West Kilombero Scarp Forest Reserve

Zoological Report

FRONTIER TANZANIA
2001

Udzungwa Mountains Biodiversity Survey

West Kilombero Scarp Forest Reserve

Zoological Report

Editors: K Doody, K M Howell & E Fanning.

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Matumizi Endelevu ya Misitu ya Asili (MEMA)
Since 1999, MEMA based in Iringa, have been administering the Udzungwa Mountains Forest Management and Biodiversity Conservation Project (UMFM) and the Natural Woodlands Management Project (NWMP), funded by Danish International Development Assistance (DANIDA).

The University of Dar es Salaam (UDSM)
The University of Dar es Salaam was established in July 1970 as a centre for learning and research in the arts and the physical, natural, earth, marine, medical and human sciences. The University is surveying and mapping the flora and fauna of Tanzania and is conducting research into the maintenance and improvement of the environment and the sustainable exploitation of Tanzania's natural resources.

The Society for Environmental Exploration (SEE)
The Society is a non-profit making company limited by guarantee and was formed in 1989. The Society's objectives are to advance field research into environmental issues and implement practical projects contributing to the conservation of natural resources. Projects organised by The Society are joint initiatives developed in collaboration with national research agencies in co-operating countries.

Frontier Tanzania (FT)
The Society for Environmental Exploration and the University of Dar es Salaam have been conducting collaborative research into environmental issues since July 1989 under the title of Frontier Tanzania, of which one component is the Frontier Tanzania Forest Research Programme (FT FRP).

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Foreword

The Udzungwa forests are unique. They represent a major part of the Eastern Arc forests, which are one of the 25 global biodiversity hotspots. Collectively, these 25 areas cover 1.4% of the planet's land area, but account for about 44% of all vascular plant species and 35% of four vertebrate groups.

The Eastern Arc Mountains have the highest levels of species endemism per unit area of remaining intact natural vegetation worldwide.

The Udzungwa Mountains contain the major part of the closed forests found in the group of Eastern Arc forests that cover an area from the Taita Hills in Kenya to Makambako in Southern Tanzania. The total area of closed natural forest in the Tanzanian part of the Eastern Arc is $1451 km^2$ or approximately 0.2% of the total area of the country. In a Tanzanian context the areas are extremely important, both for their biodiversity and water catchment values (for example 34% of all Tanzanian mammal species are found in the Eastern Arc forests).

The Udzungwa mountains have been legally protected with Forest Reserve status for many years due to their water catchment value. The water that drains from the mountains is of both local and national importance for domestic consumption, livestock, irrigated agriculture and hydroelectric power production.

The biodiversity values specific to the forests of Nyumbanitu/Ndundulu and New Dabaga/Ulangambi are described in the Udzungwa Mountains Biodiversity Survey Reports and represent the foundation for the development of the Udzungwa Forest Management Plans.

The Udzungwa Mountains Forest Management and Biodiversity Conservation Component of MEMA contracted the biodiversity surveys to Frontier Tanzania. MEMA is supporting the Forestry & Beekeeping Division and the Iringa District Council to develop and test models for Participatory Forest Management in the Udzungwa Mountains.

Participatory Forest Management is a new strategy that enhances the protection and sustainable utilisation of forests through the involvement of the communities neighbouring the forests. Communities living near the forests are hence able to monitor closely the activities in the forests while they at the same time often are the major users of the products that can be harvested in the forests. Indeed, the continued harvesting at planned and sustainable levels is a key to committed and responsible community involvement. Sometimes the term 'use-it-or-lose-it' is used to describe this strategy.

The central and local governments have accepted that community participation is the way forward. The Ministry and the local Council fully support the communities being active forest managers.

The great challenge now to all foresters, other professionals and local leaders involved in participatory forest management in the Udzungwas is to ensure that the communities are aware of the unique biodiversity values of their forests. That will hopefully lead to comprehensive, but locally manageable, joint forest management agreements between the

Forestry & Beekeeping Division, Iringa District Council and the communities surrounding the forests.

These reports are the result of the enduring effort by Frontier researchers, volunteers and villagers during almost two years of biodiversity surveys on the steep and wet slopes of the Udzungwa Mountains. The task has strained the human and material resources to their maximum capacity, so I am happy to see that the surveys are safely accomplished. I admire the spirit of the team and their ability to pursue the goal under challenging conditions. Their work is highly appreciated and the output constitutes a valuable and essential part of the framework needed to ensure that the unique Udzungwa forest ecosystems are maintained to the benefit of present and future generations of the Wazungwa people and all the rest of us.

Iringa, March 5th 2001

Henrik Lerdorf
Technical Advisor
MEMA

1.0 Contents

2.0 Acknowledgements

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Finally we would like to sincerely thank the Chairmen, Village Governments and people of Udekwa, Ifuwa, Ilamba and Kidabaga.

Kathryn Doody
KM Howell
Eibleis Fanning

30th April 2001

3.0 Introduction

3.1 Frontier Tanzania

Frontier Tanzania (FT) is a collaborative project first formed in 1989 between the University of Dar es Salaam (UDSM) and the Society for Environmental Exploration (SEE). SEE is a non-profit making company limited by guarantee. Its principal activity is the promotion and organisation of practical research and conservation projects manned by volunteers that will assist national authorities in host countries to develop, maintain or improve the environment and promote the sustainable use of natural resources. UDSM is an institution of higher learning where training and research are conducted. It also provides consultancy to government institutions, parastatals and individuals. The resulting organisation from the collaboration between these two institutions is known as Frontier Tanzania.

Since 1989 the aims of the Frontier Tanzania Forest Research Programme (FT FRP) have been to provide baseline information on the biological values of strategically selected forests as a basis for management planning and long-term monitoring, as well as training Tanzanian personnel and overseas students in the use of biological inventory techniques. The FT FRP worked in the Tanzanian Coastal Forests between 1989 and 1994, then moved to the East Usambaras where baseline biodiversity surveys are still being undertaken.

3.2 Matumizi Endelevu Ya Misitu Ya Asili (MEMA)

Since 1999, MEMA based in Iringa, has been administering two projects, the: Udzungwa Mountains Forest Management and Biodiversity Conservation Project (UMFM) and the Natural Woodlands Management Project (NWMP). It is the UMFM project funded by Danish International Development Assistance (DANIDA) that contracted Frontier Tanzania to undertake this survey.

This report is the culmination of work begun by FT in January 1999 working with the Udzungwa Mountains Joint Forest Management and Biodiversity Conservation Project (MEMA) funded by DANIDA, providing baseline biodiversity data. The biological data provided, together with separate MEMA socio-economic surveys will be used to draw up joint forest management plans.

3.3 Data Citation

Any publication that uses this data must acknowledge all collaborating parties (UDSM, FBD, MEMA, DANIDA, SEE and FT FRP). It should contain the following sentence:

“This publication uses material collected during the Udzungwa Mountains Biodiversity Surveys; a collaborative venture between the Society for Environmental Exploration and the University of Dar es Salaam (through the Frontier Tanzania Forest Research Programme), and the Udzungwa Mountains Forest Management and Biodiversity Conservation Component, MEMA, supported by the Danish Government through DANIDA’’

3.4 Survey period and personnel

The survey of West Kilombero Scarp Forest Reserve was conducted between July to December 1999, and July to September and November to December 2000.

The survey was conducted by Frontier Tanzania staff, volunteers and local people from Udekwa and Ifuwa villages.

3.5 How to Use This Report

3.5.1 UMBS Reports

This report is one of a series of seven completed by Frontier Tanzania researchers. All the reports are the culmination of the two year long Udzungwa Mountains Biodiversity Survey. The reports include the findings of botanical, forest use and zoological surveys conducted in New Dabaga/Ulangambi and West Kilombero Scarp Forest Reserves.

The aim of the reports is to provide detailed information on our findings in the two target reserves, with emphasis on the importance of the forested areas for the conservation of biodiversity. In order to achieve this, a **Botanical and Forest Use Report** and a **Zoological Report** have been written for each reserve, which are broken down into sections tackling each of the survey methods in turn. Each section has been written to give the reader enough detail to understand the findings without extensive reference to other reports in the series. In an attempt to make each section understandable without reference to other reports there is some repetition between sections, this is due to the similar needs of most forest dependent taxa, and the inevitable overlap of some surveys.

To minimise extensive repetition between sections, all recommendations for management and monitoring of the forests arising from the surveys are discussed in more detail in a separate **Management and Summary Report** for each of the two reserves. Within this same report, the key findings from all surveys are summarised in the executive summary, which is also included in both the Botanical and Forest Use and Zoological Reports. Short summaries are presented with each section of these two reports, as well as one copy of all of these in the Management Report. The purpose of this is to give a brief overview of the UMBS project for use by managers, MEMA and the Forestry and Beekeeping Division of Iringa.

Brief descriptions of methods are included where relevant. However, detailed explanation of the methods used can be found in a **Methods Manual**. This gives methods for all surveys plus a bibliography of texts from which the methods have been derived. This also lists the animal and plant identification guides that were used in the field.

3.5.2 Database

The other major output of UMBS is a Microsoft Excel database. All zoological data will also be added to the National Biodiversity Database at the Department of Zoology and Marine Biology, University of Dar es Salaam. The UMBS database will include all data collected from the surveys in NDUFR and WKSFR and will include details on taxonomic identification, habitat details, current location of all specimens, collection localities and dates.

The Frontier Tanzania team has made every effort to ensure that this database can be understood by anyone who should wish to use it. For information regarding this, contact MEMA at the address given at the front of this report.

Hard copies of all original data sheets are stored at Frontier Tanzania and MEMA.

Please contact MEMA for information regarding the data.

3.5.3 Reports in This Series

Frontier Tanzania (2001a). New Dabaga/Ulangambi Forest Reserve – Management and Summary Report. Doody, KZ, Howell, KM, & Fanning, E, (Eds.). *Report for the Udzungwa Mountains Forest Management and Biodiversity Conservation Project, MEMA, Iringa, Tanzania.* 1-77 pp.

Frontier Tanzania (2001b). West Kilombero Scarp Forest Reserve – Management and Summary Report. Doody, KZ, Howell, KM, & Fanning, E, (Eds.). *Report for the Udzungwa Mountains Forest Management and Biodiversity Conservation Project, MEMA, Iringa, Tanzania.*1-78 pp.

Frontier Tanzania (2001c). New Dabaga/Ulangambi Forest Reserve – Botanical and Forest Use Report. Doody, KZ, Howell, KM, & Fanning, E, (Eds.). *Report for the Udzungwa Mountains Forest Management and Biodiversity Conservation Project, MEMA, Iringa, Tanzania.*1-117 pp.

Frontier Tanzania (2001d). West Kilombero Scarp Forest Reserve – Botanical and Forest Use Report. Doody, KZ, Howell, KM, & Fanning, E, (Eds.). *Report for the Udzungwa Mountains Forest Management and Biodiversity Conservation Project, MEMA, Iringa, Tanzania.* 1-45 pp.

Frontier Tanzania (2001e). New Dabaga/Ulangambi Forest Reserve – Zoological Report. Doody, KZ, Howell, KM, & Fanning, E, (Eds.). *Report for the Udzungwa Mountains Forest Management and Biodiversity Conservation Project, MEMA, Iringa, Tanzania.* 1-160 pp.

Frontier Tanzania (2001f). West Kilombero Scarp Forest Reserve – Zoological Report. Doody, KZ, Howell, KM, & Fanning, E, (Eds.). *Report for the Udzungwa Mountains Forest Management and Biodiversity Conservation Project, MEMA, Iringa, Tanzania.* 1-191 pp.

Frontier Tanzania (2001g). Methods Manual. *Report for the Udzungwa Mountains Forest Management and Biodiversity Conservation Project, MEMA, Iringa, Tanzania.*

4.0 Executive Summary - West Kilombero Scarp Forest Reserve

4.1 Introduction

The following report is one of six presenting the results of botanical, zoological and forest use surveys of West Kilombero Scarp Forest Reserve (WKSFR) and New Dabaga/Ulangambi Forest Reserve in Iringa region, south-central Tanzania. Fieldwork was carried out by Frontier Tanzania as part of the "Udzungwa Mountains Biodiversity Survey". The aim of this was to collate and analyse information on wildlife and forest use and thus to determine the biodiversity and conservation priorities of WKSFR. The findings are intended for use by Danida's MEMA project "Udzungwa Mountains Forest Management and Conservation" in the preparation of management plans.

WKSFR lies in a sparsely populated area 70km east of Iringa town. The habitat consists of moist evergreen forest, riverine woodland and wooded grassland. Within the Forest Reserve, surveys have primarily been carried out in the three evergreen forest fragments of Ndundulu, Nyumbanitu and Ukami. The total cover of these forests is 135km^2 between altitudes of 1,040-2,480m a.s.l.. Wooded grassland and riverine habitats outside of the main forest fragments were also surveyed for comparison.

Fieldwork was divided into botanical and forest use surveys from July-December 1999 and zoological surveys from July-December 2000. The following summary provides information on all of these surveys, although the detailed findings of these are presented in separate reports (Frontier Tanzania, 2001d&f).

4.2 Forest Use

Natural Forest Resources

Transect surveys assessing human disturbance have determined that the level of extraction of natural resources from West Kilombero forests is low. Further casual observations and interviews conducted in Udekwa and Ifuwa villages revealed that most natural resources were taken from woodland and riverine sources outside the reserve. Hunting, honey collection, pole cutting and medicinal plant collection do, however, take place inside the Forest Reserve, predominantly near settlements and forest edge. Villagers expressed that medicinal plants are the most important resource from the Forest Reserve, as some of these cannot be replaced by a woodland resource.

The villages of Udekwa and Ifuwa are expanding and cultivated areas have appeared near the forest reserve boundary. Some villagers were worried about the increasingly longer distances they had to walk to collect firewood. Concern was also raised about a shortage of fertile land leading to clearance of woodland areas. This increasing demand for land results from both an increasing human population and the rapid degradation of cultivated areas.

The forest is also the scene for cultural events such as sacrifices for rain and celebrations of ancestors.

Bushfires
Charred ground and burnt plant remains were widespread in the wooded/scrubby grassland adjacent to the forest fragments. Reports from scientists and villagers further suggested that bushfires are often an annual occurrence in the area. These are started by human activities, which are mostly deliberate. Upon return to WKSFR in November 2000, the entire grassland area between Ndundulu and Nyumbanitu had been swept by fire, killing all herbaceous vegetation and even some trees.

Both the maintenance of savanna and the prevention of forest expansion are facilitated by persistent bushfires. This is further demonstrated by differences in vegetation from aerial photographs and systematic surveys at forest edge. Primarily, in areas of reduced fire, there is significantly more regenerating vegetation and even the appearance of forest tree species. Fire started from an unknown source has also reduced forest cover in the north of Ndundulu forest.

4.3 Botanical Survey

The botanical survey was based primarily around 20m×50m vegetation plots, in which all trees above 10cm diameter at breast height (dbh) were measured and identified. Regenerating trees and shrubs were sampled within 3m×3m plots in the centre of the larger plots. To supplement these, fertile specimens of opportunistically encountered plants were also collected.

From all surveys, the WKSFR forests are highly diverse, both in terms of species content and forest communities. This is demonstrated by comparison with the heavily disturbed New Dabaga/Ulangambi Forest Reserve. In WKSFR there are no super-dominant species such as in NDUFR and there is a comparatively low proportion of secondary tree species. There is also a threefold decrease in the mean number of regenerating trees in WKSFR, demonstrating the stable nature of much of the forest.

Trees above 10cm dbh from vegetation plots are tentatively identified from 44 families, 106 genera and 141 species. Of these, 16 species are found to be endemic to the Eastern Arc Mountains. The dominant tree species are *Cola* sp., *Cassipourea gummiflua*, *Bersama abyssinica*, *Syzygium guineense* and *Octolobus spectabilis*. None of these dominant trees are secondary species. An estimated 258 additional plant species including 13 endemics have also been collected opportunistically, giving a combined total of 399 species and 29 endemics. Identification of these is still however continuing.

Distinct tree communities were revealed. A *Cassipourea/Cola/Craterispermum* community was the dominant forest type at most altitudes. Additionally, a *Hagenia/Tecomaria* community dominated at high altitudes (>2000m), and at mid-altitudes (1850-2000m), a *Neoboutonia/Aphloia/Podocarpus* community was common. Two further undifferentiated forest types were also found.

The conservation importance of WKSFR is confirmed by the large regional variation. Importantly, this shows the biodiversity value of the reserve as a whole and there is no clear area that can justifiably be designated for sustainable extraction. Further comparison of the evergreen forest with plots in wooded grassland and mono-dominant riverine forest also reveals the far higher biodiversity of the evergreen forest. Therefore management initiatives should seek to preserve all forested areas.

4.4 Zoological Survey

The zoological survey was carried out using a combination of live trapping, timed searches, transect surveys and casual observations. Seven taxonomic groups were selected for detailed study (**Table 4.4A**).

Ten trapsites were sampled for eight days, each in different habitats within the evergreen forests of Nyumbanitu, Ndundulu and Ukami. These sites were selected using information gained about plant communities from the earlier vegetation surveys. The aim of this was to obtain a good impression of the biodiversity from the reserve as a whole. For comparison with the evergreen forest, four additional trapsites were positioned in other habitats outside of the main forest blocks. These were each sampled for four days.

A summary of the fauna recorded from WKSFR by this survey is presented in **Table 4.4A**. In total this list comprises 344 species identified by taxonomists and field biologists including Frontier Tanzania researchers. Taxonomic identification was however not available for all specimens at the time of writing. In addition to **Table 4.4A** there are species remaining to be identified from most taxa and thus species numbers are likely to increase. In particular, 155 shrew, 158 amphibian and thousands of invertebrate specimens still await identification.

Table 4.4A. Summary of animal species of conservation importance recorded from West Kilombero Scarp Forest Reserve. Sources of information for forest dependence and range restriction can be found in the relevant sections of the Zoological Report. Identification of several specimens from most taxa is still pending and thus these figures are likely to increase.

Taxonomic group	Total no. of species	Forest dependent	Restricted range***	IUCN conservation concern
Butterflies	102	47	23	0
Millipedes	38*	-	-	-
Molluscs	54*	-	-	-
Amphibians	20	9	11	9
Reptiles	19	9	9	0
Birds	151	43	22	9
Mammals	54	15	11	9**

* Identification of millipede and mollusc specimens was not available at the time of writing. Instead the number of “morpho-species” classified by Frontier Tanzania researchers are indicated.
** A further nine mammal species are of IUCN Lower Risk or Data Deficient.
*** Restricted Range = Tanzania, Northern Malawi

Most evident from the collections made is the high number of restricted range and forest dependent species (**Table 4.4A**). The forests of WKSFR therefore have massive importance for the conservation of animal biodiversity. This is most noticeable from comparisons made with New Dabaga/Ulangambi Forest Reserve (NDUFR) and other areas in the Eastern Arc and Africa. There are also numerous signs of animals that are sparse or even absent from NDUFR, especially amongst the larger mammals. In particular the rare Abbot’s duiker and Udzungwa red colobus appear to have relatively healthy numbers in comparison to NDUFR. This is most likely to have resulted from the sparse human population in the area and the resulting low level of human disturbance.

There are however some highly threatened species whose distributions appear to be patchy within the reserve. The most apparent examples are seen amongst the birds and primates, including the Amani sunbird, banded green sunbird, Usambara weaver and Sanje crested mangabey. The implications for management of this are given below.

4.5 Management Recommendations

Reducing Threats to Biodiversity

Priorities for management to conserve biodiversity are a vital part of this report. For this reason, suggestions for management and monitoring have been treated in separate sections to the biological surveys. It should however be considered that these are only suggestions and should not be undertaken without considerable discussion and additional research. Additional phases of the MEMA project have and will further investigate these and other issues to determine priorities for Joint Forest Management.

The impact of fires constitutes the biggest single obstacle in the efforts to sustain the biodiversity values within WKSFR. To conserve these values it is proposed that all annual bushfires are ceased. From surveys at forest edge, the cessation of fire is likely to result in increased regeneration of woody and forest species. By prevention of fires there is therefore excellent potential to connect the main forest fragments and therefore to establish a number of "corridors" for the dispersal of species. This may be facilitated by a mosaic of mono-dominant riverine forest that already exists within the expanse of wooded grassland. This will be most important for patchily distributed plants or animals.

Improvement of honey production in the villages could replace honey collection in the Forest Reserve. Further development of animal husbandry in the villages, including pigs, guinea pigs and chickens could also replace hunting. This would both reduce the ignition of fires in relation to these activities and would reduce the human presence in the areas of evergreen forest. To assist this, it is also necessary to re-mark the boundaries of the reserve.

Logging, pole cutting and other tree felling should be avoided within the reserve. These and other resources may instead be obtained from a woodland source outside of the reserve. With technical support and with large scale awareness raising, there is potential for a sustainably managed woodland. This could provide most resources obtained from within the forest although some resources are thought to be only available from a forest source, e.g. medicinal plants. Subject to further studies, access to the reserve with a permit and limited sustainable extractions of non-threatened and readily renewable evergreen forest species for medicinal purposes could be allowed, if closely monitored and properly administered.

Overall, the preservation of the reserve is of primary importance. Forest use should firstly be carefully monitored to ensure that extractions do not increase above the current low level. With the fast expansion of nearby villages and the planned development of a road to serve Udekwa village, this may however be difficult. The incorporation of the reserve into the adjacent Udzungwa Mountains National Park should also therefore be considered. Such a move has been suggested previously and would provide maximum legislation for the protection of the area. There is an overriding need however for the managing authorities of the Tanzania National Parks Authority (TANAPA) and MEMA to co-operate and to find a solution that will best conserve the rich wildlife communities of WKSFR whilst providing for the needs of the Udekwa and Ifuwa communities.

Income Generation

Initiatives should also be undertaken to improve current practices to limit the need for new agricultural land. This will serve to alleviate poverty whilst further directing activities away from the valuable forest habitat. Enhanced land use planning and development of sustainable use practices in the still extensive miombo woodland areas should also be implemented as a matter of high priority. Agriculture, bean growing, pig farming and tourism could be considered as ways for future increased cash income. These and other potential resources of income should be fully investigated by the MEMA project.

Eco-tourism is taking place on a small scale, but in the right hands the business could be taken further with limited implications for the forest biodiversity. However, mechanisms should be in place which secure a fair share to the villages.

It is important to take into consideration that it is the poorest representatives living around the Forest Reserve, which are most dependent on natural resources. So any restrictions imposed via the management plan are likely to have the greatest implications for these groups. All intended management initiatives have to be carefully planned and screened for maximum sustainability before implementation takes place. A strictly precautionary principle should be employed due to the unique internationally important biodiversity value of the forest reserve.

5.0 Aims

- **To conduct baseline forest and biodiversity surveys.**
  Based on systematic surveys, field observations, and casual collections.

- **To collate and disseminate baseline biodiversity information.**
  Through the production of reports.

- **To provide information on the biological value and use of the forests to assist in the development of Joint Forest Management plans.**
  Based on systematic surveys of forest use/human impact, field observations of forest use/human impact, and Participatory Rural Appraisal technique. Management recommendations and monitoring schemes will be suggested, based on baseline forest/biodiversity data and forest use/ human impact data.

6.0 Study Area

6.1 The Eastern Arc Mountains

Thomas Lehmberg, Lars Dinesen

The Eastern Arc Mountains (**Figure 6A**) are defined as the broken mountain chain stretching from Taita Hills in south-eastern Kenya and extending down to the south-western part of Tanzania, with the Udzungwa Mountains being the last in the chain (Lovett & Wasser, 1993). Each mountain range is separated from the next by drier woodland and savanna vegetation, although they all share a common geological history which dates back to at least the Miocene (Griffiths, 1993). Evidence shows that each mountain range is a block-fault mountain, shaped by periods of repeated uplift and vertical movements followed by longer periods of stability and erosion (Griffiths, 1993). The high proportion of endemic forest-dwelling organisms in the Eastern Arc is ascribed to the long presence of a humid forest cover fostered by a seasonal, but highly predictable rainfall pattern (Lovett 1993). This precipitation arises from moisture evaporating from the Indian Ocean, being subsequently carried towards the East African coast and discharged (Lovett, 1990 & 1993).

The Udzungwa Mountains, the largest of the Eastern Arc Mountain blocks, comprise a number of highly fragmented forest patches of varying sizes and composition (**Figure 6B**). The Mwanihana forest on a southeast-facing escarpment is the easternmost, with a long altitudinal gradient of continuous forest cover, whereas the westernmost forest fragments are smaller and drier, mainly situated on the highland plateau. Extensive forest areas are still present further down the escarpment as well. The large Luhombero forest on the plateau, has the highest peak in the Udzungwas reaching 2576m and forest cover extending up to around 2400m. There is still some uncertainty about the total forest cover in the Udzungwas. Rodgers and Homewood (1982) estimate 450 km^2 of evergreen forest, whereas Dinesen *et al.* (2001) has an estimate of 1800 km^2, including secondary forest, bamboo and groundwater dependent forest. The large majority of forests are situated in Catchment Forest Reserves designated because of their recognised importance as water catchment areas both locally and nationally. The Udzungwa Mountains National Park gazetted in 1992 covers almost 2000 km^2 of the eastern part of the Udzungwas (**Figure 6B**) and encompasses the entire Mwanihana forest (formerly Mwanihana Forest Reserve), large parts of the Luhombero and Matundu forests as well as smaller fragments.

Whereas the Usambara and Uluguru Mountains have been the subject of biological studies for more than 70 years, it is only quite recently that attention has been focused on the Udzungwa Mountains. During the last three decades, the Udzungwa Mountains have received ever-increasing interest from biologists due to the continued discovery of taxa new to science. The taxonomic groups that have received most attention are primates and birds, whereas other larger mammals, spiders, plants, and frogs have been subject to few studies. Other groups have hardly been studied, and due to the very fragmented nature of the forests, basic distribution data is lacking for the majority of groups. For a review of biological studies see Lovett and Wasser (1993) and Dinesen *et al.* (*2001*).

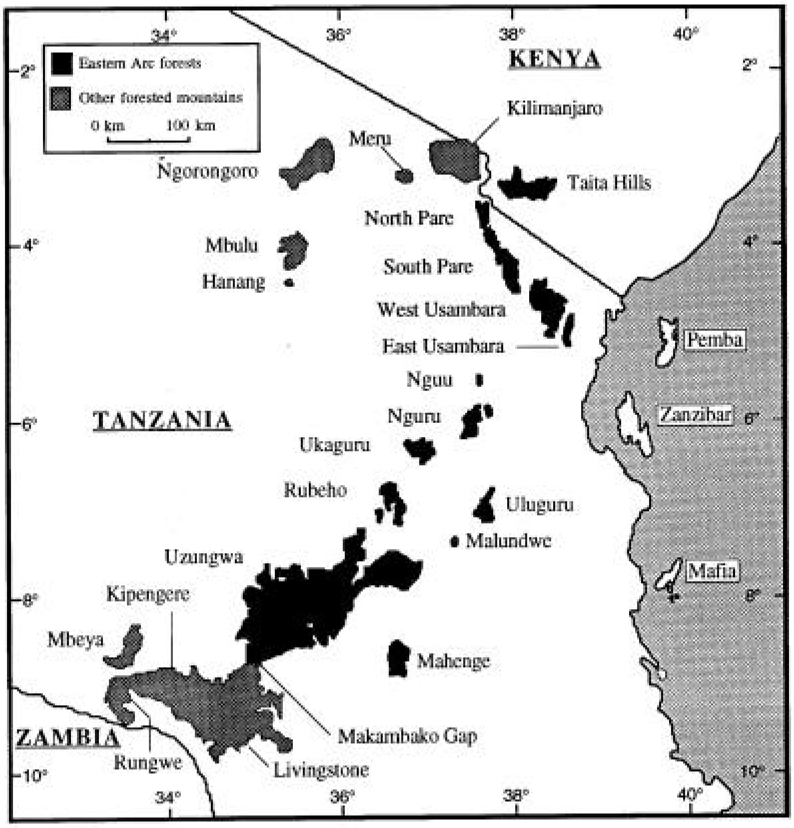


Figure 6A. Mountains of eastern Tanzania and southern Kenya that support moist forest. Eastern Arc Forests shown in black. From Lovett (1993).

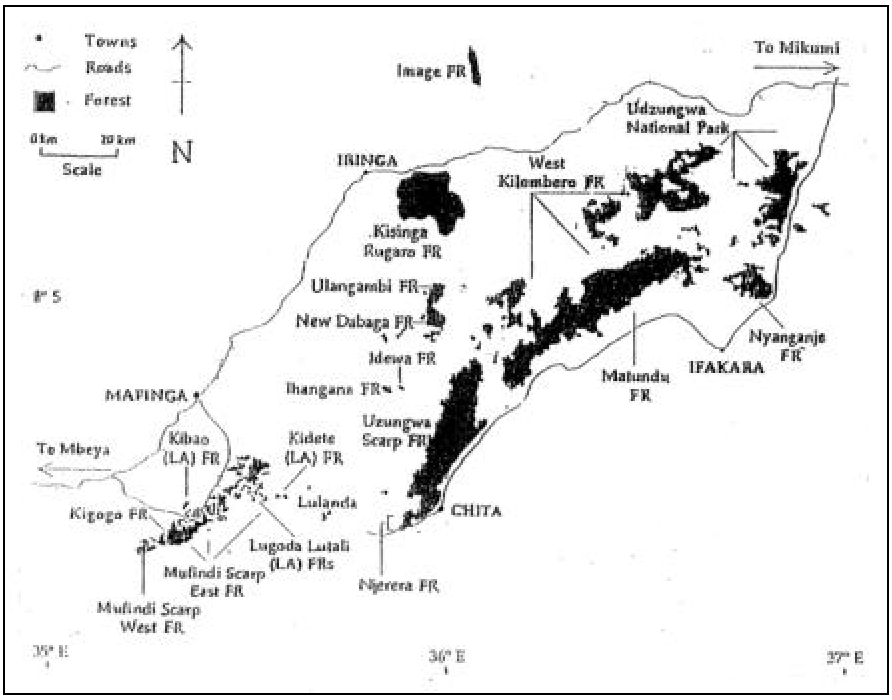


Figure 6B. Forest Reserves of the Udzungwa Mountains. From Moyer (1992).

6.2 Description of Reserve

6.2.1 General Description

Name: **West Kilombero Scarp Forest Reserve**
Iringa District, Iringa Region, Tanzania.

Area: 104,296 ha; 1043 km^2 Forested: 305 km^2 (Ndundulu, Nymbanitu, & Ukami).

Boundary Length: The boundary is not clearly marked.

Status: Catchment Forest Reserve. Gazetted in 1957. Originally comprised 195,253 ha, however, 91,000 ha given over to the formation of the Udzungwa Mountains National Park.

Maps: Ordnance Survey topographic maps 1:50,000 Series Y742
Sheets 216/2, 216/3, 216/4, 217/1, 217/2, 217/3, 217/4, 234/1, 234/3. Forest reserve boundary is not marked on Ordnance Survey Map. Aerial photographs available from the MEMA project for 1956, 1978 and 1999.

6.2.2 Location

Grid Reference: 36°05'E - 36°33'E; 7°38'S - 8°17'S

Elevation: 320 – 2576m a.s.l.

West Kilombero Scarp Forest Reserve is located 70km east of Iringa town. The area was accessed by a poor road from Ilula town, passing through Ifuwa village and terminating just south of Udekwa village (see **Figure 5.2A**). Udekwa is the nearest village to the study area. Due to the poor road, Udekwa is rather isolated. There is no bus service linking Udekwa to Iringa. However, trucks service Udekwa twice a week.

Aside from Udekwa and Ifuwa villages (west of the reserve), and Ikula village (north of the reserve) the area is remote and uninhabited. To the east, the reserve is bordered by the Udzungwa Mountains National Park and the Ruipa River, to the south is Matundu Forest Reserve (**Figure 6B**). The reserve's other borders are comprised of uninhabited miombo/acacia woodland and grassland.

For the purpose of this report, the name "West Kilombero Scarp Forest Reserve" or "WKSFR" is used to refer to the northern part of the reserve including the three montane forest fragments of Ndundulu, Nyumbanitu and Ukami and surrounding wooded grassland (see **Figure 5.2A**). The reserve actually extends south of this area, however this study does not cover the southern half. The area between forests is made up of grassland and miombo/acacia woodland on the slopes with riverine forest and marsh in the low-lying wet valleys.

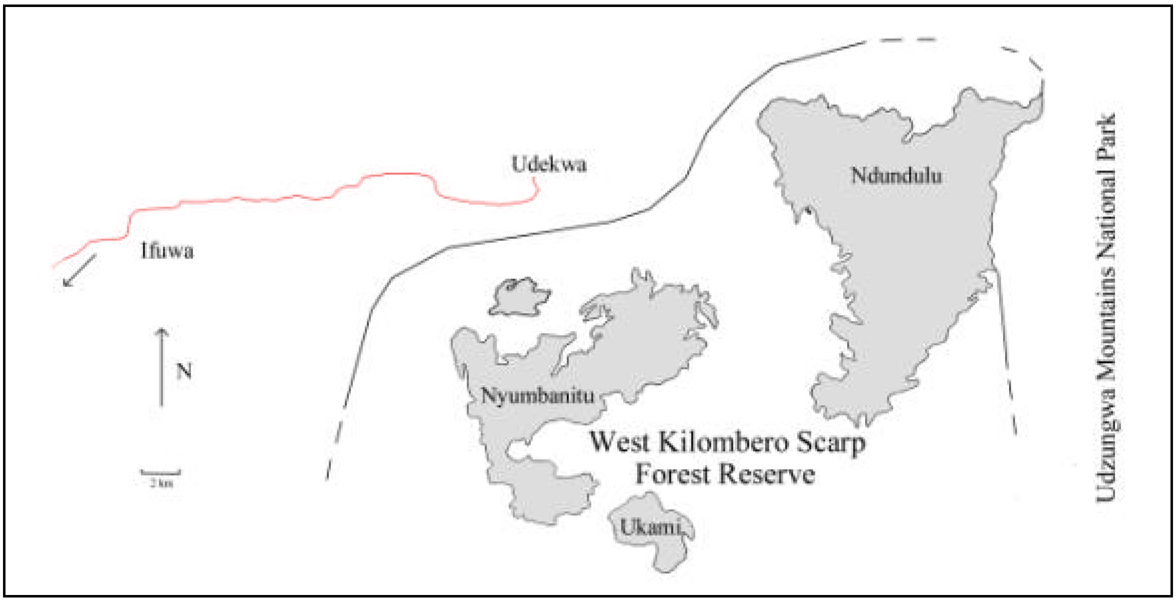


Figure 6.2A. Map of West Kilombero Scarp Forest Reserve including approximate location reserve boundary (dark solid/dashed line) and road (light line) from Udekwa to Iringa (through Ifuwa). The three main forest fragments are labelled: Ndundulu, Nyumbanitu, and Ukami.

6.2.3 Soils

Soils are brown sandy loams over crystalline gneiss.

6.2.4 Climate

Climate is that of oceanic rainfall with oceanic/continental temperatures. For the upland plateau areas the nearest rainfall station with comparable results is at the Brooke Bond Tea Estates to the south. Estimated rainfall is between 1500-2000 mm/yr. Estimated mean temperature is ~20°C max. (December), ~15°C min. (July). Dry season is between June and November.

For the lowland areas, the nearest rainfall station is at Lumemo. Estimated rainfall is 1350mm/yr with permanent riverine ground water. The mean temperature ranges between 27°C (max; December) and 19°C (min; July). The dry season is between June and October.

6.2.5 Vegetation

In upland areas, the vegetation is composed of moist and dry montane and upper montane forest with extensive areas of bamboo and upland grassland. In the drier lower-lying areas, forest is replaced by woodland/grassland.

Montane Forest: Typical trees include: *Cassipourea gummiflua*, *Maesa lanceolata*, *Neoboutonia macrocalyx*, and *Cola* sp..

Upper Montane Forest: Typical trees include: *Aphloia theiformis*, *Bersama abyssinica*, *Syzygium guineense*, *Hagenia abyssinica* and *Ocotea usambarensis.*

Riverine Forest: Within woodland/grassland usually dominated by *Syzygium cordatum* with varying amounts of *Bridelia micrantha*, *Faurea* sp. and *Rauvolia caffra*.

Woodland: In higher altitudes dominated by *Protea* sp., while in lower altitudes it is dominated by *Brachystegia* sp.

6.2.6 Catchment Value

The reserve includes a number of catchments due to its large area and its relatively high rainfall. A number of rivers flow south (e.g. Ruipa) into the Mgeta and Ruipa catchments which feed into the Kilombero valley (agricultural area). A number of rivers flow north into the Lukosi catchment which feeds into the Great Ruaha River and is the basis for the generation of electrical power at the Kidatu Hydro-electric Dam.

Frontier Tanzania Udzungwa Mountains Biodiversity Survey

West Kilombero Scarp Forest Reserve

7 Zoological Surveys

7.0 Zoological Surveys

7.1 Introduction to Zoological Sections

7.1.1 Introduction

The zoological report has been divided up into sections on the basis of the methods used to sample the different taxonomic groups (see **Appendix 7.1A**). The fauna has thus been divided up into eleven groups. Each section describes the methods employed in some detail, however, for a full description see the UMBS Methods Manual (Frontier Tanzania, 2001g). A summary of the taxonomic nomenclature used within each section and a list of Kihehe animal names are presented in **Appendices 7.1A & B**.

The methods employed during the zoological survey of West Kilombero Scarp Forest Reserve (WKSFR) and New Dabaga/Ulangambi Forest Reserve (NDUFR) are similar to those used by Frontier Tanzania in the East Usambara Mountains and some of the coastal forests of Tanzania. This allows future comparison between surveys carried out in the Udzungwas and these other areas.

The zoological surveys presented here from WKSFR took place from July to September and November to December 2000, with some opportunistic collections during 1999.

7.1.2 Information on Trapsites

Four trapsites (trapsites A-D) were sampled for four days, while ten trapsites (trapsites 1-10) were sampled for eight days. Trapsites 1-10 are referred to as sites within 'evergreen forests' or 'areas within the main forest blocks', while trapsites A-D have been grouped together as 'other habitats' or 'non-evergreen forest areas.' These groupings are accurate descriptions of most trapsites. However the classification of some trapsites requires some justification.

Trapsite 9, although placed outside the main forest blocks, was placed in diverse riverine forest with large canopy trees (canopy height: 20-30m). This area of riverine forest is comparable in habitat structure to the evergreen forest trapsites and continuous with the Nyumbanitu forest block.

Trapsite A and B were placed in woodland habitats, while D was placed in a grassland habitat. Trapsite C however, was placed in riverine forest outside the main forest blocks. The habitat at trapsite C differs markedly from trapsite 9 in being a mono-dominant forest (*Syzygium cordatum*) with a canopy height of less than 10m. Furthermore, the riverine forest at trapsite C does not appear to be connected to any of the forest blocks.

Figure 7.1A shows the location of each of the trapsites. **Appendix 7.1C** highlights the grid reference and our field names of the trapsites and main campsite. Where possible, the local name of the area or an area near the trapsite has also been included in the appendix.

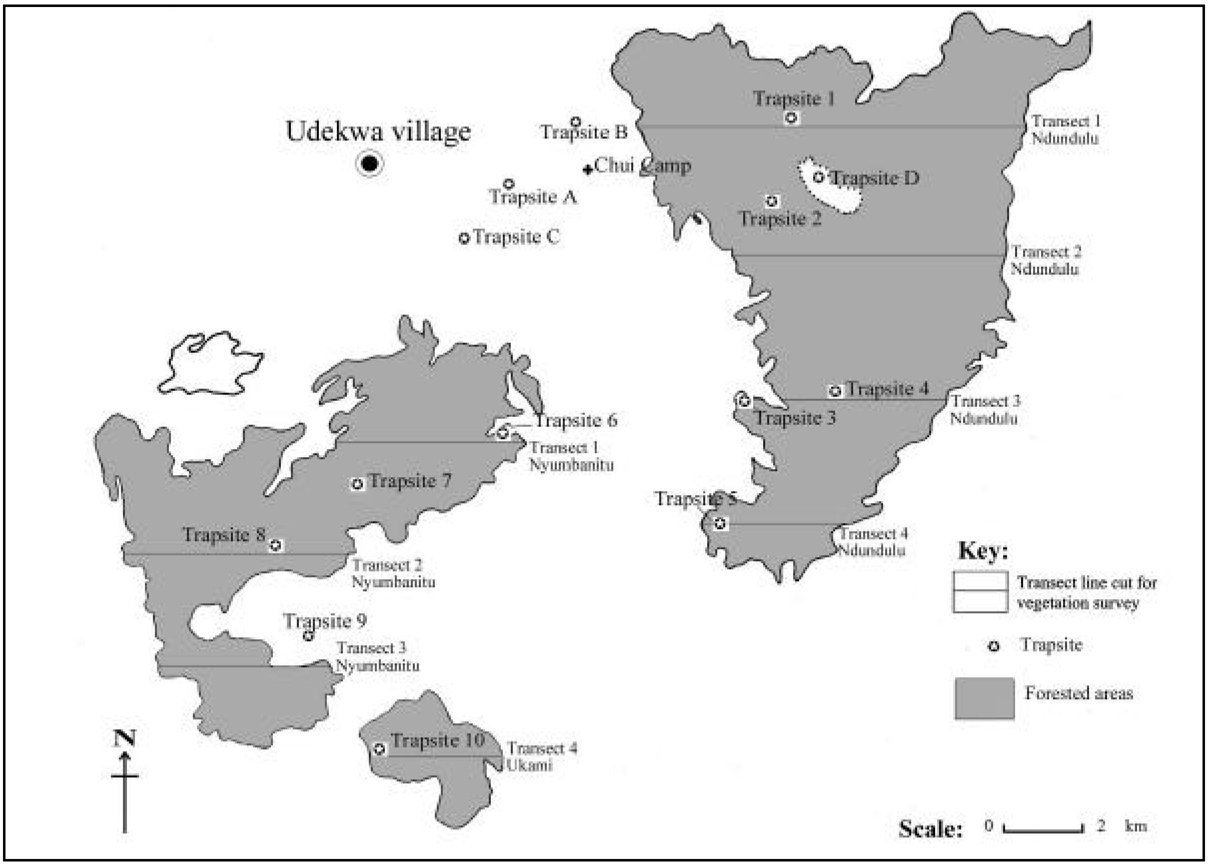


Figure 7.1A. Location of trapsites in West Kilombero Scarp Forest Reserve. Trapsite D was placed in a grassland area of unknown size (at least $0.5km^2$) within the Ndundulu forest block.

Habitat Information of Trapsites

Trapsites were placed to sample a maximum diversity of habitats and therefore also species. Presented in **Table 7.1A** is a summary of the habitat details at the various trapsites. The table also includes dates of when the trapping took place.

Table 7.1A. Summary of habitat details at each trapsite.

Trapsite	Date (from-to)	Altitude (m a.s.l.)[~]	Vegetation type	Canopy cover[+]	Canopy height[+]	Distance to water*
A	08/07/00 11/07/00	1370	Open miombo woodland (*Uapaca kirkiana* and *Brachystegia spiciformis*).	10-50%	<10m	None
B	04/12/00 07/12/00	1480	Open acacia (*Acacia* sp.) woodland.	10-50%	<10m	None
C	13/07/00 17/07/00	1430	Mono-dominant *Syzygium cordatum* riverine forest.	>50%	<10m	3-25m
D	25/07/00 29/07/00	1890	Grassland	<10%	<10m	0-100m
1	15/07/00 22/07/00	2070	Montane forest. Dominant species: *Hagenia abyssinca*. *Hagenia/ Tecomaria* community.	10-50%	10-20m	None
2	21/07/00 28/07/00	1940	Bamboo forest (*Arundinaria alpina*).	>50%	<10m	None
3	03/08/00 10/08/00	1440	Montane forest near edge. Dominant species: *Syzygium guineense* and *Bersama abyssinica*.	>50%	10-20m	5-150m
4	13/08/00 21/08/00	1360	Montane forest (centre). Dominant species: *Cassipourea* sp. *Cassipourea/Cola /Craterispermum* community.	10-50%	10-20m	3-80m
5	03/08/00 10/08/00	1550	Montane forest. Dominant species: *Cola* sp. *Cassipourea /Cola /Craterispermum* community.	>50%	10-20m	0-100m
6	26/08/00 02/09/00	1530	Montane forest near edge. Dominant species: *Bersama abyssinica*.	>50%	10-20m	45-200m
7	14/08/00 22/08/00	1550	Montane forest (centre) near marshy area. *Cassipourea/Cola/ Craterispermum* community.	10-50%	10-20m	1-150m
8	12/11/00 20/11/00	1400	Montane forest (centre). Dominant species: *Millettia usaramensis*.	>50%	10-20m	50-150m
9	25/08/00 01/09/00	1140	Species rich riverine forest. Dominant species: *Schrebera alata* and *Parinari* sp.	10-50%	10-20m	45-200m
10	23/11/00 30/11/00	1150	Sub/Montane forest. Dominant species: *Allanblackia stuhlmannii*.	>50%	20-30m	0-50m

+ Canopy cover and height: figures are estimates for the whole trapsite.
* Water association: figures stated are estimates of the nearest and furthest points of the trapsite.
^ Vegetation community as described in Section 7.2 (Frontier Tanzania, 2001d).

7.1.3 Definitions of Terms

Where species have been identified and tabulated in the various sections, species are described in terms of their ecological requirements and endemic status. These terms will be used throughout the report, and are defined in **Box 7.1A**.

Box 7.1A. Terms used for ecological requirements and levels of endemism in this report.

Ecological requirements are defined in terms of:	
Forest dependent species (F)	The species is dependent on forested areas as defined by authors cited in each section. The distribution of these species is restricted to forested areas.
Forest dwelling species (´)	The species is forest dwelling, but not forest dependent, i.e. the species is found in forest or forest edge as well as other habitats.
Non-forest species (O)	The species does not generally occur within forests.
Levels of endemism are defined in terms of:	
Endemic (E)	The species only occurs within the Udzungwa Mountains.
Near-endemic (NE)	The species is restricted in range to the Eastern Arc Mountains, Tanzania and Northern Malawi. Within this area the species may have a very localised distribution as defined by subdivisions in the NE category in each section using numbers in superscript (e.g. ^{2}NE = Udzungwa and Usambara Mountains).
Limited range or restricted range	This refers to endemic and near-endemic species.

7.1.4 Statistical Tests Used

Statistical tests have been used to test the ecological relationships of the various taxa and therefore to explain their distribution between trapsites. **Box 7.1B** and **Box 7.1C** highlight the two most commonly used tests (for a more detailed description of the tests see Dytham, 1999).

Box 7.1B. Tests to look at differences: independent samples *t*-test and Mann-Whitney *U* test.

The independent samples *t*-test was used to compare means between two sets of data. The *t*-test assumes that the data are continuous, at least approximately normally distributed and that the variances of the two sets of data were the same. If these assumptions are violated, then the Mann-Whitney *U* test was used. The Mann-Whitney *U* test also tests for differences between two sets of data, however, medians are tested as opposed to means.

Box 7.1C. Tests to look at relationships: Pearson’s correlation and Spearman’s rank-order correlation.

These tests look at whether two sets of observations are associated or correlated, the strength of the correlation and whether it is significant or not. Pearson’s correlation assumes that the variables being tested are measured on a continuous scale and normally distributed. If these assumptions were violated, the Spearman’s rank order correlation was used.

7.2 The Small Mammal Fauna of West Kilombero Scarp Forest Reserve

J. Elmer Topp-Jørgensen, Andrew R. Marshall and Henry Brink.

7.2.1 Summary

The small mammal fauna of West Kilombero Scarp Forest Reserve was surveyed between July and December 2000, using a combination of bucket pitfalls, Sherman traps and larger mesh traps. Ten trapsites were placed in the main forest block and four were positioned in non-evergreen forest habitats (miombo woodland, acacia woodland, mono-dominant riverine forest and grassland). Evergreen forest sites were trapped for eight days and other habitats for four days.

The term "small mammals" refers in this study to the members of the family Soricidae and the orders Macroscelidea and Rodentia. "Small rodents" refer to species of the family Rodentia caught in Sherman traps and bucket pitfalls (*Beamys hindei* and *Tatera* sp. being the largest species).

The list of small mammals species observed in WKSFR includes 16 species of rodents, at least four species of shrew (155 specimens await identification) and two species of elephant shrew. One casually observed species, Zanj elephant shrew (*Rhynchocyon petersi*) is listed as "Endangered" by IUCN, while *Crocidura monax* and *Beamys hindei* are listed as "Vulnerable". Six of the specimens identified to date are forest dependent and five of these are restricted to forests in Tanzania, Kenya and Malawi.

Thirteen species of rodents were caught in Sherman traps and bucket pitfalls in the reserve as a whole. Nine rodent species were caught in evergreen forest areas and nine in other habitats, with *Graphiurus* sp., *Lemniscomys griselda* and *Rhabdomys pumilio* only recorded from the latter. Only one species occurred exclusively in evergreen forest, *B. hindei.*

The identification of *Dasymys incomptus* and *Mus minutoides/musculoides* (uncertainty about identification) from forested areas in WKSFR, combined with Frontier Tanzania surveys in New Dabaga/Ulangambi Forest Reserve and data from Stanley *et al.* (1998), increases the number of small rodent species known from forested areas in the Udzungwa Mountains to 16. This is the highest number recorded for an Eastern Arc forest, thus highlighting the great biodiversity value of this mountain region.

Two records were made of the servaline genet (*Genetta servalina lowei*), which according to Kingdon & Howell (1993) is known from only one individual collected in the Dabaga area in the 1930s. A slight morphological difference was also noted between four-toed elephant shrews (*Petrodromus tetradactylus*) caught in evergreen forest and miombo woodland, but taxonomic verification is needed to tell if the individuals belong to different sub-species.

The patchy distribution of some small mammal species suggests that the diversity of the small mammal fauna is closely linked with habitat heterogeneity. Therefore management should seek to preserve the mosaic of habitats found in West Kilombero Scarp Forest Reserve.

7.2.2 Introduction

Small mammals constitute a highly successful group adapted to a wide array of niches both in natural environments and in human dominated landscapes. In tropical forests small mammals play an important role as dispersal agents and pollinators, and their impact on seed and seedling survivorship through predation is thought to play a major role in forest dynamics (Fleming, 1975; and various citations in Struhsaker, 1998). They are also important prey for many medium-sized carnivores and raptors (Chandrasekar-Rao and Sunquist, 1996), and therefore play an important ecological role in natural forest ecosystems.

The rodent fauna is widely distributed in Eastern Arc although many species are restricted to montane or sub-montane habitats, while shrew species are more patchily distributed indicating a higher level of speciation in the individual Eastern Arc mountain regions (Stanley *et al*., 1998). Although surveys have been carried out in most major Eastern Arc Mountain regions, knowledge of the small mammal fauna is incomplete and further investigation is needed.

This survey investigates the species richness, abundance and distribution of the small mammal fauna in West Kilombero Scarp Forest Reserve, and compare results with previous studies in Udzungwa Mountains and other Eastern Arc forests. Notes are also presented on small species of Carnivora caught during the survey.

Definition of Terms
"Small mammals" refers to the members of the orders Macroscelidea and Rodentia and to the family Soricidae.

"Small rodents" refers to species of the family Rodentia caught in Sherman traps and bucket pitfalls (*Beamys hindei* and *Tatera* sp. being the largest species).

Aims

- To survey and list the small mammal fauna of West Kilombero Scarp Forest Reserve.
- To discuss diversity and abundance of the small mammal fauna within evergreen forest and compare with results obtained in non-evergreen forest habitats.
- To compare results with other Eastern Arc forests.
- To make recommendations for management.

7.2.3 Method

The small mammal fauna of West Kilombero Scarp Forest Reserve was surveyed by a combination of bucket pitfalls and Sherman traps. In other areas such methods have shown to document most of the medium-sized to small mammal fauna effectively (Stanley *et al*., 1998). Small mammals were trapped from July through to December 2000 at ten sites in evergreen forest and four sites in other habitats (Miombo woodland, Acacia woodland, grassland and riverine forest). Evergreen forest sites were trapped for eight nights and other habitats for four nights.

Bucket Pitfall Trapping
Shrews and small rodents were sampled using bucket pitfall lines (see Frontier Tanzania, 2001g for detailed description of methods). One pitfall line consisted of 11 buckets positioned at 5m intervals. The buckets were dug into the ground so the rim was level with the soil. Buckets measured 29.5cm in diameter at the rim and were 33cm deep (20 litre). A 55m long and approximately 0.5m high drift fence of transparent plastic ran the length of the pitfall line bisecting each bucket.

