New Dabaga/Ulangambi Forest Reserve

Zoological Report

FRONTIER TANZANIA
2001

Udzungwa Mountains Biodiversity Survey

New Dabaga/Ulangambi Forest Reserve

Zoological Report

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

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University of Dar es Salaam
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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 1451km^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 Excell 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 – New Dabaga/Ulangambi Forest Reserve

4.1 Introduction

Three reports present management recommendations and the results of forest use, botanical and zoological surveys of New Dabaga/Ulangambi Forest Reserve (NDUFR) in Iringa region, south-central Tanzania. Fieldwork was carried out by Frontier Tanzania as part of its "Udzungwa Mountains Biodiversity Survey." The findings are intended for use by Danida's MEMA project "Udzungwa Mountains Forest Management and Conservation" in the preparation of Joint Forest Management Plans.

New Dabaga/Ulangambi Forest Reserve is a montane forest fragment of 37km^2, at altitudes of 1740-2100m. It is set in a human dominated landscape with six villages nearby. Farmland, grassland and plantation forests occur right up to the Forest Reserve boundary.

Fieldwork was divided into forest use and botanical surveys from July to September 1999 and zoological surveys from October to November 2000. The following summary provides information on all of these surveys and suggested input to Joint Forest Management plans. Detailed findings of the surveys are presented in separate reports (Frontier Tanzania, 2001a,c&e).

4.2 Forest Use Surveys

From transect surveys of human disturbance, NDUFR shows signs of a high level of natural resource extraction. The Forest Reserve is surrounded by human settlements whose inhabitants have extracted natural resources from the forest for generations. Commercial logging has been intense in the past, but the establishment of exotic tree plantation early this century and recent management initiatives (e.g. cessation of commercial logging within the reserve and the planting of more exotic tree plantations outside the reserve) have reduced the pressure on the Forest Reserve's wood resources, despite the growing human population. The most often encountered forms of disturbance were logging and pole harvesting. Poles and timber have been extracted at a higher level in the western part of the reserve where settlements are more abundant. However, current timber and pole extraction is low.

Animals in the forest are subjected to a severe hunting level, with a minimum of 33 set traps per km^2. Evidence was also found of honey collection. Other forest products taken from the Forest Reserve include plants for medicinal purposes and construction material for mats and thatched roofs.

Fires had recently swept in to the northern part of the Forest Reserve destroying forested habitat (estimated at 25ha) and maintaining areas of grassland (estimated at 3ha).

4.3 Botanical Surveys

Botanical survey was based primarily around 20m×50m vegetation plots, in which all trees above 10cm dbh* were measured and identified. Regenerating trees and shrubs were sampled within 3m×3m plots at the centre of the larger vegetation plots. Fertile specimens of plants encountered opportunistically were also collected. Furthermore, five indicator plant species were selected for a detailed assessment of their populations.

Trees over 10cm dbh were identified from 32 families, 55 genera and 71 species. Another 122 plant species were recorded by opportunistic collections. At least seven of the species recorded were found to be endemic to Tanzania.

The high level of past human disturbance has had a marked effect on the forest structure and tree species composition. This is evident from comparison with the less disturbed West Kilombero Scarp Forest Reserve. Statistical tests indicated a significantly higher number of regenerating trees and a much higher number of secondary trees recorded in plots at NDUFR. Furthermore, the forest tree community was found to be largely undifferentiated. The five most dominant trees (*Macaranga kilimandscharica, Cassipourea gummiflua, Aphloia theiformis, Nuxia floribunda* and *Rapanea melanophloeos*) accounted for 48% of all trees recorded in the vegetation plots, with the secondary tree species *M. kilimandscharica* being superdominant (20% of all trees recorded). In addition, formerly logged areas tended to have a broken/open canopy and were often dominated by a dense shrub layer.

Three plots were set up outside of the Forest Reserve in exotic plantation forests (pine and black wattle) and in a 6ha village government forest fragment. The 6ha indigenous forest fragment, despite having a mono-dominant (*Parinari*) canopy, had a higher number of regenerating forest species than many forest reserve plots, probably due to the presence of a closed canopy.

The five indicator species subjected to detailed assessment are forest dependent or canopy trees in NDUFR and at the same time used by the people in the nearby villages. Four of the five indicator species showed a distribution that was dependent on a minimum 40 % canopy cover. If the canopy continues to be degraded, low density species dependent on a closed canopy may be lost, resulting in a loss of biodiversity. In ecological terms, the potential for the sustainable utilisation of non-timber forest products form the five species was low.

4.4 Zoological Survey

The fauna of NDUFR were sampled through a combination of live trapping, timed area searches, and observations along linear transects. Seven taxonomic groups were selected for detailed study (see **Table 4A**).

Five trapsites within the Forest Reserve were sampled for eight days. The trapsites were selected to sample a maximum diversity of habitats, and therefore also species. This was achieved by using information gained about plant communities and habitat structure from the earlier vegetation surveys. For comparison with the five forest trapsites, four trapsites were placed outside of the Forest Reserve. These trapsites were sampled for four days.

* dbh: diameter at breast height, measured 130cm above ground.

A summary of the fauna recorded from NDUFR is presented in **Table 4A**. In total this list comprises 195 species identified by taxonomists and Frontier Tanzania researchers. **Table 4A** also shows the high number of forest dependent (82) and restricted range (43) species recorded at NDUFR. This is especially encouraging due to the disturbed state of the Forest Reserve, and also highlights the importance of maintaining and restoring the forest habitat to improve conditions for these forest dependent species.

Taxonomic identification was however not available for all specimens at the time of writing. This is particularly true of taxa that require extensive comparison with museum collections and expert knowledge (e.g. shrews, millipedes and molluscs). The incomplete nature of current identifications combined with the likelihood that there are species missed by this survey, as highlighted by the species accumulation curves, suggests that there are more species to add to the NDUFR species list.

Table 4A. Summary of animal species of conservation importance recorded from New Dabaga/ Ulangambi Forest Reserve[+]. Sources of information for forest dependence and range restriction can be found in the relevant sections of the Zoological Report.

Taxonomic group	Total no. of species	Forest dependent	Restricted range[~]	IUCN conservation concern
Butterflies	50	29	17	0
Millipedes	13*	-	-	-
Molluscs	21*	-	-	-
Amphibians	18	4	6	6
Reptiles	8	3	3	0
Birds	84	36	12	2
Mammals	35	10	5	4

+ Includes species from four trapsites placed outside the Forest Reserve (all less than 1km from the Forest Reserve).
* Identification of millipede and mollusc specimens was not available at the time of writing. Instead the number of "morph-species" classified by Frontier Tanzania researchers are indicated.
~ Restricted range: Eastern Arc Mountains, Tanzania and northern Malawi.

Certain forest dependent and/or restricted range species (e.g. Abbot's duiker and Udzungwa red colobus) are present within the reserve at low numbers. This is thought to be due to the high levels of hunting and/or habitat degradation within the Forest Reserve, and requires active management.

Of note was the high number of forest dependent species recorded within the 6ha village government forest fragment. Two particularly noteworthy records, both from this forest fragment, are the first capture of a male *Galagoides orinus* and the first record in the Udzungwa Mountains of the amphibian *Leptopelis vermiculatus* (both species are forest dependent).

4.5 Management Recommendations

The high biodiversity value, the presence of numerous forest dependent species, and several IUCN species of conservation concern highlight the need for a precautionary approach to management of NDUFR. The following management recommendations are proposed from a

biodiversity prospective, and further investigation is advised prior to implementation of these recommendations.

Being heavily exploited for timber in the past, the forest in NDUFR needs time to recover. Management activities should therefore seek to re-establish forest cover, thereby improving conditions for forest dependent species and biodiversity in general. It is therefore proposed that logging, tree felling, polecutting, and honey extraction should be avoided. Possibilities of sustainable medicinal plant extraction should be investigated further. Access to the Forest Reserve should be allowed for people on foot crossing from villages to cultivated areas.

The high level of hunting threatens the populations of larger mammals (e.g. Abbot's duiker, Harvey's duiker, suni and bush pig). These larger mammals are present in the reserve at low numbers; therefore hunting of these animals should be drastically reduced or stopped.

Furthermore, establishment of additional plantations outside the Forest Reserve using indigenous and exotic species should be encouraged to supply the community with a required wood source. Identification of income generating activities outside the forest reserve is also needed (e.g. fruit processing).

A forest buffer zone is recommended around the outside of the Forest Reserve. The buffer zone would minimise the risk of fires entering the Forest Reserve, by serving as a focal point for certain income generating schemes (e.g. timber and pole extraction, honey production, medicinal plant harvesting). The zone should consist of indigenous tree species (e.g. *Albizia* spp.).

Nearby village government forests containing indigenous species should be supported and incorporated into the management plan. These forest fragments have been managed in a sustainable manner and they should be an integral part of an overall Joint Forest Management strategy. These forest fragments have also been shown to support forest dependent fauna and flora, and therefore these fragments could form an integral part of a system of corridors or stepping stones for dispersal of forest dependent species.

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 Udzungwa Mountains reaching 2576m and forest cover extending up to around 2400m. There is still some uncertainty about the total forest cover in the Udzungwa Mountains. 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 Udzungwa Mountains (**Figure 6B**) and encompass the entire Mwanihana forest, large parts of the Luhombero and Matundu forests as well as smaller fragments.

Whereas the Usambara and Uluguru Mountains have been subject to biological studies for more than 70 years, it is only quite recently that the 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 having 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*).

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

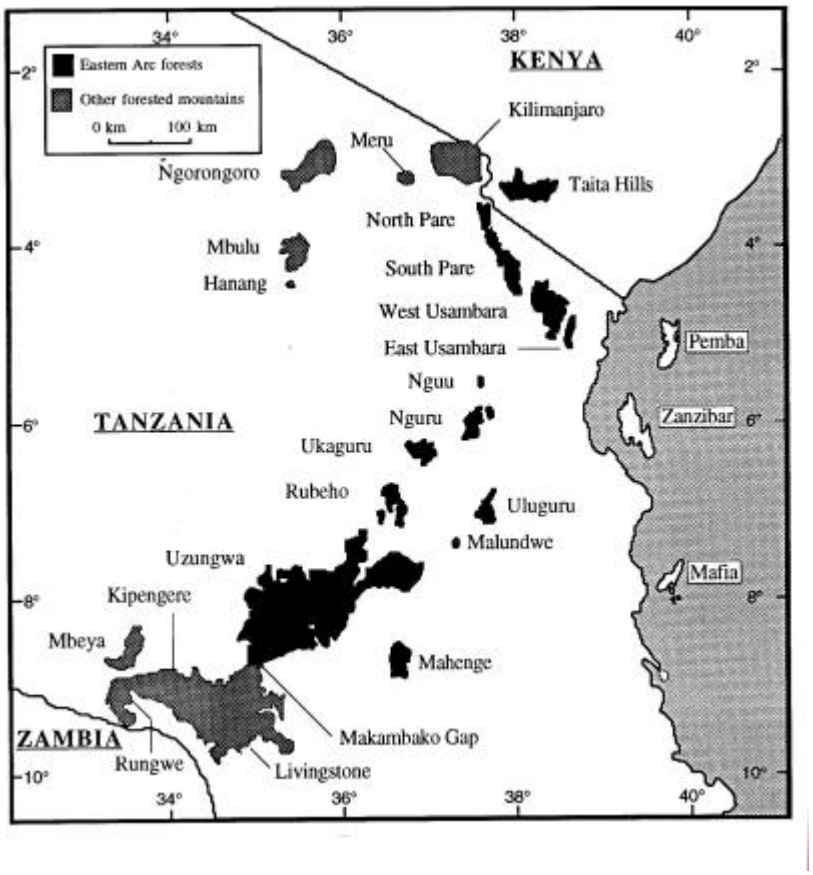
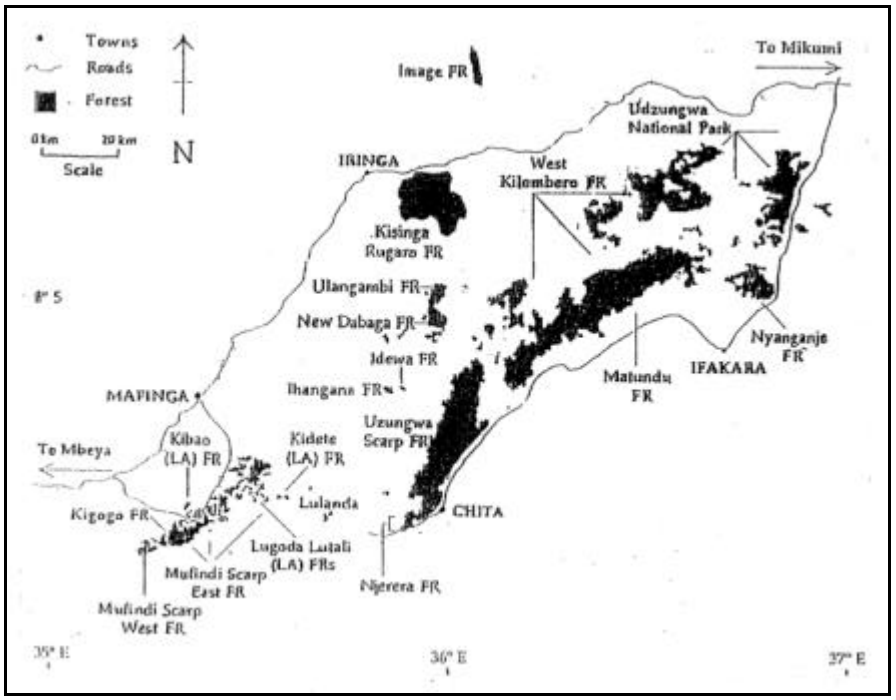


Fig. 6B. Forest Reserves of the Udzungwa Mountains. From Lovett (1992).



6.2 Description of Reserve

6.2.1 General Description

Name: New Dabaga/Ulangambi Forest Reserve
Iringa District, Iringa Region, Tanzania.

Area: 3728 ha; 37.3 km^2

Boundary: Length 40 km. Clearly marked with eucalyptus trees, except along parts of the northwestern boundary. New Dabaga is continuous with Ulangambi Forest Reserve in the North.

Status: Catchment Forest Reserve. Ulangambi Forest Reserve gazetted in 1930. New Dabaga Forest Reserve gazetted in 1932.

Maps: Ordnance Survey topographic maps 1:50,000 Series Y742 Sheet 233/2. Forest reserve boundary correctly marked on Ordnance Survey Map. Aerial photographs available from the MEMA project for 1956, 1978 and 1999. Special map: New Dabaga/Ulangambi Forest Reserve Cover Type Map HIMA/DANIDA 1990 Forest Inventory Project. One sheet (1:25,000) 1990.

6.2.2 Location

Grid Reference: 35°54'E - 35°57'E, 8°01'S - 8°06'S

Elevation: 1740 – 2100 m a.s.l.

New Dabaga/Ulangambi Forest Reserve is located 45km southeast of Iringa. It is bordered by Kidabaga village (southwestern border). Other nearby villages include Ilamba, Lusinga, Magome, and to a lesser extent Isele and Lulanzi (see **Figure 6.2A**). There are numerous roads around the reserve (especially on the western side of the reserve). These roads are made up of old logging roads, roads linking the various villages, and roads linking plantations to the main Kidabaga-Iringa road. There is a twice-daily bus service linking Kidabaga to Iringa.

The forest is surrounded by grassland, fields, small patches of black wattle (*Acacia mearnsii*) and Pine (*Pinus sp.*) plantations, tea plantations and patches of *Parinari excelsa* village government forest. Farmland/grassland occurs right up to the forest edge.

6.2.3 Soils

Soils are brown sandy loams over crystalline gneiss with areas of clay with stones.

6.2.4 Climate

Climate is that of oceanic rainfall with oceanic/continental temperatures. The nearest rainfall station is at Iringa. However, the nearest 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). The dry season is between June and November.

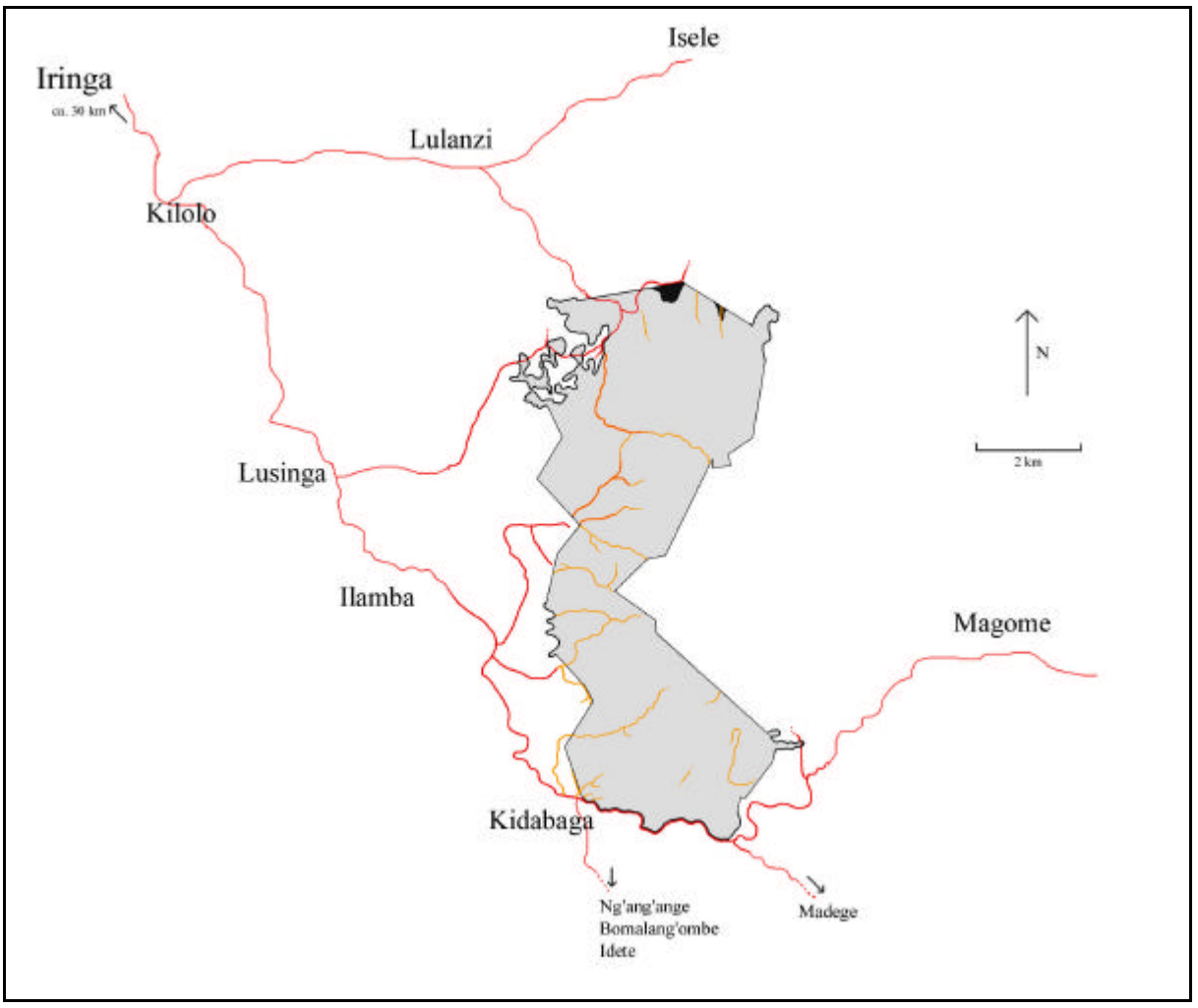


Figure 6.2A. Map of New Dabaga/Ulangambi Forest Reserve including villages and paths.

6.2.5 Vegetation

The forests of New Dabaga/Ulangambi are a mosaic of upper montane and montane forests, with patches of bamboo. Species more typical of montane forests occur in the valleys with upper montane species occurring on upper slopes. The forest has been heavily disturbed by logging and fires, resulting in a broken canopy with tangled vegetation in many areas. Aerial photo interpretation (HIMA, 1990) gave the following areas: forested, 3296 ha; bush heathland, 308 ha; and grassland, 96 ha.

Montane Forest: Canopy height up to 25 m in the valleys. Trees include: *Albizia gummifera, Bridelia micrantha, Cassipourea gummiflua, Chrysophyllum gorungosanum, Ochna holstii, Ocotea usambarensis, Polyscias fulva, Schrebera alata, Syzygium guineense,* and *Zanthoxylum gilletii*.

Upper Montane Forest: Canopy height 10-15 m on the upper slopes. Trees include: *Albizia gummifera, Aphloia theiformis, Bersama abyssinica, Diospyros whyteana, Macaranga kilimandscharica,* and *Prunus africana.*

Interviews with elderly members of the local community established that the original canopy (prior to logging) of the Forest Reserve was dominated by *Ocotea usambarensis, Parinari excelsa*, *Cassipourea gummiflua*, *Chrysophyllum gorungosanum,* and *Polyscias fulva.*

6.2.6 Catchment Value

There are no major rivers that originate from the reserve. However, there are numerous small streams with their origins in the reserve; in the Ulangambi part of the reserve 13 streams cross the forest reserve boundary. These streams are used locally for crop irrigation and general water supply.

Frontier Tanzania Udzungwa Mountains Biodiversity Survey

New Dabaga/Ulangambi Forest Reserve

7 Zoological Surveys

7.0 Zoological Survey

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 have 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 New Dabaga/Ulangambi Forest Reserve (NDUFR) and West Kilombero Scarp Forest Reserve (WKSFR) 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 Udzungwa Mountains and these other areas.

The zoological surveys presented here from NDUFR took place from October to November 2000, with some opportunistic collections during 1999.

7.1.2 Information on Trapsites

Four trapsites (trapsites A-D) were sampled for four days, while five trapsites (trapsites 1-5) were sampled for eight days. Trapsites 1-5 were placed within the Forest Reserve, while trapsites A-D were placed outside the Forest Reserve. **Figure 7.1A** shows the location of each of the trapsites, while **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.

Trapsites A, B and C were placed in wooded habitats, while trapsite D was placed in an open habitat. Trapsite A was placed in a 6ha village government forest fragment. Trapsite B and C were placed in plantation forests (pine and black wattle respectively). Trapsite D was placed in a fallow field.

Within the Forest Reserve, trapsites 3, 4 and 5 were placed in comparatively undisturbed areas. Trapsite 1 was placed in a heavily disturbed area with a broken canopy (10-50%) and dense ground/shrub layer. Trapsite 2 was placed next to an old logging road at a site of past logging (over 10 years ago).

Habitat Information of Trapsites
Trapsites were placed to sample a maximum diversity of habitats and therefore also species. A summary of the habitat details at the various trapsites is presented in **Table 7.1.**

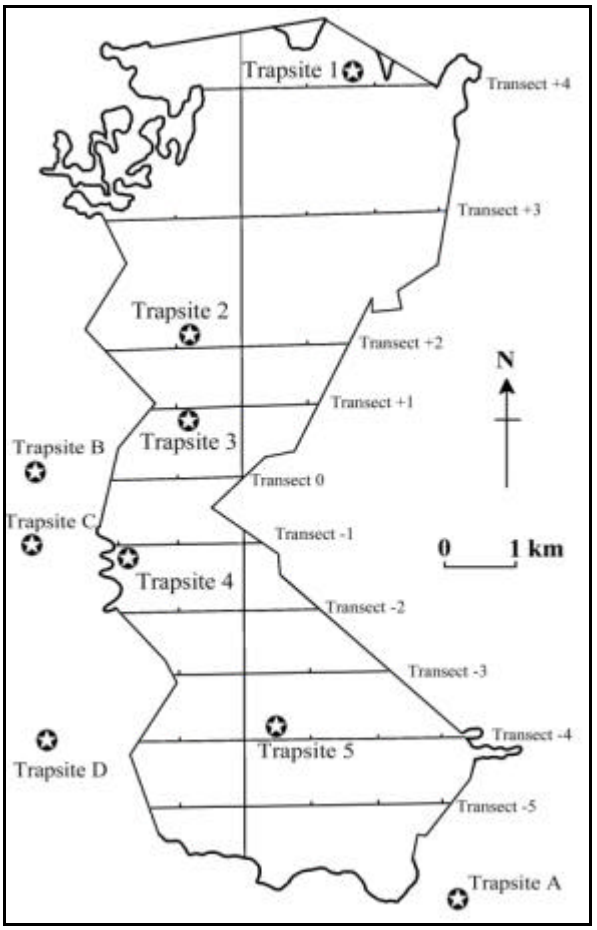


Figure 7.1A. Trapsites sampled during zoological surveys in and around New Dabaga/Ulangambi Forest Reserve.

Table 7.1A. Summary of Habitat Details at each Trapsite.

Trapsite	Date (from-to)	Altitude	Vegetation Type^	Canopy Cover+	Canopy height+	Distance to water*
A	09/11/00 12/11/00	1825	Village government forest (6ha), dominated by *Parinari excelsa*.	>50%	10-20m	None
B	11/10/00 14/10/00	1985	Pine plantation (*Pinus caribaea*).	>50%	10-20m	None
C	11/10/00 14/10/00	2025	Black wattle plantation (*Acacia mearnsii*).	10-50%	<10m	None
D	25/11/00 28/11/00	1915	Fallow field; ranging from 1 year to 6 years since last cultivation.	<10%	<10m	5-125m
1	17/10/00 24/10/00	1910	Scrub/thicket/bush bordered by montane forest.	10-50%	<10m	1-100m
2	27/10/00 03/11/00	1950	Montane forest; previously logged (over 10 years ago). *Macaranga/ Cassipourea/Garcinia* community.	>50%	10-20m	None
3	17/10/00 24/10/00	1945	Montane forest. *Macaranga/ Cassipourea/Garcinia* community.	10-50%	10-20m	2-75m
4	27/10/00 03/11/00	1930	Montane forest. *Macaranga/ Cassipourea/Garcinia* community.	>50%	10-20m	0-50m
5	15/11/00 22/11/00	1850	Montane forest; forest centre. *Macaranga/Aphloia* community.	>50%	10-20m	0-200m

^ Vegetation community as described in Section 7.2 (Frontier Tanzania, 2001d).
+ 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.

7.1.3 Definitions of Terms

Where species have been identified and tabulated in the various sections, species are described in terms of ecological requirements and endemic status. These terms will be used throughout the report, and are defined in **Box 7.1A**. A list of Kihehe names for mammals found within the reserve is presented in **Appendix 7.1B.**

Box 7.1A. Ecological requirements and levels of endemism.

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 New Dabaga/Ulangambi Forest Reserve

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

7.2.1 Summary and Recommendations

The small mammal fauna of New Dabaga/Ulangambi Forest Reserve (NDUFR) was surveyed during the months October and November 2000, using a combination of bucket pitfalls and Sherman traps. Five trapsites were positioned inside the forest reserve and four in other habitats. Other habitats included a Village Government forest, black wattle (*Acacia mearnsii*) plantation, pine (*Pinus caribaea*) plantation and a fallow field. Forest reserve sites were trapped for eight days, other habitats for four days.

The term "small mammals" refers in this study to members of the family Soricidae and the orders Macroscelidea and Rodentia. "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).

The list of small mammals recorded from natural forest in NDUFR includes 12 species of rodents, one species of Macroscelidae and a minimum of two species of shrew. In addition two species were recorded only outside natural forest (*Otomys* sp. and *Rhabdomys pumilio*). Two species are listed as "Vulnerable" according to IUCN (*Rhynchocyon cirnei* and *B. hindei*) while data is deficient for two species. Of the species identified to date, four species are forest dependent and only one subspecies (*Paraxerus lucifer lucifer*) is restricted to forested areas in Tanzania. It is however likely that this number will increase when identifications of collected shrews are finalised.

Eleven species were captured in Sherman traps and bucket pitfalls in and around NDUFR. Ten species were caught in natural forest and eight in non-natural forest habitat. Species unique to natural forests in this study are *Graphiurus* sp., *Dasymys incomptus* and *Tatera* sp.. All three of these species have not previously been recorded from the Udzungwa Mountains, and the two latter are first records from forested areas in the Eastern Arc. Neither of the species however are typical forest species, but are found in a variety of habitats.

The identification of *Graphiurus* sp., *D. incomptus* and *Tatera* sp. from forested areas in NDUFR, combined with Frontier Tanzania surveys in West Kilombero Scarp 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.

Although many species were found outside natural forest habitat, several rodent species depend on forests for their survival. Management activities should therefore focus on maintaining/improving forest quality.

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 Eastern Arc Mountains are home to many endemic and restricted range shrews and rodents. The rodent fauna is widely distributed throughout the 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 will investigate the small mammal fauna found in New Dabaga/Ulangambi Forest Reserve and compare results with previous studies in Udzungwa Mountains and other Eastern Arc forests.

Definitions of Terms Used in this Study
"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 New Dabaga/Ulangambi Forest Reserve.
- To compare rodent diversity and abundance between natural forest and other habitats.
- To compare results with other Eastern Arc regions.
- To suggest input to joint forest management plans based on the results.

7.2.3 Method

The small mammal fauna of New Dabaga/Ulangambi Forest Reserve was surveyed by combining pitfalls and Sherman traps (see Frontier Tanzania, 2001g for detailed description of method). Such methods have shown to document most of the medium-sized to small mammal fauna effectively (Stanley *et al.*, 1998). Small mammals were trapped during October and November 2000 at five trapsites inside the forest reserve and four in other habitats (Village Government Forest, fallow field, black wattle plantation and pine plantation). Forest reserve sites were trapped for eight nights and others for four nights.

Bucket Pitfall Trapping
Shrews and small rodents were sampled using bucket pitfall lines. 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. The traps were baited with chicken, mice or vegetables mixed with peanut butter. 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 taxonomical verification, while all other individuals were released in the trapping area. All released individuals were marked individually by cutting sections of fur in a unique pattern, and every re-capture was recorded.

Shrews
Identification of shrews involves looking at 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 species determinations were unavailable for inclusion into this report, but Frontier Tanzania researchers have tentatively identified some specimens to genus level.

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 researchers. The initial problems with identification of *Praomys delectorum*, *Hylomyscus dennieae* and *Grammomys* sp. experienced in WKSFR, was avoided in NDUFR by clarification of the differences between the species by W. T. Stanley. All collected specimens will later be identified and verified by W. T. Stanley.

Species of the genera *Mus, Dendromys, Graphiurus, Grammomys, Otomys* and *Tatera*, were only identified to genus level due to the possible presence of more than one species in each genus.

