R and L; Robertson, coll. notes	Rare, less than 5 locs.
Sterculiaceae	*Nesogordonia holtzii* (Engl.) Capuron	F, W, T	T, S	K7; T3, 6, 7, 8; Maf; MZ	R and L; KTSL; FZ; Op. Bot.; Clarke '95; Grnw. '88	= *N. parvifolia*
Sterculiaceae	*Sterculia appendiculata* K. Schum.	F, W	T	S.Som; K7; T3, 6, 7; 8; Z; MN, MT, MMS; S.Mal	FZ; pers obs.; KTSL; Iv. 1991; Friis; EA	
Sterculiaceae	*Sterculia schliebenii* Mildbr.	F, W	T	K7; T3, 6, 8; MN	R and L; UDSM herb.; FZ; EA	Rare, less than 5 locs.
Tecophilaeceae	*Cynastrum hostifolium* Engl.	F, W, T	H	T6, 8; Moz	FTEA; UDSM herb.; Op. Bot. 1980	
Thymelaceae	*Craterosiphon* sp. ?nov. (Bidgood *et al.* 1683)	T	C	T8 endemic	Voll. and Bid., 1992; Notes	Rondo endemic
Thymelaceae	*Synaptolepis alternifolia* Oliv.	F, W, B, G, T	C, S	T3, 6, 7, 8; Moz; Mal; Zim	FTEA	
Thymelaceae	*Synaptolepis kirkii* Oliv.	F	C, S	K7; T3, 6, 8; Z; P; Maf; Moz	R and L; FTEA; Greenway 1988	Extends into Natal

Family	Species	Habitat	Habit	Distribution	Data sources	Notes
Tiliaceae	*Carpodiptera africana* Griseb.	F, BW, W, B, T	T, S	K7; T3, 6, 8; Z; MN, MSS	FZ; KTSL; Op. Bot. 1980; Iversen 1991	
Tiliaceae	*Glyphaea tomentosa* Mast. in Oliv.	W	T	MN, MZ, MMS	FZ	
Tiliaceae	*Grewia calymmatosepala* K. Schum.	F	C, S	K7; T3, 6	KTSL; R and L; Clarke 1995; Iv. 1991	
Tiliaceae	*Grewia conocarpa* K. Schum	F, T	T, S	T6, 8; Z; MN	FZ; Op. Bot. 1980	
Tiliaceae	*Grewia ectasicarpa* S. Moore	F, BW, W	C, S	K7; T3, 6; Z	R and L; KTSL; Clarke 1995	
Tiliaceae	*Grewia forbesii* Harv. ex Mast.	F, B, T, G	T, L, S	K4, 6, 7; T2, 3, 6, 8; Z; Maf; S.Mal; MN	FZ; KTSL; Op. Bot. 1980; Greenway '88; EA	
Tiliaceae	*Grewia goetzeana* K.Schum.	F, W, B, T, G	T, S	T3, 6, 8	Clarke 1995; Iv. 1991; B and G 1949	
Tiliaceae	*Grewia holstii* Burret	F, W, B, G, T	T, L, S	S.Som; K7; T3, 6, 8; Z; MN	FZ; KTSL; Iv. 1991; Op. Bot. '80; Friis and Voll.	
Tiliaceae	*Grewia hornbyi* Wild	W	S	MSS, MLM	FZ	
Tiliaceae	*Grewia lepidopetala* Guerke	F, Sw	T, S	T6, 8; Mal; Zim	Op. Bot. 1980; Clarke 1995; B and G, 1949	
Tiliaceae	*Grewia leptopus* Ulbr.	F, T	S	T6, 8	Clarke 1995	
Tiliaceae	*Grewia limae* Wild	W	T, S	MN endemic	FZ	
Tiliaceae	*Grewia plagiophylla* K. Schum.	F, B, W, T	T, S	K7; T3, 6	R and L; KTSL; Clarke 1995; EA; B and G, 1949	
Tiliaceae	*Grewia* sp. ?nov. aff. *calymmatosepala* (Bid. *et al.* 1337)	F	S	T8 endemic	Voll. and Bid., 1992; Notes	Rondo endemic
Tiliaceae	*Grewia* sp. ?nov. aff. *lepidopetala* (Bid. *et al.* 1801)	T, Ro	S	T8 endemic	Voll. and Bid., 1992; Notes	
Tiliaceae	*Grewia* sp. ?nov. aff. *meizophylla* (Bidgood *et al.* 1685)	T	T	T8 endemic	Voll. and Bid., 1992; Notes	Rondo endemic
Tiliaceae	*Grewia stuhlmannii* K. Schum.	F, W, B, T, G	C, S	K7; T3, 6, 8; P	R and L; KTSL; Iv. 1991; Op. Bot.; Bntje '90	
Tiliaceae	*Grewia sulcata* Mast.	F, W, B, T	S	K7; T6, 8; E.Zim, S.Zim; S.Mal; MN, MT, MMS, MLM	FZ; KTSL; Op. Bot. 1980; B and G, 1949	Extends into Transvaal
Tiliaceae	*Grewia transzambesiaca* Wild	BW	T, S	MZ, MMS	FZ	
Tiliaceae	*Grewia vaughanii* Exell	F, B, T	T, S	K7; Z; Maf; T8	R and L; KTSL; Voll. and Bid. '92; Grnw. '88	
Tiliaceae	*Triumfetta kirkii* Mast	?F, T	H	T8; MN, MMS	FZ; Op. Bot. 1980	Rare, less than 5 locs.
Tiliaceae	*Triumfetta* sp. ?nov. aff. *T. pentandra* Not matched	W	H	T6, 8	Op. Bot. 1980	Selous endemic
Turneraceae	*Hyalocalyx setifer* Rolfe	F	H	T8; MZ	Kew Bull. **5**, 335	
Turneraceae	*Loewia thomasii* (Urb.) J. Lewis	Shore?	S	K7 endemic?	FTEA	
Turneraceae	*Tricliceras auriculatum* (A. and R. Fernan.) R. Fernandes	Ro	H	MN endemic	FZ	?Rare, less than 5 locs?
Turneraceae	*Tricliceras elatum* (A. and R. Fernandes) R. Fernandes	W, T, G	H	MN endemic	FZ	?Rare, less than 5 locs?
Turneraceae	*Tricliceras lanceolatum* (A. and R. Fernan.) R. Fernandes	F	H	MN endemic	FZ	?Rare, less than 5 locs?
Turneraceae	*Tricliceras thomasii* (Urb.) Story	G?	S	K1, 7	Kew Bull. **45**, 277–280	
Turneraceae	*Tricliceras xylorhizum* Verdc.	B, Ro	H	K7 endemic	Kew Bull. **45**, 277–280	
Urticaceae	*Laportea lanceolata* (Engl.) Chew	F	H	K7; T3, 6	R and L; FTEA	Possibly in E. Zaire
Urticaceae	*Pouzolzia fadenii* Friis and Jellis	F	H	K7 endemic	R and L; FTEA	Rare, less than 5 locs.
Urticaceae	*Pouzolzia shirensis* Rendle	F?	S, H	S.Mal endemic	FZ	Shire Highlands endemic
Urticaceae	*Urera sansibarica* Engl.	F, B	L	K7; T3, 6; Z; Maf; MZ, MMS	R and L; FTEA; FZ; Greenway 1988	= *U. fischeri*
Velloziaceae	*Xerophyta nutans* L.B. Smith and Ayensu.	Ro	S, H	T8 endemic	FTEA	Rare, 1 loc. only
Verbenaceae	*Clerodendrum incisum* Klotzsch	F, BW, T	S	Som; K7; T3, 6, 8; Moz inc. MN, MZ	R and L; FTEA	
Verbenaceae	*Clerodendrum kissakense* Gurke	W, G	S, H	T6, 8; Moz	FTEA	
Verbenaceae	*Clerodendrum lutambense* Verdc.	F	H	T8; Moz	FTEA	?Rare, less than 5 locs?
Verbenaceae	*Clerodendrum polyanthum* Guerke	F ?	T, S	T6 endemic	FTEA	Rare, 1 loc. only
Verbenaceae	*Clerodendrum robustum* Klotzsch	F, W, G, B	S	K7; T3, 6, 8; Maf; Moz; Mal; Zim inc. MN	FTEA	
Verbenaceae	*Clerodendrum* sp. A of FTEA	F	S	T8 endemic	FTEA	Mlinguru endemic

Family	Species	Habitat	Habit	Distribution	Data sources	Notes
Verbenaceae	*Clerodendrum* sp. B of FTEA	W	S	T8 endemic	FTEA	
Verbenaceae	*Clerodendrum* sp. G of FTEA	F	S	T8 endemic	FTEA	Lake Lutamba/Litipo endemic
Verbenaceae	*Clerodendrum tricholobum* Guerke	F, W, B	S	K7; T3, 6, 8; Moz	R and L; FTEA	Rare in Kenya
Verbenaceae	*Holmskioldia gigas* Faden	F	T	K7; T8	KB **43**, 659–662; Clarke 1995	Rare, 1 loc. only
Verbenaceae	*Premna chrysoclada* (Boj.) Guerke	F, W, B, T, G, Wa	T, S	K7; T3, 6, 8; Z	R and L; FTEA	
Verbenaceae	*Premna discolor* Verdc.	F	C, S	K7 endemic	R and L; FTEA	Rare, 3 locs. only
Verbenaceae	*Premna gracillima* Verdc.	F, T	S	K7; T8	R and L; FTEA	Probably also in Mozambique
Verbenaceae	*Premna hans-joachimii* Verdc.	F, B	T, S	T8 endemic	FTEA	Rare, 2 locs. only
Verbenaceae	*Premna hildebrandtii* Guerke	F, W, T, G, Ro	T, C, S	K4, 7; T3, 6, 8; P	FTEA	
Verbenaceae	*Premna schliebenii* Werderm.	F, G	T	T3, 6; Moz	FTEA	
Verbenaceae	*Premna* sp. A. of FTEA	F	S	T8 endemic	FTEA	Rondo endemic
Verbenaceae	*Premna* sp. B of FTEA	T	S	T8 endemic	FTEA	Makonde Plateau endemic
Verbenaceae	*Premna tanganyikensis* Moldenke	F, T	T, S	T8; Moz	Voll. and Bid., 1992; FTEA	Rare, less than 5 locs.
Verbenaceae	*Premna velutina* Guerke	F, W, G, Sw	T, S	K?4, 7; T3, 6, 8; Moz.	FTEA	
Verbenaceae	*Vitex mossambicensis* Guerke	T	T, S	T8; Moz	FTEA	
Verbenaceae	*Vitex schliebenii* Moldenke	B, T	T, S	S.Som; K7; T8; Moz; S.Mal	KTSL; Friis and Voll.; FTEA	Extends into Natal
Verbenaceae	*Vitex* sp. A of FTEA	F	T, S	T6 endemic	FTEA	Kimboza endemic
Verbenaceae	*Vitex* sp. B of FTEA	F	T	T6 endemic	FTEA	Pande endemic
Verbenaceae	*Vitex zanzibarensis* Vatke	F, W, T	T, S	K7; T3, 6, 8	R and L; FTEA	Probably also in Mozambique
Violaceae	*Rinorea elliptica* (Oliv.) Kuntze	F	T, S	K7; T2, 3, 6, 8; Moz inc. MMS, MSS; E.Zim; Mal;	FTEA; Palgrave	
Violaceae	*Rinorea scheffleri* Engl.	F	T, S	T3 endemic	FTEA	East Usambara endemic
Violaceae	*Rinorea* sp. ?nov.	F	T, S	K7 endemic	R and L; Robertson, notes	Shimba Hills end., a hybrid?
Violaceae	*Rinorea* sp. ?nov. aff. *ferruginea* (Bidgood *et al.* 1352)	T	S	T8 endemic	Voll. and Bid. 1992; Notes	Rondo endemic
Violaceae	*Rinorea* sp. A of FTEA	F	T	T6 endemic	FTEA; Rodg. *et al.*, 1983; Frontier coll.	Rare, 2 locs. only
Violaceae	*Rinorea* sp. nr. *beniensis* Engl. (cf. *R.* sp. A of FTEA)	F	T	K7 endemic?	R and L	Rare, less than 5 locs.
Violaceae	*Rinorea* sp. nr. *ferruginea* Engl. (R and L 6310)	F	T, S	K7 endemic	R and L; Robertson, coll. notes	Gongoni endemic?
Viscaceae	*Viscum* sp. ?nov. (Bid. *et al.* 1940)	BW	Paras.	T8 endemic	Voll. and Bid. 1992; Notes	
Vitaceae	*Cissus bathyrhakodes* Werderm.	W, BW, Ro	H	T8; MZ, MMS	FTEA; FZ	
Vitaceae	*Cissus cucumerifolia* Planch.	F, W, G, Ro	L	T6, 8; MN, MMS; C.Mal, S.Mal	FTEA; FZ	
Vitaceae	*Cissus egestosa* Werderm.	F, B, Ro	C	T6, 8	FTEA	
Vitaceae	*Cissus migeodii* Verdc.	F, BW, G	C	T8 endemic	FTEA	
Vitaceae	*Cissus phymatocarpa* Masinde and L.E. Newton	F, B, T, Ro	C	K4, 7; T3, 6, 8; Z; P	R and L; FTEA	
Vitaceae	*Cissus quinquangularis* Chiov.	F, BW, Ro. T	C	Som; K7; P	R and L; FTEA; Beentje 1990	
Vitaceae	*Cissus rondoensis* Verdc.	F	C	T8 endemic	FTEA	Rondo endemic
Vitaceae	*Cissus sciaphila* Gilg.	F, W	L, C	K7; T3, 6, 8; Z; P	FTEA	
Vitaceae	*Cissus* sp. aff. *integrifolia* Planchon (R and L 5824)	F	C	K7 endemic	R and L; Robertson, notes	?Rare, less than 5 locs?
Vitaceae	*Cissus sylvicola* Masinde and L.E. Newton	F, T, Ro	L	K7; T3, 6	R and L; FTEA	
Vitaceae	*Cissus wallacei* Verdc.	F, W, G	C, S	T6, 8	FTEA	Rare, 2 locs. only
Vitaceae	*Cyphostemma amplexum* (Bak.) Descoings	F	C	T8; MN	FZ; Voll. and Bid. 1992	
Vitaceae	*Cyphostemma bidgoodae* Verdc.	F	C	T8 endemic	FTEA	Rondo endemic

Family	Species	Habitat	Habit	Distribution	Data sources	Notes
Vitaceae	*Cyphostemma duparquetii* (Planch.) Descoings	F, T, Ro	C	K7; T3, 6; Z; ?P	FTEA	
Vitaceae	*Cyphostemma feddeanum* (Gilg. and Brandt) Descoings	?	H	T6 endemic	FTEA	Rare, 1 loc. only
Vitaceae	*Cyphostemma pachyanthum* (Gilg. and Brandt) Desc.	F	C	K7; T3, 6	R and L; FTEA	Rare, extends up to Amani
Vitaceae	*Cyphostemma paucidentatum* (Klotzsch) Wild and	F, W, B	C	Z; T6, 8; Zim; Moz inc. MSS	FTEA	Extends into Transvaal
Vitaceae	*Cyphostemma sanctuarium-selousii* Verdc.	W	C, H	T8 endemic	FTEA	Selous endemic
Vitaceae	*Cyphostemma* sp. A of FTEA	W	H?	T6 endemic	FTEA	Rare, 1 loc. only
Vitaceae	*Cyphostemma* sp. C of FTEA	F	H	T3 endemic	FTEA	Rare, 1 loc. only
Vitaceae	*Cyphostemma* sp. I of FTEA	F	C	K7 endemic	FTEA; R and L (as sp. 1 of FTEATS)	Rare, 2 locs. only
Vitaceae	*Cyphostemma* sp. L of FTEA	F	C	K7 endemic	FTEA	Buda endemic
Vitaceae	*Cyphostemma* sp. nr. *bambuseti* (Gilg. and Brandt) Wild	F	C	K7 endemic	R and L; Robertson, notes	Tana River endemic?
Vitaceae	*Cyphostemma* sp. P of FTEA	F	C	T6 endemic	FTEA	Kimboza endemic
Vitaceae	*Cyphostemma trachyphyllum* (Werderm.) Descoings	F, W, G	C	T3, 8; MN; Mal	FZ; FTEA	
Vitaceae	*Cyphostemma zanzibaricum* Verdc.	W	C	Z; P	FTEA	Zanzibar and Pemba endemic
Vitaceae	*Cyphostemma zimmermannii* Verdc.	F	C	K7; T3	R and L; FTEA	Extends up to Amani
Xyridaceae	*Xyris parvula* Malme	B	H	Maf endemic	Greenway 1988; Not in Kew	Mafia Island endemic
Zamiaceae	*Encephalartos hildebrandtii* A.Br. and Bouche	F, B	T	K7; T3, 6; Z; MZ	R and L; FZ; Frontier coll.; FTEA	1 record in Uganda
Zingiberaceae	*Afromomum amaniense* Loes.	F	H	K7; T3, 6	R and L; FTEA	Rare in Kenya
Zingiberaceae	*Afromomum orientale* Lock	F, Wa	H	K7; T6	R and L; FTEA	Rare in Kenya
Zingiberaceae	*Afromomum* sp. nov. aff. *alboviolaceum* (M.-Redh. and T. 7610)	F	H	T8 endemic	Voll. and Bid. 1992; Notes	Rondo endemic
Zingiberaceae	*Costus sarmentosus* Bojer	F	H	K7; T3, 6: Z; P	R and L; FTEA	Rare in Kenya
Zingiberaceae	*Siphonochilus* sp. not matched in EA (R and L 5700)	F	H?	K7 endemic	R and L	Rare, less than 5 locs.
Fern Adiantac.	*Adiantum mendoncae* Alston	F	Fern	E.Zim; S.Zim; MN, MMS	FZ	
Fern Aspleniac.	*Asplenium* sp. ?nov. (Bid. *et al.* 2039)	F	Fern	T8 endemic	Voll. and Bid. 1992; Notes	
Fern Blechnac.	*Stenochlaena tenuifolia* (Desv.) Moore	F	Fern	P; Maf; MN, MZ, MMS, MSS, MLM	Greenway 1988; FZ; Beentje 1990	Extends into South Africa
Fern Dryop.	*Tectaria puberula* (Desv.) C.Chr.	F	Fern	K1, 7; Z	R and L; EA citing Johns, 1991	Less than 5 sites
Fern Marsileac.	*Marsilea fadeniana* Launert	Sw	Fern	K7 endemic	R and L; EA citing Johns, 1991	Less than 5 sites
Fern Pteridac.	*Pteris* sp. cf. *atrovirens* Willd. (L and R 2729)	F	Fern	K7 endemic?	R and L	Shimba Hills endemic?
Fern Selaginac.	*Selaginella eublepharis* A. Br.	F, B	Fern	K7; T3, 6, 7; Z	Iv. 1991; EA citing Johns, 1991	
Fern Thelypt.	*Christella shimbae* Holttum	F	Fern	K7 endemic	R and L	Shimba Hills endemic?