Three pitfall lines were set at each trapsite. Care was taken to position the lines in habitat types representative of the area, if possible including both moist and dry habitats.

Sherman Traps
Medium to large-sized rodents were captured live using 100 small Sherman traps (8cm x 9cm x 24cm) and five large Sherman traps (10cm x 11cm x 37.5cm). Traps were set approximately within 5m of the three pitfall lines with 30 traps set on two lines and 40 set on the third. The distance between traps was 2-5m. About ten of the small Sherman traps were set in trees or shrubs between 0.5m and 3m above the ground, the rest were placed at ground level. Traps were baited every afternoon between 16:00 and 18:00 with freshly fried coconut mixed with peanut butter and they were checked the following morning between 07:00 and 09:00. Traps were left closed during the day.

Records of the number of sprung and un-sprung traps were recorded daily with information on whether bait was present or absent. After every night of trapping, the number of trap nights was subsequently calculated for each trapsite using the number of un-sprung traps with bait and sprung traps containing animals.

Large Mesh Traps
Larger “Tomahawk” style mesh traps that were not part of the systematic survey were also set at most trapsites. One very large mesh trap (approximately 30cm x 30cm x 80cm) and one or two smaller (approximately 20cm x 20cm x 45cm) were set to catch medium-sized mammals. Results for these traps will be presented separately from Sherman trap and bucket pitfall results.

Identification
To facilitate identification, biometrics and detailed habitat information were recorded on a standardised data sheet for all animals (see Frontier Tanzania, 2001g). A number of specimens were preserved in formalin for taxonomic verification, while all other individuals were released in the trapping area. All released individuals were marked by cutting sections of fur in a unique pattern, and every re-capture was recorded.

Shrews

Identification of shrews involves examination of teeth and skull morphometrics. Many species look almost identical externally and it has therefore been impossible to determine shrew species in the field. Instead specimens have been sent to Mr. W. T. Stanley from the Division of Mammals at the Field Museum, Chicago in USA for identification. Unfortunately, the identifications will not be completed before the deadline of this report, but W. T. Stanley has provided identification to genus or species level for some specimen during a brief visit to Tanzania.

Rodents

Voucher specimens have been collected of all rodent species. A maximum of three individuals of each species were collected from each trapsite, unless the identification was considered to be uncertain. Identification was carried out in the field by Frontier Tanzania field staff and W. T. Stanley has verified collected specimens from 11 of the 14 trapsites. W. T. Stanley will later identify and verify all specimens.

Species of the genus *Mus* can look very similar externally. W. T. Stanley has identified some individuals to species during his brief visit, but the majority of *Mus* individuals await identification.

Initial problems with the identification of *Praomys* sp., *Hylomyscus* sp. and *Grammomys* sp. have resulted in few records of the latter two, which have been recorded as *Praomys* sp.. These species will therefore be grouped together in the analysis as the *Praomys* group. Differentiating between species on the basis of measurements proved to be impossible in most cases.

Species of the genera *Dendromys* and *Graphiurus* was only identified to genus level, due to the possible presence of more than one species in each genus. Many individuals of *Mus* sp. as well as casually observed species were also only identified to genus level.

7.2.4 Results

The Small Mammal Fauna, its Forest Dependency and Conservation Status

When encountered, notes on the presence of other species of Soricidae, Macroscelidea and Rodentia were recorded. In total 23 species of small mammals (as defined in introduction) were recorded from West Kilombero Scarp Forest Reserve representing five species of shrew (Soricidae), two species of elephant shrew (Macroscelidea) and 16 species of rodent (Rodentia) (see **Table 7.2A**). One of these species was represented by two subspecies. Six species of the small mammals encountered in WKSFR are forest dependent according to Kingdon & Howell (1993); one shrew, one elephant shrew and four rodents (see **Table 7.2A**). One species is listed as "Endangered" by IUCN (Hilton-Taylor, 2000), two are listed as "Vulnerable", while data is deficient for two species (see **Table 7.2A**). See **Appendix 7.5A** for complete list of mammals recorded for WLSFR.

Kingdon & Howell (1993) list *Lophuromys flavopunctatus* as a forest dependent species. During 16 trap nights 12 individuals were caught outside forests compared to 24 individuals caught during 80 trap nights in forest (see **Appendix 7.2A**). This survey therefore questions the forest dependency of this species (see also Frontier Tanzania, 2000e). The species *Hylomyscus denniae* was absent from three non-evergreen forest sites and only one *Praomys* group individual (species unknown) was recorded from the fourth. Three forest sites where all individuals were identified recorded 47 individuals of this species, and based on composition of collected specimens it is estimated that 160 individuals of *H. denniae* were found in total. This means that a maximum of one of 160 individual was found outside evergreen forest habitats, suggesting that *H. denniae* might be a forest dependent species.

Table 7.2A. List of smaller mammals encountered in West Kilombero Scarp Forest Reserve, their distribution and conservation status.

Order and family	Species	Forest dependency	Conservation status IUCN (2000)	Endemism and distribution of species
INSECTIVORA				
Soricidae	*Myosorex kihaulei*			E
	Crocidura hildegardeae	F		?
	Crocidura monax		VU	K, T
	Crocidura olivieri			?
	Sylvisorex sp.			?
MACROSCELIDEA				
Macroscelidinae	*Petrodromus tetradactylus tetradactylus*			?
	Petrodromus tetradactylus rovumae			?
Rhynchocyoninae	*Rhynchocyon petersi**	F	EN	K, T
RODENTIA				
Sciuridae	*Paraxerus lucifer lucifer**	F		K, Ma, T^
Myoxidae	*Graphiurus* sp.			?
Hystricidae	*Hystrix* sp.			?
Thryonomyidae	*Thryonomys* sp.*			?
Dendromurinae	*Dendromys* sp.			?
Cricetomyinae	*Beamys hindei*	F	VU	K, Ma, T
	Cricetomys gambianus			W
Muridae	*Lophuromys flavopunctatus*	F		W
	Praomys delectorum	F		K, Ma, Mo, T
	Hylomyscus denniae			K, T, U, Ma
	Mus bufo			?
	Mus minutoides / musculoides			?
	Grammomys ibeanus			?
	Dasymys incomptus		DD	?
	Rhabdomys pumilio		DD	W
	Lemniscomys griselda			?

*- Species observed in forest reserve but not caught during the survey.
^ - Subspecies confined to Eastern Arc Mountains (Kingdon, 1997).
F - Forest dependent according to Kingdon & Howell (1993).
Conservation status categories: EN = Endangered; VU = Vulnerable; DD = Data deficient (Hilton-Taylor, 2000).
Endemism and distribution categories: E = endemic to the Udzungwa Mountains; K = Kenya; Ma = Malawi; Mo = Mozambique; T = Tanzania; W = Widespread (Kingdon, 1997; Hilton-Taylor, 2000).

Sherman Trap and Bucket Pitfall Survey

A total of 1,085 small mammals were captured in West Kilombero Scarp Forest Reserve during this study. 801 of these were caught in traps and 284 in bucket pitfalls. 709 were unique individuals (i.e. not counting recaptured and animals that escaped before processing), of which 517 were rodents, 192 shrews (see **Table 7.2B**) and two were four-toed elephant shrews (*Petrodromus tetradactylus*). 439 unique individuals were caught in Sherman traps and 270 in bucket pitfalls (see **Table 7.2C**). Only unique individuals will be used for comparison between areas and for assessing the effect of environmental factors. This is done to avoid bias from animals which are "trap happy" or "trap shy", and from the removal and preservation of different numbers of individuals from different trapsites for distribution to taxonomists (which for obvious reasons can't be recaptured).

A minimum of 13 species of rodents (*Mus* sp. pending identification) were recorded from 12 genera and four families during the Sherman trap and bucket pitfall survey (see **Table 7.2B** & **Appendix 7.2A**). A minimum of five species of shrew (*Crocidura hildegardeae*, *Crocidura monax*, *Crocidura olivieri*, *Myosorex kihaulei* and *Sylvisorex* sp.), have been collected (see **Table 7.2B** & **Appendix 7.2A**). 155 individuals of shrew are however pending identification. One species of elephant shrew was also caught in the reserve (see **Appendix 7.2A**).

Members of the "*Praomys* group" were the most frequently caught "species"; 365 individuals recorded from 13 of 14 trapsites. If the species composition of individuals identified with certainty from the *Praomys* group (see **Appendix 7.2A**) represent the relationship between the species in the reserve, 50.5% (54 of 107) or 184 individuals of the *Praomys* group are *Praomys delectorum.* This makes it the most abundant species in the reserve, closely followed by *Hylomyscus denniae* with 160 individuals. *Lophuromys flavopunctatus* and *Mus* sp. were recorded at 10 and 12 trapsites respectively, although at much lower abundance (36 and 64 individuals respectively). Most other species were present at even lower abundance and found at far fewer trapsites (see **Appendix 7.2A**).

Table 7.2B. Number of small rodent and shrew species caught per trapsite during pitfall and trap survey, listed along side number of Sherman trap nights, number of bucket pitfall nights (number of buckets x number of trap nights) and trapsite altitude.

Trapsite	Rodent species	Rodent individuals	Shrew species#	Shrew individuals	Number of trap nights	Number of pitfall nights	Altitude m asl
Evergreen forest							
1	3	55	3	11	794	264	2070
2	3	75	3	7	798	264	1940
3	6	14	2	17	650	264	1440
4	5	41	2	8	734	264	1360
5	6	65	2	12	751	264	1550
6	4	13	3	15	711	264	1530
7	5	30	3	9	830	264	1550
8*	4	63	2	36	777	264	1400
9	7	83	2	13	808	264	1140
10*	6	4	3	31	494	264	1145
Total	9	444	4	159	7347	2640	1140-2070
Non-evergreen forest							
A^	6	23	1	3	434	132	1370
B*	5	24	3	22	370	132	1480
C	2	2	2	3	402	132	1430
D	5	24	3	5	408	132	1890
Total	9	73	4	33	1614	528	1370-1890
West Kilombero Scarp Forest Reserve							
Total	13	517	5	192	8961	3168	1140-2070

* - Trapsites surveyed during the short rainy season from mid-November to December
^ - Two individuals of the four-toed elephant shrew (*P. tetradactylus*) were also caught in Sherman traps at this trapsite.
# - Based on 37 identification to species level and 91 identifications to genus level. 64 individuals were only identified to family.

Table 7.2C. Small rodent and shrew captures from eight nights of trapping in evergreen forest areas and four nights in both evergreen and non-evergreen habitats. Listed are the number of unique individuals and trap-rate for rodents and shrews caught in Sherman traps and bucket pitfalls.

Trapsite	Number of unique rodents: Sherman traps	Bucket pitfalls	Per 100 trap nights	Per 33 bucket nights	Number of unique shrews: Sherman traps	Bucket pitfalls	Per 100 trap nights	Per 33 bucket nights
Forest 8 days	372	70	5.01	0.88	7	152	0.09	1.90
Forest 4 days	200	35	5.35	0.88	5	109	0.13	2.73
Non-forest*	53	22	3.28	1.38	7	26	0.43	1.63
Total*	425	92	3.28	1.38	14	178	0.43	1.63

* In addition to rodents and shrews, two individuals of *P. tetradactylus* were caught in Sherman traps.

Evergreen Forest Trapsites

Small Rodents

The accumulation curve for rodent species caught at evergreen forest sites is clearly levelling off at nine species (see **Figure 7.2A**), with only one new species recorded for the last five sites. This indicates that the rodent population in WKSFR is well represented in the study.

The number of rodent species caught per trapsite varied between three and seven for evergreen forest sites. High altitude trapsites 1 and 2 have the lowest number of species (three), while trapsites 3, 5, 9 and 10 are most species rich (see **Table 7.2B**). The number of rodent individuals caught at each trapsite varied greatly from 11 (trapsite 2) to 114 animals (trapsite 10). Altitude had no significant effect on rodent species richness (Pearson Correlation: p=0.053, r^2=0.390, df=10) and abundance richness (Pearson Correlation: p=0.230, r^2=0.174, df=10) although both indicate a trend with fewer species and lower abundance at higher altitudes (see **Table 7.2B**). Eight of 13 individuals of *Dendromys* sp. were recorded from the trapsite highest in altitude, thus opposing the above trend although correlation with altitude was not significant for this species.

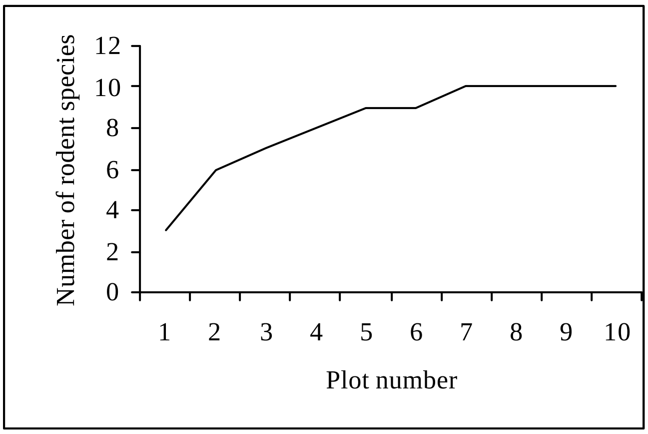


Figure 7.2A. Species accumulation curve for rodents trapped at evergreen forest sites in West Kilombero Scarp Forest Reserve.

Shrews

The number of shrew individuals caught at evergreen forest sites varied from seven to 17 in the dry season, increasing to 31 and 36 for the two trapsites surveyed during the short rainy season (October to December) (see **Table 7.2B**). Highlighting the positive effect of rain on the number of shrew individuals caught.

Evergreen Forest Trapsites vs. Non-Evergreen Forest Trapsites

Small Rodents

Nine rodent species were caught in evergreen forest (see **Table 7.2B**) and four of these were not found in other habitats (although two of them are *Mus* sp. of which 30 individuals were caught in non-evergreen forest habitats and await identification to species level). Nine species were caught in non-evergreen forest habitats and three of these were found only in this habitat. Evergreen forest sites and other habitats shared a minimum of eight species (some specimens pending identification) (see **Appendix 7.2A**).

Using data from the first four days of trapping (see **Appendix 7.2B**), mean rodent species richness and abundance were compared between evergreen forest sites and non-evergreen forest sites using a *t*-test (and Mann-Whitney test where variances were not equal). However, no difference was observed in mean number of species (*t*-test: t=1.078, df=12, p=0.302) and mean rodent abundance (*t*-test: t=0.587, df=12, p=0.568). The amount of data for six species was insufficient to justify any comparisons of individual species abundance between evergreen and non-evergreen forest sites. The median abundance of *Praomys* group (*Grammomys* sp., *Hylomyscus denniae* and *Praomys delectorum*) individuals was found to be higher in evergreen forest compared to non-evergreen forest (Mann-Whitney by normal approximation: Z=-2.404, n=14, p=0.016). No other species or group of species showed a difference in the number of individuals caught.

Elephant Shrews

Two individuals of the four-toed elephant shrew (*Petrodromus tetradactylus tetradactylus*[*]) were caught in Sherman traps in miombo woodland (site A).

Shrews

Four species of shrew were caught at evergreen forest trapsites and four in non-evergreen habitats. The few individuals identified to species, however, do not justify comparison of shrew species richness between evergreen forest and non-evergreen forest trapsites. Of the species identified so far (37 individuals), *Crocidura monax* have only been identified for evergreen forest trapsites and *Crocidura olivieri* only from non-evergreen forest habitats.

Three of four trapsites in non-evergreen forest, sites A, C and D, caught three, three and five individuals respectively. This is lower than most trapsites in evergreen forest using data from first four days of trapping (see **Appendix 7.2B**). The remaining non-evergreen forest site, trapsite D in acacia woodland, was sampled after the onset of the short rains. Here 22 shrew individuals were caught. This is higher than for any dry season trapsites in evergreen forest, but lower than evergreen forest trapsites sampled after initiation of rain. This suggests that rain is one of the most important factors influencing the number of caught shrews. No significant difference was observed between the mean number of shrews caught in evergreen forest and non-evergreen forest habitats comparing all sites (*t*-test: t=0.878, df=12 p=0.397). But comparison of dry season trapsites alone, revealed significantly higher abundance of

[*] Subspecies identified from distribution and morphological description of P. tetradactylus subspecies by Kingdon (1974). Specimen identification still awaits verification by expert taxonomist.

shrews in evergreen forest using only data from the first four days of trapping (*t*-test: *t*=2.810, df=9, *p*=0.020,).

Efficiency of trapping method
The trapping methods used in this survey are efficient with different taxonomic groups. Shrews were caught more frequently in bucket pitfalls than in Sherman traps and vice versa for rodents (see **Figure 7.2B and Appendix 7.2B&C)**. The efficiency however also differed within rodent taxa. Small sized animals (*Dendromys* sp. and *Mus* sp.) were more often caught in bucket pitfalls than in Sherman traps while larger species, on the contrary, predominantly were caught in traps (See **Figure 7.2B**).

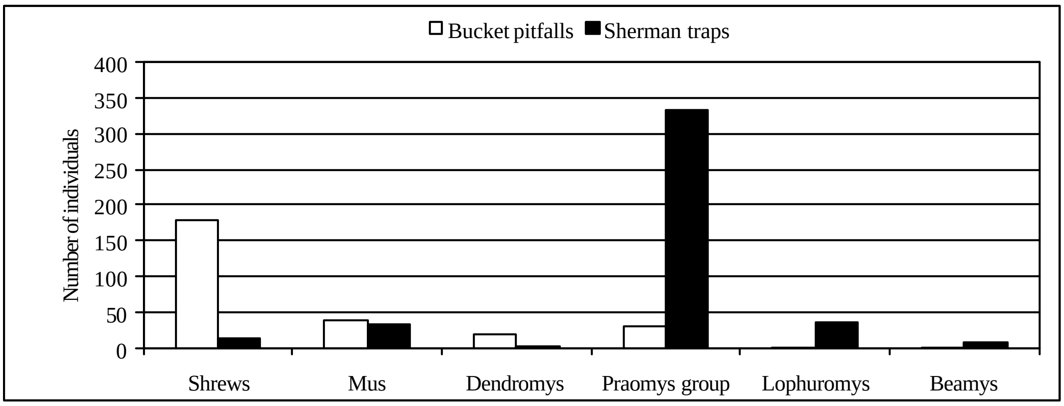


Figure 7.2B. Comparison of the effectiveness of the two trapping techniques for the most frequently encountered small mammals. Numbers represent unique individuals to avoid bias from collection of specimens and trap happiness or shyness.

Rain
The *t*-test was used to compare mean trap efficiency before and after the onset of the short rainy season (see **Appendix 7.2B**). Using data from the first four days of trapping to account for different sampling intensities, showed that bucket pitfalls were more efficient at catching shrews after the rain comparing all sites (*t*-test: *t*=-3.050, df=12, *p*=0.010). Comparing results from evergreen forest sites also showed a significant increase in the number of unique shrews caught after the onset of rain (*t*-test: *t*=-8.322, df=12, *p*<0.001). Rain had no effect on Sherman trap success for both rodent and shrew species.

Comparison of Rodent and Shrew Abundance
Positive correlation was observed between number of rodents and number of shrews caught at each trapsite (Pearson Correlation: (all sites, data from four nights) *p*=0.010, r^2=0.434, *n*=14; (evergreen forest sites, data from eight nights) *P*=0.006, r^2=0.635, *n*=10) (see **Table 7.2B** & **Appendix 7.2B**).

Mesh Trap Results
During 234 trap nights (number of set traps added for every day of trapping), nine individuals of five different species were captured in mesh traps (see **Table 7.2D**). Of these species, two are subspecies with restricted ranges (*Genetta servalina lowei* and *Nandinia binotata arborea*, pictures were taken before animals were released) (see **Table 7.2D**). None of the species or subspecies are "Endangered" (Hilton-Taylor, 2000). The three individuals of *P. tetradactylus* from miombo woodland (two caught in Sherman traps, one in mesh trap) differed morphologically from individuals caught in evergreen forest areas and are probably

a different subspecies. The evergreen forest type resembles *P. t. rovumae* by having knob-tipped bristles growing from a glandular tract that lines the underside of the tail (Kingdon, 1974), while the individuals caught in miombo woodland resembles *P. t. tetradactylus*, lacking features of the above subspecies (Kingdon, 1974). Both types are recorded from Tanzania, but identifications, however, need verification by W. T. Stanley.

Table 7.2D. List of species caught in large mesh traps in West Kilombero Scarp Forest Reserve.

Trapsite	Species	Common name	Endemism and Distribution Data from Kingdon (1997)
2 & 5	*Genetta servalina lowei*	Servaline genet	(E)*
3	*Nandinia binotata arborea*	African palm civet	(EA)*
4	*Atilax paludinosus*	Marsh mongoose	W
4	*Petrodromus tetradactylus*[^]	Four-toed elephant shrew	W[#]
7	*Petrodromus tetradactylus*[φ]	Four-toed elephant shrew	W[#]
8	*Petrodromus tetradactylus*[φ]	Four-toed elephant shrew	W[#]
A	*Petrodromus tetradactylus*[φ]	Four-toed elephant shrew	W
A	*Cricetomys gambianus*	Giant pouched rat	W

Distribution categories: E = endemic to the Udzungwa Mountains, EA = found only in East African isolated forest (from Kenya to Zimbabwe), W = widespread (more than ten countries). Brackets refer to subspecies.

* - Species widely distributed, but subspecies only found in East African isolates (Kingdon, 1997). Identified by field staff.

[#] - Differing from individuals caught in miombo woodland (trapsite A) by having knob-tipped bristles lining the underside of the tail, distinct black and white markings at the base of the ears and larger pads under the feet.

^ - Subspecies *P. t. tetradactylus.*

[φ] – Subspecies *P. t. rovumae.*

7.2.5 Discussion

The Small Mammal Fauna, its Forest Dependency and Conservation Status

Six of the 23 small mammal species encountered in WKSFR are forest dependent and six are restricted to East Africa and northern Malawi (see **Table 7.2A**). Eight of the 23 species fall under one of these categories and may therefore be vulnerable to destruction of natural habitat.

Hilton-Taylor (2000) lists two species as “Vulnerable” (*Crocidura monax* and *Beamys hindei*) and one species as “Endangered” (*Rhynchocyon petersi*). Current lack of knowledge of the basic ecology and distribution of small mammals may however be the reason for the inclusion of so few Eastern Arc mammal species on the IUCN red list. *Beamys hindei* is listed as “Vulnerable” and is found primarily in forest habitats in Kenya, Tanzania and northern Malawi. Other species are more restricted in their distribution and not known any better than *B. hindei.* Stanley *et al*. (1998) mentions five species of shrew which are very restricted in their distributions and possibly endemic to Eastern Arc, but none of these are listed.

Although many species were found outside natural forest habitats, several species depend on forest for their survival. The managing authority should therefore aim at protecting the mosaic of habitats in WKSFR, especially focusing on the preservation of forested areas (see **Box 7.2A** for notes on the seven species which are considered priority species for management to Box 7.2A).

Box 7.2A. Brief description of species of conservation concern with notes on records from this study.

The species listed here include only tentatively identified species. In particular, it is likely that more species of shrew will be found when collected animals have been identified. The criteria used here for being regarded as a species of conservation concern is a range restricted to East Africa, northern Malawi and northern Mozambique (see **Table 7.2A**).

Crocidura kihaulei has only ever been found in forested areas in the Uluguru and Udzungwa Mountains, including six individuals from 4 trapsites identified so far in this study. The limited knowledge of this species and the restricted known range make preservation of forested habitats very important for the conservation of this species.

Crocidura monax is listed as "Vulnerable" by Hilton-Taylor (2000) although Stanley *et al*. (1998) reports the species to be more widespread than the majority of shrews encountered during their study on Eastern Arc small mammals. According to Hilton-Taylor (2000) *C. monax* is recorded from Kenya and Tanzania. Only three individuals at one trapsite were recorded in WKSFR in this study (155 shrews still pending identification).

Rhynchocyon petersi is found in coastal and montane forests and thickets in Kenya and Tanzania (Kingdon, 1997). It is listed as "Endangered" by Hilton-Taylor (2000) and more knowledge on the ecology and distribution of the species is needed to come up with efficient conservation strategies (Kingdon, 1997). It has been casually observed on two occasions during fieldwork in WKSFR.

Paraxerus lucifer is restricted to Kenya, Tanzania and Malawi, while the subspecies *P. l. lucifer* is restricted to Eastern Arc mountains (Kingdon, 1997). It was casually observed at five trapsites in WKSFR. According to Kingdon (1997) all subspecies populations are "Vulnerable" and totally dependent on continued protection of the relict forest fragments where they occur.

Beamys hindei is considered to be "Vulnerable" by Hilton-Taylor (2000). Nine individuals were found at four trapsites in WKSFR. It was only recorded from evergreen forest sites, but during surveys in New Dabaga/Ulangambi Forest Reserve it was also caught in a six year old fallow field roughly one kilometre from the forest and in a black wattle (*Acacia mearnsii*) plantation. The species still depends on forest for its survival (Hilton-Taylor, 2000), but it shows potential for dispersing between forest patches if corridors or stepping-stones of the right habitat type exist.

Praomys delectorum is according to Kingdon (1974) "principally found in Southern Forests" in Tanzania, however its range has been extended to include all major Eastern Arc regions. Stanley *et al*. (1998) report it to be the most abundant species in all regions except for the Udzungwas. *P. delectorum* was also the most abundant in this study, thus contradicting the findings by Stanley *et al*. (1998) who found *Lophuromys flavopunctatus* to be the most abundant species in the Udzungwas.

Hylomyscus denniae is a relict species with a discontinued distribution and mainly found in mountain regions (Kingdon, 1974). Predominantly confined to high altitude forest (Stanley *et al*., 1998) this species relies on the persistence of high altitude forest habitat for its long-term survival. This species is not categorised as forest dependent by Kingdon and Howell (1993), although this study suggests this. Further investigation should however be carried out in order to draw any conclusions.

Sherman Trap and Bucket Pitfall Survey

The trapping methods employed in this study may not reflect the true ratio between the species caught in West Kilombero Scarp Forest Reserve. Trapping from late afternoon to early morning may mean that diurnal species are underrepresented in the results. Insectivorous species, like *Lophuromys flavopunctatus* and *Graphiurus* sp. (Basuta, 1979: cited in Struhsaker, 1998), may also be underrepresented if they are not attracted to the coconut and peanut butter bait used in this study and if they are not susceptible to pitfall trapping. The large size of *L. flavopunctatus* may also allow this species to jump out of buckets, and the arboreal behaviour of *Graphiurus* sp. mean they are rarely caught at ground level (Struhsaker, 1998) where trapping intensity was highest. Therefore the survey may not represent the true ratio between species, but given the high trapping intensity, including trapping in daylight (early morning and evening), it is thought that most species susceptible to the employed trapping methods have been captured in the study. This is also evident from the species accumulation curve for rodents, where only one new species was recorded for the last five trapsites. 155 shrews still await identification, hence nothing can be said about this group based on this survey, but Stanley *et al*, (1998) mentions that this combination of methods have shown to document small mammal faunas effectively.

Evergreen Forest Sites

Small Rodents

13 species of rodents were recorded from West Kilombero Scarp Forest Reserve. The species accumulation curve suggests that the study include most of the small rodent species found in the area. The *Praomys* group, *L. flavopunctatus* and *Mus* sp. were widespread in the reserve while others showed a more patchy distribution. *Praomys delectorum* and *Hylomyscus denniae* are generalist species (Kingdon, 1974) found at most trapsites in forested areas. *Lophuromys flavopunctatus* and *Mus* sp. were also recorded from most evergreen forest trapsites (ten and 12 respectively), although at lower abundances. The patchy distribution of other species could therefore reflect the heterogeneity of forested habitats in WKSFR.

Mr. W. T. Stanley identified one individual of *Mus* caught inside the forest as *Mus minutoides* or *Mus musculus*. Stanley *et al*. (1998) recorded neither of these species in their survey of small mammals in the Udzungwa Mountains. The species has also recently been recorded at the Kihansi area within the Udzungwas (K. M. Howell, *pers. comm.*) The range of this species may therefore be extended to forested areas of the Udzungwa Mountains once identification has been made with certainty.

The number of *Dendromys* sp. recorded for trapsite 1 was unusually high compared to other evergreen forest sites. The high altitude *Hagenia* forest at trapsite 1 had an open structure resulting in a dense ground vegetation and shrub layer which is thought to benefit climbing species like *Dendromys* sp.. This habitat was found only at high altitudes, but since several animals were also caught in miombo woodland (see **Appendix 7.2A**), which also has a dense ground cover, it is more likely to be the habitat type that determines the abundance of this species rather than altitude directly.

Species richness and abundance showed no correlation with altitude. Stanley *et al*. (1998) reports a non-random distribution along an elevational gradient in the Udzungwas. The major differences observed by Stanley *et al*. (1998) were however occurring between high altitudes and altitudes lower than the ones sampled in WKSFR. This study therefore does not contradict their findings.

Shrews

Three species of shrew were recorded from evergreen forest sites. Among these were the IUCN "Vulnerable" (Hilton-Taylor, 2000) *Crocidura monax* and the recently discovered *Myosorex kihaulei*. The number of individual shrews was positively correlated with rain (discussed below), but no significant relationship was observed with altitude. Many shrew species are restricted to montane forest sites in Eastern Arc, but current knowledge is too scarce to conclude the degree of endemism (Stanley *et al*., 1998). Nevertheless, the forest adaptation and patchy distribution of this insectivore group calls for conservation strategies designed to protect this fauna and the unique habitat in which they live (Stanley *et al*., 1998).

Evergreen Forest Sites vs. Non-Evergreen Forest Sites

Small Rodents

Only two species of small rodents were limited to evergreen forest in this survey (*Beamys hindei* and *Hylomyscus denniae*). This high overlap of species between evergreen forest sites and other habitats shows that many rodents can inhabit or disperse across gaps in forest habitat. This is also acknowledged by Stanley *et al*. (1998) who argues that this ability to disperse between mountains in times of forest expansion has led to a widely distributed rodent fauna in the Eastern Arc Mountains.

Species recorded from only two or fewer trapsites seem to be species with specific adaptations to certain habitat types. These include *Dasymys incomptus*, *Rhabdomys pumilio*, *Lemniscomys griselda*, and *Graphiurus* sp.. *D. incomptus* was caught at two sites, one individual deep inside evergreen forest and two at the open grassland site. Based on data presented by Stanley *et al*. (1998), this is the first record of this species in evergreen forests of the Eastern Arc (also found in New Dabaga/Ulangambi Forest Reserve (NDUFR), see Frontier Tanzania, 2000d). Kingdon (1997) describes its preferred habitat as wetter grassy areas, especially at higher altitude. All three captures in WKSFR were from water logged areas along streams, two caught in grassland, one deep inside the forest at trapsite 7. This species therefore seems to prefer moist habitats regardless of the presence of forest cover. *Rhabdomys pumilio* and *Lemniscomys griselda* were in this study limited to non-evergreen forest habitats highlighting the species' specific adaptations to grass dominated groundcovers (Kingdon, 1997). *Graphiurus* sp. is insectivorous and highly arboreal (Struhsaker, 1998), and therefore less prone to ground trapping. The species was only caught once in miombo woodland, but it was recorded inside forest in NDUFR[*]. The low number of species confined to specific habitat types has resulted in the relatively low difference in rodent species composition between evergreen forest and other habitat types.

Shrews

In this study, one species of shrew, *Crocidura monax*, has so far only been identified from evergreen forest sites, while *Crocidura olivieri* only has been identified from non-evergreen forest sites. The number of unidentified shrews (155) however does not allow any conclusions to be drawn, and whether there are differences in species composition remains a question until identifications have been returned.

Number of shrew individuals did not differ between evergreen forest sites and non-evergreen forest habitats when all trapsites were compared. The abundance of shrews was however higher in evergreen forest than in non-evergreen forest habitats comparing only sites sampled in the dry season (see later for discussion on the influence of rain). Shrews generally prefer moist habitats (Kingdon, 1997) and it is therefore not surprising that shrews are found in higher numbers under dense forest covers. It is therefore tempting to say that the conservation of evergreen forest is more important than conservation of non-evergreen forest habitats for shrews. This is however only based on number of individuals, and identification of shrew specimens is needed to compare shrew species composition between these habitats.

Effectiveness of Trapping Methods

The two trapping methods employed in this study are effective with different taxonomic groups. Bucket pitfall trapping is effective at surveying insectivorous shrews and rodents

[*] - *Graphiurus* sp. individuals from NDUFR looked different from the individual caught in WKSFR. The collected specimens await identification by W. T. Stanley to verify of whether they are different species or subspecies.

with small body size (Stanley *et al*., 1998). This was also supported by this study, where small mammals (*Dendromys* sp. and *Mus* spp.) most frequently were caught in bucket pitfalls, while Sherman traps on the other hand predominantly caught medium to large rodents, which are often able to escape out of the bucket pitfalls. Supporting findings by Stanley *et al*. (1998), *Mus* spp. was caught almost equally in pitfalls and Sherman traps (although slightly more frequently in buckets). The reason for this is probably the small size of *Mus* spp., which meant that they were too small to escape pitfalls and that the species is attracted to bait.

For monitoring purposes, Sherman traps can be used to sample the small rodent population in an area, as little training is needed to enable observers to identify most species. On the other hand bucket pitfalls will include a high proportion of shrews which can only be identified by a taxonomic expert. The difficulties connected to the identification of shrew species, therefore makes them of little use for monitoring.

Rain

The onset of rain had a positive effect on the number of shrews caught. W. T. Stanley (Stanley, *pers. comm.*) has also observed this during his studies of the small mammal fauna of Eastern Arc. This may be the result of a change in shrew behaviour with the onset of rain. The reason for this increase in movement is unknown. Possible reasons could be a higher activity level to keep warm in a moist habitat, temporary flooding of sleeping sites or an increase in shrew movement related to the breeding season which may be triggered by the onset of rain. The latter being supported by the survey in NDUFR (see Frontier Tanzania, 2001d), where most records of pregnancies and lactating females coincided with the beginning of the rains.

Linzey & Kesner (1997) report a correlation between rodent abundance and rain in a woodland savannah ecosystem. This study found no significant correlation between rain and the number of rodents caught. Kasenene (1989, cited in: Struhsaker, 1998) also reports a lag time between rain and an increase in rodent abundance which also would explain the lack of correlation from this study.

Comparison of Rodent and Shrew Abundance

Kasenene (1980: cited in Struhsaker, 1998) notes an increase in rodent abundance in lightly logged areas of Kibale Forest. This may reflect an increase in the number of niches and overall food availability. The correlation, found in this study, between the number of rodent and shrew individuals possibly reflects this. Where conditions favour an abundant rodent fauna, conditions also are in favour of more shrew individuals.

Comparison with other Eastern Arc Forests

<u>Small Rodents</u>

The Udzungwa Mountains are more species rich in terms of the number of small rodent species (as defined in introduction) compared to any other Eastern Arc mountain region (see **Table 7.2E**). Of all small rodent species found within the Eastern Arc forests, two species are limited to the Udzungwas (*Otomys anchietae* and *Mus triton*) according to Stanley *et al*. (1998) while this study add one species not previously recorded from Eastern Arc forests. All three species are however found in areas outside the Eastern Arc forests (Kingdon, 1997; Hilton-Taylor, 2000). *O. anchietae*, which is categorised as a low risk, near threatened species by IUCN (Hilton-Taylor, 2000), was not recorded during this survey, but an unidentified *Otomys* was observed in a snare set in a field a few hundred metres from New Dabaga/Ulangambi Forest Reserve. None of the *Mus* individuals identified to date have been identified as *Mus triton.* The remaining 14 species are widespread and found in at least two other countries (Kingdon, 1997).

East Usambara Mountains is the only other Eastern Arc region containing small rodent species (one) that are not found in other Eastern Arc forests (Stanley *et al*., 1998). This high overlap of species again highlights the widespread rodent fauna found within the Arc.

West Kilombero Scarp Forest Reserve has nine species of small rodents compared to the ten species recorded in New Dabaga/Ulangambi Forest Reserve. NDUFR possesses two species not found under forest in WKSFR (*Graphiurus* sp. and *Tatera* sp.), while a *Mus* spp. identified as *M. minutoides* or *M. musculoides* was found only in WKSFR.

Table 7.2E. Number of small rodent species (defined in introduction) caught in evergreen forest during Sherman trap and bucket pitfall surveys in different Eastern Arc mountain regions. Data from Stanley *et al*. (1998) and Frontier Tanzania studies where stated.

Eastern Arc Mountain region	No of rodent species caught in evergreen forest	Rodent species only recorded outside evergreen forest
South Pare	9	
West Usambara	10	
East Usambara	14#	
Nguru	5	
Uluguru	5	
Udzungwa	16*	
Udzungwa Mountain forest reserves (this study)		
West Kilombero Scarp FR	9^	3^
New Dabaga/Ulangambi FR	10	2^

* - Stanley *et al.* (1998) recorded 12 species from the Udzungwa Mountains, this study adds two (*Mus minutoides/musculoides and Dasymys incomptus*) and Frontier Tanzania surveys in New Dabaga/Ulangambi Forest Reserve adds a further two species to this (*Graphiurus* sp. and *Tatera* sp.) (see Frontier Tanzania, 2001f). *Stanley et al. (1998) has not recorded D. incomptus and Tatera sp. inside Eastern Arc forests.*

\# - Stanley *et al.* (1998) recorded 11 species from in East Usambara Mountains. Including Frontier Tanzania studies (Frontier Tanzania, unpubl.), 13 species are found in the East Usambara Mountains

^ - Minimum number of species. *Mus* sp. pending identification.

Diverse habitat mosaics, such as that observed in WKSFR (see Frontier Tanzania, 2000d) are known to support more small mammal species than habitats with fewer niches (Kemper & Bell, 1985). Human disturbance may however also increase the number of niches thus leading to a more species rich small mammal fauna (Kasenene, 1980, cited in: Struhsaker, 1998). Two species of *Mus* have been identified to species level in WKSFR so far, but the total number of *Mus* species is uncertain as many individuals await identification. Only one individual of *Mus* sp. was recorded from forested areas in NDUFR, although in a very disturbed area with a dense shrub cover. Kasenene (1980, cited in: Struhsaker, 1998) found that *M. minutoides* increased with logging. NDUFR has been logged in the past, but the genus is almost absent from the reserve. Either because of the presence of a different species of *Mus* not positively affected by logging, or due to most sampling occurring in the least disturbed areas. The relatively high number caught in WKSFR (40) may therefore reflect a high degree of natural habitat heterogeneity.

Graphiurus sp. is present at low abundance in both areas and is not a typical forest species (Kingdon, 1997). *Tatera* sp. caught in forest in NDUFR is a savannah adapted species and have not been captured in forest during surveys of Eastern Arc forests by Stanley *et al*. (1998). It was captured far from the forest edge (ca. 1.8km) in a dry type of forest with relatively low canopy (< 10m). The differences in species composition between WKSFR and NDUFR, can hence be explained by the capture of low abundance species not confined to forests and the low number of *Mus* sp. found in NDUFR.

Shrews

According to Stanley *et al*. (1998), East and West Usambara forested areas both contain more shrew species than the Udzungwas, but they also believe that future studies are likely to increase the known distribution of several species (Stanley *et al*., 1998). One should therefore bear in mind that in this study 155 shrew individuals await identification, and with the more patchy distribution of this group (Stanley *et al.*, 1998) it is likely that more species with limited ranges will be found.

Mesh Traps

Half of the individuals caught in the large "Tomahawk" mesh traps were four-toed elephant shrews (*P. tetradactylus*). The three individuals caught at evergreen forest sites differed somewhat from individuals found in the Miombo woodland, and may be a different subspecies. The subspecies caught within evergreen forest resembles *P. t. rovumae*, described by Kingdon (1974), while the individuals caught in miombo woodland resembles *P. t. tetradactylus*. Verification of these subspecies identifications is however needed.

A giant pouched rat (*Cricetomys gambianus*) was caught in Miombo woodland, but evidence of its presence in forest habitats was also observed. It is widely distributed and recorded from most habitats south of Sahara (Kingdon, 1974).

The four small carnivores captured were all from the Ndundulu forest block. None of the three species are threatened. The subspecies of the african palm civet (*Nandinia binotata arborea*) is however restricted to east African isolates and the subspecies of the servaline genet (*Genetta servalina lowei*) is only known from one incomplete specimen collected in the Dabaga area in the 1930s (Kingdon & Howell, 1993 and Kingdon, 1997). The two records of *Genetta servalina lowei* from this survey therefore document the presence of this species in Udzungwa for the first time since its collection in the 1930s, thus further highlighting the high biodiversity value of the area.

7.2.6 Conclusion

Based on previous surveys and surveys by Frontier Tanzania, the small rodent fauna in Udzungwa Mountains is the richest in number of species of all surveyed Eastern Arc regions. It is the third richest in terms of shrew species despite a relatively low trapping effort in the area. All rodent species recorded in this study are widespread in the Eastern Arc, while one of four species of shrew (of individuals identified so far) is only recorded from the Udzungwa Mountains. The diverse small mammal fauna of West Kilombero Scarp Forest Reserve reflects the heterogeneity of the habitat. Although some generalist species were found all over the reserve, many species show a patchy distribution. The species *Dasymys incomptus* had not been recorded from forested areas in the Udzungwas prior to this study.

The presence of a diverse small mammal fauna is closely linked to the heterogeneity of the habitat in WKSFR. It is therefore recommended that management initiatives focus on maintaining the mosaic of habitats found in the reserve, with emphasis on the preservation of forest habitat.

This study also recorded two individuals of the servaline genet (*Genetta servalina lowei*) previously only known from one incomplete specimen collected in the 1930s. Two subspecies of four-toed elephant shrew (*Petrodromus tetradactylus*) were also recorded in the reserve. One of these, *P. t. rovumae*, was only found in evergreen forest and the other, *P. t. tetradactylus*, only in miombo woodland.

7.3 Bats of West Kilombero Scarp Forest Reserve

Henry Brink, Andrew R. Marshall, J. Elmer Topp-Jørgensen

7.3.1 Summary

Bats of West Kilombero Scarp Forest Reserve (WKSFR) were sampled during the periods July to September, and November to December 2000. Sampling was carried out using mist nets. Bats encountered opportunistically (e.g. roosting) were also collected. A total of 122 hours were spent mist netting. Nineteen bats were caught, representing four families, at least six genera, and at least seven species. The sample size is, however, thought to be too small to comprise a representative species list of WKSFR.

Three factors were important when mist netting. Nets should be checked regularly (every 15 minutes or constantly watched). The siting of nets in well-used bat flyways and the arrangement of the nets in these flyways were also paramount to trapping success.

All bats identified to species level were forest dwelling. That is they are found in forests, but may also be found in other more open habitats. Although bats may forage widely for food, they require sheltered areas to roost. The forested areas of WKSFR offer a variety of potential roost sites, most notably the numerous hollow trees and caves. Fruit bats play an important role in the dispersal of seeds and the pollination of flowers, and hence are important for the diversity of the forest. It is thought that the maintenance of forested areas for roosting combined with a mosaic of other habitats for foraging should benefit bat diversity.

7.3.2 Introduction

Bats are divided into two distinct sub-orders: Megachiroptera (fruit bats) and Microchiroptera (insect bats). Insect bats are thought to share an ancient common ancestry with insectivores, while fruit bats may have more recent affinities with primates (Kingdon, 1997). Fruit bats are limited to equatorial regions stretching from Australia through South Eastern Asia to Africa. Insect bats, however, have an almost worldwide distribution, with a greater range of forms and global distribution than any other order of mammals. This diversity is related to both the mobility and great age of this group (Kingdon, 1997).

Current knowledge of the Tanzanian bat fauna is far from complete (Kock & Howell, 1988). This is primarily due to limited research on bats (large areas of Tanzania have yet to be surveyed) and their elusive behaviour. Extensive surveys, however, have been carried out by Frontier Tanzania in the coastal forests of Tanzania (see Kock *et al.*, 2000; Burgess *et al.*, 2000; Cockle *et al.*, 1998). Nonetheless, the status of bat populations (both in terms of numbers and distribution) is poorly known for most of the Eastern Arc region. This is especially true of the Udzungwa Mountains, as highlighted in opportunistic collections in Mwanihana Forest Reserve (now part of the Udzungwa Mountains National Park) during the late 1980s, which revealed two additions to the Tanzanian bat fauna; *Rhinolophus blasii empusa* and *Rhinolophus swinnyi* (Kock & Howell, 1988).

Aim

- To provide a representative species list for the bats of West Kilombero Scarp Forest Reserve (WKSFR), and discuss the bat fauna with forest management efforts in mind.

7.3.3 Methods

Bats were sampled during the periods July to September, and November to December 2000. Sampling of bats was carried out by mist netting (as described in the Methods Manual: Frontier Tanzania, 2001g). Mist nets were placed across flight corridors, such as paths and rivers, with the top of the net at a maximum height of 3m. At each trapsite within the evergreen forest blocks (Ndundulu, Nyumbanitu and Ukami), at least six hours were spent bat netting. Nets were generally set up at dusk (18.30) and left open for at least four hours. At some trapsites, trapping was carried out all night. Trapping intensity varied markedly from trapsite to trapsite, depending primarily on the level of other field activities and weather conditions. Trapping and biometric information was recorded on standardised data sheets. Bats that were encountered opportunistically (e.g. roosting) were also collected.

7.3.4 Results and Discussion

Mr. W. T. Stanley (Field Museum of Natural History, Chicago) and Prof. KM Howell (University of Dar es Salaam) have identified some of the bats. However, identifications are still only preliminary for many of the specimens, and many have only been made to genus level. This is due to the need to examine the dental and cranial characteristics of the specimens, and to compare these characteristics with material in different museums. Interpretation of the bat collection will therefore be difficult. Taxonomic nomenclature follows Kingdon (1997). Specimens have been deposited at the Field Museum of Natural History, Chicago.

A total of 122 hours were spent mist netting. Eighteen bats were caught in mist nets. One bat was collected by hand whilst roosting. From **Table 7.3A** it is apparent that the hours spent bat netting did not necessarily relate to the number of bats caught. Far more important was the siting of the mist nets. Rivers, streams and animal paths form good bat flyways through the forest habitat. Hence, 74% of bats were caught over streams/rivers, while 21% were caught over paths. Furthermore, it was not uncommon to observe bats flying up to the nets, and then over the nets or turning around and flying away. Thus, the arrangement of nets, once a well used flyway was identified, was important. Net arrangements that forced bats to avoid one net, but in doing so fly into another net proved most successful, as seen in the 'wedge technique' (see **Figure 7.3A** and **Box 7.3A**). The regular checking of nets (every 15 minutes or constantly watched) was also important to trapping success, as bats are very adept at biting their way out of the nets.

Table 7.3A. Trapping success of bats in WKSFR.

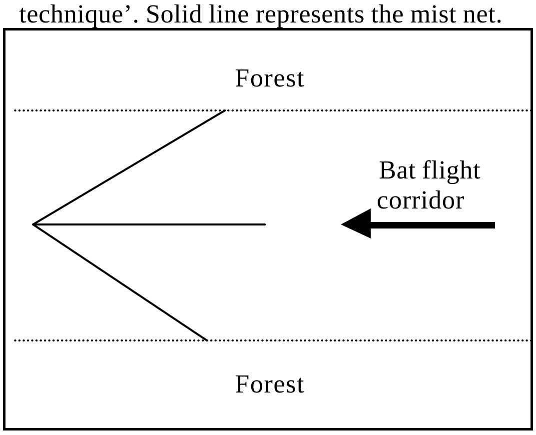
Trapsite	Habitat & Altitude (m a.s.l.)	No of Nets	Hours Trapping+	Bats Caught
1	Montane forest; 2070m	6mx2.6m x2 nets 2.6mx2.6m x1 net	**16 hours**	0
2	Bamboo forest; 1940m	6mx2.6m x3 nets	8 hours	0
3	Montane forest; 1440m	6mx2.6m x3 nets 2.6mx2.6m x1 net	8 hours	0
4	Montane forest; 1360m	6mx2.6m x3 nets	8 hours	0
5	Montane forest; 1540m	6mx2.6m x3 nets	9 hours 30 minutes	3
6	Montane forest; 1530m	6mx2.6m x3 nets	7 hours	3
7	Montane forest; 1560m	6mx2.6m x3 nets	12 hours 30 minutes	3
8	Montane forest; 1400m	6mx2.6m x3 nets 2.6mx2.6m x1 net	**14 hours**	5
9	Riverine forest; 1200m	6mx2.6m x2 nets 2.6mx2.6 x1 net	10 hours	1
10	Montane forest; 1150m	6mx2.6m x3 nets	6 hours	3
A	Miombo woodland; 1370m	6mx2.6m x2 nets 2.6mx2.6m x2 nets	**23 hours**	0
B	Acacia woodland; 1480m	None	None	0
C	Riverine forest; 1430m	None	None	0
D	Grassland; 1890m	None	None	1*

*** Bat collected opportunistically roosting in *Hagenia abyssinica* tree in forest near grassland.**
+ Numbers in bold indicate that bat netting was carried out all night.

Box 7.3A. Arrangement of nets

Echolocation allows insect bats to "spot" nets, thereby necessitating elaborate net arrangements. The 'wedge technique' forces bats to fly along one net, until the next net is "spotted." At which stage the angle between the nets is too tight for the bat to turn and avoid the nets. Similarly, nets placed parallel to each other at different heights a cross a flight corridor, were used to good effect. The first net is placed high (so there is a 1m gap at the bottom), while the second net is placed low (flush with the ground). The bat is forced to fly low to avoid the first net, but in doing so can not avoid the second net.

Figure 7.3A. View from above of the 'wedge technique'. Solid line represents the mist net.



Bat collections are presented in **Table 7.3B**. These include bats from four families and six genera.

Table 7.3B. Bats collected from West Kilombero Scarp Forest Reserve (July-December, 2000). Where the code number is given as "0" the specimen was not collected, but biometric information was recorded. Specimen identification has been verified in some cases by Prof. K.M. Howell or Mr. W.T. Stanley as indicated. Other specimens are awaiting full identification.

Identification and code (KMH) number		Verification	Forest Species#	Altitude (m a.s.l.)	Habitat+
PTEROPODIDAE					
22750	*Lissonycteris angolensis*		×	1400	MF
RHINOLOPHIDAE					
22187	*Rhinolophus clivosus*	Stanley	×	1450	MF
22230	*Rhinolophus clivosus*	Stanley	×	1630	MF
22231	*Rhinolophus simulator*	Stanley	×	1570	MF
19011	*Rhinolophus sp.*		?	1900	FE
22278	*Rhinolophus sp.*		?	1450	MF
22279	*Rhinolophus sp.*		?	1450	MF
22810	*Rhinolophus sp.*		?	1110	MF
22815	*Rhinolophus sp.*		?	1110	MF
0	*Rhinolophus sp.*		?	1110	MF
HIPPOSIDERIDAE					
22757	*Hipposideros ruber*	Howell	×	1400	MF
VESPERTILIONIDAE					
22078	*Miniopterus sp.*	Stanley	?	1450	RF
22080	*Miniopterus sp.*	Stanley	?	1450	RF
22277	*Myotis welwitschii*	Stanley	×	1450	MF
22751	*Myotis welwitschii*	Howell	×	1400	MF
22232	*Pipistrellus sp.*	Stanley	?	1570	MF
22209	UNIDENTIFIED		?	1200	RF
22754	UNIDENTIFIED		?	1400	MF
22756	UNIDENTIFIED		?	1400	MF

- Forest Species (based on Kingdon, 1997; Kingdon & Howell, 1993): F = Forest-dependent; × = Forest dwelling; species found in forest or forest edge but may be found in other habitats; O = Non-forest species.
\+ - Habitat: MF = Montane forest; RF = Riverine forest; FE = Forest edge.

The presence of *Myotis welwitschii* is of interest. The two specimens caught during this survey represent the second and third records of this species in the Udzungwa Mountains (WT Stanley, pers. comm.). *M. welwitschii* has a patchy distribution across equatorial Africa. Information on its distribution is poorly known, as evident in its recent range extension to include Uganda and Burundi (Stanley *et al.*, 1996). Members of the genus *Myotis* are specialist feeders, feeding on small insects caught in slow flight within 5m of the ground (Kingdon, 1997).