7.2.4 Results

The Small Mammal Fauna, its Forest Dependency and Conservation Status
Including casual observations, a total of 17 species of small mammals (as defined in introduction) were recorded for New Dabaga/Ulangambi Forest Reserve and surrounding areas (see **Table 7.2A**). 14 species belonging to the family Rodentia were recorded in and around the reserve (see **Table 7.2A**). Only two shrew genera were recorded, but 78 collected specimens await identification by a taxonomical expert, hence the number of different shrew species may increase. One species of Macroscelidea was found caught in snares on two occasions and also observed casually inside the forest reserve and in the Village Government Forest (trapsite A).

Four of the rodent species recorded in and around NDUFR were forest dependent. Of these, the subspecies, *Paraxerus lucifer lucifer*, is considered near endemic and *Beamys hindei* is listed as "Vulnerable" by IUCN (Hilton-Taylor, 2000) (see **Table 7.2A**). In addition, *Rhynchocyon cirnei* of the family Macroscelidae, is also listed as "Vulnerable" (Hilton-Taylor, 2000). All other identified species are widespread and found in four or more countries (see **Table 7.2A**). See **Appendix 7.5B** for a list of all mammal species recorded in and around NDUFR.

Table 7.2C. List of small mammal species encountered in and around New Dabaga/Ulangambi Forest Reserve, their distribution and conservation status. Once identifications to species level have been returned more detailed information can be obtained on species distribution, forest dependency and conservation status. There are several question marks in the table due to incomplete identification.

Order and family/ subfamily	Species	Forest dependency	Conservation status	Endemism and distribution of species
INSECTIVORA				
Soricidae	*Myosorex* sp.	?	?	?
	Crocidura sp.	?	?	?
MACROSCELIDAE				
Rhynchocyoninae	*Rhynchocyon cirnei**		VU	Ma, Mo, T, U, DRC, Z
RODENTIA				
Sciuridae	*Paraxerus lucifer lucifer**	F		(NE)
Myoxidae	*Graphiurus* sp.	?	?	?
Gerbillinae	*Tatera* sp.	?	?	?
Dendromurinae	*Dendromys* sp.	?	?	?
Cricetomyinae	*Beamys hindei*	F	VU	K, Ma, T, Za
	*Cricetomys gambianus**			W
Otomyinae	*Otomys* sp.^	?	?	?
Muridae	*Lophuromys flavopunctatus*	F		W
	Praomys delectorum	F		K, Ma, Mo, T
	Hylomyscus denniae			K, Ma, T, U
	Mus sp.	?	?	?
	Grammomys sp.	?	?	?
	Dasymys incomptus		DD	
	Rhabdomys pumilio		DD	W

* - Species observed in forest reserve, but nor caught during the survey.
^ - Specimen seen caught in snare in field outside the forest reserve (not collected).
# - Local names of some of the species are presented in **Appendix 7.1B**.
Forest dependency (F) as according to Kingdon & Howell (1993)
Conservation status categories as according to Hilton-Taylor (2000): VU = Vulnerable; DD = Data Deficient.
Endemism and distribution categories: (NE) = near endemic subspecies, found only in Tanzania; DRC = Democratic Republic of Congo; K = Kenya; Ma = Malawi; Mo = Mozambique, T = Tanzania; U = Uganda; W = widespread (found in more than ten counties); Z = Zambia (Species distributions taken from Kingdon, 1997).

Sherman Trap and Bucket Pitfall Survey

A total of 1,063 small mammals were captured in New Dabaga/Ulangambi Forest Reserve during this study. 669 of these were unique individuals (i.e. not counting recaptured animals (374) and animals which escaped prior to processing (20)), including 590 rodents, 78 shrews and one dwarf galago (*Galagoides orinus*) (see **Table 7.2B**). Of these unique individuals, 565 were caught in Sherman traps, while 104 were caught 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 total of eleven rodent species were recorded from eleven genera and five families during Sherman and bucket pitfall trapping (see **Appendix 7.2A**). Based on tentatively identified individuals, at least two genera of shrews were found in and around NDUFR (see **Appendix 7.2A**). All 78 collected specimens however await identification by W. T. Stanley, after which the total number of species will be known.

The one individual caught of the dwarf galago (*G. orinus*) is only the second specimen ever to be collected of this species, and the first male (Andrew Perkin, *pers. comm.*; see section 8).

The number of unique individuals caught of each species is listed for all trapsites in **Appendix 7.2A**. *Praomys delectorum* was the most abundant species with 215 captures from eight of the nine surveyed trapsites. *Grammomys* sp. was recorded 127 times, occurring at all trapsites, while 140 individuals of *Hylomyscus dennieae* were caught at seven of nine trapsites. *Beamys hindei* and *Lophuromys flavopunctatus* were also widespread in the study (found at eight and seven trapsites respectively), although at much lower abundance (28 and 22 individuals respectively). Two species were recorded from approximately half of the trapsites: 18 *Dendromys* sp. individuals were caught at five trapsites and 23 individuals of *Mus* sp. were found at four trapsites. Four species (*Graphiurus* sp., *Rhabdomys pumilio* and *Tatera* sp.) were recorded from ten or less individuals and from three or less trapsites.

Shrews were caught at all trapsites in numbers varying from one to 14. Based on tentative identifications, the genus *Crocidura* is present at eight of the nine surveyed trapsites and *Myosorex* is present at five (see **Appendix 7.2A**).

Table 7.2B. Number of species and unique individuals of small rodents and shrews caught per trapsite during Sherman and pitfall trapping. Also listed are the number of Sherman trap nights, bucket pitfall nights (number of buckets x number of trapping nights) and altitude for all surveyed trapsites.

Trapsite	Rodent species	Rodent individuals	Shrew genera	Shrew individuals	Number of trap nights	Number of pitfall nights	Altitude m a.s.l.
Forest reserve sites							
1	7	82	2	10	778	264	1910
2	5	108	1	9	752	264	1950
3	5	52	2	14	761	264	1945
4	7	84	2	14	783	264	1930
5*	9	79	2	13	782	264	1850
Total	10	405	2	60	3856	1320	1910-1950
Non-forest reserve sites							
A^	5	65	2	5	388	132	1825
B	5	10	2	2	399	132	1985
C	6	66	1	1	391	132	2025
D*	6	44	1	10	403	132	1915
Total	8	185	2	18	1581	528	1825-2025
Summary of all trapsites in and around New Dabaga/Ulangambi Forest Reserve							
Total	11	590	2	78	5437	1848	1825-2025

*- Trapsites surveyed during the short rainy season (November-December)
^ - One *Galagoides orinus* was also recorded at this trapsite in a Sherman trap.
# - Species only tentatively identified by Frontier Tanzania researchers. Once identifications of collected specimens is returned it is likely that more species will be added.

Table 7.2C. Results from eight trap nights in NDUFR and results from four nights of trapping at trapsites both inside and outside the forest reserve. 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				Number of unique shrews			
	Sherman traps	Bucket pitfalls	Per 100 trap nights	Per 33 bucket nights	Sherman traps	Bucket pitfalls	Per 100 trap nights	Per 33 bucket nights
Forest 8 days	379	24	10.01	0.60	8	52	0.21	1.30
Forest 4 days	160	12	8.18	0.60	8	17	0.41	0.85
Non-forest	172	16	9.31	1.00	6	12	0.38	0.75
Total	541	40	9.95	0.71	14	64	0.26	1.14

Natural Forest Trapsites

Small rodents

The species curve for New Dabaga/Ulangambi Forest reserve levels off at nine species, suggesting few species remain to be found in the reserve (see **Figure 7.2A**). It should however be noted that this result is based on only six trapsites in natural forest, and preferably more sites should be investigated in order to draw conclusions.

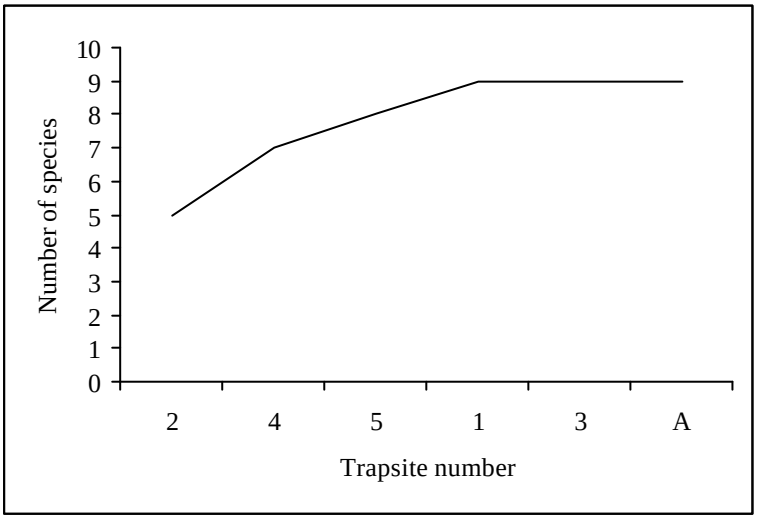


Figure 7.2A. Species accumulation curve for rodents trapped from natural forest sites in New Dabaga/Ulangambi Forest Reserve. Trapsites are arranged randomly.

The number of small rodent species (as defined in introduction) caught per trapsite varied between five and nine (see **Table 7.2B**). Based on eight days of trapping, trapsite 5 with nine species is the most species rich trapsite in the forest reserve, while trapsite 2 and 3 with five species have the lowest number (see **Table 7.2B**). Five species was also recorded from trapsite A in a small natural forest fragment outside the forest reserve, but from only four days of trapping.

Trapsite 2 with 108 unique individuals had the highest small rodent abundance of all the trapsites in NDUFR. Trapsites 1, 4 and 5 caught between 73 and 75 individuals, while trapsite 3 with 52 individuals had the lowest abundance of small rodents (see **Appendix 7.2B**).

Praomys delectorum, *Hylomyscus denniae* and *Grammomys* sp. was by far the most frequently encountered species in natural forest sites within the forest reserve. *Grammomys* sp. were caught 95 times, *H. denniae* 116 times and *P. delectorum* 146 times. All other species were recorded 18 times or less in the forest reserve (see **Appendix 7.2A**).

Shrews

The number of shrew individuals varied between nine and 14 for forest reserve trapsites (see **Appendix 7.2A&B**). Shrews therefore seem to be equally distributed over the reserve. The tentative identifications carried out by Frontier Tanzania researchers preclude any comparison of shrew diversity.

Natural Forest Trapsites vs Non-Natural Forest Trapsites

Trapsite A in a small natural forest fragment outside of NDUFR was grouped together with forest reserve trapsites, in order to compare natural forest (trapsites 1-5 and A) with non-natural forest trapsites (B, C and D).

Small Rodents

Ten species of small rodents (as defined in introduction) were recorded from natural forest compared to eight species found in plantation forests (trapsites B and C) and fallow field (trapsite D) combined (see **Table 7.2B**). Three species (*Graphiurus* sp., *Dasymys incomptus* and *Tatera* sp.) were unique to natural forests and one species (*Rhabdomys pumilio*) was only recorded from the fallow field trapsite. Seven species were shared between natural forest and other habitats (see **Appendix 7.2A**).

The species unique to natural forest trapsites were all caught in low numbers (five, one and one respectively), while ten individuals were caught of *R. pumilio* in non-natural forest habitats (see **Appendix 7.2A**).

Trapsites A (Village Government Forest) and C (black wattle plantation) had the highest abundance of rodents compared to any other area using only the first four days of trapping (see **Appendix 7.2C**). Trapsite B (pine plantation) and trapsite 1 have the lowest rodent abundance.

The *t*-test was employed to compare mean rodent abundance and species richness between natural forest trapsites and trapsites in other habitats (if variances differed between samples the Mann-Whitney *U*-test was used). The tests were based on the first four nights of trapping and captures per 100 trap nights (see **Appendix 7.2C**), to account for different Sherman trap sampling intensities between trapsites. No significant difference was observed in mean species richness (*t*-test: t=-1.528, df=7, p=0.170). Tests of rodent abundance were made separately for pitfalls and Sherman traps. Again, no difference was observed in the mean number of rodent individuals caught per 100 trap nights (*t*-test: (Sherman traps) t=0.161, df=7, p=0.877; (bucket pitfalls) t=-1.782, df=7, p=0.118).

For species caught at more than four trapsites (includes all species not unique to natural forest or other habitats), the number of individuals recorded per 100 trap nights was compared between natural forest sites and other habitats. Using only the first four days of trapping, one significant result was observed: more individuals of *Mus* sp. were caught in non-natural forest sites than natural forest sites (Mann-Whitney *U*-test:, Z=-2.761, n=9, p=0.006).

Shrews

The number and uncertainty of shrew identifications again preclude comparison of shrew species diversity between natural forest trapsites and trapsites in other habitats. Shrew data will therefore only be used to compare shrew abundance between these groups of trapsites. In total 78 shrews were caught: 65 in the natural forest and 13 in other habitats (see **Appendix 7.2A**).

Trapsites 3, 5, B and C have three or fewer shrew individuals caught within the first four days of trapping (see **Appendix 7.2C**). Using *t*-test to compare shrew abundance showed no significant difference between natural forest and other habitats (*t*-test: (Sherman traps) t=-0.075, df=7, p=0.318; (bucket pitfalls) t=1.076, df=7, p=0.942).

Effectiveness of Trapping Methods

The two trapping methods used during the survey were effective for different taxonomical groups. Bucket pitfall trapping was efficient at catching shrews (see **Figure 7.2B**) and *Dendromys* sp., while Sherman traps predominantly caught medium to large rodents that are able to jump out of the bucket (see **Figure 7.2B**). Using a *t*-test to compare mean number of small rodent captures showed that buckets were more effective than Sherman traps at catching shrews (*t*-test: t=-7.255, df=8, p<0.001), while Sherman traps were more effective for rodents (*t*-test: t=8.035, df=8, p<0.001).

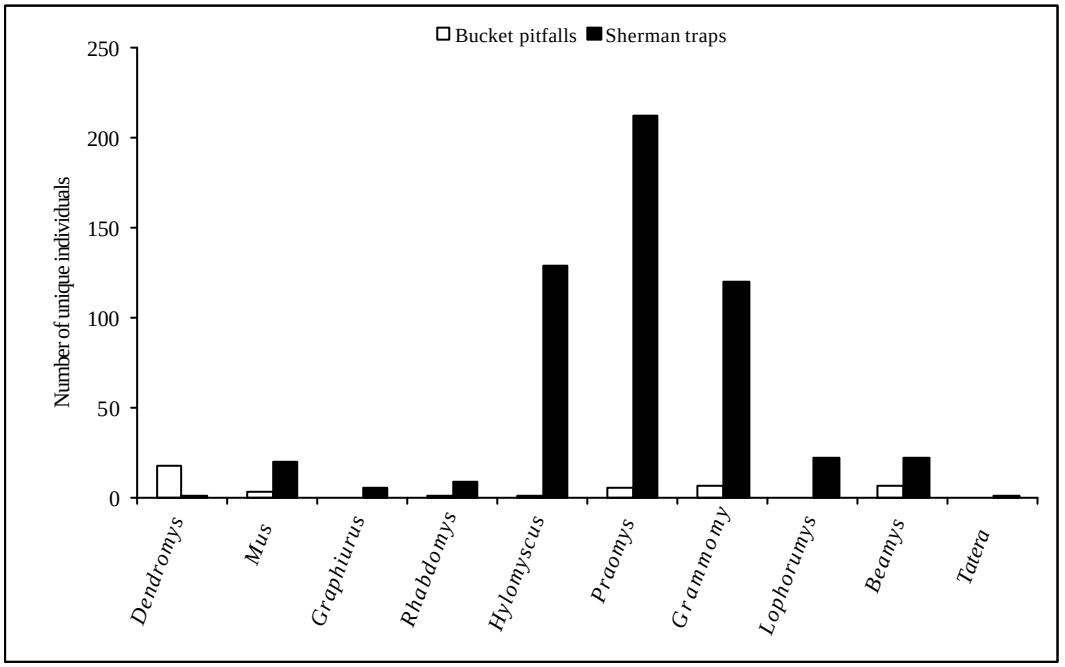


Figure 7.2B. A comparison of the effectiveness of the two trapping methods for all captured small mammal species. Numbers represent unique individuals to avoid bias from collection of specimen and trap happiness or shyness.

Rain

The *t*-test was used to compare small mammal captures before (seven trapsites) and after the onset of rain (two trapsites) (see **Appendix 7.2C**). Results however showed no significant effect of rain on mean species richness and abundance for shrews or small rodents.

Mesh Trap Results

During 91 trap nights no captures were made in the large "Tomahawk" mesh traps.

7.2.5 Discussion

The Small Mammal Fauna; its Forest Dependency and Conservation Status
Species considered important for management are those species which are forest dependent, listed as "Endangered" or "Vulnerable" by IUCN and species with limited distribution. Only four rodent species and one elephant shrew recorded in the reserve fall under these categories (see **Table 7.2A** and **Box 7.2A** for description of species considered forest dependent according to this study). Most other rodent species recorded from the reserve are widespread, although some also have their stronghold in forest areas (e.g. *Hylomyscus* sp.; this study and Frontier Tanzania, 2001f).

Further identification, especially of shrews (which tend to be more restricted in distribution) may increase the list of species considered important for conservation.

Three species of small rodents (as defined in introduction) caught in NDUFR had not previously been observed in Eastern Arc forests. These were however not species with specific adaptations to forest habitat, but species typical of drier savannah habitat and moist grassy vegetation (see below). Although many species were found outside natural forest habitat, several rodent species depend on forests for their survival. Management activities should therefore focus on maintaining/improving forest quality. Although there is no immediate threat to the small rodent population in NDUFR, the establishment of a habitat mosaic between larger forest fragments including the Village Government Forest type, black wattle plantations and fallow fields (2-6 years of age), will allow rodent species to disperse more easily to neighbouring forests, thus enabling populations to mix.

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

The species listed here includes only tentatively identified species. It is likely that more shrew species of conservation concern will be found when collected animals are identified. The criteria used here to define species of conservation concern is species listed as "Vulnerable" by Hilton-Taylor (2000) or a range limited to East African, northern Malawi and northern Mozambique (see **Table 7.2A**).
The chequered elephant shrew, *Rhynchocyon cirnei*, was casually observed on several occasions in the forest reserve and in the Village Government Forest (trapsite A). In the dry season it inhabits forests and gallery forest, while it during the wet season may use grassland habitats (Kingdon, 1997). Natural forest is therefore the most important habitat for this species. It is listed as "Vulnerable" by Hilton-Taylor (2000), the major threat being destruction of habitat.
The Tanganyika mountain squirrel, *Paraxerus lucifer lucifer*, was observed regularly within the forest reserve and in the Village Government Forest (trapsite A). The species *P. lucifer* is found in Kenya, Tanzania and Malawi, while the subspecies *P. l. lucifer* is restricted to Eastern Arc Mountains. According to Kingdon (1997), all subspecies are vulnerable and totally dependent on continued protection of the relict forest fragments where they occur.
Beamys hindei is considered a "Vulnerable" (Hilton-Taylor, 2000) and forest dependent species (Kingdon & Howell, 1993). 28 unique individuals were caught, of which 18 were from natural forest, five were from the Village Government Forest, four from black wattle plantation and one from the fallow field. The species still depends on forests for its survival, but it shows potential for dispersing between major forest fragments if corridors or stepping-stones exist of the right type of habitat.
Praomys delectorum is according to Kingdon (1974) "principally found in Southern Forests" in Tanzania. However, the range of *P. delectorum* has recently 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 in the Udzungwa Mountains. Frontier Tanzania's Udzungwa Mountain Biodiversity Surveys have found *P. delectorum* to be the most abundant species in both New Dabaga/Ulangambi Forest Reserve and West Kilombero Scarp Forest Reserve.
Hylomyscus denniae is a relict species with a discontinuous distribution and mainly found in mountain regions (Kingdon, 1974). This species is somewhat more arboreal than *P. delectorum*, which may account for the lower number of individuals caught of this species. Predominantly confined to high altitude forest (Stanley *et al*., 1998), this species relies on the persistence of such a habitat for its long-term survival.

Sherman Trap and Bucket Pitfall Survey

The trapping methods employed in this study may not reflect the true ratio between the species caught in New Dabaga/Ulangambi 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.

Natural Forest Trapsites

Small Rodents

Ten small rodent species were recorded during trapping activities from natural forest sites in New Dabaga/Ulangambi Forest Reserve. Adding the three casually observed species from the forest, the total number of small mammals belonging to Rodentia and Macroscelidae is 13 (see **Table 7.2A**). These casually observed species include the forest dependent Tanganyika mountain squirrel (*Paraxerus lucifer lucifer*), giant pouched rat (*Cricetomys gambianus*) and IUCN "Vulnerable" Chequered elephant shrew (*Rhynchocyon cirnei*). In total four species are forest dependent according to Kingdon & Howell (1993), and two are listed as "Vulnerable" by Hilton-Taylor (2000) (see **Table 7.2A**).

A survey of the small mammal fauna in West Kilombero Scarp Forest Reserve questions the forest dependency of *Lophuromys flavopunctatus* (Frontier Tanzania, 2001f). The capture of nine unique individuals in a fallow field is the highest number of individuals caught at any trapsite during this study, despite only four days of trapping (see **Appendix 7.2A**). This study therefore also supports the exclusion of *L. flavopunctatus* from the forest dependent category. *Hylomyscus denniae* were recorded from the black wattle plantation outside natural forest. This trapsite was especially rich in rodent diversity and abundance, and all forest dependent species were recorded from this site. This habitat therefore seems to offer conditions similar to natural forests. *H. denniae* may therefore be regarded as a forest dependent species, which also is suggested by surveys in WKSFR (Frontier Tanzania, 2001f).

Trapsite 5 was the most species rich site within natural forest, closely followed by trapsites 1 and 4 (see **Table 7.2B**). This is due to the record of one individual of *Tatera* sp., which is an arid species common in savannah habitats (Stanley *et al*., 1998). Stanley *et al.* (1998) have not recorded the species from Eastern Arc forests and Kingdon (1997) reports the genus to be absent from rain forest habitats. It is therefore surprising that this individual was captured more than 1800m inside the forest edge in montane forest. It may be due to the dry type of forest with a relatively low canopy and very little ground cover. The richness of this site could probably be ascribed to this dry type of forest combined with adjacent moist forest habitats resulting in a habitat rich in niches.

An area rich in microhabitats is known to support more small mammal species than habitats with fewer niches (Kemper & Bell, 1985). Lightly logged areas and forest edge habitat have a more complex structure and thereby more niches than mature forest environments. The very disturbed nature of trapsite 1 and the proximity of the forest edge for site 4 may therefore explain the higher number of species found here compared to sites 2 and 3 (see **Table7.2B**). Trapsite A (Village Government Forest) had the same species richness as sites 2 and 3, despite trapping only being carried out over four days. The site however had a higher abundance of rodents and it is possible that more trap nights would reveal more species.

In line with Stanley *et al*. (1998) surveys of other Eastern Arc Mountains and Frontier Tanzania (2001f) surveys in WKSFR, *Praomys delectorum* was the most abundant species in this study (see **Appendix 7.2A**). Stanley *et al*. (1998) however reports *Lophuromys flavopunctatus* to be the most frequently encountered species in their survey of the Udzungwa Mountains. This probably reflects the diverseness of habitats found within these mountains, where different macro-habitats differ in rodent composition and abundance. Other abundant species include the very closely related *Hylomyscus denniae* and *Grammomys* sp., while the forest dependent and "Vulnerable" (Hilton-Taylor, 2000) *Beamys hindei* was the fourth most abundant species. *Dendromys* sp., *Graphiurus* sp., *Mus* sp. and *Tatera* sp. were all recorded

from three trapsites or fewer, thus indicating a very low abundance or specific adaptations to certain environmental conditions.

Shrews

The uniform distribution of shrews (see **Table 7.2B**) indicates a low variability in shrew habitat within the natural forest. It should however be noted that most trapsites were sampled in the dry season and with rain having a positive effect on trap efficiency for shrews (Frontier Tanzania, 2001f), it is possible that differences might have been found if trapping had taken place during the rains.

Natural Forest Trapsites vs Non-Natural Forest Trapsites

Ten species were recorded from natural forest and eight from other habitats. Three species were confined to natural forest (*Graphiurus* sp., *Tatera* sp. and *Dasymys incomptus*), while one (*Rhabdomys pumilio*) was only caught in other habitats (see **Appendix 7.2A**). This high overlap of species (seven) between natural forests and other habitats shows that many rodents can inhabit or disperse across gaps in natural forest. This is also supported by studies in West Kilombero Scarp Forest Reserve (Frontier Tanzania, 2001f) and has allegedly led to a widely distributed rodent fauna in the Eastern Arc Mountains (Stanley *et al*., 1998).

The three species found exclusively in natural forest (*Graphiurus* sp., *Tatera* sp. and *D. incomptus*) were only recorded on five, one and one occasions respectively. This suggests either a very low abundance or, more likely, a size and behaviour that make these species less prone to being caught in the pitfalls and traps used in this study. In WKSFR, a *Graphiurus* sp. was caught in miombo woodland (Frontier Tanzania, 2001f) and *Tatera* sp. was observed in a snare in a cultivated area in NDUFR. This combined with *Tatera* sp. not being a typical forest species (Kingdon, 1997; Linzey & Kesner, 1997 and Stanley *et al*., 1998) suggests that these species are not exclusively forest dependent. *Dasymys incomptus* is according to Kingdon (1997) most common in wetter grassy areas, and in this study was recorded from a water logged area few metres from a stream. In WKSFR, this species was also highly associated with water and caught both within and outside natural forest habitats (Frontier Tanzania, 2001f). This also suggests that *D. incomptus* is not a typical forest species. *R. pumilio* on the other hand is a typical non-forest species and was not recorded in forest by Stanley *et al*. (1998) or during the Udzungwa Mountains Biodiversity Surveys by Frontier Tanzania. The difference in species composition between natural forest and other habitats can therefore be ascribed to the few records in natural forest of species not depending or typical for this habitat and the captures of the distinct grassland species *R. pumilio* outside the natural forest.

Based on the first four days of trapping, the abundance of rodents were highest in the Village Government Forest (trapsite A) and black wattle plantation (see **Appendix 7.2C**). This is thought to be a result of an abundant food source. The Village Government Forest is dominated by *Parinari excelsa*. The fruit of this tree is known to be a favourite food source for many rodents and the range of a rodent individual can be limited to the area directly beneath a mature *P. excelsa* tree (Kingdon, 1974). Furthermore, the small size of this natural forest fragment means that a high proportion of the habitat is forest edge, which increases the number of niches and therefore the possibility of supporting more rodent species. The black wattle plantation is a uniform and mono-dominant habitat with a low diversity of niches. However, black wattle seeds constitute an abundant and apparently highly favoured food source for many rodents, thus explaining the large rodent population in this habitat despite the uniform habitat.

The number of rodent species found in the pine plantation (trapsite B) equals that of three other trapsites. The abundance of these species, however, was less than half of that recorded for rodent populations at the other sites (see **Appendix 7.2A**). Most of the ten individuals caught in the pine plantation were caught in a newly logged area or near the plantation edge bordered by a fallow field. The low abundance of vegetable food in the pine plantation may be the reason for the low number of rodent captures, but the proximity of other habitats and the logging activity could also have increased the number of individuals caught in the pine plantation. Either way this habitat supports the lowest number of rodents and therefore acts more like a barrier to the animals rather than as a dispersal corridor or a stepping stone between forested habitats.

The fact that no difference in rodent diversity and total number of individuals was observed between natural forest trapsites and trapsites in other habitats supports the argument above regarding a widely distributed rodent fauna in the Eastern Arc Mountains. The genus *Mus* was the only taxon caught both within and outside natural forest, that were caught more often outside natural forest than inside. This may reflect a specific non-forest adaptation of this particular species of *Mus*, which only was recorded once in natural forest from a very disturbed forest area (trapsite 1).

Shrews

No difference was observed in the number of shrews caught during the first four days of trapping between natural forest and other habitats. In other studies, rain has shown to have an effect on the number of shrews caught (Frontier Tanzania, 2001f; W. T. Stanley, personal communication). Ideally, studies should therefore have been carried out during the rainy season in order to compare shrew abundance and diversity.

Effectiveness of Trapping Methods

The two trapping methods employed in this study showed to be efficient with different taxonomic groups. Bucket pitfalls were most efficient at catching shrews and *Dendromys* sp., while Sherman traps were most efficient for remaining taxa. In this study *Mus* sp. were most frequently caught in Sherman traps while other studies have shown the species to be caught almost equally in the two trapping methods (Stanley *et al*., 1998; Frontier Tanzania, 2001f). Why this study differs from the others is unclear, but it could be a change in behaviour related to the onset of rain. Although sample size is too small to draw conclusions results indicate that this might be the reason, since one of 19 (5%) individuals was caught in bucket pitfalls in the fallow field after the onset of the short rainy season, while two of four (50%) were caught in pitfalls before the rain began.

Rain

Linzey & Kesner (1997) report a correlation between rodent abundance and rain in a woodland savannah ecosystem. This study showed that rain had no effect on rodent and shrew abundance. This may be due to the low number of trapsites sampled after the rains, and the type of these habitats; a drier type of montane forest with low canopy and a fallow field. Kasenene (1989, cited in: Struhsaker, 1998) also reports a time lag between rain and an increase in rodent abundance which also would explain the lack of correlation from this study. Shrew abundance is also known to increase with rain (Stanley, *pers. comm.*). No correlation was observed in this study, but it is believed that if similar habitats had been sampled before and after the onset of rain, an increase in shrew captures would be observed (Frontier Tanzania, 2001f).

Comparison with other Eastern Arc Forests

The number of small rodent species for six Eastern Arc areas and the two forest reserves surveyed by the Udzungwa Mountain Biodiversity Surveys is listed in **Table 7.2D**. Among the listed areas, the Udzungwa Mountains are the most species rich site when data from previous studies by Stanley *et al*. (1998) and results from this survey are combined. Four species (*Tatera* sp., *Otomys anchieta, Mus triton* and *Dasymys incomptus*) recorded from the forested areas of Udzungwa Mountains have not been recorded in any other Eastern Arc forests by neither Stanley *et al*. (1998), or Frontier Tanzania (Frontier Tanzania, unpubl.). The 12 remaining species are widespread within the
Eastern Arc and found in at least two other countries.

The East Usambara Mountains is the only other Eastern Arc region which contains 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 generally widespread small rodent fauna found within the Eastern Arc.

Table 7.2D. Number of small rodent species (as defined in introduction) caught in Sherman traps and bucket pitfalls 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, while this study adds three species (*Graphiurus sp*., *Dasymys incomptus* and *Tatera* sp.) and Frontier Tanzania surveys in WKSFR add one species (*Mus minutoides/musculoides*).

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

^ Minimum number of species. *Mus* spp. are pending identification.