Key:

Collector abbreviations

Specimen citations are given for a number of the indeterminate species from the Kenya Coast (K7). These have been abbreviated as per page 2:11 of Robertson and Luke (1993).

Habitat

F = Forest, **W** = Woodland, **BW** = *Brachystegia* Woodland, **B** = Bushland, **T** = Thicket, **G** = Grassland, **Wa** = Wasteland, cultivation, **Ro** = Rocks, **Mg** = Mangrove, **Shore** = Littoral, **Sw** = Swamp

Habit / Growth Form

T = Tree, **L** = Liana, **C** = Climber, **S** = Shrub, **H** = Herb, **E** = Epiphyte, **Paras.** = Parasite.

Distribution (as per FTEA and FZ)

Som = Somalia; **S.Som** = southern Somalia (Jubbaland); **K** = Kenya; **T** = Tanzania; **Z** = Zanzibar Island; **P** = Pemba Island; **Maf** = Mafia Island; **Moz** = Mozambique (exact distribution not known); **MN** = Mozambique, Niassa Province; **MZ** = Mozambique, Zambesia Province; **MMS** = Mozambique, Manica e Sofala Province; **MSS** = Mozambique, Sul do Save / Gaza-Inhambane Province; **MLM** = Mozambique Lourenço Marques / Maputo Province; **MT** = Mozambique, Tete Province; **Mal** = Malawi (exact distribution not known); **S.Mal** = Southern Malawi; **Zim** = Zimbabwe (exact distribution not known); **E.Zim** = Eastern Zimbabwe.

Distributions into Natal, the Transvaal or Zululand are given in the **Notes** column.

Data sources:

Adams and Holland 1978 = Adams, B.R. and Holland, R.W.K. (1978). The genus *Sarcostemma* in East Africa. *Cactus and Succulent Journal* **50**: 107–111.

B and G 1949 = Brenan, J.P.M. and Greenway, P.J. (1949). *Check-list of the forest trees and shrubs of the British Empire. 5 Tanganyika Territory.* Parts 1 and 2. Imperial Forestry Institute, Oxford.

Beentje 1988 = Beentje, H.J. (1988). Atlas of rare trees of Kenya. *Utafiti* **1**: 71–120.

Beentje 1990 = Beentje, H.J. (1990). *A reconnaissance survey of Zanzibar forests and coastal thicket.* Zanzibar Environmental Study Series Number 7 of 1990.The Commission for Lands and Environment, Zanzibar.

Bot. Notiser = *Botanisk Notiser.*

Bot. Tidsskrift = *Botanisk Tidsskrift.*

Clarke 1995 = Clarke, G.P. (1995). *Tanzanian Coastal Forest Research Programme, Checklist of the vascular plants from 13 Coastal Forests in Tanzania.* Frontier-Tanzania Technical Report No. 15. The Society for Environmental Exploration/the University of Dar es Salaam, London and Dar es Salaam.

D-Lm. = Dowsett-Lemaire, F. (1990). The flora and phytogeography of the evergreen forests of Malawi II: Lowland forests. *Bull. Jard. Bot. Nat. Belg. / Bull. Nat. Plantentuin Belg.* **60**: 9–71.

Dis. Pl. Af. = *Distributiones Plantarum Africanarum.* (1969-).

Drum. = Drummond, R. (in prep.) 'Botanical checklist for the Haroni and Rusitu Forests, Melsetter District, Zimbabwe'.

Faden = Faden, R.B. (1991). The Morphology and Taxonomy of *Aneilema* R. Brown (Commelinaceae). *Smithsonian Contributions to Botany* **76**: 1–166.

Friis and Voll. = Friis, I. and Vollesen, K. (1989). Notes on the vegetation of southernmost Somalia, with some additions to the flora. *Willdenowia* **18**: 455–477.

Friis 1991 = Friis, I. (1991). *Skovtræsfloraen i det nordøstlige tropiske Afrika (Etiopien, Djibouti og Somalia) – en sammenfattende redegørelse for tidligere studier.* Botanisk Museum, Copenhagen.

Frontier coll. = Collections by the Frontier-Tanzania Coastal Forest Research Programme (1989–1994), identified at Kew.

FTEA = Turrill, W.B. and Milne-Redhead, E. *et al.* (1952-). *Flora of Tropical East Africa.* A.A. Balkema, Rotterdam.

FSOM = Thulin, M. *et al.* (1993-). *Flora of Somalia.* Royal Botanic Gardens, Kew.

FZ = Exell, A.W. and Wild, H. *et al.* (1960-). *Flora Zambesiaca* London: Crown Agents for Overseas Governments and Administrations. Later editions published by Royal Botanic Gardens, Kew on behalf of the Flora Zambesiaca Managing Committee.

Goldsmith 1976 = Goldsmith, B. (1976). The trees of Chirinda Forest. *The Rhodesia Science News* **10**: 40–50.

Gomes = Gomes e Sousa, A. (1966 and 1967). *Dendrologia de Moçambique.* Volume I and II. Instituto de Investigaçao Agronomica de Moçambique, Lourenço Marques.

Greenw. 1988 = Greenway, P.J. with Rodgers, W.A., Wingfield, R.J. and Mwasumbi, L.B. (1988). The vegetation of Mafia Island, Tanzania. *Kirkia* **13**: 197–238.

Haw. 1993 = Hawthorne, W.D. (1993). East African coastal forest botany. In Lovett, J.C. and Wasser, S.K. (eds.). *Biogeography and Ecology of the Rain Forests of eastern Africa.* Cambridge University Press, Cambridge. Pp 57–99.

Hawth. 1984 = Hawthorne, W. D. (1984). 'Ecological and biogeographical patterns in the Coastal Forests of East Africa'. Unpublished PhD thesis, University of Oxford, Oxford.

Iv. 1991/Iversen 1991 = Iversen, S.J. (1991). The Usambara Mountains, NE Tanzania: Phytogeography of the vascular plant flora. *Symbolae Botanicae Upsaliensis* **XXIX**: 1–234.

Johansson = Johansson, D.R. (1978). *Saintpaulias* in their natural environment with notes on their present status in Tanzania and Kenya. *Biological Conservation* **14**: 45–62.

Kapuya 1994 = Kapuya, J.A. (1994). 'Phenological and island vegetation studies of Pangani Falls'. Report to NorConsult, Dar es Salaam.

Kapuya 1995 = Kapuya, J.A. (1995). 'Salvage of the African Violet (*Saintpaulia tongwensis*) community at Pangani Falls'. Report to NorConsult, Dar es Salaam.

Kew Bull. = *Kew Bulletin*. Royal Botanic Garden, Kew, London.

KTSL = Beentje, H.J. (1994) *Kenya trees, shrubs and lianas*. National Museums of Kenya, Nairobi.

Manktelow 1996 = Manktelow, M. (1996). *Phaulopsis* (Acanthaceae) – a monograph. *Acta Universitatis Upsaliensis Symbolae Botanicae Upsalienses* **31**: 1–183.

Medley 1992 = Medley, K.E. (1992). Patterns of forest diversity along the Tana River, Kenya. *Journal of Tropical Ecology* **8**: 353–371.

Mwas. *et al.* 1994 = Mwasumbi, L.B., Burgess, N.D. and Clarke, G.P. (1994). The vegetation of Kiono and Pande forests, Tanzania. *Vegetatio* **113**: 71–81.

Mziray 1992 = Mziray, W. (1992). Taxonomic studies in Toddalieae Hook.f. (Rutaceae) in Africa. *Acta Universitatis Upsaliensis Symbolae Botanicae Upsalienses* **XXX**: 1–95.

Op. Bot. 1980 = Vollesen, K. (1980) Annotated check-list of the vascular plants of the Selous Game Reserve, Tanzania. *Opera Botanica* **59**: 1–117.

Palgrave = Palgrave, K.C. (1977). *Trees of Southern Africa.* C. Struik Publishers, Cape Town and Johannesburg.

Pennington 1991 = Pennington, T.D. (1991). *The genera of Sapotaceae.* Royal Botanic Gardens and New York Botanical Garden, Kew and New York.

R and L = Robertson, S.A. and Luke, W.R.Q. (1993). *Kenya Coastal Forests.* Report of the NMK/WWF Coast Forest Survey.Worldwide Fund for Nature, Nairobi.

Rodg. *et al.* 1983 = Rodgers, W.A., Mwasumbi, L.B., Griffiths, C.J. and Vollesen, K. (1983). The Conservation Values and Status of Kimboza Forest Reserve, Tanzania. Unpublished report. Forest Conservation Working Group, University of Dar es Salaam, Dar es Salaam.

Ruffo 1991 = Ruffo, C.K. (1991). 'A report on species identification for Jozani and Ngezi forest inventory'. Unpublished report by the Tanzania Forestry Research Institute, Lushoto.

Seyani = Seyani, J.H. (1991). Dombeya in Africa. *Opera Botanica Belgica* **2**: 1–186.

SREA = Haines, R.W. and Lye, K.A. (1983). *The Sedges and Rushes of East Africa.* East African Natural History Society, Nairobi.

Temu 1990 = Temu, R.P.C (1990). Taxonomy and biogeography of woody plants in the Eastern Arc Mountains, Tanzania: case studies in *Zenkerella*, *Scorodophloeus* and *Peddiea*. *Comprehensive Summaries of Uppsala Dissertations from the Faculty of Science* **286**: 1–68.

Verdcourt 1996 = Verdcourt, B. (1996). *Sanrafaelia* a new genus of Annonaceae from Tanzania. *Garcia de Orta, Ser. Bot.* **13**: 43–44.

Voll. and Bid. 1992 = Vollesen, K. and Bidgood, S. (1992). 'Kew Expedition to Tanzania and Malawi Jan – April 1991.' Unpublished report to the Royal Botanic Garden, Kew.

White, 1988 = White, F. (1988). The taxonomy, ecology and chorology of African Ebenaceae. II. The non-Guineo-Congolian species of *Diospyros* (excluding sect. Royenna). *Bull. Jard. Bot. Nat. Belg.* **58**: 325–448.

EA = East African Herbarium (Nairobi) LEAPMASTER database.

Kew = Specimens examined at Kew Herbarium.

Notes = Collection notes (deposited at Kew).

UDSM = Specimens examined at the herbarium of the University of Dar es Salaam.

Acknowledgements

Assistance with the compilation of this list was kindly provided by Henk Beentje, Sally Bidgood, Diane Bridson, David Goyder, Jon Lovett, Roger Polhill, Gerald Pope, Sylvia Phillips, Anne Robertson, Kaj Vollesen and Bernard Verdcourt.

Appendix 4 Birds of the eastern African Coastal Forests

	Forest	So	Kenya																											Tanzania									Islands			%
	depend.	JR	BO	TR	DK	GD	SO	MT	GN	TL	WA	SH	DJ	KN	TM	MU	GN	BU	MR	DZ	MA	EU	KL	GG	MS	KZ	PA	PU	KZ	VI	KI	MC	KW	LI	RO	NY	CH	PD	NG	PI	ZI	MI	occ.
Order **FALCONIFORMES**																																											
Family **ACCIPITRIDAE** – Hawks, Eagles, Vultures, etc.																																											
Southern Banded Snake Eagle *Circaetus fasciolatus*	F	x	.	x	x	x	x	x	x	.	.	x	x	.	.	x	x	x	.	.	.	x	x	x	x	x	x	x	x	.	.	.	x	x	x	.	.	x	.	.	.	.	58.5
Great Sparrowhawk *Accipiter melanoleucus*	F	.	.	.	.	x	x	.	.	.	x	x	x	x	x	x	.	.	.	.	x	x	.	.	.	x	.	x	.	.	.	.	.	.	.	.	.	.	.	x	x	.	34.1
African Goshawk *Accipiter tachiro*	F	x	x	x	x	x	x	x	x	x	.	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	97.6
Ayres' Hawk Eagle *Hieraaetus ayresii*	F	.	.	x	.	.	x	.	.	.	.	x	.	.	.	.	.	.	x	.	.	x	.	.	.	.	.	.	.	.	.	.	.	x	x	x	.	.	.	.	.	.	19.5
African Crowned Eagle *Stephanoaetus coronatus*	FF	.	.	x	.	.	x	x	.	x	.	x	x	.	x	x	x	x	x	x	x	x	x	x	.	x	x	x	x	x	.	x	x	.	x	x	x	x	x	.	.	.	68.3
Bat Hawk *Macheiramphus alcinus*	F	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4.9
Order **GALLIFORMES**																																											
Family **NUMIDIDAE** – Guineafowls																																											
Crested Guineafowl *Guttera pucherani*	F	x	x	x	.	.	x	x	x	x	.	x	.	x	x	.	x	x	x	x	x	.	.	x	x	x	x	x	x	x	x	x	x	x	x	x	.	x	x	.	x	.	75.6
Order **GRUIFORMES**																																											
Family **RALLIDAE** – Rails and Crakes																																											
Buff-spotted Flufftail *Sarothrura elegans*	FF	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	x	?	.	.	.	.	.	.	.	.	.	.	x	x	.	9.8
Order **COLUMBIFORMES**																																											
Family **COLUMBIDAE** – Doves and Pigeons																																											
Lemon Dove *Aplopelia larvata*	FF	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	x	.	.	.	.	.	.	x	.	.	.	.	.	.	.	9.8
Eastern Bronze-naped Pigeon *Columba delegorguei*	FF	.	.	.	.	.	x	.	.	.	.	x	.	.	.	x	.	.	x	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	x	.	17.1
Tambourine Dove *Turtur tympanistria*	F	x	x	x	x	x	x	.	x	x	x	x	x	x	x	x	x	x	x	x	x	x	.	x	x	x	x	x	x	x	.	x	x	x	x	.	x	x	x	x	x	x	90.2
Pemba Green Pigeon *Treron pembaensis*	f	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	2.4
African Green Pigeon *Treron calva*	F	.	x	x	x	x	x	.	.	.	x	x	.	.	.	x	x	.	x	.	x	x	.	x	x	x	.	x	x	x	.	x	.	.	x	.	.	x	x	.	x	x	58.5
Order **PSITTACIFORMES**																																											
Family **PSITTACIDAE** – Parrots and Lovebirds																																											
Brown-headed Parrot *Poicephalus cryptoxanthus*	F	.	.	.	x	.	x	x	x	.	.	x	.	.	.	.	.	.	.	x	x	.	.	.	x	.	.	x	.	x	.	x	x	x	.	x	x	x	x	x	.	.	43.9
Order **CUCULIFORMES**																																											
Family **MUSOPHAGIDAE** – Turacos																																											
Fischer's Turaco *Tauraco fischeri*	F	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	58.5
Livingstone's Turaco *Tauraco livingstonii*	F	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	x	x	x	x	.	x	x	x	x	x	.	x	x	.	.	.	.	29.3
Family **CUCULIDAE** – Cuckoos and Coucals																																											
Barred Long-tailed Cuckoo *Cercococcyx montanus**	FF	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	x	.	x	.	.	.	x	.	.	.	.	x	x	x	.	x	x	x	.	.	.	24.4
Emerald Cuckoo *Chrysococcyx cupreus*	F	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2.4
Yellowbill *Ceuthmochares aereus*	F	.	x	x	x	x	x	x	.	x	x	x	x	x	x	x	x	x	x	x	x	x	.	x	x	x	x	x	x	x	x	x	.	x	x	.	.	x	x	x	x	x	85.4