Three species of insect bat recorded by this survey (*Rhinolophus clivosus*, *Rhinolophus simulator*, *Hipposideros ruber*) are widely distributed. *R. clivosus* and *H. ruber* feed on a wide range of insects. The genus *Rhinolophus*, like *Myotis*, forages at low levels (Kingdon, 1997). The distribution of the two remaining insect bat genera recorded by this survey contrast each other. All four African *Miniopterus* species are well known and widespread, while the status of the 16 African species within the *Pipistrellus* genus are poorly known or unknown (Kingdon, 1997).

Lissonycteris angolensis is a fruit bat of widespread distribution, found mainly in forests of low and high altitude (Kingdon, 1997). The distribution of fruit bats is limited by their need for a year-long supply of fruits and flowers, and thus they are highly dependent on forested areas.

Mist netting as a method to sample bats is not without its limitations. Few fruit bats were caught during the course of this survey, as fruit bats tend to fly high above the ground. The most frequently caught genus (*Rhinolophus*), conversely, forages for insects near the ground. Therefore, this sample method is biased towards low-flying species.

Open Areas and Forested Areas

All species recorded in this study were caught in forested areas. Bats were often seen flying in open habitats at dusk, but trapping in open areas with mist nets proved difficult. Streams, rivers and animal paths through forested habitats form natural bat channels, and therefore were the most effective areas for catching bats with mist nets.

Baagøe (1996) in a study of Microchiroptera in a montane forest (1800m a.s.l.) in tropical Africa noted eight different species. The study showed that the eight species were very clearly segregated as to where and how they fly and hunt their prey; most species had their day roosts in the forest, but only one species spent considerable time hunting in the forest. During the course of the field survey in WKSFR, two bats were encountered roosting, both inside the forest. The roosting sites were trees; a *Rhinolophus* sp. was collected from a *Hagenia abyssinica* tree and a fruit bat was disturbed from its roost in a large hollow *Ocotea usambarensis* tree.

In a study of upland riverine habitat in Britain, the distribution of *Myotis daubentonii* and *Pipistrellus pipistrellus* was shown to be linked to the presence of bankside vegetation and tree cover (Warren *et al*., 2000); significantly more bats were recorded at sections of the river with smooth water surface and trees on both banks. Bat abundance was correlated to an increased abundance of insects at these forested riverine sections. This may go some way to explaining the increased trapping success in WKSFR at trapsite 8, where mist nets were set up over an area of smooth water with dense shrub vegetation and mature trees on both banks. On the night previous to bat netting, numerous insects were observed just above the water surface and five times bats were observed skimming the surface of the water.

Comparison with other Eastern Arc Mountains

This survey seems comparable to other Eastern Arc forests in terms of number of individuals and genera caught (**Table 7.3C**). There is also a fairly high level of species overlap between the different Eastern Arc mountain blocks; of the five species identified here, three have been recorded by Frontier Tanzania surveys in the East Usambaras (*Lissonycteris angolensis*, *Hipposideros ruber*, and *Rhinolophus clivosus*).

Table 7.3C. Frequency of bats recorded from Eastern Arc forests. Numbers of genera are listed in preference to species due to incomplete identification. These areas have been surveyed using identical methods, although the trapping intensity varied.

Forest Reserve	Family	Genera	Individuals	Trapping Intensity	Source
UDZUNGWA MOUNTAINS					
WKSFR	4	6	19	122 hours	This study
New Dabaga/Ulangambi	2	3	14	61 hours	Frontier Tanzania (2001e)
USAMBARA MOUNTAINS					
Mtai	4	8	20	120 hours	Doggart *et al.* (1999b)
Semdoe	0	0	0	33 hours	Doggart *et al.* (2001)
Magoroto	5	7	17	146 hours	Bayliss *et al.* (1996)
Manga	5	9	20	420 hours	Doggart *et al.* (1999a)

Bats and Conservation

In cleared or open habitats, fruit bats are important agents in reforestation (Kingdon, 1997). Fruit bats disperse seeds by picking fruit in one tree and defecating the seeds elsewhere. In open areas, isolated trees or thickets serve as perches for the fruit bats where they drop the seeds. Furthermore, fruit bats that visit flowers are often important pollinators. Thus, fruit bats have an important role in the distribution of certain species and expansion of forested areas.

All bats recorded by this survey were forest dwelling. Despite the fact that bats may forage widely, they require sheltered areas to roost. The forested areas of WKSFR offer a variety of potential roost sites, most notably the numerous hollow trees and caves. Thus, it is thought that the maintenance of forested areas for roosting combined with a mosaic of other habitats for foraging should benefit bat diversity.

7.3.5 Conclusion

This survey recorded 19 individuals, representing four families, at least six genera, and at least seven species. This small sample size makes it doubtful that the survey has provided a comprehensive species list for WKSFR. High-flying genera, such as *Otomops*, are notably absent from our sample.

In terms of management plans, bat diversity will benefit from forested areas (as roosting sites) and a mosaic of other habitats (as foraging areas).

7.4 The Eastern Tree Hyrax (*Dendrohyrax validus*) in West Kilombero Scarp Forest Reserve

J. Elmer Topp-Jørgensen, Henry Brink, Andrew R. Marshall.

7.4.1 Summary

The eastern tree hyrax (*Dendrohyrax validus*) was surveyed in West Kilombero Scarp Forest Reserve using the circular plot count method to count vocalizations. Results were gathered from 10 sites. Data was recorded from mid July to August and in November 2000.

D. validus is abundant within the forested areas of WKSFR. At sites where hyrax calls were recorded, the average number of individuals was estimated to be six individuals within the census radius of 50m. However, the uncertainty with which the census radius was estimated does not justify a density estimate. It should however be noted that the method holds great potential for assessing hyrax densities if distance estimates are precise or can be calibrated.

The *D. validus* distribution within the forest areas was somewhat affected by forest structure. In areas with broken canopy hyraxes were either absent or present at low numbers. The most likely explanation for this is a low number of possible shelter trees and a reduction in the number of arboreal pathways between trees. The latter means that in order to get from the tree in which the animal resides to neighbouring food trees, the hyrax may have to move along the ground where it is more vulnerable to predators.

Three distinct calls were defined in this study, Type A, B and C. The three calls seem to have different functions. The Type A call is used as an advertising call constantly reminding neighbouring individuals of its presence. The number of Type C calls increased significantly with increasing number of individuals and therefore is believed to express a higher level of aggression.

D. validus is highly dependent on forest for its survival. Management interventions should therefore focus on issues seeking to maintain the quality of the forested areas in West Kilombero Scarp Forest Reserve.

7.4.2 Introduction

The eastern tree hyrax (*Dendrohyrax validus*) has a patchy distribution with locally distinct populations (Kingdon, 1997). It is listed as "Vulnerable" by IUCN (Hilton-Taylor, 2000), and destruction of forest habitat is considered to be the most immediate threat to the species (Kingdon, 1997). Very limited literature is available on *D. validus,* and this is reflected in the low number of references used in the section.

The relatively large incisors of hyraxes have led to stories regarding its possession of a fierce bite. Myths exist of hyrax skeletons attached to leopards and hunters being bitten in the throat as they climb up tree trunks inhabited by the animal. According to the myth, once the jaw has sunk into flesh, it will not open unless the head is separated from the body. Despite these stories the hyrax is hunted for its meat and skin. They are caught in snares when they descend to the ground, or their trees are cut down or burned and they are subsequently caught with the aid of spears and dogs.

D. validus is an arboreal browser active at night. The possession of a relatively long row of molars makes them very rapid feeders. This combined with an abundant food source can lead to very high densities of the species. They are solitary and defend their territory vigorously (Kingdon, 1997). This is apparent in undisturbed forests inhabited by the eastern tree hyrax, where loud advertising calls uttered by both males and females can be heard all night.

In West Kilombero Scarp Forest Reserve *D. validus* is subjected to hunting. This is however on a very small scale and judged on sightings of camps, mostly near the forest edge. Hunters are primarily after larger game in the area, but will also target hyraxes opportunistically. Hyraxes are also important prey for crowned eagles (*Stephanoaetus coronatus*) and leopards (*Panthera pardus*) and according to villagers they constitute the majority of these species diet.

Aims

- To compare relative abundance of *D. validus* between sites in West Kilombero Scarp Forest Reserve.
- To investigate call frequencies and discuss their function.
- To compare relative abundance of *D. validus* in WKSFR with New Dabaga/Ulangambi Forest Reserve.

7.4.3 Methods

The "Circular Plot Count" method was used to estimate *D. validus* relative abundance in the evergreen forests of West Kilombero Scarp Forest Reserve (see Frontier Tanzania, 2001g). Surveys were carried out between July and November 2000 at five sites in Ndundulu, four in Nyumbanitu and one in Ukami (See Section 7.1).

Circular Plot Count

Point sampling of biological populations were introduced by Bitterlich in 1948 as a way of estimating tree abundance (Warren, 1979). The circular spot count method has proven useful for assessing the abundance of the nocturnal *D. validus* based on its frequently uttered calls (Topp-Jørgensen & Pedersen, 2000.). In theory observations made under the Circular Plot Counts are made from arbitrarily chosen points (or stations) and the distance to each individual is estimated and the compass direction recorded (Ramsey & Scott, 1979). These measurements can then be used for estimating the minimum number of calling individuals within the chosen census radius (Ramsey & Scott, 1979; Reynolds, 1980).

In this study *D. validus* calls heard within 50m of a fixed point were recorded within the first hour of calling after dusk. The survey was initiated from the first call heard within the census radius. For each call the time, type of call (see below), compass direction and a distance estimate were noted. At the end of every count the minimum number of calling individuals within the 50m radius was estimated on the basis of these data. Notes were taken during the census to make it easier to discern between individuals when the number of calling individuals was estimated.

The fixed points were chosen so that no area within the 50m radius was hidden behind a ridge, and positioned sufficiently far away from noisy waterways. Three counts were carried out at each trap site on rain free nights. If no calls were heard from the location of the circular plot count, the site was subsequently shifted to another area, given a suitable place could be found nearby. Results are presented as an average number of calling individuals and a call frequency for each type of calls.

Calls were divided into three common types:

i) **Type A**: Between five and ten sharp barks descending in volume and slightly accelerating.
ii) **Type B**: Starting as a short Type A call quickly followed by a series of eight or more accelerating barks descending in volume.
iii) **Type C**: Starting as 1-3 series of rapid barks followed by a long series of 1-2 barks for up to ca. three minutes.

To limit differences between observers in estimating the 50m radius, an experienced observer accompanied inexperienced observers on their first circular plot count. No density estimate will however be attempted in the study due to likely inter-observer differences in distance estimates. Instead results of the number of individuals heard within 50m can be regarded as a measure of abundance. With calibration of distance estimates the method holds potential for density estimation.

Additional notes on hyrax calls uttered during the day were taken during primate survey transect walks.

7.5.4 Results

Hyrax Abundance and Call Frequency

Three hyrax skulls have been collected from WKSFR and have all been identified as *Dendrohyrax validus* based on measurements of molars and premolars. Two identifications were made by Dr. Dieter Kock at the Zoological Museum at University of Frankfurt, while the third was identified by a Frontier Tanzania researcher based on measurement details from Dr. D. Kock. Based on this and the call types defined above it is believed that only one species has been recorded during the survey in WKSFR.

Based on sites with three repetitions (zoological survey trapsites 1, 2, 3, 4, 5 and 7), the mean number of individuals calling within a 50m radius was six. The number of individuals within the census radius varied from two to 12 (see **Appendix 7.4A**). Using data from sites where the same location was sampled three times showed that the estimated number of individuals per hour varied by a maximum of three individuals within a site (see **Appendix 7.4A**).

Table 7.4A. Estimated minimum number of calling individuals and number of calls per hour within 50m presented for each site in West Kilombero Scarp Forest Reserve. Results only presented for sites where hyrax calls were heard.

Site	Number of repetitions	Number of individuals within 50m	Total number of calls per hour within 50m	Calls per hour per individual	Altitude	Distance to forest edge
1	3	4.7	50	11	2100	300
2	3	8.3	38	5	1910	200
3^	3	4.7	18	4	1440	150
4	3	4.0	18	5	1360	2000
5	3	3.7	17	5	1400	300
7	3	11.0	77	7	1550	1200
8	2	0.5	3	5	1450	600

^ - This site was close to forest edge and due to change of personnel, data was sampled at two different sites.

Table 7.4B. Mean frequency of the three main types of call in WKSFR. Results presented only for sites where hyrax calls were recorded.

Site	**Type A** calls per hour	**Type A** Calls per hour per individual	**Type B** Calls per hour	**Type B** calls per hour per individual	**Type C** calls per hour	**Type C** calls per hour per individual
1	25	5.8	1.3	0.29	0.7	0.14
2	34	5.4	2.0	0.24	2.0	0.24
3^	21	4.9	1.0	0.21	0.3	0.07
4	14	4.6	2.7	0.67	1.7	0.42
5	8	2.2	2.0	0.55	0.0	0.00
7	42	4.88	8.3	0.76	4.3	0.39
8	3	5.2	0	0	0	0

^ - This site were close to forest edge and due to change of personnel, data was sampled at two different sites.

The type A call was by far the most frequent of all calls (see **Table 7.4B**) averaging a frequency of 6.3 per individual per hour, followed by Type B with 0.52 per individual per hour and Type C with 0.28 per individual per hour.

The call types were tested for correlation with number of individuals within 50m using Pearson Correlation and data from sites 1, 2, 3, 4, 5, 7, and 8 where individuals were heard within the census radius. There was a positive correlation between number of individuals within 50m and the number of Type C calls uttered per individual per hour (Pearson Correlation: p=0.039, r^2=0.608, n=7). No correlation was observed between hyrax density and the number of Type A and Type B calls per hour per individual (Pearson Correlation: (Type A) p=0.587, r^2=0.063, n=7; (Type B) p=0.392, r^2=0.149, n=7).

15 daytime primate census walks of three kilometres along two different transects (transects 1 and 2 in Ndundulu) recorded 56 *D. validus* calls.

The Importance of Plot Count Location

At four sites initial plot counts recorded no calling hyraxes (sites 2, 5, 6 and 10). At two of these sites (sites 2 and 5) the census site was moved and both subsequently recorded *D. validus* calls within 50m.

The tall diverse riverine forest at site 9 was very close to a large river and the noise from this made it impossible to hear animals calling. In addition, no animals were heard in the drier forest surrounding the campsite and hence no attempt of a count survey was carried out.

Attempts were made to survey inside the bamboo (*Arundinaria alpina*) area at site 2, but no individuals were heard during an hour census, and hence the locality was moved to a more diverse evergreen forest area.

One attempt was made near forest edge at site 5 where no calls heard. The three repetitions at site 5 were at a site subsequently placed 300m from forest edge.

One attempt was made at site 6 and site 10 respectively without any calls heard. No more counts were attempted.

7.4.5 Discussion

Abundance
D. validus is abundant in WKSFR. The densities of this near endemic species however, varied greatly between sites. Even count locations in close proximity varied substantially. This was shown for sites where no animals were heard at first location, but where up to an average of 8.3 individuals were estimated to be within 50m at another nearby location (site 2).

The second location at site 5, where hyraxes were recorded, had a high proportion (approximately a third) of the census area occupied by shrubby vegetation. The remaining part of the plot was made up of tall mature forest. The presence of a large open area and the resulting lower number of potential sheltering trees may therefore explain the low abundance at this site compared to other sites where hyraxes were recorded. It may however also be important that hyraxes in areas with broken canopy more often have to descend to the ground to get from one tree to another. At such time they are more vulnerable to terrestrial predators. The absence of hyrax from the bamboo dominated area at site 2 can also be explained by the absence of trees for shelter.

No obvious structural or ecological differences were observed that could explain the high number of individuals recorded from the second location at sites 2 and at site 7. Both sites had a dense canopy cover, with many large trees. Similar habitats were sampled at other site where no individuals were heard calling. It could therefore be the presence and abundance of specific tree species that offer sheltering places or the presence of a preferred food source.

The lack of knowledge on the ecology and behaviour of *D. validus* is apparent. The calling behaviour of *D. validus* offers excellent opportunities for vocalization studies and density estimation. The species however remains little studied. This study highlights the need for further research in order to investigate the ecological affinities of *D. validus* and to explain the patchy distribution within its habitat.

Frequency of Call Types
The three call types defined above were clearly distinct. Considerable variations within these types were however noted, with some individuals having very distinct calls. The functions of the calls are probably connected to defending of territories and mating behaviour. It should be noted that the frequencies of the three call types might differ between different seasons.

Although data from February-March (Topp-Jørgensen & Pedersen, unpubl.) and Frontier Tanzania surveys from mid July to November, do not indicate such a difference, further studies are needed to verify this.

The Type C call was positively correlated with hyrax abundance. A high abundance increases encounters with animals in neighbouring territories. The increase in Type C calls uttered per individual with increasing hyrax density therefore suggests that this call may have to do with competition within the hyrax community. It could have a more aggressive territorial function than the common call type (Type A) or it could be related to increased competition for partners.

The Type A call was by far the most frequently heard by the highly territorial *D. validus*. The frequency with which it is uttered suggests that this call type is used for advertisement.

Comparison with New Dabaga/Ulangambi Forest Reserve
The low abundance of *D. validus* observed in NDUFR (see Frontier Tanzania, 2001e), compared to its abundance in WKSFR, is thought to be caused by a high level of ground snaring and logging in NDUFR. The latter has led to a broken canopy in many places making animals more prone to snaring and the extensive areas of shrubby vegetation may favour the needs of *Heterohyrax brucei* (yellow spotted hyrax), which is also present in NDUFR.

The few calls in NDUFR are thought to be caused by the low abundance, but may also due to a hunting induced change in behaviour, resulting in individuals calling less frequently. The low number of calls heard during the day in NDUFR (four calls recorded during 22 transect walks) and the low number of latrines compared to WKSFR (Topp-Jørgensen & Pedersen, unpubl.) also suggests that hunting may change the behaviour of *D. validus*.

7.4.6 Conclusion

Dendrohyrax validus were abundant in West Kilombero Scarp Forest Reserve. Densities were found to vary greatly between sites. The main factors thought to influence this patchy distribution are the lower abundance of trees for shelter and reduced number of arboreal pathways in these areas. Three main call types were defined and seem to have different functions within the hyrax community. The population in WKSFR is little affected by hunting, and the single most important factor ensuring its survival in WKSFR is management initiatives seeking to maintain forest quality.

7.5 Large Mammals in West Kilombero Scarp Forest Reserve

J. Elmer Topp-Jørgensen, Henry Brink and Andrew R. Marshall.

7.5.1 Summary and Recommendations

The "Fixed Area Search Method" (Eberhardt, 1978) and the "Line Intersect Method" (Eberhardt, 1978) were used to estimate the relative abundance of mammals at 7 sites in West Kilombero Scarp Forest Reserve from July to December 2000. A total of 7 km of transects were surveyed. In addition to this casual observations of large mammals and their spoors* were recorded for all habitat types within the reserve.

West Kilombero Scarp Forest Reserve is home to 28 species of large mammals. Seven of these species and subspecies are restricted to Tanzania. A total of nine species or subspecies are forest dependent including six of seven species or subspecies of restricted range. Furthermore, 11 of the 28 large mammals recorded form the reserve, are listed by IUCN as "Endangered", "Vulnerable" or "Lower risk". The presence of this unique diversity of large mammals can be accredited to the size of WKSFR and the mosaic of habitat types found in reserve, including grassland, woodland, and montane and sub-montane forest.

The reserve, with its many threatened species of large mammals, probably supports the richest large mammal fauna within the Eastern Arc Mountains. Comparison with the highly disturbed NDUFR shows that the large mammal populations have been reduced drastically as a result of hunting and habitat degradation. It is therefore essential that the managing authority aim to conserve the high biodiversity value in WKSFR, through cessation of fires, regulation of hunting and prevention of natural habitat destruction.

The study of spoors of large mammals showed a uniform distribution of smaller sized species compared to species of larger size. The results were not used to estimate densities of the seven surveyed species, but the data may act as a baseline for future monitoring of population trends if this is deemed necessary by the managing authority.

* *In this study the term "Spoor" refers to all signs produced by animals.*

7.5.2 Introduction

Livestock is present in the Udzungwas, but production has long been insufficient to meet demands. Subsistence hunting is therefore widespread in the natural forests of Udzungwa Mountains and to some people the local wildlife population is the main source of animal protein (Zilihona *et al*. 1998; Topp-Jørgensen & Pedersen, 2000). Areas in the Udzungwas with a long history of hunting have already seen the disappearance of many large sized species, especially Elephant (*Loxodonta africana*), Aardvark (*Orycteropus afer*), Buffalo (*Syncerus caffer*) and the range restricted Abbots duiker (*Cephalophus spadix*) are sensitive to hunting (Topp-Jørgensen and Pedersen, unpubl.).

Previous expeditions to WKSFR have noted the presence of a large mammal fauna rich in species (Dinesen & Lehmberg, 1996; Topp-Jørgensen and Pedersen, unpubl.). The wildlife is however subjected to poaching (Frontier Tanzania, 2001d; Andrew Perkin, *pers. comm*.), and there is therefore an urgent need to evaluate the effect of hunting locally on animal populations and to implement management plans that will ensure the survival of large mammal species in WKSFR.

Large mammals are here defined as mammals, which generally are too large to be caught in bucket pitfalls and Sherman traps used in the survey of the small mammal fauna (section 7.2). The large mammals therefore include bushbabies, elephant shrews, squirrels, cane rat (*Thryonomys* sp.), giant pouched rat (*Cricetomys gambianus*) and species larger than the size of these.

Aims

- To produce list of large mammal species recorded in WKSFR
- To provide management recommendations based on large mammal species richness and relative abundance
- To evaluate effect of hunting and forest degradation through comparison of relative abundances of large mammals between WKSFR and NDUFR
- To provide baseline data for monitoring trends in the mammalian fauna

7.5.3 Methods

The “Fixed Area Search Method” (Eberhardt, 1978) and the “Line Intersect Method” (Eberhardt, 1978) were used to estimate the relative abundance of mammals at 7 sites in West Kilombero Scarp Forest Reserve from July to December 2000 (see Frontier Tanzania, 2001g). Transect data was obtained from 4 evergreen forest sites in Ndundulu, two sites in Nyumbanitu and one in Ukami. Species lists were obtained through casual observation from one evergreen forest site in Ndundulu and two in Nyumbanitu, as well as 4 sites outside evergreen forest (Acacia woodland, Miombo woodland, Grassland and Riverine forest dominated by *Syzygium cordatum*) (see section 7.1).

Fixed Area Search Method

Long and narrow (rectangular) plots transecting topographical gradients are more efficient than square plots, which often represent local extremes. The survey was therefore carried out along the transect lines closest to the five trapsites for the length of 1km (see section 7.1). The width of the searching area depended on the type of spoor. For point-like spoors of large mammals in montane forest, a width of 10m (5m either side of the transect line) has proved to be efficient for burrows (Topp-Jørgensen and Pedersen, 2000), while a width of 4m was used for dung piles (Frontier Tanzania, 2001g). All spoors originating from large mammals were identified. Since burrowing animals may have several entrances to a den system, attention was paid to distance between holes. This allowed for the estimation of the number of den systems rather than number of holes alone, which might be biased by the presence of several entrances originating from one animal. A distance of 10m between entrance holes was employed to discern between den systems. Notes on whether the holes seemed in use or abandoned were also taken.

Line Intersect Method
Whenever a transect was intersected by a path, a maximum of 3 minutes was spent assigning it to a species on the basis of footprints and dung. If no clear footprints or dung piles were found, the path was discarded as being old. The survey was carried out along 1 km of transect and only paths from animals large enough to leave clear prints are included in the relative density estimation (number of paths intersecting the transect line per km transect).

A Frontier Tanzania researcher and one or two trackers conducted sampling. To ensure the detection of all spoors, the census speed was adjusted to vegetation type and topography. All other spoors observed were recorded casually and included in the species list for each site.

7.5.4 Results

Large Mammals Recorded for WKSFR
All species of large mammals observed in WKSFR are listed in **Table 7.5A** (see **Box 7.5A** for definition of categories used in Table 7.5A). In total 28 species of large mammals (as defined in introduction) were recorded in WKSFR. Among these were four near endemic species (Udzungwa red colobus, *Procolobus gordonorum*, Zanzibar galago, *Galagoides zanzibaricus*, mountain galago, *Galagoides orinus* and Abbot's duiker, *Cephalophus spadix*) and two endemic subspecies (Servaline genet, *Genetta servalina lowei and* Sanje crested mangabey, *Cercocebus galeritus sanjei*) (see **Table 7.5A**). Nine species are considered forest dependent according to Burgess *et al*. (2000) and Kingdon & Howell (1993), of which six are endemic or near endemic and six are listed as "Endangered" or "Vulnerable" by IUCN (Hilton-Taylor, 2000). Thirteen species are known to occupy forest as well as other habitats and six species are normally regarded as non-forest species.

In addition to the 28 species recorded during Frontier Tanzania fieldwork, four widespread and non-forest dependent species were reported by villagers to be present in WKSFR (see **Table 7.5B**). See **Appendix 7.5A** for a list of all mammal species recorded in WKSFR.

Table 7.5A. List of large mammal species recorded from WKSFR. Taxonomy follows Kingdon (1997) unless another is stated.

Species	**Common name**	**Forest dependency**	**IUCN status**	**Endemism**
Procolobus gordonorum	Udzungwa red colobus	[a]F	VU	[1]NE
Colobus angolensis palliatus	Black and white colobus	F	DD	
Papio cynocephalus	Yellow baboon	×		
Cercocebus galeritus sanjei^	Sanje mangabey*	F	(EN)	(E)
Cercopithecus mitis	Sykes' monkey	F		
Galagoides zanzibaricus#	Zanzibar galago	F	LR/nt	[2]NE
Galogoides orinus	Mountain galago~	F	DD+	[2]NE
Thryonomys sp.	Cane rat	O		
Hystrix sp.	Porcupine	×		
Cricetomys gambianus	Giant pouched rat	×		
Mellivora capensis	Ratel (honey badger)	O		
Aonyx capensis	African clawless otter	O		
Atilax paludinosus	Marsh mongoose	O		
Crocuta crocuta	Spotted hyena	×	LR/cd	
Genetta servalina lowei	Servaline genet	×		(E)
Nandinia binotata arborea	African palm civet	F		
Panthera pardus	Leopard	×		
Panthera leo	Lion	O	VU	
Orycteropus afer	Aardvark	×		
Dendrohyrax validus	Eastern tree hyrax	×	VU	
Loxodonta africana	African elephant	×	EN	
Hippopotamus amphibius	Hippopotamus	O		
Potamochoerus larvatus	Bush pig	×		
Syncerus caffer	African buffalo	×	LR/cd	
Tragelaphus scriptus	Bushbuck	×		
Neotragus moschatus°	Suni	×	LR/cd	
Cephalophus harveyi	Harvey's duiker	F	LR/cd	
Cephalophus spadix	Abbot's duiker	F	VU	NE

* - Not recorded by this study, but observed by Dinesen & Lehmberg (1996).

^ - Taxonomy unclear for the species, listed name is from Ehardt *et al.* (2000) who is currently working with primates in the Udzungwa Mountain National Park.

- A new revision of the galago taxonomy has led to exclusion of the species *G. udzungwensis*, which is now included under *G. zanzibaricus* (Andrew Perkin, *pers. comm.*.). The common name used in this study will therefore be Zanzibar galago.

+ - Based on IUCN criteria, present data suggests the species to be listed as "Vulnerable" (Andrew Perkin, *pers. comm.*)

~ - Kingdon (1997) uses the common name Usambara galago, but when the species first was described in 1936 by Washburn, it was named mountain galago (Andrew Perkin, *pers. comm.*).

° - Uncertainty of which of the two small forest antelopes are present in WKSFR. *Neotragus moschatus* was recorded in New Dabaga/Ulangambi Forest Reserve, but it is possible that *Cephalophus monticola* (blue duiker) is present in WKSFR. Further investigation is needed.

Box 7.5A. Definition of categories used in **Table 7.5A** and **Table 7.5B**.

Forest dependency: F = Forest specialist; × = Found in forest as well as other habitats; O = Normally regarded as a non-forest species. Based on Burgess *et al*. (2000) unless otherwise stated; [a] = Kingdon & Howell (1993).

IUCN status: EN = endangered; VU = vulnerable; LR/nt = lower risk, near threatened; LR/cd = lower risk, conservation dependant; DD = data deficient. Taken from Hilton-Taylor (2000).

Endemism: E = endemic to the Udzungwa Mountains; NE = near endemic, limited to Tanzania and Eastern Arc Mountains down to northern Malawi; W = widely distributed. Based on Kingdon (1997) unless other is stated; [1]= Ehardt *et al*. (2000); [2]= Andrew Perkin (*pers. comm*.).

Letters in brackets refer to subspecies.

Table 7.5B. List of large mammals not recorded during fieldwork, but claimed to be present in he reserve by villagers.

Species	Common name	Forest dependency	IUCN status	Endemism
Cercopithecus aethiops	Vervet monkey	×		
Leporidae sp.	Hare sp.	[a]O		
Phacochoerus africanus	Common warthog	O		
Oreotragus oreotragus	Klipspringer	[a]O		

Spoor Surveys

Spoor surveys were carried out at seven trapsites in WKSFR (section 7.1) between July 2000 and December 2000. A total of 7 km of transects were surveyed.

Line Intersect Survey

Seven species were observed to use regular pathways in WKSFR that allowed assessment of relative abundance. **Table 7.5C** lists the number of paths per km for each of these species at the seven surveyed trapsites. The table shows that the largest species (elephant and buffalo) have a patchy distribution within the reserve, while smaller species are more uniformly distributed.

The small forest antelopes had a higher average number of paths assigned to them than all other species (see **Table 7.5C)**. Bush pigs were assigned approximately half as frequent with 15 paths per km, closely followed by Abbot’s duiker/bushbuck with 12 paths per km. The similar size of Abbot’s duiker and bushbuck footprints did not allow for any differentiation between these species during the line intersect survey. Four paths per kilometre were recorded for both buffalo and elephant. It should however be noted that it does not take more than a small herd of elephant to create numerous paths that are very obvious because of their weight. The elephant paths recorded in this study may therefore not be regularly used pathways, but possibly only reflect recent elephant presence in the area.

Table 7.5C. Number of paths observed for all species during the transect survey (trapsites 1, 3, 4, 5, 6, 8 and 10). Numbers listed are per kilometre transect.

Species	Trap site 1	Trap site 3	Trap site 4	Trap site 5	Trap site 6	Trap site 8	Trap site 10	Average number of paths per km
Suni°	15	53	36	18	65	20	32	34
Harvey’s duiker	18	36	20	18	46	16	39	28
Abbot’s duiker/bushbuck*	19	7	13	19	9	11	10	12
Bush pig	12	6	13	13	27	9	26	15
Buffalo	3	1	1	22	0	0	0	4
Elephant	14	2	0	8	0	4	0	4
Total number of paths / km	81	105	83	98	147	60	107	

° - Uncertainty of which of the two small forest antelopes are present in WKSFR. Neotragus moschatus was recorded in New Dabaga/Ulangambi Forest Reserve, but it is possible that *Cephalophus monticola* (blue duiker) is present in WKSFR. Further investigation is needed.

* - The similar size of Abbot’s duiker and bushbuck resulted in difficulties in assigning paths to these species. In this assessment of paths, they are therefore grouped together. Based on dungpile abundance, six out of ten individuals are bushbuck, while the assigning of paths by experienced trackers from neighbouring villages showed 7 Abbot’s duiker paths per km transect and 5 bushbuck paths per km (the latter figures are however very uncertain due to the similarity of their footprints).

Burrows

Burrows of giant pouched rat and aardvark were recorded at varying abundances at the surveyed trapsites (see **Table 7.5D**), probably reflecting a low sample effort. The average density of burrows from the reserve as a whole is on the other hand thought to be representative for the area due to the number of repetitions. The abundance of giant pouched rat and aardvark burrows in WKSFR was found to be 2.6 per ha and 7.7 per ha respectively. The den systems of the two species may have several entrance holes. Insufficient notes were however taken on the distance between entrance holes to allow estimation of the number of den systems made by the two species. Instead, the number of 50m transect sections with observations of entrance holes will be used as a measure of their abundance. These figures are listed in **Table 7.5D**.

Information on whether burrows were in use or not, was only recorded for a very limited number of transect sections. The results showed that four of twelve 50m sections had aardvark burrows in use. If these relationships reflect the true relationship for the entire reserve, this would mean that 1.3 50m sections per km transect would include aardvark den systems in use. Too few records of giant pouched rat burrows do not justify similar estimations.

Table 7.5D. Number of burrows and den systems observed within 5m from the transect line. The numbers are per one kilometre and therefore also per ha.

Species	**Trap site 1**	**Trap site 3**	**Trap site 4**	**Trap site 5**	**Trap site 6**	**Trap site 8**	**Trap site 10**	**Average**
Burrows								per ha
Giant pouched rat	0	8	11	0	5	0	1	3.6
Aardvark	1	19	2	12	15	6	0	7.7
50m sections with burrows								per km
Giant pouched rat	0	4	4	0	4	0	1	1.9
Aardvark	1	5	2	7	8	5	0	4.0

Table 7.5E. List of dungpiles recorded within two metres of the surveyed transects (trapsites 1, 3, 4, 5, 6, 8 and 10). Numbers represent dungpiles per km transect. Animals listed in taxonomic order (according to Kingdon, 1997).

Species	**Trap site 1**	**Trap site 3**	**Trap site 4**	**Trap site 5**	**Trap site 6**	**Trap site 8**	**Trap site 10**	**Dungpiles per ha**
Colobus sp.	1	1	1	1				1.43
Blue monkey			1					0.36
Cane rat					2			0.71
Genet or African palm civet	1							0.36
Eastern tree hyrax	2	5	3	1				3.93
Elephant	20			3		2		8.93
Bush pig	3	1	4		1		2	3.93
Buffalo	1			5				2.14
Bushbuck	3			2		1		2.14
Blue duiker or Suni		7	3	3	4	12	2	11.07
Harvey's duiker	1	2	2	11		3	2	7.50
Abbot's duiker	1	2				1		1.43

Dung Survey

Dungpiles were most abundant for the two species of small antelope (Harvey's duiker and Suni) which also had the highest number of paths assigned to them, and for the elephant (see **Table 7.5E**) who's dungpiles may persist for extensive periods. Dung from eastern tree hyrax and bush pig was both found in densities of 3.93 dungpiles per ha. All other species had recorded 2.14 dungpiles per ha or less.

Comparison of relative abundance between WKSFR and NDUFR

Species recorded during spoor surveys in both West Kilombero Scarp Forest Reserve and New Dabaga/Ulangambi Forest Reserve were compared for differences in relative abundance using t-test to compare means. The mean number of suni, red duiker and bush pig paths per kilometre transect were significantly higher in WKSFR than in NDUFR (Man Whitney U-test: (suni) Z=-2.847, n=12, p=0.004: (Harvey's duiker) Z=-2.852, n=12, p=0.004; (bush pig) Z=-2.857, n=12, p=0.004). No significant difference was observed between the mean number of giant pouched rat entrance holes per ha (t-test: t=0.068, df=10, p=0.947).

7.5.5 Discussion

West Kilombero Scarp Forest Reserve is home to an impressive diversity of large mammals (as defined in introduction). Of the 28 species recorded, only hippopotamus and honey badger were not recorded in forest-clad areas of the reserve. These two species are amongst six recorded species, which normally are regarded as non-forest species. As many as thirteen species are known to occur in both forests as well as other habitats, while nine species are considered dependent of forest habitat. It therefore seems that the high degree of large mammal diversity in WKSFR can be accredited to the mosaic of habitat types including grassland, woodland, and montane and sub-montane forest.

Seven of the recorded species and subspecies are restricted to Tanzania. Of these, five are primates, including three species of monkey and two species of bushbaby. The two remaining are the Abbot's duiker and the subspecies of the servalina genet, which prior to Frontier Tanzania surveys in the Udzungwa Mountains, was only known from one incomplete specimen collected in the Dabaga area (Kingdon & Howell, 1993). The area is also supporting populations of eleven species or subspecies, which are considered "Endangered", "Vulnerable" or "Lower risk" by IUCN (Hilton-Taylor, 2000). Included among these are species with large homeranges like the elephant and lion. Their presence in WKSFR can probably be ascribed to the huge area of WKSFR and the close proximity of even larger wilderness areas like the Kilombero Valley and Selous Game Reserve, which like WKSFR contains vast areas subjected to relatively little human disturbance. Half of the 28 species observed in WKSFR are either species of restricted range or species listed in one of the above three IUCN categories. The high number of threatened species including many non-forest species highlights the benefit of a varied habitat mosaic for the diversity of large mammals, and further act to stress the conservation importance of WKSFR (see **Box 7.5B** for brief description of priority species for management).

Box 7.5B. Brief description of species considered of importance for management in WKSFR. These are species of restricted distribution (endemic or near endemic) or species listed by IUCN (Hilton-Taylor, 2000).

Species described in more detail in other sections: The three monkey species falling under one of the above categories are described in more detail in section 7.6, the IUCN "Vulnerable" eastern tree hyrax is discussed in section 7.4, while section 8 elaborates on the observation of two near endemic species of bushbaby.

Hyena, *Crocuta crocuta*: Casual observations of dung, footprints and broken bones recorded this species in grassland areas, in riverine forest and well inside forested areas. Outside wildlife protection areas the hyena populations are declining due to an increase in livestock and the expansion of farming (Kingdon, 1997). The species is listed as "Lower risk/conservation dependent by IUCN (Hilton-Taylor, 2000) and therefore relies on protection of natural habitats for its survival.

Lion *Panthera leo*: This, the largest terrestrial carnivore in Africa, is like the hyena declining rapidly in areas not under protection, and Kingdon (1997) hypothesises that "before long the lion will only survive in large national parks and reserves. This IUCN "Vulnerable" species (Hilton-Taylor, 2000) was recorded from footprints in forested areas of the reserve as well as riverine forest and in the grassland area between the major forest blocks, Ndundulu and Nyumbanitu.

Elephant *Loxodonta africana*: Low ivory prices and extensive legal protection between 1920 and 1970 allowed the elephant populations to recover in many areas after having declined for many years (Kingdon, 1997). An increase in the value of the species' highly modified incisors (tusks) led to the killing of many elephants in the 1980s (Kingdon, 1997), reducing the population significantly. Due to this population decline the elephant is listed as "Endangered" by IUCN (Hilton-Taylor, 2000). This study recorded elephant presence over most of the reserve (see discussion of relative abundance of elephants in the reserve below). Although the species is still widespread, its survival will depend on protection of natural habitats, as conflicts between the species and people over land will increase as the human population increases. During a break in Frontier Tanzania fieldwork activities (October 2000) the reserve was visited by poachers who were found in possession of elephant meat and tusks (Andrew Perkin, *pers. comm*.). The protection status of the reserve therefore, does not safeguard the presence of the elephant in West Kilombero Scarp Forest Reserve.

Buffalo *Syncerus caffer*: Recorded from prints and dung as well as direct sightings from many areas in the reserve. It seems especially abundant in forest edge areas, where also most hunters' camps were observed. Buffalo remains were observed at one hunter camp in riverine forest, and poachers visiting the area in October 2000 killed one buffalo (Andrew Perkin, pers. comm.). The species is listed as "Lower risk/conservation dependent" by IUCN (Hilton-Taylor, 2000), and Kingdon (1997) report the species to be abundant in many reserves and therefore he does not consider it in danger of extinction in east Africa.

Suni, *Neotragus moschatus*/blue duiker, *Cephalophus monticola*: This study knows of no collections of skull collections from West Kilombero Scarp Forest Reserve, that can ascertain which of the small species of forest duikers are present in the reserve. Suni is listed as "Lower risk/conservation dependent" by IUCN, while blue duiker is not listed (Hilton-Taylor, 2000). Clarification of the present species is therefore needed. Whichever species is present, it seems abundant in the reserve based on the large number of paths assigned (see discussion on relative abundance below).

Harvey's duiker, *Cephalophus harveyi*: This forest dependent species was observed from dung and tracks as well as from direct sightings over most of the reserve. In additions to tall forest it was recorded from small riverine thickets dominated by *Syzygium cordatum* trees. *C. harveyi* is listed as "Lower risk/conservation dependent" by IUCN (Hilton-Taylor, 2000) and Kingdon (1997) notes that the species is common although populations are declining as a result of destruction of its preferred habitats.

Abbot's duiker, *Cephalophus spadix*: Near endemic, limited in distribution to eastern and southern Tanzania, where it is restricted to montane forest areas (Kingdon, 1997). Abbot's duiker is listed as "Vulnerable" according to IUCN (Hilton-Taylor, 2000). The species is sensitive to hunting and also threatened by destruction of forest habitats (Kingdon, 1997 and Topp-Jørgensen & Pedersen, unpubl.). The protection of forested areas is therefore essential for the survival of this "Vulnerable" species of restricted range.

Comparison of Large Mammal Species Richness with Usambara Mountains

During five years surveys in the Usambara Mountains, Frontier Tanzania found 25 species of large mammals (defined in introduction). During just under a year of surveying in WKSFR 28 species were recorded. The large size of WKSFR (1043km^2) compared to size (153km^2) and scattered distribution of forest reserves surveyed in the Usambara Mountains, may explain some of the differences in species composition between these areas. Generally WKSFR is home to the largest species including hyena, lion, elephant, hippopotamus, buffalo and Abbot's duiker, while the more prolonged surveys in the Usambaras has more records of small carnivores (Frontier Tanzania, unpubl.). The human population's demand for agricultural land in the Usambaras has led to a fragmentation of natural habitats. This breaking up of wilderness areas coupled with hunting probably have led to the disappearance of the largest species of mammals from the Usambaras. Therefore the rich diversity of large mammals in WKSFR can probably be ascribed to the presence of a mosaic of natural habitats, the low level of hunting and the size of neighbouring ecosystems like Selous Game Reserve and the Kilombero Valley.

Spoor Survey

Spoor surveys are useful for monitoring trends in mammal populations over time, but it can only be used for density estimation if the number of spoors, which represent one individual, is known (i.e. the number of dungpiles representing one individual). The results from this survey therefore only compare relative abundances within the reserve and at the same time acts as a baseline for future monitoring of population trends if this is deemed necessary by the managing authority.

Comparison of relative abundances between WKSFR and the highly disturbed NDUFR revealed significant differences in the abundance of forest antelopes and bush pigs, while the number of entrance holes to giant pouched rat holes were recorded at similar abundances. The hunting level in NDUFR therefore seems to have reduced forest antelope and bush pig populations significantly. The near endemic and IUCN "Vulnerable" Abbot's duiker was only recorded from two dungpiles during approximately 16 weeks of fieldwork in the reserve, stressing this species vulnerability to hunting and habitat degradation (Kingdon, 1997) and thus highlighting the need for management intervention if the species is to persist in NDUFR.

Line Intersect Survey

The distribution of the small forest antelopes (Harvey's duiker and suni) seems to be more or less uniform across the reserve (see **Table 7.5C**). The paths assigned to these species were often interspersed and they did not seem to occupy separate sections of the surveyed transects. This suggests relatively little inter-specific competition that allows the homeranges of these species to overlap.

The Abbot's duiker and bushbuck were grouped together due to difficulties in differentiating between their footprints. Combined, the two species seem to make up a uniform distribution within forested areas of the reserve, although the number of paths were relatively low compared to smaller forest antelope species. The ecological preference differs between the species indicating that they may occupy different areas within the reserve. With the spoor data it is however impossible to assess their individual status. The near endemic Abbot's duiker is of more interest for management of WKSFR due to its restricted range and forest dependency. Other studies have shown the Abbot's duiker to be very sensitive to hunting (Frontier Tanzania, 2001f and Topp-Jørgensen & Pedersen, unpubl.), several observations of its dung (which can be distinguished more easily from bushbuck than their footprints) were made both within the surveyed areas and outside. This indicates, what was also suggested by the ethno-ecological survey (Frontier Tanzania, 2001d), namely that hunting is very limited within the forested areas of WKSFR. The species however, remain dependent on forest habitats not impacted by humans, considering with the threatened status of the species it should be a priority species for the managing authority.

Elephants and buffaloes exhibit a more patchy distribution within the reserve, and were both absent from three of the seven areas surveyed (see **Tables 7.5C&E**). No buffalo paths were recorded during the spoor survey in Nyumbanitu and Ukami. Casual observations of buffaloes and their spoors revealed however their presence in this area, especially near the forest edge. Buffaloes were recorded from a mono-dominant riverine forest area about 2.5km from Udekwa village, while elephant were recorded from the grassland area between Ndundulu and Nyumbanitu forests approximately 5km from the village. It therefore seems that elephants and buffaloes may use areas near the villages despite being hunted. This study, however, does not quantify the abundance of the species in these areas and it is therefore possible that the species occurs at lower abundance near settlements.

Fixed Area Search

The burrows recorded during the Fixed Area Search may be occupied by other species than its creator, and therefore may only act as an indicator of the abundance of burrow dwelling mammals. The presence of the giant pouched rat burrows was recorded at four of the seven surveyed areas in WKSFR. Aardvark burrows were recorded at six of the seven survey sites within the natural forest. This is evidence of a recent presence over most of the reserve, although the burrows may have been taken over by other species. Freshly dug aardvark burrows were observed casually on several occasions in the reserve, and show a continued presence of the species. However, the fact that many other species uses its burrows makes it impossible to discuss its distribution any further.

Dung Survey

Not surprisingly, the abundance of a species influences the abundance of dungpiles originating from the species. The chance of detecting a dungpile also depends on the size of the pile, and dungpiles with a slow decay rate will accumulate over time more so than rapidly decaying dung. It is therefore not surprising that the most frequently encountered dung is from the species most abundant in the reserve according to the survey of paths (Harvey's duiker and suni), and from the elephant with its long-lasting dungpiles.

The low sampling intensity and the low density of dung make it difficult to use data for more detailed abundance measures. But dung is still a valuable instrument in efforts to produce more complete species lists.

7.5.6 Conclusion

West Kilombero Scarp Forest Reserve is home to 28 species of large mammals, including seven species and subspecies that are restricted to Tanzania and nine species or subspecies that are forest dependent. Furthermore, 11 of the 28 large mammals recorded form the reserve, are listed by IUCN as “Endangered”, “Vulnerable” or “Lower risk”. The large mammal populations in the reserve seem largely unaffected by hunting. The presence of this unique diversity of large mammals can probably be accredited to the size of WKSFR and the mosaic of habitat types found in reserve, including grassland, woodland, and montane and sub-montane forest.

Due to the richness of large mammal species and the high number of species considered of conservation concern, it is essential that the managing authority aim to conserve the high biodiversity value in WKSFR. This should be done through cessation of fires, regulation of hunting and prevention of natural habitat destruction.

7.6 Priorities for the Conservation of Monkeys in West Kilombero Scarp Forest Reserve Based on Comparison of Density and Socioecology with New Dabaga/Ulangambi Forest Reserve

Andrew R. Marshall, Henry Brink, J. Elmer Topp-Jørgensen

7.6.1 Summary and Recommendations

Ten species of primate are known from the Udzungwa Mountains, making it one of the most important areas for primate conservation in East Africa. Amongst these are four forest dwelling monkey species, (Udzungwa red colobus, *Procolobus gordonorum*, Sanje crested mangabey, *Cercocebus galleritus sanjei*, Angolan black and white colobus, *Colobus angolensis palliatus* and Sykes' monkey, *Cercopithecus mitis* (subsp.). The former two of these are of restricted range and of considerable conservation concern (IUCN vulnerable and endangered respectively).

There has been little previous study of Udzungwa primates in most forest fragments beyond details of presence/absence and not even that information is available for some forests. Previous limited surveys of West Kilombero Scarp Forest Reserve (WKSFR) have reported the presence of six monkey species including the four species of forest dwelling monkeys, which are the focus of this study.

Transect line survey and opportunistic encounters recorded the presence of black and white colobus, Sykes' monkey and the Udzungwa red colobus in most forested areas of the reserve. From 96h of transect line surveys in Ndundulu forest (the easternmost forest fragment of WKSFR), most visual records were of the black and white colobus, whereas Sykes' monkey vocalisations were heard most often. The Sanje mangabey was not recorded at any point during fieldwork, and thus its distribution within the reserve (known from Ndundulu forest only) is thought to be highly restricted.

By detailed comparison with New Dabaga/Ulangambi Forest Reserve (NDUFR), and with reference to previous studies in the Udzungwas and elsewhere, the potential effect of habitat quality is demonstrated and discussed. Primarily, there is a notably higher group density (measured as groups per kilometre transect) and group size in WKSFR than in NDUFR. This difference is apportioned to the generally low degradation of habitat in WKSFR. There are also a relatively high number of associations between different species in WKSFR, which may again have been affected by habitat degradation. Is it more likely however that the high abundance of predators in WKSFR benefits large aggregations of mixed species. Comparison between transect lines within the two reserves also appears to support these suggestions.

Observed changes in monkey ecology with habitat quality provide just one example of how human impacts on forested areas can affect wildlife. Such changes are indicative of monkey populations under environmental stress and thus the ecology of many taxa is likely to be under similar pressures. In WKSFR however, populations of the three observed species appear to be healthy. Habitat fragmentation from logging and bushfires may have affected the social group structure of monkeys in the north of Ndundulu forest, although group density remains high.

The importance of WKSFR to Udzungwa primate conservation cannot be stressed enough. It is one of only three known forests containing the Sanje mangabey (despite no records in this survey) and is a major stronghold for populations of the Udzungwa red colobus. There are two priorities for action:

- The preservation of the forested areas is vital. Forest use must be monitored closely by the MEMA project to ensure that the current low level of exploitation does not elevate. If forest use should begin to elevate, future inclusion of the reserve into the bounds of the adjacent Udzungwa Mountains National Park should also be considered to safeguard the long-term protection of the area.

- Also of concern is the isolated nature of the Nyumbanitu and Ukami forest fragments. Simple cessation of annual bushfires, which would allow re-colonisation by forest/woodland of the extensive grassland areas, may be sufficient to connect these fragments. Most importantly, such a connection could potentially open up the forests of Nyumbanitu and Ukami to the Sanje mangabey populations, which are currently limited in WKSFR to Ndundulu forest.

7.6.2 Introduction

The Udzungwa Mountains are home to one of the most diverse primate communities in East Africa. Among the ten known species, there are two restricted range monkeys of conservation concern. The most poorly known and most highly threatened of these is the IUCN endangered Sanje crested mangabey, *Cercocebus galleritus sanjei*[*] (Hilton-Taylor, 2000). Discovered only as recently as 1979 (Homewood & Rodgers, 1981), this Udzungwa endemic sub-species is only known from three areas of forest (Dinesen *et al.*, 2001; Ehardt, *et al.*, 2000) and is the only representative of the genus *Cercocebus* in Tanzania. The second restricted range primate, the Udzungwa red colobus, *Procolobus gordonorum*[*] (IUCN vulnerable: Hilton-Taylor, 2000) is known from several Udzungwa forests plus two lowland forest fragments to the east of the Udzungwa Mountains National Park. Like the mangabey, populations are highly restricted by forest fragmentation. Two further species present in the Udzungwa forests are the Angolan black and white colobus, *Colobus angolensis palliatus*[*] (IUCN data deficient: Hilton-Taylor, 2000) and Sykes' monkey, *Cercopithecus mitis* (subsp.)[*].

More widespread primate species found mostly in the Udzungwa savannas include vervet monkeys, *Cercopithecus aethiops rufoviridis* and yellow baboons, *Papio cynocephalus cynocephalus*. There are also at least four species of galagos (*Otolemur crassicaudatus*, *O. grantii*, *Galagoides orinus* and *G. udzungwensis*/*zanzibaricus* [Perkin, *pers. comm.*]).

Despite the diversity and restricted range of the Udzungwa primate fauna, much of this vast area remains unsurveyed. Dinesen, *et al.* (2001) have made the most geographically extensive Udzungwa primate records during ornithological surveys in the area. Ehardt *et al.* (2000) have also set up ongoing studies in Mwanihana forest in the Udzungwa Mountains National Park (UMNP). Additional brief visits were made by Ehardt *et al.* (2000) to other forests of UMNP to assess the primate communities. A handful of earlier, shorter surveys and anecdotal information complete the current knowledge of the Udzungwa primates. In many forests, only the presence or absence of forest primate species is known and in some areas, not even this is available. Ironically, the best known forest primate community in the area is that of the ill-fated Magombera forest in the north west corner of the Selous Game Reserve. This former forest reserve was cut in half by railroad construction. Following this, the northern half of the forest was subsequently cleared for agriculture, thereby seriously threatening the monkey populations (Rodgers *et al.*, 1980; Decker, 1994 & 1996).