In New Dabaga/Ulangambi Forest Reserve ten species were caught in natural forest compared to nine species recorded from natural forests in West Kilombero Scarp Forest Reserve. There was an overlap of eight species between these two forest reserves. Three species were not shared between the forested areas in the reserves, these are one species of *Mus* from WKSFR and *Graphiurus* sp., and *Tatera* sp. from NDUFR. The trap-rates for the two species from NDUFR are very low (see **Appendix 7.2A**). *Graphiurus* sp. was caught five times in NDUFR, and once in WKSFR (outside evergreen forest in miombo woodland), and *Tatera* sp. was trapped once in NDUFR.

Forested areas in both East and West Usambara Mountains contain more shrew species than the Udzungwa Mountains. This however may reflect different sampling intensities and it is likely that future studies will increase the known distribution of several species (Stanley *et al*., 1998). One should therefore bear in mind that 78 individuals of shrews await

identification, and with the more patchy distribution of this group (Stanley *et al*., 1998), it is likely that more shrew species will be found.

7.2.6 Conclusion

Combined with previous surveys in the region, results have shown that Udzungwa Mountains is the most species rich region within the Eastern Arc Mountains. Sixteen small mammal species were recorded in and around New Dabaga/Ulangambi Forest Reserve. Fourteen of these were recorded inside the forest reserve in natural forest. The difference in species composition between natural forests and other habitats is due to few records of two non-forest dependent species in forest and one typical grassland species only recorded in non-natural forest habitats. Several species are of considered of conservation concern. Therefore the managing authority should seek to maintain or improve the forest quality in NDUFR.

7.3 Bats of New Dabaga/Ulangambi Forest Reserve

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

7.3.1 Summary

Bats of New Dabaga/Ulangambi Forest Reserve (NDUFR) were sampled during the period October to November 2000. Sampling was carried out using mist nets. Bats encountered opportunistically (e.g. roosting) were also collected. A total of 61 hours were spent mist netting. Fourteen bats were caught, representing two families and three genera. Only one individual was identified to species level, thereby making any interpretation of results difficult. The small sample size and few genera recorded compared to other areas (e.g. West Kilombero Scarp Forest Reserve), makes it doubtful that a representative species list has been compiled.

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 New Dabaga/Ulangambi Forest Reserve (NDUFR).

7.3.3 Method

Bats were sampled during the period October to November 2000. Sampling of bats was carried out by mist netting (as described in the Methodology 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 forest reserve, 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

All identifications are currently preliminary, and only one bat has been identified to species 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. Without accurate identifications, little interpretation of the bat collection can be made. The discussion will, therefore, be kept very brief (for a more detailed discussion see Section 7.3; Frontier Tanzania, 2001f). Taxonomic nomenclature follows Kingdon (1997). Specimens have been deposited at the Field Museum of Natural History, Chicago.

A total of 61 hours were spent mist netting. Thirteen bats were caught in mist nets, and one 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. For example, 11 of the 14 bats caught during the survey of NDUFR, were netted in a six hour period. Rivers, streams and animal paths form good bat flyways through the forest habitat. Hence, 86% of bats were caught over streams/rivers, while 7% 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 NDUFR.

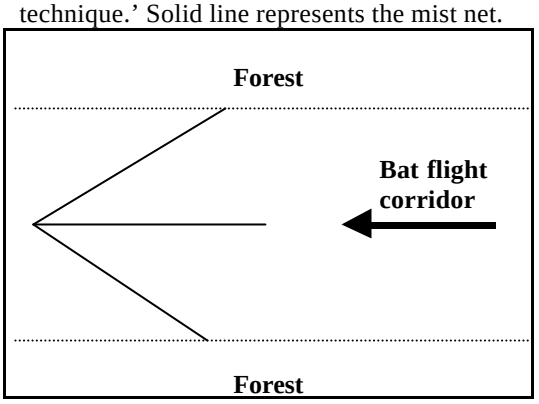
Trapsite	**Habitat & Altitude (m a.s.l.)**	**No of Nets**	**Hours Trapping**[+]	**Bats Caught**
1	Scrub/thicket/bush; 1910m	6mx2.6 x5 nets 2.6mx2.6m x1 net	10 hours	1
2	Montane forest; 1950m	6mx2.6 x3 nets 2.6mx2.6m x1 net	6 hours	0
3	Montane forest; 1945m	6mx2.6m x 3 nets	**11 hours**	0
4	Montane forest; 1930m	6mx2.6m x 3 nets	12 hours	12
5	Montane forest; 1850m	6mx2.6m x 3 nets	**11 hours**	0
A	*Parinari* fragment; 1825m	None	None	0
B	Pine plantation; 1985m	6mx2.6m x 3 nets	**11 hours**	0
C	Black wattle; 2025m	Together with Pine	-	0
D	Fallow field; 1915m	None	None	0

* 1 bat caught opportunistically within the forest reserve.
\+ Numbers in **bold** indicate 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 two families and three genera, which is lower than at other forest reserves surveyed by Frontier Tanzania (see **Table 7.3C**; Frontier Tanzania, 2001f).

Table 7.3B. Bats collected from New Dabaga/Ulangambi Forest Reserve (July-December, 2000).

Identification	Forest Species[#]	Endemism	IUCN Status	Altitude (m a.s.l.)	Habitat[+]	Number caught
RHINOLOPHIDAE						
Rhinolophus clivosus	×			1930	MF	1
Rhinolophus sp.	?	?	?	1900	RF/MF	4
VESPERTILIONIDAE						
Miniopterus sp.	?	?	?	1930	MF	8
Pipistrellus sp.	?	?	?	1910	MF	1

- Forest Species: F = Forest-dependent; × = Species found in forest or forest edge as well as other habitats; O = Non-forest species.
+ - Habitat: MF = Montane Forest ; RF = Riverine Forest.

All genera recorded by this survey are insect bats; no fruit bats were recorded by this survey. *Rhinolophus clivosus* is a widely distributed species. 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).

Mist netting as a method to sample bats is not without its limitations. No fruit bats were caught during the course of this survey, as fruit bats tend to fly high above the ground. The most often caught genus (*Rhinolophus*), conversely, forages for insects near the ground. Therefore, this sample method is biased towards low-flying species.

7.3.5 Conclusion

This survey recorded 14 individuals, from two families and three genera. This small sample size and few genera recorded makes it doubtful that the survey has provided a representative species list for NDUFR.

7.4 Eastern Tree Hyrax (*Dendrohyrax validus*) in New Dabaga/ Ulangambi Forest Reserve

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

7.4.1 Summary and Recommendations

Knowledge of the basic ecology of the tree hyrax is extremely limited. A lack of research into the needs of tree hyraxes is regrettable because their uneven abundance and patchy distribution will need to be understood before practical conservation plans can be attempted. This study aims to assess the influence of habitat degradation and hunting on the hyrax population in New Dabaga/Ulangambi Forest Reserve.

No systematic survey was carried out of the eastern tree hyrax population in New Dabaga/Ulangambi Forest Reserve due to the low number of calling individuals. Calls were, however, instead recorded during a stay in the forest in August 1999 and during bat-netting activities in October and November 2000.

Two species of hyrax are present in NDUFR, based on vocalisations of *Dendrohyrax validus* and a skull collected from *Heterohyrax brucei*. No calls were heard of *H. brucei* during the fieldwork, and hence the abundance of this species could not be assessed by the employed method. This study therefore focuses on the near endemic *D. validus*, which is listed as "Vulnerable" by IUCN.

The abundance of *D. validus* in NDUFR is very low compared to undisturbed areas in the Udzungwa Mountains. Notably the high level of ground snaring coupled with logging seems to have reduced *D. validus* density. Indirectly, extensive logging, which has taken place throughout the reserve, may have affected the hyrax population as it has removed potential nesting trees and reduced arboreal pathways. The reduction of arboreal pathways has forced the animal into moving on the ground to get from one tree to another, thus becoming more vulnerable to ground snaring.

The low abundance of *D. validus* may also be a result of competition with *H. brucei* for food or shelter. The method employed in the study may have underestimated *D. validus* abundance if a change in behaviour has been induced by hunting, e.g. animals remain quiet throughout the night in order not to reveal their presence, and therefore cannot be heard calling. Nevertheless, the population of *D. validus* has been adversely affected by the history of human forest use. Management initiatives should therefore focus on improving conditions for this near endemic species, through improvement of forest quality and a regulation of the hunting level.

7.4.2 Introduction

New Dabaga/Ulangambi Forest Reserve is home to two species of hyrax. The eastern tree hyrax (*Dendrohyrax validus*) and the yellow spotted hyrax (*Heterohyrax brucei*). These belong to distinct lines of Procavia, the former is a tree hyrax the latter a bush hyrax. *D. validus* is a solitary, forest adapted species unique to the Eastern Arc Mountains and eastern coastal forests (Kingdon, 1997 and Burgess *et al*., 2000), while *H. brucei* often occurs in colonies and is found in a wider range of habitats (Kingdon, 1997). The eastern tree hyrax will be the focus of this study.

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 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.

The eastern tree hyrax has a patchy distribution with locally distinct populations. 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). Results from this study will be compared to data from other forests in the Udzungwa Mountains.

Aims

- To evaluate the effect of human forest use on the tree hyrax population in NDUFR.
- To make recommendations for management initiatives connected to the protection of this species.

7.4.3 Method

Note on Hyrax Species Present in NDUFR

One skull was collected from NDUFR and later identified as *Heterohyrax brucei* by Dieter Kock at the University of Frankfurt in Germany. This species is most often found in drier habitats (i.e. not evergreen forests) although occasionally they are recorded from forested areas (D. Kock, *pers. comm*.).

According to Kingdon (1997), the call of *H. brucei* differs significantly from the calls uttered by other hyraxes including *D. validus*. The hyrax calls heard in NDUFR all resembled calls heard in West Kilombero Scarp Forest Reserve, where the only recorded species is *D. validus*. It is therefore believed that two species of hyrax occur in NDUFR. This study focuses on the relative abundance of *D. validus* based on its nightly calls. The behaviour of *H. brucei* (i.e. no calls recorded in NDUFR) mean that other techniques have to be applied to assess the abundance of this species, and the species was therefore not included in this study.

Tree Hyrax Survey
The calls uttered at night by *D. validus* have proven valuable for density estimation of this species (Topp-Jørgensen & Pedersen, 2000). Very few calls from the eastern tree hyrax (*Dendrohyrax validus*) were however heard in New Dabaga/Ulangambi Forest Reserve, and therefore no systematic survey (see Frontier Tanzania, 2001f&g) was carried out. Instead all vocalisations of this species were recorded casually during bat netting (described in section 7.3). This data were collected in August 1999 and October-November 2000.

7.4.4 Results

During bat netting activities in New Dabaga/Ulangambi Forest Reserve (61 hours) two individuals were heard calling near trap site 5, one about 50m away and one more than 100m away. During the botanical phase in 1999, about 15 calls were heard from two individuals in plot 29. Both individuals were more than 150 m away and calling was initiated at ca. 22.45.

No animals were seen during the day and no latrines were found during fieldwork activities (July-September 1999, January 2000 and October-November 2000). Four calls were however heard during the day under 22 transect walks to survey primate populations.

7.4.5 Discussion

The high level of logging, which has taken place in New Dabaga/Ulangambi Forest Reserve has removed potential nesting trees and reduced arboreal pathways. In NDUFR the eastern tree hyraxes often have to descend to the ground in order to get from one tree to another due to the reduction in arboreal pathways. With the high level of ground trapping in this forest (32.6 active traps per km^2; Frontier Tanzania, 2001c), logging may therefore indirectly have reduced the *D. validus* population substantially.

The presence of another species of hyrax in NDUFR may also mean that competition between the two species may have reduced the abundance of *D. validus* in the reserve. It is hypothesised that shelter may be a limiting factor for hyrax abundance in some areas of WKSFR (Frontier Tanzania, 2001f). It could therefore also be that the two hyrax species in NDUFR are competing for shelter, especially if logging has removed potential trees for shelter. Furthermore, *D. validus* and *H. brucei* are both arboreal browsers (Kingdon, 1997) and therefore may compete for food. *H. brucei* is not a typical forest species and the presence of *H. brucei* in NDUFR, could be due to a high degree of disturbance. Further studies are however needed before anything can be concluded with certainty.

Comparisons of tree hyrax populations from undisturbed and hunting disturbed areas have shown a hunting induced change in their behaviour. In the undisturbed West Kilombero Scarp Forest Reserve (WKSFR) the average call frequency for *D. validus* within a radius of 50m was 6.9 calls per individual (see Frontier Tanzania, 2001f). Daytime tree hyrax calls were also heard on 56 occasions in WKSFR during 15 transect walks at two different transects (transects 1 and 2 in Ndundulu), and latrines were regularly encountered. In the nearby Udzungwa Scarp Forest Reserve (USFR), however, hyraxes have become almost exclusively nocturnal and the habit of having latrines was markedly reduced compared to undisturbed areas (Topp-Jørgensen & Pedersen, unpubl.). Such a change in behaviour would make it more difficult for predators (including humans) to locate the animal. In USFR, *D.*

validus' urge to call at night however did not seem to be affected by hunting. The hunting pressure in NDUFR is more severe than in USFR and this may have induced further changes to the behaviour of the tree hyrax. Thus further explaining the low number of hyrax calls heard at night.

This survey in WKSFR and previous surveys in USFR have shown that densities of around 8 individuals per ha are not uncommon (Topp-Jørgensen & Pedersen, unpubl.). The average number of individuals recorded from WKSFR was six individuals within an estimated distance of 50m (see Frontier Tanzania, 2001f).

In summary, the very low abundance of *D. validus* observed in NDUFR is thought to be the result of a severe hunting level over a substantial amount of time and competition with *H. brucei*. The method employed may also not justify comparison of relative abundance based on calls from NDUFR, if *D. validus* has changed its calling behaviour.

Management Recommendations
D. validus is restricted to Tanzania and is listed as "Vulnerable" by IUCN (Hilton-Taylor, 2000). Furthermore the species is highly dependent on forest habitat, making it a priority species for management. *Hunting and possibly also logging in the reserve have adversely affected D. validus*. Management initiatives should therefore focus on improving forest quality and reducing the level of ground snaring.

The long gestation period of eight months (Kingdon, 1997) and small litter size prevent a rapid recovery of the species, whilst continued hunting keeps the population at a minimum. It is therefore unlikely that the hyrax will increase in numbers unless the hunting level is reduced markedly. An increase in canopy cover would also have a positive effect on the population size and may also mean less competition from *H. brucei*, which is not a typical forest species. Management plans should therefore seek to incorporate these two aspects in order to increase the abundance of this "Vulnerable" species restricted to the Eastern Arc.

7.4.6 Conclusion

Hunting coupled with tree felling has severely reduced the density of the eastern tree hyrax (*Dendrohyrax validus*) in New Dabaga/Ulangambi Forest Reserve. Competition with *H. brucei* may also have affected the *D. validus* population adversely. Animals have changed their behaviour in response to being hunted and are now less active during the day and the use of latrines appears to have been abandoned. It is also hypothesised that the very few individuals were heard calling at night in NDUFR could be due to a hunting induced change in behaviour. Management initiatives should focus on improving forest quality to reduce competition with *H. brucei* and reduce the level of hunting in the reserve in order to allow the population of this restricted range species to recover.

7.5 Large Mammals in New Dabaga/Ulangambi Forest Reserve

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

7.5.1 Summary and Recommendations

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 (Galagoides), elephant shrews (Rhynchocyonidae), squirrels (Sciuridae), cane rat (Thryonomyidae), giant pouched rat (*Cricetomys gambianus*) and species of larger size than these.

A list of large mammals of New Dabaga/Ulangambi Forest Reserve (NDUFR) was compiled through casual and systematic observations of animals and their spoors[*]. A systematic survey of spoors was carried out along five different transects in NDUFR. Along these transects, burrows within 5m of the transect were recorded, dung within 2m, and paths intersecting the transect line were recorded if they could be assigned to a species. In total 4.65km of transect were surveyed. Throughout fieldwork, notes were also taken on all encountered large mammals or their spoors.

A total of 17 species of large mammals were recorded from NDUFR and surrounding areas. Sixteen species were recorded from natural forest areas, while only one species was observed in black wattle (*Acacia mearnsii*) plantations. Seven species were forest dependent, and five were listed as "Vulnerable" or "Lower risk" by IUCN. Further highlighting the importance of forested areas are records of five near endemic species and subspecies of which four are dependent on natural forests.

The largest species of mammals disappeared from the area a long time ago, probably several decades before the establishment of the reserve in the early 1930s. This is thought to be due to the relatively small size of NDUFR, its long-term isolation in a landscape dominated by humans, as well as a substantial hunting level over most of the reserve. The relative abundance survey showed a significant reduction in the abundance of all three forest antelopes and bush pig. Of these, Abbot's duiker and Harvey's duiker are of conservation concern. Many of the species, which are of priority for management are low in numbers due to extensive hunting and/or forest degradation resulting from logging (this study; sections 7.4 and 7.6). In particular Abbot's duiker (*Cephalophus spadix*) is very sensitive to hunting, it is therefore imperative that all hunting of this species is stopped in order to ensure a continued presence in NDUFR of this IUCN "Vulnerable" species restricted to the Eastern Arc.

Species such as the two smallest forest antelopes, Harvey's duiker (*Cephalophus harveyi*) and suni (*Neotragus moschatus*), seem to have been reduced in numbers compared to the undisturbed forest areas in WKSFR. On the other hand, smaller species such as giant pouched rat (*Cricetomys gambianus*) and chequered elephant shrew (*Rhynchocyon cirnei*) probably are little affected by the severe hunting level in the reserve. It is also noted that these observations are a snapshot in time, and that future monitoring would reveal more detailed information on population trends.

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

In order to ensure the presence of the large mammal species of conservation concern in NDUFR, it is suggested that management should focus on improvement of forest quality and seek to reduce the level of hunting. Large species in particular would also benefit from establishment of corridors or stepping-stones for dispersal. Nearby forest fragments (trapsite A: Village Government Forests) show potential for incorporation in such a venture.

7.5.2 Introduction

Large mammals are in this study defined as mammals, which generally are too large to be trapped in bucket pitfalls and Sherman traps used in the survey of the small mammal fauna (section 7.2). These include the bushbabies, elephant shrews, squirrels, cane rat, giant pouched rat and species larger than the size of these.

Livestock is present in the Udzungwa Mountains, but production has long been insufficient to meet demands. Subsistence hunting is therefore widespread in the natural forests of Udzungwa Mountains, the local wildlife population is an important source of animal protein (Zilihona *et al*., 1998). Areas in the Udzungwa Mountains with a long history of hunting have already seen the disappearance of many large mammals including elephant (*Loxodonta africana*), aardvark (*Orycteropus afer*), buffalo (*Syncerus caffer*) and the range restricted Abbot's duiker (*Cephalophus spadix*) (Topp-Jørgensen & Pedersen, 2000 and unpubl.). There is therefore an urgent need to evaluate the effect of hunting on animal populations and to implement management plans that will ensure the survival of large mammalian species.

Various methods have been developed to estimate the abundance of animals. Often they include direct observations of individuals, which together with distance estimates are used to extract a density (Eberhardt, 1978 and Seber, 1973 and 1986). Direct observation of mammals in a dense forest environment often however proves difficult and very time consuming due to the low abundance and secretive behaviour of many forest dwelling species (Stander, 1998). The spoors left behind by many animals are however relatively abundant and often easily detectable. Spoors have probably been used since the beginning of mankind to guide hunters to game and to detect the presence of enemies (Tyson, 1959). Spoor observation has also shown potential for assessing trends of rare and elusive species in a forest environment (Koster & Hart, 1988). So, where the study allows for it, indirect sampling by counting spoors can provide a cost-efficient, repeatable and objective measure of abundance.

Aims

- To produce list of large mammal species recorded in NDUFR
- 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 Method

The "Fixed Area Search Method" (Eberhardt, 1978) and the "Line Intersect Method" (Eberhardt, 1978) were used to estimate the relative abundance of mammals at five trapsites in New Dabaga/Ulangambi Forest Reserve between October and November 2000 (see Frontier Tanzania, 2001g). Species lists were obtained through casual observation from four sites outside the reserve (trapsite A: Village Government Forest, trapsite B: pine (*Pinus caribaea*.) plantation, trapsite C: black wattle (*Acacia mearnsii*) plantation and trapsite D: fallow field) (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 (transects +4, +2, +1, -1 and –4; 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.

Casual Observations
Casual observations of spoor or direct sightings of all large mammals were recorded when encountered. These observations will be used to produce a more complete species list for large mammals in NDUFR.

7.5.4 Results

Table 7.5A lists all large mammals observed in and around NDUFR, including information on forest dependency, conservation status and endemism. In total 17 species of large mammals were observed in and around NDUFR. Of these seven were forest dependent, five are found in both forests and other habitats, while three normally are regarded as non-forest species (Burgess *et al*., 2000). Four species are classified as “Vulnerable” by IUCN (Hilton-Taylor, 2000) (Udzungwa red colobus, *Procolobus gordonorum*, chequered elephant shrew, *Rhynchocyon cirnei*, eastern tree hyrax, *Dendrohyrax validus* and Abbot’s duiker) and one as “Lower risk/conservation dependant” (suni, *Neotragus moschatus*). Data is deficient for two species (black and white colobus, *Colobus angolensis palliatus* and mountain galago, *Galagoides orinus*), while the remaining ten species are not listed (Hilton-Taylor, 2000). Four species and one subspecies are near endemics, restricted to the Eastern Arc, Tanzania and Malawi (Kingdon, 1997). Harvey’s duiker, *Cephalophus harveyi*, is found in four countries, from the coastal areas of Somalia, though Kenya to Tanzania and Malawi. The subspecies of black and white colobus is found in the area restricted by the near endemic category plus coastal forests of Kenya (Kingdon, 1997), while all other species are widely

distributed and found in at least five countries. See **Appendix 7.5B** for a list of all mammal species recorded from NDUFR.

Sixteen species were recorded from natural forest areas in NDUFR, while only the greater galago (*Otolemur crassicaudatus*) was recorded outside, in the black wattle plantation. Casual observations are presented in **Appendix 7.5A**.

Table 7.5A. List of species of large mammals observed in New Dabaga/Ulangambi Forest Reserve and at four trapsites outside the reserve. Forest dependency, conservation status and distribution are listed for all species (see definitions in **Box 7.5A**). Taxonomy follows Kingdon (1997).

Order and species	Common name	Forest dependency	Conservation status	Endemism
PRIMATES				
Procolobus gordonorum	Udzungwa red colobus	F[1]	VU	NE
Colobus angolensis palliatus	Black and white colobus	F	DD	
Cercopithecus aethiops	Vervet monkey	×		W
Cercopithecus mitis	Sykes' monkey	F		W
Otolemur crassicaudatus	Greater galago	×		W
Galagoides orinus	Mountain galago	F[3]	DD	NE
MACROSCELIDAE				
Rhynchocyon cirnei	Chequered elephant shrew	O	VU	W
LAGOMORPHA				
Leporidae sp.	Unidentified hare	O	?	?
RODENTIA				
Paraxerus lucifer lucifer	Tanganyika mountain squirrel	F[2]		(NE)
Cricetomys gambianus	Giant pouched rat	×		W
CARNIVORA				
Genetta sp.[+]	Unidentified genet	?	?	?
HYRACOIDEA				
Heterohyrax brucei[#]	Yellow spotted hyrax	O[2]		W
Dendrohyrax validus^	Eastern tree hyrax	×	VU	NE
ARTIODACTYLA				
Potamochoerus larvatus	Bush pig	×		W
Cephalophus harveyi[~]	Harvey's duiker	F		
Cephalophus spadix	Abbot's duiker	F	VU	NE
Neotragus moschatus	Suni	×	LR/cd	W

[#] - Identified by Dieter Kock at Zoological Museum in Frankfurt, Germany.

^ - Species identified from calls. Given the high diversity of calls uttered by hyraxes identification should preferably be verified from a collected individual.

[+] - In the 1930s, a servaline genet (*Genetta servalina lowei*) was collected from the Dabaga area. This species is forest dependent and only recorded from the Udzungwa Mountains (Kingdon & Howell, 1993, Frontier Tanzania, 2001f).

[~] - Skull collected, but the identification is awaiting verification by W. T. Stanley.

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

Forest dependency: F = Forest dependent, × = found in forests and also other habitats, O = normally regarded as a non-forest species (Burgess *et al*., 2000). Forest dependency for species not mentioned in Burgess *et al*. (2000) is taken from [1]Kingdon & Howell (1993), [2]Kingdon (1997) and [3]Ehardt *et al*. (2000).

Conservation status according to IUCN (Hilton-Taylor, 2000): VU = vulnerable; LR/cd = lower risk, conservation dependent; LR/nt = lower risk, near threatened; DD = data deficient.

Endemism: NE = near endemic, distribution limited to the Eastern Arc, Tanzania and Malawi; W = widespread, found in more than five countries. Data from Kingdon (1997). Letters in brackets refer to subspecies.

? = animal only identified to genus.

Relative Abundance

In total 4.65 km of transect was surveyed in NDUFR. Five different transects were surveyed (see section 7.1), of which four were surveyed for one kilometre and transect –4 for 650m.

The fixed area search recorded a total of 15 burrows of giant pouched rat (*Cricetomys gambianus*) comprising 12 den systems of which six seemed not to be in use (see **Table 7.5B**). Using the total surveyed area of 4.65ha this gives a density of active den systems of 1.29 per ha.

Only one dungpile of three different species were recorded from all transect lines: Harvey's duiker (*Cephalophus harveyi*), a hyrax (*Heterohyrax brucei*, see discussion) and a genet (*Genetta* sp.).

Paths from three large mammals were observed in the reserve. Suni (*Neotragus moschatus*) paths were recorded 14 times, Harvey's duiker paths 24 times and bush pig (*Potamochoerus larvatus*) paths 7 times (see **Table 7.5B**). Human paths were encountered on nine occasions. Harvey's duiker and human paths were recorded from four of five transect lines, while other species were all recorded from three (see **Table 7.5B**).

Table 7.5B. Observations of large mammal spoors during fixed area and line intersect surveys. Number in brackets refers to den systems in current use.

Species and spoor	Transect +4	Transect +2	Transect +1	Transect -1	Transect –4	Per kilometre
Giant pouched rat holes	0	0	9 (2)	2 (2)	4 (2)	3.23 (1.29)
Suni paths	3	5	0	0	6	3.01
Harvey's duiker paths	1	4	0	12	8	5.38
Bush pig paths	3	0	1	3	0	1.51
Human paths	1	3	1	4	0	1.94

Comparison of Relative Abundance Between WKSFR and NDUFR

Species recorded during spoor surveys in both New Dabaga/Ulangambi Forest Reserve and West Kilombero Scarp 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

Large Mammals of NDUFR

The total number of species of large mammals (as defined in introduction) observed in and around NDUFR was seventeen. This is well below the number recorded from West Kilombero Scarp Forest Reserve (WKSFR)(Frontier Tanzania, 2001f) and is due to a combination various factors. Those considered to be most important for the explanation of the low number of large mammals are the size of NDUFR, its long-term isolation in a landscape dominated by humans, as well as a substantial level of hunting over most of the reserve.

The greater galago was the only species recorded outside natural forest and it was only recorded from black wattle plantations. The greater galago could often be heard calling at night and were observed to feed on the sap from the plantation trees.

Sixteen of the recorded species were from natural forest areas. Of these seven were forest dependent species of which four are primates. NDUFR also supports populations of five species or subspecies that are considered near endemic and only one of these is not forest dependent. With the limited distribution of forested areas in mind, protection of existing forests is considered important for these species. Furthermore seven species are listed by IUCN as "Vulnerable", Low risk" or "Data deficient" (i.e. distribution and abundance not well known), of which four are forest dependent. The seven species considered to be of importance for management are described in some detail in **Box 7.5B** based observations made in the reserve.

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

Primates (three species)
Udzungwa red colobus, and black and white colobus are two of three IUCN listed primate species that occur in NDUFR. For detailed discussion of these species, see section 7.6.

The mountain galago has been classified as "Endangered" by Honess (1996, cited in: Ehardt *et al*., 2000) using IUCN criteria. Ehardt *et al*. (2000) however hypothesise that the species eventually will be classified as "Vulnerable" once its distribution and abundance is studied in more detail. The species has been heard calling within the forest reserve, but was also caught in a Sherman trap (see section 7.2). The status of the population of this species in NDUFR is unknown, and can only be revealed through more detailed studies. The specimen caught in the Sherman trap is the second specimen ever collected, and the first male of the species (Andrew Perkin, *pers. comm.*). It was caught in a Village Government Forest outside the reserve. This locally managed natural forest fragment is dominated by mature *Parinari excelsa* trees and is positioned a few hundred metres from the forest reserve.

Chequered elephant shrew
The chequered elephant shrew was observed on several occasions inside the forest reserve and in the Village Government Forest (trapsite A). Forest is its preferred habitat, but during wet periods it may make use other habitat types (Kingdon, 1997). The species was found in snares on three occasions within the reserve, but numerous sightings suggest the population is not in danger of extinction in the reserve.

Eastern tree hyrax
The identification of this species is based on calls alone. These were similar to calls heard in WKSFR, where all identified skulls were *D. validus.* One skull collected in NDUFR, was however identified as *H. brucei*. Judging by the very few calls heard of *D. validus*, this species is present at a very low density. It should however be noted that this could be due a hunting induced change in behaviour or competition with *H. brucei* (see section 7.4 for a more detailed discussion of hyrax abundance in NDUFR).

Abbot's duiker
The near endemic and "Vulnerable" (Hilton-Taylor, 2000) Abbot's duiker was only recorded from two dungpiles. No paths were assigned to this species in NDUFR. This is a very low observation rate compared to WKSFR (1.43 dunpiles per ha and several paths per kilometre; Frontier Tanzania, 2001f) and suggests that the species is approaching extinction in the reserve. As noted from studies in Udzungwa Scarp Forest Reserve, This species is very sensitive to hunting (Topp-Jørgensen & Pedersen, unpubl.). An immediate stop to hunting of this species is considered vital for its future survival in NDUFR. Populations are very fragmented due to the patches of the preferred forest habitat. Connecting NDUFR to larger neighbouring major forest blocks through establishing a suitable habitat mosaic for dispersal is therefore considered important for the long-term survival of the species in NDUFR.

Relative Abundance

Human presence in and around New Dabaga/Ulangambi Forest Reserve has led to the disappearance of many large mammals found elsewhere in the Udzungwa Mountains at similar altitudes (Frontier Tanzania, 2001f). According to villagers, they are thought to have disappeared well before the gazettement of the forest reserve in the early 1930s. Based on the information given by these villagers, the lost species probably include aardvark (*O. afer*), elephant (*L. africana*), buffalo (*S. caffer*) and possibly also leopard. Aardvark burrows usually persist for quite some time and are often taken over by other species. The fact that no burrows made by this species were found further supports that the species disappeared from the area a long time ago.