	Forest	So									Kenya																				Tanzania								Islands			%
	depend.	JR	BO	TR	DK	GD	SO	MT	GN	TL	WA	SH	DJ	KN	TM	MU	GN	BU	MR	DZ	MA	EU	KL	GG	MS	KZ	PA	PU	KZ	VI	KI	MC	KW	LI	RO	NY	CH	PD	NG	PI	ZI	MI	occ.
Order **STRIGIFORMES**																																											
Family **STRIGIDAE** – Owls																																											
Usambara Eagle-Owl *Bubo vosseleri*	FF	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2.4
African Wood Owl *Strix woodfordii*	F	x	.	x	x	x	x	.	x	x	.	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	.	x	x	x	x	x	x	.	x	x	x	.	85.4
African Barred Owlet *Glaucidium capense*	F	x	x	x	x	x	x	x	x	.	.	x	x	x	.	.	x	.	.	x	.	.	.	.	.	.	.	x	.	.	.	.	.	.	x	.	.	.	.	.	.	x	39.0
Sokoke Scops Owl *Otus ireneae*	FF	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4.9
Pemba Scops Owl *Otus pembaensis*	f	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	2.4
Pel's Fishing Owl *Scotopelia peli*	F	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2.4
Order **CAPRIMULGIFORMES**																																											
Family **CAPRIMULGIDAE** – Nightjars																																											
Fiery-necked Nightjar *Caprimulgus pectoralis*	F	.	x	x	x	x	x	.	x	.	.	x	.	x	.	.	.	.	.	.	.	.	.	x	x	x	x	x	x	x	.	x	.	.	x	x	.	x	x	.	.	.	48.8
Order **APODIFORMES**																																											
Family **APODIDAE** – Swifts and Spinetails																																											
Böhm's Spinetail *Neafrapus boehmi*	F	.	.	.	.	x	x	x	.	x	.	x	x	.	.	.	.	.	x	x	x	x	x	x	x	x	.	x	x	x	.	x	x	x	x	.	.	x	x	.	.	x	58.5
Mottled Spinetail *Telecanthura ussheri*	F	.	.	x	.	x	x	.	x	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	12.2
Order **TROGONIFORMES**																																											
Family **TROGONIDAE** – Trogons																																											
Narina's Trogon *Apaloderma narina*	F	x	x	x	x	x	x	x	x	x	.	x	x	.	x	x	x	.	x	x	x	x	x	x	x	x	x	x	x	x	.	x	x	x	x	x	x	x	x	.	x	x	87.8
Order **CORACIIFORMES**																																											
Family **BUCEROTIDAE** – Hornbills																																											
Silvery–cheeked Hornbill *Bycanistes brevis*	F	.	.	x	.	x	x	x	.	.	.	x	x	x	x	x	x	x	x	x	x	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	36.6
Trumpeter Hornbill *Bycanistes bucinator*	F	.	.	x	.	x	x	x	x	x	.	x	.	.	.	.	x	x	x	x	x	x	x	x	x	x	x	x	x	.	x	x	x	x	x	x	x	x	x	.	.	.	70.7
Order **PICIFORMES**																																											
Family **CAPITONIDAE** – Barbets and Tinkerbirds																																											
White-eared Barbet *Stactolaema leucotis*	F	.	.	.	.	.	.	.	.	.	.	x	x	.	.	.	.	.	.	x	x	x	.	x	.	.	.	x	x	.	.	.	x	.	.	.	.	x	x	.	.	.	26.8
Green Barbet *Stactolaema olivacea*	FF	.	.	.	.	x	x	.	.	.	.	x	x	x	x	x	x	x	x	x	x	x	.	.	.	.	.	x	.	.	.	.	.	.	x	.	.	x	x	.	.	.	41.5
Yellow–rumped Tinkerbird *Pogoniulus bilineatus*	F	.	.	x	.	x	x	.	.	.	x	x	.	x	x	x	x	x	x	x	x	.	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	.	x	x	78.0
Eastern Green Tinkerbird *Pogoniulus simplex*	FF	.	.	.	.	x	x	.	x	.	x	x	.	.	x	x	x	x	x	.	x	.	.	x	x	x	x	x	x	.	.	x	x	x	x	.	x	x	x	.	x	.	61.0
Family **PICIDAE** – Woodpeckers, Wrynecks and Piculets																																											
Golden-tailed Woodpecker *Campethera abingoni*	F	x	.	x	x	x	x	.	.	.	.	x	.	.	.	.	.	.	x	.	.	x	.	.	.	x	.	x	.	.	.	.	x	x	x	x	.	x	x	.	.	.	39.0
Mombasa Woodpecker *Campethera mombassica*	F	.	x	.	.	.	x	x	x	x	.	x	x	x	.	.	x	x	x	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	29.3
Order **PASSERIFORMES**																																											
Family **EURYLAIMIDAE** – Broadbills																																											
African Broadbill *Smithornis capensis*	FF	.	.	.	.	.	x	.	.	.	.	x	x	.	.	.	x	x	x	.	x	x	.	x	x	x	x	x	x	x	.	x	x	x	x	x	x	x	x	.	.	.	56.1
Family **PITTIDAE** – Pittas																																											
African Pitta *Pitta angolensis***	FF	.	.	.	.	x	x	.	.	.	.	.	.	x	.	.	.	.	.	.	.	x	.	.	.	.	.	x	.	x	.	.	x	x	x	.	x	.	.	.	.	.	24.4
Family **MOTACILLIDAE** –Wagtails, Pipits and Longclaws																																											
Sokoke Pipit *Anthus sokokensis*	FF	.	.	.	x	x	x	.	x	.	.	x	.	.	.	.	.	.	.	x	x	.	x	.	.	x	.	x	.	x	.	.	.	.	.	.	.	.	.	.	.	.	26.8
Family **PYCNONOTIDAE** – Bulbuls																																											
Stripe-cheeked Greenbul *Andropadus milanjensis**	FF	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4.9
Little Greenbul *Andropadus virens*	F	.	.	x	.	.	.	.	.	.	.	x	x	x	x	x	x	x	x	.	x	x	.	.	.	.	.	x	x	x	.	x	.	x	x	.	.	.	.	.	x	x	46.3

	Forest	So									Kenya																			Tanzania										Islands		%
	depend.	J R	B O	T R	D K	G D	S O	M T	G N	T L	W A	S H	D J	K N	T M	M U	G N	B U	M R	D Z	M A	E U	K L	G G	M S	K Z	P A	P U	K Z	V I	K I	M C	K W	L I	R O	N Y	C H	P D	N G	P I	Z I	M I	occ.
Order **PASSERIFORMES** (cont.)																																											
Family **PYCNONOTIDAE** – Bulbuls (cont.)																																											
Yellow-bellied Greenbul *Chlorocichla flaviventris*	F	x	x	x	x	x	x	.	x	.	x	x	x	.	.	.	.	.	x	.	.	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	.	.	.	70.7
Eastern Nicator *Nicator gularis*	F	x	x	.	x	x	x	x	x	x	.	x	.	.	.	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	.	x	.	82.9
Tiny Greenbul *Phyllastrephus debilis*	FF	.	.	.	.	.	x	.	.	.	.	x	x	.	.	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	.	x	x	x	.	.	.	63.4
Fischer's Greenbul *Phyllastrephus fischeri*	FF	.	x	x	.	x	x	.	.	.	.	x	x	.	.	x	x	x	x	x	x	x	.	x	x	x	x	x	x	x	x	x	x	x	x	.	x	x	x	.	.	.	68.3
Yellow-streaked Greenbul *Phyllastrephus flavostriatus*	FF	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.	x	.	x	x	x	x	.	.	.	x	x	x	.	x	x	x	.	.	.	29.3
Brownbul *Phyllastrephus terrestris*	F	.	x	x	.	x	x	.	.	.	x	x	.	x	.	x	x	x	x	.	x	x	.	x	x	.	.	x	.	x	.	.	.	x	.	.	.	x	x	.	.	.	48.8
Family **TIMALIIDAE** – Babblers																																											
Pale-breasted Illadopsis *Illadopsis rufipennis*	FF	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	x	x	.	.	.	.	.	.	.	.	.	.	.	.	.	7.3
Family **TURDIDAE** – Thrushes and Robins																																											
White-chested Alethe *Alethe fuelleborni*	FF	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	x	.	.	.	.	.	.	.	.	x	.	.	.	.	.	7.3
Red-capped Robin Chat *Cossypha natalensis***	F	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	.	x	x	x	.	x	x	95.1
Red-tailed Ant Thrush *Neocossyphus rufus*	FF	.	x	x	.	x	x	.	.	x	.	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	.	.	x	x	x	.	x	x	x	.	x	.	75.6
White-starred Robin *Pogonocichla stellata*	F	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	x	.	.	x	x	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	12.2
East Coast Akalat *Sheppardia gunningi*	FF	.	.	x	.	.	x	.	.	.	.	x	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	x	x	.	.	.	.	x	x	.	x	.	.	.	x	.	24.4
Swynnerton's Robin *Swynnertonia swynnertoni*	FF	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2.4
Spotted Ground Thrush *Zoothera guttata***	FF	.	.	x	.	x	x	.	x	.	x	x	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	x	x	.	.	.	.	x	x	.	.	.	.	.	.	.	26.8
Orange Ground Thrush *Zoothera gurneyi**	FF	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	x	.	.	.	x	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	9.8
Family **MUSCICAPIDAE** – Flycatchers																																											
Ashy Flycatcher *Muscicapa caerulescens*	F	x	x	x	x	x	x	.	.	.	.	x	.	.	x	x	x	.	x	x	x	x	.	.	.	x	.	x	.	.	.	.	.	x	.	.	.	.	.	.	.	.	41.5
Family **SYLVIIDAE** – Warblers																																											
White-winged Apalis *Apalis chariessa*	FF	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2.4
Black-headed Apalis *Apalis melanocephala*	FF	x	x	x	x	x	x	.	x	x	.	x	x	.	.	x	x	x	x	x	x	x	.	x	x	x	.	x	x	.	.	.	.	x	x	.	.	.	x	.	.	.	61.0
Kretschmer's Longbill *Macrospehnus kretschmeri*	FF	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	x	x	.	x	x	.	.	.	x	.	x	.	.	.	.	.	.	.	17.1
Green-capped Eremomela *Eremomela scotops*	F	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2.4
Family **ZOSTEROPIDAE** – White eyes																																											0.0
Yellow White-eye *Zosterops senegalensis*	F	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	x	.	.	.	.	x	x	x	.	.	.	.	.	x	.	.	.	x	.	.	.	17.1
Pemba White-eye *Zosterops vaughani*	f	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	2.4
Family **MONARCHIDAE** – Monarchs and Fantails																																											
Little Yellow Flycatcher *Erythrocercus holochlorus*	FF	x	.	x	.	x	x	.	.	x	.	.	x	.	.	x	x	x	x	.	x	x	x	x	x	x	x	x	x	.	.	.	.	.	.	.	.	.	.	.	.	.	46.3
Livingstone's Flycatcher *Erythrocercus livingstonei*	f	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	x	x	x	x	x	x	.	.	.	17.1
Crested Flycatcher *Trochocercus cyanomelas*	FF	x	x	x	.	x	x	.	x	.	.	x	.	.	.	x	x	x	x	x	x	x	.	x	x	x	x	x	x	x	.	x	x	x	x	x	x	x	x	.	x	.	73.2
Family **PLATYSTEIRIDAE** – Wattle-eyes																																											
Forest Batis *Batis mixta*	FF	.	.	.	.	.	x	.	x	.	.	x	x	x	x	x	x	x	x	x	x	x	.	x	x	x	x	x	x	.	.	x	x	.	.	.	.	.	.	.	.	.	51.2
Reichenow's Batis *Batis reichenowi*	FF	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	x	.	x	x	x	.	.	.	12.2
East Coast Batis *Batis soror*	F	.	.	x	x	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	x	x	.	x	x	19.5
Black-throated Wattle-eye *Platysteira peltata*	F	x	.	x	.	.	x	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	x	x	.	.	x	.	x	x	.	.	x	x	x	.	x	34.1
Family **PRIONOPIDAE** – Helmet Shrikes																																											
Chestnut-fronted Helmet Shrike *Prionops scopifrons*	F	x	x	x	.	x	x	x	x	.	.	x	.	.	.	.	.	.	x	x	x	.	.	x	x	x	x	x	x	x	.	x	x	x	x	.	.	x	x	.	.	.	58.5

	Forest depend.	So										Kenya																		Tanzania										Islands		%
		JR	BO	TR	DK	GD	SO	MT	GN	TL	WA	SH	DJ	KN	TM	MU	GN	BU	MR	DZ	MA	EU	KL	GG	MS	KZ	PA	PU	KZ	VI	KI	MC	KW	LI	RO	NY	CH	PD	NG	PI	ZI	MI	occ.
Order **PASSERIFORMES** (cont.)																																											
Family **MALACONOTIDAE** – Bush Shrikes																																											
Black-backed Puffback *Dryoscopus cubla*	F	x	x	x	x	.	x	.	x	.	x	x	x	.	x	x	.	.	x	.	.	x	.	x	x	x	.	x	x	x	.	x	x	x	x	x	x	x	x	.	x	x	70.7
Four-coloured Bush-Shrike *Malaconotus quadricolor*	F	.	.	.	.	x	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	x	x	.	x	x	x	.	.	x	x	x	x	x	x	x	.	.	.	36.6
Family **DICRURIDAE** – Drongos																																											
Square-tailed Drongo *Dicrurus ludwigii*	F	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.	x	x	x	x	x	x	x	.	x	x	x	x	x	x	x	x	.	.	.	41.5
Family **ORIOLIDAE** – Orioles																																											
Green-headed Oriole *Oriolus chlorocephalus*	F	.	.	.	.	.	x	.	.	.	.	x	.	.	.	.	.	.	x	.	x	x	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.	14.6
Family **STURNIDAE** – Starlings and Oxpeckers																																											
Black-bellied Starling *Lamprotornis corruscus*	F	x	x	x	x	x	x	x	x	x	.	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	.	x	x	x	.	.	90.2
Family **NECTARINIIDAE** – Sunbirds																																											
Collared Sunbird *Anthreptes collaris*	F	x	x	x	x	x	x	.	x	.	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	.	x	x	x	x	x	x	x	x	.	x	x	90.2
Uluguru Violet-backed Sunbird *Anthreptes neglectus*	F	.	.	x	.	x	.	.	.	.	.	.	.	.	.	.	x	x	.	.	.	x	.	x	x	x	.	x	x	.	.	.	x	x	x	.	x	x	x	.	.	.	39.0
Amani Sunbird *Anthreptes pallidigaster*	F	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4.9
Plain-backed Sunbird *Anthreptes reichenowi*	FF	.	.	x	.	x	x	.	x	.	.	x	x	.	.	.	.	.	x	x	x	x	x	x	x	x	x	.	.	.	.	.	.	x	x	x	x	x	x	.	.	.	51.2
Banded Green Sunbird *Anthreptes rubritorques**	FF	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2.4
Olive Sunbird *Nectarinia olivacea*	FF	x	x	x	.	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	.	x	x	x	x	x	x	95.1
Pemba Sunbird *Nectarinia pembae*	f	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	2.4
Family **PLOCEIDAE** – Weavers, etc.																																											
Dark-backed Weaver *Ploceus bicolor*	F	x	x	x	.	x	x	.	.	.	.	x	x	.	.	x	x	x	x	x	x	x	.	x	x	x	x	x	x	x	.	.	x	x	x	x	x	x	x	.	x	.	70.7
Clarke's Weaver *Ploceus golandi***	FF	.	.	.	x	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4.9
Family **ESTRILDIDAE** – Waxbills, etc.																																											
Peter's Twinspot *Hypargos niveoguttatus*	F	.	x	.	.	x	x	x	x	.	x	x	x	x	x	x	.	.	x	x	x	x	x	x	x	x	x	x	x	x	.	x	x	x	x	x	x	x	x	.	.	x	78.0
Green-backed Twinspot *Mandingoa nitidula*	FF	.	.	x	.	x	x	x	x	.	x	x	x	.	.	.	.	x	x	x	x	x	.	x	x	x	x	x	x	x	x	x	x	x	x	.	x	x	x	x	x	x	75.6

Non-Forest Birds (forest visitors) frequently recorded in Coastal Forests: Lizard Buzzard *Kaupifalco monogrammicus*, Harrier Hawk *Polyboroides radiatus*, Little Sparrowhawk *Accipiter minullus*, Long-crested Eagle *Lophaetus occipitalis*, Brown-necked Parrot *Poicephalus robustus*, Ring-necked Dove *Streptopelia capicola*, Red-eyed Dove *Streptopelia semitorquata*, Emerald-spotted Wood Dove *Turtur chalcospilos*, Broad-billed Roller *Eurystomus glaucurus*, Klaas's Cuckoo *Chrysococcyx klaas*, Black Cuckoo *Cuculus clamosus*, Thick-billed Cuckoo *Pachycoccyx audeberti*, African Pygmy Kingfisher *Ispidina picta*, Crowned Hornbill *Tockus alboterminalis*, Scaly-throated Honeyguide *Indicator variegatus*, Bearded Woodpecker *Thripias namaquus*, Black-collared Barbet *Lybius torquatus*, Greater Honeyguide *Indicator indicator*, Pallid Honeyguide *Indicator meliphilus*, Lesser Honeyguide *Indicator minor*, Green-backed Woodpecker *Campethera cailliautii*, Black Saw-wing *Psalidoprocne holomelas*, Northern Brownbul *Phyllastrephus strepitans*, Common Bulbul *Pycnonotus barbatus*, Eastern Bearded Scrub Robin *Cercotrichas quadrivirgata*, Lead-coloured Flycatcher *Myioparus plumbeus*, Grey-backed Cameroptera *Cameroptera brachyura*, Tawny-flanked Prinia *Prinia subflava*, Paradise Flycatcher *Terpsiphone viridis*, Black and White Flycatcher *Bias musicus*, Retz's Helmet Shrike *Prionops retzii*, Tropical Boubou *Laniarius ferrugineus*, Black Cuckoo-shrike *Campephaga flava*, Black-headed Oriole *Oriolus larvatus*, Violet-backed Starling *Cinnyricinclus leucogaster*, Amethyst Sunbird *Nectarinia amethystina*, Lesser Seed Cracker *Pyrenestes minor*, Black and White Mannikin *Lonchura bicolor*.

Key:

* = Altitudinal migrant. Except for Stripe-cheeked Greenbul and Banded Green Sunbird, these species have, or probably have, breeding populations in Coastal Forests.

** = Afrotropical migrant.

Forest depend. = Forest dependence (see text for definitions); **JR** = Jubba River, **BO** = Boni, **TR**= Tana River, **DK** = Dakatcha, **GD** = Gede, **SO** = Sokoke, **MT** = Mtswakara, **GN** = Gandini, **TL** = Teleza, **WA** = Waa, **SH** = Shimba Hills, **DJ** = Diani/Jadini, **KN** = Kinondo, **TM** = Timbwa, **MU** = Muhaka, **GN** = Gongoni, **BU** = Buda, **MR** = Mrima, **DZ** = Dzombo, **MA** = Marenji, **EU** = East Usambara, **KL** = Kilulu, **GG** = Gendagenda, **MS** = Msubugwe, **KZ** = Kiono (Zaraninge), **PA** = Pande, **PU** = Pugu, **KZ** = Kazimzumbwi, **VI** = Vikindu, **KI** = Kisiju, **MC** = Mchungu, **KW** = Kiwengoma, **LI** = Litipo, **RO** = Rondo, **NY** = Nyangamara, **CH** = Chitoa, **PD** = Pindiro, **NG** = Ngarama, **PI** = Pemba Island, **ZI** = Zanzibar Island, **MI** = Mafia Island.

% **occ** = percentage occurrence in forest sites.