Two primate surveys have been conducted in the West Kilombero Scarp Forest Reserve (WKSFR) over the past ten years. The first of these (Dinesen *et al.*, 2001), conducted in 1992, sparked major interest in WKSFR primates through the discovery of the Sanje crested mangabey in the eastern portion of Luhombero forest (in line with the rest of this report, the name "Ndundulu" is used for this area). The Udzungwa red colobus, Sykes' monkey and black and white colobus were also noted in high numbers in Luhombero as well as Ukami and Nyumbanitu. Vervet monkeys and yellow baboons are present outside of the forest areas.

[*] Taxonomy generally follows Butynski *et al.* (1998). Following Kingdon (1997) and Struhsaker (*pers. comm.*), the scientific name *P. gordonorum* is however used in preference to *P. badius gordonorum.* The common name "Udzungwa red colobus" for *P. gordonorum* is also used in preference to Uhehe, Gordon's or Iringa red colobus (after Dinesen, *et al.*, 2001; Struhsaker, *pers. comm.*). For simplicity, the Angolan black and white and Udzungwa red colobus are referred to as "black and white colobus" and "red colobus" in the results and discussion sections. The subspecies of *C. mitis* is also uncertain.(Ehardt *et al.*, 2000; Butynski *et al.*, 1998) and thus "(subsp.)" is used.

Following this in 1998, Pedersen & Topp-Jørgensen (2000) conducted transect surveys (also in Ndundulu) to examine the impact of hunting on primate populations.

Observations made during line transect surveys are here used to assess the density and socioecology of diurnal forest dwelling monkeys of Ndundulu Forest Reserve. This will be supported using notes gathered opportunistically from Nyumbanitu, Ukami, Ndundulu and elsewhere in WKSFR. The focus here is to build on observations made by previous studies and to make comparisons with New Dabaga/Ulangambi Forest Reserve (NDUFR) which was sampled using similar methods (Frontier Tanzania, 2001e).

The key aim is to determine whether monkey populations are being affected by the marked contrast in the level of habitat degradation of the two focal forests (NDUFR is highly degraded secondary forest; WKSFR is mostly primary forest). Studies outside of the Udzungwas on different species have found that primate social organisation can be considerably affected by degradation of habitat. In particular, when an area of forest is disturbed by human activities, primate food sources may become clumped or reduced in number or diversity. This often results in the reduction of social group size and the frequent splitting of groups into smaller foraging parties (e.g. Struhsaker, 2000a; Struhsaker, 2000b; Siex & Struhsaker, 1999; Struhsaker, 1998; Johns & Johns, 1995; Decker & Kinnaird, 1992). From preliminary studies in other Udzungwa forests, reversion to such "fission-fusion" social organisation has been suggested to occur in the Udzungwa red colobus (Ehardt *et al.*, 2000), although considerable further investigations are required to substantiate this. In addition, population density and associations between different monkey species may also be affected by habitat degradation (e.g. Ehardt *et al.*, 2000; Struhsaker, 2000a).

By analysing changes in population dynamics, primates can act as an indicator of the effect of human activities on wildlife. Such studies are crucial in understanding the needs of animal communities. The findings also have clear implications for formulation of management priorities for conservation.

Aims

- To determine the species composition, group density per transect and distribution of primates in WKSFR.
- To make conclusions about the effect of habitat quality on monkey populations by comparison between transect lines within WKSFR and with the more disturbed New Dabaga/ Ulangambi Forest Reserve (NDUFR; Frontier Tanzania 2001e).
- To discuss priorities for the conservation of WKSFR primates.

7.6.3 Methods

A total of twenty repetitions of census transects were made. Eleven and nine repetitions were made in a straight line along Ndundulu transect lines '1' and '3' respectively (**Figure 7.6A**). Transects were 3km long, and were walked at a pace of around 0.7km/h, beginning at 0700h.

To avoid the considerable variation that can result from inter-observer reliability (e.g. Mitani *et al.*, 2000), one researcher (ARM) carried out all surveys, often accompanied by one or two research assistants. Along each walk, all primate groups were noted and a maximum of ten minutes was spent with each group to record the following details:

- species identification,
- method of detection (i.e. visual, vocalisation or movement),
- observer location,
- distance and compass bearing of first individual observed from each group,
- time of first encounter with group,
- habitat details (percentage canopy cover, canopy height, slope, topography),
- altitude,
- associated species (sightings of different species within 20m of one another),
- number of individuals observed and estimate of group size (individuals were defined as being part of a group if less than 20m from its nearest conspecific),
- any additional notes (e.g. diet, behaviour, gender and age).

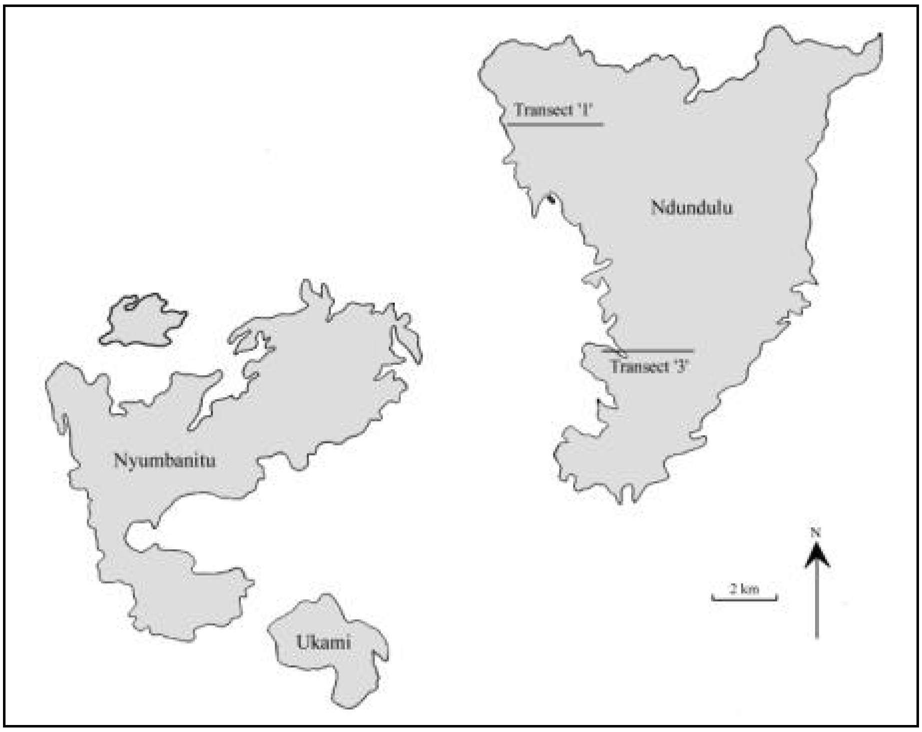


Figure 7.6A. Monkey census transects in West Kilombero Scarp Forest Reserve. Shading indicates areas of evergreen montane/submontane forest.

Where species identification or group size estimates were uncertain, a numerical quality rating was applied to indicate the reliability of the observation. Doubtful estimations were removed completely from final analysis.

For every walk, the start/finish times, start/finish temperature, number of observers and the date were also noted. For each line, the altitude and canopy cover and height were also taken at 50m intervals, along with brief descriptions of habitat structure including dominant tree species and general state of the forest. This was used to expand on information from vegetation plots and disturbance transects conducted in 1999 (Frontier Tanzania, 2001c).

Additional walks were also conducted along Ndundulu transect lines '2' and '4', Nyumbanitu transect lines '2' and '3' and Ukami transect line '4' (for location of these transects see section 7.1). Encounters with monkey groups during these and opportunistic encounters made by all Frontier Tanzania researchers were also noted.

Similar methods were also employed along two transects in New Dabaga/Ulangambi Forest Reserve (Frontier Tanzania, 2001e) and will be used for comparative purposes.

7.6.4 Results

Species Composition

From 96h of census transect walks, 205 records of monkey groups were made. Of these, 49 records were of Udzungwa red colobus[†], 67 of Angolan black and white colobus, 74 of Sykes' monkeys and 15 were of uncertain identification. No records of either sightings or vocalisations of the Sanje crested mangabey were made. These observations are summarised as the number of groups per kilometre transect in **Figures 7.6B&C**. See also section 7.5 for a full primate species list for the area.

The most frequently observed monkey species during the census transects was the black and white colobus (mean 0.58 groups/km compared with 0.49 for red colobus and 0.34 for Sykes' monkeys). In terms of vocalisations, Sykes' monkeys were however heard more often than all other species. This species was equally common to both transect lines. There were however clearly more colobus monkeys in the vicinity of transect '1' compared to transect '3' (**Figure 7.6B**).

The number of vocalisations and visual records of all monkey species are greater for Ndundulu than NDUFR. This difference is most notable for the black and white colobus (**Figure 7.6C**).

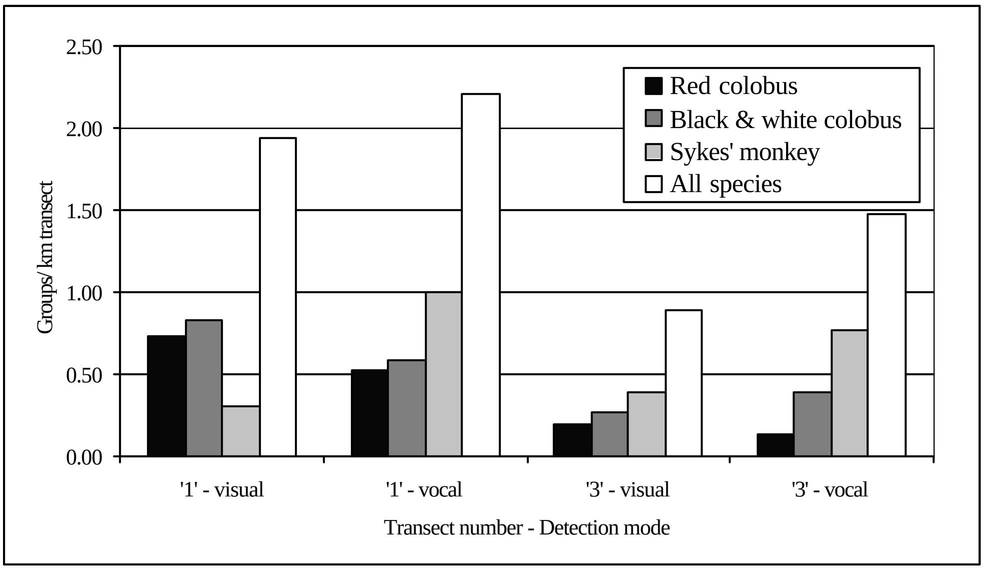


Figure 7.6B. Mean frequency of monkey groups per kilometre transect in West Kilombero Scarp Forest Reserve.

[†] For simplicity, the Angolan black and white and Udzungwa red colobus are referred to simply as "black and white colobus" and "red colobus" in the results and discussion sections.

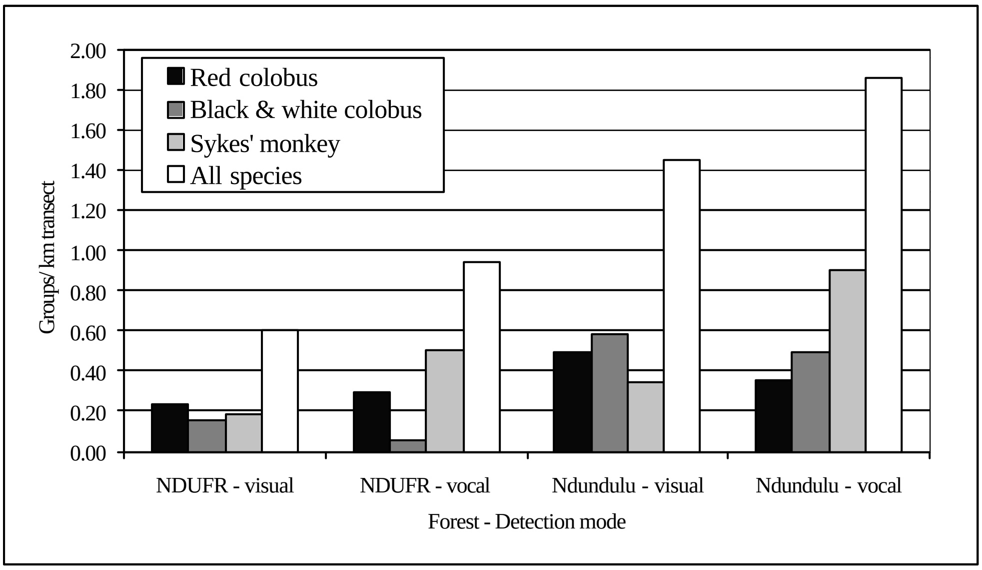


Figure 7.6C. Mean frequency of monkey groups per kilometre from two pairs of transects in New Dabaga/Ulangambi Forest Reserve and Ndundulu forest in West Kilombero Scarp Forest Reserve (Frontier Tanzania, 2001f).

Social Group Dynamics

During census walks, counts of the number of individuals could only reliably be made when an entire group fled in view along the same route. In many cases however, monkeys tend to flee in a frenzied panic and thus are impossible to count accurately. From those groups observed during census walks which did not flee, counts could also rarely be made due to the "ten minute per group" methodology.

The few group counts made are presented in **Appendix 7.6A**. Red colobus group size clearly showed the most variation, with complete counts ranging between 12 and 33 individuals. Estimates of group size however were made up to 50 individuals in a group (**Appendix 7.6A**). One researcher (HB) also encountered a seemingly huge group of red colobus whilst walking through Nyumbanitu forest. This aggregation took around half an hour to pass at walking pace and may have numbered up to one hundred individuals. It was unclear however whether this was one group or a series of groups and thus has been omitted from **Appendix 7.6C**. No observations of solitary red colobus were made.

Black and white colobus groups contained mostly between seven and nine individuals, with two observations of solitary individuals. One solitary adult female black and white colobus with an infant was also observed. Only one group count of Sykes' monkeys was made, which was around 22 individuals. Two observations of solitary Sykes' individuals were made outside of the main forested areas. One of these was an adult male skipping through the grass towards a small forest fragment near to the western end of transect '1'. The second solitary Sykes' was seen giving a "pyow" call in a similar fragment whilst walking through grassland around 2km south of the western end of transect line '1'.

Interspecific Associations

A summary of all interspecific associations seen during transect walks is presented in **Figure 7.6D**. During surveys along transect lines '1' and '3', a total of 49 groups were seen associating with other monkey species (mean 55% of observations between the two transects). Of these, the two species of colobus were seen associating most frequently, totalling 42% of colobus observations (30 out of 72). A small difference can be seen in the proportion of mixed species associations between the two transect lines '1' and '3' (**Figure 7.6E**), which is mostly accounted for by the low proportion of associations with Sykes' monkeys from the latter (**Figure 7.6D**). No sightings of mixed species groups containing all three species were made during repetitions of the two principle transect lines. However, in the tall evergreen forest fragment of Ukami, one such aggregation was seen. The same group was observed twice within a three day period and contained ≥7 black and white colobus and a number of red colobus and Sykes' monkeys.

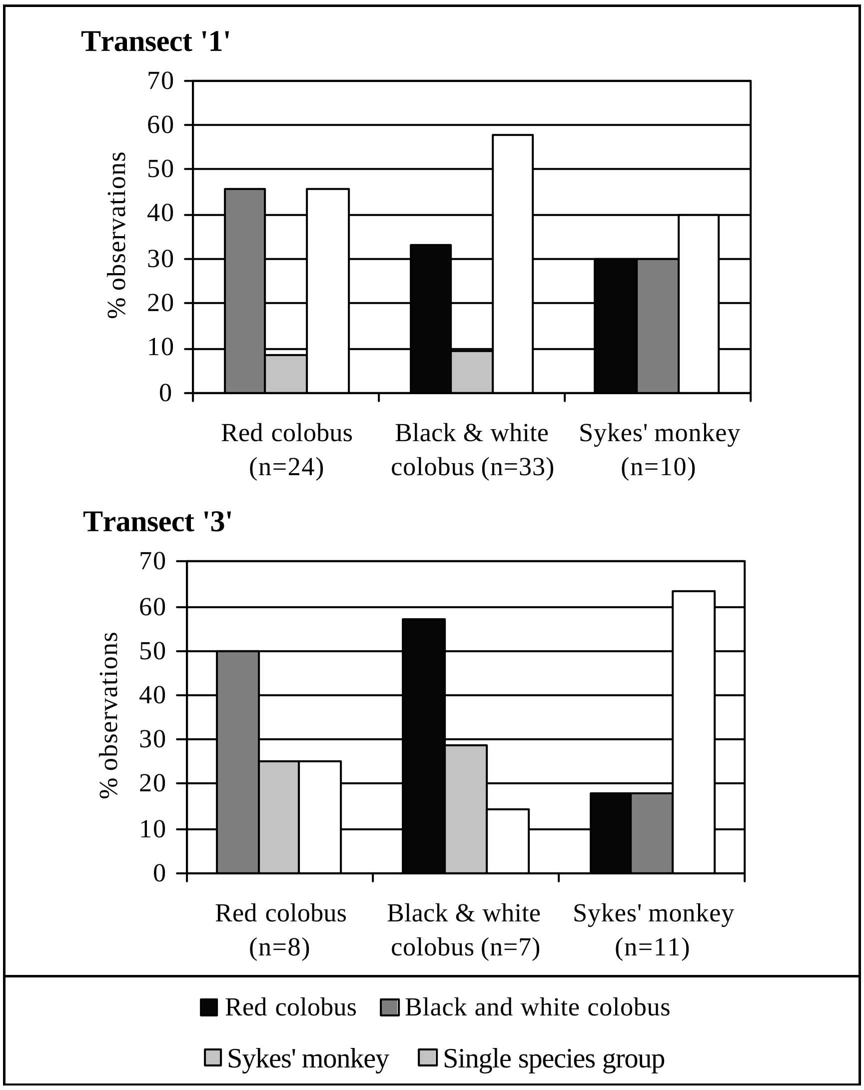


Figure 7.6D. Mixed species monkey groups observed during transect line surveys. Bars indicate the percentage of sightings of each species seen associating with other monkey species.

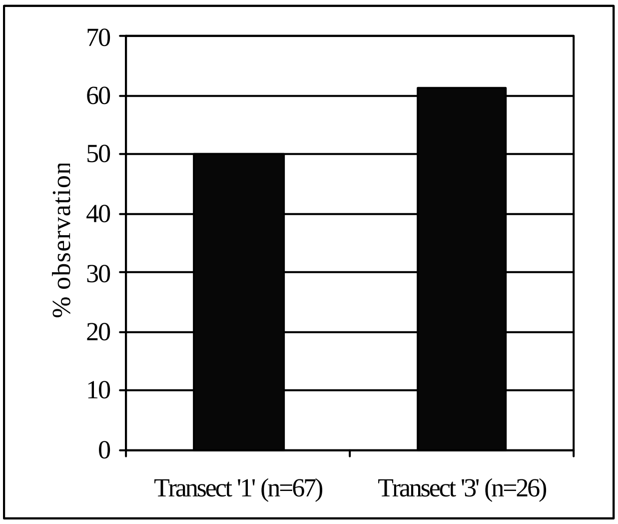


Figure 7.6E. Percentage of sightings of mixed species monkey groups from the two principle transects in West Kilombero Scarp Forest Reserve.

Comparable interspecific association data collected in NDUFR is presented in **Figure 7.6F**. There are a considerably greater number of associations in Ndundulu. Also in contrast to Ndundulu, in NDUFR there were also no observations of Sykes' monkeys associating with either of the colobines.

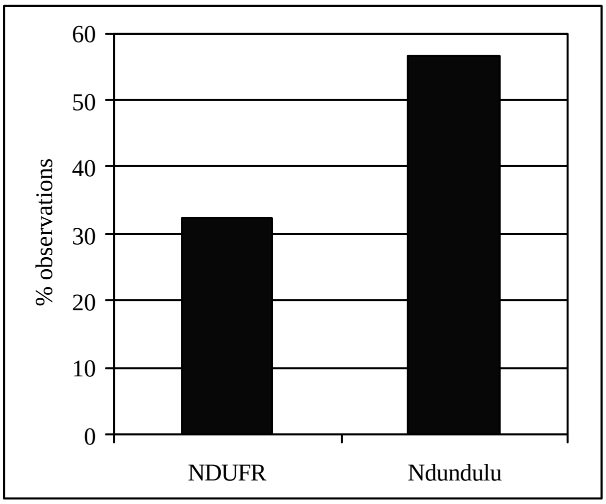


Figure 7.6F. Mean percentage of sightings of mixed species monkey groups from two pairs of transects in New Dabaga/Ulangambi Forest Reserve and Ndundulu forest in West Kilombero Scarp Forest Reserve.

Additional Observations

Extending from the main evergreen forest fragments of WKSFR are several stretches of tree-species rich gallery forest. Within such forest, approximately 500m from the south-western edge of Nyumbanitu forest, all three monkey species were observed. It is not certain how far these stretches of gallery forest extend, however they may join on to the extensive mosaic of

Syzygium riverine forest found in low lying valleys between the forests of Ndundulu and Nyumbanitu.

Finally, in August and November 1999, two monkey skulls were found in Ndundulu forest. The identification of the first of these has been confirmed by Dr. Dieter Kock of the Frankfurt Zoological Museum as of Udzungwa red colobus. This specimen is now stored in Frankfurt. The second, from a smaller, younger monkey, has similar shape and dimensions to the first and thus is likely to be the same species. This skull is however less well preserved and awaits taxonomic verification.

7.6.5 Discussion

The monkey groups of WKSFR essentially differ from NDUFR in three ways. Namely, groups in WKSFR are larger, at higher densities and more likely to be of mixed species (**Table 7.6B**). In addition, one species found in WKSFR is absent from NDUFR (the Sanje crested mangabey, *C. g. sanjei*). The Frontier Tanzania surveys have also emphasised many differences between the history, current threats, vegetation and fauna of these two forests (Frontier Tanzania, 2001c&d). From these, the following discussion will attempt to piece together the major influences on the observed differences between monkey communities.

Table 7.6B. Summary of differences observed in monkey socioecology, species richness and group density between West Kilombero Scarp Forest Reserve and New Dabaga/Ulangambi Forest Reserve. Group sizes are based on complete counts only (**Appendix 7.6A**). Few opportunities arose to make reliable estimates of Sykes' monkey group size and hence estimates for this are only made for the two colobus species.

	WKSFR	NDUFR
Mean groups/ km transect (visual)	1.45	0.60
Mean groups/ km transect (vocal)	1.86	0.94
Maximum group count		
P. gordonorum	33**	24
C. a. palliatus	12	8
Mean group size*		
P. gordonorum	21.2	10.4
C. a. palliatus	10.7	6.25
% no. of solitary adults/subadults***		
P. gordonorum	0.0	13.0
C. a. palliatus	21.4	33.3
% interspecific associations	0.57	0.32
Number of species present in forest	4	3

* Includes complete counts of groups only and excludes all solitary individuals or solitary mothers with infants.

** Mixed group of thirty-three red colobus and at least nine black and white colobus.

*** Includes only those groups for which group size estimates or complete counts have been made (**Appendix 7.6A**).

Interspecific Associations, Group Size, Density & Diversity

These three aspects of monkey socioecology all vary between the two reserves of West Kilombero Scarp and New Dabaga/Ulangambi. Before making conclusions on the major factors affecting these, other potential influences will however first be discussed. In reality, several factors are likely to have caused the observed differences, many of which are interrelated.

Altitude

The geographical limits of many taxonomic groups, including several elsewhere in this report, are limited by altitudinal barriers. However, the altitudinal range of the NDUFR and WKSFR transect lines was small (1700-2000m) and was therefore unlikely to explain differences in the primate communities.

Hunting

In WKSFR, the hunting levels are low to non-existent for monkeys. Villagers say there is no hunting of monkeys because they resemble people, whereas some knew of the hunting of duikers, hyrax, bush pigs, buffalo and elephants (Frontier Tanzania, 2001d). From field observations and encounters with poachers by TANAPA and scientists, there is also evidence of low level hunting of several animals, but not monkeys. Only one mammal snare was found during our entire fieldwork period, in the miombo (*Brachystegia* sp.) woodland around three kilometres from the forests of Ndundulu and Nyumbanitu. This was most likely set to catch bush pigs. Two small snares set to catch birds were also found in the "Luala" grassland in the centre of Ndundulu forest.

Struhsaker (1999) has collated observations from several examples where primate communities have been either severely reduced or completely exterminated as a result of hunting. In the more accessible NDUFR, there is widespread hunting of many animals (Frontier Tanzania, 2001c&e). Like WKSFR, hunting of monkeys is not however thought to be carried out in excess and thus is not likely to be the major determinant of monkey densities and socioecology in these two reserves.

Forest Fragment Size

Large areas of interconnecting habitat are very important for dispersal and population viability or effective population size (e.g. Soulé, 1987). Primarily, the more available habitat there is, the more opportunity there is for monkey (or other animal) groups to find food, sleeping sites or any other requirements for survival.

One difference in the WKSFR and NDUFR primate community, which may have been affected by forest fragment size, is the presence of the Sanje crested mangabey. This endangered and endemic subspecies is only known from some of the biggest continuous areas of natural evergreen forest in the Udzungwa range (West Kilombero and Udzungwa Scarp Forest Reserves and Mwanihana forest in UMNP; 250, 230 and 522km^2 forest area respectively; Dinesen *et al.*, 2001). As noted, the mangabey was not however recorded from WKSFR during field periods in 1999 or 2000, despite our extensive coverage of the reserve. Likewise, transect survey by Pedersen & Topp-Jørgensen (2000) and two passing visits by Ehardt *et al.* (2000) and primatologists in 2000 (Perkin, *pers. comm.*) did not record the mangabey. From observations made in 1992, Dinesen *et al.* (2001) also highlight the extremely limited distribution of this species. From the low disturbance level in the reserve, it seems unlikely that the mangabey has disappeared entirely from Ndundulu since the observations of Dinesen *et al.* (2001).

Comparisons of Udzungwa monkey populations made by Dinesen *et al.* (2001) suggest, however, that forest fragments even smaller in size than NDUFR are still able to support densities which are comparable with the largest Udzungwa forest fragments. Examples of this are equally frequent observations of monkeys from Iwonde, Ukami, Magombera and Kalunga, which are all less than 11km^2 in size (compare Dabaga which is over 37km^2) and from the larger forests of Mwanihana and Luhombero (both over 170km^2; Dinesen *et al.*, 2001). It is therefore unlikely that the large size difference between Ndundulu (which is part of the Luhombero forest, area 250km^2) and NDUFR is the primary determinant of the low densities in NDUFR. Unless reduction in forest size in NDUFR somehow affects the availability of food species, it also seems unlikely that fragment size should affect either interspecific associations or group dynamics.

Tree Species Composition
Vegetation surveys of trees above 10cm dbh and regenerating trees and shrubs have revealed a remarkably different flora between the two Forest Reserves (Frontier Tanzania, 2001c&d). To summarise this, 50m×20m plots of vegetation in WKSFR revealed five major forest tree communities, each with considerably different species compositions. The most dominant tree is *Cola usambarensis* (10% of trees identified from plots), followed by *Cassipourea gummiflua* (8.8%). However, in NDUFR there is a predominance of scrubby, secondary growth, with the pioneer tree, *Macaranga kilimandscharica*, dominant throughout the reserve (this species was found in 33 out of 34 plots spread evenly across the reserve and accounts for 20.4% of all identified trees). In WKSFR, this tree only represented 0.5% of identified trees.

As outlined in the introduction, several authors have observed changes in monkey ecology with habitat degradation (e.g. Struhsaker, 2000a; Struhsaker, 2000b; Siex & Struhsaker, 1999; Struhsaker, 1998; Johns & Johns, 1995; Decker & Kinnaird, 1992). Primarily with a sparse, clumped distribution of food trees, intragroup competition becomes greater and groups are more likely to fragment for varying intervals of time i.e. reversion towards a fission-fusion type social system (e.g. Struhsaker, 1998). In Ndundulu forest, there is however a low proportion of solitary individuals and large groups of both colobus species. This is likely to be a result of low forest degradation. Similarly, in Mwanihana forest, which has undergone some light logging, Ehardt *et al.* (2000) recorded groups up to 55 individuals in size. Dinesen *et al.* (2001) also reports sighting a group of about 100 individuals in Ndundulu forest, including all four Udzungwa forest monkey species. By contrast, Kalunga forest to the east of UMNP has suffered from heavy logging. Here, Ehardt *et al.* (2000) observed red colobus groups of similar size to groups in NDUFR (9, 19, 24 and 24 in Kalunga compared to the mean 14.7 for NDUFR).

Variation in habitat quality may also have influenced the considerable differences in the number of groups per kilometre transect between Ndundulu and NDUFR (**Figure 7.6C** and **Table 7.6B**). Similar to Ndundulu, transect walks in Mwanihana forest and other areas of Ndundulu have recorded red colobus densities of ≥0.70 and 0.44 groups respectively (Ehardt *et al.*, 2000; Pedersen & Topp-Jørgensen, 2000). Conversely, in areas of human impacted forest in the Udzungwas, considerably reduced group density has been seen, e.g. red colobus: 0.20 groups/km in Udzungwa Scarp Forest Reserve (Pedersen & Topp-Jørgensen, 2000).

The habitat difference between transect line '1' and transect line '3' in Ndundulu are also considerable. Notably in some areas along line '1', commercial logging companies have removed an unknown number of trees. This coupled with signs of bushfire within the forest has resulted in a more fragmented canopy. Paradoxically, the number of red and black and white colobus groups per kilometre transect is markedly greater for transect line '1' (**Figure 7.6B**). There are of course likely to be natural background fluctuations in density, however the marked differences seem unnaturally high. For red colobus, one interpretation of this may be that transect line '1' groups tend to split frequently into foraging parties. This may explain the observation of some smaller sized parties in this area (e.g. 12, 12 and 16; **Appendix 7.6A**). Thus red colobus group density estimates may be somewhat inflated along transect line '1'. The transect line '1' monkeys may also benefit from the emergence of a high diversity of pioneer species along with the continued persistence of many primary forest species. Such an effect has been noted by Howard (1991) (cited in Struhsaker [1998]) in Kalinzu forest in Uganda where primate abundance actually increased markedly between 10 and 17 years after logging. This observation was assigned to a major increase in a particular food tree species. Accordingly, there are some tree species which are abundant along transect line '1' and not along other transect lines. One example, *Neoboutonia macrocalyx*, was observed being eaten by both Sykes' monkeys and black and white colobus. There is also a high density of the primary forest tree *Podocarpus latifolius*, the berries of which were observed being eaten by red colobus.

The large increase in associations between different monkey species in WKSFR could also be due to habitat quality as has been seen in Kibale forest Uganda (Struhsaker, 1998). Within both reserves, there are however no strong differences in intergroup associations, despite some differences in tree species composition between transect lines and thus other factors may be having a greater effect.

Predation
In WKSFR, both of the major predators of the forest monkeys are common (Frontier Tanzania, 2001f). The primary predator of Udzungwa primates, the crowned hawk eagle, *Stephanoaetus coronatus*, was seen and heard regularly (section 7.7). There were also several records of tracks, stools and even some vocalisations of leopards (section 7.5), which are also known to take monkeys (Struhsaker, 2000a). By contrast, unlike most other Udzungwa forests, there seems to be a lack of predators in NDUFR. This inverse relationship between monkey group density and predator presence therefore suggests that predators are not a cause of reduced monkey density in NDUFR. The only other forest for which comparable transect walks have been made is Mwanihana (UMNP) where eagles and leopards are present and monkey group densities are also high (0.7 to 0.88 parties/ km transect).

With regard to mixed groups, Struhsaker (2000a) concluded that the single most important predictor of African forest monkey polyspecific associations is predator abundance. The observation of increased interspecific associations in the predator-rich Ndundulu is in keeping with this. Further support is given by the lack of intrareserve difference in the proportion of associations between transects within NDUFR and Ndundulu. The predator levels are not thought to differ between transects within the reserves and thus this is as expected given Struhsaker's (2000a) findings. In drawing conclusions from this it must however be considered that the rate of interspecific associations is also likely to be density dependent.

Examples from elsewhere have also shown that monkey group size can be reduced in areas of low predation level (Struhsaker, 2000a&b). The advantages for group living to resist predation for several animal groups has been widely reported (e.g. Krebs & Davies, 1993). However, habitat quality can have a marked effect on group size as explained above and in degraded habitats, the increased costs of foraging in a large group can outweigh the costs of predator avoidance (Struhsaker, 2000a).

Measurement of Group Density
Because of inherent complications in extrapolating population density, the above results are presented and compared in terms of the number of groups per kilometre transect (**Figure 7.6B&C**; **Table 7.6B**). This method of displaying the data allows a straightforward comparison between two areas surveyed using similar methods. As well as removing the difficulty in making extrapolations for patchy distributions as in NDUFR, this also removes the bias of estimating distances to groups in order to estimate an effective strip width (e.g. Mitani *et al.*, 2000; Oates, 1996). Long-term empirical study by Mitani *et al.* (2000) notes that a difference between observers of only ten metres in the estimated sighting distance may result in a 20% difference in density estimates. Thus by using groups per distance transect,

more reliable comparisons can be made between different areas surveyed by different observers.

Whatever method of displaying the effective density, the important point is that habitat quality appears to play a major role in the shaping of monkey populations. In the human impacted NDUFR, populations are depleted and socioecology is considerably altered compared to other Udzungwa forests. Furthermore, habitat fragmentation in Udzungwa forests has also undoubtedly restricted the dispersal of several forest species. Long discussion of how to estimate density should not stand in the way of these facts and should be addressed in management plans and future studies (see below).

Testing Observed Trends

The line transect repetitions used above preclude detailed statistical comparison. This is primarily because repeated observations along transects are not independent of one another. In order to make firm conclusions there is however a need for error bars, and quantitative examination of vegetation and forest use data. This and additional data mentioned in the methods that has not been used here, including new dietary records for red colobus, will be explored for subsequent publication. The purpose of this report is however to provide basic details important for management.

Future Studies

- Also needed to completely assess the monkey populations of the reserve are repeated transect walks in other areas of the reserve, especially the forests of Nyumbanitu and Ukami.
- Research into the primary food tree species of the monkeys would also provide valuable clues as to the specific habitat requirements and could assist in establishing priority areas for monkey conservation.
- Tracking of groups to determine size and dynamics is essential to determine the exact social structure of the groups, e.g. are they exhibiting fission-fusion dynamics in the north of Ndundulu? Accurate group counts often however take days (or more) to collect, especially if group members are constantly leaving and rejoining the groups.
- All of the above are of primary importance for the Sanje mangabey and Udzungwa red colobus for which there is still a lot to be learned about ecology and distribution.

7.6.6 Conclusion

Many of the listed factors that may influence monkey socioecology and distribution are of course not mutually exclusive. Thus, as stated, observed patterns are likely to be a complex interplay of several factors. Most relevant for management initiatives however is the apparent effect of habitat quality. Comparison with NDUFR has demonstrated how primarily, habitat degradation can lead to both reduction in density and changes in social organisation. It is imperative therefore that the mostly undisturbed forest of WKSFR is preserved from future harmful activities (see management priorities below).

The lack of records of the Sanje mangabey from the above study suggests that its distribution is highly restricted. From the large size of the forests in which it is known, it appears that this endangered species may be dependent on expansive areas of forest for survival. The ecology of the mangabey is however extremely poorly understood. As discussed, it is unlikely that populations have been wiped out in Ndundulu. It is however possible that the mangabey ranges over large areas and has thus avoided further detection. Groups may even range across the boundary of the Udzungwa Mountains National Park to the east of Ndundulu. Current priorities for ecologists must therefore lie in further study to determine the habitat needs of this species and of the Udzungwa red colobus which is also poorly known.

Management Priorities

- The preservation of the forested areas is vital. In practice, as seen from continued exploitation of NDUFR and several other Tanzanian Forest Reserves, this may however be difficult. With the fast expansion of Udekwa village and plans for a new road to the area, the pressure on the forested areas is also likely to increase. Forest use must be monitored closely to ensure that the current low level of exploitation does not elevate. Furthermore, initiatives to provide an alternative woodland source to channel natural resource use away from the forest should be considered. If forest use should begin to elevate, future inclusion of the reserve into the bounds of the adjacent Udzungwa Mountains National Park should also be considered to safeguard the long-term protection of the area.

- Also of concern is the isolated nature of the Nyumbanitu and Ukami forest fragments. Simple cessation of annual bushfires, which would allow re-colonisation by forest/woodland of the extensive grassland areas, may be sufficient to connect these fragments. Observations of three forest dwelling monkey species in gallery forest extending from the western edge of Nyumbanitu suggests that even the formation of narrow corridors would allow some dispersal. Most importantly, such a connection could potentially open up the forests of Nyumbanitu and Ukami to the Sanje mangabey populations, which are currently limited in WKSFR to Ndundulu forest.

7.7 Bird Observations from West Kilombero Scarp Forest Reserve

Andrew R. Marshall, J. Elmer Topp-Jørgensen, Henry Brink

7.7.1 Summary and Recommendations

The Udzungwa Mountains contain more restricted range birds than any other area in Eastern Arc Mountain Range. The Udzungwa avifauna is therefore a key factor in demonstrating the conservation value of the area.

Between 1991 and 1995 a team of four Danish ornithologists spent 465h in West Kilombero Scarp Forest Reserve observing birds. This coupled with observations made by the Frontier Tanzania research team has allowed us to draw up a reasonably accurate list of species present.

A total of 151 species have been recorded, including one endemic to the Udzungwa Mountains and at least 16 near endemic forest dependent species. Many of these birds are also considered globally threatened, two of which are IUCN endangered: Amani sunbird, *Anthreptes pallidigaster* and Usambara weaver, *Ploceus nicolli*. Seven others are considered IUCN vulnerable: the Udzungwa forest partridge, *Xenoperdix udzungwensis*, dappled mountain-robin, *Modulatrix orostruthus*, Swynnerton's robin, *Swynnertonia swynnertoni*, Iringa ground robin, *Sheppardia lowei*, rufous-winged sunbird, *Nectarinia rufipennis*, banded green sunbird, *Anthreptes rubritorques*, and white-winged apalis, *Apalis chariessa*. These make West Kilombero Scarp Forest Reserve one of the most important centres for species of restricted range and conservation concern, both in the Eastern Arc Mountain chain and in Africa.

This is clearly an area of major importance for Eastern Arc birds, with both high avian diversity and many restricted range species. Each year, these birds draw a small number of visitors, whose enthusiasm and determination suggests that there is scope for tourism.

The forest reserve however remains fragmented and there do not appear to be any forest passages connecting the isolated fragments of Ukami, Nyumbanitu and Ndundulu. This is of particular concern for the forest dependent species that require strictly forested habitats to disperse. The establishment of forested corridors by active management or cessation of fires would significantly improve this situation.

An important consideration is that some threatened birds were observed only rarely within the reserve. The Amani sunbird, banded green sunbird and Usambara weaver were particularly scarce. These same species are also scarce in other fragments of the Udzungwas and thus it is important to conserve all known habitat of these species in the most effective way possible. This should involve close monitoring of forest use and co-operation between management authorities.

7.7.2 Introduction

In terms of restricted range species, the Eastern Arc Mountain chain is one of the three most important bird areas in Africa (ICBP, 1992). Furthermore, within this chain, the Udzungwa Mountains contain the largest area of high altitude natural forest (Fjeldså, 1999). As a result of this and the long-term climatic stability of the Udzungwa forests, there are more restricted range birds than any other site in East Africa (Stattersfield *et al.*, 1998). To emphasise this point, **Table 7.7A**, updated from Stuart *et al.* (1993)[*], lists the number of forest dependent and East Coast Escarpment endemic birds in the Udzungwas in comparison to six other forests in Tanzania and Malawi.

Table 7.7A. Forest dependent bird species richness and endemism in eight forests of the Tanzanian East Coast Escarpment[1]. Updated from Stuart *et al.* (1993) [‡].

Forest area	Number of montane forest species	Number of East Coast Escarpment endemics
East Udzungwa [2]	45	13
Usambara	41	9
Uluguru	41	9
Nguru	31	7
Ukaguru	28	6
Mount Rungwe	35	3
Nyika Plateau (Malawi)	31	2

[1] This includes the Mountains of Eastern Tanzania and Malawi.
[2] This includes all areas of the Udzungwas east of Mufindi, including WKSFR.

The high conservation value of the Udzungwa avifauna has only been recently revealed, but has quickly attracted a lot of attention (Dinesen *et al.*, 2001; Butynski & Ehardt, *in press*; Fjeldså, 1999; Dinesen, 1998; Romdal, 1998; Fjeldså & Rabøl, 1995; Dinesen *et al.*, 1994; Dinesen *et al.*, 1993; Stuart *et al.*, 1993; Jensen & Brøgger-Jensen, 1992). West Kilombero Scarp Forest Reserve (WKSFR) has been particularly well covered by ornithologists (Dinesen *et al.*, 1993; Dinesen *et al.*, 2001; Dinesen, 1998) and has been shown to contain most birds of conservation interest known from the Udzungwas. In all, there are seventeen restricted range forest species known from the reserve (Dinesen, 1998).

Despite several ornithological surveys, complete bird lists have not been published for the reserve.

Aims

- To present a comprehensive bird list for WKSFR, with emphasis on forest dependent and restricted range species.
- To make management suggestions for the conservation of the WKSFR avifauna.

[‡] Stuart *et al*. (1993) list 42 Udzungwa "montane forest species" (defined by forest dependence and restricted altitudinal range). Not included in this are the Udzungwa forest partridge, *Xenoperdix udzungwensis*, Usambara eagle owl, *Bubo vosseleri*, and oriole finch, *Linurgus olivaceus*. The latter two of these are however listed by Stuart *et al*. (1993) as montane forest species. Respectively, Dinesen (1998) and Jensen & Brogger-Jensen (1992) list this species as present in the Udzungwas. Documentation of the partridge had not been made by this time. These 45 species are defined in this report as the "forest dependent" Udzungwa species.

7.7.3 Methods

Bird observations made in WKSFR between 1991 and 1995 by a team of four Danish ornithologists (Messrs. Lars Dinesen, Thomas Lehmberg, J. Otto Svendsen and Louis A. Hansen) are presented. We are very grateful for access to their unpublished information, which comprises 465h of field observation.

Frontier Tanzania researchers also noted records of bird species whenever encountered during the fieldwork period (July to December 1999 and 2000). For two days during July 2000, Mr. David Moyer from the Wildlife Conservation Society (WCS) further assisted with observations, for which we are also grateful.

Taxonomy and common names follow Zimmerman *et al.* (1996). No collections were made and thus all identifications were made from field observations.

7.7.4 Results

151 bird species observations are presented in **Table 7.7B** (forest dependent and restricted range birds) and **Appendix 7.7A** (all other WKSFR bird records). 21 species are of restricted range, including one endemic to the Udzungwa Mountains and 20 endemic to the Eastern Arc Mountains, Tanzanian coastal forests and Malawi ("NE" category – see section 7.1 and **Table 7.7B**). At least 17 of those of restricted range are forest dependent species. 22 birds are CITES listed and nine are considered IUCN globally threatened, two of which are endangered: Amani sunbird, *Anthreptes pallidigaster* and Usambara weaver, *Ploceus nicolli* (Hilton-Taylor, 2000). Seven species are considered IUCN vulnerable: Udzungwa forest partridge, *Xenoperdix udzungwensis*, dappled mountain-robin, *Modulatrix orostruthus*, Swynnerton's robin, *Swynnertonia swynnertoni*, Iringa ground robin, *Sheppardia lowei*, rufous-winged sunbird, *Nectarinia rufipennis*, banded green sunbird, *Anthreptes rubritorques*, and white-winged apalis, *Apalis chariessa*. Moreau's sunbird, *Nectarinia moreaui*, which is IUCN lower risk, may also be present, however the division between this and the more widespread eastern double-collared sunbird, *N. mediocris* is vague (Dinesen, *pers. comm.*; Butynski & Ehardt, *in press*). For this reason, these two species have not been separated here.

Dates and localities of observations from the brief study by David Moyer and observations made by Frontier Tanzania researchers are presented in **Appendices 7.7B** and **7.7C**.

Table 7.7B. List of forest dependent birds and non-forest dependent birds of restricted range (*) for West Kilombero Scarp Forest Reserve. The list refers to birds recorded from all three of Ndundulu, Nyumbanitu and Ukami forests as well as from the area of wooded grassland stretching from Udekwa village and southwards to the Ukami forest fragment. Based on unpublished data collected by Lars Dinesen, Thomas Lehmberg, J. Otto Svendsen and Louis A. Hansen. See foot of table for explanation of codes.

Common name	Genus	Species and subspecies	Endemism†	Conservation status§
FALCONIFORMES				
Mountain buzzard	*Buteo*	*oreophilus*		II
GALLIFORMES				
Udzungwa forest partridge	*Xenoperdix*	*udzungwensis*	[6] NE	VU
COLUMBIFORMES				
Olive pigeon	*Columba*	*arquatrix*		
Lemon (or cinnamon) dove	*Aplopelia*	*larvata*		
CUCULIFORMES				
Barred long-tailed cuckoo	*Cercococcyx*	*montanus*		
TROGONIFORMES				
Bar-tailed trogon	*Apaloderma*	*vittatum*		
PASSERIFORMES				
Moustached green tinkerbird	*Pogoniulus*	*leucomystax*		
Olive woodpecker	*Dendropicos*	*griseocephalus*		
PASSERIFORMES				
Green-throated (mountain) greenbul	*Andropadus*	*chlorigula*	[1,3] NE	
Stripe-cheeked greenbul	*Andropadus*	*milanjensis*		
Shelley's greenbul	*Andropadus*	*masukuensis*		
Placid greenbul (=olive mountain greenbul)	*Phyllastrephus*	*cabanisi placidus*		
African hill babbler	*Pseudoalcippe*	*abyssinica*		
Olive-flanked robin-chat (=olive-flanked ground-robin)	*Cossypha*	*anomala*	[4] NE	
Dappled mountain-robin	*Modulatrix*	*orostruthus*	[2] NE	VU
Spot-throat	*Modulatrix*	*stictigula*	[1,3] NE	

Continued below…

Common name	Genus	Species and subspecies	Endemism[†]	Conservation status[§]
PASSERIFORMES continued				
Swynnerton's robin	*Swynnertonia*	*swynnertoni*	[4] NE	VU
White-starred robin	*Pogonocichla*	*stellata*		
Iringa ground robin	*Sheppardia*	*lowei*	[1,3] NE	VU
Sharpe's akalat	*Sheppardia*	*sharpei*	[1,3] NE	
(Northern) olive thrush	*Turdus*	*olivaceus*		
Orange ground thrush	*Zoothera*	*gurneyi*		
White-chested alethe	*Alethe*	*fuelleborni*	[4] NE	
African dusky flycatcher	*Muscicapa*	*adusta*		
Red-capped forest warbler	*Orthotomus*	*metopias*	[1,3] NE	
Evergreen forest warbler	*Bradypterus*	*lopezi*		
Yellow-throated woodland warbler	*Phylloscopus*	*ruficapillus*		
Black-lored cisticola*	*Cisticola*	*nigriloris*	[1] NE	
Bar-throated apalis	*Apalis*	*thoracica*		
Brown-headed apalis	*Apalis*	*alticola*		
Chapin's apalis	*Apalis*	*chapini*	[1,3] NE	
White-winged apalis	*Apalis*	*chariessa*	[4] NE	VU
White-tailed crested flycatcher	*Trochocercus*	*albonotatus*		
Fülleborn's black boubou	*Laniarius*	*fuelleborni*	[1] NE	
Grey cuckoo-shrike	*Coracina*	*caesia*		
Kenrick's starling	*Poeoptera*	*kenricki*	[5] NE	
Waller's starling	*Onychognathus*	*walleri*		
Amani sunbird*	*Anthreptes*	*pallidigaster*	[5] NE	EN
Banded green sunbird	*Anthreptes*	*rubritorques*	[2] NE	VU
Eastern double-collared sunbird/ Moreau's sunbird [+]	*Nectarinia*	*mediocris/ moreaui*		LR [+]
Rufous-winged sunbird	*Nectarinia*	*rufipennis*	E	VU
Usambara weaver	*Ploceus*	*nicolli*	[2] NE	EN
Red-faced crimsonwing	*Cryptospiza*	*reichenovii*		
(Yellow-browed) streaky seed-eater*	*Serinus*	*striolatus whytii*	[1] NE	
Kipengere seedeater	*Serinus*	*melanochrous*	[1] NE	LR
Oriole finch	*Linurgus*	*olivaceus*		

* Non-forest dependent species.

[†] Endemism defined in Section 7.1: E = endemic to Udzungwa Mountains, NE = near-endemic species including [1] Tanzania-Malawi Mountain endemics (Stattersfield *et al*. 1998), [2] Eastern Arc Endemics (Dinesen, 1998) and [3] East Coast Escarpment endemics (Stuart *et al.*, 1993), [4] Near-endemic to East Coast Escarpment forests (Stuart *et al.*, 1993), [5] Near-endemic to Tanzania-Malawi Mountains (Stattersfield *et al.*, 1998), [6] Endemic to Udzungwa and Rubeho Mountains.

[§] IUCN conservation status as defined by Hilton-Taylor (2000): EN = Endangered species, VU = Vulnerable species, LR = Lower risk. CITES conservation status is listed as appendix I, II or III.

[+] Taxonomy of the eastern double-collared sunbird is complicated (Butynski & Ehardt, *in press*; Jensen & Brøgger Jensen, 1992; Dinesen, *pers. comm.*), hence identification between *C. mediocris* and *C. moreaui* has not been made. *C. moreaui* is considered IUCN Lower Risk (Hilton-Taylor, 2000).

7.7.5 Discussion

There are 45 forest dependent bird species present in the Udzungwa Mountains. 42 of these have been shown by this study to inhabit the West Kilombero Scarp Forest Reserve (this becomes 43 with the inclusion of Moreau's sunbird, *Nectarinia moreaui* – see **Table 7.7B**). Only two forest dependent species known from the Udzungwas are not recorded by this survey. One of these, the Usambara eagle owl, *Bubo vosseleri* has in fact since been recorded from Ndundulu forest (Moyer, *pers. comm.*) and thus can be added to the list. That leaves only one Udzungwa species not known from WKSFR: Mrs. Moreau's warbler, *Bathmocercus winifredae* (Dinesen, 1998). WKSFR is therefore one of the most diverse forest areas in Tanzania (compare **Table 7.7A**).

One additional forest species to those given by Stuart *et al.* (1993) is the Udzungwa forest partridge. Numerous observations of *X. udzungwensis* by ornithologists (e.g. Dinesen *et al.*, 1994; Dinesen *et al.*, 2001), suggest that Luhombero[§] is the major stronghold for the species. This partridge, which is closely related to the Indo-Malayan hill-partridges and hence unique amongst African perdicines, was originally discovered in WKSFR (Dinesen *et al.*, 1994). Encouragingly, it has since been observed within the Udzungwa Mountains National Park (Butynski & Ehardt, *in press*) and has more recently been reported in the Rubeho Mountains. Despite these recent discoveries the partridge is still thought to be in low numbers (Dinesen *et al.*, 2001). Also in especially low numbers are the Amani sunbird, banded green sunbird and Usambara weaver, which were observed on less than ten occasions each over the 465h of field observation (Dinesen, *pers. comm.*).

Along with Mwanihana and Udzungwa Scarp, Dinesen *et al.* (2001) rank WKSFR as being of the highest conservation concern of all Udzungwa Mountain forests and the most important for birds. No other Udzungwa forest has as many globally threatened or endemic bird species. This diversity is at first surprising considering the relatively low altitudinal range in WKSFR compared with other forest reserves such as Udzungwa Scarp (range 300-2050m a.s.l.), which has seven globally threatened species (Dinesen, 1998).

Because of the remarkable avifauna, along with the presence of rare primate and duiker species, and the value of the reserve for water catchment, it has been proposed that the boundary of the Udzungwa Mountains National Park be extended to include WKSFR (Dinesen & Lehmberg, 1996). A move such as this would safeguard this important area and should be seriously considered in conjunction with the current Joint Forest Management (JFM) plans. This could be achieved through close collaboration and co-operation between the JFM and UMNP management authorities (see Frontier Tanzania, 2001b). It is also important that strict monitoring of forest use is carried out to ensure that the current low level of exploitation does not increase.