Human paths are abundant in the reserve (see **Table 7.5B** and Frontier Tanzania, 2001c) and numerous snares were observed along these. Based on the number of traps observed within transects established during botanical fieldwork, the density of active traps were estimated to be 32.6 per km^2 (Frontier Tanzania, 2001c). With the higher abundance of snares found along human paths, the actual number is considered to be even higher.

The fixed area search survey revealed a density of active den systems made by *C. gambianus* of 1.29 per ha. This relatively high density compared to the undisturbed West Kilombero Scarp Forest Reserve with 1.9 entrance holes per ha and the difference was not significant. This suggests that this species is little affected by hunting, despite an estimate of 32.6 active snares per km^2 (Frontier Tanzania, 2001c). Similar results have been seen in Udzungwa Scarp Forest Reserve (Topp-Jørgensen & Pedersen, unpubl.). It is possible that other species occupy some of the den systems, but there have been no records of dung or prints to suggest this.

Suni and Harvey's duiker still occur over most of the reserve, but at significantly lower relative abundance than in the undisturbed forests of WKSFR (Frontier Tanzania, 2001f). Where hunting is moderate, medium sized species like the above forest antelopes are reduced in numbers, but do not necessarily disappear from the area (e.g. Topp-Jørgensen & Pedersen, unpubl.). This seems also to be the picture in NDUFR when compared to the undisturbed West Kilombero Scarp Forest Reserve, although monitoring is recommended in order to verify this.

The paths of bush pigs were also recorded on relatively few occasions and results differed significantly between NDUFR and WKSFR. Bush pigs are considered to be a pest in cultivated areas around NDUFR (Frontier Tanzania, 2001c). Because of this and its meat, it has been hunted throughout the reserve as is evident from the number of pitfall traps and other specially designed pig traps (Frontier Tanzania, 2001c). Despite several observations of recent bush pig activity, the number of paths per kilometre is still lower than from the undisturbed WKSFR (Frontier Tanzania, 2001f).

Management

NDUFR is home to seven species, which are of particular interest for management, since they are considered of conservation concern or restricted range (see **Box 7.5B**). The relative abundance survey showed a significant reduction in the abundance of all three forest antelopes and bush pig in comparison to WKSFR. Of these, Abbot's duiker and Harvey's duiker are of conservation concern. Many of the seven species, which are of priority for management are low in numbers due to extensive hunting and/or forest degradation resulting from logging (this study; sections 7.4 and.6).

Large species of mammals are considered to be more dependent on management interventions for their future survival in NDUFR than are smaller species. Management should therefore act to reduce level of hunting, improve forest quality and investigate the possibilities of establishing dispersal corridors or stepping stones between NDUFR and neighbouring forest blocks (e.g. Udzungwa Scarp Forest Reserve).

The Village Government Forest and small natural forest patches have shown potential for providing stepping stones of dispersal for some forest dependent species, including Abbot's duiker, black and white colobus, Tanganyika mountain squirrel and chequered elephant shrew. Importantly, it is the mosaic of habitats between major forest areas that is important for whether animals will be able to disperse between these. It is therefore suggested that a more detailed study is carried out to clarify the need and possibilities of establishing such a dispersal corridor if such a venture is deemed relevant for the UMFM project by the managing authority.

7.5.6 Conclusion

The size of NDUFR, its long-term isolation in a landscape dominated by humans, as well as a substantial hunting level over most of the reserve has led to the disappearance of many large mammal species. Seventeen large mammal species (as defined in introduction) were recorded in and around NDUFR. Sixteen were found inside the forest reserve including seven forest dependent species or subspecies, and seven species of restricted range or IUCN conservation concern. As a result of hunting and forest degradation, the abundance of many terrestrial large mammals is drastically reduced compared to WKSFR. Especially Abbot's duiker, which is on the verge of going extinct in the area, and a stop to hunting is imperative for its future survival in the reserve.

Species considered of priority for management, are limited range species or species considered of conservation concern by IUCN. The low abundance of many of these species has been ascribed to hunting and habitat degradation. Management initiatives should therefore aim to reduce the level of hunting and improve forest quality. The possibility of linking NDUFR with neighbouring forest blocks through establishment of dispersal corridors/stepping stones should also be investigated.

The data on relative abundance presented in this study can act as a baseline for future monitoring of population trends in NDUFR.

7.6 Priorities for the Conservation of Monkeys in New Dabaga/ Ulangambi Forest Reserve Based on Comparison of Group Density and Socioecology with West Kilombero Scarp 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. Prior to this survey, no detailed monkey census had been carried out in New Dabaga/Ulangambi Forest Reserve (NDUFR). This is most notable from the Udzungwa red colobus not being recorded from the area since 1951.

Twenty-one census transect walks made along two transect routes recorded the presence of black and white colobus, Sykes' monkey and the Udzungwa red colobus. Of these, most visual records were of the red colobus, whereas Sykes' monkey vocalisations were heard most often. It was apparent however that the transect lines surveyed were located in two of the most intact areas of forest and thus are likely to represent some of the highest monkey densities in NDUFR. This was highlighted by a single census walk in the north of the reserve, where the forest canopy is heavily degraded and very few monkeys were seen. A low frequency of casual observations in other heavily disturbed areas of the reserve during the five months of fieldwork further emphasises a lower abundance outside of areas of intact canopy.

Encouragingly, red colobus group density on one of the transect lines in NDUFR is comparable to that seen using identical methods in Ndundulu forest in West Kilombero Scarp Forest Reserve. Further comparison with Ndundulu forest and other forests in the Udzungwa Mountains however stresses the generally low monkey density of NDUFR. There is also a considerable reduction in group size and in associations between different species. From the elimination of other factors and from previous studies in Tanzania and elsewhere, the observed differences are likely to be due to two major factors. Most importantly for conservation, habitat quality appears to be having the highest impact on both primate density and group size. Also important however are differences in predation between the two reserves, which have probably resulted in the lack of interspecific associations in NDUFR, where there are few or no predators. Comparison between transect lines within the two reserves also appears to support these suggestions. Hunting may also be having an effect, primarily on Sykes' monkeys, which are persecuted as pests.

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 are likely to be under similar pressures. It is therefore suggested that management priorities should aim to restore the degraded areas of forest (as described in Frontier Tanzania, 2001a) to allow the current patchy distribution of monkey groups to colonise other areas of forest within the reserve. In conjunction with this, the progress of forest recovery should be monitored closely to ensure that management activities are successful and that the forest is not further exploited.

Monkeys observed in small fragments of village government and privately owned forests outside of NDUFR also suggest there is potential for the protection/development of these areas to act as stepping stones or corridors to assist dispersal beyond the boundaries of the reserve.

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*[1] (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 Udzungwa primate species found mostly in the 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 surveys 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 information 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. Soon after this, the northern half of the forest was cleared for agriculture, thereby seriously threatening the monkey populations (Rodgers *et al.*, 1980; Decker, 1994 & 1996).

Prior to this study, no primate census work has been conducted in the New Dabaga/Ulangambi Forest Reserve (NDUFR). Rodgers (1981) mentions two previous short expeditions to NDUFR, which noted the presence of black and white colobus in the reserve in 1950 and 1972. The latter of these surveys however failed to note the presence of red colobus from four days of observation. Subsequently, Rodgers & Homewood (1982) also list the red colobus as absent from the reserve and thus has not been documented for at least fifty years. The Sanje mangabey has never been documented from NDUFR. Conversely, Sykes'

[1] 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.

monkeys are present in all documented Udzungwa forests (Dinesen *et al., 2001*) including NDUFR.

Observations made during line transect surveys are here used to assess the diurnal forest monkeys of New Dabaga/Ulangambi Forest Reserve. Additional notes gathered opportunistically on diet, interspecific associations and other aspects of ecology are also discussed. The focus here is however to provide sufficient detail to assist the formulation of joint forest management plans.

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 Udzungwa Mountains 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 forest use on wildlife. Such studies are crucial in understanding the needs of animal communities. They also have clear implications for formulation of management priorities for conservation.

Aims

- To determine the species composition, relative group density per transect and distribution of primates in NDUFR.
- To make conclusions about the effect of habitat quality on monkey populations by comparison between transect lines within NDUFR and with the less disturbed West Kilombero Scarp Forest Reserve (WKSFR; Frontier Tanzania 2001f).
- To discuss priorities for the conservation of NDUFR primates.

7.6.3 Methods

A total of twenty-one repetitions of census transects were made. Eleven repetitions were made in a straight line along transect '-4' and ten were made in a "U" shape beginning on transect line '1' and finishing on transect line '0' (for the remainder of this section, this transect will be referred to as "transect '1'": **Figure 7.6A**). These lines were selected for their relatively intact canopy and so represent some of the most undisturbed forest in the reserve. Transects were 3km long, (barring two repetitions of transect '-4', which were 2.5km long) and were walked at a pace of around 0.7km/h, beginning at 0700h. One repetition of a 2.5km transect was also walked along the highly degraded forest of line '4' (**Figure 7.6A**).

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. A maximum of two research assistants were also present on most walks. However to further avoid bias from multiple observers, only monkeys detected by ARM are used for making density estimates. 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 (%age 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, sex and age).

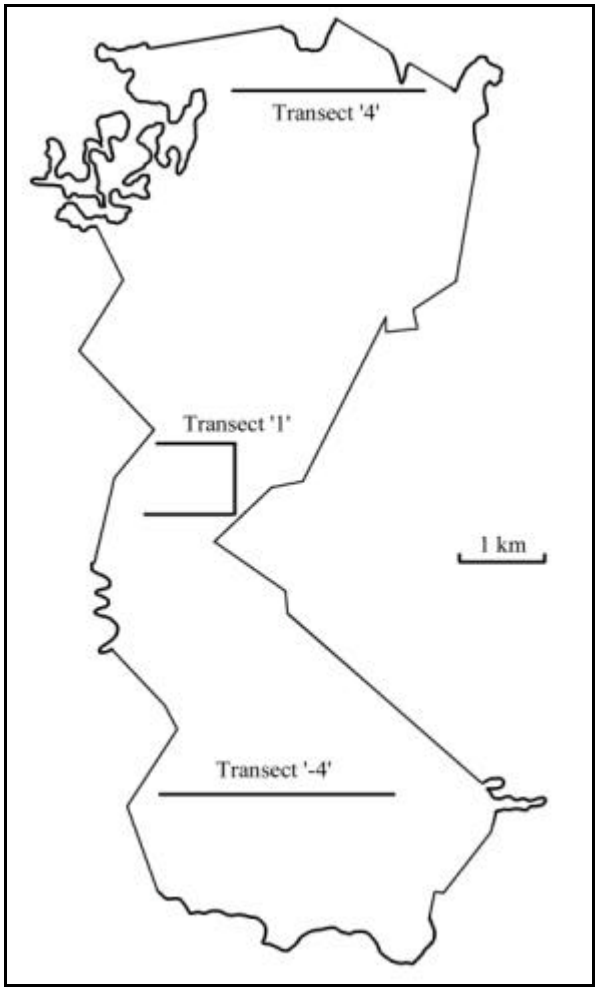


Figure 7.6A. Monkey census transects in New Dabaga/Ulangambi Forest Reserve. North is upwards on the map.

Where species identification or group size estimates were uncertain, a numerical quality rating was applied to indicate the reliability of the observation. Only reliable species identifications were used in estimates of abundance. Similarly, when estimating mean groups sizes, only complete group counts were used.

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).

In addition to census walks, opportunistic encounters with monkey groups by all Frontier Tanzania researchers were also noted.

Similar methods were also employed along two transects in West Kilombero Scarp Forest Reserve (Frontier Tanzania, 2001f) and will be used for comparative purposes.

7.6.4 Results

Species Composition
From 105h of census transect walks, 107 records of monkey groups were made. Of these, 35 records were of Udzungwa red colobus[2], 19 of Angolan black and white colobus, 43 of Sykes' monkeys and ten were of uncertain identification. 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 red colobus (mean 0.24 groups/km compared with 0.18 for Sykes' monkeys and 0.16 for black and white colobus). There are also clearly more monkeys of all species in transect '1' compared to transect '-4'. Casual observations suggest that densities in other areas of NDUFR may be even lower.

In terms of vocalisations, Sykes' monkeys were heard more often than all other species. This may however be due to generic differences in calling rate as opposed to a reflection of abundance.

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

[2] 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 section.

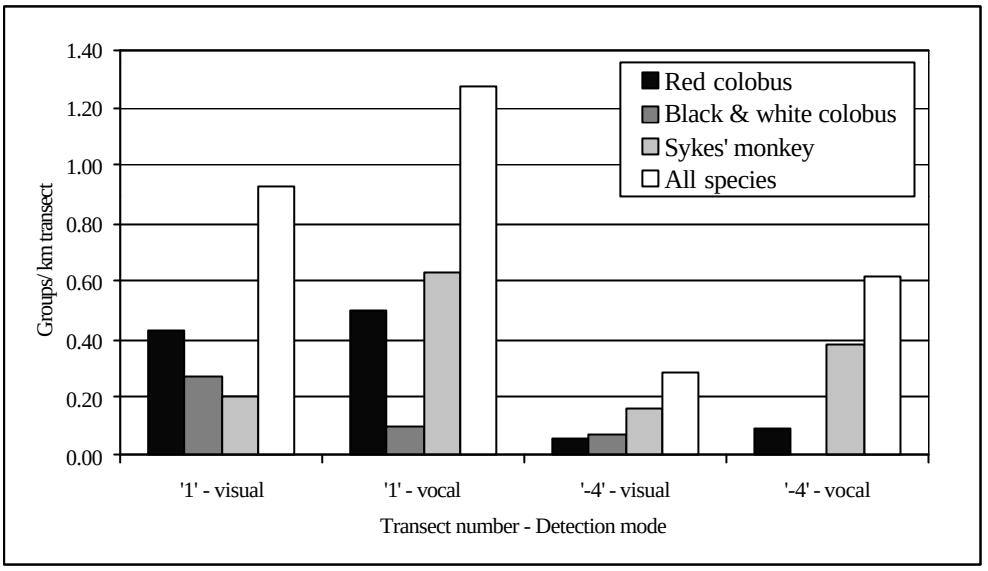


Figure 7.6B. Mean frequency of monkey groups per kilometre transect in New Dabaga/Ulangambi Forest Reserve.

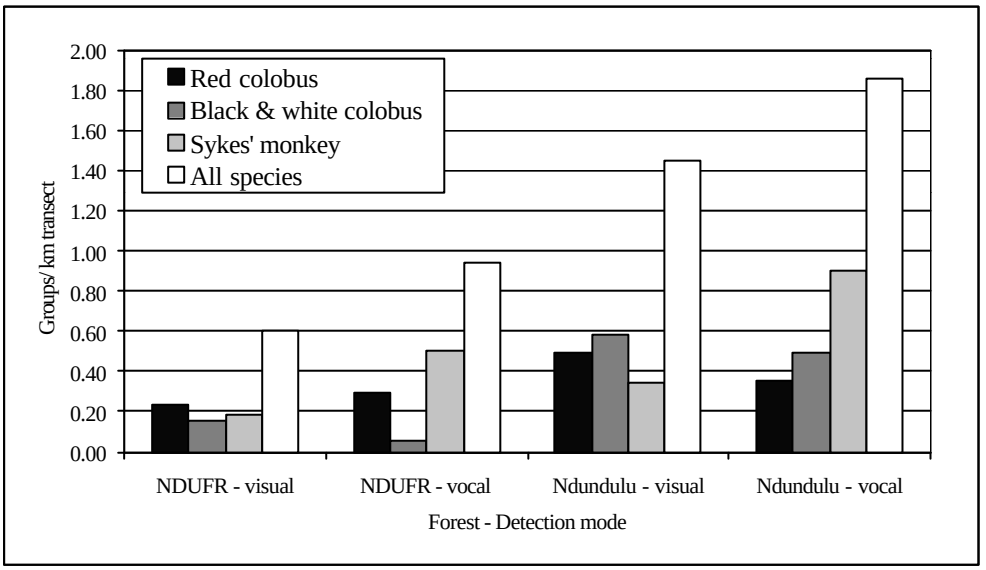


Figure 7.6C. Mean frequency of monkey groups per kilometre from two pairs of transects in New Dabaga/Ulangambi Forest Reserve and Ndundulu forest in West Kilombero Scarp Forest Reserve (Frontier Tanzania, 2001f).

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, monkeys tend however 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 between two and twenty-four individuals per group. No observations of solitary red colobus were made. However one adult female with an infant was

observed with two medium-sized black and white colobus. Similarly, one subadult/adult was seen within a group of seven black and white colobus. Black and white colobus groups contained mostly between five and eight individuals, with four observations of solitary individuals. No reliable group counts of Sykes' monkeys were made.

Interspecific Associations

Several sightings were made of mixed species groups. In total, from census transects alone, the two colobus species were seen together in sixteen out of thirty-four colobus groups observed (47% of observations). On no occasion however, neither during casual nor transect observations were Sykes' monkeys seen associating with either of the colobines. Two records of Sykes' monkey calls were however heard near to mixed groups of both colobus species on transect line '1'. **Figure 7.6D** summarises all cases of colobus associations seen during transect walks in NDUFR. Comparable data collected in Ndundulu forest (WKSFR) is presented in **Figure 7.6E**. There is considerably greater number of associations in Ndundulu. By contrast there is little difference in the proportion of mixed species associations between the two transects in NDUFR.

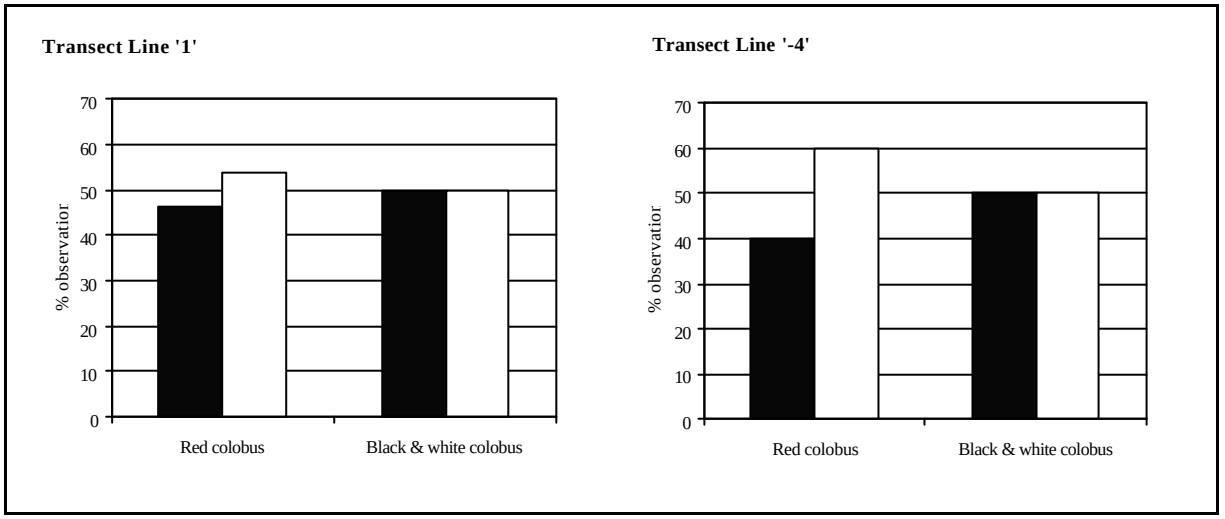


Figure 7.6D. Interspecific associations between red and black and white colobus monkeys. Bars indicate the proportion of sightings of each colobus seen containing both species (n = 34). Shaded bars indicate mixed species groups and plain bars single species groups. No interspecific associations with Sykes' monkeys were observed (n = 13).

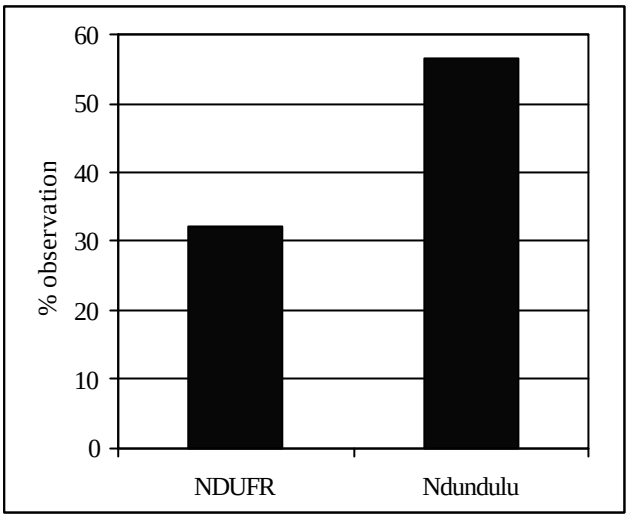


Figure 7.6E. Mean proportion of sightings of mixed species monkey groups from two pairs of transects in New Dabaga/Ulangambi Forest Reserve and Ndundulu forest in West Kilombero Scarp Forest Reserve.

Additional Observations

Generally within the reserve, casual encounters suggest that the central portion of the reserve around transect '1', contains one of the highest, if not the highest density of monkeys in the reserve as a whole. During five months of fieldwork, few monkey groups (<20) were observed outside of this area. The majority of observations outside of this were in tall canopy forest.

Observations from one census walk made along 2.5km of transect '4' revealed only one small group of blue monkeys (≥8), one small group of black and white colobus (≥3), plus one solitary black and white colobus. The forest habitat along this transect line is excessively degraded, with a complete loss of canopy and a densely tangled shrub layer for around a third of the transect.

Monkeys were also observed in habitats outside of the reserve. In the *Parinari excelsa* dominated village government forest fragment in the Msonza area, a solitary adult black and white colobus was recorded on two separate occasions in March and July 2000. In December 2000, there were at least two colobus in this same fragment. In June 2000, a group of at least five black and white colobus were also observed in a small, privately owned forest fragment of around 2km^2, to the east of the reserve.

Finally, in August 1999, one monkey skull was found to the south of census transect '1'. The identification of this has been confirmed by Dr. Dieter Kock of the Frankfurt Zoological Museum as that of an Udzungwa red colobus.

7.6.5 Discussion

The monkey groups of NDUFR essentially differ from WKSFR in three ways. Namely, groups in NDUFR are smaller, at lower densities and less likely to be of mixed species (**Table 7.6A**). The Frontier Tanzania surveys have however 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 7.6A. Summary of differences observed in monkey socioecology, species richness and group density between New Dabaga/Ulangambi Forest Reserve and West Kilombero Scarp 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.

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

* 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 and Density

These three aspects of monkey socioecology all vary between the two reserves of New Dabaga/Ulangambi and West Kilombero Scarp. 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

Of the monkeys, the Sykes' and vervet monkeys are particularly persecuted as they raid the crops in farmland adjacent to the forest. One villager reported seeing both of these species in cultivated fields daily whilst walking to and from his plot. Iron leg traps which are sprung when an animal steps on a sensitive plate, were seen in farmland. Also observed were constructions made from logs and poles cut from the forest, erected to guide an animal into a baited chamber where it knocks a small supporting stick, sending a larger log falling down to crush it. These two traps may be effective for monkeys, but also for duikers and bush pigs, the latter of which are also major pests for farmers. Several signs of snares, pitfall traps and active hunting with dogs were also noted during survey of forest use (Frontier Tanzania, 2001c). Most of these are however designed for catching smaller or more terrestrial prey such as rats, elephant shrews, duikers, hyrax and bush pigs.

Struhsaker (1999) has collated observations from several examples where primate communities have been either severely reduced or completely exterminated as a result of hunting. The hunting level of monkeys inside NDUFR is however thought to be minimal. In total, three instances were observed inside the Forest Reserve: one iron leg trap and two log fall traps. From comments made by villagers it is also unlikely that there are guns in the immediate area. This is despite the discovery of a gun cartridge during 1999 fieldwork. These are essential for hunting the primarily arboreal colobus monkeys. This suggests that the threat by hunting to forest monkeys is low, especially for colobus.

In Ndundulu, the hunting levels are low to non-existent for monkeys. Villagers say there is no hunting of monkeys because they resemble people, whereas many knew of the hunting of duikers, hyrax, bush pigs, buffalo and elephants. From field observations and encounters with poachers by TANAPA and scientists, there is also evidence of low level hunting of several other 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.

Forest Fragment Size

Comparisons of Udzungwa monkey populations made by Dinesen *et al.* (*2001*) suggest 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 33km^2) and from the larger forests of Mwanihana and Luhombero (both >170km^2; Dinesen *et al.*, *2001*). Furthermore, the patchy distribution of monkey groups in NDUFR, including a seemingly complete absence in some areas suggests that the forest is not at its full carrying capacity. It is therefore unlikely that the large size difference between Ndundulu (which is part of the Luhombero forest, area 250km^2) and NDUFR is a primary determinant of the low densities in NDUFR. Unless reduction in forest size affects the availability of food species, it also seems unlikely that fragment size should affect either interspecific associations or group dynamics.

This is not however to say that larger forest fragments are no more important for conservation than smaller ones. 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 of the requirements for survival. There does for example appear to be a relationship between Sanje mangabey populations and forest fragment size.

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*).

Tree Species Composition
Vegetation surveys of trees above 10cm dbh and regenerating trees and shrubs has revealed a remarkably different flora between the two Forest Reserves (Frontier Tanzania, 2001c&d). The primary difference is the predominance of secondary growth in NDUFR, 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 over 20% of all identified trees). Based on aerial photographs and ground observations, a conservative estimate of around 10% of the reserve has suffered a complete loss of canopy, predominantly due to past commercial logging, which ceased in the early 1990s and is still evident in the reserve from overgrown logging roads. Also apparent is the generally higher density and smaller size of trees in NDUFR (Frontier Tanzania, 2001c&d). This is thought to be due to the logging of trees in NDUFR followed by subsequent increased competition between the regenerating trees.

The dominance of scrubby, patchy habitat and of secondary tree species has major implications for monkeys. The primary factor is a reduction or clumping of food tree species, due to the patchy nature of the habitat. The second is a general decrease in habitat suitable for primate living – i.e. for shelter, sleeping sites and arboreal pathways, which are lost with a reduction in trees. Both of these points have the effect of increased competition and an increase in the energetic costs of locomotion to arboreal primates (Struhsaker, *pers. comm.*).

The observed reduction in primate group size is therefore likely to be a response to these habitat changes. As outlined in the introduction, several authors have observed such changes 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). This may explain the high proportion of solitary individuals and small groups of both colobus species in NDUFR. Limited data are available for Sykes' monkeys in NDUFR. Kalunga forest to the east of UMNP has also suffered from logging in the past. 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). By contrast in Mwanihana the same study recorded a single group of 55 individuals. Dinesen (*pers. comm.*) also reports sighting a group of well over one hundred individuals in Ndundulu forest, including all four Udzungwa forest monkey species.

Variation in habitat may also have influenced the considerable differences in the number of groups per kilometre transect between the forests (**Figure 7.6C** and **Table 7.6A**). There are of course likely to be natural background fluctuations in density, however the marked differences seem unnaturally high. The effect of habitat quality on this is supported by comparable group densities in other areas of human impacted forest in the Udzungwa Mountains, e.g. red colobus: 0.20 groups/km in Udzungwa Scarp Forest Reserve (Pedersen & Topp-Jørgensen, 2000). By comparison, census 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). Variation in habitat quality (particularly of

food species) may also be responsible for differences in both group size and density between transects within the two reserves.

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

Unlike most other Udzungwa forests, there also seems to be a lack of predators in NDUFR. No records of the major predator of Udzungwa primates, the crowned hawk eagle, *Stephanoaetus coronatus*, were made in the area (section 7.7). Neither were there any sightings, calls, spoors, stools or reports from villagers of leopards (section 7.5), which are also known to take monkeys (Struhsaker, 2000a). In WKSFR, both of these are common (Frontier Tanzania, 2001f). 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 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.

Similarly, monkey group size has also been shown to 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 (**Figures 7.6B & 7.6C**; **Table 7.6A**). 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). A long-term empirical study by Mitani *et al.* (2000) note 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 the monkey populations of NDUFR are depleted and socioecology is considerably altered compared to other Udzungwa forests. Long discussion of how to estimate density should not stand in the way of this fact and it 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.

7.6.6 Conclusion

Many of the listed factors that may influence monkey socioecology and distribution are of course not mutually exclusive. 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. Primarily, habitat degradation has at least played a part in, if not been entirely responsible for the pronounced reduction in density and changes in social organisation in New Dabaga/Ulangambi Forest Reserve. Importantly however, this has not eliminated the Udzungwa red colobus in NDUFR as once feared, thus providing additional impetus for the conservation of NDUFR. In fact, during transect survey walks, the red colobus was seen more times than both of the other two forest species (black and white colobus and Sykes' monkey). The distribution in the reserve of all forest dwelling monkey species is however extremely uneven and mostly limited to areas of closed canopy.

The forest of New Dabaga/Ulangambi is intensively used by people, with several paths running through the reserve and numerous signs of medicinal plant collection and pole cutting. The current pressures are however markedly less than they were ten years ago (Frontier Tanzania, 2001c). Importantly, there is currently no commercial logging and observations of fresh pit-sawing sites are scarce. The only direct threat to the monkeys is hunting. From observations and interviews with villagers this however appears to be primarily aimed at the Sykes' and vervets.

Management Recommendations
The isolated nature and high human impact on NDUFR makes it a priority area for management activities. Namely, with appropriate management, including active assistance in the restoration of degraded areas of forest, especially in the north of the reserve, there is potential for improving habitat and hence increasing populations of all three monkey species. The presence of Sykes' monkeys and black and white colobus in fragments in the vicinity of NDUFR suggests there is also potential for the planting of indigenous trees such as *Parinari excelsa*, to develop corridors or stepping stones to assist dispersal (see Frontier Tanzania, 2001a).

7.7 Bird Observations from New Dabaga/Ulangambi Forest Reserve

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

7.7.1 Summary and Recommendations

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

In order to gain an overview of the bird species in the New Dabaga area, Elia Mulungu (WCS) spent three days in the field, carrying out bird surveys in three areas. This, coupled with observations made by the Frontier Tanzania research team is used to produce a list of species present along with some remarks on the influence of habitat quality.

Despite its isolation and high level of human impact, at least 34 forest dependent and 12 restricted range species were observed. This includes two species of IUCN conservation concern which were observed within the forest including the Kipengere seedeater, *Serinus melanochrous* (lower risk) and Usambara weaver, *Ploceus nicolli* (endangered). The forest of NDUFR should therefore be considered an important area for conservation. In addition to these, the blue swallow, *Hirundo atrocaerulea* (vulnerable migrant), was also seen in the area during 2000 fieldwork.