Appendix 5 Mammals of the eastern African Coastal Forests

		So	Kenya							Tanzania																		Islands			Ml	Zi	Mz
	Forest depend.	JR	TR	AS	SH	EU	KL	AC	TW	MB	GG	MJ	ZK	RN	PK	RS	VI	KI	MC	NK	KG	TO	LI	RO	PD	CH	NG	KM	PI	ZI	MI	ML	HR	MZ
Order **INSECTIVORA**																																		
Family **SORICIDAE** – Shrews																																		
Crocidura fuscomurina (Heuglin, 1865)	F	.	.	[]	.	x	.	.	.	.	.	.	x	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Crocidura hildegardae Thomas, 1904	F	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	[]	.	.
Crocidura hirta (Peters, 1852)	f	.	.	.	.	x	.	.	.	.	x	.	x	x	x	.	.	.	.	x	.	.	.	[]	.	.	.	.	.	.	.	.	[]	.
Crocidura jacksoni Thomas, 1904	F	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.	x	.	[]	x	.	.	.
Crocidura luna Dollman, 1910	f	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	[]	[]	.
Crocidura xanthippe Osgood, 1910	f	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.
Crocidura parvipes Osgood, 1910	F	.	.	[]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Crocidura voi Osgood, 1910	f	.	.	[]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Crocidura sp. (not identified)	-	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.	x	.	.	.	.	.	.
Suncus varilla (Thomas, 1895)	f	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Shrew species a	FF?	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Shrew species b	FF?	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Shrew species c	FF?	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Shrew species d	FF?	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Shrew species e	FF?	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.
Order **CHIROPTERA**																																		
Family **PTEROPODIDAE** – Fruit bats																																		
Eidolon helvum (Kerr, 1792)	f	.	.	.	.	[]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	[]	[]	.	.	.	[]
Epomophorus labiatus (Temminck, 1837)	F	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.
Epomophorus wahlbergi (Sundevall, 1846)	F	[]	.	[]	.	x	.	x	.	x	x	x	x	.	.	.	.	.	.	x	.	.	x	x	.	.	.	.	[]	[]	.	.	[]	[]
Myonycteris relicta Bergmans, 1980	FF	.	.	.	[]	.	.	.	.	.	x	x	x	.	.	x	.	.	.	.	x	x	.	x	.	.	.	.	.	.	.	.	.	.
Pteropus seychellensis Milne-Edwards, 1877	f	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.
Pteropus voeltzkowi Matschie, 1909	F	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	[]	.	.	.	.	.
Rousettus aegyptiacus (E. Geoffroy, 1810)	f	.	.	.	.	x	.	x	.	.	.	x	.	.	x	.	.	.	.	.	x	.	.	.	.	.	.	.	.	[]	x	[]	.	[]
Rousettus angolensis (Bocage, 1898)	F	.	.	.	.	x	.	.	x	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	[]
Family **EMBALLONURIDAE** – Sheath-tailed bats																																		
Coleura afra (Peters, 1867)	f	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Taphozous hildegardeae Thomas, 1909	f	.	.	.	.	.	x	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	[]	.	.	.	.
Family **NYCTERIDAE** – Slit-faced bats																																		
Nycteris aurita Andersen, 1912	F	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Nycteris grandis Peters, 1865	F	.	.	.	.	x	.	.	.	.	x	x	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.
Nycteris hispida (Schreber, 1775)	F	.	.	.	.	.	.	.	x	.	.	.	.	.	x	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Nycteris macrotis Dobson, 1876	FF	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Nycteris thebaica E. Geoffroy, 1810	f	.	.	[]	.	.	x	.	.	.	.	.	.	.	[]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Nycteris woodi K Andersen, 1914	F	[]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

		So	Kenya			----------														Tanzania										Islands			Ml	Zi	Mz
	Forest depend.	J R	T R	A S	S H	E U	K L	A C	T W	M B	G G	M J	Z K	R N	P K	R S	V I	K I	M C	N K	K G	T O	L I	R O	P D	C H	N G	K M	P I	Z I	M I	M L	H R	M Z
Order **CHIROPTERA** (cont.)																																		
Family **MEGADERMATIDAE** – Large-winged bats																																		
Cardioderma cor (Peters, 1872)	f	[]	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	[]	.
Lavia frons (E. Geoffroy, 1810)	f	[]	[]	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Family **RHINOLOPHIDAE** – Horseshoe and Leaf-nosed bats																																		
Hipposideros caffer (Sundervall, 1846)	F	.	.	.	.	.	.	x	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	[]	[]	.	[]	.	.
Hipposideros commersoni (E. Geoffroy, 1813)	f	[]	.	.	.	.	.	x	.	.	x	.	.	.	x	x	.	.	.	.	.	.	.	.	.	.	.	.	[]	[]	.	.	.	.
Hipposideros cyclops (Temminck, 1853)	FF	.	.	.	[]	x	.	+	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hipposideros ruber (Noack, 1893)	F	.	.	.	.	x	x	x	x	.	x	x	x	x	x	.	.	.	.	x	x	x	.	.	.	.	.	.	.	[]	x	.	.	.
Rhinolophus clivosus Cretzschmar, 1828	f?	.	.	.	[]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	[]	.
Rhinolophus deckenii Peters, 1867	F	.	.	.	.	x	x	.	x	.	.	.	.	.	.	.	.	.	.	x	x	x	.	.	.	x	.	.	[]	[]	.	.	.	.
Rhinolophus eloquens K. Andersen, 1905	-	.	.	.	.	x	x	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Rhinolophus fumigatus Rüppell, 1842	f	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Rhinolophus hildebrandti Peters, 1878	f	.	.	.	.	[]	.	x	x	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	[]	.	.	.	.	.	.	.	.
Rhinolophus landeri Martin, 1838	F	.	.	.	.	x	.	.	.	.	.	.	.	.	x	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Rhinolophus swinnyi Gough, 1908	-	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	[]	.	.	.	.
Rhinolophus sp.A nov.	FF?	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Triaenops persicus Dobson, 1871	F	.	.	.	.	x	.	x	.	.	x	x	x	.	x	x	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.
Family **VESPERTILIONIDAE** – Vesper bats																																		
Chalinolobus argentatus (Dobson, 1875)	F	.	.	.	.	.	.	.	.	.	.	x	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Chalinolobus kenyacola (Peterson, 1982)	FF	.	[]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Chalinolobus variegatus (Tomes, 1861)	f	.	.	.	.	.	.	.	.	.	x	.	x	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Eptesicus capensis (A. Smith, 1829)	F	.	.	.	.	.	.	.	.	.	.	.	x	.	x	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Eptesicus rendalli (Thomas, 1889)	f	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.
Eptesicus somalicus (Thomas, 1901)	f?	.	.	.	.	.	.	.	x	.	x	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Kerivoula africana Dobson, 1878	FF	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.
Kerivoula argentata Tomes, 1861	f	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.
Miniopterus minor Peters, 1866	f	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Myotis bocagei (Peters, 1870)	F	.	.	.	.	x	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.
Myotis tricolor (Temminck, 1832)	f	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Myotis welwitchii (Gray, 1866)	f?	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.
Nycticeius schlieffeni (Peters, 1859)	f	[]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Pipistrellus eisentrauti Hill, 1968	F	[]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Pipistrellus nanus (Peters, 1852)	F	.	.	.	.	.	.	[]	.	.	x	x	.	.	x	.	.	.	.	.	x	.	x	[]	.	.	.	.	.	.	.	.	.	.
Pipistrellus rusticus (Tomes, 1861)	F	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Scotoecus albofuscus (Thomas, 1890)	f	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.
Scotoecus hirundo de Winton, 1899	f	[]	.	.	.	x	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Scotophilus dinganii (A. Smith, 1833)	F	[]	.	.	.	.	x	.	.	.	.	.	.	.	x	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	[]	.	.
Scotophilus nigrita (Schreber, 1774)	F	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Scotophilus viridis (Peters, 1852)	f	.	.	.	.	.	x	.	x	.	x	x	x	.	.	.	.	.	.	x	x	.	x	x	.	Ndimba FR			.	.	x	.	.	.

	Forest depend.	So JR	Kenya TR	AS	SH	Tanzania EU	KL	AC	TW	MB	GG	MJ	ZK	RN	PK	RS	VI	KI	MC	NK	KG	TO	LI	RO	Islands PD	CH	NG	KM	PI	ZI	MI	Ml ML	Zi HR	Mz MZ
Order **CHIROPTERA** (cont.)																																		
Family **MOLOSSIDAE** – Free-tailed bats																																		
Mops brachypterus (Peters, 1852)	f	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	[]	.	.	.	.
Otomops martienssensi (Matschie, 1897)	F	.	.	.	.	[]	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Tadarida aegyptiaca (E. Geoffroy, 1818)	f	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Tadarida fulminans (Thomas, 1903)	f	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	Nyangao FR			.	.	.	.	.	.
Order **PRIMATES**																																		
Family **GALAGONIDAE** – Bushbabies																																		
Galago senegalensis E. Geoffroy, 1796	F	[]	[]	.	.	.	.	[]	.	.	.	.	.	.	[]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	[]
Galago sp. nov. A	FF	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Galago sp. nov. B	FF	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	x	.	.	.	.	.	.	.	.	.
Galagoides demidoff (Fischer, 1806)	FF	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Galagoides zanzibaricus (Matschie, 1893)	FF	[]	[]	[]	.	o	o	.	o	.	o	o	.	o	o	o	.	.	o	o	.	o	o	o	[]	[]	[]	.	.	[]	.	[]	.	.
Otolemur crassicaudatus (E. Geoffroy, 1812)	F	[]	.	[]	.	.	.	[]	.	[]	.	.	.	.	o	.	.	.	.	.	.	.	[]	[]	.	.	.	.	.	.	[]	.	[]	[]
Otolemur garnetti (Ogilby, 1838)	F	.	.	[]	.	o	o	.	o	o	o	o	o	.	o	.	.	o	.	o	.	o	o	o	[]	.	[]	.	[]	[]	.	.	.	.
Family **CERCOPITHECIDAE** – Cheek-pouch monkeys																																		
Cercocebus galeritus Peters, 1879	FF	.	[]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cercopithecus mitis Wolf, 1822	FF	[]	[]	[]	[]	+	+	+	+	.	+	+	+	.	+	+	+	+	+	+	+	+	+	+	[]	[]	[]	.	.	[]	+	[]	[]	[]
Chlorocebus aethiops (Linnaeus, 1758).	F	.	[]	[]	[]	+	+	+	.	.	+	+	.	+	+	.	+	.	.	.	+	.	+	+	.	.	[]	.	[]	.	+	[]	.	[]
Colobus angolensis Sclater, 1860	FF	.	.	.	[]	+	+	+	+	.	+	+	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Papio hamadryas (Linnaeus, 1758)	F	[]	[]	[]	.	.	.	.	.	.	+	+	+	+	[]	+	+	.	.	.	+	+	.	.	.	.	[]	.	.	.	.	[]	.	.
Procolobus pennantii kirkii Waterhouse, 1838	FF	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	[]	.	.	.	.
Procolobus rufomitratus (Peters, 1879)	FF	.	[]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Order **CARNIVORA**																																		
Family **CANIDAE** – Dogs																																		
Canis adustus Sundevall, 1847	F	.	[]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	+	[]	.	[]	.	.	.	.	.	.	.
Otocyon megalotis Müller, 1836	F	.	[]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Family **FELIDAE** – Cats																																		
Caracal caracal (Schreber, 1776)	F	.	.	[]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Felis silvestris Schreber, 1775	F	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	[]	.	.	.	.	.	.	.
Leptailurus serval (Schreber, 1775)	F	[]	[]	[]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Panthera leo (Linnaeus, 1758)	f	[]	[]	.	.	.	.	.	.	.	.	o	*	.	*	*	.	.	*	.	*	.	o	*	[]	[]	[]	.	.	.	.	.	.	.
Panthera pardus (Linnaeus, 1758)	F	[]	[]	[]	.	*	.	.	.	.	.	*	*	.	[]	.	.	.	+	o	o	*	o	o	[]	[]	[]	.	.	[]	.	.	[]	[]
Family **HERPESTIDAE** – Mongooses																																		
Atilax paludinosus (G.[Baron] Cuvier, 1829)	f	.	[]	.	.	+	.	.	.	[]	.	+	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	[]	.	.	.	.	.
Bdeogale crassicauda Peters, 1852	F	.	.	[]	[]	x	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	[]	.	.	.	.	.	.	[]	.	.
Galerella sanguinea (Rüppell, 1836)	F	[]	.	[]	.	.	.	.	.	[]	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	[]	.	.	[]	.	[]	.	.
Genetta species	F	[]	[]	[]	.	+	.	.	.	.	+	.	.	.	[]	.	.	.	.	.	.	.	.	.	.	[]	.	.	.	.	.	.	[]	.
Helogale parvula (Sundevall, 1847)	f	[]	.	[]	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Herpestes ichneumon (Linnaeus, 1758)	F	.	.	[]	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+	.	.	.

	Forest depend.	So JR	Kenya TR	Kenya AS	Kenya SH	Tanzania EU	KL	AC	TW	MB	GG	MJ	ZK	RN	PK	RS	VI	KI	MC	NK	KG	TO	LI	RO	PD	CH	NG	KM	Islands PI	Islands ZI	Islands MI	Ml ML	Zi HR	Mz MZ
Order **CARNIVORA** (cont.)																																		
Family **HERPESTIDAE** – Mongooses (cont.)																																		
Ichneumia albicauda (G. [Baron] Cuvier, 1829)	F	□	□	□	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Nandinia binotata (Gray, 1830)	FF	.	.	.	.	+	.	.	.	.	+	.	.	.	□	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	□	□	□
Family **HYAENIDAE** – Hyaenas																																		
Crocuta crocuta (Erxleben, 1777)	F	.	□	□	□	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	*	.	□	.	□	.	.	.	.	□	.	.
Family **MUSTELIDAE** – Mustelids																																		
Aonyx capensis (Schinz, 1821)	f	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.	o	o	.	.	.	.	.	.	.	.	.	.	.	.
Mellivora capensis (Schreber, 1776)	f	□	.	□	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	+	□	.	.	.	.	.	.	.	.	.
Family **VIVERRIDAE** – Genets and Civets																																		
Civettictis civetta (Schreber, 1776)	F	□	□	□	.	+	o	.	.	+	.	+	+	.	□	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.
Order **PROBOSCIDEA**																																		
Family **ELEPHANTIDAE** – Elephants																																		
Loxodonta africana (Blumenbach, 1776)	F	□	□	□	□	.	.	.	.	*	.	+	*	.	.	+	.	.	+	o	+	o	o	o	□	□	□	.	.	.	.	.	.	□
Order **PERISSODACTYLA**																																		
Family **RHINOCEROTIDAE** – Rhinoceroses																																		
Diceros bicornis (Linnaeus, 1758)	f	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	□	.	.	.	.	.	.	.
Order **HYRACOIDEA**																																		
Family **PROCAVIIDAE** – Hyraxes																																		
Dendrohyrax arborius (A. Smith, 1927)	FF	.	.	.	□	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	□	.	□
Dendrohyrax validus True, 1890	F	.	.	.	.	o	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	□	□	.	.	.
Order **TUBULIDENTATA**																																		
Family **ORYCTEROPODIDAE** – Ant bears																																		
Orycteropus afer (Pallas, 1766)	f	□	□	□	□	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	o	o	*	*	□	.	.	.	.	.	.	.	.	.
Order **ARTIODACTYLA**																																		
Family **SUIDAE** – Pigs																																		
Phacochoerus africana (Gmelin, 1788)	f	□	□	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Potamochoerus larvatus (F. Cuvier, 1822)	F	□	□	□	□	o	+	.	.	.	x	+	x	+	+	.	.	.	.	+	+	+	x	+	□	□	□	.	.	□	□	.	□	□
Family **HIPPOPOTAMIDAE** – Hippopotamuses																																		
Hippopotamus amphibius Linnaeus, 1758	f	□	□	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	*	.	□	.	□	.	.	.	.	.	.	.
Family **BOVIDAE** – Horned ungulates																																		
Cephalophus adersi Thomes, 1918	FF	.	.	□	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	□	.	.	.	.
Cephalophus harveyi (Thomas, 1893)	FF	.	□	.	□	.	.	.	.	.	.	.	□	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cephalophus monticola (Thunberg, 1789)	FF	.	.	.	.	□	.	□	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	□	□	+	□	□	□
Cephalophus natalensis A. Smith, 1834	FF	□	□	□	.	.	+	.	.	□	+	+	+	.	+	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	□
Cephalophus spadix True, 1890	FF	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	□
Hippotragus niger (Harris, 1838)	F	.	.	.	+	.	.	.	.	.	+	+	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.

		So	Kenya			Tanzania																		Islands							MI	Zi	Mz
	Forest depend.	JR	TR	AS	SH	EU	KL	AC	TW	MB	GG	MJ	ZK	RN	PK	RS	VI	KI	MC	NK	KG	TO	LI	RO	PD	CH	NG	KM	PI	ZI	MI	ML	HR	MZ
Order **ARTIODACTYLA** (cont.)																																		
Family **BOVIDAE** – Horned ungulates (cont.)																																		
Kobus ellipsiprymnus (Ogilby, 1833)	f	.	□	□	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Madoqua kirkii (Günther, 1880)	f	□	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Neotragus moschatus (Von Dueben, 1846)	F	.	.	□	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	+	□	.	□	.	.	□	+	.	.	□
Syncerus caffer (Sparrman, 1779)	F	□	□	□	□	.	.	.	.	.	*	+	+	+	.	.	.	.	.	.	+	+	*	*	□	□	□	.	.	.	.	.	.	.
Tragelaphus scriptus (Pallas, 1766)	F	□	.	□	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	*	*	□	.	□	.	.	.	.	□	.	.
Tragelaphus angasii Gray, 1849	f	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	□
Order **PHOLIDOTA**																																		
Family **MANIDAE** – Pangolins																																		
Manis temminckii Smuts, 1832	f	.	□	.	.	.	.	.	.	.	+	.	.	.	□	.	.	.	.	.	.	.	.	.	□	.	.	.	.	.	.	.	.	.
Order **RODENTIA**																																		
Family **SCIURIDAE** – Squirrels																																		
Heliosciurus rufobrachium (Waterhouse, 1842)	F	□	□	□	□	.	+	.	.	+	.	.	.	.	.	.	.	.	+	+	+	+	+	+	.	□	.	.	.	□	+	.	.	□
Paraxerus flavovittis (Peters, 1852)	F	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	+	.	.	.	.	.	.	.	.	.	□
Paraxerus ochraceus (Huet, 1880)	F	□	□	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Paraxerus palliatus (Peters, 1852)	FF	.	□	□	□	+	+	.	.	.	+	+	+	.	.	.	.	.	+	+	.	.	+	+	□	□	□	.	.	□	+	□	□	□
Family **MURIDAE** – Murid rats and mice																																		
Acomys cahirinus (Desmarest, 1819)	f	□	.	□	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Acomys spinosissimus Peters, 1852	f	.	.	□	.	.	.	x	x	.	.	.	.	x	□	x	.	.	.	x	.	x	x	□	.	.	.	x.	.	.	.	□	□	.
Acomys wilsoni Thomas, 1892	f	.	□	□	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.
Mastomys natalensis (Smith, 1834)	f	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.
Beamys hindei Thomas, 1909	F	.	.	□	□	x	.	.	.	.	.	.	x	.	.	x	.	.	.	x	.	.	.	x	.	.	.	.	.	.	.	□	.	.
Cricetomys gambianus Waterhouse, 1840	F	.	.	□	.	x	x	.	.	.	x	+	+	.	+	.	.	.	.	+	.	.	.	o	.	.	.	+	.	□	x	□	□	□
Grammomys dolichurus (Smuts, 1832)	F	□	□	.	.	x	.	.	.	.	x	.	x	.	x	.	.	.	x	x	.	.	.	.	.	.	.	.	.	.	.	□	.	□
Grammomys caniceps Hutterer & Dieterlen, 1984	F	Malindi.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Grammomys cometes Thomas & Wroughton, 1908	F	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	□
Grammomys macmilliani (Wroughton, 1907)	-	.	.	.	.	.	.	x	.	.	x	.	x	.	x	.	.	.	x	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.
Lemniscomys griselda (Thomas, 1904)	f	.	□	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	□	.	.	.	.	.	.	.	.	.	.
Mus minutoides Smith, 1834	F	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	□	.	.	.	.	.	.	.	□	.	.
Pelomys fallax Peters, 1852	F	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	□	.
Praomys spp.	f	.	.	□	□	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.	□	.	.
Rattus rattus (Linnaeus, 1758)	f	.	.	.	.	x	.	.	.	.	.	.	.	.	□	.	.	.	+	.	x	.	.	.	.	.	.	.	.	□	x	.	.	.
Saccostomus mearnsi Heller, 1910	f	□	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Tatera robusta (Cretzschmar, 1826)	f	□	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	□	.	.	.	.	.	.	.	.	.	.
Tatera valida (Bocage, 1890)	f	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Family **MYOXIDAE** – Dormice																																		
Graphiurus murinus (Desmarest, 1822)	F	.	.	□	.	.	.	.	.	.	x	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	□	.
Graphiurus n.sp. cf *parvus*	FF?	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