The survival of forest dependent birds is however dependent on the availability of necessary habitat to disperse (e.g. Newmark, 1991). Many species recorded from WKSFR, including the bar-tailed trogon, square-tailed drongo, Swynnerton's robin and rufous-winged sunbird are particularly sensitive to habitat fragmentation and can be strictly confined to areas of intact forest (Fjeldså, 1999). Forest dependent birds will also be unable to naturally colonise or re-colonise from source populations elsewhere (e.g. Romdal, 1998; Newmark, 1991). This is especially true for the forests of Ukami and Nyumbanitu, which are isolated from the larger Ndundulu forest by fire-maintained grassland.

[§] Luhombero refers to Ndundulu and the adjoining forest within the Udzungwa Mountains National Park (total area around 250km^2; Dinesen, 2001).

7.7.6 Conclusion

Of all the taxonomic groups in West Kilombero Scarp Forest Reserve, birds have received the most attention. This new data serves to further highlight the phenomenal biodiversity of the reserve, both in comparison to other forests in the Eastern Arc. In particular, the 17 species endemic to the Eastern Arc, Tanzania and Malawi emphasise the need for the conservation of this important bird area.

The bird fauna of WKSFR attracts ornithologists from around the world who are prepared to make the long, difficult, journey to the reserve (Frontier-Tanzania, 2001d). The visitor levels are very low, however the enthusiasm and determination of these few to reach the area suggests that there is definitely scope for tourism. The forest reserve however remains fragmented and there appear to be no forest passages connecting the isolated fragments of Ukami, Nyumbanitu and Ndundulu. This is of particular concern for the montane-forest species, which require strictly forested habitats to disperse.

Management and Monitoring Recommendations

- Development of ornithological tourism.
- Encouragement of growth of forest corridors (e.g. by cessation of bushfires).
- Prevention of damaging activities by monitoring and collaboration between management authorities.

See Frontier Tanzania (2001b) for more detail on management.

7.8 Assessment of Reptile Collections from West Kilombero Scarp Forest Reserve

Andrew R. Marshall, J. Elmer Topp-Jørgensen, Henry Brink

7.8.1 Summary and Recommendations

Since short surveys in the 1950s, the herpetofauna of the Udzungwa Mountains has been much neglected. In recent years, three areas of Udzungwa forests have been surveyed although the reptilian inhabitants of several forests remain unstudied and undocumented. Much of the remainder of the Eastern Arc reptiles are also poorly known. In this respect, knowledge of East African reptiles lags behind other areas of the world. By contrast, the reptilian fauna of many countries (e.g. much of Asia, West Africa and America) has been inventoried and is currently undergoing detailed ecological study (Howell, 1993).

The reptiles of West Kilombero Scarp Forest Reserve were surveyed using a combination of bucket-pitfall traps and opportunistic collections. From this, reptiles from seven families were collected including 17 genera and 19 species. The reptile fauna varies considerably between different study sites. This coupled with the heterogeneity of habitats within the reserve, which may also influence faunal diversity, further demonstrates the important contribution to biodiversity of the reserve as a whole. In particular there are nine near endemic species.

The two forest trapsites at the lowest altitudes had the largest number of reptiles. This may be due to restrictions of cooler, high altitude climates on cold-blooded animals. This may also explain the relatively low frequency of reptile records from forest areas (only 19 individuals) compared to lowland Eastern Arc forests sampled using similar methods. Increased walks for opportunistic sampling may however have increased the number of records.

Despite the low number of records, three species are listed which do not appear to be previously recorded for the Udzungwas (*Bitis gabonica*, *Melanoseps uzungwensis* and *Lygodactylus angularis*). Such a high proportion of range extensions emphasises the importance of WKSFR for forest reptiles. Furthermore, three species previously defined as forest dependent were also found over 500m outside of forest habitats in fire-maintained wooded grassland. From both of these observations there is also a clear need for further study in the Udzungwas and equally important, the publication of findings.

Management priorities for reptiles are similar to those for other taxa. Namely, in addition to the preservation of diverse habitats, the forest dependent species may benefit from some means of dispersal. This can be achieved by the prevention of bushfires, which would encourage the formation of forested corridors to connect the Nyumbanitu, Ndundulu and Ukami forest fragments.

7.8.2 Introduction

Amongst all African vertebrates, the herpetofauna is by far the most poorly known (Howell, 1993). Howell (1993) reviews current knowledge and concludes that there is much to be learnt. In particular, the forest reptiles have received very little attention, with the reptilian inhabitants unknown from many of the Eastern Arc forest fragments. Frontier Tanzania surveys in the East Usambara Mountains and Coastal forests have recently begun to provide more information. However, large tracts of forest, including much of the Udzungwa Mountain Range have remained unstudied. In this sense, East African herpetology lies far behind that of other parts of the world including Asia, America and West Africa, where forests have been surveyed and ecological and taxonomic investigations are now taking place (Howell, 1993).

Myers *et al.* (2000) list the Eastern Arc and Coastal Forests of Tanzania as one of the top fifteen areas in the world for reptile endemism. The Eastern Arc has a particularly unique reptilian fauna compared to other African populations. Notably, in the Udzungwa forests there are fourteen forest reptile species out of sixteen (87.5%) that are endemic to the Tanganyika-Nyasa forest block (Howell, 1993). Amongst these are five species endemic to the Udzungwa forests alone. Despite this uniqueness, the Udzungwa forest reptiles have received very little attention since short explorations of the plateaus by Loveridge in the 1930s, 40s and 50s (Howell, 1993). Emmrich (1994) also mentions three references to Udzungwa herpetological survey in the 1980s and 1990s. These limited studies, plus additional collections made by Howell (1993), have recently provided important information on some areas including Mufindi, Kihansi Gorge and Mwanihana forest (Howell, *pers. comm.*).

Current estimates of endemism rank the forests of the Usambara and Uluguru Mountains higher than the Udzungwas (37.5% and 33.3% compared to 31.3% of forest species respectively). This is surprising given that the Udzungwas contain the largest area of montane forest in East Africa (Fjeldså, 1999). Although still poorly known, the Usambaras and Ulugurus have however received more reptilian study than the Udzungwas. Howell (1993) makes the important point that according to Island Biogeography theory, such a large forested area is likely to surpass the level of endemism of other Eastern Arc montane forest blocks. Further explorations are required to ascertain the true level of endemism in the Udzungwas. This study assesses the reptilian fauna of the poorly studied West Kilombero Scarp Forest Reserve (WKSFR).

Aims

- To provide a list of reptiles recorded from WKSFR during the periods of field study and to comment on their value to biodiversity.
- To suggest priorities for management and for future research.

7.8.3 Methods

Reptiles were surveyed using both systematic and opportunistic methods at all selected trapsites (section 7.1). For all collections, habitat details were noted as outlined in the Frontier Tanzania Methods Manual (Frontier Tanzania, 2001g).

Ground-dwelling reptiles were caught using the same arrangement of bucket-pitfall traps used to sample amphibians and small mammals (sections 7.9 and 7.9; Frontier Tanzania, 2001g). These were arranged in three lines of eleven 20*l* buckets. The lines were placed subjectively in the chosen areas to ensure accurate representation of habitat types. Within each line, buckets were spaced five metres apart and were dug into the ground so that the lip of each bucket was flush with ground level. To direct animals into the buckets a 55×1.5m length of clear plastic was fixed upright through the centre of all the buckets on each line. These were fastened in place using sticks tied with string (Frontier Tanzania, 2001g). This apparatus was left in place for a total of eight trapping nights at all trapsites within evergreen forest areas (trapsites 1-10) and four nights at all sites outside of the main forest blocks (trapsites A-D).

Reptiles were collected by hand whenever encountered. To avoid impacting on populations, no more than three specimens of each species were taken. All specimens collected were sent to Dr. Jens Rasmussen at the Zoological Museum, University of Copenhagen and some subsequently to Dr. Don J. Broadley the Zimbabwe Museum of Natural History.

Final verification to species level was only made shortly before completion of this report. All statistical analysis was therefore based solely on early identifications to genus level.

Taxonomy generally follows Howell & Broadley (1991). Where alternative nomenclature was supplied by taxonomists, this has however been used in preference.

7.8.4 Results

Reptile collections and observations are presented in **Table 7.8A**. A minimum of 19 species were recorded from 17 different genera in seven families (40 individuals). Nine species (17 individuals) were recorded from montane evergreen forest. At least ten are forest dependent species as defined by Howell (1993). Nine of these are of restricted range with five species known from only two ranges (*Chamaeleo werneri*, *Cnemaspis uzungwae*, *Buhoma procterae*, *Lygodactylus angularis* and *Melanoseps uzungwensis*; Broadley, 2000a; Broadley & Howell, 1991; Rasmussen, 1995). The latter of these (*M. uzungwensis*) is the first collected specimen since 1929 and represents a range extension of 120km north-east of the Kigogo type locality (Broadley, 2000b). Five other specimens await identification beyond genus level.

The majority of records (83%) are from casual encounters with reptiles, with the remainder found in bucket pitfall traps. Several of the reptile records (16) were made in 1999 during botanical fieldwork. Also apparent from **Table 7.8A** is the high proportion of records from outside of the main evergreen forest fragments (53% of records).

Table 7.8A. Reptile observations and collections made from West Kilombero Scarp Forest Reserve. Initials adjacent to species names indicate confirmed identifications (JR = Dr. Jens Rasmussen; DJB = Dr. Don Broadley; KMH = Prof. Kim Howell). Where identifications have not been verified, taxonomy follows Broadley & Howell (1991). Bold type indicates records from within the evergreen forest fragments.

Identification and code (KMH) numbers	Forest species*	Endemism[#]	CITES [†]	Frequency (in, out)	Habitat [‡]
ATRACTASPIDIDAE					
Atractaspis aterrima [JR]	F	[1] NE	.	1	WG
COLUBRIDAE					
++ *Duberria* (*lutrix*) *shirana* [DJB, JR]	×	.	.	4	WG(2), **M**, **MF**
Lamprophis capensis [JR]	?	.	.	2	WG, **FE**
***Lamprophis fuliginosus* (?)**	O	.	.	1	WG
Natriciteres sp. (?)	?	?	?	1	M
Natriciteres olivacea [JR]	×	.	.	1	RF
***Natriciteres variegata sylvatica* [JR]**	**F**	**[5] NE**	**.**	**1**	**RF**
Philothamnus angolensis [DJB]	×	.	.	1	WG
Philothamnus sp.	**?**	**?**	**?**	**1**	**MF**
+ ***Thelotornis capensis mossambica* [JR]**	×	.	.	2	WG, FE
***Buhoma* (*Geodipsas*) *procterae* [JR]**	**F**	**[4] NE**	**.**	**3**	**MF(3)**
VIPERIDAE					
§§ ***Bitis gabonica* [JR]**	**F** ^	**.**	**.**	**3**	**MF**, FE(2)
GEKKONIDAE					
Lygodactylus angularis [JR]	O	[3] NE	.	3	G(3)
***Cnemaspis uzungwae* [JR]**	**F**	**[6] NE**	**.**	**2**	**MF(2)**
CHAMAELEONIDAE					
§§ ***Chamaeleo werneri* [DJB, KMH, JR]**	**F**	**[1] NE**	**II**	**5**	**MF(4)**, WG
***Bradypodion* sp.**	**?**	**?**	**II**	**1**	**MF**
***Rhampholeon* sp.**	**?**	**?**	**.**	**2**	**MF(2)**
***Bradypodion oxyrhinum* [JR]**	**F**	**[1] NE**	**II**	**1**	**RF**
SCINCIDAE					
+ *Leptosiaphos kilimensis*	F	[1] NE	.	1	WG
***Melanoseps uzungwensis* [DJB]**	**F**	**[2] NE**	**.**	**1**	**MF**
***Mabuya varia varia* [JR]**	**O**	**.**	**.**	**2**	**MF**, G
SCINCIDAE					
+ *Agama* sp.	O	?	?	1	WG

* Forest species codes as given in section 7.1: F = Forest-dependent species as defined by Howell (1993), × = Species found in forest or forest edge as well as other habitats, O = Non-forest species (Broadley & Howell, 1991; Branch, 1998), ? = Insufficient identification to determine habitat preference.

[#] Endemism codes as given in section 7.1: E = Endemic to the Udzungwa Mountains (Howell, 1993), NE ("Near Endemic") = Endemic to the Eastern Arc, Tanzanian coastal forests and Malawi – six categories are used here: [1] NE = Endemic to Uluguru and Udzungwa Mountains (Howell, 1993), [2] NE = Endemic to Udzungwa and West Usambara Mountains (Howell, 1993), [3] NE = Only previously known from Malawi, Zambia and Kilombero valley Tanzania (Broadley, 2000a), [4] NE = Only previously known from Uluguru and Udzungwa Mountains (Rasmussen *et al*., 1995), [5] NE = Only previously known from the Ubena and Rungwe Mountains (Howell, 1993) and Udzungwa Mountains (Rasmussen, *pers. comm.*). [6] NE = Endemic to Udzungwas and one other forest. ? = Insufficient identification to determine endemism.

[†] CITES conservation status listed as appendix I, II, or III.

[‡] Habitat: MF = Montane forest, RF = Riverine forest, WG = Fire-maintained wooded grassland/ bushland outside of forest, FE = Forest edge, M = Marsh/ swamp, G = Grassland clearing within forest ("Luala" valley), PF = Plantation forest. Numbers in brackets indicate the number of specimens found if more than one.

\+ Specimens stolen in December 1999. Identification tentatively determined *in situ* using synoptic keys (Broadley & Howell, 1991). Where there are two symbols this represents two stolen specimens.

[§] Identification made by observation only. Two symbols indicate two individuals observed without collection.

[^] The gaboon viper, *B. gabonica* is widespread but not recorded from Udzungwa by Howell (1993).

To examine distributions, the reptiles recorded from trapsites situated within evergreen forest are presented in **Figure 7.8A**. Most evident from this is the comparatively high number of reptiles found at the most southerly and generally lower altitude sites. Statistical examination of this is difficult given the low numbers involved and the large number of trapsites at mid-range altitudes (trapsites 3 to 8 are all between 1360 and 1550m a.s.l.). Correlation with altitude is not significant for neither the number of individuals nor genera richness (individuals: p=0.201, r^2=0.1953, n=10; genera: p=0.277, r^2=0.1454, n=10). When this group is split by latitude however, there are significantly more individual reptiles from the five most southerly forest sites (trapsites 5, 7, 8, 9, 10) than the five most northerly (trapsites 1, 2, 3, 4, 6) (t-test: $t_{0.05(2),8}$=2.324, p=0.049). The number of genera has a similar trend, although not significant (t-test: $t_{0.05(2),8}$=2.021, p=0.078). There is no significant difference between the frequencies found in the forests of Ndundulu (trapsites 3, 5, 7, 8, 9) versus Nyumbanitu (trapsites 10, 11, 12, 14, 15) (t-test – genera: $t_{0.05(2),8}$=1.291, p=0.233; individuals: $t_{0.05,8-}$=1.606, p=0.147).

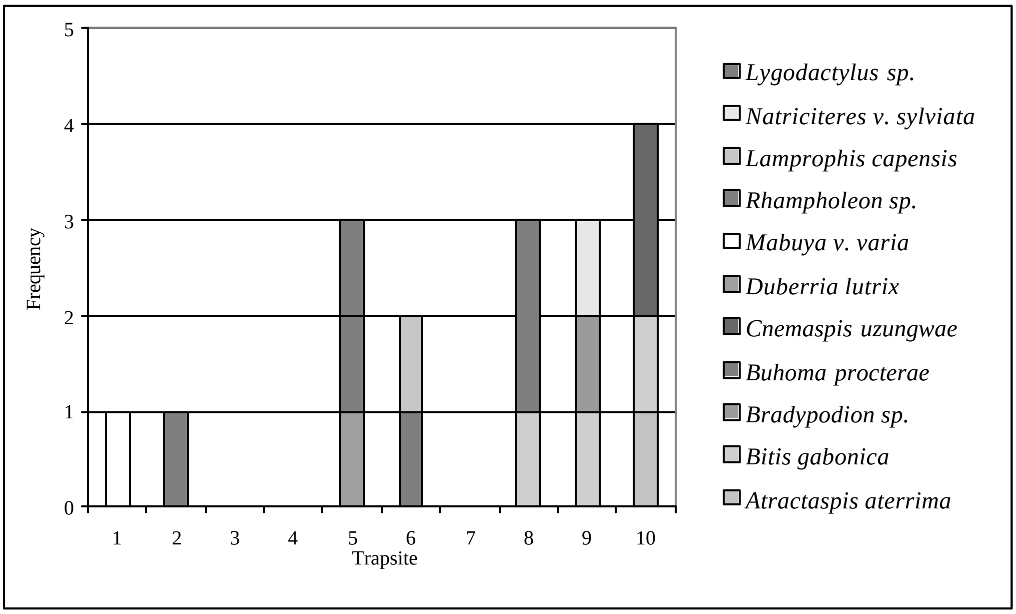


Figure 7.8A. Reptile species recorded from evergreen forest trapsites (June-December 2000). Trapsites 1-5 are in Ndundulu, trapsites 6-9 are in Nyumbanitu and trapsite 10 is in Ukami. See section 7.1 for details of trapsites.

7.8.5 Discussion

From the reptile collections made, 47% are near endemics of restricted range. This high proportion shows the importance of WKSFR for the conservation of reptiles. The number of species recorded in WKSFR is however considerably lower than in other Eastern Arc forests (**Table 7.8B**). Furthermore, only five of the seventeen forest dependent species known from the Udzungwas have been recorded. The full list of these from Howell (1993) is presented in **Appendix 7.8A**. This is most likely due to the high altitude and moist, cool climate, which may be a limiting factor to animals that depend on ectothermy. The relatively high number of reptiles caught at some of the lower altitude trapsites supports this to some extent. Although altitude does not correlate with reptile numbers, trapsites 9 and 10 (the sites with lowest altitude), had the most reptiles. Moreover, the larger snakes (e.g. *B. gabonica*, *T. c. mossambica*) were only ever observed at two of the lower altitude sites (trapsites 8 and 9 in south Nyumbanitu: approximately 1400 and 1140m a.s.l. and trapsite 10 in Ukami: 1145m a.s.l.). New Dabaga/Ulangambi Forest Reserve, in which trapsites were all located above 1800m a.s.l., shows even lower reptilian species richness (**Table 7.8B**).

An important consideration in all comparison of reptile abundance is that **Table 7.8A** is unlikely to be a fully comprehensive list. Additional snakes were seen fleetingly in some areas including one very large snake in the grassland towards the north of the reserve. Previous researchers also report a spitting cobra, *Naja* sp., inside Ndundulu forest (Lehmberg, *pers. comm.*). Records may have been increased with deliberate walks to search for reptiles. Such walks are important for collecting many reptiles, as highlighted by the low number caught from buckets in this study. Large snakes and climbing lizards are particularly well equipped to escape from buckets and some groups, such as the chameleons, rarely even enter them. The number of records from both WKSFR and NDUFR is however surprisingly low considering the long time period spent in the area (nearly one year including the botanical phase of work). Comparison to the lower altitude forests therefore suggests that altitudinal differences are still likely to be having some influence on diversity.

Table 7.8B. Frequency of reptile fauna recorded from Eastern Arc forests. These have been surveyed using similar methods to those employed in this Frontier-Tanzania survey. Summary data from WKSFR along with trapping intensity is included for comparison.

Forest Reserve	Family	Species	No. of trapping days	No. specimens/ trapping days	Source
UDZUNGWA MOUNTAINS					
WKSFR*§	5	12	80	0.2	This study
New Dabaga/Ulangambi*#	2	4	40	0.1	Frontier Tanzania (2001e)
USAMBARA MOUNTAINS					
Mtai+	10	31	80	0.4	Doggart *et al.* (1999b)
Semdoe**	6	16	50	0.3	Doggart *et al.* (2001)
Magoroto+	12	16	-	-	Bayliss *et al.* (1996)
Manga+	9	27	50	0.5	Doggart (1999)
Kwamgumi+	12	27	50	0.5	Doggart *et al.* (1999a)
Segoma**	11	27	50	0.5	Doody *et al.* (2001)

** Lowland forests + Lowland/ Submontane forests § Montane/ Submontane forest # Montane forest
* To make WKSFR and NDUFR figures comparable, only reptiles caught in areas of natural forest are listed.

A similar number of reptiles have been collected from Ndundulu and from Nyumbanitu forests. The species composition of the two forests is however very different, with only one species (*Rhampholeon* sp.) present in both. In fact, even the difference in species composition between trapsites is remarkably great (**Fig. 7.8A**), indicating that different areas of the forest may have environmental conditions suitable for different species.

Over half of the reptiles were found outside of the forest (twenty-one out of forty records – **Table 7.8A**), primarily in the expanse of fire-maintained wooded grassland between the forests. The evergreen forest blocks, due to a combination of high altitude and dense vegetation are cloaked in mist or clouds for much of the year. By comparison, the dry, exposed grassland habitat may be more conducive to reptile living. As would be expected however, most of the forest-dependant species are recorded from the main montane forest fragments. Some observations are however made of forest species over 500m outside of the main forest blocks (**Table 7.8A**: *C. werneri*, *L. kilimensis* and *A. aterrima*). The presence outside of the forest of species categorised as forest dependent emphasises the need for further investigation into the habits of these species. In particular, *A. aterrima* is only known from a few specimens in the Udzungwas (Howell, *pers. comm.*).

Also apparent from **Table 7.8A** are three reptile species found outside of their known range (*B. gabonica*, *M. uzungwensis* and *L. angularis*). Of these, *B. gabonica* (the gaboon viper) is already known from numerous forested areas across southern and eastern Africa (Broadley & Howell, 1991). This lack of knowledge of even the most widespread of forest reptiles, highlights the paucity of study in the Udzungwas. Lack of information has also resulted in none of the above reptiles being assigned IUCN conservation status. Besides chameleons, CITES trade restrictions also afford low protection for Tanzanian reptiles. Using unpublished material, Prof. Kim Howell (UDSM) has formulated protection status levels for most Tanzanian reptiles using IUCN criteria and has estimated that nearly half of the above species are deemed of conservation concern (Howell, *pers. comm.*).

7.8.6 Conclusion

Most apparent from all of the above is the general lack of knowledge of the ecology of forest dwelling reptiles. Primarily, it is unclear whether altitude has influenced the few records made during the course of this study. There is clearly great scope for future reptile projects in the area to ascertain differences from lowland forest fauna and to extend the species list presented here.

Despite only limited collections, the WKSFR area is of importance for forest reptile conservation. Amongst those reptiles listed are several restricted range montane forest species (47% of species) including four limited to only two locations. As with other taxa, true forest species are unable to disperse far from isolated forest fragments and thus populations remain confined. The WKSFR area does however show a high diversity of habitats (e.g. Frontier Tanzania, 2001d) in which both specialised montane reptiles may find a niche as well as lower altitude species including the larger snakes. Although limited data is presented here, it is apparent that the reptilian fauna varies greatly in different parts of the reserve, thus demonstrating the biodiversity importance of all habitats and of the reserve as a whole.

7.9 Amphibians of West Kilombero Scarp Forest Reserve

Henry Brink, J. Elmer Topp-Jørgensen, Andrew R. Marshall

7.9.1 Summary and Recommendations

The amphibian fauna of West Kilombero Scarp Forest Reserve (WKSFR) was sampled using a combination of bucket pitfall trapping and opportunistic collections. Ten sites were sampled within evergreen forest (trapsite 1-10), and four trapsites were placed outside evergreen forest (trapsite A-D). Trapsites within the forest were sampled for eight days, while those outside were for four days. Amphibian communities of WKSFR were surveyed from July to September, and again in November 2000.

A total of 2088 amphibians were caught (includes 18 individuals caught opportunistically during 1999), of which 275 were retained for taxonomic purposes. Species identification is still preliminary. Within this amphibian collection, there are at least six families, ten genera and 14 species*. It is felt that this survey provides a representative sample of the terrestrial amphibian fauna of WKSFR. No amphibians endemic to the Udzungwa Mountains were recorded by this survey. All species listed as forest dependent are limited range species (six species), three of which are restricted to the forests of Eastern Tanzania. The presence of these limited range forest dependent species highlights the conservation importance of WKSFR.

Amphibian diversity varied between trapsites. Four factors were thought to be important in explaining this variation, namely, altitude, precipitation, distance to water and canopy cover. The proximity of water was shown to have a significant influence on the number of species recorded; more species were recorded near water.

Of note was the collection of one individual of the genus *Hoplophryne*, which represents the first record of this genus in the Udzungwas, thereby highlighting the incomplete nature of current knowledge.

The amphibian fauna of limited distribution tends to be forest dependent, and forested areas occupy a minute portion of the Tanzanian landscape (less than 3%) stressing the importance of conserving these forest fragments in Tanzania (as highlighted in Howell, 1993; Schiøtz, 1981). WKSFR possesses some of the largest tracts of primary forest within the Udzungwas and Tanzania, therefore efforts should be concentrated on maintaining and expanding these forested areas.

Just prior to completion of this report additional species determinations were available, this section uses preliminary findings as the basis of its analysis but more recent determinations show that within this amphibian collection, there are at least six families, 12 genera and 20 species. One of the species is endemic to the Udzungwa Mountains. There are a further 10 near endemic species, of which nine are forest dependent. Eight species have an IUCN criteria of vulnerable, while one species is near threatened. Three records are of particular interest:

- The record of *Arthroleptis xenodactylus* represents the first record of the species in the Udzungwa Mountains.
- The record of *Hoplophryne* represents the first record of the genus in the Udzungwa Mountains.
- A species currently being described (*Arthroleptides* sp. nov.) was recorded by this survey of WKSFR.

Up to date figures will be used in the executive summary and management sections.

* Number of species used in the Executive Summary and Management Sections based on Table 7.9F; Frontier Tanzania, 2001f.

7.9.2 Introduction

No single amphibian species is distributed throughout Africa. The distribution of species falls into distinct patterns. The amphibian fauna of tropical Africa can be divided into three types; those of the savanna, bushland and forest (Schiøtz, 1999). The savanna and bushland species tend to be comparatively widely distributed, as the savanna and bushland habitat forms a continuous belt across tropical Africa. Forest species, however, are restricted to two main areas (Schiøtz, 1999). One area is the West African-Central African forest belt, while the other is the small, fragmented forest remnants of Eastern Arc Mountains and coastal forests of Tanzania. Given the minute size of these Eastern Arc forests, their amphibian faunas are surprisingly rich, and most of the forest-dependent amphibian species are all limited in range to this chain of forests (Schiøtz, 1999). The Udzungwa Mountains have the most extensive areas of natural evergreen forest within the Eastern Arc.

Of all the vertebrates, the herpetofauna of the forests of Eastern Africa are among the poorest known and receive the least attention (Howell, 1993). The earliest comprehensive effort to tackle the taxonomy and biology of the amphibia of Eastern Africa were those of Arthur Loveridge. Loveridge (1957) produced a regional checklist in which he summarised taxonomic and distributional findings for the herpetofauna of Eastern Africa. With the exception of the work by Schiøtz (1975 & 1999) on tree frogs, no comprehensive study has been published on any group of amphibians of Eastern African forests since that of Loveridge. Furthermore, it was not until relatively recently (1980s) that field studies were undertaken in the Udzungwa Mountains for amphibians. These studies, based primarily in Mwanihana Forest Reserve (now included in the Udzungwa Mountains National Park) yielded a new species (*Phrynobatrachus uzungwensis*; Grandison & Howell, 1983) and several range extensions of species previously believed to be restricted to the Usambaras/Ulugurus (Howell, 1993). Since then further studies have been carried out on the Udzungwa plateau.

A recurrent theme in much of the literature is the pressing need for further study to expand current knowledge of amphibian ecology, distribution and taxonomy in Eastern Africa (Howell, 1993; Vestergaard, 1994; Schiøtz, 1999). The Udzungwas, compared to other Eastern Arc forests such as the Usambaras and Ulugurus, have been very little studied. This study seeks to add to current knowledge on Udzungwa amphibians.

Aims

- To provide a representative species list of amphibians present in West Kilombero Scarp Forest Reserve (WKSFR).
- To study the distribution of species and individuals within the reserve (i.e. by comparing trapsite data).
- To ascertain what factors may be influencing this distribution.
- To provide recommendations for the conservation of the WKSFR amphibian fauna.

7.9.3 Method

Amphibian communities of WKSFR were sampled from July to September, and again in November 2000. A combination of bucket pitfall trapping and casual collections were used to sample the amphibian communities at ten trapsites within the evergreen forest (i.e. Ndundulu, Nyumbanitu and Ukami forest fragments) and four outside (see Section 7.1).

Bucket Pitfall Trapping
Bucket pitfall trapping (see Frontier Tanzania, 2001g) was used to sample terrestrial vertebrates. Three bucket lines were set up at each trapsite. A bucket line consisted of eleven 20 litre plastic buckets, each of which was sunk into the ground until the rim was level with the ground or slightly below. Buckets were placed at 5m intervals and a single sheet of plastic of 55m length was erected as a 'drift fence,' so that it ran continuously down the centre of the line of buckets. The plastic drift fencing was held perpendicular to the ground by stakes placed at 1m intervals. The bottom of the fence was maintained flush with the ground by piling soil and leaf litter on the bottom 10cm (lip) of plastic sheeting. Two slits were made in the lip above the bucket to prevent animals from using the lip as a bridge. Trapping was carried for eight nights at trapsites within evergreen forest (trapsite 1-10) and for four nights at trapsites outside the forest (trapsite A-D[*]).

Casual Collections
In addition to the above method, amphibians encountered opportunistically were identified, measured and released or collected (depending on certainty of identification). Bucket pitfall trapping principally samples ground dwelling amphibians, the opportunistic collections are therefore important in providing a more representative list of amphibian species present in the reserve (i.e. tree frogs).

Identification
Frontier field staff have preliminarily identified specimens. Special thanks must go to Simon Loader, who proved invaluable in the preliminary identification of species. However, identification of some of the specimens and verification of most of the species collected during the zoological survey period still has to be completed. Specimens collected opportunistically (18 specimens) during the botanical research phase (July to December 1999) have been identified /verified by Prof. JC Poynton (Natural History Museum, London), and are included here. However, analysis of species distribution will be based on the data collected during the zoological study period only. Some of the specimens collected during the zoological period have been identified by Prof. K.M. Howell (University of Dar es Salaam). Nomenclature principally follows Howell (1993), and where species are absent from Howell's list, Schiøtz, (1999) and Vestergaard (1994).

Location of Specimens
Amphibian specimens have been deposited at the Natural History Museum, London. Duplicates have been deposited in the collection of the Department of Zoology and Marine Biology, University of Dar es Salaam.

[*] Trapsite A in miombo woodland; Trapsite B in acacia woodland; Trapsite C in riverine forest/woodland; Trapsite D in grassland.

7.9.4 Results

A total of 2,088 amphibians were caught, of which 275 were retained for taxonomic purposes. Within this amphibian collection, there are at least six families, ten genera and 14 species. These species are listed in **Table 7.9A**. Six of these species are forest dependent, and only found in the forests of Southern Kenya, Tanzania and Northern Malawi. Four of these forest dependants are limited in range to Eastern Tanzania.

Table 7.9A. Amphibian species list for West Kilombero Scarp Forest Reserve.

Identification	Verification	Forest Species#	Endemism*	IUCN Status+	CITES Status~
ARTHROLEPTIDAE					
Arthroleptis reichei	Poynton	F	6NE		
Arthroleptis stenodactylus		×			
Arthroleptis xenodactyloides		×			
BUFONIDAE					
Nectophrynoides viviparus	Poynton	F	3NE	Vu	Appendix I
HYPEROLIIDAE					
Afrixalus sp. P&B		O			
Afrixalus sp.		?	?	?	
Hyperolius puncticulatus	Poynton	×			
Hyperolius sp.		?	?	?	
MICROHYLIDAE					
Callulina kreffti	Howell	F	4NE	Vu	
Probreviceps macrodactylus	Poynton	F	1NE	NT	
Hoplophryne sp.	Clarke¬	F	7NE	En	
RANIDAE					
Arthroleptides martiensseni	Howell	F	5NE	Vu	
Phrynobatrachus sp.		?	?	?	
Rana angolensis	Howell	×			
Strongylopus fasciatus fuelleborni	Howell	×			
SCOLECOMORPHIDAE					
Scolecomorphus sp. *cf. vittatus*	Wilkinson¬	F	2NE		

* Endemism (based on UDSM, 1996; Vestergaard, 1994; Howell, 1993): E = Endemic: occurs only within the Udzungwa Mountains; NE = Near endemic; Eastern Arc, Southern Highlands, and Northern Malawi. 1NE = Udzungwa, Usambara, Rungwe, Uluguru; 2NE = Udzungwa Uluguru, Usambara; 3NE = Udzungwa, Ukinga, Poroto, Rungwe, Uluguru; 4NE = Usambara, Nguru, Uluguru, Udzungwa, Taita Hills (Kenya); 5NE = Udzungwa, Uluguru, Magoroto, Usambara; 6NE = Uluguru, Udzungwa, Poroto, Rungwe, Misuku Hills (Malawi); 7NE = Ulugurus, Usambara, Magrotto. Unless stated localities are in Tanzania.

Forest Species (based on Schiøtz, 1999; Vestergaard, 1994; Howell, 1993): F = Forest dependent, restricted to forested areas only; × = Forest dwelling (including forest margin) but not forest dependent i.e. the species occur in forested areas as well as other vegetation types; O = Non-forest species. These species do not occur within forests.

\+ IUCN status compiled from National Biodiversity Database (UDSM, 1996) using IUCN criteria: En = Endangered; Vu = Vulnerable; NT = Near threatened.

~ CITES Status (Convention on International Trade of Endangered Species): Appendix I = No trade allowed.

¬ Clarke & Wilkinson: Last minute identification by BT Clarke & M Wilkinson (Natural History Museum, London).

A further 12 forest dependent species have been recorded from the Udzungwas, but were not recorded by this survey of WKSFR. It should be noted that some of these species are only known from a few localities within the Udzungwas (e.g. *Phylictimantis keithae*). These species are listed in **Table 7.9B**.

Table 7.9B. Forest dependent amphibians recorded in the Udzungwa Mountains previously (data from Howell, 1993).

*Arthroleptis affinis**	*Leptopelis barbouri**
*Bufo brauni**	*Leptopelis uluguruensis**
Nectophrynoides asperginis^{E+}	*Phylictimantis keithae* ^{E}
*Nectophrynoides tornieri**	*Spelaeophryne methneri**
Nectophrynoides wendyae^{E}	*Phrynobatrachus uzungwensis**
*Afrixalus ulugurensis**	*Scolecomorphus kirkii*
Hyperolius mitchelli	

* = Distribution restricted to Tanzania. *E* = Endemic to the Udzungwa Mountains.
$^{E+}$ = Endemic to the Udzungwas, only known from Kihansi Gorge (Poynton *et al*., 1998).

Figure 7.9A is a species accumulation curve by trapsite. The trapsites are randomly ordered, and do not include the trapsites outside the forest. The curve shows a gradual increase in the number of species by trapsite. The curve does appear to be levelling off, although an asymptote has not been reached.

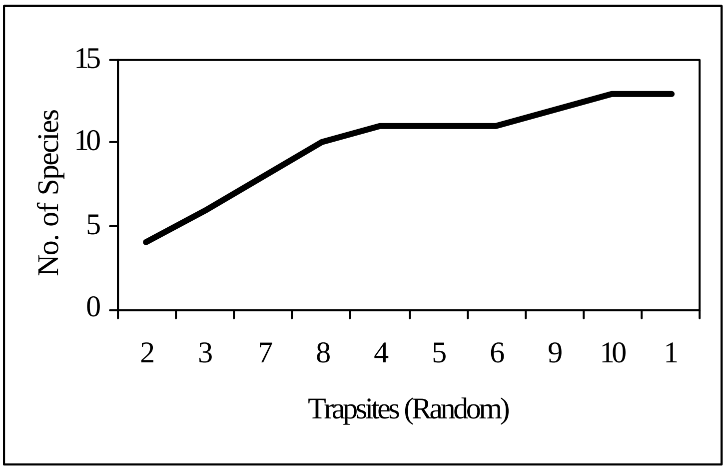


Figure 7.9A. Species accumulation curve.

Amphibian Distribution by Trapsite

The distribution of amphibians in terms of both numbers and species caught was not uniform across the reserve. Furthermore, the distribution of limited range (endemic and near-endemic) species also varied between trapsites. The mean number of individuals caught at each trapsite is 148 (does not account for differences in sampling intensity between forest and non-forest trapsites). As seen from **Table 7.9C**, the number of individuals caught was well below 148 at all trapsites besides trapsite 8. 1558 individuals were caught at trapsite 8, which accounted for 75% of all individuals caught at WKSFR. The mean number of individuals caught, with the omission trapsite 8, is 39. The mean number of species caught at each trapsite is four, with an average of one limited range species at each trapsite. No amphibians were caught at trapsite A, and few individuals were caught at trapsite 7. However, trapsite 7 had the joint highest number of species and limited range species.

Table 7.9C. Amphibians in relation to trapsites. Evergreen forest sampled for eight days, non-evergreen for four days.

Trapsite	Number caught	Number of families	Number of genera	Number of species	Limited range species
Non-evergreen forest					
A	-	-	-	-	-
B*	38	2	2	2	-
C+	13	2	2	2	-
D+	33	4	4	4	-
Evergreen forest					
1	41	3	3	4	2
2	39	4	4	4	1
3+	109	2	2	3	1
4+	38	3	3	5	1
5+	80	4	4	5	2
6+	57	3	5	5	-
7+	9	6	6	7	3
8*+	1556	4	5	6	3
9+	25	2	2	2	1
10*+	32	4	6	7	3
Total7	2070	6	10	14	7

+ Indicates water association (<50m to water) * Sampled after onset of the short rains (13 Nov. 2000)
Note; 18 individuals caught during 1999, not included in the above table.

Table 7.9D highlights the distribution of genera by trapsite, as not all individuals were identified to species level.

Table 7.9D. Species distribution by trapsite.

	Trapsites within forest										Trapsites outside				
Genera#	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**A**	**B**	**C**	**D**	**Total**
Afr/Hyp		1		4		6	2					1	1	3	18
Art									1						1
Arth	9	5	100	30	59	46	2	1543	24	16		37	11	3	1885
Call								3							3
Hopl										1					
Nect	18	33		3			2							7	63
Prob	9		4		20		1	6		7					47
Phryn						4		1		3					8
Rana						1	1			2					4
Scol					1		1	3		3					8
Stro														20	20
Unknown	5		5	1									1		13

Genera: *Afr/Hyp = Afrixalus/Hyperolius; Art = Arthroleptides; Arth = Arthroleptis; Call = Callulina; Hopl = Hoplophryne; Nect = Nectophrynoides; Prob = Probreviceps; Phryn = Phrynobatrachus; Scol = Scolecomorphus; Stro = Strongylopus.*

Arthroleptis accounted for 91% of all amphibians caught, and was present at all trapsites except trapsite A. The genus was present in extremely high numbers at Trapsite 8. As seen in **Figure 7.9B**, this marked increase in individuals of the genus *Arthroleptis* corresponded to the start of the short rains, which began on the evening of the 13th November. The short rains continued until the end of the survey period in December. Trapsite 10 and B were also surveyed during the short rains, however numbers recorded at both trapsites were much lower than at trapsite 8. Other trapsites that were surveyed during periods of sporadic showers were 3, 4, 5, and 7.

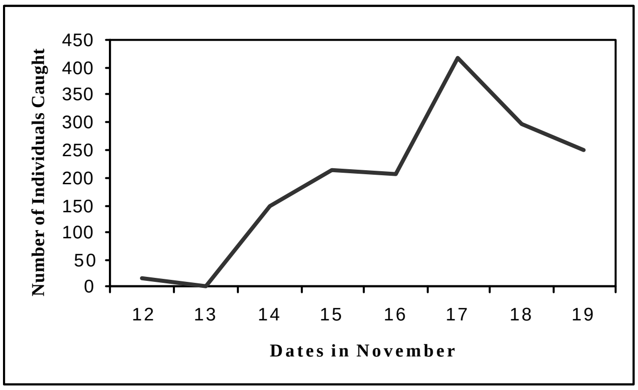


Figure 7.9B. Number of *Arthroleptis* recorded at trapsite 8 over time. Rain began on evening of the 13th.

As seen from **Table 7.9D**, *Arthroleptis* was the genus caught most often at all trapsites, except 1, 2, 7, and D. At trapsite 1 and 2, *Nectophrynoides** accounted for the most individuals. Trapsite 1 and 2 were both located above 1900m a.s.l., and surveyed in July 2000. At trapsite 7, two individuals of each of the following genera were caught; *Nectophrynoides*, *Arthroleptis* and *Hyperolius*. Trapsite 7 was characterised by very few individuals of all genera being caught. At trapsite D, *Strongylopus*# was the most frequently caught genus. Trapsite D was located at 1890m a.s.l., and placed in an open grassland habitat near a stream with marshy areas.

Altitude

The number of individuals of each species was tested for correlation with altitude. Due to the difference in trap days, data from trapsites within the forest was limited to the first four days. None of the associations were significant, except that of *Nectophrynoides viviparus* which had a significant positive correlation between number of individuals recorded and altitude (Pearson correlation: $r^2 = 0.453$, $n = 14$, $p = 0.008$), as highlighted in **Figure 7.9C**. The number of species recorded at each trapsite was also tested for a correlation with altitude. However, no significant correlation was noted.

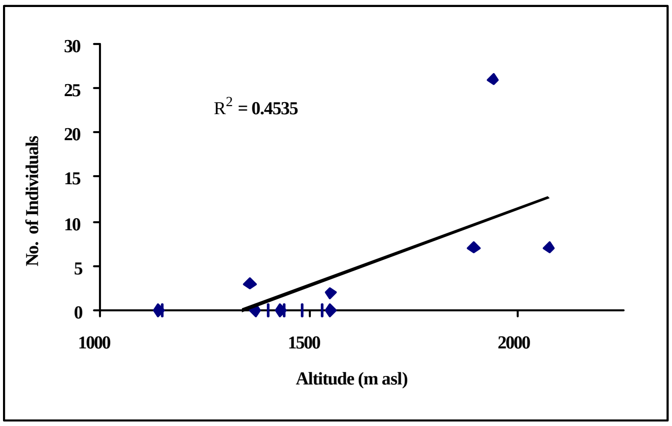


Figure 7.9C. Distribution of *Nectophrynoides viviparus* in relation to altitude.

* All *Nectophrynoides* identified to date are of the species *viviparus*.
# All *Strongylopus* identified to date are of the species *fasciatus fuelleborni*.

Water Association

Rana, Strongylopus, and *Phrynobatrachus* showed a strong association with water. All *Rana* individuals were recorded within 50m of water, while 80% of *Strongylopus* individuals were caught within 30m of water and 88% of *Phrynobatrachus* individuals were recorded within 2m of water. Trapsites within 50m of water were grouped (trapsites 3, 4, 5, 6, 7, 8, 9, 10, C, D), and independent samples *t*-test was used to test whether the number of species was significantly different from trapsites without any water association (trapsite 1, 2, A, B). For trapsites within evergreen forest, data was only used from the first four days of trapping. A significantly lower number of species were recorded at trapsites without any water association, than trapsites with streams and marshes nearby (*t*-test: $t_{0.05(2)12} = -2.76$, $p = 0.017$).

Canopy Cover

The following species were only recorded within forested areas; *Rana angolensis, Arthroleptides martiensseni, Phrynobatrachus* sp., *Callulina kreffti, Probreviceps macrodactylus*, and *Scolecomorphus kirkii*. Conversely, *Strongylopus f. fuelleborni* was only recorded from a grassland area. *Afrixalus, Hyperolius, Arthroleptis* and *Nectophrynoides viviparus* were recorded both outside and within forested areas. A total of at least ten genera were recorded from within evergreen forest, while at least five genera were recorded from non-forest trapsites. Canopy cover was used to group trapsites (less than 50% and more than 50% canopy cover). Independent samples *t*-test was then used to test whether the number of species was significantly different between the two groups. Again, data for trapsites within the forest blocks was limited to the first four days. No significant difference was noted in species richness between trapsites with over 50% canopy cover and trapsites with less than 50% canopy cover (*t*-test: $t_{0.05(2)12} = -1.445$, $p = 0.174$).

Precipitation

A marked increase in the abundance of individuals, particularly within the genus *Arthroleptis*, was noted during the heavy rains of November (e.g. trapsite 8), and a slight increase in the number of individuals during the drizzles of early August (e.g. trapsite 3 and 5). Trapsites were grouped into those where no rain was recorded (trapsites 1, 2, 6, 9, A, C, D) and those where rain fell (trapsites 3, 4, 5, 7, 8, 10, B), and *t*-test was used to test whether the number of individuals and species recorded within the two groups were the same (evergreen forest data limited to the first four days). More species were recorded during periods of rain than during dry periods, however, the results were marginally not significant (*t*-test $_{0.05(2)12}$ $t = -1.961$, $p = 0.073$). More individuals were noted during wet periods, however, the results were not significant (*t*-test $_{0.05(2)12}$ $t = -1.226$, $P = 0.244$).

7.9.5 Discussion

Very few of the forest dependent amphibians found in the eastern forests of Africa are found elsewhere (Howell, 1993; Schiøtz, 1981). Speciation in this group has been rapid enough and the means of dispersion limited enough to lead to this high level of taxonomic isolation. The Udzungwa Mountains have large areas of evergreen forest suitable for these forest dependent amphibians. Amphibian diversity in WKSFR differed from trapsite to trapsite. Various factors were thought to be important in influencing the distribution of the amphibian species recorded by this survey. These varied from the proximity of water bodies to the way data was collected.

Data Collection and Analysis

The method employed in surveying amphibians in WKSFR was a combination of bucket pitfall trapping and opportunistic collections. As mentioned previously, bucket pitfall trapping principally samples ground dwelling amphibians. To compliment this, opportunistic collections of arboreal amphibians were carried out. As is apparent from the results, the vast majority of amphibians recorded were caught in buckets (98% of all amphibians recorded by the survey during July to December 2000 were caught in buckets). Therefore, it is felt that the results of this survey are biased towards terrestrial amphibians.

Trapping success varied markedly between trapsites. The placement of buckets is critical to sampling success. Trapsites were placed in such a way as to sample a diversity habitats (see Section 7), within which bucket lines were placed to sample a diversity of microhabitats. Topography, canopy cover and distance to water association varied between the bucket lines and individual buckets. For example, at trapsite 7, no amphibians were caught at bucket line A, while a third of the individuals recorded at the trapsite were caught at bucket line C (a third caught opportunistically). Bucket line A was placed along a ridge with no water association, while bucket line C was placed in valley within close proximity to a stream. Furthermore, the lowest number of individuals and the highest number of species were recorded at trapsite 7. Trapsites and bucket lines were placed to sample a maximum diversity of habitats and therefore species, and not to record a maximum number of individuals.

A variety of tests have been carried out to describe the variation in amphibian diversity recorded at the different trapsites. When considering the results of these tests it is important to consider two points, this survey was not set up with these tests in mind and the small sample size (i.e. 14 trapsites) means that the tests are highly susceptible to individual trapsite variation. Therefore, the test results should be viewed cautiously.

Amphibian Diversity

Amphibian diversity is sensitive to a number of environmental characteristics. Species composition and/or species richness of tropical amphibian communities change over gradients in precipitation, soil moisture, altitude, forest type and forest structure (Pearman, 1997). Within this survey of WKSFR, species richness was tested for relationships with altitude, distance to water association, canopy cover, and precipitation. Species richness did not significantly vary with altitude or canopy cover. However, more species were noted during periods of precipitation (although not significant; t-test $_{0.05(2)12}$ $t = -1.961$, $p = 0.073$). This is thought to be due to an increase in amphibian activity during periods of rains (e.g. due to burrows flooding), which resulted in more species being recorded. Furthermore a marked increase in the number of individuals was noted after onset of rain (e.g. trapsite 8; **Figure 7.9B**). A significant increase in the number of species was noted at trapsites near water.

ARTHROLEPTIDAE

Three species, all of the genus *Arthroleptis*, were identified. The genus is exclusively terrestrial and breeds away from water (Passmore & Carruthers, 1995). The habitat of the genus is the leaf litter of wooded areas. The degree of dependency on forest cover varies between the species (see **Table 7.9A**). *A. reichei* is forest dependent, while *A. stenodactylus* and *A. xenodactyloides* may be found in open wooded areas or forested areas.

Discussion will be limited to the genus level as not all recorded individuals within this family were identified to the species level. The genus *Arthroleptis* was recorded at all trapsites within the forest blocks, and three outside. The genus was well represented in this survey, accounting for 91% of all individuals caught. *Arthroleptis*' strictly terrestrial behaviour was thought to explain its high representation in this survey. The number of *Arthroleptis* individuals recorded was seen to increase during periods of rain, as noted at trapsite 8 (see **Figure 7.9B**). At trapsite 8, 1545 *Arthroleptis* individuals were caught (82% of all individuals of this genus). *Arthroleptis* lay eggs enclosed in a stiff jelly in nests among decaying vegetation (e.g. leaf litter), froglets emerge from the capsules about four weeks after laying (Wagner, 1965). There is no free-living aquatic larval stage. Passmore & Carruthers (1995) note that emergence from water habitats is sometimes synchronised within populations, resulting in an *en masse* exodus of many individuals, which may allow a few to escape under the cover of those captured by predators. It is hypothesised that this *en masse* emergence may have occurred in the terrestrial habitat of trapsite 8 (as 95% of the snout-vent measurements were well below 20mm). This emergence may have been triggered/aided by the start of the short rainy season.

BUFONIDAE

One species, *Nectophrynoides viviparus*, was recorded from this family in WKSFR. The genus has developed ovoviviparity, thereby negating the need for permanent water for successful reproduction. The genus is restricted to areas above 400m (Poynton *et al.*, 1998). This survey of WKSFR recorded a significant increase in the number of *N. viviparus* with altitude (from 1140m to 2070m a.s.l.). This increase is thought to be related to habitat structure. *N. viviparus* was predominantly recorded amongst the leaf litter on the forest floor, however, a few individuals were observed climbing in low shrubs (up to 1.5m). An abundance of *N. viviparus* was noted in *Hagenia abyssinica* dominated montane forest and bamboo thickets in Ndundulu. Both these habitats tend to be restricted to altitudes above 1500m (Lovett, 1993). The *H. abyssinica* forest, with dense ground vegetation to a height of 1m, affords *N. viviparus* hiding places, as does the dense basal arrangements of bamboo plants. Seven individuals were also recorded from an upland grassland area (1890m a.s.l.) in Ndundulu (trapsite D). This upland grassland area was typified by areas of very short grass and areas with dense 1m high ground vegetation (i.e. sedges and bracken). Stewart & Plough (1983) highlighted the importance of retreat sites for tropical forest frog populations. This survey of WKSFR suggests that it is the presence of these hiding areas/retreat sites (i.e. dense vegetation to 1m), that is important for *N. viviparus* distribution. The record of *N. viviparus* in an open grassland habitat (trapsite D) suggests that the species may not be as forest dependent as previously thought, although it should be noted that the individuals were caught within close proximity of the forest edge (ranging from 75-150m from forest edge).

HYPEROLIIDAE

Two species have been identified from this family of tree frogs, neither of which is forest dependent. However, of the 18 individuals of this family collected, only six have been identified to species level. The family is under-represented in this survey due to their limited terrestrial habit, as highlighted in the fact that only eight individuals were caught in buckets. The genera *Hyperolius* and *Afrixalus* occur within close proximity to water (Passmore &

Carruthers, 1995). Of those individuals identified as *Hyperolius* or *Afrixalus* in WKSFR, 61% were collected near water. Also of note is the absence of the genus *Leptopelis* from this survey of WKSFR, which was recorded in Frontier's survey of New Dabaga/Ulangambi Forest Reserve (Frontier Tanzania, 2001e).

MICROHYLIDAE

Three different Microhylids were identified from WKSFR, two to species level. The two identified species, *Callulina kreffti* and *Probreviceps macrodactylus*, are forest dependent. In WKSFR, the two species were only recorded at trapsites within evergreen forest. *C. kreffti* was only recorded from one trapsite; all individuals were caught in buckets on the same day following a heavy storm. *C. kreffti* is a dextrous tree climber, which may explain its low representation in this survey. *P. macrodactylus* was present at 6 trapsites within evergreen forest. The species is terrestrial, hiding under rocks and logs during the day, and therefore was well recorded by this survey (47 individuals caught).