A number of the bird species recorded are montane forest dependent species and hence require natural forest habitat to survive. This also means that many are unlikely to be able to disperse far beyond the forest boundary. To assist this, investigation into the formation of forested corridors or stepping stones to other nearby forest fragments is suggested. An encouraging sign of the potential for this is the abundance of forest birds observed in a *Parinari excelsa* fragment surveyed in the Msonza area.

The isolated nature of NDUFR, which is over 10km from the nearest forest fragment of comparable size, means that forest dependent species are unlikely to be able to colonise or re-colonise from elsewhere. The conservation of the species that are already present can however be assisted by the improvement of canopy cover. This may require active assistance of tree growth by removal of restricting herbaceous vegetation.

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 (Fjedså, 1999). As a result of this and the old age 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 Udzungwa Mountains in comparison to six other forest ranges in Tanzania.

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) [3].

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 Udzungwa Mountains east of Mufindi, including NDUFR.

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). The little available knowledge suggests that New Dabaga/Ulangambi Forest Reserve (NDUFR) contains eight restricted range species including the globally threatened Iringa ground robin, *Sheppardia lowei* (IUCN vulnerable: Hilton-Taylor, 2000) (Dinesen, 1998). There have, however, been no recent bird surveys of NDUFR. Prior to this Frontier Tanzania survey, the most recent ornithological information dates from 1969 (see Dinesen, 1998; Jensen & Brøgger-Jensen, 1992).

Aims

- To present a list birds for NDUFR, with particular emphasis on those which are forest dependent or of restricted range.
- To make management suggestions for the conservation of the NDUFR avifauna.

[3] 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 Udzungwa Mountains. 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

For three days in November 2000 (26th to 28th), ornithologist Mr. Elia Mulungu from the Wildlife Conservation Society (WCS), made bird observations in three areas of NDUFR. One whole day was spent in each of (a) the "Malenga Makali" area within the central portion of the reserve and (b) the southern portion of the reserve near to Kidabaga village. One day was also spent in the *Parinari excelsa* dominated village government forest fragment in the "Msonza" area outside of the reserve (see section 7.1 for details). Frontier Tanzania researchers made notes of birds encountered primarily between October-November 2000. Mr. David Moyer (WCS) has also kindly provided unpublished data collected along the southern edge of NDUFR in 1992.

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

During fieldwork in 1999/2000, a total of 86 species have been recorded, including 34 forest dependent species and 12 endemic to the Eastern Arc, Tanzanian coastal forests and Malawi (**Appendix 7.7A** and **Table 7.7B**). Amongst these are two forest species of IUCN conservation concern, one considered endangered and one lower risk: the Usambara weaver, *Ploceus nicolli* and Kipengere seedeater, *Serinus melanochrous* respectively (Hilton-Taylor, 2000). 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*; Jensen & Brøgger-Jensen, 1992). For this reason, these two species have not been separated here. Another species considered vulnerable (Hilton-Taylor, 2000), the blue swallow, *Hirundo atrocaerulea*, which is a rare migrant (Neil Baker, *pers. comm.*), was also observed on at least three occasions flying low over cultivation. More detailed notes on casual observations of birds recorded by Frontier Tanzania researchers are presented in **Appendix 7.7B**.

Table 7.7B. List of forest dependent birds and non-forest dependent birds of restricted range or conservation concern (*). Observations are from (1) the southern end of New Dabaga/Ulangambi Forest Reserve, (2) Malenga Makali area in the central part of the reserve and (3) *Parinari excelsa* dominated village government forest. All observations here were made by Mr. Elia Mulungu between 26th-28th November 2000. See foot of table for explanation of codes. Taxonomy follows Zimmerman *et al.* (1996).

Common name	Genus	Species and subspecies	Conservation Status §	Endemism†	Location 1	2	3
FALCONIFORMES							
Mountain buzzard	*Buteo*	*oreophilus*	II		•	•	
COLUMBIFORMES							
Olive pigeon	*Columba*	*arquatrix*			•	•	
Lemon (or cinnamon) dove	*Aplopelia*	*larvata*			•	•	
CUCULIFORMES							
Barred long-tailed cuckoo	*Cercococcyx*	*montanus*			•	•	

Table 7.7B (continued).

Common name	Genus	Species and subspecies	Conservation Status [§]	Endemism[†]	Location 1	2	3
TROGONIFORMES							
Bar-tailed trogon	*Apaloderma*	*vittatum*			•	•	
PICIFORMES							
Moustached green-tinkerbird	*Pogoniulus*	*leucomystax*			•	•	
Olive woodpecker	*Dendropicos*	*griseocephalus*			•	•	
PASSERIFORMES							
Blue swallow *	*Hirundo*	*atrocaerulea*	VU		•		
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	•	•	
(Northern) olive thrush	*Turdus*	*olivaceus abyssinicus*			•	•	•
Orange ground thrush	*Zoothera*	*gurneyi*			•	•	•
Sharpe's akalat	*Sheppardia*	*sharpei*		[1,3] NE	•	•	
Spot-throat	*Modulatrix*	*stictigula*		[1,3] NE	•	•	•
White-chested alethe	*Alethe*	*fuelleborni*		[4] NE	•	•	•
White-starred robin	*Pogonocichla*	*stellata*			•	•	•
African dusky flycatcher	*Muscicapa*	*adusta*			•	•	
Yellow-throated woodland warbler	*Phylloscopus*	*ruficapillus*				•	
Red-capped forest warbler	*Orthotomus*	*metopias*		[1,3] NE	•	•	
Bar-throated apalis	*Apalis*	*thoracica*			•	•	•
Chapin's apalis	*Apalis*	*chapini*		[1,3] NE	•	•	•
Black-lored cisticola *	*Cisticola*	*nigriloris*		[1] NE	•	•	
Evergreen forest warbler	*Bradypterus*	*lopezi mariae*			•	•	•
White-tailed crested flycatcher	*Trochocercus*	*albonotatus*			•	•	•
Fülleborn's (black) boubou	*Laniarius*	*fuelleborni*		[1] NE	•	•	•
Grey cuckoo-shrike	*Coracina*	*caesia*			•	•	•
Waller's starling	*Onychognathus*	*walleri*			•		
Usambara weaver	*Ploceus*	*nicolli*	EN	[2] NE			•
Eastern double-collared sunbird/ Moreau's sunbird [+]	*Nectarinia*	*mediocris/ moreaui*	[+] LR	[+ 2] NE	•	•	•
Red-faced crimsonwing	*Cryptospiza*	*reichenovii*			•	•	
(Yellow-browed) streaky seed-eater *	*Serinus*	*striolatus whytii*		[1] NE	•		
Kipengere seedeater	*Serinus*	*melanochrous*	LR	[1] NE	•		
Oriole finch	*Linurgus*	*olivaceus*				•	

* Non-forest dependent species.

[†] Definition of endemism are given in Section 7.1: NE = near-endemic species to Tanzania, the Eastern Arc and northern Malawi including: [1] Tanzania-Malawi Mountain endemics (Stattersfield *et al.* 1998), [2] Eastern Arc Endemics (Dinesen, 1998), [3] East Coast Escarpment endemics (Stuart *et al.*, 1993), [4] Near-endemic to East Coast Escarpment forests (Stuart *et al.*, 1998).

[§] IUCN conservation status as defined by Hilton-Taylor (2000): EN = Endangered species, VU = Vulnerable species, LR = Lower Risk: i.e. restricted range species not threatened by global extinction but still of conservation concern. CITES status is listed as appendix I, II or III.

[+] Taxonomy of the eastern double-collared sunbird complex is unresolved (Butynski & Ehardt, *in press*; Jensen & Brøgger-Jensen, 1992; Dinesen, *pers. comm.*), hence identification between *C. mediocris* and *C. moreaui* has not been made here. *C. moreaui* is classed as IUCN lower risk.

RM = Rare migrant (Neil Baker, *pers. comm.*). This was observed flying above cultivation.

7.7.5 Discussion

There are 45 forest dependent bird species present in the Udzungwa Mountains (**Table 7.7A**). New Dabaga/Ulangambi Forest Reserve and adjacent area has been shown above to be inhabited by at least 34 of these (**Table 7.7B**). Despite being short of the 45 bird species known from the Udzungwa Mountains, in terms of the number of montane forest species, this figure puts NDUFR on the same level as 22 out of the 50 most important montane areas for avian endemism in Africa (Stuart *et al.*, 1993). In comparison to other Tanzanian forests, there are also more forest and endemic bird species in NDUFR than many whole forest ranges (**Table 7.7A**).

Amongst those birds found in NDUFR (**Table 7.7B** and **Appendix 7.7A**) are at least 12 near endemics and 12 CITES listed species. Two further species are listed of IUCN conservation concern: the endangered Usambara weaver and lower risk Kipengere seedeater (Hilton-Taylor, 2000) (this increases to three with the inclusion of Moreau's sunbird, *Nectarinia moreaui* – see **Table 7.7B**). These demonstrate that NDUFR has high importance for conservation. The presence of the Usambara weaver, which was confirmed by Mr. Mulungu from direct observation, vocalizations and characteristic foraging behaviour, is of particular importance as this is one of the two most threatened birds in the Udzungwa Mountains (the Amani sunbird, *Anthreptes pallidigaster*, is also IUCN endangered). This species has not been previously recorded from the Dabaga area (Dinesen, 1998). The migrating blue swallow (vulnerable) also clearly uses the area although is not resident.

The principle areas surveyed by Mr. Mulungu were predominantly intact forest (mean canopy height ~15m; mean canopy cover ~70%). As found in the Frontier Tanzania vegetation survey, however, much of NDUFR is heavily degraded by past tree felling and fires. The list presented in **Table 7.7B** is therefore unlikely to reflect the species found in more degraded areas. Some of the species known from NDUFR such as the bar-tailed trogon and square-tailed drongo are particularly sensitive to disturbance and can be strictly confined to areas of intact forest (Fjeldså, 1999). Hence in the scrubby habitat dominant in the extreme north and various other parts of the reserve, many species will be absent. The shrubby habitat may also account for records of species normally associated with non-forest habitats, such as the fan-tailed warbler and common stonechat (**Appendix 7.7A**). The restricted dispersal ability of forest dependent birds (e.g. Fjeldså, 1999; Newmark, 1991) is an important consideration for management. Many forest dependent birds will be unable to naturally colonise or re-colonise from source populations elsewhere (e.g. Romdal, 1998; Newmark, 1991) due to the isolated nature of NDUFR. The nearest forest fragment of comparable size is over 10km away.

A large number of montane forest species (25) were found in the *Parinari excelsa* dominated village government forest (VGF) in the Msonza area (**Table 7.7A** and **Appendix 7.7A**). This high number is especially encouraging considering the small size of this fragment (around 6ha) and the short time spent observing there. Especially encouraging is the record of the Usambara weaver from this fragment. This species was not recorded from the reserve itself, however following this record in a fragment, there is a strong likelihood of it being in the reserve. The observation of many forest birds is encouraging as it suggests that VGFs may be a useful tool for increasing bird dispersal. Primarily, they can function as "stepping stones", or as part of a forest corridor as well as being additional population sinks to the main forest block. VGFs are however managed locally and their existence therefore depends completely on the will of the local community. With appropriate education and management assistance, the long-term survival and even expansion of such fragments could be possible. Because of the limited dispersal of many species it is however important that fragments are in close

proximity to the Forest Reserve and to one another. Further survey is needed to determine this distance, although Fjeldså (1999) notes that some species around Udzungwa Scarp Forest Reserve did not disperse beyond 200-300m.

The bird lists presented, as stated, are mostly based on three days of observation during non-systematic bird walks. Consequently, the list should not be read as a comprehensive checklist of NDUFR birds. This is highlighted by one unexpected absentee from **Table 7.7C**, the brown-headed apalis, *A. alticola* (Moyer, *pers. comm.*). This species was however recorded from NDUFR in 1992 and is unlikely to have left the area since that time. The seasonal sightings of this bird in other Udzungwa forests (Lehmberg, *pers. comm.*) may be responsible for the absence of this and other common birds.

One village elder from Kidabaga village (Mr. Nguzi) has reported the presence of the crowned eagle, *Stephonoaetus coronatus* (Moyer, *pers. comm*). Its absence from this and previous surveys (Jensen & Brøgger-Jensen, 1992), cannot however confirm this. This has important implications for other animals, especially for small to medium-sized mammal species for which this is a major predator elsewhere in the Udzungwa Mountains (e.g. section 7.6).

The IUCN vulnerable Iringa ground robin (or akalat), *S. lowei*, has also not been recorded by our study. This means that this bird has not been observed in NDUFR since 1962 (Ripley & Heinrich, 1966 & 1969: cited in Jensen & Brøgger-Jensen, 1992). This does not bode well for *S. lowei*, as despite the brevity of this study, which may mean birds have been missed, the presence of this species cannot be confirmed. There are also several other species recorded from elsewhere in the Udzungwa Mountains, which have never been found in NDUFR (**Table 7.7C**). Many of these species are generally not found at the high altitudes of NDUFR and thus may never have been present and have been rarely observed even in the larger reserves (Dinesen, *pers. comm.*). It is therefore difficult to conclude whether any species have been lost, either due to the isolated nature of the reserve or the high human pressure on the forest.

Table 7.7C. Forest birds known from the Udzungwa Mountains but not recorded from the New Dabaga/Ulangambi Forest Reserve by this Frontier-Tanzania study. Only those in bold type have been previously recorded from NDUFR.

Common name	Genus	Species and subspecies	Forest species*	Endemism†	Conservation status§
Udzungwa forest partridge	*Xenoperdix*	*udzungwensis*	F ‡	[6] NE	VU
Usambara eagle-owl	*Bubo*	*vosseleri*	F	[2] NE	VU
Dappled mountain robin	*Modulatrix*	*orostruthus*	F	[2] NE	VU
Iringa ground robin	***Sheppardia***	***lowei***	**F**	**[1,3] NE**	**VU**
Kenrick's starling	*Peoptera*	*kenrickii*	F	[5] NE	
Mrs. Moreau's warbler	*Bathmocercus*	*winifredae*	F	[2] NE	VU
Brown-headed apalis+	***Apalis***	***alticola***	**F**		
White-winged apalis	*Apalis*	*chariessa*	F	[4] NE	VU
Banded green sunbird	*Anthreptes*	*rubritorques*	F	[2] NE	VU
Amani sunbird	*Anthreptes*	*pallidigaster*	×	[5] NE	EN
Rufous-winged sunbird	*Nectarinia*	*rufipennis*	F	E	VU

* Forest species defined in section 7.1: F = montane forest species (using information from Stuart *et al.* (1993); see **Table 7.7A**), × = species occurring in forest or forest edge as well as other vegetation types (Zimmerman, 1996).

† 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.

§ Conservation status as defined by Hilton-Taylor (2000): EN = Endangered species, VU = Vulnerable species.

+ Last recorded in 1992 by David Moyer.

7.7.6 Conclusion

The New Dabaga/Ulangambi Forest Reserve is an isolated forest fragment with no vegetation linking it to other forested areas. This situation has considerable implications for the passage of forest birds and thus for the long-term viability of populations, especially if habitat degradation continues. Despite this, a large number of important bird species have been shown to occur in the reserve, including many forest dependent, endemic and globally threatened species. This is perhaps surprising and also very promising considering the habitat degradation and low altitudinal span compared to other Udzungwa forests. In the past, forests impacted by human activity have been dismissed as having little or no worth for wildlife. This however is not the case and even heavily damaged forests can retain most of their conservation value (e.g. Johns & Johns, 1995).

Management and Monitoring Recommendations

- Forest species present in fragments outside of the reserve also highlight potential for the establishment of vegetative corridors to other nearby forests, perhaps to the "Mission" forest to the south or to one of many smaller fragments. This could be achieved by planting *Parinari excelsa* trees, which dominate many of the small forest patches in the vicinity of NDUFR. The maintenance or even expansion of such fragments may also serve as forest stepping stones, which may allow some birds to disperse.
- Prevention of damaging activities by close monitoring, feedback and co-operation with village officials.
- Forest habitat improvement by removal of scrubby vegetation that may be restricting tree growth. Enrichment planting may also be considered to further enhance forest cover.

7.8 Assessment of Reptile Collections from New Dabaga/ Ulangambi 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 New Dabaga/Ulangambi Forest Reserve and surrounding area were surveyed using a combination of bucket-pitfall traps and opportunistic collections. From this, eight species from five families are listed. These include three near endemic forest dependent species.

In comparison to other Eastern Arc forests sampled using identical methodology, the reptilian diversity in NDUFR appears to be particularly low. Most notably, only six records of reptiles were made in the reserve itself. Low sampling intensity, the high altitude climate and habitat degradation may have affected this.

Montane forest reptile ecology is however very poorly known. In particular, there is little information about baseline diversity or population levels prior to habitat degradation. Management initiatives have been suggested to improve NDUFR habitat, such as active assistance of forest re-growth. Although not specifically designed with reptiles in mind, this may assist forest reptile populations. Without influx of species due to the isolated nature of the reserve, however, once forest-dependent species are lost, they are unlikely to return naturally. Further management initiatives to encourage the connection of NDUFR by forest corridors to adjacent forest fragments may assist this, and would also assist dispersal of those species already present.

Following and during implementation of management initiatives, there will be great potential for detailed studies of changes in reptile populations with habitat improvement. This would provide much needed information to assist with management and conservation of reptiles in montane forest.

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 herpetofauna has 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 Udzungwa Mountains (37.5% and 33.3% compared to 31.25% of forest species respectively). This is surprising given that the Udzungwa Mountains 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 Udzungwa Mountains. 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 Udzungwa Mountains. This study assesses the reptilian fauna of the poorly studied New Dabaga/Ulangambi Forest Reserve (NDUFR).

Aims

- To provide a list of reptiles recorded from NDUFR 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 Methodology Report (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 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 subsequently to Dr. Don J. Broadley at the Zimbabwe Museum of Natural History.

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**. Records are made from five families including eight different species, four of which are recorded from montane forest. At least three species are forest dependent as defined by Howell (1993) (*Chamaeleo tempeli, C. werneri* and *Bradypodion oxyrhinum*). The latter two of these species are also restricted in distribution to the Udzungwa and Uluguru Mountains alone (Howell, 1993).

Only four reptiles were recorded from bucket-pitfall traps, whilst ten were recorded opportunistically. The majority of records (twelve out of sixteen) are from casual encounters with reptiles. This compares to only four found in bucket pitfall traps. Seven of the reptile records were made in 1999 during botanical fieldwork. Also apparent from **Table 7.8A** is the high proportion of records from outside of the main forest fragments (ten individuals, or 62.5% of records).

Table 7.8A. Reptile observations and collections made from New Dabaga/Ulangambi Forest Reserve. Initials adjacent to species names indicate confirmed identifications (JR = Dr. Jens Rasmussen; DJB = Dr. Don Broadley; KMH = Prof. Kim Howell). Taxonomy follows Broadley & Howell (1991).

Identification and code (KMH) numbers	Forest species*	Endemism #	CITES †	Frequency	Habitat ‡
TYPHLOPIDAE					
Typhlops sp.	-	.	.	1	MF
COLUBRIDAE					
Psammophylax variabilis DJB	O	.	.	1	CF
Philothamnus hoplogaster JR	O	.	.	1	PF
VIPERIDAE					
+ *Bitis* sp.	?	?	?	1	PF
SCINCIDAE					
Mabuya varia varia JR	O	.	.	3	FF(3)
CHAMAELEONIDAE					
++ *Chamaeleo werneri* KMH, JR	F	[1] NE	II	5	PF, MF(2), B, V
+ *Chamaeleo tempeli* JR	F	[2] NE	II	2	MF (2)
Chamaeleo sp.	-	-	II	1	CF
+ *Bradypodion oxyrhinum* (?)	F	[1] NE	II	1	MF

* Forest species codes as given in section 7.1: F = Forest dependent species (Howell, 1993), O = Non-forest species (Branch, 1998).

Endemism codes as given in section 7.1: [1] NE = Endemic to Uluguru and Udzungwa Mountains (Howell, 1993), [2] NE = Tanzania endemic (Howell, 1993).

† CITES Conservation status listed as appendix I, II or III.

‡ Habitat: MF = Montane forest, PF = Plantation forest, CF = Cultivated field, B = bush/scrub, V = Village, PF = Plantation forest, FF = Fallow field. Numbers in brackets refer to the quantity found in each habitat.

+ Identification made by observation only. Two of these indicate two individuals observed without collection.

7.8.5 Discussion

Ten out of the 16 reptiles (62.5% of records) were found outside of the Forest Reserve in plantation forests and fields (**Table 7.8A**). Notably, *Chamaeleo werneri* (Werner's three-horned chameleon), an Eastern-Arc endemic and forest-dependant species (Howell, 1993), was regularly found outside of the reserve, once even on a road in Kidabaga village. This may suggest that *C. werneri* is less dependent on forest habitat than first thought, highlighting the lack of knowledge of the ecology of Udzungwa reptiles. It could also suggest that the degraded habitat in NDUFR has induced uncharacteristic behaviour patterns. This however is unlikely as this species has also been observed outside of the forest in West Kilombero Scarp Forest Reserve (WKSFR; Frontier Tanzania, 2001f). Human activities are often responsible for distributing reptiles as children may pick up and move chameleons, or they can be transported on wood piles (Howell, *pers. comm.*). In WKSFR however, human activity is minimal and therefore this species has undoubtedly dispersed naturally. This may also be the case in NDUFR, although the area is far more populated and thus human transport remains a possibility.

The number of species recorded for NDUFR is considerably lower than in other Eastern Arc forests where similar sampling methods have been employed (**Table 7.8B**). The high altitude and moist, cool climate in the study area may be responsible, as this may limit the distribution of animals that rely on ectothermy. This could also explain the absence of 14 out of 17 forest dependent species known from the Udzungwa Mountains (Howell, 1993; **Appendix 7.8A**), including all Udzungwa endemics. The considerable forest degradation, which has occurred through most of the reserve, may also have played a part.

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

Forest Reserve	Family	Species	No. of trapping days	No. species/ trapping days	Source
UDZUNGWA MOUNTAINS					
NDUFR* #	2	4	40	0.1	This study
West Kilombero Scarp * §	5	12	80	0.2	Frontier Tanzania (2001f)
USAMBARA MOUNTAINS					
Mtai+	10	31	80	0.4	Doggart *et al*. (1999b)
Semdoe**	6	16	50	0.3	Doggart *et al*. (2000)
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)

* To make WKSFR and NDUFR figures comparable, only reptiles caught in areas of natural forest are listed.

** Lowland forests + Lowland/ Submontane forests § Montane/ Submontane forest # Montane forest

An important consideration in all comparison of reptile abundance is the relatively low sampling intensity. Unlike studies in the other forests listed in Table 7.8B, the base camps used to conduct this survey were all bar one outside of the forest reserve and thus the opportunity for casual collections of forest species is likely to have been less. The number of records from NDUFR and from the larger WKSFR, is however strikingly low considering the long time period spent in the area (around five months in NDUFR including the botanical phase of work). Comparison to the lower altitude forests therefore suggests that altitudinal differences are still likely to be having a large influence on diversity.

7.8.6 Conclusion

The reptilian diversity in New Dabaga/Ulangambi Forest Reserve is clearly lower than in many Eastern Arc forests. Montane conditions may be partly responsible for this, as reptiles generally require warm, humid environments. Some species have of course adapted to this, however this is not true of most species and thus diversity may be naturally low. Low opportunistic sampling intensity may also have resulted in a reduced collection.

The forest dependent reptile fauna is likely to be threatened by continued degradation of the forest. As with other taxa, forest dependent species are also mostly unable to disperse from or repopulate isolated forests such as NDUFR and thus the number of forest dependent species can only at best remain static.

Hindering all conclusions and recommendations however is the vast lack of knowledge of basic montane forest reptile ecology. As stated by Howell (1993), a lot more research is required both in the Udzungwa Mountains and in the Eastern Arc as a whole. Long-term studies of changes in reptile populations following management initiatives to restore the forest habitat in NDUFR may provide some much needed information. Suggestions for management are made in Frontier Tanzania (2001c): these include the creation of a buffer zone, active assistance of forest regeneration by clearing of scrubby vegetation, cessation of all tree felling and the formation of forested corridors to nearby forest fragments.

Only following management initiatives will the feasibility of improving reptile populations and diversity be known.

7.9 Amphibians of New Dabaga/Ulangambi Forest Reserve

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

7.9.1 Summary and Recommendations

The amphibian fauna of New Dabaga/Ulangambi Forest Reserve (NDUFR) was sampled using a combination of bucket pitfall trapping and opportunistic collections. Five sites were sampled within the forest reserve (trapsite 1-5), and four trapsites were placed outside the reserve (trapsite A-D). Trapsites within the forest reserve were sampled for eight days, while those outside were sampled for four days. Amphibian communities of NDUFR were surveyed from October to November 2000.

A total of 553 amphibians were caught of which 103 were retained for taxonomic purposes. Specimen identification is still preliminary. Within this amphibian collection, there are at least four families, ten genera and 14 species[*]. It is felt that this survey provides a sample of the majority of amphibian fauna of the area. The Udzungwa endemic, *Phlyctimantis keithae* (not forest dependent), was recorded on four occasions and three forest dependent species were recorded by this survey. All species listed as forest dependent are limited in range to the forests of eastern Tanzania.

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

Of note was the collection of *Leptopelis bocagii* (open habitat species) and *Leptopelis vermiculatus* (forest dependent species) during this survey, which represents the first record of both species in the Udzungwa Mountains. These range extensions emphasise the incomplete nature of current knowledge.

Open habitats and disturbed habitats, near irrigation ditches or streams (i.e. trapsite D and 1, respectively) may support a greater diversity of species than comparatively undisturbed forest habitats (e.g. trapsite 4). However, the species of these open/disturbed areas are generally adaptable and widespread. The forest dependent amphibian fauna (e.g. at trapsite 4) tends to have a limited distribution. Forested areas occupy a minute portion of the Tanzanian landscape (less than 3%), thereby stressing the importance of conserving these forest fragments (as highlighted in Howell, 1993; Schiøtz, 1981). NDUFR has been subjected to heavy past disturbance, therefore, management efforts should seek to maintain current forested areas and re-establish canopy cover in the degraded areas. Several limited range species were recorded within a 6ha village government forest (trapsite A), which suggests its potential within a system of forested corridors/stepping stones.

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

Just prior to publication of this report, additional species determinations were provided by Prof. Poynton. These are included as a separate subsection, but details are summarised in below.

Within this amphibian collection, there are at least four families, 11 genera and 18 species. Two of the species are endemic to the Udzungwa Mountains (both are not forest dependent). There are a further four near endemic species, all of which are forest dependent. One species has an IUCN criterion of endangered, while four species are vulnerable and one is near threatened. Four records are of particular interest:

- The records of *Arthroleptis xenodactylus, Leptopelis bocagii,* and *Leptopelis vermiculatus* all represent the first record of these species in the Udzungwa Mountains.
- A species currently being described (*Bufo* sp. nov.) was recorded by this survey of NDUFR.

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

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 forest faunas are surprisingly rich, and their forest-dependent amphibian species are all endemic 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 till 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.

Increasingly, studies have focused on the affects of tropical forest degradation on amphibian diversity (e.g. Vallan, 2000; Pearman, 1997; Andreone, 1994). New Dabaga/Ulangambi Forest Reserve (NDUFR) offers the opportunity to study amphibian diversity in a human impacted habitat.

Aims:

- To provide a representative species list of amphibians present in New Dabaga/ Ulangambi Forest Reserve.
- To study the distribution of species and individuals between different trapsites.
- To ascertain what factors may be influencing this distribution.
- To provide recommendations for future joint forest management plans.

7.9.3 Method

Amphibian communities of NDUFR were sampled from the beginning of October to the end of November 2000. A combination of bucket pitfall trapping and casual collections were used to sample the amphibian communities at five trapsites within the forest reserve and four outside (see Section 7).

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 the forest reserve (trapsites 1-5) and for four nights at trapsites outside the forest reserve (trapsites 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 casual 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 specimens. 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 (5 specimens) during the botanical research phase (July to September 1999) have been identified/verified by Prof. JC Poynton (British Natural History Museum), and are included here. However, analysis of species distribution will be based on data collected during the zoological period. Some of the specimens collected during the zoological period have been identified by Prof. KM 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 village government forest fragment (6ha) dominated by *Parinari excelsa*; Trapsite B in pine plantation; Trapsite C in black wattle plantation; Trapsite D in fallow field.

7.9.4 Results

A total of 553 amphibians were caught, of which 103 were retained for taxonomic purposes. Within this amphibian collection, there are at least four families, ten genera and 14 species. These species are listed in **Table 7.9A**. One of the species is endemic to the Udzungwa Mountains, while three other species are forest dependent with ranges limited to Eastern Tanzania.

Table 7.9A. Amphibian species for New Dabaga/Ulangambi Forest Reserve

Identification	Verification	Forest Species	Endemism*	CITES Status~	IUCN Status+
ARTHROLEPTIDAE					
Arthroleptis stenodactylus		×			
Arthroleptis xenodactyloides	Howell	×			
Arthroleptis sp.		?	?	?	?
BUFONIDAE					
Bufo gutturalis	Poynton	O			
Bufo sp.¬		?	?	?	?
Nectophrynoides tornieri?		F	[3]NE	Appendix I	Vu
Nectophrynoides viviparus	Poynton	F	[2]NE	Appendix I	Vu
HYPEROLIIDAE					
Afrixalus *sp. P & B*		O			
Hyperolius pictus?	Howell	O			
Hyperolius *sp.*		?	?	?	?
Leptopelis bocagii	Howell	O			
Leptopelis vermiculatus	Howell	F	[1]NE		NT
Phlyctimantis keithae	Howell	×	E		En
RANIDAE					
Ptychadena *sp.*		?	?	?	?
Ptychadena uzungwensis	Poynton	O			
Rana angolensis	Poynton	×			
Strongylopus fasciatus fuelleborni	Howell	×			

*Endemism (based on Vestergaard, 1994; Howell, 1993): E = Endemic: occurs only within the Udzungwa Mountains; NE = Near endemic, species with limited ranges; Eastern Arc, Southern Highlands, and Northern Malawi. [1]NE = Usambara and Rungwe; [2]NE = Udzungwa, Ukinga, Poroto, Rungwe, Uluguru; [3]NE = Udzungwa, Usambara, Uluguru.

#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. The species occurs 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) based on IUCN criteria: En = Endangered; Vu = Vulnerable; NT = Near threatened.