		So	Kenya			Tanzania																						Islands			Ml	Zi	Mz
	Forest depend.	JR	TR	AS	SH	EU	KL	AC	TW	MB	GG	MJ	ZK	RN	PK	RS	VI	KI	MC	NK	KG	TO	LI	RO	PD	CH	NG	KM	PI	ZI	MI	ML	HR	MZ
Order **RODENTIA** (cont.)																																		
Family **THRYONOMYIDAE** – Cane-rats																																		
Thryonomys swinderianus (Temminck, 1827)	f	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
Sub-Order **HYSTRICOGNATHI**																																		
Family **HYSTRICIDAE** – Porcupines																																		
Hystrix afriaeaustralis Peters, 1852	F	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	[]	.	.	.	.	.	.	[]	[]	[]
Hystrix cristata Linnaeus, 1758	F	[]	.	[]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hystrix (not identified to species)	F	.	[]	.	.	o	o	.	o	.	o	.	o	.	o	.	.	.	.	.	o	o	.	.	.	.	.	.	.	.	o	.	.	.
Order **MACROSCELIDAE**																																		
Family **MACROSCELIDIDAE** – Elephant-shrews																																		
Petrodromus tetradactylus Peters, 1846	F	.	.	[]	.	+	+	.	+	.	+	+	+	.	x	+	.	.	.	+	+	.	+	+	.	.	[]	.	.	[]	+	[]	[]	[]
Rhynchocyon chrysopygus Günther, 1881	FF	.	.	[] (and other small forests in coastal Kenya).											.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Rhynchocyon cirnei Peters, 1847	f	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	.	.	.	.	+	.	+	+	[]	[]	[]	.	.	.	.	[]	.	[]
Rhynchocyon petersi Bocage, 1880	FF	.	.	.	[]	+	.	.	+	.	+	+	+	.	+	+	.	+	x	.	+	o	x	.	.	.	.	.	.	[]	+	.	.	.

Key: Species names and the order of families follow Wilson and Reeder (1993). Names within families are alphabetically arranged.

x = confirmed by specimen (bats and rodents by Dieter Kock and Kim Howell, shrews by Paula Jenkins, elephant-shrews by Clare FitzGibbon; *Beamys hindei* by Clare FitzGibbon, Herwig Leirs and Dieter Kock), + = sight records only, o = calls or signs only, * = reports of local people, [] = literature records.

Forest dependence: FF = Forest specialist, F = found in forest and also other habitats, f = normally regarded as a non-forest species (as assessed by NDB from Wilson and Reeder, 1993).

JR = Jubba valley in Somalia (Varty, 1988; 1990); **TR** = Tana river and delta in Kenya (Andrews *et al.*, 1975; Rodgers *et al.*, 1982); **AS** = Arabuko-Sokoke (Rodgers *et al.*, 1982; Thomas, 1984; Davies *et al.*, 1992; FitzGibbon, 1994; FitzGibbon *et al.*, 1995); **SH** = Shimba Hills (Aggundey and Schlitter, 1984; 1986; Bergmans, 1980; Rodgers *et al.*, 1982; Schlitter *et al.*, 1986; Davies *et al.*, 1992); **EU** = lowland Usambara forests in Tanzania (Frontier-Tanzania; Rodgers *et al.*, 1982; Rodgers and Homewood, 1982; Cambridge-Tanzania Rain Forest Survey, 1994); **KL** = Kilulu (Frontier-Tanzania); **AC** = Amboni Caves (Mkulumuzi) (Frontier-Tanzania); **TW** = Tongwe (Frontier-Tanzania); **MB** = Msubugwe (Frontier-Tanzania; Faldborg *et al.*, 1991); **GG** = Gendagenda (Frontier-Tanzania); **MJ** = Mkwaja (Frontier-Tanzania); **ZK** = Zaraninge-Kiono (Frontier-Tanzania); **RN** = Ruvu North (Frontier-Tanzania); **PK** = Pugu/Kazimzimbwe (Frontier-Tanzania; Howell, 1981); **RS** = Ruvu South (Frontier-Tanzania); **VI** = Vikindu (Frontier-Tanzania); **KM** = Kimboza Forest (lowland Ulugurus) (Frontier-Tanzania); **KI** = Kisiju (Frontier-Tanzania); **MC** = Mchungu (Frontier-Tanzania); **NK** = Namakutwa (Frontier-Tanzania); **KG** = Kiwengoma (Frontier-Tanzania); **TO** = Tong'omba (Frontier-Tanzania); **LI** = Litipo (Frontier-Tanzania; Eriksen *et al.*, 1994); **RO** = Rondo (Frontier-Tanzania; Christensen, 1987; Eriksen *et al.*, 1994); **PD** = Pindiro (Frontier-Tanzania; Eriksen *et al.*, 1994); **CH** = Chitoa (Frontier-Tanzania; Eriksen *et al.*, 1994); **NG** = Ngarama (Eriksen *et al.*, 1994); **PI** = Pemba Island (Pakenham, 1984); **ZI** = Zanzibar Island (Jozani) (Pakenham, 1984; Archer *et al.*, 1991); **MI** = Mafia Island (Frontier-Tanzania); **ML** = lowland forets of Malawi (Ansell and Dowsett, 1988), **HR** = lowland forests of Zimbabwe (Cotterill, 1994); **MZ** = lowland forests of southern Mozambique (Smithers and Lobão Tello, 1976).

Localities and data-sources: (General = Swynnerton and Hayman, 1951; Rodgers and Homewood, 1982; Kingdon, 1971–1982).

Appendix 6 Reptiles of the eastern African Coastal Forests

	Kenya		Tanzania																Islands			Mal.		Mozam.			Zi.
	TR	SH	AS	KL	AC	TW	GG	MB	MJ	ZK	PF	PK	RS	MC	KG	TO	NK	RP	PI	ZI	MI	KI	NB	SM	IF	DF	BA	HR
Order **CHELONII** – Chelonians																												
Suborder **CRYPTODIRA** – Modern Chelonians																												
Family **TESTUDINIDAE** – Tortoises																												
Kinixys belliana belliana Gray, 1891	.	.	[]	.	.	.	.	.	.	0	.	0	.	.	.	.	.	.	.	.	0	.	.	.	.	.	.	.
Order **SQUAMATA** – Scaled reptiles																												
Sub-order **SAURIA** – Lizards																												
Family **GEKKONIDAE** – Geckos																												
Lygodactylus uluguruensis† Pasteur, 1964	.	.	.	.	.	.	.	.	*	.	.	(also lower slopes of Uluguru North).								.	.	.	.	.	.	.	.	.
Lygodactylus conradti§ Matschie, 1892	.	.	Kambai and other sites in East Usambaras.									.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Lygodactylus broadleyi§ Pasteur, 1995	.	.	.	*	.	.	.	.	.	*	.	.	.	.	*	.				.	.	.	.	.	.	.	.	.
Lygodactylus rex§ Broadley, 1963	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.
Lygodactylus viscatus§ (Vaillant, 1873)	.	.	.	*	.	.	.	.	.	*	.	.	.	.	*	*	*	.	.	*	*	.	.	.	.	.	.	.
Lygodactylus williamsi§ Loveridge, 1952	Endemic to Kimboza Forest (0737 B2)																											
Lygodactylus kimhowelli§ Pasteur, 1995	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Homopholis wahlbergii (A. Smith, 1849)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	*	.
Urocotyledon wolterstorffi† (Tornier, 1900)	Tanga, East Usambara forests and Uluguru Mts									.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cnemaspis barbouri† Perret, 1986	.	.	.	.	*	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cnemaspis uzungwae† Perret, 1986	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	*	.	.	.	.	.	.	.	.	.	.	.	.
Hemidactylus mabouia (Moreau de Jonnès, 1818)	.	.	*	*	.	*	*	.	*	*	.	*	*	*	.	.	*	+	*	*	*	*	.	*	*	.	.	*
Hemidactylus platycephalus Peters, 1854	+	.	*	*	*	*	*	.	*	*	.	.	.	.	.	*	*	+	*	*	*	*	*	.	*	.	*	*
Family **AGAMIDAE** – Agamas																												
Agama mossambica (Peters, 1854)	.	.	.	.	.	.	*	.	.	.	.	*	.	.	*	*	*	+	.	.	.	.	.	*	*	*	.	*
Family **CHAMAELEONIDAE** – Chameleons																												
Bradypodion tenue§ (Matschie, 1892)	.	*	Eastern Usambaras																									
Bradypodion mlanjense§ (Broadley, 1965)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.
Chamaeleo d. dilepis Leach, 1819	+	[]	*	.	.	.	.	.	.	.	.	*	.	.	.	.	*	+	+	+	.	.	*	*	*	.	*	*
Chamaeleo melleri (Gray, 1864)	.	.	.	.	.	.	.	.	.	.	+	+	.	.	*	.	.	.	.	.	.	.	.	*	.	.	.	.
Rhampholeon platyceps† Günther, 1893	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.
Rhampholeon chapmani§ Tilbury, 1992	Endemic to Malawi Hills Forest, S. Malawi (1635C3)																											
Rhampholeon brevicaudatus† (Matschie, 1892)	.	[]	.	.	.	+	.	.	.	*	.	*	*	.	*	*	.	*	.	.	.	.	.	.	.	.	.	.
Rhampholeon brachyurus† Günther, 1893	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.
Rhampholeon k. kerstenii (Peters, 1868)	.	+	[]	*	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Family **SCINCIDAE** – Skinks																												
Subfamily **SCINCINAE**																												
Sepsina t. tetradactyla§ Peters, 1874	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	*	.	.	.	.	.	*	.	.	.	.

		Kenya											Tanzania										Mal.		Mozam.		Zi.
																			Islands								
	TR	SH	AS	KL	AC	TW	GG	MB	MJ	ZK	PF	PK	RS	MC	KG	TO	NK	RP	PI	ZI	MI	KI	NB	SM	IF	DF	BA	HR
Family **SCINCIDAE** – Skinks (cont.)																												
Scelotes duttoni§ Broadley, 1990	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.
Scelotes insularis§ Broadley, 1990	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	*	.
Melanoseps ater† (Günther, 1874)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.
Melanoseps rondoensis§ Loveridge, 1942	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.
Melanoseps loveridgei† Brygoo and Roux-Estève, 1981	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.
Scolecoseps litipoensis§ Broadley, 1995	Type specimen from Litipo Forest (1039B2)																											
Subfamily **LYGOSOMATINAE**																												
Mabuya m. maculilabris (Gray, 1845)	+	.	*	.	.	.	*	.	.	*	.	*	.	.	.	.	*	.	.	+	*	.	*	*	*	.	.	.
Mabuya m. albotaeniata Boettger, 1913	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.
Mabuya boulengeri Sternfeld,1911	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	*	.	*	.	*
Lygosoma lanceolatum Broadley, 1990	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.
Lygosoma afrum (Peters, 1854)	+	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	*	.	.	*	.	*	.	.	.
Lygosoma mabuiiformis Loveridge 1935	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Lygosoma mafianum Broadley, 1994	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	*	.	.	.	.	.	.
Lygosoma pembanum Boettger, 1913	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.
Lygosoma tanae Loveridge 1935	[] Also southern Somalia																											
Acontias plumbeus Biaconi, 1849	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*
Family **LACERTIDAE** – Lacertid Lizards																												
Holaspis guentheri laevis† Werner, 1895	.	.	.	.	.	.	.	.	.	0	.	.	.	.	.	.	.	.	.	.	.	.	.	*	*	*	.	.
Gastropholis prasina§ Werner, 1904	.	.	0	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Gastropholis vittata§ Fischer, 1886	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Family **CORDYLIDAE** – Girdled Lizards																												
Cordylus t. tropidosternum (Cope, 1869)	.	.	*	+	.	*	*	.	*	+	.	.	*	.	*	.	.	+	*	.	*	.	.	.	.	.	.	.
Family **GERRHOSAURIDAE** – Plated Lizards																												
Gerrhosaurus major major Duméril, 1851	.	[]	*	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	*	.
Family **VARANIDAE** – Monitor Lizards																												
Varanus a. albigularis (Daudin, 1802)	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	*	.
Varanus n. niloticus (Linnaeus, 1776)	+	.	*	.	.	.	0	.	.	0	0	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	+
Suborder **AMPHISBAENIA** – Worm Lizards																												
Family **AMPHISBAENIDAE** – Tropical Worm Lizards																												
Zygaspis violacea (Peters, 1854)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.
Loveridgea ionidesi (Battersby, 1950)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.
Chirindia swynnertoni Boulenger, 1907	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	*
Chirindia rondoensis (Loveridge, 1941)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.
Ancylocranium ionidesi haasi Gans and Kochva, 1965	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.
Suborder **SERPENTES** – Snakes																												
Family **TYPHLOPIDAE** – Blind Snakes																												
Ramphotyphlops braminus (Daudin, 1803)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.
Typhlops obtusus† Peters, 1865	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.

	Kenya							Tanzania										Islands				Mal.		Mozam.			Zi.
	T R	S H	A S	K L	A C	T W	G G	M B	M J	Z K	P F	P K	R S	M C	K G	T O	N K	R P	P I	Z I	M I	K I	N B	S M	I F	D F	B A	H R
Suborder **SERPENTES** – Snakes (cont.)																												
Typhlops rondoensis§ Loveridge, 1942	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.
Typhlops fornasinii Bianconi, 1847	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.
Rhinotyphlops lubriciformis§ (Peters, 1874)	.	.	*	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.
Rhinotyphlops pallidus (Cope, 1868)	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.
Family **LEPTOTYPHLOPIDAE** – Worm Snakes/Thread Snakes																												
Leptotyphlops macrops§ Broadley and Wallach, 1996	.	.	*	.	.	.	.	.	*	.	.	.	.	*	. and Kambai forest (0838 D3).						.	.	.	.	.	.	.	
Leptotyphlops pembae Loveridge, 1941	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.
Leptotyphlops conjunctus incognitus Broadley and Watson, 1976	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	*
Family **VIPERIDAE** – Adders and Vipers																												
Subfamily **CAUSINAE** – Night Adders																												
Causus defilippii (Jan, 1862)	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	*	.	.	*	*	*
Subfamily **VIPERINAE** – True Vipers																												
Bitis g. gabonica† (Duméril and Bibron, 1854)	.	.	.	0	.	0	.	.	.	+	.	+	.	.	.	.	+	+	.	.	.	.	*	.	.	.	.	*
Family **ATRACTASPIDIDAE** – Burrowing Snakes																												
Subfamily **ATRACTASPIDINAE** – African Burrowing Snakes																												
Atractaspis bibronii A. Smith, 1949	+	.	*	.	.	.	+	.	.	.	.	.	.	.	*	.	*	+	.	+	.	.	.	*	.	.	.	*
Subfamily **APARALLACTINAE** – Centipede Eaters																												
Aparallactus guentheri† Boulenger, 1895	+	.	*	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*
Aparallactus werneri† Boulenger, 1895	.	.	.	.	.	.	.	.	.	?	.	*	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.
Aparallactus turneri§ Loveridge, 1935	[]	.	O	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Family **ELAPIDAE** – Cobras, Mambas and relatives																												
Subfamily **BUNGARINAE** – Cobras and Mambas																												
Naja melanoleuca Hallowell, 1857	.	.	*	.	.	.	.	.	.	0	.	*	.	0	.	.	.	.	.	.	+	.	*	*	.	.	*	*
Dendroaspis angusticeps† (A. Smith)	.	.	*	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	+	.	+	.	*	.	.	*	.	*
Family **COLUBRIDAE** – Typical Snakes																												
Subfamily **LAMPROPHIINAE**– House and Wolf Snakes																												
Lycophidion pembanum Laurent, 1968	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.
Lycophidion capense loveridgei Laurent, 1968	+	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.
Subfamily **PSAMMOPHIINAE** – Sand and Grass Snakes																												
Psammophis phillipsii (Hallowell, 1844)	+	.	*	.	.	.	.	.	.	.	.	.	.	.	.	*	.	+	.	+	.	.	.	.	.	*	.	*
Subfamily **NATRICINAE** – Marsh Snakes																												
Natriciteres variegata pembana (Loveridge, 1935)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	*
Natriciteres variegata sylvatica§ Broadley, 1966	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	+	.	*	.	.
Natriciteres olivacea Peters, 1854	+	.	[]	.	.	*	.	.	.	.	.	.	.	.	*	*	.	.	.	+	.	.	*	.	.	.	.	.
Subfamily **COLUBRINAE**																												
Tribe **COLUBRINI** – Shovel-snout Snakes																												
Scaphiophis albopunctatus Peters, 1870	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Prosymna janii§ Bianconi, 1862	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.
Prosymna semifasciata§ Broadley, 1996	.	.	Types from Kwamgumi Forest Reserve (0438 D3)																									

	Kenya			Tanzania														Islands				Mal.		Mozam.			Zi.
	TR	SH	AS	KL	AC	TW	GG	MB	MJ	ZK	PF	PK	RS	MC	KG	TO	NK	RP	PI	ZI	MI	KI	NB	SM	IF	DF	BA	HR
Tribe **COLUBRINI** – Shovel-snout Snakes (cont.)																												
Prosymna stuhlmanii (Pfeffer, 1893)	+	.	.	.	.	.	.	.	.	*	.	*	.	.	.	.	.	.	.	+	.	.	.	.	.	.	*	.
Meizodon krameri Schatti 1985	[]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Tribe **PHILOTHAMNINI** – Green and Bush Snakes																												
Philothamnus macrops§ (Boulenger, 1895)	.	.	.	.	.	.	*	.	.	.	.	.	.	.	*	.	.	*	.	+	.	.	.	.	.	.	.	.
Philothamnus hoplogaster (Günther, 1863)	+	.	.	.	.	.	.	.	.	*	.	*	.	.	*	*	.	+	*	.	*	.	*	*	*	*	.	*
Philothamnus angolensis Bocage, 1882	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	*
Philothamnus natalensis§ (A. Smith, 1848)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	*	.
Philothamnus punctatus Peters, 1866	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	*	.	*	.	.	.	.	.
Philothamnus semivariegatus (A. Smith, 1847)	.	.	.	.	.	.	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	*	.	.	*	.
Tribe **DISPHOLIDINI** – Boomslangs and Bird Snakes																												
Dispholidus typus typus (A. Smith, 1829)	.	.	*	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	*	.	.	*	*	*
Thelotornis capensis mossambicanus (Bocage, 1895)	.	[]	*	.	.	0	+	.	.	+	+	.	*	.	*	*	+	+	*	.	*	.	.	*	*	*		*
Tribe **BOIGINI** – Cat-eyed Tree Snakes																												
Crotaphopeltis tornieri† (Werner, 1908)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.
Dipsadoboa werneri† (Boulenger, 1897)	East Usambara Mts and Tanga																											
Dipsadoboa f. broadleyi Rasmussen, 1989	+	.	*	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.
Dipsadoboa f. flavida (Broadley and Stevens, 1971)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.
Dipsadoboa aulica (Günther, 1864)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.
Tribe **DASYPELTINI** – Egg Eaters																												
Dasypeltis medici (Bianconi, 1859)	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	*	.	*	*	.	.	.	.