The third Microhylid has been identified as *Hoplophryne* sp., and was caught in a bucket pitfall trap. To date the genus is only known from the Usambaras, Magrotto and Ulugurus. Only one individual of this genus was collected at trapsite 10 in the Ukami forest block. The individual was collected at an altitude of 1120m a.s.l. in submontane forest (grid ref: 7° 53' 19.5" S; 36° 23' 11.6" E).

RANIDAE

Four genera of this family were recorded in WKSFR, three of which were identified to species level. All genera are found close to water (Passmore & Carruthers, 1995; Vestergaard, 1994). *Arthroleptides martiensseni* was collected clinging to a rock (80cm above ground) by a waterfall. Similarly, *Phrynobatrachus* sp., *Rana angolensis*, and *Strongylopus fasciatus fuelleborni* were strongly associated with water in their distribution within WKSFR.

SCOLECOMORPHIDAE

Scolecomorphus vittatus was recorded at four trapsites within evergreen forest. It was not recorded outside the forest. *Scolecomorphus* is a leaf litter dweller, which is thought to inhabit burrows (Nussbaum, 1985). During periods of heavy rain, more individuals were collected. This was thought to be as a result of its burrows flooding, and individuals being driven to the surface.

The Importance of Forests; Forest Dependency and Endemism

No amphibians endemic to the Udzungwa Mountains were recorded by this survey of WKSFR. However, it is striking that all seven of the species listed as forest dependent (see **Table 7.9A**) are limited range species. Four of these are restricted to the forests of Eastern Tanzania. Animals that are strictly forest dependent, will not survive outside forested areas. Physiological limitations are thought to be important in defining forest dependence in amphibians. These limitations include the amphibians' moist, permeable skin and the susceptibility of amphibian eggs to desiccation. Amphibians that are non-forest dependent have developed ways to counter these physiological limitations. These developments include burrowing (as in *Breviceps*) and living in or near water bodies (as in *Strongylopus*) to avoid desiccation in open habitats. Similarly, eggs laid in aquatic habitats reduce the risk of desiccation.

This survey of WKSFR has recorded one species previously described as forest dependent in open situations (*Nectophrynoides viviparus* in grassland), although it should be noted that these records were within 150m of the forest edge. The record of a forest dependent species outside the forest and the first record of the genus *Hoplophryne* in the Udzungwas, highlights the incomplete nature of current knowledge.

The amphibian fauna of limited distribution tends to be forest dependent and forested areas occupy a minute portion of the Tanzanian landscape (less than 3%; Rodgers, 1993), hence stressing the importance of conserving these forest fragments (as highlighted in Howell, 1993; Schiøtz, 1981).

The Eastern Arc, a Comparison

Comparing the diversities and endemism of Eastern Arc amphibians based on current data, the greatest diversity and endemism are found in the Usambaras and the Ulugurus, with numbers of species and endemics decreasing on moving south towards the Udzungwas (Howell, 1993). However, it should be borne in mind that the Udzungwas represent the largest mountainous forested area in Tanzania and until the early 1980s was virtually unstudied biologically. The Udzungwas lag considerably behind the Ulugurus and Usambaras in terms of research. There is, however, every reason to believe that further work will reveal more species in common with the northerly mountains of the Eastern Arc as well as others endemic to the Udzungwas (Vestergaard, 1994; Howell, 1993). A comparison of similar surveys carried out by Frontier Tanzania in Usambaras and Udzungwas is presented in **Table 7.9E**.

Table 7.9E. Comparison of amphibian species richness between Forest Reserves surveyed by Frontier Tanzania

Forest Reserve and location	Reference	Number of families	Number of species
West Kilombero Scarp Forest Reserve; Udzungwa Mts.	This Study	6	14
New Dabaga/Ulangambi Forest Reserve*; Udzungwa Mts.	Frontier Tanzania (2001e)	4	14
Semdoe Forest Reserve; Usambara Mts.	Doggart *et al*. (2001)	6	11
Magoroto Forest Reserve; Usambara Mts.	Bayliss *et al*. (1996)	7	29
Mtai Forest Reserve; Usambara Mts.	Doggart *et al* .(1999a)	7	27
Manga Forest Reserve; Usambara Mts.	Doggart *et al* .(1999b)	8	22

* New Dabaga/Ulangambi Forest Reserve includes species from trapsites placed outside the reserve (less than 1km from reserve). However, for convenience this area will be referred to as New Dabaga/Ulangambi Forest Reserve (NDUFR) in this section. Within the reserve, only seven species were recorded.

From the above table, it would appear that the Usambaras are more species rich than the Udzungwas. However, it should be noted that not all the Udzungwa specimens collected in 2000 have been identified to species level, and the majority of specimens still have to have preliminary identifications verified.

Comparison of species numbers between WKSFR and New Dabaga/Ulangambi Forest Reserve (NDUFR) reveals similar numbers of species recorded at both areas, and five species being recorded in both reserves. These overlapping species include; *A. stenodactylus, A. xenodactylus*, *N. viviparus*, *R. angolensis* and *S. f. fuelleborni.* However, in terms of forest dependent species, four more forest dependent species were recorded at WKSFR than NDUFR. Furthermore, four genera recorded at NDUFR were not recorded at WKSFR, while six WKSFR genera were not recorded at NDUFR. The comparison highlights that there are some similarities between the WKSFR and NDUFR amphibian populations, yet at the same time the differences stress the conservation value of the individual areas.

Management Recommendations

In terms of amphibian diversity, this section makes the following recommendations:

- The greatest threat to amphibian diversity is the loss of habitat. This is particularly true of amphibians adapted/dependent on the moist forest interiors, as forested areas are isolated and very limited in distribution. The Udzungwas form the largest area of mountainous forest in the Eastern Arc, within which WKSFR possesses large areas of evergreen forest. To benefit amphibian biodiversity, management efforts should seek to maintain/expand these forest habitats (for forest dependent species), whilst maintaining a mosaic of wetland/riverine habitats (for amphibian diversity in general).
- To increase the biodiversity value of the area a system of forested corridors connecting the various forest fragments should be investigated. This would allow the mixing of forest dependent populations, and make the populations in specific forest fragments less susceptible to detrimental habitat change (as discussed in Section 9; Frontier Tanzania, 2001b).
- The Udzungwa Mountains have been virtually ignored in terms of amphibian research, although this is gradually changing. Further research is needed into the distribution, ecology and habitat requirements of the Udzungwa amphibian species, so that better informed decisions can be made for their conservation.

7.9.6 Conclusion

This survey of WKSFR identified amphibians from at least six families, ten genera and 14 species. From the species accumulation curve, the number of new species encountered per trapsite was seen to increase gradually. The curve seems to be levelling off. It is thought that this survey has provided a representative sample of the reserve's ground dwelling amphibians (at least nine species recorded). However, it is felt that this survey has not provided a representative sample of arboreal or scansorial amphibians, as is highlighted in the low numbers of these species recorded and the absence of expected genera (e.g. *Leptopelis*).

The distribution of individuals and species varied within the reserve. This variation in species and individuals was thought to be influenced by altitude, canopy cover, distance to water, and precipitation. The proximity of water was shown to have a significant influence on species numbers; more species were recorded near water.

The first record of the genus *Hoplophryne* in the Udzungwas highlights the incomplete nature of current knowledge.

Seven amphibian species recorded by this survey were forest dependent, and all were limited in range to forested areas of Eastern Africa. These forested areas account for a minute proportion of the Eastern African landscape. Thereby highlighting the importance of maintaining the reserve's forested areas.

7.9.7 Additional Identifications of Amphibians

Eight new species identifications were received shortly before the deadline for this report. Presented in **Table 7.9F** is the most up to date list of amphibian species recorded in West Kilombero Scarp Forest Reserve (WKSFR). Species identifications that have not as yet been verified by taxonomists are not included on this list. We gratefully acknowledge the effort involved in identifying these specimens so quickly. These identifications should be viewed as preliminary subject to a more comprehensive study (Poynton, *pers. comm.*). It should also be noted that 158 specimens have yet to be looked at by taxonomists.

Table 7.9F. Amphibian species list for West Kilombero Scarp Forest Reserve

Identification	Verification¬	Forest species#	Endemism*	IUCN status+
ARTHROLEPTIDAE				
Arthroleptis affinis	Poynton^	F	8NE	Vu
Arthroleptis reichei	Poynton	F	6NE	
Arthroleptis stenodactylus	Poynton	×		
Arthroleptis xenodactyloides	Poynton	×		
Arthroleptis xenodactylus	Poynton^	F	9NE	Vu
BUFONIDAE				
Nectophrynoides viviparus	Poynton	F	3NE	Vu
HYPEROLIIDAE				
Afrixalus morerei	Poynton^	O	E	Vu
Hyperolius kivuensis	Poynton^	O		
Hyperolius puncticulatus	Poynton	×		
Hyperolius pictus	Poynton^	O	10NE	
MICROHYLIDAE				
Callulina kreffti	Howell	F	4NE	Vu
Probreviceps macrodactylus	Poynton	F	1NE	NT
Hoplophryne sp. cf. *ulugurensis*	Poynton^	F	7NE	Vu
RANIDAE				
Arthroleptides martiensseni	Howell	F	5NE	Vu
Arthroleptides sp. nov.	Poynton^			
Phrynobatrachus parvulus	Poynton^			
Phrynobatrachus rungwensis	Poynton^			
Rana angolensis	Howell	×		
Strongylopus fasciatus fuelleborni	Howell	×		
SCOLECOMORPHIDAE				
Scolecomorphus sp. *cf. vittatus*	Wilkinson	F	2NE	Vu

¬Verification; Prof. JC Poynton (Natural History Museum, London), Prof. KM Howell (University of Dar es Salaam), Dr. M. Wilkinson (Natural History Museum, London). ^ = Recent identification.

#Forest Species (based on Schiøtz, 1999; Vestergaard, 1994; Howell, 1993): F = Forest dependent, restricted to forested areas only; × = Forest dwelling (including forest margin) but not forest dependent, i.e. the species occur in forested areas as well as other vegetation types; O = Non-forest species. These species do not occur within forests.

*Endemism (based on UDSM, 1996; Vestergaard, 1994; Howell, 1993): E = Endemic: occurs only within the Udzungwa Mountains; NE = Near endemic; Eastern Arc, Tanzania, and Northern Malawi. 1NE = Udzungwa, Usambara, Rungwe, Uluguru; 2NE = Udzungwa, Usambara, Uluguru; 3NE = Udzungwa, Ukinga, Poroto, Rungwe, Uluguru; 4NE = Usambara, Nguru, Uluguru, Udzungwa, Taita Hills (Kenya); 5NE = Udzungwa, Uluguru, Magrotto, Usambara; 6NE = Uluguru, Udzungwa, Poroto, Rungwe, Misuku Hills (Malawi); 7NE = Ulugurus, Usambara, Magrotto; 8NE = Udzungwa and Usambaras; 9NE = Usambaras and Udzungwa; 10NE = Udzungwa, Southern Highlands and Northern Malawi. Unless stated localities are in Tanzania.

+IUCN status compiled from National Biodiversity Database (UDSM, 1996) using IUCN criteria: En = Endangered; Vu = Vulnerable; NT = Near threatened.

A total of 2,088 amphibians were caught, of which 275 were retained for taxonomic purposes. Within this amphibian collection, there are at least six families, 12 genera and 20 species. One of the species is endemic to the Udzungwa Mountains. There are a further 10 near endemic species, of which nine are forest dependent. Eight species have an IUCN criteria of vulnerable, while one species is near threatened. Three records are of particular interest:

- The record of *Arthroleptis xenodactylus* represents the first record of the species in the Udzungwa Mountains.
- The record of *Hoplophryne* represents the first record of the genus in the Udzungwa Mountains.
- A species currently being described (*Arthroleptides* sp. nov.) was recorded by this survey of WKSFR.

The eight new species identifications have not been incorporated into this section. However, the up to date figures will be used in the executive summary and management sections.

7.10 Mollusc Diversity in West Kilombero Scarp Forest Reserve

J. Elmer Topp-Jørgensen, Andrew R. Marshall, Henry Brink

7.10.1 Summary and Recommendations

The mollusc fauna of West Kilombero Scarp Forest Reserve (WKSFR) was sampled using a combination of plot surveys, direct timed searching and casual collections. Ten sites were sampled in evergreen forest; five in the Ndundulu forest area including an area dominated by bamboo, four in Nyumbanitu and one in Ukami. Four trapsites were in non-evergreen forest habitats including miombo and acacia woodland, grassland and riverine forest. For each site, collected molluscs have been counted and divided into morpho-species.

The mollusc fauna of forested areas in WKSFR is the second most species rich area within the Eastern Arc Mountains. With its 54 morpho-species (60 including non-evergreen forest habitats) the area is equivalent to some of the richest land-snail faunas recorded worldwide. The area has more than twice the number of species than its fellow Udzungwa site of New Dabaga/Ulangambi Forest Reserve (NDUFR). This reflects the presence of an undisturbed and very diverse forest habitat in WKSFR, covering a significant altitudinal span.

Rain had a significant effect on the results. Sites sampled after the onset of the rainy season were richer in species than sites sampled in the dry season. Molluscs are sensitive to desiccation and therefore prefer moist habitats. Where large fluctuations occur in the microclimate mollusc species may enter a dormant stage during dry periods. This is thought to have affected results, primarily for the miombo woodland site but also for drier habitats in evergreen forest.

In this study woodland areas tend to be as species rich as evergreen forest sites, although differing in species composition. During the dry season however, species can be difficult to locate in the woodland area as they bury deep into the ground or hide in cracks and crevices or on vegetation in order to escape desiccation. The grassland and riverine forest sites are considered to have a low number of species due to the uniform nature of the habitat. Compared to the woodland sites these sites have a more constant microclimate because they were found on waterlogged ground and thus are not expected to show similar fluctuations in the number of species and individuals collected.

The implication of changes in forest structure in relatively stable forest environments is likely to be more severe in tropical areas than in temperate regions, because of the high solar radiation which may cause desiccation. In temperate climate zones it has been shown that silvicultural management can have a considerable negative impact on molluscan faunas. Furthermore, the record of 36 morpho-species recorded only in forested areas and six from other habitats only. A management plan should therefore seek to maintain an altitudinal range of forest cover as well as preserve the diversity of habitats found in WKSFR.

7.10.2 Introduction

Terrestrial molluscs (snails and slugs) have been collected in East Africa since the beginning of the 19th century (Seddon *et al*., 1996 and Verdcourt, 2000). The first collections were often casual and carried out by missionaries, doctors or botanists. Recently mollusc research has changed from being comparisons of taxonomic checklists to the use of quantitative methods to analyse mollusc diversity and biogeographical relationships (Tattersfield *et al.*, 1998).

On mainland Tanzania 417 species of molluscs have been recorded, of which 223 have been found in Eastern Arc forests. This number is however likely to increase, once identification work has been completed on recent collections. Most sampling has been concentrated in the Usambara and Uluguru Mountains and only recently has significant material been collected from other Eastern Arc mountains including the Udzungwas (Tattersfield *et al.*, 1998).

Terrestrial molluscs belong to the second most diverse animal phylum on earth. Some species are indicators of certain environmental conditions, i.e. undisturbed ecosystems or degraded habitat (Tattersfield *et al.*, 1998). The identification of such indicator species for the Eastern Arc would make molluscs a valuable monitoring tool as they are simple and rapid to sample (Tattersfield *et al.*, 1998). There is however considerable difficulties related to the identification of molluscs, which mean that molluscs would be of limited use for monitoring for most managing authorities.

Aims

- To document the mollusc fauna of West Kilombero Scarp Forest Reserve.
- To compare natural forest with managed habitats outside the reserve.
- To compare molluscan diversity with other Eastern Arc regions.

7.10.3 Methods

The mollusc fauna of West Kilombero Scarp Forest Reserve was sampled between July and December 2000. A combination of plots, timed direct searches and casual collections were used to assess the mollusc diversity at 14 trap sites. Ten sites within the two main evergreen forest areas of Ndundulu and Nyumbanitu, and four outside (acacia woodland, grassland, miombo woodland and riverine forest dominated by *Syzygium cordatum*; see Section 7.1 for positions)(for details on methodology, see Frontier Tanzania, 2001g). Trapsites 8, 10 and B (acacia woodland) were sampled after the onset of the rainy season.

Plot Surveys
At each trapsite three 1m x 1m plots were searched thoroughly for 2 person-hours (usually 4 persons for half an hour) (total sampling intensity: $3m^2$/6 person-hours). The three sampling areas were positioned 10m from one end of three bucket pitfall traplines. Care was taken to ensure that quadrats were positioned in places most representative of the area. Twigs and leaf litter were carefully examined for surface and leaf-dwelling molluscs before being removed from the sample plot. Burrowing molluscs were collected by carefully sieving the top layer of soil through ones fingers to a depth of approximately 10cm depending on the texture of the soil (deeper for loose soils, less for hard soils).

Timed Direct Searches
To supplement the plot searches, timed direct searches were carried out in the vicinity of the trap site (usually within 100m of the bucket trap lines) for a fixed period of 4 person-hours (usually 4 persons for one hour or 8 persons for 30 minutes)(total sampling effort: 4 person-hours). These searches were targeted at areas not represented in the sampling plots, i.e. tree bases, dead logs and moist areas along streams or in marsh areas.

Casual Collections
In addition to the above collection methods, casually encountered molluscs were collected. Some species were however left if they were regarded as abundant and found frequently during the plot and direct fixed time searches.

Identification
It has not been possible within the timeframe of this project to obtain taxonomic determinations for collected specimens. Instead Frontier-Tanzania field staff have (as partly done by Tattersfield *et al.*, 1998), divided the samples into morpho-species (individuals which look similar). These morpho-species (hereafter simply referred to as "species") are used to analyse mollusc diversity between trap sites in the study area and to compare mollusc species richness with other Eastern Arc forests.

Analysis
Species richness will be presented using the number of species and individuals recorded for plot surveys and a total number of species per site (including direct searches and casual collections). Results are presented for each trap site, and species richness will be tested for correlation with altitude and water association. The total number of species for the entire forest reserve will be compared with the species richness of other Eastern Arc forests.

Live as well as dead molluscs are included in the analysis. It is assumed that all morpho-species are living in the survey area although only empty shells might have been found for some species.

7.10.4 Results

In total 1098 molluscs representing 60 morpho-species were found in West Kilombero Scarp Forest Reserve. 54 of these were found in evergreen forest sites (including bamboo dominated area: trapsite 2), while 24 species occurred at other sites. 20 species were only found after initiation of the short rainy season (November-December).

Of the 54 species found in evergreen forest, 21 species were recorded at only one trap site. Of these species limited to only one trapsite, 12 were found at sites sampled after the onset of rain (trapsites 8 and 10) (see **Appendix 7.10A** for a list of morpho-species recorded for each site). One species (‘c’) was recorded from all fourteen sites. Three other species were present in half of the trap sites or more (‘a’, ‘e’ and ‘p’) (see **Appendix 7.10A**).

Table 7.10A. Number of species and individuals recorded during plot surveys and total number of species recorded per trapsite. Trapsites arranged after total number of species recorded at the trapsite.

Trap site	Number of species in sample plots	Number of individuals in sample plots	Total number of species on site
C	2	5	4
D	4	20	4
A	1	5	5
2	2	3	9
4	1	2	10
9	6	29	11
3	6	13	12
5	7	8	15
1	11	47	15
6	10	35	16
10*	10	21	17
7	2	4	18
B*	9	18	18
8*	12	24	21

*- Trapsites sampled after the onset of the short rainy season

Trapsite 8 was found to be the most species rich of all sites, acacia is shared second with site 7 (sampled in the dry season), while site 10 is the fourth richest site. Three sites were sampled after the onset of rain. Significant differences between sites sampled before and after the onset of rain were observed in the number of species found in plot surveys (t-test: t=-2.606; df=12; p=0.023) as well as the total number of species per site (t-test: t=-2.618; df=12; p=0.022). Sites sampled after rain being the most diverse.

No correlation between mollusc abundance and altitude was observed.

To see how well the mollusc fauna at each trapsite was represented by the plot surveys, plot survey results were compared to the total number of species found at the sites. The difference between the mean number of species found during plot surveys, and the mean total number of species recorded for each trap site differed significantly (Paired t-test: t=-6.441; df=13; p<0.001). The grassland site is the only site where the number of species in the plot survey is equal to the total number of species found. In evergreen forest sites the difference between number of species found in plots and in total ranges from four to 16 (trapsite 7), while it ranges from zero to nine (trapsite B in acacia woodland) for other sites (see **Tables 7.10A**).

Evergreen Forest Sites vs. Non-Evergreen Forest Sites

Three of the non-evergreen forest sites have the lowest total numbers of species recorded (trapsites A, C and D). The fourth non-evergreen forest site (B in acacia woodland) is shared second with regard to molluscan species richness (see **Table 7.10A**).

For three evergreen forest sites (trapsites 2, 4 and 7), the number of species found during the plot surveys were similar to the number recorded for three non-evergreen forest sites poorest in species richness (trapsites A and C, see **Table 7.10A**). These low diversity sites all have few individuals collected during the plot survey and/or few species (see **Table 7.10A**). Acacia woodland (trapsite B) is the fifth most species rich trapsite according to the plot survey.

No significant differences were observed between evergreen forest sites and non-evergreen forest sites when looking at all sampled areas. However, when comparing only those sites sampled before the occurrence of rain, significant differences were observed in the total number of species (t-test: t=4.651; df=9; p=0.001). Evergreen forest sites having a more diverse mollusc fauna than non-evergreen forest sites.

36 species were recorded for forest sites only (nine after onset of rain) and six from other habitats only (four after onset of rain), while 18 species are shared. Nine species were recorded for non-evergreen forest sites before the onset of rain. Seven of these were shared with evergreen forest sites.

Evergreen Forest Sites

54 species were recorded from evergreen forest trapsites. The species accumulation curve shows sign of levelling off. Three trapsites increases the number of species with at least seven new species. These are plots 5, 10 and 8 of which the two latter were sampled after the onset of rain (see **Figure 7.10A**). It therefore seems that more species could be found if more sampling was carried out during the rainy season.

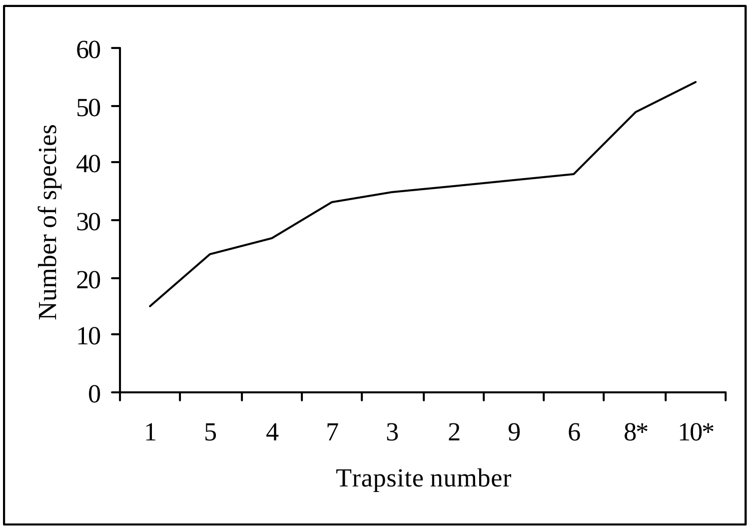


Figure 7.10A. Species accumulation curve for molluscs recorded in evergreen forest areas of West Kilombero Scarp Forest Reserve. Trapsites are arranged randomly (* = Trapsites sampled after the nset of the small rainy season).

Trapsite 6 shared 13 (81%) of its 16 species with trapsite 7, and trapsite 4 shared seven (70%) of its ten species with trapsite 5. All these trapsites are roughly at the same elevation:

Trapsite 6	1530m a.s.l.
Trapsite 7	1550m a.s.l.
Trapsite 4	1360m a.s.l.
Trapsite 5	1550m a.s.l.

Trapsite 10 (at 1145m a.s.l.) shares four species or less with seven of the eight evergreen forest sites sampled before the rains. One of these sites sampled before the rains, is trapsite 9 from a similar altitude (1140m a.s.l.).

No relationship between mollusc diversity (number of individuals in plots and total number of species) and altitude was observed.

Ndundulu vs. Nyumbanitu (including Ukami)
33 species were recorded for sites in Ndundulu and 45 for Nyumbanitu sites, while 24 were shared between the areas. 16 of the species recorded only from Nyumbanitu were found after initiation of the rain, while five were found before. Nine species were found only in Ndundulu.

No difference in molluscan diversity was observed between the two major forest areas.

7.10.5 Discussion

The pronounced difference between the number of species found during the plot survey and the total number of species found on a site (see **Table 7.10.A**), highlights the importance of direct searching in habitat suitable for molluscs (i.e. moist areas, dead logs and tree bases). The plot survey results should therefore be used with caution when comparing molluscan species diversity between sites.

Molluscs are highly dependent on moisture to prevent them from drying out. Many species have some protection in the form of a shell and most species are only active at night or in damp weather (Seddon *et al.*, 1996). Tattersfield *et al.* (1998) also suggests that exceptionally dry field conditions could reduce sampling efficiency for some species. Dryness is therefore though to be an important factor in determining molluscan diversity and abundance.

Evergreen Forest Sites vs. Non-Evergreen Forest Sites
Comparing data from all surveyed sites reveals no difference between evergreen forest sites and non-evergreen forest sites with respect to molluscan species richness. The results however show a significant difference in the total number of species recorded per site before and after the onset of rain. When comparing only sites sampled before the rain, a higher mean total number of species is observed at the evergreen forest sites compared to other areas.

In dry periods some species enter a dormant stage. Snails usually retreat inside their shells for protection against desiccation while slugs compensate for the lack of shell by being able to bury deep into the soil or into cracks and crevices (Seddon *et al.*, 1996). This might explain the low number of species found at three trapsites not under evergreen forest cover (trapsite A in miombo woodland, C in riverine forest and D in grassland), as these were surveyed in the dry season.

The grassland area (trapsite D) was relatively small and located inside the forested area of Ndundulu. The exposed nature of grassland meant that the temperature varied greatly at this site. Molluscs are, as mentioned previously, very sensitive to desiccation, and this could have led to the low number of species found at this trapsite. The riverine site (trapsite C) was found in a waterlogged area under fairly dense canopy. The mollusc fauna recorded is thought to be representative of the area despite being sampled before the rain because of the constant microclimate provided by the waterlogged area and the presence of a canopy. The miombo woodland area (trapsite A) appeared similar in structure and topographical position to the acacia site (trapsite B), but the area supported much fewer species and individuals. The difference between the two woodland areas is therefore probably the result of the occurrence of rain prior to sampling in acacia woodland.

Seddon *et al*. (1996) reports that East African woodlands tends to support fewer species than undisturbed, primary forests. The data for the acacia woodland site (trapsite B) do not support this. This might be because of the altitude and the proximity of evergreen forest, which minimises microclimate fluctuations enabling a rich mollusc fauna to survive the drier periods in woodland habitats. The low number of species recorded for the miombo woodland site (trapsite A), is therefore probably the result of molluscs being dormant during droughts and hiding in areas not reached during collections (i.e. deep under ground or in crevices).

The positive effect of rain on mollusc species richness meant that the number of species in non-evergreen forest was similar to species richness in evergreen forest. In terms of species composition however there are noticeable differences between evergreen forest and non-evergreen forest habitats. The number of species restricted to evergreen forest sites (36) was six times the number of species restricted to other habitats. Also 18 of the 24 species recorded for other habitats were shared with the evergreen forest. This shows the presence of few non-evergreen forest species and many forest dependent species.

Evergreen Forest Sites

In temperate regions, high altitudes have a similar but impoverished mollusc fauna compared with lower elevation sites (Dance, 1972 cited in: Tattersfield *et al*., (1998)). Tattersfield *et al.* (1998) contradicts this in their surveys of the tropical Eastern Arc mollusc fauna. They found essentially different molluscan communities at high and low elevations. Supporting Tattersfield *et al*. (1998), this study found no correlation between species richness and altitude was observed. In coastal forests of Tanzania, Verdcourt (2000) found that species were unevenly spread across habitat types. Results from WKSFR show similarities as well as dissimilarities between sites at identical altitudes indicating that habitat differences are at least as important as elevation in determining molluscan species composition. The variety of habitats found within the forested areas in WKSFR (see Frontier Tanzania, 2001d) may therefore be the reason for the very diverse molluscan fauna found in the area.

The species accumulation curve rises steeply at three trapsites. Trapsite number five increases the number of new species with five. This is not surprising given that it is the second trapsite on the list and there is an altitudinal difference of 520m between the two first sites (see argument above). The two other drastic increases are both from trapsites sampled after the onset of rain. It therefore seems that the 54 mollusc species is an underestimate of the total number of species, and that more mollusc species would have been found in the area if sampling had been continued in the rainy season.

Ndundulu vs. Nyumbanitu (including Ukami)
Nyumbanitu was the only forest to be sampled after the onset of rain. Of its 21 species not found in Ndundulu (see **Appendix 7.10A**), only five were found before the rain. Nine species were only found in Ndundulu, further indicating differences in the molluscan fauna of the two forests, and again the high degree of habitat variability in WKSFR is thought to be the main reason for this.

Comparison with other Eastern Arc Forests

Tattersfield *et al*. (1998) have surveyed the mollusc fauna of many Eastern Arc forests. Their methodology, however, differs slightly from the one used in this survey. They sieve a volume of leaf litter / soil (c. 4 litre) which can be compared to our 1m x1m plots. Their direct timed searching involved two persons searching for two hours within a plot (usually of 20-40m in diameter) and therefore was fairly similar to the method employed in this study. Due to the difference in sampling methodology only species richness in terms of total number of species will be compared between Eastern Arc forests. It should however be remembered that the sampling intensity in this study WKSFR exceeds that of the forests sampled by Tattersfield *et al*. (1998).

Tattersfield *et al*. (1998) reports species richness to be highest in Usambara and Uluguru within the Eastern Arc forests due to collection efforts being concentrated here. This study of the evergreen forest of West Kilombero Scarp Forest Reserve however recorded a mollusc fauna which is the second most species rich forest in the Eastern Arc after Bomole (Tattersfield *et al*., 1998). Including non-evergreen forest habitats it is has more species than any of the Eastern Arc forests surveyed by Tattersfield *et al*. (1998) (see **Table 7.10B**). It has more than twice the number of species of the other Udzungwa site of New Dabaga/Ulangambi Forest Reserve (see **Table 7.10B**). Together with Bomole forest (57 species) in East Usambara, the molluscan species richness of WKSFR is equivalent to the richest molluscan communities in the world Tattersfield *et al*. (1998).

Table 7.10B. Number of species recorded for Eastern Arc forests (data from Tattersfield *et al*. (1998), except for West Kilombero Scarp FR and New Dabaga/Ulangambi FR (Frontier Tanzania, 2001e)).

Eastern Arc Blocks	Forests	Total number of species at site
East Usambara	Amani-East	15
	Amani-Zigi	16
	Bomole	57
	Kihuhwi-Zigi	15
	Kwamkoro	15
	Monga	23
West Usambara	Ambangulu	23
	Mazumbai	36
Nguru	Kwelikwiji	8
	Manyangu	10
	Nguru South	13
Uluguru	Kimboza	45
	Uluguru North	34
Udzungwa	West Kilombero Scarp	54 (60*)
	New Dabaga/Ulangambi	21 (27*)

*Number in brackets includes non-forest habitats.

7.10.6 Conclusion

West Kilombero Scarp Forest Reserve contains the second most species rich mollusc fauna in the Eastern Arc. The variety of habitats and the considerable altitudinal span have resulted in the development of one of the richest land-snail faunas recorded worldwide. Rain was also found to have a beneficiary effect on the sampling of molluscan communities. Rapid fluctuations in the microclimate in areas not under canopy, reduced both species richness and diversity. There were noticeable differences in species composition between evergreen forest and non-evergreen forest habitats highlighting the importance of maintaining the heterogeneity of habitats in WKSFR. It should therefore be the aim of any management initiatives to maintain an altitudinal forest cover and preserve the diverse habitat mosaic of the reserve to ensure the persistence of a rich mollusc fauna.

7.11 Millipede Diversity and Distribution – West Kilombero Scarp Forest Reserve

Andrew R. Marshall, Henry Brink, J. Elmer Topp-Jørgensen

7.11.1 Summary and Recommendations

Knowledge of millipedes (class Diplopoda) is extremely limited, especially in the montane forests of Tanzania. Notably, only about six of the eleven Tanzanian families are known in any detail and only one has been extensively documented. For this reason, most millipede collections made from Tanzania are likely to contain several undescribed species and even new genera. Hoffman (1993) estimates that only one in eight millipede species has been described.

Endemism in millipedes is extremely high and few species occur in more than one mountain range. The Udzungwa Mountain range has been surveyed by only one expedition, which concentrated on Mwanihana forest. This short study however found four endemic genera and eleven endemic species from the family Oxydesmidae (Hoffman, 1993). When compared to species endemism of this family in other Eastern Arc forests, this places the Udzungwas above all others. Much of the Udzungwas are however unexplored and given this high level of millipede endemism, there are clearly more discoveries to be made.

Millipedes from the previously unstudied populations of West Kilombero Scarp Forest Reserve (WKSFR) were sampled using a combination of quadrats and timed casual searches. From these, 4,941 millipedes were collected. Taxonomic verification was however unavailable at the time of report writing, so these were classified into thirty-eight morpho-species in order to investigate diversity.

Comparison with millipedes collected from New Dabaga/Ulangambi Forest Reserve (NDUFR) highlights the high level of endemism of forest millipedes. Most notably, only ten out of the thirty-eight morpho-species in WKSFR were also found in NDUFR. WKSFR also has an exceptionally high diversity of millipedes, including twelve morpho-species that were only found at one trapsite.

The millipede fauna within the forest is also clearly more abundant and species rich than that outside. Notably, twenty-one out of the thirty-eight morpho-species (51.2%), were found only in the forest trapsites. Given the extremely low dispersal ability of millipedes beyond environmental boundaries, most of these "forest species" are likely to be restricted to and dependent on these forests for survival.

Differences in millipede diversity between and also within the two reserves are likely to be due to factors influencing desiccation. This is the primary limiting factor to millipede distribution (Hoffman, 1993). In particular, canopy fragmentation increases the exposure of the forest floor to drying out, and forest use should be monitored to ensure that harmful activities are not threatening this (see Frontier Tanzania, 2001b). The onset of rains in WKSFR highlighted this dependence on moisture, with a significant increase in species richness after the rains began.

7.11.2 Introduction

Millipedes (class Diplopoda) are “myriapodous arthropods” i.e. from one of four groups of arthropods (phylum Arthropoda), which share the common feature of having many legs and an elongated body. As is the case with most arthropods, millipede taxonomy is poorly understood and most collections from the tropics are likely to contain a large proportion of new species and even genera. To put this in quantitative terms, Hoffman (1993) estimates that only about one eighth of millipedes collected worldwide have been described. Specifically in Tanzania, Frontier Tanzania surveys over the past ten years in the Usambara Mountains and coastal forests have found over twenty-five new genera (Hoffman, 1995 *pers. comm.*).

Being detritivores, millipedes play an important role in the recycling of dead plant matter and thus are a vital part of the forest ecosystem. They are also highly restricted by ecological barriers and hence show substantial speciation and endemism (Hoffman, 1993). Few species, for example, are known from more than a single mountain range within Tanzania. There are also no genera in common between the Tanzanian basement forests and those of the Congo and Cameroon forests (Hoffman, 1993). The loss of even the smallest forest fragments may therefore result in millipede species extinction.

Only one documented survey of Udzungwa forests has been made. This was limited solely to one forest at the far eastern end of the Udzungwa Mountain range - Mwanihana (now part of the Udzungwa Mountains National Park; Hoffman, 1993). From this short survey, and from other limited surveys in Tanzania, only one Tanzanian millipede family is well known. Strikingly, within this one studied family (Oxydesmidae), the Udzungwa Mountains have the highest number of endemic species of all Eastern Arc forests, with four endemic genera and eleven endemic species. This compares with the next highest area for endemism, the Uluguru Mountains, which has five endemic oxydesmid genera and seven endemic species.

Further study of Udzungwa diplopods is therefore imperative, both to provide information on the taxa and more relevant to the current project, to assess biodiversity. In addition, a large collection of millipedes can be made from relatively few field hours in comparison to other taxonomic groups. Hindering interpretation of collections however is the lack of millipede expertise, which means that many specimens take years to be identified.

Aim

- To assess millipede diversity in West Kilombero Scarp Forest Reserve. This will be facilitated by comparison with New Dabaga/Ulangambi Forest Reserve (NDUFR; Frontier Tanzania, 2001e), which was surveyed using identical methodology.

7.11.3 Methods

Ground-dwelling millipedes were primarily sampled by timed searching of 3m×3m quadrats. Three of these were placed approximately 5m from one end of lines of bucket pitfall traps used to sample small mammals and herpetofauna (sections 7.2, 7.8 and 7.9). Where the habitat was deemed unrepresentative of the trapsite, quadrats were moved subjectively into a more representative position, taking care to avoid paths, large rocks or difficult terrain. The leaf litter and topsoil within quadrats was searched thoroughly by hand for a total of eight person hours per quadrat at all trapsites.

In addition, the general proximity of all trapsites was searched for two person hours. During such searches, particular attention was paid to rotting logs, the underside of rocks and other such microhabitats, which may have been missed by the quadrat samples.

Taxonomic verification was not available at the time of report writing. Consequently, to investigate the diversity of the collections, morpho-species were tentatively defined based on physical characteristics. In an attempt not to over estimate diversity, millipedes were grouped into morpho-species conservatively, i.e. where there was doubt as to whether two millipedes differed, they were grouped together.

Data Analysis – Principle Component Analysis

A small number of tests were carried out to explore the diversity and distribution of morpho-species. These were mostly similar to tests used in other sections and explained in section 7.1. In addition, Principle Component Analysis (P.C.A.) was used to determine similarities between trapsites and to generate further hypotheses (**Box 7.11A**). Following this, trapsites with the most similar levels of all variables were identified and labelled by eye. Following this, subsequent testing was used to determine any significant trends.

Box 7.11A. Principle Component Analysis (P.C.A.).

Put simply, this method takes given variables (e.g. species richness, number of individuals, etc.) and plots them in a way that explains the most variance in the data (in this study the variance among trapsites). P.C.A. is not a statistical test; it is simply an aid to data exploration. Additional statistical comparisons are therefore required to test observed trends.

7.11.4 Results

Millipedes were found at all trapsites, both within and outside of the evergreen forests of Ndundulu, Nyumbanitu and Ukami (**Appendix 7.11A**). From the 4,941 specimens collected, thirty-eight morpho-species were identified. Of these however, 1,550 were immature millipedes. These could not be confidently assigned to any morpho-species group and thus are all classified as morpho-species '42' and have been excluded from all analysis.

It emerged during surveys that quadrat searching was far more thorough and consistent than casual searching. Because of this, all comparisons made between the number of individuals in different areas are based on quadrat data alone. Species richness is however considered more consistent and all comparisons of this are made including both quadrat and casual data.

Sampling effort focused primarily on the areas of evergreen forest. **Figure 7.11A** shows a species accumulation curve created by summing the frequency of new morpho-species recorded from successive randomly ordered forest trapsites. Noticeable steps in the curve resulting from the two forest trapsites sampled during rains suggest that further morpho-species may have been discovered with additional rainy season sampling. The curve does however level off and thus the observed morpho-species compliment is likely to be representative of the parent population.

Some morpho-species are clearly widespread in the reserve ('3', '4', '5' and '8'). Some however are restricted to only one or two trapsites ('6', '11', '13', '15'-'19', '21', '22', '24'-'33', '35' and '36'). In an attempt to describe this distribution, using the observations in **Appendix 7.11A** together with observations made in New Dabaga/Ulangambi Forest Reserve (Frontier Tanzania, 2001e), three categories of morpho-species are defined:

- "Forest species" – Morpho-species found only in forested areas of WKSFR and/or NDUFR.
- "Unique species"– Morpho-species found in WKSFR but not in NDUFR.
- "Rare species" – Morpho-species found only at one trapsite.

A summary of the morpho-species assigned to these important categories is given in **Table 7.11A** and **Figure 7.11B**. Interpretation of this must consider that the three definitions refer only to the distribution of these species in and around WKSFR and NDUFR. No comparable data is available for areas beyond these.

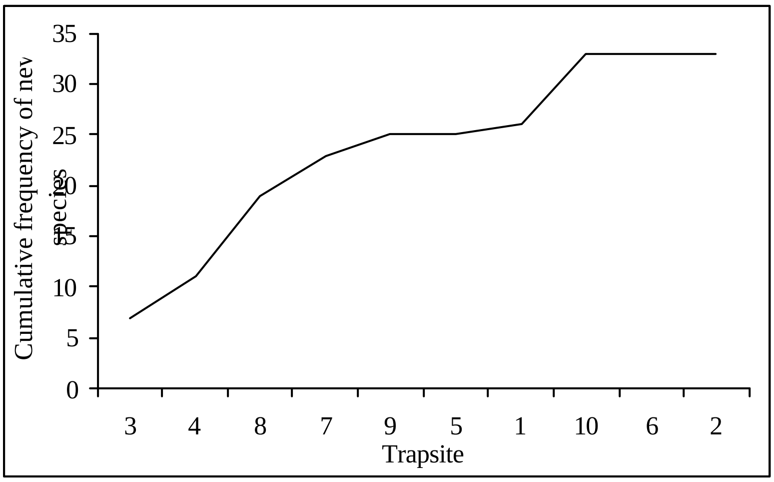


Figure 7.11A. Species accumulation curve for evergreen forest trapsites in West Kilombero Scarp Forest Reserve. Trapsites are ordered randomly.

Table 7.11A. Frequency of individuals and morpho-species in West Kilombero Scarp Forest Reserve. See text for definitions of "forest", "unique" and "rare" species. Trapsites from the three evergreen forest fragments of Ndundulu, Nyumbanitu and Ukami are listed separately.

	Ndundulu (5 trapsites)	Nyumbanitu (4 trapsites)	Ukami (1 trapsite)	Total forest (10 trapsites)	Other habitats (4 trapsites)	WKSFR Total (14 trapsites)
Total number of individuals [1]	1532	1457	153	3142	385	3491
Mean individuals per trapsite [1]	306.4	364.3	153.0	314.2	96.3	249.4
Total number of species	15	23	15	33	16	38
Mean no. species/ trapsite	7.8	11.0	15.0	10.9	5.8	2.7
"Forest species"	7	12	8	21	0	21
Mean "forest species"/ trapsite	3.0	4.8	8.0	4.2	0	[2]4.2
"Unique species"	2	7	5	17	[3]5	27
"Rare species"	2	5	5	12	[3]5	17

[1] These figures are calculated from quadrat data alone.
[2] This calculation does not include non-forest trapsites.
[3] All species unique to non-forest sites were only found in *Acacia* woodland (trapsite 'B').

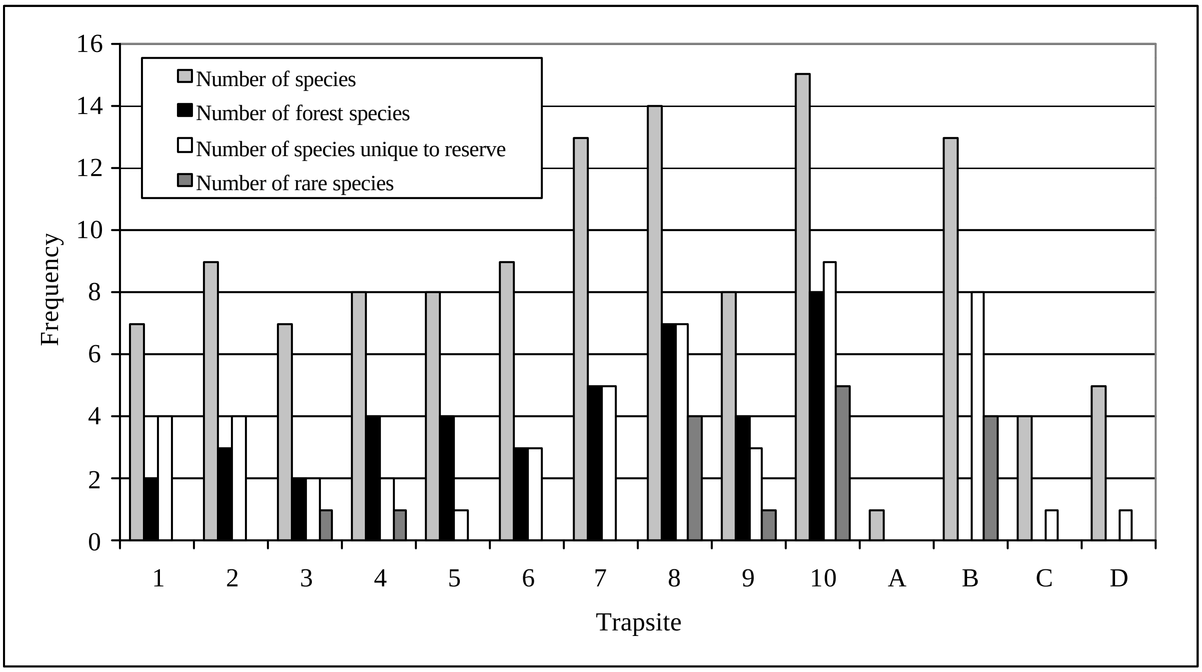


Figure 7.11B. Frequency of millipede morpho-species found at trapsites in West Kilombero Scarp Forest Reserve. Definitions of categories as defined in text.

Principle Component Analysis using the components: species richness, Shannon Index of diversity, number of individuals caught, and frequency of forest, rare and unique species, reveals three distinct groups of trapsites (**Figure 7.11C**). The most apparent of these comprises trapsites B, 8 and 10, which were sampled during the onset of the rainy season in November and December 2000. Further tests reveal that the number of species caught per trapsite increased significantly during this time (*t*-test: p=0.003, $t_{(0.05(2),12)}$=3.670).

Of those trapsites not affected by the rains, there appears to be a clear split between trapsites within (number codes) and trapsites outside (letter codes) of the evergreen forest fragments (**Figures 7.11B&C**). Accordingly, a significantly larger number of both individuals and morpho-species were found in the forest trapsites (*t*-test - individuals: p=0.009, $t_{(0.05(2),9)}$=3.35; species richness: p=0.003, $t_{(0.05(2),9)}$=3.990).

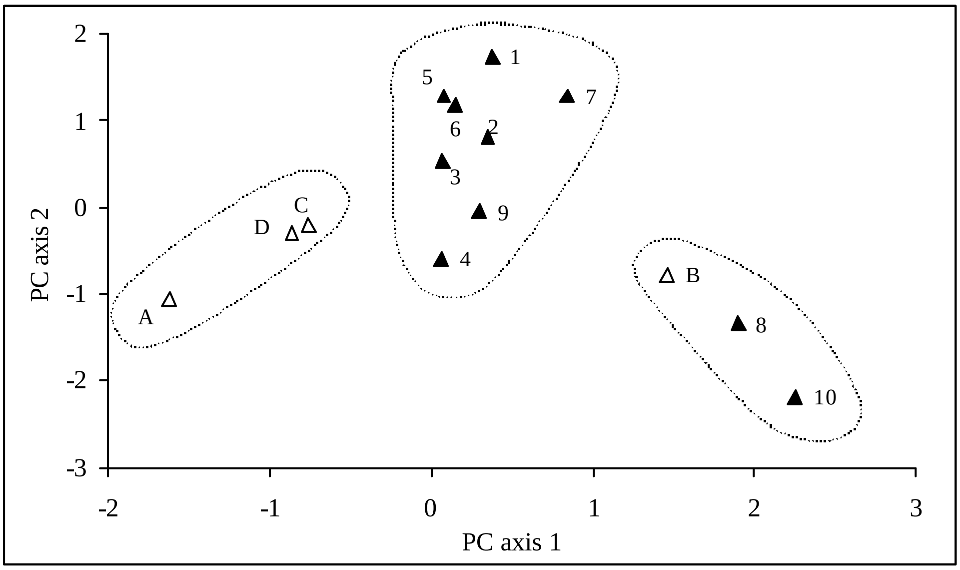


Figure 7.11C. Principal Component Analysis of millipede diversity at trapsites in West Kilombero Scarp Forest Reserve, using the variables: species richness, number of individuals, rare species, unique species and forest species. Shaded and open points indicate trapsites within and outside of the evergreen forest fragments respectively.

Comparison with New Dabaga/Ulangambi Forest Reserve

Similar data to that presented above for WKSFR was also collected in NDUFR (Frontier Tanzania, 2001e). Brief descriptions of these results are presented in **Table 7.11B** and **Appendix 7.11B**. Comparison of the millipede fauna from forest trapsites in WKSFR and NDUFR shows no significant difference between the mean number of individuals or species per trapsite (*t*-test - individuals: p=0.137, $t_{(0.05(2),13)}$=1.583; species: p=0.607, $t_{(0.05(2),13)}$=0.528). Importantly however, only ten species were found both in WKSFR and NDUFR. Furthermore, there are a significantly larger number of species unique to WKSFR than to NDUFR (Mann-Whitney: p=0.024, n=15 Z=2.258). A similar trend is seen for “rare” morpho-species, although not significant (Mann-Whitney: p=0.067, n=15, Z=1.832).

Note on Interpreting Results

Analysis of morpho-species diversity and distribution has involved a number of statistical tests. This may have the effect of bias in favour of significant results (e.g. Mduma & Sinclair, 1994). Given the high significance of most positive results (p<0.01 in most cases), this however is not considered to be a problem.

Table 7.11B. Frequency of individuals and morpho-species in the main evergreen forest blocks of West Kilombero Scarp and New Dabaga/Ulangambi Forest Reserve. See text for definitions of "forest", "unique" and "rare" species.

	WKSFR (10 trapsites)	NDUFR (5 trapsites)
Total number of individuals [1]	3142	1029
Individuals per trapsite[1]	314.2	205.8
Total number of species	33	13
Mean no. species/ trapsite	10.9	9.0
"Forest species"	21	5
Mean "forest species"/ trapsite	4.2	[2] 1.0
"Unique species"	17	2
"Rare species"	12	1

[1] These figures are calculated from quadrat data alone.
[2] This calculation does not include non-forest trapsites.

7.11.5 Discussion

The comprehensive coverage of the WKSFR and NDUFR surveys has resulted in one of the largest collections of millipedes for any of the Eastern Arc forests. The thirty-eight morpho-species found are therefore likely to be a good representation of the WKSFR community. The purposefully conservative grouping of millipedes into morpho-species may also result in there being more true species than thirty-eight.

From previous experiences in the better known Usambara Mountains and Tanzanian coastal forests, collections have generally contained a large number of undescribed species. For example, from five forests surveyed in the 1990s, around 40% of species were previously undescribed (Hoffman, 1995 & 1998 *pers. comms.*). If a similar trend is seen for this WKSFR collection, around fifteen morpho-species collected in WKSFR are likely to be new. Given also the relatively limited knowledge of Udzungwa millipedes, and the conservative nature of the above morpho-species grouping, this figure could potentially be even greater.

Rains

Of the thirty-eight morpho-species found, twenty-eight were present in the three trapsites sampled after the onset of the November-December wet season. Millipedes are particularly vulnerable to desiccation and are equipped with several features to counter this. Structurally, millipedes have a hard, water-resistant exoskeleton, which prevents water loss. Behaviourally, by rolling up into a coil millipedes are also able to trap air and hence increase humidity in their immediate surroundings. Hoffman (1993) states that factors influencing desiccation are likely to be the major constraint on millipede distribution.

Most species of millipede lay batches of eggs in the soil or in mud nests, which hatch after several weeks. In order to survive the dry season however, other species hatch and develop to maturity inside specially constructed moulting chambers (Ruppert & Barnes, 1994). There are therefore two possibilities why rain resulted in a greater number of millipede species. Firstly, the high number of unidentifiable immature millipedes found in the dry season may have been from a number of species that were not found as adults. These may have hatched from nests, and given that millipedes only generally take a few weeks to develop (Ruppert & Barnes, 1994), could have reached maturity in time for the rains. Secondly, millipedes in nests or undergoing growth in moulting chambers (and even imagos attempting to resist desiccation) may have been buried deep in the soil and hence not seen. A small number of immature millipedes in moulting chambers were however found in shallow soil. Whatever the case, this highlights the importance of wet season sampling when assessing millipede diversity.