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

¬*Bufo* sp. is definitely distinct from *Bufo gutturalis.*

A further 13 forest dependent species have been recorded from the Udzungwa Mountains, but were not recorded by this survey of NDUFR. It should be noted that some of these species are only known from a few localities within the Udzungwa Mountains (e.g. *Phrynobatrachus uzungwensis*). 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 uluguruensis**
Arthroleptis reichei	*Callulina kreffti*
*Bufo brauni**	*Spelaeophryne methneri**
Nectophrynoides wendyae^{E}	Arthroleptides martiensseni*
*Afrixalus ulugurensis**	*Phrynobatrachus uzungwensis**
Hyperolius mitchelli	*Scolecomorphus kirkii*
*Leptopelis barbouri**	

* = Distribution restricted to Tanzania. *E* = Endemic to the Udzungwa Mountains

Figure 7.9A is a species accumulation curve by trapsite. The trapsites are randomly ordered, and do not include the trapsites outside the forest reserve. The number of new species encountered was initially seen to increase markedly (between trapsite 2 and 1). After the first three trapsites, the curve had reached an asymptote and no new species were added. However, it should be noted that with few trapsites, the shape of the curve is highly dependent on the order of the trapsites, especially if there is a lot of variation in species numbers between trapsites.

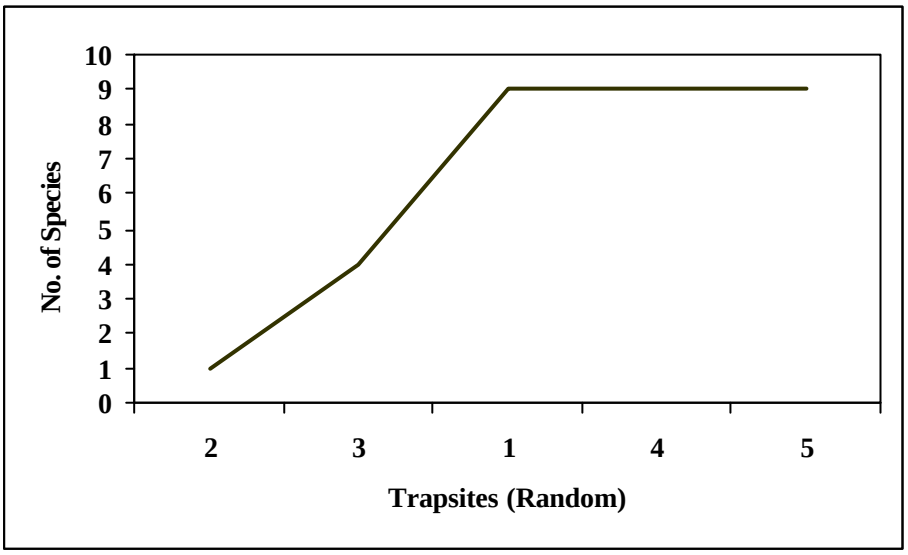


Figure 7.9A. Species accumulation curve

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 recorded at each trapsite is 59. As seen from **Table 7.9C**, no amphibians were recorded in the pine or black wattle plantations (trapsite B & C, respectively). Three trapsites possessed numbers of individuals that were well above the mean (trapsite D, 3 & 4), while at the rest of the trapsites very few individuals were recorded. Trapsites D, 3 and 4 are located within close proximity of water (50m). The mean number of species recorded at each trapsite is three, with an average of one limited range species at each trapsite. Of note is the high number of species recorded at trapsite D (fallow field) and the high number of limited range species recorded at trapsite A (*Parinari excelsa* dominated forest fragment), both of which are outside the forest reserve.

Table 7.9C. Amphibians in relation to trapsites. Trapsites outside the reserve for four days, trapsites within reserve for eight days.

Trapsite	Number caught	Number of families	Number of genera	Number of species	Limited range species
Outside reserve					
A	7	3	5	5	2
B	-	-	-	-	-
C	-	-	-	-	-
D+	91	4	8	8	1
O	19	3	5	5	-
Forest reserve					
1+	6	3	5	5	1
2	1	1	1	1	-
3+	252	2	2	2	1
4+	159	3	3	4	2
5	13	2	2	2	1
Total	548	6	10	14	6

O refers to amphibians collected opportunistically outside the reserve. The majority were collected around main camp in a field with many irrigation ditches.
+ Trapsites located with water association (i.e. within 50m).
Note; 5 individuals caught during 1999, not included in the above table.

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

Table 7.9D. Distribution of genera by trapsite

	Trapsites within the forest reserve					Trapsites/collections outside the reserve					
Genera	1	2	3	4	5	A	B	C	D	O*	Total
Afrixalus						1					1
Arthroleptis	1	1	241	146	12	3			2		406
Bufo									56	1	57
Hyperolius	1					1			2	10	14
Leptopelis						1			1		2
Nectophrynoides			10	11							21
Phlyctimantis	1				1	1			1		4
Ptychadena									3	2	5
Rana	1			2					1	3	7
Strongylopus	1								23	2	26
Unknown	1		1						2	1	5

O* refers to amphibians collected opportunistically outside the reserve. The majority were collected around main camp in a field with many irrigation ditches.

Arthroleptis accounted for 74% of all amphibians caught, with the vast majority being caught within the forest reserve. The highest numbers of *Arthroleptis* individuals were caught at trapsite 3 and 4. *Arthroleptis* was the most numerous genus at all trapsites, except trapsite D. At trapsite D, the genus *Bufo* was the most dominant.

Water Association

Amphibians recorded in NDUFR showed a strong association with water, whereby 68% of amphibians were caught within 50m of water. Several genera showed a particularly strong association with water, namely; *Nectophrynoides*, *Ptychadena*, *Hyperolius* and *Rana*[*]. All *Rana* individuals were recorded within 5m of water, while 71% of *Hyperolius* individuals

[*] All *Rana* identified to date are of the species *angolensis*.

were caught within 5m of water. Sixty % of *Ptychadena* individuals were recorded within 30m of water, and 52% of *Nectophrynoides* individuals were caught within 10m of water. Trapsites within 50m of water were grouped (trapsites 1, 3, 4, D), and independent samples *t*-test was used to test whether the number of species and individuals were significantly different from trapsites without any water association (trapsite 1, 2, A, B). For trapsites within the forest reserve, data was only used from the first four days of trapping. A significantly higher number of individuals were recorded at trapsites with streams and marshes nearby, than trapsites without any water association (*t*-test: $t_{0.05(2)7} = 2.615$, $p = 0.035$). The number of species was, however, not significantly different between trapsites with and without water association (*t*-test: $t_{0.05(2)7} = 1.367$, $p = 0.214$).

Canopy Cover

The genus *Nectophrynoides* was only recorded within the forest reserve, while the genera *Bufo, Leptopelis, Ptychadena* and *Afrixalus* were only recorded from outside the reserve. The rest of the genera were recorded both inside and outside the forest reserve. It is important to note that trapsite A, although outside the reserve is situated in a forest fragment dominated by *Parinari excelsa* (village government forest), where the canopy cover exceeds many areas within the reserve. 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 and individuals were significantly different between the two groups. Again, data for trapsites within the forest reserve was limited to the first four days. No significant difference was noted in species richness and individual numbers between trapsites with over 50% canopy cover and trapsites with less than 50% canopy cover (Species; *t*-test: $t_{0.05(2)7} = -.286$, $p = 0.783$. Individual; *t*-test: $t_{0.05(2)7} = -1.219$, $p = 0.262$).

Precipitation

The short rains began on the 13 November in NDUFR and continued to the end of the survey period. Trapsites 5 and D occurred within this period of rain. A marked increase in the number of species recorded was noted at trapsite D. Trapsites were grouped into those where no rain was recorded (trapsites 1, 2, 3, 4 A, B, C) and those where rain fell (trapsites 5, D), and were tested for whether the number of species and individuals recorded within the two groups were the same (forest reserve data limited to the first four days). No significant differences were noted in individual (*t*-test: $t_{0.05(2)7} = 0.137$, $p = 0.895$) and species numbers (Mann-Whitney: $p = 0.5$, $Z = -0.897$, $n = 9$).

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 forest suitable for these forest dependent amphibians. However, many of these forests are small and isolated, and increasingly being impacted upon by humans. NDUFR is an example of an isolated forest fragment of 3728ha, set in a human impacted landscape. The distribution of amphibians within the reserve, and outside the reserve varied markedly. Various factors were thought to be important in influencing the distribution of the amphibian species recorded by this survey. These factors varied from the proximity of water bodies to the way data was collected.

Data Collection and Analysis
The method employed in surveying amphibians in NDUFR 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. However, bucket pitfall traps accounted for 518 (or 95%) of all individuals caught in NDUFR. Therefore, it is felt that the results of this survey are biased towards terrestrial amphibians.

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 that the survey was not set up with these tests in mind, trapsites and bucket lines were placed to sample a maximum diversity of habitats and therefore species. Furthermore, the small sample size (i.e. 9 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 NDUFR, species richness and the number of individuals were tested for relationships with water association, canopy cover and precipitation. The only significant relationship was between the number of individuals and water association; more individuals were recorded at trapsites near water.

ARTHROLEPTIDAE
Two species, of the genus *Arthroleptis*, were identified from the family Arthroleptidae. The genus is exclusively terrestrial and breeds away from water (Passmore & Carruthers, 1995). The preferred habitat of the genus is the leaf litter of wooded areas. Both *A. stenodactylus* and *A. xenodactyloides* are forest dwelling, but also inhabit more open wooded areas (see **Table 7.9A**).

Discussion will be limited to the genus level as not all recorded individuals within this family were identified to species level. The genus was recorded at all trapsites within the reserve, and at two outside the reserve. The genus was well represented in this survey, accounting for 74% of all individuals caught. *Arthroleptis*' terrestrial behaviour was thought to explain its high representation in this survey[*]. The genus showed a preference for natural forested areas, with 99% of individuals being recorded within the reserve. At trapsites 3 and 4, numerous *Arthroleptis* individuals were recorded (241 and 146 respectively). Both trapsites were typified by a closed canopy, dense leaf litter layer, and a stream nearby. *Arthroleptis* lay their eggs in nests among decaying vegetation (i.e. leaf litter). It is thought that the habitat conditions at trapsite 3 and 4, form ideal breeding areas for *Arthroleptis*; that is, a dense leaf litter layer for egg nests and a moist environment (canopy and water association) to prevent desiccation.

BUFONIDAE
Two genera, comprising at least four species (*Bufo gutturalis*, *Bufo* sp.[~], *Nectophrynoides viviparus*, *Nectophrynoides tornieri*), were recorded from this family in NDUFR. Discussion

[*] Although it should be noted that an *A. stenodactylus* was caught in a Sherman trap place on a branch 1.5m above the ground.
[~] *Bufo* sp. is definitely distinct from *Bufo gutturalis*.

of this family will be limited to the genus level as not all recorded individuals were identified to the species level. *Bufo,* a widespread genus, is often found in dry open habitats some distance form the water, where it generally spends day light hours in sheltered retreats, either underground or beneath logs or stones (Passmore & Carruthers, 1995). Although *Bufo* may be found some distance from water, it requires permanent water to breed and lay its eggs. In NDUFR, the terrestrial niche occupied by *Arthroleptis* in forested/wooded areas, was filled by *Bufo* in more open situations (e.g. trapsite D).

The genus *Nectophrynoides* differs markedly from *Bufo* in being restricted to Tanzania, where its range is generally limited to upland forested areas (Poynton *et al.,* 1998). Furthermore, some form of ovoviviparity has developed within the *Nectophrynoides* genus, thereby negating the need for permanent water for successful reproduction. *Nectophrynoides* was only recorded at two trapsites (3 & 4), both within the forest reserve in areas with closed canopy.

HYPEROLIIDAE

The majority of individuals belonging to the four genera from this family were recorded outside the forest reserve. In the NDUFR area, 14 individuals of the genus *Hyperolius* were collected. *Hyperolius* showed a strong affinity with water, with 71% of individuals being collected within 5m of water. *Hyperolius'* non-terrestrial habit was highlighted in the fact that only two individuals were caught in bucket-pitfall traps. The genus was mostly recorded in open habitats, only one individual was recorded from an area of closed canopy (trapsite A[+]). Only one specimen of the genus *Afrixalus* was collected. The individual was collected in a *Parinari excelsa* dominated forest fragment (trapsite A).

Two individuals of the genus *Leptopelis* were recorded by this survey. The individuals represent two species, *Leptopelis bocagii* and *Leptopelis vermiculatus* (both identified by Prof. KM Howell). Both individuals were caught in bucket pitfall traps outside the reserve. *Leptopelis bocagii* is a widespread species (from Ethiopia to northern Namibia) of open upland areas (Schiøtz, 1999). The species is terrestrial, where it is thought to spend a lot of time buried underground (Schiøtz, 1999). This record of the species in the NDUFR area represents the first record of the species in the Udzungwa Mountains (based on Schiøtz, 1999). The species was caught in a fallow field (trapsite D) 600m from NDUFR at an altitude of 1920m a.s.l. (Grid ref: 8° 05' 37.9"S; 35° 54' 05.6"E). *Leptopelis vermiculatus*, however, is a limited range arboreal species restricted to forested areas of Tanzania (Schiøtz, 1999). Schiøtz (1999) describes the distribution of *Leptopelis vermiculatus* as being "known from the eastern Usambaras and from Rungwe Mts., but strangely enough not with certainty from Uluguru and Udzungwa Mountains." *Leptopelis vermiculatus* was caught in a *Parinari excelsa* dominated forest fragment (trapsite A) 500m from NDUFR at an altitude of 1820m a.s.l. (Grid ref: 8° 06' 47.4"S; 35° 56' 50.4"E).

Four individuals of the species *Phlyctimantis keithae* were caught during this survey. The species is endemic to the Udzungwa Mountains, where it is only known from a few localities. Howell(1993) lists the species as forest dependent, while Schiøtz (1999) states that species may be abundant in open farmland far from any forest, but is also found in forest. This survey of NDUFR recorded the species in the following habitats: disturbed montane forest with broken canopy and dense shrub layer (trapsite 1); montane forest at the centre of the southern part of the reserve (trapsite 5); *Parinari excelsa* dominated forest fragment outside the

[+] One individual was collected opportunistically from trapsite 1 within the reserve. However, trapsite 1 was typified by having a broken canopy.

reserve (trapsite A); and, a fallow field 600m from NDUFR (trapsite D). Therefore, *P. keithae* is viewed as forest dwelling, but not forest dependent by this survey. Further study is required to identify what factors may be restricting its distribution.

RANIDAE

Three genera from this family were recorded by this survey, namely; *Ptychadena, Rana,* and *Strongylopus*[*]. Both the genera *Rana* and *Ptychadena* have strong associations with water. *Strongylopus* are generally found in or near bodies of water with grassy margins (Passmore & Carruthers, 1995). In this survey of NDUFR, *Strongylopus* did not show a strong association with water, with only 23% of individuals recorded within 50m of water[+]. The majority of *Strongylopus* individuals were caught in a fallow field (trapsite D) after the short rains had begun, this increased moisture may explain why the majority of this genus were recorded away from water. This family was predominantly caught in open areas outside the forest (i.e. trapsite D).

Forests, the Human Landscape, and Amphibians

It is noticeable that all three of the species listed as forest dependants (see **Table 7.9A**) 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 of 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 *Leptopelis bocagii*) and living in or near water bodies (as in *Rana angolensis*) to avoid desiccation in open habitats. Similarly, eggs laid in aquatic habitats reduce the risk of desiccation.

NDUFR is heavily disturbed due to past logging and fires. This has resulted in a broken canopy and dense scrub vegetation in many places. Within the reserve seven species were recorded, three of which were limited range species. Of note was the absence of the terrestrial Microhylid, *Probreviceps macrodactylus* (no Microhylids recorded at NDUFR). In the undisturbed forests of West Kilombero Scarp Forest Reserve, *P. macrodactylus* was relatively abundant (recorded at six of the ten forest trapsites). Recent studies in Madagascar on forest amphibians, revealed that terrestrial amphibian species that show a reproduction strategy independent of water (e.g. certain Microhylids) were most sensitive to habitat degradation and fragmentation (Vallan, 2000; Andreone, 1994). The absence of any records of Microhylids in NDUFR, may therefore be indicative of the disturbed state of the reserve.

Open habitats and disturbed habitats near irrigation ditches or streams (i.e. trapsite D and 1, respectively) may support a greater diversity of species than primary undisturbed forest. However, the species of these open/disturbed areas are generally adaptable and widespread. All the species currently identified from trapsite D and 1 are widespread, except for *P. keithae*.

No amphibians were recorded in the pine and black wattle plantations (trapsite B & C, respectively). It is suggested that these habitats were too dry to support amphibians. Furthermore, at trapsite B the ground was carpeted in a layer of pine needles; the acidic nature of these needles may be detrimental to terrestrial amphibian ecology.

[*] All *Strongylopus* identified to date are of the species *fasciatus fuelleborni*.

[+] In West Kilombero Scarp Forest Reserve, *Strongylopus fasciatus fuelleborni* showed a strong association with water; 80% of individuals recorded within 30m of water (Frontier Tanzania, 2001f).

Trapsite A, within the 6ha *Parinari excelsa* village government forest, had the same number of species (5 species) as the most species rich forest site despite being sampled for only four days*. Furthermore, one forest dependent and two limited range species were recorded at trapsite A. Thereby highlighting the potential of *P. excelsa* type forests to act as habitat corridors.

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 forests (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 Udzungwa Mountains (Howell, 1993). However, it should be borne in mind that the Udzungwa Mountains represent the largest mountainous forested area in Tanzania and until the early 1980s was virtually unstudied biologically. The Udzungwa Mountains lag considerably behind the Ulugurus and Usambaras in terms of research, there is 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 Udzungwa Mountains (Vestergaard, 1994; Howell, 1993). The incomplete nature of current knowledge is highlighted in the range extensions of *L. bocagii* and *L. vermiculatus*. A comparison of similar surveys carried out by Frontier Tanzania in Usambaras and Udzungwa Mountains 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
New Dabaga/Ulangambi Forest Reserve* (NDUFR); Udzungwa Mts.	This Study	4	14
West Kilombero Scarp Forest Reserve (WKSFR); Udzungwa Mts.	Frontier Tanzania (2001f)	6	14
Semdoe Forest Reserve; East Usambara Mts.	Doggart *et al*. (2000)	6	11
Magoroto Forest Reserve; East Usambara Mts.	Bayliss *et al*. (1996)	7	29
Mtai Forest Reserve; East Usambara Mts.	Doggart *et al* .(1999a)	7	27
Manga Forest Reserve; East 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 **Table 7.9E**, it would appear that the Usambaras are more species rich than the Udzungwa Mountains. 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

* Trapsites within the forest reserve sampled for eight days.

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 report 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. To benefit amphibian diversity, management efforts should seek to maintain/re-establish 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 isolated NDUFR with other 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 (Frontier Tanzania, 2001a). The presence of forest dependent species in the *Parinari excelsa* forest fragment (trapsite A) highlights its potential within this system of forested corridors or stepping stones.

- 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. This is especially important in NDUFR with its heavily disturbed forest habitat.

7.9.6 Conclusion

This survey of the NDUFR area identified amphibians from at least four families, ten genera and 14 species. *Phlyctimantis keithae*, the Udzungwa endemic, was recorded by this survey. From the species accumulation curve of trapsites within the forest reserve, the curve reached an asymptote after three trapsites. The curve suggests that this survey has provided a sample of the majority of NDUFR amphibians.

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

The range extensions of *Leptopelis bocagii* and *Leptopelis vermiculatus* emphasize the incomplete nature of current knowledge.

Three amphibian species recorded by this survey were forest dependent, all of which were limited in range to forested areas of eastern Tanzania. These forested areas account for a minute proportion of the Tanzanian landscape. Therefore, efforts should seek to re-establish canopy cover in the degraded parts of the reserve, whilst maintaining 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 New Dabaga/Ulangambi Forest Reserve (NDUFR). 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 50 specimens have yet to be looked at by taxonomists.

Table 7.9F. Amphibian species for New Dabaga/Ulangambi Forest Reserve

Identification	**Verification¬**	**Forest Species#**	**Endemism***	**CITES Status~**	**IUCN Status+**
ARTHROLEPTIDAE					
Arthroleptis affinis	Poynton^	F	[3]NE		Vu
Arthroleptis xenodactyloides	Howell	×			
Arthroleptis xenodactylus	Poynton^	F	[4]NE		Vu
BUFONIDAE					
Bufo gutturalis	Poynton	O			
Bufo sp. nov.	Poynton^				
Nectophrynoides viviparus	Poynton	F	[2]NE	Appendix I	Vu
HYPEROLIIDAE					
Afrixalus morerei	Poynton^	O	E		Vu
Hyperolius pictus	Howell	O			
Hyperolius puncticulatus	Poynton^	×			
Leptopelis bocagii	Howell	O			
Leptopelis vermiculatus	Howell	F	[1]NE		NT
Phlyctimantis keithae	Howell	×	E		En
RANIDAE					
Phrynobatrachus rungwensis	Poynton^				
Ptychadena grandisonae	Poynton^				
Ptychadena porosissima	Poynton^	O			
Ptychadena uzungwensis	Poynton	O			
Rana angolensis	Poynton	×			
Strongylopus fasciatus fuelleborni	Howell	×			

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

*Endemism (based on Vestergaard, 1994; Howell, 1993): E = Endemic: occurs only within the Udzungwa Mountains; NE = Near endemic, species with limited ranges; Eastern Arc, Tanzania, and Northern Malawi. [1]NE = Usambara and Rungwe; [2]NE = Udzungwa, Ukinga, Poroto, Rungwe, Uluguru; [3]NE = Udzungwa and Usambaras; [4]NE = Usambara and Uluguru.

#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. The species occurs 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) based on IUCN criteria: En = Endangered; Vu = Vulnerable; NT = Near threatened.

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

Within this amphibian collection, there are at least four families, 11 genera and 18 species. Two of the species are endemic to the Udzungwa Mountains (both are not forest dependent). There are a further four near endemic species, all of which are forest dependent. One species has an IUCN criterion of endangered, while four species are vulnerable and one is near threatened. Four records are of particular interest:

- The records of *Arthroleptis xenodactylus*, *Leptopelis bocagii*, and *Leptopelis vermiculatus* all represent the first record of these species in the Udzungwa Mountains.
- A species currently being described (*Bufo* sp. nov.) was recorded by this survey of NDUFR.

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

7.10 Mollusc Diversity in New Dabaga/Ulangambi Forest Reserve

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

7.10.1Summary and Recommendations

The mollusc fauna was sampled at nine trapsites using a combination of plot surveys, direct timed searching and casual collections. Five sites were within the forest reserve, one site in village government forest (site A), one site in a fallow field (D) and two sites in plantation forests (black wattle (*Acacia mearnsii*) (site C) and pine (*Pinus caribaea*) (site B)). For each site, collected molluscs have been counted and divided into morpho-species.

The mollusc fauna of New Dabaga/Ulangambi Forest Reserve (NDUFR) with 21 morpho-species is an average Eastern Arc forest in terms of species richness. West Kilombero Scarp Forest Reserve (WKSFR), also in the Udzungwa Mountains, is more diverse (54 morpho-species). This is probably due to a higher altitudinal span and the variety of habitats found in WKSFR compared to the similar ecological conditions found in NDUFR.

Within the forest reserve there were few differences between sites in species richness and diversity for reasons mentioned above. Comparisons between sites differing in disturbance level showed no apparent affect on the molluscan communities. Although not significant, the results indicate that mollusc diversity might be more dependent on whether or not the site is associated with a water source. The species accumulation curve suggest that the mollusc fauna is well represented in this study, but a increase in the number of plots is recommended in order to make any conclusions.

Forest reserve sites were more species rich and more diverse than sites outside the reserve. Site A in natural forest contained only species found in the reserve. The site was low in species and high in number of individuals probably due to the highly uniform *Parinari excelsa* habitat. Little overlap in species composition was observed between natural forest sites and trapsite D (fallow field). This indicates the presence of different molluscan communities in these habitats. Probably with forest dependent species in the natural forest and species adapted to more arid conditions in the fallow field. The plantation forests had the lowest abundance of molluscs.

The biggest threat to the mollusc fauna of NDUFR is destruction of habitat. The forest shows a uniform distribution of species with moist areas harbouring more diverse communities than drier areas. Essential for the conservation of molluscan diversity in the forest reserve is therefore that catchment areas are left undisturbed and that a management planning aims to protect against further destruction of natural forest.

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 taxonomical checklists to the use of quantitative methods that are used 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 Udzungwa Mountains (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 (Seddon *et al*., 1996 and 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 New Dabaga/Ulangambi 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 New Dabaga/Ulangambi was sampled during October and November 2000. A combination of plots, timed direct searches and casual collections were used to assess the mollusc diversity at five trap sites within the forest reserve (trapsites 1-5) and four outside (Village Government Forest (A), pine (*Pinus sp.*) plantation (B), black wattle (*Acacia mearnsii*) plantation (C) and fallow field (D); see **Section 7.1** for positions of trapsites)(for details on methodology see Frontier Tanzania, 2001g).

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 under 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 1073 molluscs representing 27 morpho-species were recorded from all trapsites in and around New Dabaga/Ulangambi Forest Reserve (see **Appendix 7.10A**). Of these 21 species were found at trap sites inside the forest reserve (trapsites 1-5) (total sample area $15m^2$) and 14 species were found in other habitats outside the reserve (trapsites A-D) (total sample area $12m^2$) including six not found in the forest. The species accumulation curve is clearly reaching an asymptote (see **Figure 7.10A**). Thus suggesting that few species remains to be found in the forest reserve.

Eight species were found to be unique to a single trapsite. Six of these being from the fallow field site (D) and two from sites in the forest (trapsite 1 and 4). Morpho-species "J" and "G" were found at nine (all) and eight trapsites respectively (see **Appendix 7.10A** for a list of morpho-species recorded from each survey site).

Trapsites D and 5 were sampled after the onset of rain. The mean total number of species was compared between trapsites sampled before and after the onset of rain using a *t*-test.

However, no significant effect of rain was observed (*t*-test: *t*=-0.315; df=7; *p*=0.762). Trapsite D was the most species rich non-natural forest area and trapsite 5 the third richest natural forest site (see **Table 7.10A**).

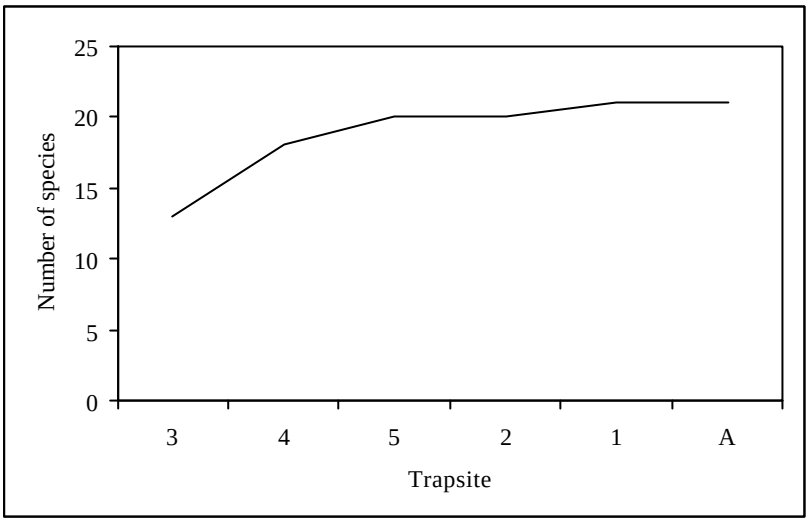


Figure 7.10A. Species accumulation curve for molluscs found at natural forest trapsites in New Dabaga/Ulangambi Forest Reserve. Trapsites arranged randomly.

Table 7.10A. Number of species and individuals recorded in three 1m x 1m sample plots and total number of species per trapsite.

Trap site	Number of species in sample plots	Number of individuals in sample plots	Total number of species at site
C	0	0	3
B	1	1	3
A	5	88	7
D*	5	8	9
2	10	46	11
5*	7	23	12
3	11	31	13
1	10	62	14
4	13	44	16

* - Trapsites sampled after the onset of the short rainy season (November-December)

Forest Sites vs Non-Forest Sites

Black wattle and pine plantation trapsites (C and B) were found to have the lowest total number of species (three) for all surveyed sites (see **Table 7.10A**). Site A and D have seven and nine species in total respectively, while forest reserve sites range between 11 and 16. Forest reserve sites and non-forest reserve sites share eight species, while 13 are only found in the forest reserve and six only outside (all in fallow field). There is significantly higher mean total species richness (*t*-test: *t*=4.254; df=7; *p*=0.004) at forest reserve sites compared to non-forest reserve sites.

Generally more individuals were found during plot surveys in forest reserve sites compared to non-forest reserve sites (see **Table 7.10A**). The exception being trapsite A (Village

Government Forest), which has the highest abundance of all sites (88 ind./3m^2) (see **Table 7.10A**).

Natural forest sites (forest reserve sites and trapsite A) were also richer in species, number of individuals and diversity than plantation forests and fallow field. The number of species shared between natural forest sites and the three remaining sites is six (see **Appendix 7.10A**).

Natural Forest Sites
Trapsite A and site 2 exhibit the lowest total number of species for the natural forest sites (see **Table 7.10A**), and both sites were not associated water. Trapsite 3 and 4 are the most species rich sites in the plot survey and in total (see **Tables 7.10A**).

The mean total species richness was not correlated with water association (*t*-test: t=0.258; df=4; p=0.109).

7.10.5 Discussion

Forest Sites vs Non-Forest Sites
Sites within New Dabaga/Ulangambi Forest Reserve were richer in species and more diverse than sites outside. Six of nine species found on the fallow field site (D) were only found there and therefore may not occur in forest. It is highly likely that the forest trapsites will possess forest dependent species when specimens are identified. This indicates that the mollusc fauna at trapsite D differs in composition from the forest fauna. This is not surprising considering the considerable difference in moisture levels between forested and non-forested habitats. 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 thought to be an important factor in determining molluscan diversity and abundance.

The plantation forests (black wattle and pine) both exhibit low diversity and few species. Although these sites have plenty of leaf litter, the ground appears dry probably due to a high degree of exposure in the absence of ground covering vegetation and a sparse shrub and canopy cover. It is also possible that the acidity found in soils under pine may affect mollusc abundance and diversity. All four species found in plantation forest were also found on forest sites. Only two were shared with site D, indicating a mollusc fauna closer to the one present in the natural forest, though much poorer in species richness and abundance.