Key: Species endemic to the Coastal Forests of eastern Africa are marked with a §; other forest endemics are marked with a †.

* = det. D.G.B.; + = literature record or voucher specimen; O = sight record; [] = personal communications (James Ashe and Steven Spawls).

Localities: **TR** = Tana Delta (0240 A2); **SH** = Shimba Hills (0439 A4); **AS** = Arabuko-Sokoke (0339 B4); **KL** = Kilulu Forest (0439 C3); **AC** = Amboni Caves (0539 A1); **TW** = Tongwe Forest Reserve (0538 B3); **GG** = Gendagenda Forest Reserves (0538 D1); **MB** = Msubugwe Forest Reserve (0538 D2); **MJ** = Mkwaja (0538 D4); **ZK** =Kiono/Zaraninge (0638 B1); **PF** = Pande Forest (0638 C1); **PK** = Pugu and Kazimzumbwi Forest Reserves (0639 C3); **RS** = Ruvu South Forest Reserve (0738 B2); **MC** = Mchungu Forest Reserves (0738 C4); **KG** = Kiwengoma Forest (0838 B2); **TO** = Tong'omba Forest Reserve (0839 C1); **NK** = Namakutwa Forest Reserve (0839 A3); **RP** = Rondo and Litipo Forest Reserves (1039 A1/B2); **PI** = Pemba Island (0539 B2); **ZI** = Zanzibar Island (Jozani Forest 0639 A2); **MI** = Mafia Island (0739 D3); **KI** = Kisiju Island (0739 A4); **NB** = Nkhata Bay forests, Malawi (1134 D1); **SM** = Southern Mulanje Forests, Malawi (1635 B1); **IF** = Inhamitanga Forest, Mozambique (1835 A1); **DF** = Dondo Forest, Mozambique (1934 D1); **BA** = Bazaruto Archipelago, Mozambique (2135 C 2/4); **HR** = Haroni-Rusitu Forests, Zimbabwe (2032 B2/2033 A1).

Notes: Localities are pinpointed by means of quarter degree references. The available data for Kenya (Tana Delta, Shimba Hills and Arabuko-Sokoke forest) are shown in the first three columns (from Loveridge, 1936; S. Spawls and J. Ashe, pers comms.), and data for Pemba and Zanzibar Islands were tabulated from the literature (Pakenham, 1983). Comparative data for Coastal Forests south of the Rovuma River are provided for the best known lowland forest areas in Malawi, Mozambique and Zimbabwe and the Bazaruto Archipelago, off the south Mozambique coast (from Broadley, 1990; 1992). Although the reptile fauna of Chirinda forest in southeastern Zimbabwe is well known and includes many Coastal Forest species, it was omitted because its vegetation is intermediate in character and it harbours some montane forest species like Marshall's Chameleon *Rhampholeon m. marshalli*. In this respect Chirinda forest resembles the forests of the East Usambara Mountains in Tanzania.

Appendix 7 Amphibians of the eastern African Coastal Forests

		Kenya		Tanzania																	Islands	
	Forest depend.	S H	A S	T W	P F	G G	M J	Z K	R N	R S	P U	K Z	V I	M C	N K	K W	T O	C H	L I	R O	Z I	M I
Order **APODA** – Apodeans																						
Family **CAECILIAIDAE** – Caecilians																						
Boulengerula changamwensis Loveridge, 1932	F	[]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Order **ANURA** – Frogs and Toads																						
Family **PIPIDAE** – Plantannas																						
Xenopus muelleri Peters, 1844	f	.	.	x	x	.	x	x	.	.	.	.	.	.	.	x	x	.	.	.	x	.
Family **BUFONIDAE** – 'True' Toads																						
Bufo gutturalis Power, 1927	f	x	[]	x	x	.	.	.	.	.	x	+	.	.	x	x	.	.	.	.	.	.
Bufo maculatus Hallowell, 1855	f	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.
Bufo steindachneri Pfeffer, 1893	f	.	[]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Bufo lindneri Mertens, 1955	f	.	.	.	.	.	.	.	.	.	x	.	x	.	.	.	.	.	.	.	.	.
Mertensophryne micranotis Loveridge, 1925	F	x	[]	.	.	.	.	.	.	.	x	+	.	.	.	x	.	.	.	x	x	.
Stephopaedes loveridgei Poynton, 1991	F	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	x	x	x	x	.	.
Stephopaedes sp.	F	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x
Family **MICROHYLIDAE** – Narrow-mouthed Toads																						
Breviceps mossambicus Peters, 1854	f	.	.	.	.	.	.	.	.	.	x	+	.	.	+	x	.	.	.	[]	.	.
Phrynomantis bifasciatus Smith, 1847	f	.	[]	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x
Spelaeophryne methneri Ahl, 1924	F	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	[]	.	.
Family **HEMISOTIDAE** – Shovel-nosed Frogs																						
Hemisus marmoratus Peters, 1854	f	.	[]	.	x	x	.	x	.	.	.	.	.	.	+	x	.	.	+	.	.	.
Family **RANIDAE** – 'True' Frogs																						
Pyxicephalus edulis Peters, 1854	f	.	[]	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	x	.	.	.
Rana angolensis Bocage, 1866	f	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.
Hylarana galamensis Dumeril and Bibron, 1841	f	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Ptychadena anchietae Bocage, 1867	f	.	.	.	.	.	.	x	.	.	x	.	x	.	+	x	.	.	.	.	.	.
Ptychadena mascareniensis Dumeril and Bibron, 1841	f	.	[]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.
Ptychadena mossambica Peters, 1854	f	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x
Phrynobatrachus acridoides Cope, 1867	f	.	[]	.	x	x	x	x	x	.	x	x	x	x	x	x	.	.	x	.	x	.
Phrynobatrachus mababiensis ?	f	.	.	.	.	x	x	x	.	.	.	x	x	.	x	.	x	.	.	.	x	.
Phrynobatrachus ukingensis ?	F	.	[]	.	.	x	.	.	.	.	.	.	x	.	.	x	.	.	.	.	.	.
Family **ARTHROLEPTIDAE** – Squeakers																						
Arthroleptis affinis Ahl, 1939	F	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	x	.	.
Arthroleptis globosa ?	f	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.
Arthroleptis stenodactylus Pfeffer, 1893	F	x	[]	.	x	x	x	x	.	x	x	x	x	x	x	x	x	x	x	x	.	x
Arthroleptis xenodactyloides Hewitt, 1933	F	.	.	.	.	x	.	.	.	.	x	.	x	.	x	x	x	x	x	x	.	.
Family **RHACOPHORIDAE** – Foam Nest Tree Frogs																						
Chiromantis xerampelina Günther, 1869	f	.	[]	.	.	x	.	x	.	.	x	x	.	.	+	x	+	.	.	.	x	.

	Forest depend.	Kenya SH	AS	Tanzania TW	PF	GG	MJ	ZK	RN	RS	PU	KZ	VI	MC	NK	KW	TO	CH	LI	RO	Islands ZI	MI
Family **HYPEROLIIDAE** – Tree, Leaf-folding, Reed and Lily Frogs and Kassinas																						
Leptopelis argenteus Pfeffer, 1893	f	.	[]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Leptopelis concolor ?	f	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.
Leptopelis flavomaculatus Günther, 1864	F	.	[]	.	.	+	.	.	.	.	.	+	.	.	x	+	x	.	.	.	x	.
Kassina maculata Dumeril, 1853	f	.	[]	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.
Kassina senegalensis Dumeril and Bibron, 1841	f	.	[]	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.	x
Afrixalus sp.	f	.	[]	.	.	.	.	.	.	.	x	x	.	.	.	.	.	.	.	.	x	.
Afrixalus brachycnemis Boulenger, 1896	f	.	.	.	.	.	.	x	.	.	.	x	.	.	.	x	.	.	.	.	.	.
Afrixalus fornasini Bianconi, 1849	f	.	[]	.	.	x	x	.	.	.	.	.	.	x	.	.	.	.	+	.	x	.
Afrixalus sylvaticus Schiøtz, 1963	F	[]	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.
Afrixalus uluguruensis Barbour and Loveridge, 1928	F	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hyperolius argus Peters, 1854	f	.	[]	.	.	.	x	.	.	x	.	.	.	.	.	.	.	.	.	.	x	x
Hyperolius marmoratus ?	f	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hyperolius mariae Barbour and Loveridge, 1928	f	.	[]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.
Hyperolius mitchelli Loveridge, 1953	F	.	.	.	.	x	.	.	.	.	.	+	.	.	.	.	.	.	.	.	x	.
Hyperolius nasutus Günther, 1865	f	.	.	.	.	.	.	x	x	.	.	.	.	x	.	.	.	.	+	.	x	.
Hyperolius parkeri Loveridge, 1933	f	.	[]	.	.	x	.	.	.	.	.	.	.	x	.	.	.	.	.	.	x	.
Hyperolius pusillus Cope, 1862	f	.	[]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hyperolius rubipes Ahl, 1931	f	.	[]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hyperolius rubrovermiculatus Schiøtz, 1975	F	[]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hyperolius tuberilinguis Smith, 1849	f	.	[]	.	.	x	.	x	x	x	.	+	x	.	.	x	.	.	.	.	x	.

Key:

x = own identification of specimen, + = Howell's identification of specimen, [] = literature record (Drewes and Loveridge).

Habitat

F = not known to breed in open situations and at least one record from Coastal Forest; f= regarded here as a non-forest species, known to breed in open situations although may enter forest.

Localities

SH = Shimba Hills (NHM, Loveridge, 1932; Schiøtz, 1975); **AS** = Arabuko-Sokoke (Drewes, pers. comm.; Drewes *et al.*, 1996); **TW** = Tongwe Forest Reserve; **PF** = Pangani Falls Forest; **GG** = Gendagenda Forest Reserve, **MJ** = Mkwaja Forest; **ZK** = Kiono/Zaraninge Forest Reserve; **RN** = Ruvu North Forest Reserve; **RS** = Ruvu South Forest Reserve; **PU** = Pugu Forest Reserve; **KZ** = Kazimzumbwi Forest Reserve; **VI** Vikindu Forest Reserve; **MC** = Mchungu Forest Reserve; **NK** = Namakutwa Forest Reserve; **KW** = Kiwengoma Forest Reserve; **TO** = Tong'omba Forest Reserve; **CH** = Chitoa Forest Reserve; **LI** = Litipo Forest Reserve; **RO** = Rondo Forest Reserve (NHM and Loveridge, 1942); **ZI** = Jozani Forest, Zanzibar Island; **MI** = Mrora Forest, Mafia Island.

Note: English Family names after Passmore, N. and Carruthers, V. (1995). *South African Frogs: A complete guide.* Revised edition. Witwatersrand University Press, Johannesburg.

Appendix 8 Molluscs of the East African Coast (Kenya and Tanzania)

Notes	Species	Habitats
*	*Neritina pulligera* (L.)	freshwater
*	*Neritina natalensis* Reeve	freshwater
+	*Cyathopoma azaniense* Verdc.	coral outcrops
*	*Maizania wahlbergi* (Benson)	forest – extends to Natal
*	*Bellamya unicolor* (Oliv.)	freshwater
	Lanistes carinatus (Oliv.)	freshwater
+	*Lanistes ciliatus* von Mts.	freshwater
	Lanistes alexandri (Bgt.)	freshwater
*	*Lanistes purpureus* (Jonas)	freshwater
+*	*Lanistes farleri* Craven	freshwater
+	*Lanistes stuhlmanni* von Mts.	freshwater
*	*Littoraria scabra* (L.)	mangrove etc.
	Littoraria intermedia (Philippi)	mangrove etc.
	Littoraria pallescens (Philippi)	mangrove etc.
	Littoraria subvittata Reid	mangrove etc.
	Littoraria glabrata (Philippi)	above high tide mark
*	*Tropidophora calcarea* (G B Sow. II)	forest, extends to Mozambique
+	*Tropidophora concinna* Prest.	coastal scrub etc.
*	*Tropidophora letourneuxi* (Bgt.)	coastal scrub etc, plantations
	Tropidophora zanguebarica (Petit)	coastal scrub etc.
+	*Gabbiella parvipila* (Verdc.)	freshwater
+	*Incertihydrobia teesdalei* Verdc.	freshwater
	Truncatella teres Pfr.	above high tide
	Truncatella guerini Villa	above high tide
	Truncatella valida Pfr.	above high tide
+	*'Assiminea' aurifera* Prest. (gen nov nr *Omphalotropis*)	bushland above littoral
+	*Eussoia oblonga* Mand.–Barth	freshwater
*	*Thiara amarula* (L.)	freshwater
	Thiara scabra (Müll.)	freshwater
*	*Melanoides tuberculata* (Müll.)	freshwater
*	*Cleopatra ferruginea* (I and H C Lea)	freshwater
*	*Cleopatra africana* (von Mts.)	freshwater
+	*Cleopatra exarata* (von Mts.)	freshwater

Notes	Species	Habitats
*	*Cerithidea decollata* (Brug.)	mangrove
	Terebralia palustris (L.)	mangrove
	Pirenella conica (Blainville)	brackish water
	Auriculastra radiolata (Morelet)	brackish water etc
	Auriculastra subula (Quoy and Gaimard)	brackish water etc
	Auriculodes gaziensis (Prest.)	brackish water etc
	Cassidula labrella (Deshayes)	brackish water etc
	Cassidula sp.	brackish water etc
	Laemodonta monilifera (H and A Adams)	brackish water etc
+	*Blauneria exsilium* Prest.	brackish water etc
	Pedipes affinis Fér.	brackish water etc
	Melampus caffer (Küster)	brackish water etc
*	*Melampus fasciatus* (Deshayes)	brackish water etc
	Melampus hypoleucus von Mts.	brackish water etc
	Melampus lividus (Deshayes)	brackish water etc
	Melampus massauensis Pfr.	brackish water etc
	Melampus parvulus Pfr.	brackish water etc
	Melampus semiaratus Connolly	brackish water etc
	Melampus semiplicatus Pease	brackish water etc
	Melampus siamensis von Mts.	brackish water etc
	Lymnaea natalensis Krauss	freshwater
*	*Afrogyrus coretus* (Blainville)	freshwater
	Ceratophallus natalensis (Krauss)	freshwater
	Segmentorbis kanisaensis (Preston)	freshwater
	unidentified ? Planorbid	?freshwater, may be terrestrial
*	*Bulinus praeclarus* (Bgt.) (= *nasutus* von Mts.)	freshwater
	Bulinus spp.	freshwater
	Bulinus forskali (Ehrenberg)	freshwater
	Onchidium sp.	slug-like, cliffs above high tide
*	*Laevicaulis alte* (Fér.)	veronicellid slug – plantations, open-ground, waste places
+	*Laevicaulis zanzibaricus* Forcart	veronicellid slug, – woodland, forest
+	*Filicaulis lamuensis* (Simroth)	veronicellid slug – ?bushland