Important Areas for Conservation of Millipede Diversity

Trapsites B, 8 and 10 are shown to be the most morpho-species rich in the reserve, primarily due to sampling in the wet season. These sites also all have a high number of unique and rare morpho-species. Similar diversity may also be seasonally present in most other sites, although this can only be proven by further rainy season sampling.

Amongst the sites not influenced by rain, four stand out. Trapsite 7, in the centre of Nyumbanitu forest has a high morpho-species richness and a large number of morpho-species unique to WKSFR. Trapsites 3, 5, 7 and 8 are also noteworthy in that they all contain a morpho-species not found at any other site.

Also amongst sites not influenced by rain, the millipede fauna within the forest is clearly more abundant and species rich than that outside. Notably, 21 out of the 38 morpho-species (55.7%), were found only in the forest trapsites. These are defined in the results as "forest species", and although this may not be completely accurate as the ecology of these specimens is not known, it provides some idea of the restricted distribution of many millipede species.

There are also some morpho-species found to be unique to non-forest sites. These were however, all found during the rains in *Acacia* woodland (trapsite 'B'). This shows that non-forest habitats are able to support a large diversity of species and even unique species for at least some of the year. Such fire-maintained wooded grassland is however extensive and mostly continuous, both in the study area and throughout Tanzania. This contrasts with the coverage of forests, which are highly fragmented and cover only 2-3% of land surface in Tanzania (Rodgers, 1993). The potential habitat for colonisation by species adapted to non-forest habitats is therefore huge in comparison to that for forest dependent species, for which grassland habitats act as an effective barrier to dispersal. For this reason, the importance for the conservation of forest habitats outweighs all others.

Comparison with New Dabaga/Ulangambi Forest Reserve

NDUFR and WKSFR have a similar diversity of morpho-species per unit area. The importance for conservation management however lies not so much in the local diversity of individual trapsites, but in the reserve-wide picture. Importantly, the species distribution in WKSFR is very different between trapsites in comparison to the similar species content in most NDUFR trapsites (compare **Appendices 7.11A&B**). Also important is the observation of more unique and rare morpho-species per trapsite in WKSFR than in NDUFR.

The difference in millipede fauna between NDUFR and WKSFR cannot simply be due to the altitudinal differences between the reserves. In particular, ten (76.9%) of the millipedes from NDUFR are present in WKSFR. Of these ten, only five are recorded from trapsites at similar high altitude to NDUFR (the high altitude trapsites are numbers 1 and 2). Similarly, many morpho-species are recorded from WKSFR which are not recorded from NDUFR at similar high altitudes. The high diversity in WKSFR is more likely to be related to the comparatively heterogeneous forest habitats, large forested area and low human impact on the reserve.

Important Morpho-species

From **Appendix 7.11A**, there are several noteworthy morpho-species. Morpho-species '4' is the most widespread, being found at all trapsites in both WKSFR and NDUFR (**Appendices 7.11A&B**). Also common to most trapsites in both WKSFR and NDUFR are morpho-species '3', '5', '7' and '8'. Morpho-species '34' is also common, but only in forested sites sampled in the dry season and not at all in NDUFR. Most strikingly however, twenty-six (63.4%) of the morpho-species identified are recorded from three trapsites or less. This compares with only five morpho-species found from three trapsites or less in NDUFR.

7.11.6 Conclusion

Clear differences between the millipede fauna of West Kilombero Scarp Forest Reserve and New Dabaga/Ulangambi Forest Reserve emphasizes the extraordinarily high degree of endemism of the diplopod class. Furthermore, the high number of rare and unique species, from different areas in WKSFR, again emphasizes the diversity within the reserve and thus the overall importance of the reserve as a whole for conservation. Several potentially forest dependent morpho-species have also been listed, hence forest habitat is particularly important for millipede conservation. To confirm and build on these findings, it is however imperative to re-evaluate once taxonomic verification has been completed.

The invertebrate community is often overlooked when formulating management plans for the conservation of natural areas. Although providing the needs for other larger mammals may secondarily help the invertebrates, few initiatives apply directly to this huge taxon.

As explained above, millipedes are especially vulnerable to desiccation. The removal of canopy in particular, results in increased exposure of the forest floor to drying out, such as has been seen in parts of NDUFR and many other tropical forests. Therefore there is a clear need to ensure the continued survival of closed-canopy forested areas in WKSFR, which should be monitored closely.

7.12 Butterfly Diversity of West Kilombero Scarp Forest Reserve

Henry Brink, Andrew R. Marshall, J. Elmer Topp-Jørgensen

7.12.1 Summary and Recommendations

The butterfly community of West Kilombero Scarp Forest Reserve (WKSFR) was sampled using a combination of butterfly traps, timed sweep netting, and casual collections. Ten sites were sampled within evergreen forest; five within Ndundulu forest block (trapsites 1-5), four within Nyumbanitu forest block (trapsites 6-9) and one in Ukami (trapsite 10). Four trapsites (trapsites A-D) were placed outside the evergreen forest; in miombo woodland, acacia woodland, riverine forest, and grassland. Butterflies were sampled from July to September and again in November to early December 2000.

A total of 672 butterflies were caught in WKSFR. The butterflies came from eight families, 52 genera and 102 species. One species was endemic (*Bicyclus uzungwensis uzungwensis*) to the Udzungwa Mountains, where it is confined to the high forests of WKSFR. At the subspecies level, a further three Udzungwa endemics were recorded. There are a further 19 near-endemic species or subspecies. These figures reflect the high biodiversity value of WKSFR.

Three factors were thought to be important in influencing butterfly diversity at the various trapsites. These were time of year, altitude and habitat heterogeneity. A significant positive correlation was noted between number of individuals caught and time of year; more individuals were caught at the end of the survey period than at the beginning. This suggests more butterflies would be recorded had sampling continued into the warmest and wettest months of the year (December to April). An increase in species and individuals was also noted with a decrease in altitude. Trapsite 9 in forest edge habitat near a river had the highest butterfly diversity, with 45 species and 122 individuals recorded.

47 species recorded by this survey were forest dependent, while 78% of limited range species were forest dependent. This highlights the importance of reserve's forested areas. The variety of habitats in WKSFR has led to the high diversity of butterflies recorded there. This stresses the importance of maintaining the mosaic of habitats found within the reserve.

7.12.2 Introduction

Tanzania, with approximately 1370 known butterfly species, has a diverse butterfly fauna. Of these 1370 species, 121 are found only in Tanzania (8.8%). Tanzania has more species of butterfly and a greater proportion of species limited to the country than other East African countries[*]. The Eastern Arc Mountains account for a high proportion of these Tanzanian endemics (see **Table 7.12A**). The Udzungwa mountains, with its large areas of montane forest and grassland, possess eight endemic species and eight endemic subspecies (de Jong & Congdon, 1993).

The distribution of butterflies is determined by their habitat requirements. Rare species with limited ranges tend to have narrower requirements than more widespread species (Pollard & Yates, 1993). This implies species endemic to a limited area will be more affected by disturbance than other wider ranging species. As a result of these factors, butterflies are increasingly being seen as potential tools in the rapid evaluation of biodiversity (e.g. Daily & Ehrlich, 1995). West Kilombero Scarp Forest Reserve (WKSFR), within the Udzungwa mountains, offers an opportunity to study butterfly assemblages within both montane forest and open habitats.

Aims

- To collect and identify a representative sample of the reserve's butterfly community.
- To compare butterfly assemblages at the various trapsites (both inside and outside evergreen forested areas).
- To ascertain what factors may be influencing the distribution of butterfly assemblages.
- To provide recommendations for the conservation of the WKSFR butterfly fauna.

Table 7.12A. Numbers of butterflies endemic to some Eastern Arc Mountains (data from de Jong & Congdon, 1993).

Site	Endemic Species	Endemic Subspecies
Usambara Mts.	12	15
Uluguru Mts.	8	10
Nguru Mts.	7	8
Udzungwa Mts.	8	8

[*] Uganda has 1242 butterfly species, of which 2.7% are only found in Uganda (TANAPA, 1999). Kenya has 895 butterfly species, of which 2.9% are only found in Kenya (TANAPA, 1999).

7.12.3 Method

Butterfly communities of WKSFR were sampled from July to September, and again in November to early December 2000. A combination of butterfly traps, timed sweep netting, and casual collections were used to sample the butterfly communities at ten trapsites within the evergreen forest blocks (i.e. Ndundulu, Nyumbanitu and Ukami) and four outside (see Section 7.1).

Butterfly Trapping

Six butterfly traps were used at each trapsite for eight days (trapsite 1-10; within or at the edge of main blocks of evergreen forest) or four days (trapsite A-D; other habitats). Three traps were placed as high as possible in the canopy (between 5-15m above the ground), while three traps were placed 1.5m above the ground. The butterfly traps used were 'Blendon' style traps, consisting of a 40cm circular plate at the base and top, with cloth mosquito netting for the sides (70cm) and under the top plate. The bottom plate was made of metal, while the upper plate was made of plastic. To allow butterflies to enter the trap, a 4-5cm gap between the base plate and the mosquito net was maintained by strings attached from the top plate to the base plate. Bait consisting of rotting bananas was placed at the centre of the base plate (for detailed discussion on what bait to use read: Kielland, 1990; Sourakov & Emmel, 1995). Bait throughout the period remained the same, however preparation of the bait differed. For the first two months, bananas were mashed in the morning and then placed in the traps in the afternoon. During the second period, a container was filled up with mashed bananas and left to rot and ferment for six to eight days before use. The traps were checked and baited daily in the afternoon (around 5pm), and any caught specimens were collected for identification or released.

Timed Sweep Netting

Two-person hours (i.e. two people for one hour) were spent each day sweep netting in the vicinity of the trapsite for butterflies. This timed sweep netting, where possible, took place between noon and two in the afternoon; as this was deemed to be the hottest part of the day, and therefore the period of the day when most butterflies would be active. In the event of rain, sweep netting was postponed till the rain had ceased.

Casual Collection

In addition to the above methods, butterflies encountered casually (e.g. on camps or while walking from camps to the trapsites) were collected. Casual collections have only been used in the compilation of the species list.

Identification

Three good books on East African butterflies exist (Congdon & Collins, 1998; Larsen, 1996; Kielland, 1990), thereby allowing for identification of many specimens to species level, and to family level in almost all cases (except for four specimens). Identifications listed here are preliminary. Further identification of some specimens and verification of all species still has to be completed.

7.12.4 Results

A total of 672 butterflies were caught in West Kilombero Scarp, of which 454 butterflies were retained for taxonomic purposes (the rest were identified and released). **Table 7.12B** is a species list of the butterflies caught in WKSFR; the butterflies come from eight families, 52 genera and 102 species. Taxonomic nomenclature follows Kielland (1990).

Box 7.12A. Key to **Table 7.12B**.

The letters (*cf*) denote that there is an element of doubt in the identification. Altitude range, ecological type and endemic status were compiled from Kielland (1990) and Larsen (1996).

Endemic status: The letters within brackets refer to sub-species, while those without refer to species.

- E - Endemic: Occurs only within the Udzungwa Mountains.
- NE - Near endemic: Species with limited ranges; Northern Malawi, Southern Highlands & Eastern Arc Mountains.

Ecological type:

- F – Forest dependent species; restricted to forested areas only.
- ×– Forest dwelling (including forest margin) but not forest dependent. The species occurs in forested areas as well as other vegetation types.
- O – Non-forest species. These species do not occur within forests.

Table 7.12B. Butterfly list for West Kilombero Scarp Forest Reserve.

Species	Known altitude range (m a.s.l.)	Endemic Status*	Ecological Type	Total caught
ACRAEIDAE				
Acraea alicia cf uzungwae	1500-2000	(E)	×	1
Acraea cf cabira	0-2100		×	2
Acraea cf cepheus bergeriana	350-2140	([1]NE)	F	1
Acraea igola	0-1200		F	3
Acraea insignis cf insignis	0-2300		×	6
Acraea cf johnstoni johnstoni	0-2150		×	4
Acraea ntebiae	800-1800		F	1
Acraea cf pharsalus pharsaloides	800-2000		×	3
Acraea servona cf orientis	250-1700		F	2
Acraea cf sotikensis	300-2200		×	3
Acraea cf ventura	1000-2000		O	3
Acraea sp.				5
Bematistes aganice	0-2140		×	2
Bematistes quadricolor itumbana	900-2340	([2]NE)	×	5
DANAIDAE				
Amauris cf crawshayi crawshayi	350-2200	[5]NE	F	1
Amauris echeria serica	400-2200		F	2
Amauris cf ellioti junia	1100-2400		F	1
Amauris niavius domicanus	800-1600		F	4
Danaus chrysippus cf chrysippus			×	4
Danaus (Tirumala) formosa formosa	300-2300		×	3
HESPERIIDAE				
Cf Celaenorrhinus bettoni	800-1700		F	1
Metisella decipiens cf decipiens	1100-1900	([3]NE)	×	6
Metisella cf formosa	1000-1800		O	1
Metisella cf orientalis	800-2700		×	4
Metisella trisignatus trisignatus	1200-2200		×	1
Metisella sp.				4
Pardaleodes incerta	0-2000		×	1
Cf Zenonia zeno	400-2600		×	2
Unidentified Hesperiidae				15

Continued below…..

Table 7.12B continued.

Species	Known altitude range (m a.s.l.)	Endemic Status*	Ecological Type	Total caught
LYCAENIDAE				
Cf Actizera lucida	0-2000		O	2
Cf Alaena picata picata	300-1500	([6]NE)	F	5
Cf Anthene hobleyi	1400-2200		F	1
Cf Anthene lasti	300-800		F	2
Cacyreus lingeus	0-2300		×	7
Cf Cacyreus virilis	0-2200		×	2
Cacyreus sp.				2
Eicochrysops sp.				2
Cf Euchrysops osiris	0-2200		O	1
Lampides boeticus	0-2500		×	4
Cf Leptotes pirithous	0-2500		×	3
Leptotes sp.				2
Cf Liptena xanthostola	900-1500		F	1
Oboronia bueronica	250-1100		F	1
Cf Termoniphas micylus	0-1500		×	2
Cf Termoniphas				2
Tuxentius cf calice	400-2000		O	1
Tuxentius cf ertli	1000-2200	[7]NE	F	7
Tuxentius sp.				1
Uranothauma cf delatorum	1600-2000		F	1
Uranothauma cf heretsia virgo	1000-2300	([8]NE)	F	2
Uranothauma cf vansomereni	800-1300		O	1
Uranothauma sp.				1
Cf Zizulu hylax	0-2600		O	3
Unidentified Lycaenidae				13
NYMPHALIDAE				
Antanartia dimorphica dimorphica	1500-2700		F	7
Antanartia schaeneia dubia	1500-2700		F	2
Cf Aterica galene	0-2200		×	1
Bebearia cf cocalia	800-1500		F	6
Catuna cf sikorna	250-1200	[5]NE	F	2
Charaxes acuminatus cf acuminatus	300-2100		F	10
Charaxes candiope candiope	0-2600		F	1
Charaxes druceanus proximans	1200-2000		×	6
Charaxes cf pollux pollux	300-1900		F	4
Charaxes varanes vologeses	0-2300		×	3
Charaxes cf xiphares brevicaudatus	800-2300	([9]NE)	F	1
Euphaedra cf crawshayi	250-1800		×	2
Eurytela hiarbas cf lita	800-2300		F	3
Euxanthe tiberius cf tiberius	0-1350		F	7
Issoria baumanni orientalis	1300-2340	([10]NE)	×	8
Junonia terea elgiva	0-2200		×	12
Junonia sp.				1
Neptis laeta	0-2200		×	2
Neptis ochracea uluguru/uzungwa	850-2300	([1]NE)	F	1
Neptis sp.				3
Phalanta cf phalanta	0-2600		O	3
Precis tugela cf aurorina	350-2500		F	4
Pseudacraea dolomena cf usagara	300-2000	([6]NE)	F	3
Pseudargynnis hegemone	800-2000		×	3
Salamis parhassus	0-2400		×	3
Salamis temora cf virescens	250-800	([1]NE)	F	1
Sallya cf moranti	0-1800		×	10
Vanessa cardui	0-3000		O	1

Continued below…..

Table 7.12B continued.

Species	Known altitude range (m a.s.l.)	Endemic Status*	Ecological Type	Total caught
PAPILIONIDAE				
Graphium policenes	0-2000		F	7
Papilio cf bromius chrapkowskoides	780-2000		F	1
Papilio dardanus cf tibullus	0-2100		F	1
Papilio cf desmondi usambarensis	300-2600	([7]NE)	F	9
Papilio echerioides	250-2200		F	6
Papilio ophidicephalus ophidicephalus	0-2000		F	1
Papilio hesperus	0-1700		×	1
Papilio pelodurus vesper	300-2000	[7]NE	F	3
Papilio phorcas cf nyikanus	300-2200	([7]NE)	F	6
Papilio sp.				3
PIERIDAE				
Belenois aurota	0-2600		×	4
Belenois cf gidica	0-2100		O	1
Belenois margaritaceae intermedia	1100-2200	(E)	F	1
Belenois zochalia aggrippinides	300-2700		×	2
Belenois sp.				2
Colias electo pseudohecate	1300-2700		O	1
Colotis cf evagore antigone	0-1800		O	1
Cf Dixeia spilleri	0-1700		O	1
Cf Dixeia				1
Eurema desjardinsi cf marshalli	400-2500		×	1
Eurema cf hapale	0-2000		×	2
Eurema cf mandarinula	1400-2600		×	3
Eurema cf regularis	300-1800		×	2
Eurema senegalensis	0-2000		F	2
Eurema sp.				23
Mylothris agathina cf agathina	0-2200		×	5
Mylothris sagala cf sagala	700-2700		F	4
Mylothris cf yulei	350-2000		F	4
Mylothris sp.				3
Nepheronia argia	75-2000		×	3
SATYRIDAE				
Aphysoneura pigmentaria uzungwae	1700-2200	([10]NE)	F	2
Bicyclus danckelmani	800-1800	[10]NE	F	181
Bicyclus simulacris	1300-2300	[5]NE	F	17
Bicyclus uzungwensis uzungwensis	1900-2400	E	F	8
Bicyclus sp.				59
Gnophodes betsimena diversa	0-2000		×	9
Henotesia cf simonsii	400-2000		O	1
Neocoenyra heckmanni uzungwae	1300-2300	(E)	O	17
Unknown (1 species)				4

*KEY to NE: [1]NE= Ulugurus & Udzungwa Mts.; [2]NE= Udzungwa, Ukaguru & Rubeho Mts.; [3]NE= Udzungwa & Tukuyu; [4]NE= Southern Highlands to Ulugurus; [5]NE= Malawi, Southern Tanzania; [6]NE= Eastern Arc Mts.; [7]NE= Eastern Arc & Northern Malawi; [8]NE= Udzungwa, Uluguru, Nguru to Tukuyu; [9]NE= Rungwe to Udzungwa; [10]NE= Southern Highlands to Udzungwa Mts.

The genus *Bicyclus* accounted for 39% of all butterflies caught, and was present at 13 of the 14 trapsites (absent from trapsite 1). *Bicyclus* was the most common and widespread genus.

At the species level, only one Udzungwa endemic was recorded by this survey; *Bicyclus uzungwensis uzungwensis*. *B. u. uzungwensis* is confined to the high forests of WKSFR. There are a further three Udzungwa endemics at the subspecies level; *Acraea alicia uzungwae, Belenois margaritaceae intermedia,* and *Neocoenyra heckmanni uzungwae*. All three have altitudinal ranges that start above 1100m a.s.l. (see **Table 7.12B**). However, only

B. m. intermedia is forest dependent. Six near-endemic species were recorded, of which five were forest-dependent species. A further 13 near-endemic subspecies were recorded by this survey, ten of which were forest-dependent.

Figure 7.12A shows the accumulation of species by trapsites (trapsites 1-10) within the forest blocks, ordered by date (July to December). The graph shows an initial gradual accumulation of species (till trapsite 7), followed by a marked increase in species at trapsite 8 and 9. The rate of increase appears to be levelling off by trapsite 10, but it is still increasing. The marked increases in species at trapsite 9 and 8 occur in late August and mid November, respectively. Both trapsites are situated in a riverine habitat, one near the forest edge (trapsite 9) and one a kilometre into the forest (trapsite 8).

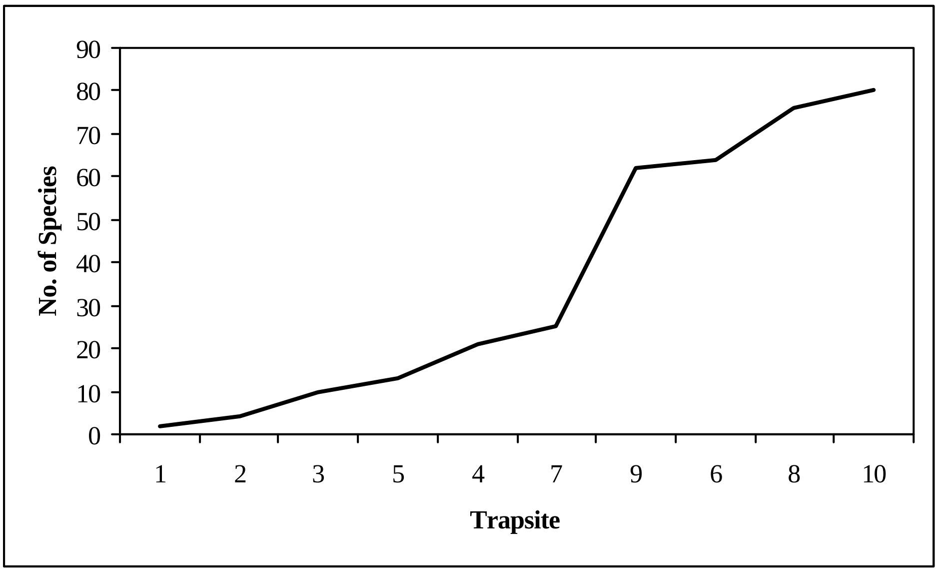


Figure 7.12A. Species accumulation curve of butterflies by trapsite (does not include casual collections).

Butterfly Distribution by Trapsite

The distribution of butterflies in terms of both numbers and species caught was not uniform across the reserve. Furthermore the distribution of forest dependent and limited range species also varied between trapsites. **Table 7.12C** highlights some patterns in distribution.

The mean number of individuals caught per trapsite is 40, and the mean number of species recorded at each trapsite is 11. The average number of species with limited ranges recorded at each trapsite is 2.6. The most individuals were caught at trapsite 8, while the most species and limited range species were recorded at trapsite 9.

Not surprisingly, trapsites within the evergreen forest blocks had a higher mean proportion of forest-dependants (56%), than trapsites outside (12%); and trapsites outside the evergreen forest recorded a higher mean proportion of open habitat species (15%), than those inside (5%).

Table 7.12C. Butterflies in relation to trapsites.

Trapsite+	Number caught	Number of families	Number of genera	Number of species	Percentage forest dependent species	Percentage non-forest species	No. of sub/species with limited ranges*
Outside forest blocks							
A	**13**	5	7	7	0%	14%	0
B	**39**	3	7	8	25%	13%	1
C	**27**	6	8	8	13%	13%	1
D	**33**	5	10	11	9%	18%	2
Evergreen forest							
1	**2**	2	2	2	50%	0%	0
2	**7**	2	2	2	50%	0%	1
3	**13**	3	3	6	67%	0%	2
4	**21**	7	8	12	67%	0%	3
5	**5**	3	4	4	75%	0%	1
6	**31**	5	9	12	17%	17%	4
7	**12**	6	8	8	63%	13%	3
8	**167**	8	15	19	63%	0%	5
9	**122**	8	32	45	40%	7%	12
10	**69**	3	11	13	69%	8%	2
Total	**672**	8	52	102	46%	15%	23

* Limited ranges refers to endemic and near-endemic species, as defined in **Box 7.12A**.
+ Note trapsites outside were sampled for four days, while evergreen forest trapsites were sampled for eight days.

Butterfly Trapping

Seventeen (possibly 18) species were caught in the butterfly traps (see **Appendix 7.12A**), of which 12 were forest-dependent. Six species were recorded at trapsites outside evergreen forest, and 14 (possibly 15) within. Four species (possibly five) were recorded in the Ndundulu forest block, and 12 (possibly 13) were recorded in the Nyumbanitu forest block. One species was recorded in all three areas, while three species were recorded in two of the areas.

As is apparent from **Appendix 7.12A**, few or no butterflies were caught in traps at trapsites A, C, D, 1, 2, 3, 4, 5 or 7. All these trapsites occurred during the July/August period. Traps set in the late-August and November period yielded more butterflies. Traps at trapsite 8 and 10 caught the highest number of individuals within the forest blocks (147 and 56 respectively), while trapsite B recorded the highest number of individuals outside forested areas. The picture is identical for species richness: seven species at trapsite 8; six species at trapsite 10; five species at trapsite B. All three of these trapsites (8, 10, B) occurred during November 2000.

Factors Affecting Butterfly Diversity

The number of species and individuals within WKSFR were tested for correlation with altitude and time of year. In performing the analysis, data from trapsites within evergreen forest was restricted to the first four days. The results highlight a decrease in the number of species with altitude. The picture is similar for altitude and number of individuals. However, both tests were not significant (Pearson Correlation: Species, $p = 0.074$, $r^2 = 0.242$, $n = 14$; Individuals, $p = 0.100$, $r^2 = 0.209$, $n = 14$). On the other hand, both the numbers of species and individuals had a positive association with time of year (progressing from July to December). The correlation between time of year and individuals was seen to be significant (Pearson Correlation: p=0.049, $r^2 = 0.285$, n =14). However, the correlation between species numbers and time of year was not significant (Pearson correlation: $p = 0.304$, $r^2 = 0.088$, n = 14).

7.12.5 Discussion

The distribution and diversity of butterfly species recorded by this survey have been affected by numerous factors. These factors range from the way butterfly data was collected to the way individual species distribution is dictated by their habitat requirements. The distribution and diversity of limited range species are of particular interest, as they tend to have narrower habitat requirements.

Data Collection
In trapping butterflies the bait used and its preparation are important. Throughout the survey period, bananas were used as bait. At the start of the survey period bananas were mashed up in the morning and placed in the traps in the afternoon. However, for the second period (November onwards), the mashed banana bait was left for six to eight days before use. This may be an important factor in the increased trapping success at trapsites 8, 10 and B.

Any trapping method will result in some species being over-represented, while others will be under represented. Species attracted to baited traps may be over-represented, as released specimens were not marked and a record was made of every capture (e.g. *Bicyclus danckelmani*). Species not attracted to the baited traps that are small and cryptically coloured or difficult to catch (e.g. high or fast flying species) may be under represented. During the timed sweep netting, it was common-practice to stop catching individuals of a species once the species had been recorded at a trapsite. This allowed for adequate species richness data, but poor abundance data.

As is clear from the species accumulation curve (**Fig. 7.12A**), there is a pronounced increase in species at trapsites 8 and 9, followed by a gradual levelling-off of the curve. The curve, however, has not levelled-off completely. This implies that there are still more species to add to the species list. However, it could be argued that the curve reflects the increase in species as a result of time of year (trapsites ordered by date) and decrease in altitude (lower altitude trapsites surveyed towards the end of the survey period).

Factors Influencing Butterfly Diversity
In explaining differences in butterfly assemblages at different sites, the most likely candidates are the associated level of habitat heterogeneity, climate and altitude (Daily & Ehrlich, 1995). The WKSFR trapsites have an altitudinal range of 930m, the highest being at 2070m a.s.l. while the lowest is at 1140m a.s.l.. Compared to other Eastern Arc forest reserves the span in altitude at WKSFR is quite pronounced. Based on butterfly species and individual data there appears to be a trend towards more species and individuals at lower altitudes.

Climatic conditions at the time of the survey are important in determining what species are recorded. It remained dry for most of the first half of the survey period, although sporadic showers occurred in August. However, during the second half of the survey period, heavy showers began on the 13th of November and continued into December. In the Udzungwa Mountains butterflies are most abundant from December to April (TANAPA, 1999). This is the wettest and warmest time of year. Trapsites 8, 10 and B were sampled during mid-November/early December, closest to this period. Trapsite B had the highest number of individuals caught outside the forest blocks, while trapsite 8 had the highest number of individuals caught within the forest blocks. At both trapsite 8 and 10 above average numbers of species were recorded. A dramatic increase in butterfly diversity was observed from late August onwards (trapsite 9). Furthermore, a significant correlation was noted between number of individuals caught at the various trapsites and time of year; more individuals were caught later in the year. It is advised that future studies trap at different trapsites simultaneously during the warmest and wettest time of year (December to April) to facilitate comparisons of the different trapsites or at one site for the whole year to allow contrasts between different annual climatic conditions.

Habitat heterogeneity and the availability of food plants will also have determined which butterfly communities were recorded at each trapsite. Larsen (1996) states that both sunlight and the presence of water are important for butterfly diversity. Accordingly, a large proportion of butterflies were caught in clearings near to water. Trapsite 9 especially, where the most butterfly species were recorded, was characterised by a fairly open canopy (10-50%) and the presence of a river (0-25m away). These habitat conditions, along with time of year (late August) and altitude (1140m a.s.l., an altitude within the range of 87% of all species recorded at WKSFR; from **Table 7.12B**) are thought to be the prime factors in explaining the high numbers of individuals and species at trapsite 9. Trapsites 4, 6, 10 and D all had relatively high species richness. Three of the trapsites are situated below 1550m a.s.l. (not trapsite D) and all are close to water (0-50m away). Conversely, trapsites 1 and 2 with low species richness were located above 1940m a.s.l., with no water nearby, and were surveyed in July.

Forest Dependence and Endemism

The Udzungwas have a high proportion of endemic montane species (of both open and forested habitats). De Jong & Congdon (1993) in a study of the uplands of eastern Africa, ranked the Udzungwas as third in terms of open habitat endemic species and sixth in terms of forest endemic species (based on the percentage of total number of taxa endemic to an area). This survey of WKSFR recorded one endemic species, three endemic subspecies, six near-endemic species, and thirteen near-endemic subspecies. Of these taxa with limited ranges, 78% are forest dependent and 43% restricted to areas above 1000m a.s.l.. In the eastern half of Africa the forests are mainly restricted to mountains and surrounded by savanna or even semi-desert (de Jong & Congdon, 1993). The greatest threat to these forest dependent montane species is the widespread reduction in forest size and quality, through a combination of fires, logging for timber, and clearance for agricultural purposes (Kielland, 1990).

One of the endemic subspecies recorded by this survey (*Neocoenyra heckmanni uzungwae*) is an open habitat montane species of grasslands. Such grassland species have different requirements to those of forest species (e.g. *Lepidochrysops* sp. feeds on a fire-dependent herb, therefore the species is dependent on the annual burning of the grassland; de Jong & Congdon, 1993). Open habitats are comparatively widespread, but for one factor or another these sub/species are limited in range to the Udzungwas. Therefore consideration should be given to their habitat requirements.

Evergreen Forest Block Trapsites Compared to Outside Trapsites

In comparing trapsites outside evergreen forest with those inside, several observations are apparent. Not surprisingly, forested areas had a higher mean proportion of forest-dependants, while trapsites outside the evergreen forest blocks recorded a higher mean proportion of open habitat species. Of interest is the high number of species recorded at trapsites placed near the forest edge (trapsite 6, 9, and 10). At this interface a mix of forest dependent, forest dwelling and non-forest species (as defined in **Box 7.12A**) were recorded. This suggests that these forest edge habitats are within the ecological ranges of a high proportion of butterflies, and therefore will support a high diversity of butterflies (as strikingly noted at trapsite 9).

Trapsites within the forest blocks also had a much higher proportion of limited range species (27%), than those outside (11%). This further highlights the conservation importance of WKSFR's forested areas.

Potential Altitudinal Range Extensions

Table 7.12D highlights some potential altitudinal range extensions, although it must be stressed that final verification of the identification of the below species has not yet been done.

Table 7.12D. Altitudinal range extensions

Species	Current altitude range (m a.s.l.)+	Altitude caught at (m a.s.l.)*
Acraea alicia cf. uzungwae	1500-2000	1150
Cf Anthene lasti	300-800	1400
Oboronia bueronica	250-1100	1150
Antanartia schaeneia dubia	1500-2700	1400
Salamis temora cf virescens	250-800	1200
Aphysoneura pigmentaria uzungwae	1700-2200	1200
Bicyclus simulacris	1300-2300	1150
Neocoenyra heckmanni uzungwae	1300-2300	1200

*Altitude caught at is the highest or lowest altitude the species was recorded at during this survey of WKSFR.
+ Altitudinal range from Kielland (1990).

The Udzungwa and Eastern Arc Mountains

The comparison of WKSFR with New Dabaga/Ulangambi Forest Reserve (NDUFR) highlights some striking differences. Fifty species were recorded from NDUFR, while 102 species were recorded from WKSFR (Frontier Tanzania, 2001e). Furthermore, 77% of individuals recorded at NDUFR can be attributed to the genus *Bicyclus*, as compared to only 39% in WKSFR. At NDUFR, no endemic species and two endemic subspecies were recorded, while at WKSFR one endemic species and three endemic subspecies were recorded. This marked difference in species richness and diversity may be influenced by the following interrelated facts:

- WKSFR covers a much larger area (104,296ha compared to 3,728ha) with a greater diversity of habitats.
- Trapsites at WKSFR covered a larger altitude range (930m compared to 200m), highlighting the comparative heterogeneous nature of WKSFR compared to NDUFR.
- Higher sampling intensity at WKSFR (4 four-day and 10 eight-day trapsites compared to 4 four-day and 5 eight-day trapsites).
- NDUFR has been subjected to a high level of past disturbance (logging and fire), while WKSFR has experienced only limited past disturbance. Hamer *et al*. (1997) noted an increase in species richness following logging due to an increase in suitable habitats for more species (i.e. more forest edge habitat). However, this increase in diversity was accompanied by a decrease in limited range forest species.

Comparing the WKSFR survey with three other similar surveys carried out by Frontier Tanzania in forest reserves in the East Usambara Mountains, it would appear that WKSFR has higher species richness (see **Table 7.12E**). The above explanation of the differences in species richness between WKSFR and NDUFR may also explain the differences between the East Usambara forest reserves and WKSFR.

Table 7.12E. Species richness in Eastern Arc Forest Reserves.

Forest Reserve & Location	Number of Species
West Kilombero Scarp F.R.; Udzungwa Mts.	102
New Dabaga/Ulangambi F.R.; Udzungwa Mts. (Frontier Tanzania, 2001e)	50
Mtai F.R.; East Usambara Mountains (Doggart *et al*., 1999a)	55
Manga F.R.; East Usambara Mountains (Doggart *et al.*, 1999b)	95
Semdoe F.R.; East Usambara Mountains (Doggart *et al*., 2001)	68

Management Requirements & Recommendation

In terms of butterfly diversity, this report makes the following recommendations:

- The greatest threat to butterfly diversity is the destruction of their habitats; this is especially true of forest dependent butterflies, as forested areas are comparatively limited. Schemes that seek to maintain WKSFR's forest habitat should be encouraged (for forest dependent species), whilst maintaining a mosaic of other habitats (for overall butterfly diversity).

- Fires should be limited to create more forest edge/shrub areas, and minimise the abrupt forest/grassland interface that is characteristic of fire affected areas. This should lead to a greater diversity of food plants and therefore butterfly species (as was noted at trapsite 9).

- To increase the biodiversity value of the area a system of forested corridors connecting the large forest blocks should be investigated. Corridors are of more importance in maintaining forest dependent butterfly diversity than patches; Daily & Ehrlich (1995) observed that "even recently isolated fragments of primary forest in the 3-30ha size range with average separation distances of 0.5-1.0km do not retain appreciable butterfly species richness or diversity." Furthermore, forested corridors would increase the amount of forest edge/shrub area, and therefore should benefit overall butterfly diversity.

- Butterflies offer the potential for a rapid appraisal of forest biodiversity and quality (Scoble, 1992). However, more study is required to establish a working model. Furthermore, there are many open habitat endemic butterflies in the Udzungwas, more research is needed into their requirements. This would allow for better informed management decisions.

7.12.6 Conclusion

This survey of WKSFR recorded butterflies from eight families, 52 genera and 102 species. As seen from the species accumulation curve, species are still to be recorded. WKSFR has high butterfly species richness, representing 7% of Tanzania's butterfly species.

Three factors were thought to be important in determining butterfly assemblages; altitude, time of year, and habitat variability. A significant positive correlation was noted between time of year and number of individuals caught. This suggests that more butterflies would be recorded if sampling continued into the warmest and wettest time of year (i.e. December to April). The highest number of species was recorded at trapsite 9 (45 species recorded), a trapsite near the forest edge characterised by a fairly open canopy (10-50%) and stream nearby (0-25m).

47 species recorded by this survey were forest dependent, while 78% of limited range species were forest dependent. This highlights the importance of reserve's forested areas. The variety of habitats in WKSFR has led to the high diversity of butterflies recorded during this survey, which stresses the importance of maintaining the mosaic of habitats found within the reserve.

Frontier-Tanzania Udzungwa Mountains Biodiversity Survey

West Kilombero Scarp Forest Reserve

8 Galago Report by Visiting Researcher

8.0 A Field Study on the Conservation Status and Species Diversity of Galagos in the West Kilombero Scarp Forest Reserve, November - December 1999.

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8.1 Summary

Ten days field work (from 26/22 – 11/12/1999) were spent with the Frontier Tanzania field project team in the West Kilombero Scarp Forest Reserve, Udzungwa Mountains, Iringa Region. This galago survey is part of a larger study on the biogeography and conservation status of galagos in the Eastern Arc Mountains and Coastal forests of Tanzania. Two forests Nyumbanitu and Ukami, within the West Kilombero Scarp Forest Reserve were visited. Two species of galago were seen and heard. The first species is probably the mountain galago *Galagoides orinus*, which was seen and heard briefly in Nyumbanitu forest. The uncertainty in the identification is due a lack of sightings and calls heard. The second galago species recorded was the Matundu galago *Galagoides udzungwensis*, which was seen and heard in riverine woodland on the edge of Ukami forest. Further research is recommended to ascertain the identity of the galago occurring in Nyumbanitu forest.

8.2 Introduction

Galago taxonomy is now undergoing some radical changes due to the way we now recognise this group of primates. Galagos, or bushbabies as they are sometimes known, occur only in Africa. They are nocturnal cryptic species, which means identifying them in the field from morphological characteristics is difficult. Recent research indicates that the number of 'species' may be underestimated when the differences in vocalizations, reproductive anatomy and genetics are considered. Traditional treatments of galago taxonomy have been based on long-established techniques of measuring relative anatomy largely based on museum collections (see **Table 8.1**).

Table 8.1. Changes in galago taxonomy at the species level by various authors.

Genus/ Author	**Schwartz (1931)**	**Napier & Napier(1967)**	**Groves (1974)**	**Olson (1979)**	**Fleagle (1988)**
Otolemur				*crassicaudatus garnetti*	*crassicaudatus garnetti*
Euoticus	*Elegantulus*		*elegantulus*		*elegantulus matshei*
Galago	*Crassicaudatus Senegalensis Alleni Demidovii*	*crassicaudatus senegalensis alleni elegantulus inustus demidovii*	*crassicaudatus senegalensis zanzibaricus inustus alleni demidovii*	*senegalensis gallarum moholi elegantulus matshei*	*senegalensis gallarum moholi*
Galagoides				*demidoff thomasi zanzibaricus alleni*	*demidoff thomasi zanzibaricus alleni*
No. Species	5	6	7	11	11

Data from field studies of galagos, has shown that anatomical differences alone could not explain the diversity of cryptomorphic galago forms. Populations that were apparently anatomically very similar were noted to be diverse in terms of vocalizations, behaviour and habitat use (Courtney & Bearder, 1989; Nash *et al.*, 1989). Galagos have been found to have very sensitive black and white vision and olfactory senses. Galagos therefore have not evolved colourful pelages such as the daytime monkeys or noticeable sexual dimorphism, but instead rely much more on olfactory and vocal communication (Bearder *et al.*, 1995). Thus isolated populations may develop divergent vocal and olfactory 'repertoires' that may ultimately become a barrier to successful breeding between the populations (Paterson, 1985; Zimmerman *et al.*, 1988). For this reason and for practical reasons the current study initially identifies galago populations in the field primarily on the basis of their calls and noting of behavioural differences. This data is then compared with morphometric and genetic analyses.

The most recent study (Honess and Bearder, 1996) using these new methods, has resulted in several changes in galago classification within the genus *Galagoides* which affects Tanzanian and East African 'dwarf galago' species composition (see **Table 8.2**).

Table 8.2. Taxonomic changes that include elevations from sub-species to species, renaming of full species and the discovery of new species.

Previous species name	Honess and Bearder (1996)	Kingdon (1997)
Galagoides demidoff orinus (Olson, 1979)	*Galagoides orinus*	*Galagoides* species nov.? o*rinus*?
Galagoides demidoff *	*Galagoides rondoensis*	*Galagoides rondoensis*
	Galagoides udzungwensis	*Galagoides udzungwensis*
Galagoides zanzibaricus grant (Olson, 1979)	*Galagoides granti*	*Galagoides granti*

* - This represents the *Galagoides* specimens collected at the Rondo plateau (Hayman, *in litt*.) in south Tanzania in the 1950's that were named as *Galagoides demidovii* (also renamed as *Galagoides demidovii orinus* by Jenkins, 1987).

Using these new and complimentary methods of identifying species there will possibly be more discoveries and taxonomy changes. This is largely due of the lack of survey effort, especially in isolated forests such as those of the Eastern Arc Mountains. The East African dwarf galagos in particular have been suggested to be a group of mammals that are relictual populations insensitive to the evolutionary pressures of habitat isolation and change (Burgess *et al.*, 1998). One of the priorities of this type of research, is to describe species in terms of vocalizations, DNA and behaviour at species type localities, and then compare data from museum collections and different populations.

8.3 Previous Galago Research in the Udzungwas.

Historically the lowland forests of the Udzungwa Mountains are important as the type locality of the Matundu galago *Galagoides udzungwensis* that was described by Honess (1996) from Matundu forest reserve. Honess (1996) conducted extensive research in the lowland forests of Matundu Forest Reserve. Work conducted by Butynski *et al*., (1998) covered some of the sub-montane and montane forests in the Udzungwa National Park where *G. orinus was* recorded for the first time in the Udzungwa Mountains. A galago specimen collected by J. Fjeldså (*pers. comm*.) from West Kilombero Scarp Forest Reserve is as yet unidentified, but is probably a *G. orinus.* The galagos known to occur in the Udzungwa mountains are shown below (Honess (1996) provides further details these species as well as the other Tanzanian galagos).

The Small Eared Greater or Garnett's Galago *Otolemur garnetti.*

This species is known to have a wide distribution in the coastal forests of eastern Africa, the Eastern Arc mountains, several inland volcanic mountains such as Kilimanjaro, the Kenya highlands, and extending down into the Livingstone Mountains and northern Malawi (Jenkins 1987; Nash *et al*, 1989; Kingdon 1997). *O. garnetti* is known to adapt to a wide variety of habitats from montane to sub-montane to lowland forests as well as plantations and 'shambas'. However, *O. garnetti* does seem to be restricted to evergreen vegetation types and occurs sympatrically with the Large Eared Greater Galago *O. crassicaudatus*, which has a wider distribution in the drier miombo and acacia woodland habitat of east and southern Africa (Kingdon, 1997). *O. crassicaudatus* was recorded around New Dabaga/Ulangambi Forest Reserve by Frontier Tanzania, but have not been recorded in West Kilombero Scarp Forest Reserve or Matundu Forest Reserve (Frontier Tanzania, 2001e; Butynski *et al*., 1998; Honess, 1996). Garnett's galago conservation status is considered "not threatened" IUCN (2000).

The Matundu Galago *Galagoides udzungwensis/zanzibaricus.*

G. udzungwensis has only recently been described from the Matundu Forest Reserve in the Udzungwa Mountains (Honess & Bearder, 1996). Some question marks have however been raised about the taxonomic validity of *G. udzungwensis* since this species has been observed to be very similar in terms of vocalizations and morphology, to the Zanzibar galago *G. zanzibaricus* (Perkin, 1998). The Matundu galago is named the Matundu or the Zanzibar galago *Galagoides zanzibaricus* in the IUCN Red List (2000). For the purposes of this report this species will referred to as *Galagoides zanzibaricus.* Using the IUCN (Hilton-Taylor, 2000) criteria, *G. zanzibaricus* is considered "Lower Risk/ Near Threatened". This species is known to occur in the lowland moist forests of the Udzungwa, Uluguru, and the East Usambara Mountains as well as the coastal forests of Unguja Island (Zanzibar), Pugu-Kasimzungwe, Zareninge and Msumbugwe FR (*pers. obs.*). This species has a distinctive advertising call the 'single unit rolling call'.

The Mountain Galago *Galagoides orinus.*

The mountain galago was originally described by Lawrence and Washburn (1936) as *Galagoides demidovii orinus,* a subspecies of Demidoff's galago *G. demidovii* that occur in the West African and Congolean rainforest ecosystems. The common name 'mountain galago' was first given by Olson (1979) who conducted the most recent taxonomic review of Galagos. This discovery was based on a single specimen from Uluguru North Forest Reserve in the Uluguru mountains by Loveridge on the 17th September 1926 and later described by Lawrence and Washburn (1936).

Recent research (Honess and Bearder, 1996) resulted in the elevation from the subspecies, *G. demidoff orinus* to full species, *G. orinus* (see **Table 8.2**) largely on the basis of differences in the vocalizations of each form. The homologous call of Demidoff's galago *G. demidoff* has a distinct and 'a highly complex crescendo structure' (Bearder *et al*., 1995, Zimmerman *et al*., 1988) as opposed to the calls of the mountain form described by Honess and Bearder (1996) as 'simple descending whistle' and a 'scaling call'.

8.4 Aims

1. To identify the species of galago occurring the some of the forests in West Kilombero Scarp Forest Reserve.

2. To obtain data to further assess the population and the conservation status of the Mountain Galago *Galagoides orinus.*

3. To obtain data on any other nocturnal mammal, bird or herpetological fauna where possible.

8.5 Methods

1. *Tape Recordings*

Galagos can most easily be identified in the field from their vocalizations. Most galagos make between four and eight different loud calls that are uttered singly or in combination. The various types of calls made depend on the behavioural status of the animal. Calls that signify the presence of one animal to another are known as advertising calls. Other calls mainly signify various states of alarm and possibly curiosity. For the purposes of species identification the advertising calls are of most interest as they are species specific whereas the alarm calls show some degrees of similarity in structure.

Tape recordings are made with a Sony WM-C6C tape recorder and Senheiser MKE-300 directional microphone. All galago calls and calls of owls, hyrax and other mammals are also recorded. Vocalisation data is analysed by a computerised digital sound analyser and compared with a library of calls of other galagos species held at the Nocturnal Primate Research Group, Oxford Brookes University, UK.

2. *Observations*

Observations are made with the aid of a Petzel headtorch with a halogen bulb. This torch picks out eyeshine that is reflected by nocturnal mammals. Once eyeshine is spotted, a four cell Maglite torch is used with binoculars (Zeiss DDR Jenoptem 10x50W), to obtain close up observations of the animal(s). Notes are made of the height of the animals in the canopy, support use, general behaviour and animal interactions.

3. *Trap Data*

Chardonneret traps baited with fruit are used to capture galagos alive. Traps are checked every 4-6 hours, and animals are extracted by hand without the need for anaesthesure. Biometric measurements are conducted and tissue samples (from the ear using a biopsy punch and stored in 90% ethanol) are collected for genetic analysis (see Bayes, 1998). Other means that have ‘accidentally’ caught dwarf galagos are; mist nets set for bats and owls, and Sherman traps baited with peanut butter and coconut set for capturing rodents and shrews. The large amounts of net hours or trap nights required to trap galagos often make these methods unpractical.

4. *Population and Ecological Data*

Night walks are conducted along pre-existing paths where possible to reduce noise and disturbance. Galago sightings and/or calls are noted but no particular time is set to complete the survey over a certain distance. From this, relative densities are estimated by counting the number of galagos encountered over a measured distance. Given a known distance from the path within which animals can be counted reliably it is possible to estimate the number animals within the area. For bushbabies this figure is approximately 30 meters either side of the path making the survey area along a 100 meter path equal to 6000 meters square. Encounter rates per hour can also give an indicator of relative animal densities as well as activity rates under variable weather conditions and moon phases. Due to variation in animal activity the accuracy of these methods may not be high.

5. *Any Other Data.*

Other data collected opportunistically includes; galago hairs, faeces and locating tree holes or nests where the animals may live during the daytime.

8.6 Results

The fieldwork revealed that at two sites in Nyumbanitu forest an animal resembling the mountain galago *Galagoides orinus,* was recorded. In Ukami forest the Matundu galago was recorded. Garnett's galago *Otolemur garnetti* was not recorded at either site. Data collection was hindered by the reluctance of the game guards to walk after 20.00hours. Therefore much survey data was collected opportunistically around campsites.

Nyumbanitu Forest

1. A Description of the Galago based on Field Observations.

Small galagos *Galagoides* sp. estimated to be between 80-120 grams with a head and body measurement of 12-14cm and the tail 14-16cm were observed well on only one occasion. These animals appeared to be cinnamon brown on the top of the dorsum and flanks with a slight orange brown tinge on the shoulders and thighs. The tail morphology was generally completely uniform in length then becoming bushy towards the end and with the fur the same colour as the dorsum apart from a darkening towards the tip.

2. *Ecological, Behavioural and Population Data.*

The 'dwarf galagos' observed and recorded were generally between 2 and 8 meters above the ground. Animals were seen to use a variety of supports from small vine tangles at less than 1cm in diameter to tree trunks more than forty centimetres in diameter. The average encounter rate was only 0.5 animals per hour.

3. Vocalizations.

The animal *Galagoides* sp. was heard rarely, but calls heard resemble those of *G. orinus*, however this does require confirmation. The loud calls are described below and the context in which they were (possibly) made is noted (see **Table 8.3**). The names given to the calls have already been used for describing the vocal repertoires of *Galagoides* species (Bearder *et al.*, 1995; Honess & Bearder, 1996).

Table 8.3. Name of each call type, description and an attempt to assign the context within which each call was given.

Name of call	Description
'Double unit call'	The double unit call is comprised of two soft units: the first unit made at a higher pitch than the second and uttered in a series up to six times at a regular tempo to form a phrase. This is probably the call Honess (1996) describes as the repetitive call but the call heard in the Udzungwa Mountains differs due the altering pitch levels. This call was heard only once for a short period, so categorising this call was inconclusive.
'Descending screeches and yaps'	This call is a mixture of phrases and screeches linked in between by yaps (very short high-pitched units) made at a constant volume regularity. Yaps may be uttered for more than a minute before breaking into screeches which only last between five to ten seconds. The whole calling bout may last between five minutes to over one hour! This call is used in intense alarm situations for example when a potential predator is spotted. This call was heard throughout the night but not heard at dawn or dusk
'Yaps'	Very short high pitch dog-like unit. This call is usually uttered in series and in conjunction with other calls like screeches and buzzes.
'High pitch squeaks'	These are very high pitch calls uttered singly or in series of two to three units or breaking into screeches. Often heard high up in the canopy. It is unclear in what behavioural context this is made.

Ukami Forest

No galagos were recorded inside the forest itself. The Matundu galago was however recorded on the forest edge in riverine forest and was identified by their calls. Two calls were most commonly heard, a) The distinctive advertisement call made by the Matundu animal called the 'single unit rolling call' was qualitatively similar to the galago seen and heard during this study and b) The alarm call also made by the Matundu galago called 'yaps and descending screeches'.

8.7 Discussion

The identity of the small galago *Galagoides sp.* in Ndundulu needs confirming. This species is likely to be the mountain galago *Galagoides orinus.* The lack of call data hinders any further analysis and the low calling levels may be due to the season or the low survey effort. The encounter rate of 0.5 animals per hour is low compared to other areas such as the Ulugurus where up to nine animals per hour can be recorded. A specimen taken by J. Fjeldså (*pers. comm.*) from Ndundulu forest in a bamboo zone requires further examination to compare with the field observations.

A specimen (KMH22496) captured just outside New Dabaga/Ulangambi Forest Reserve in a village government forest and one captured in Kilanzi Kitungulu Forest Reserve (Helle Hansen *pers. comm.*), both approximately 40km west from West Kilombero Scarp FR in the Udzungwa Mountains, were provisionally identified as *G. orinus* (Frontier Tanzania, 2001e). Specimen KMH22496 was a male and allowed the first description of penile of *G. orinus* which is known to be an important tool for identifying galago species (Anderson, 1998). This and other data

(Butynski *et al.*, 1998; Honess, 1996) suggest that this species is quite widespread in the sub-montane and montane forests of the Udzungwa Mountains.