Trapsite D in fallow field was sampled after the onset of the rain. This may have increased species richness, which before the rain might have been lower due to the lack of a canopy to protect against desiccation. In the three plots, five species recorded were represented by a total of eight individuals. This suggests a low abundance of molluscs possibly due to the small amount of leaf litter created during the fallow period and due to some degree of exposure in the newest fallow areas. Surveys in West Kilombero Scarp Forest Reserve (also in Udzungwa Mountains) have shown molluscan diversity to increase after the onset of rain (Frontier Tanzania, 2001f). In drier periods molluscs may be less active and stay in areas not reached by the survey methods employed in this study.

Trapsite A (Village Government Forest) has a dense vegetation cover including a canopy to protect against excessive evaporation. This should make conditions ideal for molluscs. The high degree of disturbance however has resulted in a uniform forest dominated by *Parinari excelsa* with few niches. This probably explains the low number of species. The species adapted to these niches therefore may become abundant, thus accounting for the high number of individuals found at this site.

Natural Forest Sites

The species accumulation curve for natural forest trapsites shows clear signs of reaching an asymptote. The survey design is therefore considered comprehensive enough to produce a list of species, but drawing ecological conclusions is difficult. In order to do that the number of plots should be increased.

Trapsite 1 had a very sparse canopy cover and dense shrub cover probably as a result of human activities in the area. In terms of number of species, this is however the second richest site. This suggests that human activities do not reduce molluscan species richness as long as a canopy of some form is present (e.g. few species were recorded in the fallow field, which has a dense shrub layer and no canopy). This is not unexpected because disturbance leads to more habitat heterogeneity with more niches, but future identification of collected specimen will reveal whether the quality of species composition has been affected by a reduction in the number of forest dependent species.

Natural forest sites with no water association (A and 2) have a lower mean number of species than sites associated with water, although the difference is not significant. The presence of water therefore seems to have a beneficial effect on the richness of the molluscan fauna.

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 x 1m plots. Their Direct Searching involved two persons searching for two hours within a plot (usually of 20-40m in diameter) and therefore 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.

NDUFR with 21 different species is an average Eastern Arc forest with regard to molluscan diversity (see **Table 7.10B**). It possesses fewer species than its fellow Udzungwa site of WKSFR, the Ulugurus and West Usambaras, but more than some East Usambara areas and more than all areas in Nguru. The low number of species in NDUFR compared to WKSFR probably reflects the lower altitudinal span and the more homogenous habitat found in NDUFR.

In temperate regions, high altitudes have a similar but impoverished mollusc fauna compared with lower elevation ones (Dance, 1972 cited in: Tattersfield *et al*., (1998)). Tattersfield *et al.* (1998) contrast this in their surveys of the tropical Eastern Arc mollusc fauna. In these they found essentially different molluscan communities at high and low elevations. NDUFR has a small altitudinal span and which is probably why no relationship between altitude and the mollusc fauna was found within the forest reserve. The higher number of species and low overlap between sites found in WKSFR probably reflects the larger altitudinal span (trapsites between 1140-2070m a.s.l.) and more diverse habitat.

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

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 (grassland, fallow field, plantations and woodlands).

Trapsites in NDUFR are at higher elevations than any of the forests surveyed by Tattersfield *et al.* (1998). The similarity between the number of species in NDUFR and other Eastern Arc forests (see **Table 7.10B**) suggests that there is no reduction in molluscan species richness with increasing altitude.

7.10.6 Conclusion

The Mollusc fauna of New Dabaga/Ulangambi Forest Reserve exhibits a molluscan species richness just below the average for an Eastern Arc forest. Trapsites in natural forest have a higher species richness and diversity than plantation forests and fallow fields. The species composition differed between fallow field and natural forest suggesting the presence of species adapted to different habitats. Species richness was higher for sites associated with water, although no statistical difference was found. It is essential for the conservation of molluscan diversity in the forest reserve that catchment areas are left undisturbed and that a management plan aims to protect against further destruction of natural forest.

Once identifications of collected specimens have been returned, more will be known about the abundance and distribution of endemic and forest dependent species.

7.11 Millipede Diversity and Distribution in New Dabaga/ Ulangambi 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. 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 Udzungwa Mountains above all others. Much of the Udzungwa Mountains 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 New Dabaga/Ulangambi Forest Reserve (NDUFR) were sampled using a combination of quadrats and timed casual searches. From these, 2,012 millipedes were collected. Taxonomic verification was however unavailable at the time of report writing, so these were classified into thirteen morpho-species in order to investigate diversity.

Comparison with millipedes collected from West Kilombero Scarp Forest Reserve (WKSFR) 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. Furthermore, there are two morpho-species that were found in NDUFR and not in WKSFR.

The millipede fauna within the forest is also clearly more diverse than that outside. Notably, five out of the thirteen morpho-species (38.5%), 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 thus should be monitored to ensure that harmful activities are not threatening this. Improvement of forest canopy in NDUFR may therefore enhance the millipede fauna.

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. However, 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.

Aims

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

7.11.3 Methods

Ground-dwelling millipedes were primarily sampled by timed searching of 3×3m 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, tentative morpho-species were 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 one millipede differed from another, they were grouped together.

Data Analysis – Principle Component Analysis
A small number of tests are carried out below to explore the diversity and distribution of morpho-species. These are mostly similar to tests used in other sections and explained in section 7.1. In addition, Principle Component Analysis (P.C.A.) is used to determine similarities between trapsites and to generate further hypotheses. 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). Following this, trapsites with the most similar levels of all variables can be identified and labelled by eye. P.C.A. is not a statistical test, it is simply an aid to data exploration. Following this, subsequent testing may be used to determine any significant trends.

7.11.4 Results

Millipedes were found at all trapsites, both within and outside of the evergreen forest (**Table 7.11A**). From the 2,012 specimens collected, thirteen morpho-species were identified, all of which were present at trapsites within evergreen forest.

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. Due to the similar species content of most trapsites (**Table 7.11A**), the curve shows a smooth gradient. The curve also appears to level off and thus the observed morpho-species compliment is thought to be representative of the NDUFR parent population.

Some morpho-species are clearly widespread in the reserve ('2'-'5', '7' and '9'-'11'). Some however are restricted to only one or two trapsites ('1', '12' and '14'). In an attempt to describe this distribution, using the observations in **Table 7.11A** together with observations made in West Kilombero Scarp Forest Reserve (Frontier Tanzania, 2001f), three categories of morpho-species are defined:

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

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

Table 7.11A. 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

* Village Government Forest fragment containing natural *Parinari excelsa* dominated forest.

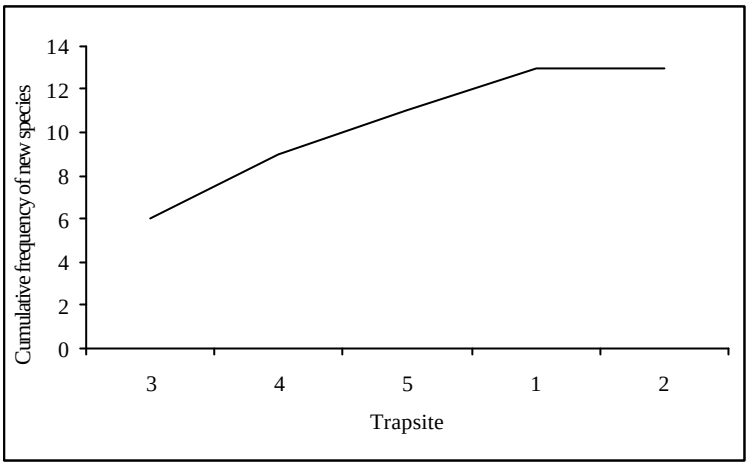


Figure 7.11A. Species accumulation curve for evergreen forest trapsites in New Dabaga/Ulangambi Forest Reserve.

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

	Forest* (5 trapsites)	VGF (1 trapsite)	Non-forest (3 trapsites)	Total NDUFR (9 trapsites)
Total number of individuals [1]	893	136	202	1231
Mean individuals per trapsite[1]	178.6	136.0	67.3	136.8
Total number of species	13	7	6	13
Mean no. species/ trapsite	9.0	7.0	3.0	6.8
"Forest species"	5	2	0	5
Mean "forest species"/ trapsite	2.0	2.0	-	[2] 2.0
"Unique species"	2	0	0	3
"Rare species"	1	0	0	1

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

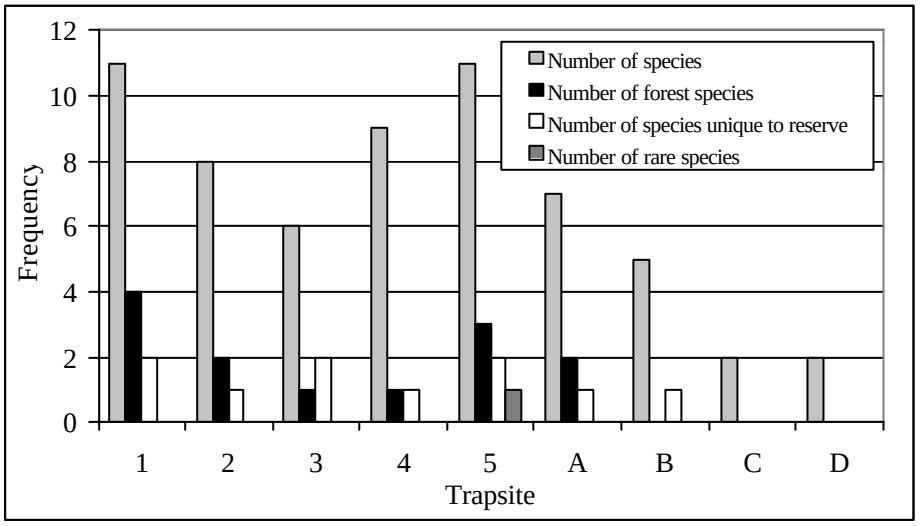


Figure 7.11B. Frequency of millipede morpho-species found at trapsites in New Dabaga/Ulangambi Forest Reserve (trapsites 1-5) and surrounding habitats (trapsites A-D). Definitions of categories as defined in text.

Principal Component Analysis using the components: species richness, number of individuals caught, and frequency of forest, rare and unique species, reveals three apparent groups of trapsites (**Figure 7.11C**). Most apparent is the close affinity between sites 'A' and 'B' to sites inside of the Forest Reserve. These two trapsites are from a *Parinari excelsa* dominated village government forest fragment to the south-east of NDUFR and pine (*Pinus caribaea*) plantation respectively. Sites 'C' and 'D', which have low species richness, are by contrast clearly outliers from the forest sites. Further tests reveal that the mean number and diversity of species caught per trapsite is significantly larger for sites in natural forest (numbered trapsites plus the village government forest trapsite 'A') than all other sites (*t*-test – Shannon diversity: p=0.016, $t_{(0.05(2),7)}$=3.175; species richness: p=0.013, $t_{(0.05(2),7}$=3.287). The number of individuals found at forest trapsites is also larger than for non-forest sites, although this is not significant (*t*-test: p=0.075, $t_{(0.05(2),7)}$=2.09). The two trapsites with the highest species richness, number of rare, unique and forest species ('1' and '5') are also clear outliers (**Figure 7.11B&C**).

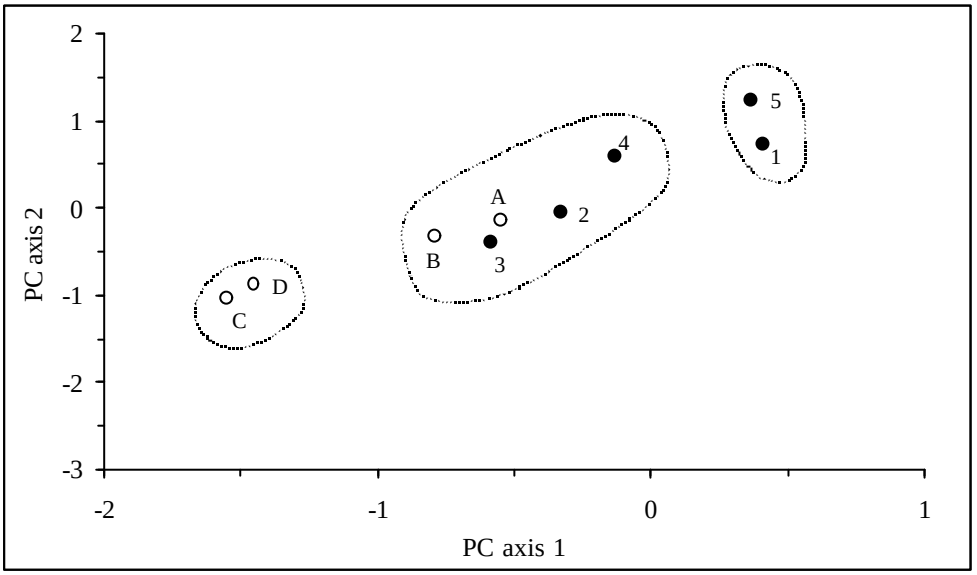


Figure 7.11C. Principle Component Analysis of millipede diversity at trapsites in New Dabaga/Ulangambi Forest Reserve, using the components: species richness and number of individuals, rare species, unique species and forest species. Shaded and open point indicate trapsites within and outside of the evergreen forest fragments respectively.

Comparison with New Dabaga/Ulangambi Forest Reserve

Similar data to that presented above for NDUFR was also collected in WKSFR (Frontier Tanzania, 2001f). Brief descriptions of these results are presented in **Table 7.11C** and **Appendix 7.11A**. Comparison of the millipede fauna from forest trapsites in WKSFR and NDUFR shows no significant difference between the mean number of individuals, species or Shannon Index 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; Shannon Index: p=0.260, $t_{(0.05(2),13)}$=1.179). Only ten species were found both in NDUFR and WKSFR. Furthermore, there are significantly fewer species unique to NDUFR than to WKSFR (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).

Table 7.11C. Frequency of individuals and morpho-species in the main evergreen forest blocks of New Dabaga/Ulangambi and West Kilombero Scarp Forest Reserves. 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.

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 all positive results ($p<0.025$), this however is not considered to be a problem.

7.11.5 Discussion

The comprehensive coverage of the NDUFR and WKSFR 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 NDUFR community. The purposefully conservative grouping of millipedes into morpho-species may also result in there being more true species than thirteen.

From previous experiences in the more well 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 NDUFR collection, approximately five morpho-species collected in NDUFR 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.

Important Areas for the Conservation of Millipede Diversity

Trapsites '1' and '5' are shown to be the most morpho-species rich of all sites. This is interesting as despite both being forest sites, these were found in quite contrasting habitats. The first of these, trapsite '1', was located in the north of the reserve in a scrubby, fire-damaged area, while trapsite '5' was located in closed canopy forest over 10m high. The similarities between trapsites '1' and '5' therefore demonstrate that degraded areas of forest are able to support millipede populations equally as diverse as intact areas of forest. However, for true forest dependent species it would figure that the presence of a canopy is more conducive to long-term survival of populations. Hoffman (1993) states that factors influencing desiccation are likely to be the biggest determinants of millipede distribution.

From this it would follow that the loss of canopy, which may lead to drying out of the forest floor, would have a harmful effect on the forest dependent millipede community.

The significant mean increase in species richness of sites within natural forest compared to those outside highlights the importance of forest habitats for millipede diversity. The comparatively high species richness of the pine plantation (trapsite 'B') is however somewhat surprising (**Table 7.11A** and **Figures 7.11B&C**). The monodominant habitat and the acidic soil conditions typical of pine forest are evidently tolerated by the five species found there. This falls just short of the six species found in the least diverse of forest sites. The comparable diversity of this non-forest site should not however detract from the value of natural evergreen forest found within the reserve and also in surrounding forest fragments. Primarily, due to the effectiveness of ecological barriers to millipede dispersal, natural forest is likely to be refuge to species unable to survive in other habitats. Because of the low coverage of forests in Tanzania (Rodgers [1993] estimates only 2-3%) it is therefore imperative that these habitats are maintained and improved where necessary.

Trapsite, 'A' which also lies outside of the Forest Reserve also, has a notable diversity. This site is the *Parinari excelsa* dominated village government forest fragment in the area of Msonza. This small patch of forest is only around 6ha in size. It does however contain many of the forest trees found within the reserve itself including *Parinari*, *Zanthoxylum* and *Cassipourea*.

Comparison with West Kilombero Scarp 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 **Table 7.11A** and **Appendix 7.11A**). Also important is the observation of more unique and rare morpho-species found in WKSFR than in NDUFR. Most strikingly though is that twenty-six (63.4%) of the morpho-species identified in WKSFR are recorded from three trapsites or less. This compares with only five morpho-species found from three trapsites or less 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.

NDUFR has a notably less diverse millipede fauna than the larger, less human impacted WKSFR. This does not however imply that the reserve is not important for millipede conservation. As discussed above, the forest habitat is clearly important over other habitats found in the surrounding area. The record of a morpho-species ('12') that was not found in WKSFR further adds to the specific importance of NDUFR.

7.11.6 Conclusion

The forest of New Dabaga/Ulangambi Forest Reserve contains a millipede fauna unique from non-forest habitats in the surrounding area. Importantly, there are seven species found in the forest and not in other habitats. Of these, using further collections from West Kilombero Scarp Forest Reserve, five are not recorded from forest and thus are potentially forest dependent. A further two morpho-species are unique to NDUFR, one of which is recorded from only one trapsite.

By categorising collections into morpho-species, some information is provided about the diplopods of NDUFR. Without identifications however, all conclusions must remain somewhat speculative. It is imperative that following taxonomic verification, the above findings are followed up to provide more information. In terms of management, it is however already clear that active assistance in the improvement of canopy cover may also assist millipede populations.

7.12 Butterfly Diversity of New Dabaga/Ulangambi Forest Reserve

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

7.12.1 Summary and Recommendations

The butterfly community of New Dabaga/Ulangambi Forest Reserve (NDUFR) was sampled using a combination of butterfly traps, timed sweep netting, and casual collections. Five sites were sampled within the forest reserve (trapsite 1-5). Four trapsites (trapsites A-D) were placed outside the forest reserve; in a 6ha *Parinari excelsa* dominated village government forest, pine plantation, black wattle plantation, and fallow field. Butterflies were sampled from early October to late November 2000.

A total of 799 butterflies were caught in NDUFR. The butterflies came from eight families, 30 genera and 50 species. No species recorded by this survey was endemic to the Udzungwa Mountains. However, at the subspecies level, there were two Udzungwa endemics (*Henotesia ubenica uzungwa* and *Acraea alicia uzungwae*). There are a further 15 near-endemic species/subspecies.

Two factors were thought to be important in influencing butterfly diversity at the various trapsites. These were time of year and habitat heterogeneity. An increase in the numbers of individuals and species were noted towards the end of the survey period. This suggests more butterflies would be recorded had sampling continued into the warmest and wettest time of the year (December to April). Trapsite 5, located at the centre of the forest reserve by a stream with canopy gaps, had the highest butterfly diversity; with 22 species and 275 individuals recorded.

Of the near-endemic butterflies recorded, 70% were forest dependent. In the eastern half of Africa, forested areas are mainly restricted to mountains and surrounded by savanna or even semi-desert. The greatest threat to these forest dependent species is the widespread reduction in forest size and quality. Therefore, schemes that seek to maintain the existing forest habitat should be supported in NDUFR.

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 these 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, especially in areas under threat or currently exposed to human disturbance (e.g. Daily & Ehrlich, 1995). New Dabaga/Ulangambi Forest Reserve (NDUFR), within the Udzungwa Mountains, offers an opportunity to study butterfly assemblages within a montane forest that has been heavily impacted by humans.

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 the forest reserve).
- 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 New Dabaga/Ulangambi were sampled during October and November 2000. A combination of butterfly traps, timed sweep netting, and casual collections were used to sample the butterfly communities at five trapsites within the forest reserve and four outside (see Section 7.1).

Butterfly Trapping
Six butterfly traps were used at each trapsite for eight days (trapsite 1-5; within forest reserve) or four days (trapsite A-D*; outside reserve). 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). Prior to use, the banana bait was placed in a plastic container and left to rot and ferment for six to eight days. 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 the most butterflies would be active. In the event of rain, sweep netting was postponed until 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 all cases. Identifications listed here are preliminary. Further identification of some specimens and verification of all species still has to be completed.

* Trapsite A in village government forest fragment dominated by *Parinari excelsa*; Trapsite B in pine plantation; Trapsite C in black wattle plantation; Trapsite D in fallow field.

7.12.4 Results

A total of 799 butterflies were caught in NDUFR, of which 257 butterflies were retained for taxonomic purposes (the rest were identified and released). **Table 7.12B** is a species list of the butterflies caught in New Dabaga/Ulangambi; the butterflies come from eight families, 30 genera and 50 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 refers to the sub-species, while those without refer to the 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 New Dabaga/Ulangambi Forest Reserve.

Species	Known altitude range (m a.s.l.)	Endemic status*	Ecological type	Total caught
ACRAEIDAE				
Acraea acuta acuta	1500-2300	([1]NE)	×	2
Acraea alicia cf uzungwae	1500-2000	(E)	×	9
Acraea cf goetzei	1200-2500	[5]NE	×	3
DANAIDAE				
Amauris cf echeria	400-2200		F	1
Amauris ellioti	1100-2400		F	2
Danaus chrysippus dorippus			×	3
HESPERIIDAE				
Metisella cf medea medea	1000-2700		F	2
Metisella cf orientalis	800-2700		F	3
Metisella sp.				1
Cf Zenonia zeno	400-2600		×	1
LYCAENIDAE				
Cf Anthene hobleyi	1400-2200		F	1
Cacyreus lingeus	0-2300		×	5
Cacyreus palemon	1500-2700		×	5
Cacyreus sp.				1
Lampides boeticus	0-2500		×	1
Cf Leptotes pirithous	0-2500		×	1
Lycaena cf abboti	1300-3000		F	2
Cf Telipina sp.				1
Tuxentius cf calice	400-2000		O	2
Tuxentius cf ertli	1000-2200	[3]NE	F	17
Uranothauma antinorii felthami	800-2000		F	1
Uranothauma cf delatorum	1600-2000		F	2
Uranothauma cf heretsia virgo	1000-2300	([2]NE)	F	1
Cf Zizulu hylax	0-2600		O	2
Unidentified Lycaenidae				1

Continued below…..

Table 7.12B (continued)

Species	Known altitude range (m a.s.l.)	Endemic status*	Ecological type	Total caught
NYMPHALIDAE				
Antanartia dimorphica dimorphica	1500-2700		F	4
Antanartia schaeneia dubia	1500-2700		F	16
Charaxes acuminatus cf acuminatus	300-2100		F	7
Charaxes congdoni	1600-2200	[1]NE	F	2
Charaxes varanes vologeses	0-2300		×	1
Issoria baumanni orientalis	1300-2340	([1]NE)	×	2
Neptis aurivilli cf aurivilli	800-2400	[4]NE	F	3
Neptis saclava marpessa	0-2200		F	1
Precis octavia	800-2600		O	4
Precis tugela	350-2500		F	3
Vanessa cardui	0-3000		O	4
PAPILIONIDAE				
Graphium policenes	0-2000		F	1
Papilio cf bromius	780-2000		F	1
Papilio chrapkowskii	1500-2200		F	1
Papilio demodocus demodocus	0-2600		×	1
Papilio cf desmondi usambarensis	300-2600	[3]NE	F	6
Papilio echerioides	250-2200		F	1
Papilio cf fulleborni fulleborni	1200-2500	[4]NE	F	16
Papilio pelodurus cf vesper	300-2000	[3]NE	F	1
Papilio phorcas cf nyikanus	300-2200	([3]NE)	F	13
Papilio thuraui	1300-2600	[4]NE	F	1
Papilio sp.				1
PIERIDAE				
Colotis regina	300-1800		O	1
Eurema sp.				7
Mylothris cf sagala	700-2700		F	5
Pontia helica johnstoni	1500-2200		O	1
SATYRIDAE				
Aphysoneura pigmentaria uzungwae	1700-2200	([1]NE)	F	1
Bicyclus danckelmani	800-1800	[1]NE	F	156
Bicyclus simulacris	1300-2300	[4]NE	F	354
Henotesia ubenica uzungwa	1300-2300	(E)	O	3

*KEY to NE (based on Kielland, 1990): [1]NE= Southern Highlands to Udzungwa Mountains; [2]NE= Ulugurus to Southern Highlands; [3]NE= Eastern Arc Mountains to Northern Malawi; [4]NE= Northern Malawi to Southern Highlands & Udzungwa Mountains; [5]NE= Southern Tanzania, South-western Uganda & Northern Malawi.

The genus *Bicyclus* accounted for 77 % of all specimens caught in NDUFR, and occurred at all nine trapsites. The genus was very abundant in forested areas and attracted to the baited traps. At some trapsites, it was not uncommon to catch ten or more of this genus in a trap on a daily basis. The majority of these butterflies were released after identification (of the 620 *Bicyclus* butterflies caught, only 14% were retained for taxonomic purposes).

At the species level, none of the butterflies caught are solely endemic to the Udzungwa Mountains. However, at the sub-species level there are two Udzungwa endemics; *Henotesia ubenica uzungwa* and *Acraea alicia uzungwae*. Both of these butterflies are non-forest dependent: *H. ubenica uzungwa* is a grassland species, while *A. alicia uzungwae* is found in both forest and open farmland habitats. Both are restricted to upland areas (above 1300m a.s.l.). There are a further 21 species restricted to altitudes above 1000 m a.s.l.. There are ten near-endemic butterflies at the species level, of which nine are forest dependent. Five more butterflies are near-endemic at the subspecies level.

Figure 7.12A shows the accumulation of species by trapsites. The trapsites have been ordered by date, and include only the trapsites located within forested areas (i.e. trapsites 1 – 5, and A). A gradual increase in species was observed between trapsite 1 and trapsite 4, thereafter 11 new species were encountered at trapsite 5. The curve appears to be levelling off, but it has not reached an asymptote.

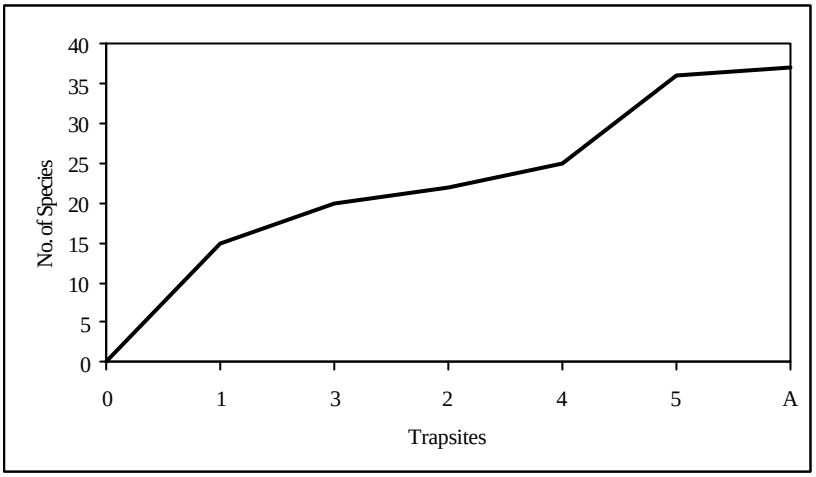


Figure 7.12A. Species accumulation curve of butterflies by trapsite (does not include casual collections).

Butterfly Distribution by Trapsite

The distribution of butterflies in terms of both numbers of individuals and species caught varied from trapsite to trapsite. **Table 7.12C** highlights some patterns in distribution.

Table 7.12C. Butterflies in relation to trapsites.

Trapsite[+]	*Number* caught	Number of *families*	Number of genera	Number of species	%age forest dependent species	%age non-forest species	No. of sub/species with limited ranges[*]
Outside forest reserve							
A	39	2	3	4	75%	25%	3
B	15	5	5	5	40%	20%	3
C	24	4	5	6	50%	0%	4
D	24	7	11	12	17%	25%	4
Inside forest reserve							
1	28	6	11	15	67%	7%	7
2	178	5	5	6	67%	0%	3
3	45	6	8	11	73%	0%	6
4	154	5	7	9	89%	0%	7
5	275	6	14	22	55%	0%	8
Total	799	8	30	50	60%	14%	14

* Limited ranges refer to endemic and near-endemic species, as defined in **Box 7.12A**.
+ Note; trapsites outside were trapped for four days, while inside for eight days.

The mean number of species recorded at each trapsite is 10, while the mean number of individuals per trapsite is 87. From **Table 7.12C**, it is clear that more species and individuals were recorded inside the reserve than outside. However, it should be borne in mind that the

trapsites inside the reserve were sampled for eight days, while those outside were sampled for four days. When this is taken account (mean per trapsite per day), the number of species recorded inside and outside are almost identical (inside =1.6; outside = 1.7), however, more individuals were recorded inside the reserve (inside = 17.0; outside = 6.4).

The presence of forest dependent and non-forest species at trapsites was closely linked to habitat structure. Of the five trapsites within the forest reserve, non-forest species were only recorded at trapsite 1. This is perhaps not surprising, given the fact that trapsite 1 represents a degraded forest habitat (canopy height <10m; canopy cover 10-50%). Outside the reserve, non-forest species were recorded at all trapsites except trapsite C. On average, forest-dependent species made up a greater proportion of the butterflies caught at trapsites in the reserve (70%) than outside (46%). Of note is the high proportion of forest dependent species (75%) caught in the 6ha village government forest patch (trapsite A).

The highest number of limited range sub/species[+] caught at one trapsite was eight (at trapsite 5). On average, trapsites within the forest accounted for more limited range sub/species (6.2) than those outside (3.5)[*]. However, the only two endemics recorded by this survey were caught outside the reserve.

Butterfly Trapping

Table 7.12D reveals the distribution of butterflies attracted to the banana baited traps. Nine species were caught in the butterfly traps, of which seven are forest dependent (*C. varanes vologese* and *H. ubenica uzungwae* are not forest dependent). Seven species were recorded at trapsites within the reserve, while five were recorded outside the reserve. Three of these species were recorded at trapsites both inside and outside the reserve.

Table 7.12D. Butterflies caught in traps.

	Outside				Inside				
Species	**A**	*B*	**C**	**D**	**1**	**2**	**3**	**4**	**5**
Aphysoneura pigmentaria uzungwae				**1**					
Antanartia dimorphica dimorphica									**3**
Antanartia schaeneia dubia	**3**					**2**			**10**
Bicyclus danckelmani	**5**			**3**		**20**	**7**	**13**	**84**
Bicyclus simulacris	**16**	**1**	**1**		**9**	**144**	**15**	**15**	**132**
Bicyclus simulacris/danckelmani	**4**							**97**	
Charaxes acuminatus acuminatus								**3**	**4**
Charaxes congdoni					**1**				
Charaxes varanes vologeses									**1**
Henotesia ubenica uzungwa	**1**			**1**					
Total	**29**	**1**	**1**	**5**	**10**	**166**	**22**	**128**	**234**

Note; trapsites outside were trapped for four days, while inside for eight days.