Notes	Species	Habitats
	Quickia concisa Morelet	sub-aquatic
	'Succinea' pseudomalonyx Dupuis and Putzeys	?sub-aquatic
	Nesopupa ?peilei Madge	bushland
	Nesopupa ?minutalis (Morelet)	bushland
	Nesopupa ?bisulcata (Jickeli)	bushland
	Pupoides coenopictus sennariensis (Pfr.)	bushland
	Pupoides coenopictus samavaensis (Palad.)	bushland
	Gastrocopta klunzingeri (Jickeli)	bushland
	Rachis punctata (Anton)	extends to India and Ceylon open places, bushland
	Rachis burtoi (Bgt.)	?bushland
*	*Rhachidina braunsi* (von Mts.)	bushland to forest
	Rhachidina melanacme (Pfr.)	?
+	*Rhachidina usagarica* (E A Sm.)	forest
+	*Rhachidina carnea* Verdc.	scrub, forest
+	*Rhachistia festiva* (Connolly)	bushland
	Rhachistia hildebrandti (von Mts.)	bushland
+	*Rhachistia lilacina* Connolly	bushland
	Rhachistia moluensis (Kobelt)	bushland
*	*Rhachistia picturata* (Morelet)	bushland to forest
	Rhachistia rhodotaenia (von Mts.)	bushland
+	*?Rhachistia obeliscus* (C R Boettger)	?
+*	*Edouardia alycaeoides* Verdc.	forest
+	*Edouardia conulina* (von Mts.)	bushland
	Edouardia tumida (Taylor)	bushland to forest
	Edouardia sp. nr. *natalensis* (Pfr.)	forest
+	*Cecilioides* sp.	dry areas
+	*Subulina mrimaensis* Verdc.	forest
+	*Subulina taruensis* Connolly	bushland
+*	*Ceras matumbianum* Thiele	forest
+*	*Ceras ordinarium* (Prest.)	forest
+	*Subulona insularis* (Germain)	forest
+*	*Subulona kilwaensis* (Germain)	forest
+*	*Pseudoglessula obtusa* C R Boettger	forest
*	*Pseudoglessula boivini* (Morelet)	extends to Natal – forest, bushland, cultivations
+	*Pseudoglessula subolivacea* (E A Sm.)	forest to bushland
+	*Pseudoglessula naegelei* C R Boettger	forest
+	*Pseudoglessula solitudinum* Connolly	bushland
+	*Pseudoglessula ingloria* Connolly	bushland
+*	*Pseudoglessula margueritae* (Preston)	bushland, plantations
+	*Pseudoglessula tribulationis* (Preston)	bushland, plantations
+**	*Pseudoglessula* sp. nov.	forest
+**	*Pseudoglessula* sp. nov.	forest
+*	*Mabiliella notabilis* (E A Sm.)	bushland/forest
+	*Curvella calorhaphe* Prest.	forest
+	*Curvella pertranslucens* Prest.	bushland to forest
+**	*Curvella* spp. nov. (2–3)	forest
	Lamellaxis gracilis (Hutton)	waste places, introduced
	Opeas delicatum Taylor	forest
+	*Opeas lamoense* (Melv. and Ponson.)	bushland, woodland, forest
+	*Opeas pervitreum* Connolly	bushland
	Opeas (Nothapalinus) suavissimum	dry areas
+*	*Opeas* spp.	forest
+	*Pseudopeas imitans* Connolly	?
+	*Pseudopeas elgonense* Connolly	?
+*	*Pseudopeas* sp.	forest
*	*Euonyma magilensis* (Craven)	forest and drier areas
+*	*Achatina albopicta* E A Sm.	bushland to forest
+	*Achatina reticulata* Pfr.	forest
*	*Achatina fulica rodatzi* Dunker ("*hamillei* Petit")	forest
	Achatina zanzibarica Bgt.	forest
+*	*Achatina allisa* Reeve (= *iredalei* Prest.)	bushland/thicket
+*	*Achatina eleanorae* Mead	?bushland/thicket
+*	*Achatina grandidieriana* Bgt.	forest
*	*Trachycystis (Psichion) ariel* (Prest.)	extends to Natal – forest
*	*Sitala jenynsi* (Pfr.)	open areas, scrub, woodland, plantations
+	*Leptichnus fischeri* Simroth	urocyclid slug – woodland, forest
+	*Pembatoxon insulare* van Goethem	urocyclid slug – ?forest
+	*Elisolimax ehlersi* (Simroth)	urocyclid slug – forest
+	*Elisolimax roebucki* (Simroth)	urocyclid slug – forest
+	*Elisolimax variabilis* (Verdc.)	urocyclid slug – forest
+*	*Elisolimax* spp.	urocyclid slug – forest
+	*?Elisolimax bussei* (Simroth)	urocyclid slug – forest
*	*Trichotoxon heynemanni* Simroth	urocyclid slug – forest
*	*Urocyclus kirki* Gray	urocyclid slug – forest
+	*Urocyclus elegans* (Simroth)	urocyclid slug – forest
*	(Urocyclid slugs not yet identified)	forest and derived plantations
+	*Trochonanina gwendolinae* (Prest.)	forest

Notes	Species	Habitats
+	*Trochonanina monozonata* (Prest.)	woodland/forest
*	*Trochonanina mozambicensis* (Pfr.)	extends to Transvaal – bushland/ forest
	Trochonanina albopicta (von Mts.)	bushland/forest
	Trochonanina bloyeti Bgt.	bushland/forest
+	*Trochonanina shimbiensis* (Prest.)	forest
+	*Trochonanina ?smithi* (Bgt.)	forest
+**	*Trochonanina* sp. nov.	forest
+*	*Trochonanina* sp.	forest
+*	*Zingis depressa* (Germain)	forest
+**	*Trochozonites* sp. nov.	forest
+*	*Trochozonites* sp.	forest
+	*Thapsia cavernicola* d'Ailly	caves
+	*Thapsia curvatula* von Mts.	forest
+	*Thapsia exasperata* Prest.	?forest
+	*Thapsia insulsa* Prest.	forest
+*	*Thapsia* spp.	forest
	Helicarion aureofuscus von Mts.	probably based on mislabelled specimen
	Halolimnohelix gaziensis (Prest.)	must be an identification error!
+*c	*Tayloria usambarica* (Craven)	forest and ?more open areas
+*c	*Tayloria grandis* Thiele	forest
+*c	*Tayloria helicoides* (C R Boettger)	forest
+c	*Tayloria shimbiensis* Connolly	forest
+c	*? Tayloria ventrosa* (Taylor)	probably a *Thapsia* – type lost
+*c	*Tayloria* sp.	forest
+*c	*Gonaxis denticulatus* (Dohrn)	?bushland, forest
+c	*Gonaxis gibbonsi* (Taylor)	bushland to forest
+*c	*Gonaxis gibbosa* (Bgt.)	bushland to forest
+c	*Gonaxis microstriata* (Prest.)	?
c	*Gonaxis bottegoi* (von Mts.)	?bushland
+*c	*Gonaxis craveni* (E A Sm.)	forest
+c	*Gonaxis kibweziensis* (E A Sm.)	bushland to forest
+c	*Gonaxis quadrilateralis* (Prest.)	forest
c	*Edentulina obesa obesa* (Taylor)	bushland to forest, even rocky grassland

Notes	Species	Habitats
+*c	*Edentulina obesa bulimiformis* (Grandidier)	bushland to forest
*c	*Edentulina ovoidea* (Brug.)	forest
+*c	*Edentulina* sp.	forest
?+c	*Gonospira expatriata* (Prest.)	link to Mascarenes if correctly placed? Lesotho – woodland/forest
+c	*Streptostele lucida* (Gibbons)	?bushland
	Streptostele herma Connolly	extends to Transvaal limestone, near caves
+c	*Streptostele taylori* (Gibbons)	bushland to forest
+c	*Ptychotrema sperabile* (Prest.)	?forest
+c	*Gulella vicina sambourouensis* (Dautz.)	bushland, woodland subsp. *vicina* in Malawi
+c	*Gulella vicina salutationis* Connolly	?
+c	*Gulella carea* (Prest.)	?
+*c	*Gulella gwendolinae gwendolinae* (Prest.)	bushland to forest subsp. *aldabrae* in Aldabra
+c	*Gulella gwendolinae scissidens* Connolly	?
+*c	*Gulella radius* (Prest.)	woodland/forest
+c	*Gulella minutissima* Thiele	?bushland
+c	*Gulella prestoni* Connolly	?forest
+cc	*Gulella calva* Connolly	bushland to forest
+c	*Gulella candela* Connolly	bushland
+c	*Gulella foveolata* (Prest.)	bushland, woodland
+c	*Gulella marionae* (Prest.)	forest
*	*Gulella planidens* (von Mts.)	?forest
+**c	*Gulella matumbiensis* Verdc.	forest
+c	*Gulella rondoensis* Verdc.	forest
c	*Gulella laevigata* (Dohrn)	open areas
c	*Gulella sexdentata* (von Mts.)	forest
+c	*Gulella jod* (Prest.)	?forest
+	*Caelatura ratidota* Charmes	bivalve – freshwater
	Aspatharia wahlbergi hartmanni (von Mts).	bivalve – freshwater
*	*Aspatharia wahlbergi guillaini* (Récluz)	bivalve – freshwater
	Etheria elliptica Lam.	bivalve – freshwater
	Corbicula africana subtruncata Germain	bivalve – freshwater
+	*Eupera triangularis* Mand.-Barth	bivalve – freshwater

Key: * = found by the Frontier-Tanzania Coastal Forest Research Programme; ** = a species apparently first discovered by the Frontier-Tanzania CFRP; + = species which is endemic to the East African coastal zone; c = carnivorous species.

Appendix 9 Species or races of butterflies mostly confined to Coastal Forests or semi- evergreen vegetation close to the coast of eastern Africa (taxonomy follows Ackery *et al.*, 1995)

	Status	Habitat	Altitude (m)	Kenya		----Tanzania----													
				AS	SH	EU	GG	PF	KZ	PH	DF	NF	KF	RP	PI	ZI	MI	KiF	LEA
Order **LEPIDOPTERA** – Butterflies and Moths																			
Superfamily **HESPERIOIDEA**																			
Family **HESPERIIDAE** – Skippers																			
Astictopterus stellatus amania Evans	++	Hw, F, Fm	0–900	x	x	x	.	.	.	.	.	.	.	.	.	.	.	x	x
Astictopterus stellatus mineni Trimen	++§	Hw, F, Fm	75–900	x	.	.	.	.	.	x	.	.	.	x	.	.	.	.	x
Astictopterus tura Evans	++	Hw, Fm	75–600	.	.	?	.	.	.	x	.	.	.	.	.	.	.	x	x
Borbo ferruginea dondo Evans	*	F	800	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.
Borbo f. ferruginea Aur	*	F	0–600	x	x	.	.	.	.	.	x	.	.	.	.	.	.	.	.
Celaenorrhinus cordeironis K	*	F	350	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.
Celaenorrhinus kimbozae K	*	F	250–400	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.
Coeliades keithloa Wallengren	‡	F, W, Fm	?	x	Coastal Kenya				.	.	.	.	.	.	.	x	.	.	.
Gorgyra diva Evans	§	F	0–400	.	x	.	.	.	.	x	.	.	.	.	.	.	.	x	x
Gorgyra subflavidus Holland	*	F	75–1200	x	x	x	.	.	.	x	.	.	.	x	x	.	.	x	x
Sarangesa tricerata compacta Evans	‡	W, Fm	?	Mikindani, south-east Lindi															
Spialia confusa obscura Higgins	*	Hw, F	0–500	x	x	x	.	.	.	x	x	.	.	.	.	.	.	x	x
Superfamily **PAPILONOIDEA**																			
Family **PAPILIONIDAE** – Swallowtails																			
Graphium angolanus howelli Tur and L	‡	W	0–60	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.
Graphium colonna Ward	§++	F, Fm	0–600	x	x	x	.	.	x	x	x	.	.	x	x	x	x	x	x
Graphium junodi Trimen	*	F	0–?	Mozambique Coastal Forests															
Graphium kirbyi Hewitson	*	F	200–500	x	x	x	.	.	.	.	.	.	.	.	.	.	x	.	x
Graphium leonidas pelopidas O	‡	W, F	0–80	.	.	.	.	.	.	.	.	.	.	.	x	?	.	.	.
Graphium leonidas zanzibaricus K	‡	W, F	0–80	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.
Graphium philonoe philonoe Ward	‡	Hw, F	50–1250	x	x	x	.	.	x	x	.	.	.	x	.	x	.	x	x
Graphium polistratus G-S	*	Hw, F	0–900	x	x	x	.	.	.	x	x	.	.	.	?	.	.	x	x
Family **PIERIDAE** – Whites																			
Appias l. lasti G-S	§	Fm, Hw	0–900	x	.	x	.	x	x	x	.	.	x	x	.	x	x	x	.
Appias phaola isokani G-S	*	F	0–400	x	.	.	.	.	x	.	.	.	.	.	.	.	.	x	x
Colotis e. eunoma Hoppfer	‡	Cd	0–?	Mozambique coast															
Colotis eunoma flotowi Suffert	‡	Cd	sea level	.	.	.	.	.	.	.	x	.	.	.	.	x	x	.	.
Eronia cleodora dilatata Butler	§	F, Hw	0–1200	x	x	x	.	.	x	x	.	.	.	x	.	.	.	x	x
Eurema floricola Bois	§	F	0–1200	.	.	x	.	.	.	x	x	.	.	.	x	x	.	x	x
Mylothris kilimensis rondonis K	*	F, Fm	400–800	.	.	.	.	.	.	.	.	.	x	x	.	.	.	.	.

	Status	Habitat	Altitude (m)	Kenya		------------------------					Tanzania					----------------------------		
				A S	S H	E U	G G	P F	K Z	P H	D F	N F	K F	R P	P I	Z I	M I	Ki F	L EA
Family **NYMPHALIDAE** – Nymphs, Commodores																			
Sub family **ACRAEINAE** – Acraeas																			
Acraea adrasta Weymer	*	F	200–1250	.	x	x	.	.	.	.	.	.	.	.	.	.	.	x	x
Acraea aganice montana Butler	++	F, Hw	0–2140	x	x	.	.	.	.	.	.	.	.	x	x	.	.	x	.
Acraea aubyni Eltringham	*	F	coast	x	x	.	.	.	.	.	.	.	.	x	.	x	.	.	.
Acraea c. cuva G-S	*	F, G	0–500	x	x	.	.	.	x	x	x	.	.	x	.	.	.	.	.
Acraea egina pembanus K	*	F	sea–level	.	.	.	.	.	.	.	.	.	.	.	x	x	.	.	.
Acraea epaea epitellus St	*	F	0–1750	x	x	x	.	.	.	x	x	.	x	x	x	.	x	x	x
Acraea matuapa G-S	‡	near forests	0–400	x	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Acraea petraea Bois	§	Hw, F	0–1500	x	x	?	.	.	x	x	x	.	.	x	.	.	.	.	.
Acraea punctimarginea Pinhey	++	F	200–350	.	.	?	.	.	.	.	.	.	.	.	.	.	.	x	.
Acraea rabbaiae Ward	§	F, Hw	0–600	x	x	.	.	.	x	x	x	.	.	.	.	.	.	.	.
Acraea satis Ward	§	F	0–900	x	x	x	.	.	x	x	x	.	x	x	.	.	x	x	x
Acraea zonata Hewitson	*	Hw, F	0–600	x	x	x	.	.	x	x	x	.	.	.	.	x	x	.	x
Sub family **DANAIDAE** – Milkweed butterflies																			
Amauris o. ochlea Bois	§	F, G	0–1000	x	x	x	.	.	.	x	x	.	.	x	x	x	.	x	x
Sub family **SATYRIDAE** – Browns																			
Coenyropsis carcassoni K	‡	W, F	0–?	.	x	.	.	.	.	x	other Kenya CF sites						.	.	.
Physcaeneura leda Gerstaecker	‡	W, F	0–1850	x	x	.	.	.	x	.	also taken near Muheza (Tanga).								
Sub family **LIMENITINAE** – Limenitids																			
Aterica galene theophanes Hopffer	‡	Hw, F	0–1800	.	x	x	.	.	.	x	x	.	.	.	.	.	.	x	x
Bebearia chriemhilda St	*	F	50–1000	x	x	x	x	.	x	.	x	x	.	.	.	.	.	.	.
Bebearia orientis insularis K	‡	Fm, G	sea level	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.
Bebearia o. orientis Karsch	‡§	Fm, G	0–1100	x	x	x	.	.	x	x	.	x	x	x	.	x	x	x	x
Cymothoe c. coranus G-S	§	F	0–300	x	x	.	.	.	.	.	.	.	.	.	x	.	.	x	x
Euphaedra castanoiedes ssp. nov.	*	F	300–1500	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.
Euphaedra neophron littoralis Talbot	‡	G, F, Hw	0–1600	x	x	x	x	.	.	.	.	.	.	.	.	.	x	.	.
Euphaedra n. neophron Hopffer	‡	G, F, Hw	0–1150	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.
Euphaedra neophron rydoni Howarth	*	F	sea level	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.
Euphaedra orientalis Rothschild	*	F	75–1000	x	x	x	x	.	x	x	.	x	x	x	.	.	.	x	.
Euptera kinugnana G-S	*	F	0–1000	x	x	x	.	.	.	x	x	.	.	.	.	.	.	x	.
Euryphura achlys Hopffer	§	Hw, F	0–1100	x	x	x	.	.	.	x	.	.	.	.	.	.	.	x	x
Harma theobene blassi Weymer	§++	F	0–1400	x	x	x	.	.	.	x	x	.	.	.	.	.	.	.	x
Neptis carcassoni vSom	§	F	200–850	x	.	x	.	.	.	x	x	x	x	x	.	.	.	x	x
Neptis rogersi Eltringham	*	F	200	x	x	x	x	.	x	x	x	.	.	.	x	.	.	.	x
Neptis t. trigonophora Butler	§	F	0–1500	x	x	x	.	.	x	x	x	.	.	x	.	.	.	x	x
Neptidopsis fulgurata platyptera Bois	*	F	0–500	x	x	.	.	.	.	x	x	.	.	.	x	x	.	.	x
Pseudacraea boisduvali pemba K	*	F, Fm	sea level	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.