The IUCN (2000) conservation status of *G. orinus* is "data deficient". Butynski *et al.* (1998) has recommend this species to be considered "Endangered" using IUCN criteria. The data from this survey and others (Perkin, 2000; Frontier Tanzania, 2001e) supports the categorisation "Endangered".

The occurrence of the *G. zanzibaricus* in riverine thicket next to Ukami forest and not in the evergreen forest at just over 1000m in altitude represents an altitudinal range extension for this species. Also surprising is lack of any galago recorded from inside the Ukami forest. Further research at a different time of year may reveal the presence of other galagos in this forest.

Surprisingly *O. garnetti* was not found in these forests since they are known to occur in other sub-montane and montane forests (mainly as an edge species) in Tanzania, such as in the East Usambara Mountains, South Pare Mountains and Mount Kilimanjaro (Nash *et al.*, 1986; Perkin, unpubl.). Other researchers have not recorded *O. garnetti* in the Udzungwa Mountain forests either (Butynski *et al.*, 1998; Honess, 1996) suggesting this species is absent from this area which is contrary to the suggested range by Nash *et al.* (1986) and Kingdon (1997).

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9 References

9.0 References

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Personal Communication

Neil Baker, Ornithologist resident in Tanzania.
David Moyer, Representative of the World Conservation Society based in Iringa.
Helle Hansen, MSc student from the University of Copenhagen.

Frontier-Tanzania Udzungwa Mountains Biodiversity Survey

West Kilombero Scarp Forest Reserve

10 Appendices

Appendix 1: Taxonomic Verification

Botany:

Dr. K. Vollesen	Kew Botanical Gardens	Kew, Richmond, Surrey, TW7 9AF, UK
Dr. R. E. Gereau	Missouri Botanical Gardens	P.O. Box 299, St. Louis, Missouri 63166-0299, USA
Dr P. Phillipson	Botany Department	Rhodes University, Grahamstown, South Arica.
Mr. F. Mbago	Department of Botany	University of Dar es Salaam, P.O. Box 35060, Dar es Salaam, Tanzania
Mr H. Ndangalasi	PhD Student	University of Dar es Salaam, P.O. Box 35060, Dar es Salaam, Tanzania
Mr B. Mhoro	Independent botanist	Dar es Salaam

Zoology:

Bats and Small mammals.

Prof. K. Howell	Department of Zoology and Marine Biology	University of Dar es Salaam, P.O. Box 35064, Dar es Salaam, Tanzania
Mr. W. Stanley	Field Museum Natural History	60605-24996 Roosevelt Road, Chicago, Illinois, USA
Dr. D. Kock	Frankfurt Zoological Museum	Saugetiere III, Senckenberg, Senckenberganlage 25, 60325 Frankfurt am Main, Germany

Amphibians

Prof. K. Howell	Department of Zoology and	University of Dar es Salaam, P.O. Box
Mr. C. Msuya	Marine Biology	35064, Dar es Salaam, Tanzania
Prof. J. Poynton	Natural History Museum	Cromwell Road, London, SW3, UK.
Dr. B. Clarke	Natural History Museum	Cromwell Road, London, SW3, UK.
Dr. M. Wilkinson	Natural History Museum	Cromwell Road, London, SW3, UK.

Reptiles

Prof. K. Howell	Department of Zoology and Marine Biology	University of Dar es Salaam , P.O. Box 35064, Dar es Salaam, Tanzania
Dr. J. Rasmussen	Zoological Museum	University of Copenhagen, Universitetsparken 15, DK-2100, Copenhagen, Denmark
Dr. D. Broadley	The Natural History Museum of Zimbabwe	P.O. Box 240, Bulawayo, Zimbabwe

Zoology – Invertebrates:

Millipedes and Mollusca

C/O Dr. N Scharff	Zoological Museum	University of Copenhagen, Universitetsparken 15, DK-2100, Copenhagen, Denmark

Butterflies

C/o Dr. N Scharff	Zoological Museum	University of Copenhagen, Universitetsparken 15, DK-2100, Copenhagen, Denmark
Mr S. Collins	African Butterfly Research Institute	P.O. Box 14308, Nairobi, Kenya Collinsabri@iconnect.co.ke

Appendix 7.1A. The division of the report.

Section	Groups	Method employed*	Taxonomic nomenclature followed~	Specimen deposited+
7.2	Small Mammals	Sherman traps, mesh traps, and bucket pitfall traps.	Kingdon (1997)	FMNH & UDSM
7.3	Bats	Mist nets.	Kingdon (1997)	FMNH & UDSM
7.4	Hyrax	Circular plot counts.	Kingdon (1997)	FZM
7.5	Large Mammals	Fixed area search and line intersect survey.	Kingdon (1997)	FZM
7.6	Monkeys	Transect counts.	Butynski *et al*. (1998)	FZM
7.7	Birds	Casual observations.	Zimmerman *et al*. (1996)	-
7.8	Reptiles	Bucket pitfall traps.	Broadley & Howell (1991)	ZMUC, UDSM, & NHMZ
7.9	Amphibians	Bucket pitfall traps.	Howell (1993)	NHM & UDSM
7.10	Mollusc	1m x 1m quadrats and timed searches.	Identified to morpho-species groups.	ZMUC
7.11	Millipedes	3m x 3m quadrats and timed searches.	Identified to morph0-species groups.	ZMUC
7.12	Butterflies	Baited butterfly traps and timed sweep netting.	Kielland (1990)	ZMUC, to be forwarded to ABRI.

* It should be noted that opportunistic collections also occurred within all taxa.

~ Taxonomic nomenclature primarily follows the authors listed in the column, however, nomenclature of certain species may be based on new evidence from other authors, as stated in each section.

+ Institution codes: UDSM (Department of Zoology and Marine Biology, University of Dar es Salaam), FMNH (Field Museum Natural History, Chicago, USA), FZM (Frankfurt Zoological Museum, Germany), ZMUC (Zoological Museum University of Copenhagen, Denmark), ABRI (African Butterfly Research Institute, Nairobi, Kenya), NHMZ (Natural History Museum of Zimbabwe), NHM (Natural History Museum, London).

Appendix 7.1B. English/Latin, Kiswahili and Kihehe names of mammals found in the and around West Kilombero Scarp and New Dabaga/Ulangambi Forest Reserves. The names were obtained through interviews with Janes Mdanga and Junus Kivike from Udekwa, John Chahe from Ifuwa, Lactali Mmehwa from Kidabaga and Lukas Myovela from Ilamba. Two lists are presented: one of larger mammals and one of small mammals encountered during trapping activities.

Large mammals

English name	**Kiswahili**	**Kihehe**
Aardvark	Muhanga	Nyamsowo
Abbot's duiker		Vinde
African civet	Fungo	Fungofungo
African clawless otter	Fisi maji	Fusi
African dormouse		Kimdere
African palm civet		Lisekelangombe / Mbogasebatwa
Baboon	Nyani	Muuma
Black and white colobus	Mbega mweusi	Mbega
Blue duiker	Digidigi	Nyalusi
Blue monkey		Ndumbili
Buffalo	Nyati	Mbogo
Bushbuck	Mbawala	Mato
Bush pig	Nguruwe	Ngubi
Bushy-tailed mongoose	Kitu	Nyakwela
Cane rat		Senzi
Caracal		Nguami
Chequered elephant shrew		Kisaangi
Crested porcupine	Nungu	Nungunungu
Eland	Pofu	Nongolo
Elephant	Tembo	Ndembo
Four toed elephant shrew		Kidoonge
Fox-like animal		Ngeve
Giant pouched rat	Panya buku	Kimuhili
Greater galago		Kipwege
Greater Kudu	Tandala	Sikilo
Hare	Sungura	Sungula
Hippopotamus	Kiboko	Kibogo
Honey badger	Nyegere	Magongo
Hyena	Fisi	Sakanga
Klipspringer	Mbuzi mavi	Ngulugulu
Bat (large)		Ngombelema
Leopard	Chui	Duma
Lesser galago		Kafuetete
Lion	Simba	Nyalupala
Pangolin	Kakakuona	Ngakaka
Red colobus	Mbega mwekundu	Nguluva
Red duiker		Funo
Rhinoceros	Kifaru	Mela
Sanje crested mangabey		Ngolaga
Servaline genet	Kanu	Kikanu
Slender mongoose		Kimunegu
Bat (small)		Kibudibudi
Squirrel		Kihindi
Suni	Suni	Kisimba
Tree hyrax	Pimbi	Miimbi
Vervet monkey	Ngedere	Ngedege
Warthog	Ngiri	Ngiri
Zanj elephant shrew	Kisangi	Kidoonge

Continued below……

Appendix 7.1B continued.

Small mammals	
Latin name	**Kihehe**
Mus sp.	Kibunda
Dendromys sp.	Kimwalunande
Tatera sp.	Ngombwe
Grammomys sp. (incl. *Praomys sp.* and *Hylomyscus sp.*)	Ngonilolo
Beamys hindei	Ngwimu
Lophuromys flavopunctatus	Nyakihuku
Rhabdomys pumilio	Piage
Shrews in general	Kinyuunga

Appendix 7.1C. Location of trapsites

Grid reference	Trapsite	Frontier field names	Botanical Plot Numbers	Local name of site	Trap days
36°26'51.0"E 07°45'39.2"S	A	Miombo	A	-	4
36°26'37.4"E 07°45'34.2"S	B	Acacia	B	-	4
36°26'50.0"E 07°45'39.2"S	C	Riverine	C	-	4
36°29'49.0"E 07°46'02.7"S	D	Luala Grassland/Little Simba	-	Luala	4
36°29'01.5"E 07°45'15.8"S	1	Tembo/Hagenia	5 Ndundulu	Chawemba	8
36°29'49.0"E 07°46'02.0"S	2	Bamboo (Close to Luala)	- Ndundulu	Machas (mountain south of bamboo trapsite)	8
36°28'23.0"E 07°48'39.0"S	3	Nyati	20 Ndundulu	Kingiro (river at Nyati camp)	8
36°30'17.2"E 07°48'29.7"S	4	Chura	24 Ndundulu	Vikongwa (stream at Chura)	8
36°28'20.6"E 07°50'02.6"S	5	Wadudu/Cola	27 Ndundulu	Egumuka (rock peak near Wadudu camp) or Tagalohelo	8
36°25'18.8"E 07°48'53.4"S	6	Firefly/Kimulimuli	1 Nyumbanitu	Ilengwe (spiritual site nearby)	8
36°23'30.7"E 07°44'47.2"S	7	Pimbi/Hyrax	- Nyumbanitu	Wanganemo (stream at Pimbi camp)	8
36°22'17.6"E 07°50'38.4"S	8	Paradiso	8 Nyumbanitu	Lulalue (name of river, upstream from trapsite 9)	8
36°22'56.4"E 07°52'00.1"S	9	Butterfly Falls/Fisi Maji Large waterfall	-	Lulalue	8
36°23'11.6"E 07°53'19.5"S	10	Ukami/Plot 17	17 Ukami	Ukami (name of forest fragment)	8
36°26'51.0"E 07°46'46.0"S	-	Chui Main Camp	-	Msula (rock peak above Chui camp)	-

Appendix 7.2A. Number of small mammal species recorded for each trapsite in WKSFR during bucket pitfall and Sherman trap surveys. Trapsites 1-10 in evergreen forest were surveyed for eight nights and trapsites A-D in non-evergreen forest habitats for four nights.

Species	1	2	3	4	5	6	7	8	9	10	A	B	C	D
Rodentia and Macroscelidae														
Beamys hindei			1	1					1	6				
Dendromys sp.	8		2				1	1	1		5	2	1	
Dasymys incomptus							1							2
Grammomys sp.	?	A	?	?	+	?	?	A	+	3	A	3	A	?
Graphiurus sp.											1			
Hylomyscus denniae	?	1	+	+	?	+	+	4	+	42	A	A	A	?
Lophuromys flavopunctatus	5		2	3	1	2			9	2		3	1	8
Lemniscomys griselda											1	2		
Mus bufo					2		3							
Mus minutoides/musculoides					1									
Mus sp.		1	1	1	1	11		3	10	6	8	15		7
Praomys delectorum	+	2	+	+	+	+	+	22	+	23	7	A	A	?
Petrodromus tetradactylus				1*			1*	1*			2*			
Rhabdomys pumilio														7
Praomys group	41	3	69	9	36	52	8	26	42	68	7	3		1
Soricidae														
Crocidura hildegardeae				7		10	3		5					2
Crocidura monax							3							
Crocidura olivieri													1	
Crocidura sp.	1	3			3	4		27	8	25		11		
Myosorex kihaulei		1		1		1	3							
Myosorex sp.	1	3	1											1
Sylvisorex sp.										1		2		
Unidentified shrews	9		16		9			9		5	3	9	2	2

A - Absent, species not found at this trapsite as all *Praomys* group individuals were collected and no individuals of this species were identified.
+ - Present, individuals collected
? - Presence possible but not certain
Numbers - Sherman trap and bucket pitfall captures of unique individuals

Appendix 7.2B. Results from 4 days of trapping, including number of unique individuals and trap-rate for rodents and shrews caught in Sherman traps and bucket pitfalls. Results are listed separately for evergreen forest trapsites (1-10) and other habitats (A-D).

	Number of unique rodents				Number of unique shrews			
Trapsite	Sherman traps	Bucket pitfalls	Per 100 trap nights	Per 33 bucket nights	Sherman traps	Bucket pitfalls	Per 100 trap nights	Per 33 bucket nights
1	16	4	4.05	1.00	1	9	0.25	2.25
2	3	0	0.75	0.00	0	5	0.00	1.25
3	43	6	13.35	1.50	0	17	0.00	4.25
4	7	0	1.83	0.00	0	6	0.00	1.50
5	27	4	6.98	1.00	0	12	0.00	3.00
6	36	2	9.73	0.50	1	12	0.27	3.00
7	4	2	0.96	0.50	0	7	0.00	1.75
8*	9	3	2.41	0.75	0	13	0.00	3.25
9	23	5	5.60	1.25	2	10	0.49	2.50
10*	32	9	11.35	2.25	1	18	0.35	4.50
Total	200	35	5.35	0.88	5	109	0.13	2.73
A	8	15	2.30	1.88	1	2	0.23	0.25
B*	19	5	5.14	0.63	2	20	0.54	2.50
C	1	1	0.25	0.13	2	1	0.50	0.13
D	23	1	5.64	0.13	2	3	0.49	0.38
Total	53	22	3.28	1.38	7	26	0.43	1.63

* - Surveyed during the small rainy season mid-November to December 2000.

Appendix 7.2C. Results from eight days of trapping in evergreen forest areas. Listed are the number of unique individuals and trap-rate for rodents and shrews caught in Sherman traps and bucket pitfalls.

	Number of unique rodents				Number of unique shrews			
Trapsite	Sherman traps	Bucket pitfalls	Per 100 trap nights	Per 33 bucket nights	Sherman traps	Bucket pitfalls	Per 100 trap nights	Per 33 bucket nights
1	48	7	6.05	0.88	2	9	0.25	1.13
2	4	0	0.50	0.00	0	7	0.00	0.88
3	65	10	10.00	1.25	0	17	0.00	2.13
4	14	0	1.91	0.00	0	8	0.00	1.00
5	35	6	4.66	0.75	0	12	0.00	1.50
6	60	4	8.44	0.50	2	13	0.28	1.63
7	8	5	0.96	0.63	0	9	0.00	1.13
8*	22	8	2.83	1.00	0	36	0.00	4.50
9	56	7	6.93	0.88	2	11	0.25	1.38
10*	60	23	10.56	2.88	1	30	0.18	3.75
Total	372	70	5.01	0.88	7	152	0.09	1.90

* - Surveyed during the small rainy season mid-November to December 2000.

Appendix 7.4A. Results of one hour circular plot counts of eastern tree hyrax calls in WKSFR.

Site	Minimum number of individuals	Type A calls	Type B calls	Type C calls	Time start	Time end	Day	Month	Year
1	4	62	1	0	19:03	20:03	18	07	2000
1	5	39	3	2	18:50	19:50	20	07	2000
1	5	43	0	0	19:00	20:00	22	07	2000
2	7	19	1	3	19:09	20:09	26	07	2000
2	8	27	1	2	19:00	20:00	27	07	2000
2	10	55	4	1	19:05	20:05	28	07	2000
3	2	4	3	0	19:23	20:23	07	08	2000
3	8	39	0	0	19:00	20:00	08	08	2000
3	4	8	0	1	19:25	20:25	09	08	2000
4	5	16	2	3	19:13	20:13	15	08	2000
4	3	8	1	2	19:13	20:13	17	08	2000
4	4	17	5	0	19:13	20:13	20	08	2000
5	3	14	3	0	19:00	20:00	07	08	2000
5	3	11	0	0	18:58	19:58	08	08	2000
5	4	19	3	0	19:11	20:11	09	08	2000
6	0	0	00	0			01	09	2000
7	10	56	5	7	18:59	19:59	17	08	2000
7	11	74	7	2	19:00	20:00	20	08	2000
7	12	64	13	4	19:01	20:01	22	08	2000
8	0	0	0	0	19:01	19:45	15	11	2000
8	1	5.2	0	0	19:27	19:50	17	11	2000
10	0	0	0	0			28	11	2000

Appendix 7.5A. List of mammal species recorded from WKSFR. Taxonomy follows Kingdon (1997) unless other is stated.

Species	Common name	Forest dependency	IUCN status	Endemism
PRIMATES				
Colobidae	*Procolobus gordonorum*	[a]F	VU	[1]NE
	Colobus angolensis palliatus	F	DD	
Cercopithecidae	*Papio cynocephalus*	×		
	Cercocebus galeritus sanjei^	F	(EN)	(E)
	Cercopithecus mitis	F		
Galagonidae	*Galagoides zanzibaricus*[#]	F	LR/nt	[2]NE
	Galogoides orinus	F	DD[+]	[2]NE
CHIROPTERA[∇]				
Pteropodidae	*Lissonycteris angolensis*	×		
Rhinolophidae	*Rhinolophus clivosus*	×		
	Rhinolophus simulator	×		
Hipposideridae	*Hipposideros ruber*	×		
Vespertilionidae	*Miniopterus* sp.	×		
	Myotis welwitschii	×		
	Pipistrellus sp.			
INSECTIVORA[∇]				
Soricidae	*Myosorex kihaulei*			E
	Crocidura hildegardeae	F		
	Crocidura monax		VU	
	Crocidura olivieri			
	Sylvisorex sp.			
MACROSCELIDEA				
Macroscelididae	*Petrodromys tetradactylus tetradactylus*			
	Petrodromus tetradactylus rovumae			
	*Rhynchocyon petersi**	F	EN	
RODENTIA				
Sciuridae	*Paraxerus lucifer lucifer**	F		
Myoxidae	*Graphiurus* sp.	×		
Hystricidae	*Hystrix* sp.	×		
Thryonomyidae	*Thryonomys* sp.*	O		
Dendromuridae	*Dendromys* sp.			
Cricetidae	*Beamys hindei*	F	VU	
	Cricetomys gambianus	×		
Muridae	*Lophuromys flavopunctatus*	F		
	Praomys delectorum	F		
	Hylomyscus denniae	×		
	Mus bufo	×		
	Mus minutoides / musculoides			
	Grammomys ibeanus			
	Dasymys incomptus	×	DD	
	Rhabdomys pumilio	O	DD	
	Lemniscomys griselda			
CARNIVORA				
Mustelidae	*Mellivora capensis*	O		
	Aonyx capensis	O		

Continued. . .

Appendix 7.5A continued.

Species	Common name	Forest dependency	IUCN status	Endemism
Herpestidae	*Atilax paludinosus*	O		
Hyaenidae	*Crocuta crocuta*	×	LR/cd	
Viverridae	*Genetta servalina lowei*	×		(E)
	Nandinia binotata arborea	F		
Felidae	*Panthera pardus*	×		
	Panthera leo	O	VU	
TUBULIDENTATA				
Orycteropodidae	*Orycteropus afer*	×		
HYRACOIDEA				
Procavidae	*Dendrohyrax validus*	×	VU	
PROBOSCIDEA				
Elephantidae	*Loxodonta africana*	×	EN	
ARTIODACTYLA				
Hippopotamidae	*Hippopotamus amphibius*	O		
Suidae	*Potamochoerus larvatus*	×		
Bovidae	*Syncerus caffer*	×	LR/cd	
	Tragelaphus scriptus	×		
	Neotragus moschatus°	×	LR/cd	
	Cephalophus harveyi	F	LR/cd	
	Cephalophus spadix	F	VU	NE

* - Not recorded by this study, but observed by Dinesen & Lehmberg (1996).

^ - Taxonomy unclear for the species, listed name is from Ehardt *et al.* (2000) who is currently working with primates in the Udzungwa Mountain National Park.

[#] - A new revision of the galago taxonomy has led to exclusion of the species *G. udzungwensis*, which now is included under *G. zanzibaricus* (Andrew Perkin, *pers. comm.*.). The common name used in this study will therefore be Zanzibar galago.

[+] - Based on IUCN criteria, present data suggests the species to be listed as "Vulnerable" (Andrew Perkin, *pers. comm.*)

° - Uncertainty of which of the two small forest antelopes are present in WKSFR. *Neotragus moschatus* was recorded in New Dabaga/Ulangambi Forest Reserve, but it is possible that *Cephalophus monticola* (blue duiker) is present in WKSFR. Further investigation is needed.

[∇] - Not all specimens identified.

Forest dependency: F = Forest specialist; × = Found in forest as well as other habitats; O = Normally regarded as a non-forest species. Based on Burgess *et al.* (2000) and Kingdon (1974 & 1997) unless other is stated; [a]= Kingdon & Howell (1993).

IUCN status: EN = endangered; VU = vulnerable; LR/nt = lower risk, near threatened; LR/cd = lower risk, conservation dependant; DD = data deficient. Taken from Hilton-Taylor (2000). Letters in brackets refer to subspecies.

Endemism: E = endemic to the Udzungwa Mountains; NE = near endemic, limited to Tanzania and Eastern Arc Mountains down to northern Malawi; W = widely distributed. Based on Kingdon (1997) unless other is stated; [1]= Ehardt *et al.* (2000); [2]= Andrew Perkin (*pers. comm.*). Letters in brackets refer to subspecies.

Appendix 7.6A. Monkey group counts and sightings of lone individuals in West Kilombero Scarp Forest Reserve. Some of these may be repeated counts of the same group (e.g. " * ").

Species	Date	Transect [distance from start point (m)]	Count	Accuracy
R	22/01/00	3 [2750]	33	[4] C
R	02/02/00	1 [1570]	11 (15)	NC
R	21/02/00	1 [220]	≥30	E
R	27/07/00	[5] *Hagenia – Neoboutonia*	33	[5] C
R	24/08/00	1 [800]	27 (>40)	NC
R	24/08/00	1 [2300]	12	C
R	24/08/00	1 [2800]	12	C
R	24/08/00	1 [430]	27 (30-40)*	NC
R	29/11/00	Ukami [1230]	35-50	E
R	04/12/00	1 [556]	20 (≥40)*	NC
R	06/12/00	1 [2010]	16	C
B&W	01/12/99	[6] Ny3 [1450]	≥9	~C
B&W	01/12/99	[6] Ny3 [980]	≥8	NC
B&W	08/12/99	Ny2 [225]	≥7	~C
B&W	22/01/00	3 [2750]	1	[4] C
B&W	02/02/00	1 [2150]	2	[3] C
B&W	21/02/00	1 [2660]	1	C
B&W	27/07/00	[5] *Hagenia – Neoboutonia*	11	[5] C
B&W	03/09/00	1 [20]	9	~C
B&W	04/12/00	1 [870]	9	C
B&W	06/12/00	1 [1298]	8 (≤11)	NC
B&W	08/12/00	1 [160]	12	C
S	25/08/00	1 [2780]	22	~C
S	July 2000	[2] Forest fragment	1	C
S	08/12/00	[1] Grassland	1	C

C = complete count, ~C = approximately complete count, NC = near complete count (estimate of group size given in parentheses), E = estimated.

[1] Seen bounding through grassland outside of forest near to beginning of transect '1'.

[2] Seen "pyow" calling from edge of small forest fragment 200m outside of Ndundulu forest.

[3] Mother with infant. More of same species >100m away.

[4] Mixed species group containing thirty-three reds plus one black and white colobus, in *Parinari excelsa* dominated forest.

[5] Mixed group containing thirty-three reds plus ~11 black and white colobus, in emergent *Neoboutonia macrocalyx* trees above *Hagenia abyssinica* dominated forest to immediate west of Luala grassland.

[6] Nyumbanitu forest, transect '3'.

Appendix 7.7A. List of non-forest dependent birds of no conservation concern from West Kilombero Scarp Forest Reserve. The list refers to birds recorded from all three of Ndundulu, Nyumbanitu and Ukami forests as well as from the area of wooded grassland stretching from Udekwa village and southwards to the Ukami forest fragment. Observations were made by Messrs. Lars Dinesen, Thomas Lehmberg, J. Otto Svendsen and Louis A. Hansen between 1991 and 1995, unless otherwise stated. See foot of table for explanation of codes.

Common name	Genus	Species and subspecies	Forest species*	CITES §
PELECANIFORMES				
Great/ eastern white pelican (flying only)	*Pelecanus*	*onocrotalus*	O	
CICONIIFORMES				
Yellow-billed stork (FT) (flying only)	*Mycteria*	*ibis*	O	
ANSERIFORMES				
African black duck	*Anas*	*sparsa*	O	
FALCONIFORMES				
Eurasian (or western) honey-buzzard	*Pernis*	*apivorus*	×	II
Black-shouldered kite (FT)	*Elanus*	*caeruleus*	×	II
African white-backed vulture	*Gyps*	*africanus*	O	II
African goshawk	*Accipiter*	*tachiro*	×	II
Great sparrowhawk (=black goshawk/ sparrowhawk)	*Accipiter*	*melanoleucus*	×	II
Little sparrowhawk	*Accipiter*	*minullus*	×	II
Eastern (pale) chanting-goshawk	*Melierax*	*poliopterus*	O	II
Dark chanting goshawk	*Melierax*	*metabates*	O	II
African harrier-hawk	*Polyboroides*	*typus*	×	II
Augur buzzard	*Buteo*	*augur*	O	II
Bateleur	*Terathopius*	*ecaudatus*	O	II
African crowned eagle (=crowned hawk-eagle)	*Stephanoaetus*	*coronatus*	×	II
Long-crested eagle	*Lophaetus*	*occipitalis*	×	II
Eleonora's falcon	*Falco*	*eleonorae*	O	II
Lanner falcon	*Falco*	*biarmicus*	O	II
Martial eagle (FT)	*Polemaetus*	*bellicosus*	O	II
GALLIFORMES				
Scaly francolin	*Francolinus*	*squamatus*	×	
Crested guineafowl	*Guttera*	*pucherani*	×	
GRUIFORMES				
Black crake	*Amaurornis*	*flavirostris*	O	
COLUMBIFORMES				
African green pigeon	*Treron*	*calva*	×	III
Eastern bronze-naped pigeon	*Columba*	*delegorguei*	×	
Tambourine dove	*Turtur*	*tympanistria*	×	III
MUSOPHAGIFORMES				
Livingstone's turaco	*Tauraco*	*livingstonii*	×	II
CUCULIFORMES				
African cuckoo	*Cuculus*	*gularis*	O	
Klaas's cuckoo	*Chrysococcyx*	*klaas*	×	
Asian lesser cuckoo	*Cuculus*	*poliocephalus*	×	
Red-chested cuckoo	*Cuculus*	*solitarius*	×	

Continued…

Appendix 7.7A (continued).

Common name	Genus	Species and subspecies	Forest species*	CITES[§]
CUCULIFORMES (continued)				
White-browed coucal	*Centropus*	*superciliosus*	O	
STRIGIFORMES				
African wood owl	*Strix*	*woodfordii*	×	II
CAPRIMULGIFORMES				
Montane nightjar	*Caprimulgus*	*poliocephalus*	×	
APODIFORMES				
African black swift	*Apus*	*barbatus*	O	
Common (or Eurasian) swift	*Apus*	*apus*	O	
White-rumped swift	*Apus*	*caffer*	O	
Mottled swift (DM)	*Apus*	*aequatorialis*	×	
Scarce swift	*Schoutedenapus*	*myoptilus*	×	
Mottled spinetail	*Telacanthura*	*ussheri*	×	
COLIIFORMES				
Speckled mousebird (FT)	*Collius*	*striatus*	×	
CORACIIFORMES				
African pygmy kingfisher	*Ispidina*	*picta*	O	
Eurasian bee-eater	*Merops*	*apiaster*	O	
Hoopoe (FT)	*Upupa*	*epops*	O	
Green woodhoopoe	*Phoeniculus*	*purpureus*	×	
Crowned hornbill	*Tockus*	*alboterminatus*	×	
Silvery-cheeked hornbill	*Ceratogymna*	*brevis*	×	
Trumpeter hornbill	*Ceratogymna*	*bucinator*	×	
PICIFORMES				
Green barbet	*Stactolaema*	*olivacea*	×	
Yellow-rumped tinkerbird	*Pogoniulus*	*bilineatus*	×	
Eastern honeybird (=green-backed honeybird)	*Prodotiscus*	*zambesiae*	×	
Scaly-throated honeyguide	*Indicator*	*variegatus*	×	
Cardinal woodpecker	*Dendropicos*	*fuscescens*	×	
PASSERIFORMES				
African broadbill	*Smithornis*	*capensis*	×	
African pied wagtail (FT)	*Motacilla*	*aguimp*	×	
Mountain wagtail	*Motacilla*	*clara*	O	
Angola swallow	*Hirundo*	*angolensis*	×	
Barn swallow	*Hirundo*	*rustica*	×	
Red-rumped swallow	*Hirundo*	*daurica*	O	
Common house martin	*Delichon*	*urbica*	O	
Black saw-wing (=black rough-wing)	***Psalidoprocne***	*holomelas*	×	
Common bulbul	*Pycnonotus*	*barbatus*	×	
Little greenbul	*Andropadus*	*virens*	×	
Yellow-streaked greenbul	*Phyllastrephus*	*flavostriatus*	×	
Pale-breasted illadopsis	*Illadopsis*	*rufipennis*	×	
Cape robin-chat	*Cossypha*	*caffra*	×	
Common stonechat	*Saxicola*	*torquata*	O	
Groundscraper thrush	*Psophocichla*	*litsipsirupa*	×	
White-eyed slaty flycatcher	*Melaenornis*	*fischeri*	×	

Continued…

Appendix 7.7A (continued).

Common name	Genus	Species and subspecies	Forest species*	CITES§
PASSERIFORMES (continued)				
Ashy flycatcher	*Muscicapa*	*Caerulescens*	×	
African reed warbler	*Acrocephalus*	*Baeticatus*	O	
Cinnamon bracken warbler	*Bradypterus*	*Cinnamomeus*	×	
Garden warbler	*Sylvia*	*Borin*	×	
Willow warbler	*Phylloscopus*	*Trochilus*	×	
Lesser swamp warbler	*Acrocephalus*	*Gracilirostris*	O	
Yellow warbler	*Chloroptera*	sp.	×	
Mountain yellow warbler	*Chloroptera*	*Similis*	×	
Winding cisticola	*Cisticola*	*Galactotes*	O	
Black-headed apalis	*Apalis*	*Melanocephala*	×	
Yellow white-eye	*Zosterops*	*Senegalensis*	×	
African paradise flycatcher	*Terpsiphone*	*Viridis*	×	
Forest batis	*Batis*	*Mixta*	×	
Uhehe fiscal shrike	*Lanius*	*collaris marwitzi*	×	
Black-fronted bushshrike	*Malaconotus*	*Nigrifrons*	×	
Black-backed puffback	*Dryoscopus*	*Cubla*	×	
Tropical boubou	*Laniarius*	*Aethiopicus*	×	
Purple-throated cuckoo shrike	*Campephaga*	*Quiscalina*	×	
Black cuckoo-shrike	*Campephaga*	*Flava*	×	
Square-tailed drongo	*Dicrurus*	*Ludwigii*	×	
Green-headed oriole	*Oriolus*	*Chlorocephalus*	×	
Pied crow	*Corvus*	*Albus*	O	
White-naped (or white–necked) raven	*Corvus*	*Albicollis*	×	
Red-winged starling	*Onychognathus*	*Morio*	O	
Collared sunbird	*Anthreptes*	*Collaris*	×	
Uluguru violet-backed sunbird	*Anthreptes*	*Neglectus*	×	
Bronze sunbird	*Nectarinia*	*Kilimensis*	×	
Malachite sunbird	*Nectarinia*	*Famosa*	×	
Olive sunbird	*Nectarinia*	*Olivacea*	×	
Variable sunbird	*Nectarinia*	*Venusta*	×	
Dark-backed weaver	*Ploceus*	*Bicolor*	×	
Grosbeak weaver	*Amblyospiza*	*Albifrons*	O	III
Common waxbill	*Estrilda*	*Astrild*	O	III
Yellow-bellied waxbill	*Estrilda*	*Quartinia*	×	
Lesser seed-cracker	*Pyrenestes*	*Minor*	×	
Green-backed twinspot	*Mandingoa*	*Nitidula*	×	III
Peter's twinspot	*Hypagros*	*Niveoguttatus*	×	

§ CITES status: given as appendix I, II or III.

* Habitat preference defined in section 7.1: × = species occurring in forest or forest edge as well as other vegetation types (Zimmerman, 1996), O = species that do not normally occur in forest or at forest edge (Zimmerman, 1996).
(DM) - Observation made by David Moyer and not Dinesen *et al*.
(FT) - Observation made by Frontier Tanzania field staff and not Dinesen *et al*.

Appendix 7.7B. Bird observations made by Frontier Tanzania researchers. Dates are accompanied by the number of individuals observed if more than one, plus the location within the reserve. All dates are from 2000 unless stated.

Common name	Genus	Species and subspecies	Date and Location * (all dates are from 2000 unless stated)
African broadbill	*Smithornis*	*Capensis*	14.8 (ND), 18.11 (NY), 29.11 (UK), Oct 1999 (ND)
African hill babbler	*Pseudoalcippe*	*Abyssinica*	July (ND)
African little sparrowhawk	*Accipiter*	*Minullus*	17.11 (ND)
Olive pigeon	*Columba*	*arquatrix*	July 1999 (ND), July (ND)
African paradise flycatcher	*Terpsiphone*	*viridis*	July & Nov 1999 (ND)
African pied wagtail	*Motacilla*	*aguimp*	Aug (NY)
Red-capped forest warbler	*Orthotomus*	*metopias*	26.11 (UK – 2 separate observations), 29.11 (UK), July (ND - 2 separate observations)
African wood owl	*Strix*	*woodfordii*	July (ND), Nov 1999 (C)
African yellow warbler	*Chloroptera*	*natalensis*	Oct 1999 (C)
African yellow white-eye	*Zosterops*	*senegalensis*	Aug (NY)
Angola swallow	*Hirundo*	*angolensis*	Aug 1999 (ND)
Augur buzzard	*Buteo*	*augur*	Sept & Nov 1999 (GR,C)
Barred long-tailed cuckoo	*Cercococcyx*	*montanus*	7.11 (ND), 10.11-20.11 (heard many times daily – NY), 29.11 (UK), 4.12 (ND), 6.12 (ND), 7.12 (ND)
Bar-tailed trogon	*Apaloderma*	*vittatum*	26.11 (UK), 29.11 (UK), 6.12 (ND)
Bar-throated apalis	*Apalis*	*thoracica*	8.12 (ND), July (ND)
Bateleur	*Terathopius*	*ecaudatus*	Oct & Nov 1999 (C)
Black-lored cisticola	*Cisticola*	*nigriloris*	Seen/ heard regularly (C)
Black saw-wing (=black rough-wing)	*Psalidoprocne*	*holomelas*	July (ND)
Black-shouldered kite	*Elanus*	*caeruleus*	Seen regularly in (GR)
Bronze sunbird	*Nectarinia*	*kilimensis*	Nov 1999 (C)
Cape robin-chat	*Cossypha*	*caffra*	July 1999 (ND), 26.11 (UK)
Common stonechat	*Saxicola*	*torquata*	Seen regularly in grassland
Crested guineafowl	*Guttera*	*pucherani*	30.8 (10 - NY), 10.11 (2 - NY), 29.11 (3 - UK), Aug (NY)
African crowned eagle (=crowned hawk-eagle)	*Stephanoaetus*	*coronatus*	Seen/heard regularly inside forest, 28.11 (GR)
Crowned hornbill	*Tockus*	*alboterminatus*	24.11 (GR), 15.11.99 (GR)
Dark-backed weaver	*Ploceus*	*bicolor*	July &October 1999 (ND), 6.12 (ND), 8.12 (ND), Aug (NY)
Eastern double-collared sunbird/ Moreau's sunbird [+]	*Nectarinia*	*mediocris/ moreaui*	Seen regularly on ridgetops (ND)
Fülleborn's black boubou	*Laniarius*	*fuelleborni*	July (ND)
Green woodhoopoe	*Phoeniculus*	*purpureus*	July 1999 (ND)
Hoopoe	*Upupa*	*epops*	Aug 1999 (GR)
Livingstone's turaco	*Tauraco*	*livingstonii*	7.11 (ND), 26.11 (UK), 29.11 (UK), 5.12 (AC), July (ND), Aug (NY), Sept 1999 (ND), Oct 1999 (C)
Long-crested eagle	*Lophaetus*	*occipitalis*	July 1999 (ND)
Malachite sunbird	*Nectarinia*	*famosa*	Seen regularly (C), July.1999 (S)
Martial eagle	*Polemaetus*	*bellicosus*	June (C), July (ND, U)
Mountain buzzard	*Buteo*	*oreophilus*	Oct 1999 (GR), 22.7 (4 – ND), 26.11 (UK), 6.12 (ND), 8.12 (ND), 12.10 ©
Green-throated (mountain) greenbul	*Andropadus*	*chlorigula*	July 1999 (ND), July (ND)
Olive-flanked robin-chat (=olive-flanked ground-robin)	*Cossypha*	*anomala*	July 1999 (ND)
Olive sunbird	*Nectarinia*	*olivacea*	July 1999 (ND)
Olive woodpecker	*Dendropicos*	*griseocephalus*	April & October 1999, 22.1 (ND), 4.12 (ND), 6.12 (ND)
Pied crow	*Corvus*	*albus*	Oct 1999 (2 - C)
Placid greenbul (=olive mountain greenbul)	*Phyllastrephus*	*cabanisi placidus*	Caught in mesh trap: photographs taken (NY)
Red-faced crimsonwing	*Cryptospiza*	*reichenovii*	24.8 (ND)

Continued…

Appendix 7.7B (continued).

Common name	Genus	Species and subspecies	Date and Location * (all dates are from 2000 unless stated)
Scaly francolin	*Francolinus*	*squamatus*	4.12 (GR), 8.12 (ND)
Sharpe's akalat	*Sheppardia*	*sharpei*	29.11 (UK)
Forest batis	*Batis*	*mixta*	Seen regularly (ND, NY)
Silvery-cheeked hornbill	*Ceratogymna*	*brevis*	Aug 1999 (ND), 25.1 (ND – juvenile found calling in shrub layer with parents overhead), 26.11 (UK), 29.11 (2 - UK), 1.8 (ND), Aug (NY), 12.10 (C), 17.11 (ND)
Speckled mousebird	*Colius*	*striatus*	June (C)
Spot-throat	*Modulatrix*	*stictigula*	July 1999 (ND)
Square-tailed drongo	*Dicrurus*	*ludwigii*	July (ND)
Udzungwa forest partridge	*Xenoperdix*	*udzungwensis*	14.2 (ND - 4 seen together on ground beneath thick, scrubby understorey along transect 1), 25.8 (ND – one seen in dense shrub)
Variable sunbird	*Nectarinia*	*venusta*	July 1999 (S), Aug (NY), seen regularly (C)
White-browed coucal	*Centropus*	*superciliosus*	22.11 (GR), Oct-Dec 1999 (C)
White-chested alethe	*Alethe*	*fuelleborni*	14.11 (Caught in bucket pitfall trap – NY)
White-naped (or white–necked) raven	*Corvus*	*albicollis*	Seen/ heard regularly throughout study period in most areas
Great/ eastern white pelican (flying only)	*Pelecanus*	*onocrotalus*	Aug (200+ flying - U)
White-starred robin	*Pogonocichla*	*stellata*	Seen regularly (ND,NY,C)
White-tailed crested flycatcher	*Trochocercus*	*albonotatus*	Oct 1999 (ND)9.11 (NY), 26.11 (UK), 4.12 (ND), 6.12 (ND), 7.12 (ND)
Yellow-bellied waxbill	*Estrilda*	*quartinia*	July 1999 (ND), 30.8 (NY), Aug (NY), seen regularly (C)
Yellow-billed stork	*Mycteria*	*ibis*	Aug (10 flying - U)
Yellow-streaked greenbul	*Phyllastrephus*	*flavostriatus*	July (ND), Aug (NY)
Yellow-throated woodland warbler	*Phylloscopus*	*ruficapillus*	14.8 (ND)
Common bulbul	*Pycnonotus*	*barbatus*	Seen and heard regularly (C)

* - Locations: ND = Ndundulu, NY = Nyumbanitu, UK = Ukami forest fragment, GR = wooded grassland, AC = *Acacia* wooded grassland, C = main "Chui" camp, U = Udekwa village, S = scrubby area in the north of Ndundulu.

[+] - Taxonomy of the eastern double-collared sunbird complex is unresolved (Butynski & Ehardt, *in press*; Dinesen, *pers. comm.*), hence identification between *C. mediocris* and *C. moreaui* has not been made here.

Appendix 7.7C. Bird observations made in Ndundulu by David Moyer (22nd-23rd July).

Common name	Genus	Species and subspecies	Location *
African goshawk	*Accipiter*	*tachiro*	L
African hill babbler	*Pseudoalcippe*	*abyssinica*	T
Olive pigeon	*Columba*	*arquatrix*	T, L
(African) rock martin	*Hirundo*	*fuligula*	L
African yellow white-eye	*Zosterops*	*senegalensis*	T
Angola swallow	*Hirundo*	*angolensis*	C, L
Bar-tailed trogon	*Apaloderma*	*vittatum*	L
Bar-throated apalis	*Apalis*	*thoracica*	T, L
Black-lored cisticola	*Cisticola*	*nigriloris*	T, C, L
Cape robin-chat	*Cossypha*	*caffra*	L
Chapin's apalis	*Apalis*	*chapini*	T
Cinnamon bracken warbler	*Bradypterus*	*cinnamomeus*	T
African crowned eagle (=crowned hawk-eagle)	*Stephanoaetus*	*coronatus*	T, L
Evergreen forest warbler	*Bradypterus*	*lopezi mariae*	T
Fülleborn’s black boubou	*Laniarius*	*fuelleborni*	T, L
Livingstone's turaco	*Tauraco*	*livingstonii*	T, L
Malachite sunbird	*Nectarinia*	*famosa*	L
Moreau’s sunbird/ eastern double-collared sunbird	*Nectarinia*	*moreaui/ mediocris*	T, L
Mottled swift	*Apus*	*aequatorialis*	C
Green-throated (mountain) greenbul	*Andropadus*	*chlorigula*	T, L
Mountain nightjar	*Caprimulgus*	*poliocephalus*	L
Moustached green-tinkerbird	*Pogoniulus*	*leucomystax*	T, L
(Northern) olive thrush	*Turdus*	*olivaceus*	T
Olive-flanked robin-chat (=olive-flanked ground-robin)	*Cossypha*	*anomala*	T, L
Stripe-cheeked greenbul	*Andropadus*	*milanjensis*	T
Red-faced crimsonwing	*Cryptospiza*	*reichenovii*	T
Red-rumped swallow	*Hirundo*	*daurica*	C, L
Scaly francolin	*Francolinus*	*squamatus*	L
Scarce swift	*Schoutedenapus*	*myoptilus*	L
Shelley's greenbul	*Andropadus*	*masukuensis*	T, L
Short-tailed (forest) batis	*Batis*	*mixta*	T
Spot-throat	*Modulatrix*	*stictigula*	T, L
(Yellow-browed) streaky seed-eater	*Serinus*	*striolatus whytii*	L
Uhehe fiscal shrike	*Lanius*	*collaris marwitzi*	L
Variable sunbird	*Nectarinia*	*venusta*	L
Waller's starling	*Onychognathus*	*walleri*	T, L
White-naped (or white–necked) raven	*Corvus*	*albicollis*	T
White-rumped swift	*Apus*	*caffer*	L
White-tailed crested flycatcher	*Trochocercus*	*albonotatus*	T

* Locations: T= Transect line 1 (“Tembo” camp), C = Chawemba peak, L = Luala valley.

+ Taxonomy of the eastern double-collared sunbird complex is unresolved (Butynski & Ehardt, *in press*; Dinesen, *pers. comm.*), hence identification between *C. mediocris* and *C. moreaui* has not been made here.

Appendix 7.8A. Forest dependent reptile species known from the Udzungwas (Howell, 1993).

Family & species	Range
GEKKONIDAE	
Lygodactylus williamsi	Udzungwa (Kimbosa forest only)
Cnemaspis dickersoni	Southern Ethiopia and Sudan south through Uganda, Kenya to central Tanzania, west to Rwanda and eastern Zaire
*Cnemaspis uzungwae**	Udzungwa (and one other forest – Howell, *pers. comm.*)
CHAMAELEONIDAE	
*Bradypodion oxyrhinum**	Udzungwa
Chamaeleo goetze	Udzungwa, Ukinga, Ubena, Poroto, Rungwe, Southern Highlands, Nyika Plateau, Malawi
Chamaeleo tempeli	Udzungwa, Ukinga, Ubena
*Chamaeleo werneri**	Uluguru, Udzungwa
Chamaeleo laterispinis	Udzungwa
Rhampholeon brevicaudatus	East Usambara, Uluguru, Udzungwa, Coastal forest
SCINCIDAE	
*Melanoseps ater**	West Usambara, Udzungwa, Southwestern and southeastern Tanzania, Shire Plateau, Misiku Mountains, Malawi, northwestern Zambia
Leptosiaphos rhomboidalis	Udzungwa
TYPHLOPIDAE	
Typhlops ulugurensis	Udzungwa
Typhlops gierrai	Uluguru, Udzungwa, Ukinga
COLUBRIDAE	
Crotaphopeltis tornieri	East & West Usambara, Uluguru, Udzungwa, Ukinga, Rungwe, Misuku Mountains, Malawi
ATRACTASPIDAE	
*Atractaspis aterrima**	Uluguru, Udzungwa, west through Uganda to Guinea
VIPERIDAE	
Atheris ceratophorus	East & West Usambara, Uluguru, Udzungwa
Adenorhinos barbouri	Udzungwa, Ukinga

* Species found during this survey. The taxonomy of this species has recently been revised and *M. uzungwensi* is now considered a distinct species (Broadley, 2000b)

Appendix 7.10A. List of mollusc morpho-species recorded for each site in West Kilombero Scarp Forest Reserve.

Species	Trap site 1	Trap site 2	Trap site 3	Trap site 4	Trap site 5	Trap site 6	Trap site 7	Trap site 8	Trap site 9	Trap site 10	Trap site A	Trap site B	Trap site C	Trap site D
'a'	X	X	X	X	X		X		X				X	
'b'	X				X									
'c'	X	X	X	X	X	X	X	X	X	X	X	X	X	X
'd'	X	X	X				X							
'e'	X	X		X	X	X			X		X		X	X
'f'	X					X	X						X	
'g'	X		X											
'h'	X			X	X	X	X							
'i'	X	X					X							
'j'			X	X	X	X			X					
'k'	X													
'l'	X													
'm'			X						X					
'n'	X								X					
'o'			X			X	X		X			X		
'p'	X		X	X	X	X	X	X						X
'q'		X			X	X	X	X				X		
'r'					X	X	X	X						
's'			X		X	X	X							
't'						X	X	X						
'u'						X	X							
'v'					X	X	X			X				
'w'					X									
'x'					X									
'y'														X
'z'							X	X		X	X	X		
'æ'											X			
'ø'	X			X	X				X		X			
'å'		X			X	X	X							
'aa'		X				X								
'ac'				X				X	X	X				
'ad'									X					
'ae'			X				X	X	X	X				
'af'				X		X	X	X		X		X		
'ag'				X										
'ai'						X								
'an'	X						X	X		X		X		
'ap'			X				X							
'ar'			X											
'as'					X									
'ba'								X						
'bb'								X						
'bc'								X		X		X		
'bd'								X		X		X		
'be'								X		X				
'bf'								X				X		
'bg'								X				X		
'bh'								X				X		
'bi'								X				X		
'bj'								X		X				
'bk'								X						
'bl'										X				
'bm'										X				
'bn'										X				
'bo'										X				
'bp'										X		X		
'bq'												X		
'br'												X		
'bs'												X		
'bt'												X		
?					X					X		X		

Appendix 7.11A. Millipede morpho-species distribution in West Kilombero Scarp Forest Reserve. Missing numbers in the morpho-species sequence correspond to millipedes found in New Dabaga/Ulangambi Forest Reserve alone (**Appendix 7.11B**).

Morpho-species	Forest trapsites										Non-forest trapsites			
	1	2	3	4	5	6	7	8	9	10	A	B	C	D
1				×	×	×	×							
3		×	×	×	×	×	×	×	×	×			×	
4	×		×	×	×	×	×	×	×	×	×	×	×	×
5		×	×	×	×	×	×	×		×		×		×
6								×						
7	×	×	×			×	×	×				×	×	×
8	×	×		×	×	×	×	×	×	×		×		×
10						×	×	×				×		
11										×				
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									×					
42*	×	×	×		×		×						×	
Total**	7	9	7	8	8	9	13	14	8	15	1	13	4	5

* Minute immature millipedes which could not be classified with a designated morpho-species have been classified as "42".
** Does not include immatures.

Appendix 7.11B. Millipede morpho-species distribution in New Dabaga/Ulangambi Forest Reserve. Missing numbers in the morpho-species sequence correspond to millipedes found in West Kilombero Scarp Forest Reserve alone (**Appendix 7.11A**).

Morpho-Species	Forest trapsites					VGF*	Non-forest trapsites		
	1	2	3	4	5	A	B	C	D
1	×					×			
2	×	×	×	×	×	×			
3	×	×	×	×	×	×	×		
4	×	×	×	×	×	×	×	×	×
5	×		×	×	×		×		×
6	×	×			×				
7	×	×		×	×	×		×	
8	×			×	×				
9	×	×	×	×	×		×		
10	×	×	×	×	×	×			
11		×		×	×	×	×		
12					×				
14	×								
Total species	11	8	6	9	11	7	5	2	2

* *Parinari excelsa* dominated village government forest fragment in Msonza area.

Appendix 7.12A. The distribution of butterflies attracted to fruit bait.

	Trapsites; non-forest				**Trapsites; Forest blocks**									
Species	**A**	**B**	**C**	**D**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
B.d.		**12**	**1**				**5**					**94**	**13**	**23**
B.u.u.				**3**		**2**								
B.s.							**1**			**7**	**1**	**3**		
E.c.									**1**					
S.m.													**5**	
C.d.		**1**											**1**	
G.b.d.													**3**	**5**
B.c.													**2**	
C.a.a.												**4**		**6**
A.s.d.												**1**		
C.p.p.												**1**		**3**
C.x.b.												**1**		
E.t.t.												**1**		**6**
C.c.c.														**1**
C.v.v.		**3**												
A.d.d.		**5**												
E.h.l.		**1**												
*B.*sp.							**1**					**42**		**12**

B.d.-Bicyclus danckelmani; B.u.u.-Bicyclus uzungwensis uzungwensis ; B.s.-Bicyclus simulacris; E.c.-Euphaedra crawshayi; S.m.-Sallya moranti; C.d.-Charaxes druceanus G.b.d.-Gnophodes betsimena diversa; B.c.-Bebearia cocalia; C.a.a.-Charaxes acuminatus acuminatus; A.s.d.-Antanartia schaeneia dubia; C.p.p.-Charaxes pollux pollux; C.x.b.-Charaxes xiphares brevicaudatus; E.t.t.-Euxanthe tiberius tiberius; C.c.c.-Charaxes candiope candiope; C.v.v.-Charaxes varanes vologeses; A.d.d.-Antanartia dimorphica dimorphica; E.h.l.-Eurytela hiarbis lita; B.sp.-Bicyclus sp.