	Status	Habitat	Altitude (m)	Kenya		--------------------						Tanzania							----------------------
				A S	S H	E U	G G	P F	K Z	P H	D F	N F	K F	R P	P I	Z I	M I	Ki F	L EA
Sub family **LIMENITINAE** – Limenitids (cont.)																			
Pseudacraea eurytus conradti O	++	F	0–1200	.	x	x	.	.	.	.	.	.	.	.	.	.	.	x	x
Pseudathyma l. lucretioides C and J	*	F	0–100	x	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Pseudathyma lucretioides rondo K	*	F	800	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.
Sallya natalensis Bois	§	Hw, F	0–1600	.	.	x	.	.	.	.	x	x	.	x	.	.	.	x	x
Sallya pseudotrimeni K	++	F	0–800 (1900)	.	.	.	.	.	.	x	.	.	.	x	.	.	.	x	x
Sub family **CHARAXINAE** – Charaxes																			
Charaxes acuminatus rondonis K	*	F	400–800	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.
Charaxes acuminatus shimbanus vSom	++	F	400	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Charaxes acuminatus usambarensis vSom	++	F	300–1800	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.
Charaxes baumanni granti Turlin	++	F, Hw	75–2000	.	.	.	.	x	.	x	.	.	.	.	.	.	.	.	x
Charaxes b. blanda Rothschild	*	Fm	?	Mikindani, south-east Lindi (see below)															
Charaxes blanda kenyae Poulton	*	F, Hw	0–100	x	x	.	Coastal Kenya												
Charaxes brutus roberti Turlin	*	F, Fm	sea-level	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.
Charaxes castor arthuri vSom	*	FM, F	sea-level	.	.	.	.	.	.	.	.	.	.	.	x	?	.	.	.
Charaxes c. contrarius vSom	*	F, Hw	0–700	x	x	x	.	.	x	x	.	.	.	x	.	.	.	x	x
Charaxes jahlusa mafiae Tur and L	*	F, Fm	sea level	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.
Charaxes l. lasti G-S	*	F, Hw	75–900	x	x	x	x	.	x	x	.	.	.	.	.	.	.	.	.
Charaxes lasti kimbozae K	*	F	200–500	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.
Charaxes pembanus Jordan	*	W, F	sea-level	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.
Charaxes pleione oriens Plantrou	++	F	250–1600	.	x	x	.	.	.	.	.	.	.	.	.	.	.	.	x
Charaxes pollux piersoni Collins	*	F	sea-level	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.
Charaxes pythodoris nesaea G-S	*	F	200–1000	x	x	?	.	.	x	.	.	x	.	.	.	.	.	.	.
Charaxes tavetensis pemba vSom	*	F, Hw	sea-level	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.
Charaxes violetta maritimus vSom	*	F	0–800	x	x	x	.	.	x	x	x	x	x	x	.	x	.	.	.
Euxanthe t. tiberius G-S	*	F	0–1350	.	x	x	.	.	x	x	.	.	.	.	.	.	.	x	x
Euxanthe wakefieldi Ward	§	F	0–600 (2000)	x	x	x	.	.	.	x	x	.	.	.	x	x	.	x	x
Sub family **NYMPHALIDAE** – Nymphalids																			
Hypolimnas antevorta Distant	++	F	300–1000	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.
Hypolimnas deceptor Trimen	§	F, W	0–900	x	x	x	.	.	x	x	x	x	x	x	x	x	x	.	x
Hypolimnas usambara Ward	*	F	0–1000	x	x	x	.	.	.	x	.	.	x	.	.	.	x	x	x
Salamis cacta amaniensis Vosseler	++	F	200–1000	x	x	x	.	.	.	.	.	.	.	.	.	.	.	x	x
Family **LYCAENIDAE** – Blues and Coppers																			
Anthene lasti G-S	*	F, Fm	300–800	x	x	x	.	.	x	.	.	.	.	.	.	.	.	x	x
Anthene rubrimaculata ssp. nov.	*	F	0–80	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.
Aphnaeus coronae littoralis Carc	‡	F, W	0–?	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Aphnaeus williamsi Carc	*	Fm	0–100	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Aslauga orientalis Cottrell	?	?	?	two sites on Kenya and Tanzania coast															
Axiocerces punicea G-S	*	F	0–1200	x	x	x	.	.	.	x	x	.	.	x	.	.	.	.	x

Rare Coastal Forest butterflies from Kenya, Tanzania and Mozambique

These species notes are arranged in alphabetical order within the main areas of endemism recognised here. Sub-species and species are considered. All the more important species in Kenya and Tanzania have been mentioned as well as those of the poorly explored Coastal Forests (hereafter CF) of Mozambique.

Lowland forests of the Eastern Arc Mountains:

Celaenorrhinus cordeironis	E. Usambaras	Previously known only from two specimens collected at Mtai in 1990 but recently found at Magrotto, Kwamgumi and Bamba Ridge by J. Bayliss (Kielland, *in lit.* to J. Bayliss). S.C. Collins (*in lit.*1997) has also noted several specimens at NMK collected by T.H.E. Jackson from Amani in August 1947.
Celaenorrhinus kimboza	Kimboza (Ulugurus)	Rare: related to the *C. sanjeensis* and *C. cordeironis* group.
Charaxes acuminatus usambarensis	East Usambara lowland forests	Occurs as low as 300m in lowland forests adjacent to the submontane forests of the East Usambara Mts. Also known from the West Usambaras and North and South Pares.
Euthecta sp. nov.	Manga (E. Usambaras)	Kielland had planned to describe this species collected by J. Bayliss in 1995. It will remain undescribed until an expert can re-examine the specimens.
Euthecta sp. nov.?	Mtai (E. Usambaras) Pugu Hills, Kiwengoma	In 1990, specimens of this *Euthecta* were collected at Mtai and Pugu Hills by N.J. Cordeiro. Kielland initially believed these to be *E. cooksoni* but later thought it to be a possible new species [see Cordeiro in Evans and Anderson (1992)]. Further work on this group in Tanzania is therefore needed.
Hypolimnas antevorta	Mtai, E. Usambaras	Also known from the Amani area (1000m). Has yet to be recorded in other East Usambara lowland forests.
Iolaus (Etesiolaus) pinheyi	Kimboza (Ulugurus)	Also noted from the Amani area (E. Usambaras).
Triclema kimboza	Kimboza (Ulugurus)	See notes under Kenya/Tanzania endemics.

Pemba, Zanzibar and Mafia Islands:

Abisara zanzibarica	Zanzibar	The nearest relative, *Abisara delicata*, occurs in the Udzungwa Mts, Nguru Mts and at Amani in the East Usambara Mts. There are no records of this genus in between these localities.
Anthene rubrimaculata ssp. nov.	Zanzibar	(see Archer *et al.*, 1991).
Baliochila lequeuxi	Mafia	Discovered in the Mrora Forest, Mafia Island, in 1990 by Kenneth Karumile (Kielland, 1994). Currently believed to be endemic to the island.
Charaxes jahlusa mafiae	Mafia	Recently discovered in the Mrora Forest, Mafia Island; an endemic race that differs from ssp. *kenyensis* and ssp. *argynnides* that occur on the nearby islands of Pemba and Zanzibar, respectively (Turlin and Lequeux, 1992).
Charaxes pembanus	Pemba	A rare butterfly occurring on the outskirts of Ngezi Forest; Pemba endemic.
Deloneura sp. nov.	Zanzibar	(see Archer *et al.*, 1991).
Graphium angolanus howelli	Pemba	A subspecies recently described from Ngezi Forest (Turlin and Lequeux, 1992).
Graphium leonidas pelopidas	Pemba	Whether *pelopidas* is a race of *leonidas* or a distinct species is disputed (see Kielland, 1990).
Iolaus (Epamera) diametra ssp. nov.	Zanzibar	(see Archer *et al.*, 1991).
Iolaus (Epamera) silanus ssp. nov.	Zanzibar	(see Archer *et al.*, 1991).

Kenya-Tanzania Coastal Forests (and some Mozambique forests):

Aslauga orientalis	Kenya/Tanzania coast	This recently described species is probably rare (habitat is uncertain); known only from a few specimens from Rabai, Kenya, and Tanga, Tanzania (Cottrell, 1981). There is no information on its preferred habitat. Cottrell (1981) mentioned a record from 'Lindi' for this species which was repeated by Larsen (1991); however, one should note that Cottrell believed this label to be wrong as two other species, similarly labeled as 'Lindi', could only have come from the Usambara Mts.
Baliochila minima	Kenya/Tanzania coast	Known from several CFs in Kenya including Ucheweni Forest (Larsen, 1991), and from Kiono/Zaraninge forest at Saadani, Tanzania.
Baliochila neavei	Mozambique	Known only from Dondo Forest and CFs in Gorongasa District (Pennington, 1994).
Baliochila stygia	Kenya Coastal Forests	Inhabits forests in the Mombasa and Rabai areas as well as the Arabuko-Sokoke forest (Kenya); it is a rare CF species (Larsen, 1991). An old record of it from Zanzibar (Kielland, 1990) must be doubtful until fresh specimens are taken from there.
Baliochila sp. nov.	Rondo	One pair of this probably new species, closely related to *B. hildegarda*, has been collected.
Baliochila sp. nov.?	Kiwengoma	Possible new species. (See notes on "*Euthecta* sp. nov.?").
Borbo ferruginea dondo	Rondo, Mozambique coast	An uncommon forest species.
Borbo f. ferruginea	coastal Tanzania/Kenya	This taxon is rare in most CFs. Apart from the localities listed above, it also occurs at Gonja Forest at the base of the South Pare Mts. (Kielland, 1990), and north to the Tana River in Kenya (Larsen, 1991).
Charaxes acuminatus shimbanus	Shimba Hills	Known from an altitude of 400m.
Charaxes baumanni granti	Pugu Hills	The population in Kimboza is very close to this race.
Charaxes b. blanda	Mikindani (near Mtwara)	Described by Rothschild in 1897 from the only known specimen collected by Reimer. Supposed to occur in coastal woodland but has not been recorded despite much search for it. S.C. Collins (*in lit.* 1997) believes that "Mikindani" could be a spelling mistake for Malindi, Kenya, which would thus account for difficulty in locating this taxon in the Lindi and Mtwara Regions of Tanzania.
Charaxes blanda kenyae	Arabuko-Sokoke, Gedi, Kilifi, Shimba Hills	A rare taxon occurring in a few wooded and forested Kenyan sites.
Coeliades keithloa	coastal Kenya to South Africa	ssp. *kenya* occurs in CFs and coastal bush and is known from the Arabuko-Sokoke Forest (Larsen, 1991), Zanzibar (S.C. Collins *in lit.* 1997) and Kilimanjaro (Kielland, 1990). Preliminary studies by S.C. Collins (*in lit.* 1997) indicate that the several subspecies ranging from Ethiopia to South Africa are in need of a taxonomic revision as some of them could be elevated to specific status.
Eresinopsides bichroma jefferyi	Kenya coast	Apart from the two sites mentioned above, this taxon also occurs at Kilifi, Shimoni and Mrima Hill. Specimens from across the border area in Tanzania should be studied further to determine whether or not they belong to this or the nominate race.
Euphaedra castanoides ssp.?	Rondo, Sanje	Probably a distinct race. The nominate race occurs in the Kigoma forests of western Tanzania.
Euthecta cooksoni	Rondo Plateau	Closest known locality to Mozambique,where the species was described from. Discovered in 1952 by D. Cookson in the Amatongas Forest, Mozambique; the following year yielded further specimens from Dondo and Inhamitango Forests, Mozambique, by Cookson and K. Pennington (Pennington, 1994).

Graphium junodi	Coastal and near-Coastal Forest	Occurs from the Delagoa Bay area to Beira in Mozambique. Apart from several coastal sites such as Dondo and Inhamitango Forests, this butterfly has also been recorded in the foothills of the Vumba, Xiluvo and Chimanimani Mts near the Mozambique and Zimbabwe border [see Pennington (1994)].
Hypolimnas usambara	Kenya/Tanzania coast	This rare species, described from East Usambaras, has since been discovered in several CFs, including Mrora Forest on Mafia. It occurs in a number of other Kenyan CFs (Diani, Rabai, Shimba, Jilore) (Larsen, 1991).
Iolaus (Argiolaus) m. maritimus	Kenya coast	Very rare but occurs in most Kenyan CFs (Larsen, 1991). The nominate race has not yet been recorded in Tanzanian CFs but the highland ssp. *usambara* inhabits the Eastern Arc mountains.
Iolaus (Epamera) aemulus apatosa	Kenya/Tanzania coast	Apart from the Arabuko-Sokoke Forest, Larsen (1991) also records this taxon from several CFs in Kenya (Kilifi, Diani, Rabai, Watamu and Malindi). Kielland (1990) did not personally collect the species in Tanzanian CFs although records exist from the coastal area. The nominate race is known from the Natal and eastern Cape Province in South Africa.
Mylothris kilimensis rondonis	Rondo, Kiwengoma	Probably occurs in other forests south of Kiwengoma and around Rondo.
Neptis rogersi	Kenya/Tanzania coast	Earlier only known from coastal Kenya, but has recently been found in Kiono Forest and Mkwaja Ranch, Tanzania.
Pentila rogersi	Kenya/Tanzania coast	The nominate race occurs in the CFs of southern Kenya and ssp. *parapetreia* in some CFs of north-eastern and eastern Tanzania. Recent records from the East Usambara lowlands include those from Manga, Magrotto and Kwamgumi Forests (Kielland, *in lit.* to J. Bayliss).
Pseudathyma l. lucretioides	Kenya coast	An endemic CF species that inhabits most CFs in Kenya; also listed from northern Tanzania without reference to a specific site (Larsen, 1991). Although its occurrence in the northern Tanzanian CFs is very possible, it is not listed from there by Kielland (1990).
Pseudathyma lucretioides rondo	Rondo	The nominate race occurs in coastal Kenya and it is therefore likely that further populations of this taxon occur in between the two locations.
Teriomima micra	Kenya/Tanzania coast	This rare taxon, previously only known from the Kenya coast (Tana River, Shimba Hills, Rabai, Arabuko-Sokoke, Diani) (Larsen, 1991) and the East Usambaras, was recently found in the Pugu Hills and Kiwengoma forest (Matumbi Hills).
Triclema kimboza	Kimboza (Ulugurus), Shimba Hills, Arabuko-Sokoke	First collected in Arabuko-Sokoke but remained unknown until J. Kielland described it from a single male from Kimboza. Subsequently re-found in Arabuko-Sokoke (Warren-Gash, 1993) and Shimba Hills (S.C. Collins *in lit.* 1997).

Dune endemics:

Colotis e. eunoma	coastal areas of Mozambique	Occurs north of Vilanculos; was common in Beira in April 1953 (Pennington, 1994).
Colotis eunoma flotowi	coastal Tanzania	Apart from localities mentioned above, it is also found in dunes south of Dar es Salaam.

More widespread species occurring in Coastal Forests:

Most species discussed here occur in Coastal Forests as well as several montane sites. A few of these taxa also occur in non-forest habitats.

Acraea aganice montana. Common in several Kenyan-Tanzanian CFs but also extends inland to the Eastern Arc mountains, Kilimanjaro (Tanzania) and Nairobi, Thika and the lower Meru Forest (Kenya).

Acraea matuapa occurs in grassy areas near CFs; listed from Kibwezi and Shimba Hills (Larsen, 1991).

Acraea punctimarginea is also known from the West Usambaras.

Aphnaeus williamsi. This rare taxon, previously known as *Aphnaeus flavescens williamsi* (see Larsen, 1991) was recently elevated to a full species in a paper by T. Bouyer (1996) in *Entomologica Africana*. It occurs on the Kenya coast from Kilifi, Arabuko-Sokoke and Mrima Hill (Larsen, 1991).

Aphnaeus coronae littoralis is reported from the Arabuko-Sokoke Forest and Tsavo National Park (Larsen, 1991). The possibility exists that this taxon is not a CF species.

Astictopterus tura is also known from the Vuma Hills in Mikumi National Park and the Morogoro area.

Baliochila amanica is a species that occurs in a few CF forests in Kenya and Tanzania but also at the bases of some Eastern Arc sites (see sites listed above); it also extends to Mt Sagala and Kasigau in Kenya (Larsen, 1991).

Baliochila dubiosa, noted as a Kenyan endemic by Larsen (1991), occurs in several CFs in Kenya and Tanzania; it also goes inland to Nairobi and Meru, Kenya, and the base of the Nguru Mts and Mikumi National Park, Tanzania (Kielland, 1990; Larsen, 1991).

Charaxes contrarius contrarius is a typical species of Kenya and Tanzania CFs, including the bases of some Eastern Arc mountains; however, another undescribed population (see Kielland, 1990) exists in the Ruaha Valley and Rubeho Mts, Tanzania.

Charaxes pythodoris nesaea. This race is rare and very local. It is found on the Kenya coast in a few CFs near Mombasa (Larsen, 1991), south to Kiono Forest near Sadaani and the East Usambara and South Pare Mts (Kielland, 1990).

Coenyropsis carcassoni. Apart from the Shimba Hills, this taxon occurs at McKinnon Road, Rabai and inland to Kasigau, inhabiting forests and coastal scrub. In Tanzania, it is known from Pugu Forest (S.C. Collins *in lit.* 1997) and in woodland near the coast at Mindu Hill, Mikumi National Park and Dar es Salaam. It is an endemic to the Tanzania-Kenya coastline.

Cymothoe coranus coranus ranges in Coastal Forest from South Africa to Kenya, inland to Zimbabwe (D'Abrera, 1980). A disjunct population, ssp. *kiellandi*, inhabits some forests in western Tanzania.

Euphraedra orientalis. Although common in several CFs as well as Eastern Arc mountains in Tanzania, this species is rare in Kenya where it is mainly found in the Shimba and Mrima Hills.

Gorgyra diva is a very rare forest taxon in Rabai and Shimba Hills (Larsen, 1991), and apart from the additional Tanzania CF sites listed above, it also occurs in western Tanzania (Kielland, 1990).

Graphium colonna commonly occurs in a number of East African CFs, but also extends to South Africa (Natal) and southern Somalia. It occurs in some of the Eastern Arc mountains (Kielland, 1990) and inland in Kenya to the Thika and Meru areas, north to Mt Kulal and the southern extreme of Ethiopia (Larsen, 1991).

Graphium kirbyi, although common in most Kenya and Tanzania CFs, also extends into the lowlands of the Eastern Arc mountains [see sites listed above and Kielland (1990)].

Iolaus (Epamera) mermis ranges further inland from the Kenyan coast to the lower Meru Forest (Larsen, 1991) and as far as Mufindi, Udzungwa Mts, in Tanzania (Kielland, 1990), which is the westernmost record.

Lachnocnema dohertyi. A species mainly known from the Mombasa area (Mkunumbi, Diani, Rabai, Ndzovani), has also been recorded from the interior of Kenya at the Ngong Hills and Kitale area (Libert, 1996). S.C. Collins (*in lit.* 1997) also reports it from Arabuko-Sokoke. Libert (1996) did not provide any habitat data for the species.

Leptomyrina hirundo, a species that is common on the coast ranging into South Africa, also occurs in the Nairobi area.

Neptis carcassoni is a relatively scarce but widespread species occurring in a number of localities in eastern Africa (see sites listed above). Kielland (1990) lists it as a lowland forest species from several sites in eastern Tanzania and Larsen (1991) records it as a CF species that extends into the Teita and Chyulu Hills, south-eastern Kenya.

Oboronia bueronica occurs in several Eastern Arc sites and along the coast. It appears to have some affinity with forested hills such as the Shimba Hills and Mtai and Kwamgumi; the latter two of which are on the foothills of the East Usambaras.

Pentila tropicalis, a widespread CF species, also extends inland in some highland forests of Kenya (Chyulu Hills, Meru Forest, Nyambeni Hills) (Larsen, 1991) and highland and lowland forests around Kilimanjaro in Tanzania (Cordeiro, in prep.; Kielland, 1990).

Sallya pseudotrimeni is also found in the Uluguru and Udzungwa mountains.

Teriomima puella. May occur in Dondo Forest, Mozambique; known from Amatongas Forest (Mozambique) and northern Malawi (Pennington, 1994).

Index

Page numbers in *italics* refer to figures; those in **bold** refer to tables; the suffix n denotes notes.

C

D

E

M

N

O

P

Q

R

S

T

U

V

W

X