Three species were recorded in the open fallow field habitat (trapsite D), of which two are forest dependent species (*B. danckelmani* and *A. pigmentaria uzungwae*). Only one species was recorded at both trapsites B and C (pine and black wattle plantations, respectively). Outside the reserve, the highest number of species and individuals were recorded at trapsite A (*Parinari excelsa* dominated forest fragment). Trapsite within the reserve were generally species richer and more individuals were recorded at them (in particular, trapsite 2, 4, and 5).

[+] Sub/species refers to species and subspecies.

[*] Does not account for different sampling intensities inside and outside the reserve.

Factors Affecting Butterfly Diversity

The number of species and individuals was tested for correlation with time of year and altitude. In performing the analysis, data from trapsites within the reserve was restricted to the first four days. Both the numbers of species and individuals had positive associations with time of year (progressing from October to November). However, both associations were not significant, although the species correlation was only marginally not significant (Pearson correlation: species, p=0.064, r^2=0.410, n=9). No significant correlation was noted with altitude. Furthermore, trapsites with over and under 50% canopy cover were grouped, as were trapsites within and outside the reserve. *T*-test was used to test whether the mean numbers of individuals and species recorded within the groups were similar (data limited to first four days for trapsites within the reserve). No significant results were recorded.

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

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**), an asymptote was not reached. 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).

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 trapsites have an altitudinal range of 200m; the highest being at 2025m while the lowest is at 1825m a.s.l. Compared to other Eastern Arc forest reserves (e.g. West Kilombero Scarp Forest Reserve), the altitude range at NDUFR is quite limited. This may explain why altitude may have had a limited influence on butterfly assemblages.

Climatic conditions at the time of the survey are important in determining what species are recorded. It remained dry for most of October and early November. Showers began on the 13th of November and continued to the end of the month (the short rains). In the Udzungwa Mountains butterflies are most abundant from December to April (TANAPA, 1999). This is the wettest and warmest time of year. Both trapsite 5 and D occurred in late November, closest to this period. The most individuals were recorded at trapsite 5. Furthermore, at the two trapsites the highest numbers of species of those inside the forest reserve (trapsite 5) and

those outside (trapsite D) were recorded (see **Table 7.12C**). A positive, although not significant, correlation was noted between the number of species and time of year (progressing from October to November). 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. Sunlight is important in enabling flight when temperature is low. While, water and damp patches are important for butterflies, either to drink from or as a source of necessary minerals. Light, availability of water, and forest clearings have probably affected butterfly communities at the different trapsites. At some trapsites (e.g. trapsite 1), it was not uncommon to observe large congregations of butterflies (mainly *Tuxentius* sp.) by water in open areas. Whilst at trapsite 5, where the highest number of species was recorded, the canopy was closed (>50%). However, 16 of the 22 species recorded at this trapsite, were caught whilst sweep netting by a stream where the canopy was relatively open (10-50%).

Butterflies, Disturbance and the Human Landscape

In looking at the trapsites outside the reserve, several observations are apparent (**Table 7.12C** & **Table 7.12E**). The trapsites in the mono-dominant pine and black wattle plantation forests (trapsite B and C, respectively) have few species but a high proportion of limited range species. Conversely, the open habitat trapsite (trapsite D) had a comparatively high number of species, but a much lower proportion of limited range species. The village government forest plot (trapsite A) had the lowest number of species, but the highest proportion of limited range species and forest dependent species. These results would seem to suggest that the small forested patches outside the reserve, may support less species than the surrounding open areas but still serve as refuges for forest-dependent species with limited ranges (especially trapsite A).

NDUFR has been heavily impacted by past logging and fires, which has resulted in a broken canopy and dense scrub vegetation in many places (e.g. trapsite 1). Hamer *et al.* (1997) in a study of lowland forests in Indonesia, highlighted that disturbed forests, with their increased diversity of microhabitats (e.g. due to increased light gaps) can support more species than undisturbed forests, but with a marked decrease in species with limited ranges. Within this survey of NDUFR, the relatively undisturbed trapsite 5 had the highest number of species and limited range sub/species. However, the heavily disturbed trapsite 1 had more species than three other comparatively less disturbed trapsites (trapsites 2, 3, 4). Of interest is the high number of limited range sub/species at trapsite 1 (7 sub/species), which is higher than or equal to three other less disturbed forest reserve trapsites (trapsites 2, 3, 4). This may reflect the fact that some of the limited range sub/species are restricted in their distribution by factors other than forest dependency (e.g. altitude).

Forest Dependence and Endemics

The Udzungwa Mountains 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 Udzungwa Mountains as third in terms of open habitat endemic species and sixth in terms of forest endemic species (based on the %age of total number of taxa endemic to an area). This survey of NDUFR recorded two endemic subspecies, ten near-endemic species, and five near-endemic subspecies. Of these taxa with limited ranges, 70 % are forest

dependent and restricted to areas above 1000 m 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 (*Henotesia ubenica uzungwa*) 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 Udzungwa Mountains. Therefore consideration should be given to their habitat requirements.

The Udzungwa Mountains and Eastern Arc Mountains

The comparison of NDUFR with West Kilombero Scarp Forest Reserve (WKSFR) highlights some striking differences. Fifty species were recorded from NDUFR, while 102 species were recorded from WKSFR (Frontier Tanzania, 2001d). 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. As noted previously, Hamer *et al*. (1997) recorded an increase in species richness following disturbance accompanied by a decrease in limited range forest species.

Comparing the NDUFR survey with three other similar surveys carried out by Frontier Tanzania in forest reserves in the East Usambara Mountains; it would appear that NDUFR has a lower species richness (see **Table 7.12F**). 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 NDUFR.

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

Forest Reserve & Location	Number of Species
New Dabaga/Ulangambi F.R.; Udzungwa Mts.	50
West Kilombero Scarp F.R.; Udzungwa Mts. (Frontier Tanzania, 2001d)	102
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*., 2000)	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. The forest of NDUFR has been subjected to intensive human disturbance in the past. Schemes that seek to encourage the regeneration of the forest canopy and quality of the habitat should be encouraged (see Frontier Tanzania, 2001a; Section 9).

- To increase the biodiversity value of the area a system of forested corridors connecting the isolated forest reserve with the smaller forest fragments dotted around the reserve 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."

- 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 Udzungwa Mountains, more research is needed into their requirements. This would allow for better informed management decisions.

7.12.6 Conclusion

This survey recorded butterflies from eight families, 30 genera and 50 species. The species accumulation curve suggests that there are more species still to be recorded from NDUFR.

Two factors were deemed to be important in determining butterfly assemblages at NDUFR; time of year and habitat heterogeneity. More species/individuals were recorded later in the survey period. This suggests that more species would be recorded if sampling continued into wettest and warmest period of the year (i.e. December-April). The most species were caught at trapsite 5, at the centre of the forest reserve by a stream where the canopy was relatively open.

Seventy % of limited range sub/species recorded by this survey were forest dependent. Forest dependent species will not survive outside forests. In Tanzania, forested areas are comparatively limited. Thereby, highlighting the importance of maintaining these forested areas for these limited range species.

Frontier-Tanzania Udzungwa Mountains Biodiversity Survey

New Dabaga/Ulangambi Forest Reserve

8 Galago Report by Visiting Researcher

8.0 Galagos of the Dabaga Highlands

Andrew Perkin (Nocturnal Primate Research Group, Oxford Brookes University, UK.)

Box 8A presents the details of a galago (bushbaby) trapped in a village government forest in Msonza area near Kidabaga village, just outside New Dabaga/Ulangambi Forest Reserve in Udzungwa Mountains.

Box 8a. Details of galago trapped in village government forest near New Dabaga/Ulangambi Forest Reserve.

KMH 22496. *Galagoides orinus* (provisional identification)

Caught in a Sherman trap (63), baited with peanut butter and coconut, and set on the ground.
Date: 12/11/2000

Habitat

Altitude: 1816masl. Slope:28 deg. Aspect: N Topography: Gentle Mid-Slope. Vegetation Type: Montane Forest. Ground layer: <10%, Shrub layer: <10%. Canopy Cover: >50%. Microhabitat: Leaf litter by tree base (trap was on the ground). Canopy height: 10-20m.

Locality

Position: 8°06'47.4 S 35°56'50.4 E, village government forest, Msonza area, near Kidabaga village, 500m from New Dabaga/Ulangambi Forest Reserve, Iringa region, Tanzania.

Biometrics

Sex: Male; Age: Adult; Head & Body: 134mm; Tail: 182mm; Ear (right): 31mm;
Hind foot (right): 43mm; Weight: 97g.

Colour Notes:

Head: Prominent white nose stripe that narrows slightly on the bridge of the nose then fades out on the forehead. Dark around the eyerings and the sides of the muzzle and creamy yellow fur on the throat and cheeks up to below the line from the base of the ear to the eye.

Ears: Virtually hairless. Dark brown with a distinctive yellow pigmentation on the ear edges at the base. Seven ear 'ribs'.

Ventrum: Yellow white belly hair with slate grey basal fur. Chest, inner fore arms and inner thighs pale brown, grey basal fur.
Dorsum: Mid brown fur at the tips with slate grey basal fur going onto forearms and thighs.

Tail: General appearance bushy but with not distinct 'bottle-brush'. Mid brown fur, each hair about 10mm long uniform in colour with no under fur. Last 40mm of tail dark brown to black.

Hands and feet: Thinly covered with pale hairs on the dorsal side and hairless on the pads. The nails are not needle shaped and there is the standard grooming claw on the forefinger.

Genital Morphology
The penis is about 15mm long cone shaped (large end at the tip) with a protruding baculum. There are unidentate spines all over the glans with the largest spines (1.5mm long) at the base on the dorsal side. Testicles are well developed/mature.

Conclusions

Based on morphology, size and pelage colour this animal (KMH22496) was provisionally identified by the author as the mountain galago *Galagoides orinus.* The small size of this galago indicates that it is in the genus *Galagoides.* This galago was found to be consistent in terms of pelage and morphology when compared with one other specimen from Kilanzi Kitungulu FR (also in the Udzungwa Mountains) (Hansen *pers. comm.*) and descriptions of *G. orinus* (Perkin, 2000; Lawrence & Washburn, 1936) and significantly differs from other *Galagoides* species (Honess, 1996; Honess & Bearder, 1996; Kingdon, 1997; Jenkins, 1987). This specimen is the first male to be captured of this species and therefore has importantly provided the first description of its penile morphology which has been shown to be important for identifying galago species (Anderson, 1998; Bearder, 1998;). The penile morphology was found to be distinctly different from that of other dwarf galago species; *G. rondoensis, G. demidoff, G. zanzibaricus* and *G. granti* (Anderson, 1998; Honess & Bearder, 1996; Kingdon 1997). The overall appearance of KMH22496, particularly the facial pattern or 'face mask', the yellow pigmentation on parts of the ear, the tail and size, have similarities with *G. rondoensis,* and *G. demidoff* (Perkin, unpubl.) that may indicate a common ancestral lineage.

This specimen is the first confirmed *G. orinus* to be captured from the Udzungwa Mountains, and the second to be captured since to type specimen was described from the Uluguru Mountains (Lawrence and Washburn, 1936). However, a galago captured 1994 from Nyumbanitu forest in West Kilombero Scarp FR is almost certainly *G. orinus* (Fjeldså, *pers. comm*.). Additional vocalization data is required from the area around New Dabaga/Ulangambi FR to fully confirm this species identity. Vocalization data from West Kilombero Scarp FR confirm the presence of *G. orinus* (see Frontier Tanzania, 2001f) which suggests that *G. orinus* occurs in montane and sub-montane forest habitats in the Udzungwa Mountains.

The other galago that occurs around New Dabaga/Ulangambi FR is the large eared greater galago *Otolemur crassicaudatus.* This species was described from vocalizations mainly the distinctive crying call (Nash *et al.,* 1989) (reminiscent of a human baby) which is this species advertising call. This large grey galago was seen in black wattle plantations adjacent to the forests. This species can be confused with the small eared greater galago *O. garnetti* (*O. garnetti* was once considered a subspecies of *O. crassicaudatus*) but is smaller (mean 767), darker in colour and has a distinctively different advertising call known as the 'trailing call' (Nash *et al*, 1989).

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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

New Dabaga/Ulangambi 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.
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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 Mr. C. Msuya	Department of Zoology and Marine Biology	University of Dar es Salaam, P.O. Box 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. Methods and Nomenclature summary.

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 morpho-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 7.1 B

Appendix 7.1B. English/latin, Kiswahili and kihehe names of mammals found in the and around West Kilombero Scarp Forest Reserve and New Dabaga/Ulangambi Forest Reserve. The names were obtained through interviews with Janus 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
Bush buck	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 ref.	**Trapsite**	**Frontier Field Names**	**Botanical Plot Numbers**	**Local Name of Site**	**Trap Days**
35°56'50.4"E 08°06'47.4"S	A	Plot MS (Msaula)	A	Village Government Forest Msonza area	4
35°53'54.2"E 08°03'43.6"S	B	Pine	B	-	4
35°54'01.3"E 08°03'59.2"S	C	Black Wattle	C	-	4
35°54'05.6"E 08°05'37.9"S	D	Plot FF (Fallow Field)	-	-	4
35°56'06.1"E 08°00'26.6"S	1	Kinyonga (Kin)	33	Msale	8
35°54'41.9"E 08°03'39.9"S	2	Plot 24	24	-	8
35°54'13.8"E 08°04'05.7"S	3	Plot 1	1	-	8
35°54'20.4"E 08°04'05.6"S	4	Plot 6	6	-	8
35°55'31.3"E 08°05'34.5"S	5	Plot 16	16	-	8
35°55'23.5"E 08°03'05.4"S	-	Mamba Main Camp	-	Malinga Makali	-

Appendix 7.2A. Number of small mammal species recorded for each trapsite in NDUFR during bucket pitfall and Sherman trap surveys.

Species	**1**	**2**	**3**	**4**	**5**	**A**	**B**	**C**	**D**
Rodents									
Beamys hindei	3	1	1	2	11	5	-	4	1
Dendromys sp.	4	-	-	5	2	-	4	-	3
Grammomys sp.	27	33	2	12	21	20	2	7	3
Graphiurus sp.	-	-	-	3	1	1	-	-	-
Hylomyscus denniae	22	39	18	28	9	15	-	9	-
Lophuromys flavopunctatus	2	1	3	3	3	-	-	1	9
Mus sp.	1	-	-	-	-	-	2	1	19
Praomys delectorum	22	34	28	31	31	24	1	44	-
Rhabdomys pumilio	-	-	-	-	-	-	1	-	9
Tatera sp.	-	-	-	-	1	-	-	-	-
Shrews									
Crocidura sp.	7	6	8	7	1	2	2	-	6
Myosorex sp.	1	-	1	2	1	3	-	-	-
Unidentified shrews	2	3	5	5	11	-	-	1	4

Appendix 7.2B. Number of unique rodents and shrew individuals caught in Sherman traps. Trapsites 1-5 were trapped for 8 nights and trapsites (A-D) for four nights.

	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	75	6	10.41	0.75	1	9	0.13	1.13
2	104	4	14.10	0.50	2	7	0.27	0.88
3	52	0	6.83	0.00	3	11	0.39	1.38
4	75	8	9.83	1.00	2	12	0.26	1.50
5*	73	6	9.33	0.75	0	13	0.00	1.63
Total	379	24	10.09	0.60	8	52	0.21	1.30

* Surveyed during the small rainy season mid-November to December 2000

Appendix 7.2C. Results from four days of trapping in and around New Dabaga/Ulangambi Forest Reserve. Listed is the number of unique rodents and shrew individuals caught in Sherman traps and bucket pitfalls. Trapsites 1-5 were positioned inside the forest reserve, while trapsites A-D were outside. Trapsites 1-5 and A were natural forest sites.

	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	42	3	10.63	0.75	1	7	0.25	1.75
2	37	2	9.30	0.50	2	4	0.50	1.00
3	22	0	5.61	0.00	3	0	0.77	0.00
4	33	6	8.53	1.50	2	5	0.52	1.25
5*	26	1	6.77	0.25	0	1	0.00	0.25
Total	160	12	8.18	0.60	8	17	0.41	0.85
A	65	2	16.75	0.50	3	2	0.77	0.50
B	6	4	1.50	1.00	0	2	0.00	0.50
C	63	4	16.11	1.00	1	0	0.26	0.00
D*	38	6	9.43	1.50	2	8	0.50	2.00
Total	172	16	10.88	1.00	6	12	0.38	0.75

* Surveyed during the small rainy season mid-November to December 2000.

Appendix 7.5A. Casual observations of large mammals in NDUFR.

Natural forest

Two dungpiles of Abbott's duiker (*Cephalophus spadix*) have been found during approximately 14 weeks of fieldwork in 1999 and 2000. Numerous sightings were made of Udzungwa red colobus (*Procolobus gordonorum*), black and white colobus (*Colobus angolensis palliatus*), blue monkey (*Cercopithecus mitis*) (see section 7.6), chequered elephant shrew (*Rhynchocyon cirnei*) and Tanganyika mountain squirrel (*Paraxerus lucifer lucifer*) (see section 7.2). A mountain galago (*Galagoides orinus*) was caught once in the Village Government Forest (trapsite A), and observations were made of *Galagoides* sp. from inside the reserve. Black and white colobus and Tanganyika mountain squirrel were also seen in the relatively small Village Government Forest, while vervet monkeys (*Cercopithecus aethiops*) were seen at the edge of a neighbouring forest fragment near the south-western corner of the reserve.

Other habitats

A greater galago (*Otolemur crassicaudatus*) was the only large mammal observed in black wattle (*Acacia mearnsii*) plantation and was neither seen nor heard inside the forest reserve.

No large mammals or their spoors were observed in the pine (*Pinus caribaea*) plantation or in the fallow field during 5 days of fieldwork in both areas.

Appendix 7.5B. List of mammal species recorded in and around New Dabaga/Ulangambi Forest Reserve. Forest dependency, conservation status and distribution are listed for all species. Taxonomy follows Kingdon (1997). There are several question marks in the table due to incomplete identifications. Not all specimens of Shrews and bats have been identified yet.

Order and family	Species	Forest dependency	Conservation status	Endemism
PRIMATES				
Colobidae	*Procolobus gordonorum*	F[1]	VU	NE
	Colobus angolensis palliatus	F	DD	
Cercopithecidae	*Cercopithecus aethiops*	×		
	Cercopithecus mitis	F		
Galagonidae	*Otolemur crassicaudatus*	×		
	Galagoides orinus	F[3]	DD	NE
CHIROPTERA				
Rhinolophidae	*Rhinolophus clivosus*	×		
INSECTIVORA				
Soricidae	*Myosorex* sp.	?	?	?
	Crocidura sp.	?	?	?
MACROSCELIDAE				
Macroscelididae	*Rhynchocyon cirnei*	O	VU	
LAGOMORPHA				
Leporidae	Unknown sp.	O	?	?
RODENTIA				
Sciuridae	*Paraxerus lucifer lucifer**	F[2]		(NE)
Myoxidae	*Graphiurus* sp.	?	?	?
Gerbillidae	*Tatera* sp.	?	?	?
Dendromuridae	*Dendromys* sp.	?	?	?
Cricetidae	*Beamys hindei*	F		
	Cricetomys gambianus*	×		
Otomyidae	*Otomys* sp.^	O		
Muridae	*Lophuromys flavopunctatus*	F		
	Praomys delectorum	F		
	Hylomyscus denniae	×		
	Mus sp.	?	?	?
	Grammomys sp.	?	?	?
	Dasymys incomptus	×		
	Rhabdomys pumilio	O		
CARNIVORA				
Viverridae	*Genetta* sp.[+]	?	?	?
HYRACOIDEA				
Procavidae	*Heterohyrax brucei*[#]	O[2]		
	Dendrohyrax validus^	×	VU	NE
ARTIODACTYLA				
Suidae	*Potamochoerus larvatus*	×		
Bovidae	*Cephalophus harveyi*[~]	F		
	Cephalophus spadix	F	VU	NE
	Neotragus moschatus	×	LR/cd	

[#] - Identified by Dieter Kock at Zoological Museum in Frankfurt, Germany.

^ - Species identified from calls. Given the high diversity of calls uttered by hyraxes identification should preferably be verified from a collected individual.

[+] - In the 1930s, a servaline genet (*Genetta servalina lowei*) was collected from the Dabaga area. This species is forest dependent and only recorded from the Udzungwa Mountains (Kingdon & Howell, 1993, Frontier Tanzania, 2001f).

[~] - Skull collected, but the identification is awaiting verification by W. T. Stanley.

* - Species observed in forest reserve, but nor caught during the survey.

^ - Specimen seen caught in snare in field outside the forest reserve (not collected).

Forest dependency: F = Forest dependent, × = found in forests and also other habitats, O = normally regarded as a non-forest species (Burgess *et al*, 2000). Forest dependency for species not mentioned in Burgess *et al.* (2000) is taken from [1]Kingdon & Howell (1993), [2]Kingdon (1997) and [3]Ehardt *et al.* (2000).

Conservation status according to IUCN (Hilton-Taylor, 2000): VU = vulnerable; LR/cd = lower risk, conservation dependent; LR/nt = lower risk, near threatened; DD = data deficient.

Endemism: NE = near endemic, distribution limited to the Eastern Arc, Tanzania and Malawi; W = widespread, found in more than five countries. Data from Kingdon (1997). Letters in brackets refer to subspecies.

Appendix 7.6A. Monkey group (or foraging party) counts and sightings of lone individuals in New Dabaga/Ulangambi 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	Aug 1999	Near transect '1'	20	E
R	04/02/00	1 [1830]	1	C[5]
R	12/09/00	-4 [2995]	17	C
R	16/09/00	-4 [1500]	16 (21)	NC
R	18/09/00	-4 [1985]	20-30	E
R	21/09/00	1 [153]	3*	C
R	22/09/00	1 [50]	5	C[1]
R	22/09/00	1 [165]	17 (24)	NC
R	24/09/00	1 [180]	3*	C
R	24/09/00	1 [440]	24	C[1]
R	24/09/00	1 [180]	17 (21)	NC
R	27/09/00	1 [1630]	3	C[2]
R	12/10/00	1 [220]	3*	C[1]
R	29/10/00	1 [670]	2	C[4]
R	Oct 2000	near transect '1'	22	E
B&W	Aug 1999	near transect '1'	10	E
B&W	01/02/00	4 [2020]	1	C
B&W	04/02/00	-4 [1830]	7	C[5]
B&W	13/09/00	-4 [550]	1	C
B&W	15/09/00	-4 [1143]	7	C
B&W	18/09/00	-4 [2290]	1	C
B&W	24/09/00	1 [440]	5	C[3]
B&W	27/09/00	1 [1620]	1	C[2]
B&W	12/10/00	1 [1225]	6	C
B&W	29/10/00	1 [670]	2	C[4]
B&W	31/10/00	1 [990]	8	~C
B&W	02/11/00	1 [2760]	8	~C
S	04/11/00	1 [730]	20-30	E

C = complete count, ~C = approximately complete count, NC = near complete count (estimate of group size given in parentheses), E = estimated.

[1] More heard 50-100m away.

[3] Count made by field assistant.

[2] Mixed species group of three red and one black and white colobus.

[4] Adult female red with large clinging infant plus two black and white colobus.

[5] Mixed species group with seven black and white plus one red colobus.

Appendix 7.7A. List of non-forest dependent birds not of conservation concern for (1) the southern end of New Dabaga/Ulangambi Forest Reserve, (2) Malenga Makali area inside the central part of the reserve and (3) *Parinari excelsa* dominated village government forest. Observations were made by Mr. Elia Mulungu between 26th-28th November 2000 unless otherwise indicated. See foot of table for explanation of codes. Latin and common names follow Zimmerman *et al*. (1996). Note that six birds listed (+) were recorded in 1992 by David Moyer and were not observed during the 1999-2000 study period.

Common name	Genus	Species and subspecies	Habitat* preference	CITES §	Location 1	2	3
FALCONIFORMES							
African goshawk	*Accipiter*	*tachiro*	×	II	•	•	
Little sparrowhawk	*Accipiter*	*minullus*	×	II		•	
African harrier-hawk	*Polyboroides*	*typus*	×	II	•	•	
Long-crested eagle	*Lophaetus*	*occipitalis*	×	II		•	
GALLIFORMES							
Red-necked spurfowl	*Francolinus*	*afer*	×		•	•	
GRUIFORMES							
Black crake	*Limnocorax*	*flavirostris*	O		•		
COLUMBIFORMES							
Eastern bronze-naped pigeon	*Columba*	*delegorguei*	×		•	•	
Tambourine dove	*Turtur*	*tympanistria*	×	III	•	•	
MUSOPHAGIFORMES							
Livingstone's turaco	*Tauraco*	*livingstonii*	×	II	•	•	
Purple-crested turaco	*Tauraco*	*porphyreolophus*	O	II	-	-	-
CUCULIFORMES							
Klaas's cuckoo	*Chrysococcyx*	*klaas*	×		•		
White-browed coucal	*Centropus*	*superciliosus*	O		•	•	
STRIGIFORMES							
African wood owl	*Strix*	*woodfordii*	×	II	•	•	
COLIIFORMES							
Speckled mousebird	*Collius*	*striatus*	×		•		
CORACIIFORMES							
Crowned hornbill	*Tockus*	*alboterminatus*	×		•	•	
Trumpeter hornbill	*Ceratogymna*	*bucinator*	×		•	•	
PICIFORMES							
Yellow-rumped tinkerbird	*Pogoniulus*	*bilineatus*	×		•		
Cardinal woodpecker	*Dendropicos*	*fuscescens*	×			•	
PASSERIFORMES							
African broadbill	*Smithornis*	*capensis*	×		•	•	
Black saw-wing (=black rough-wing)	*Psalidoprocne*	*holomelas*	×		•		
Common bulbul	*Pycnonotus*	*barbatus*	×		•	•	•
+ Little greenbul	*Andropadus*	*virens*	×		-	-	-
Cape robin-chat	*Cossypha*	*caffra*	×		•	•	

Continued below…..

Appendix 7.7A (continued).

Common name	Genus	Species and subspecies	Habitat* preference	CITES §	Location 1	2	3
PASSERIFORMES (cont.)							
Common stonechat	*Saxicola*	*torquata*	O		•	•	
+ African dusky flycatcher	*Muscicapa*	*adusta*	×		-	-	-
African yellow warbler	*Chloroptera*	*natalensis*	O		•	•	
Blackcap	*Sylvia*	*atricapilla*	×		•	•	
Black-headed apalis	*Apalis*	*melanocephala*	×		•	•	•
+ Winding cisticola	*Cisticola*	*galactotes*	O		-	-	-
Cinnamon bracken warbler	*Bradypterus*	*cinnamomeus*	×		•	•	
Fan-tailed warbler	*Schoenicola*	*platyura*	O		•		
Tawny-flanked prinia	*Prinia*	*subflava*	×		•		
Yellow white-eye	*Zosterops*	*senegalensis*	×		•	•	•
Forest batis	*Batis*	*mixta*	×		•	•	•
Red-backed shrike	*Lanius*	*collurio*	×		•		
Uhehe fiscal shrike	*Lanius*	*collaris marwitzi*	×		•	•	
Black-fronted bushshrike	*Malaconotus*	*nigrifrons*	×		•	•	•
Black-backed puffback	*Dryoscopus*	*cubla*	×		•	•	
Tropical boubou	*Laniarius*	*aethiopicus*	×		•	•	
Marsh tchagra	*Tchagra*	*minuta*	O		•		
+ Square-tailed drongo	*Dicrurus*	*ludwigii*	×		-	-	-
Pied crow	*Corvus*	*albus*	O		•	•	
Olive sunbird	*Nectarinia*	*olivacea*	×		•	•	•
+ Malachite sunbird	*Nectarinia*	*famosa*	O		-	-	-
Collared sunbird	*Anthreptes*	*collaris*	×		•	•	•
+ Reichenowe's weaver	*Ploceus*	*baglefecht*	×		-	-	-
Dark-backed weaver	*Ploceus*	*bicolor*	×		•	•	•
Spectacled weaver	*Ploceus*	*ocularis*	×		•	•	
Montane marsh widowbird	*Euplectes*	*psammocromius*	O		•	•	
o Yellow-mantled widowbird	*Euplectes*	*macrourus*	O	III	-	-	-
Common waxbill	*Estrilda*	*astrild*	O	III	•		
Yellow-bellied waxbill	*Estrilda*	*quartinia*	×		•		
African firefinch	*Lagonosticta*	*rubricata*	O	III	•	•	

§ CITES protection listed as appendix I, II or III.

・Species observed by Elia Mulungu within NDUFR.

+ Species recorded along southern edge of NDUFR by David Moyer in 1992.

o Spceies observed only by Frontier Tanzania researchers in cultivation outside of NDUFR (see **Appendix 7.7B**). The observation of *E. macrourus* is a new record for the area (Moyer, *pers. comm.*). This species was distinguished from *E. psammocramius* by its bright yellow mantle.

* 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) and were only observed on cultivated land outside of NDUFR.

Appendix 7.7B. Bird observations made in the area of New Dabaga/Ulangambi Forest Reserve by Frontier Tanzania staff during 1999 and 2000.

Common name/ Hehe name	Latin name	Date	Location*
Lemon (or cinnamon) dove	*Aplopelia larvata*	30. 7. 99	15
Blue swallow	*Hirundo atrocaerulea*	18. 10, 27. 10	C, L
Hornbills	*Bycanistes sp.*	Nov 2000	-4
Crowned hornbill/ Lisusobembe	*Tockus alboterminatus*	8. 9, 22. 9; 5. 10	M; -4
Forest batis	*Batis mixta*	9. 9, 27. 9	-4
Eastern double-collared sunbird/ Moreau's sunbird	*Nectarinia mediocris/ moreaui*	9. 9	-4
Bar-tailed trogon	*Apaloderma vittatum*	12. 9, 13. 9, 16. 9	-4
Barred long-tailed cuckoo	*Cercococcyx montanus*	13. 9, 5. 10, 18. 9	-4
Red-capped forest warbler	*Orthotumus metopias*	16. 9	-4
African wood owl	*Strix woodfordii*	16. 9	-4
Green-throated (mountain) greenbul	*Andropadus chlorigula*	18. 9	-4
Stripe-cheeked greenbul	*Andropadus milanjensis*	21. 9	M
Dark-backed weaver	*Ploceus bicolor*	24. 9	M
Speckled mousebird	*Colius striatus*	24. 9	C
Common waxbill	*Estrilda astrild*	24. 9	C
Olive pigeon	*Columba arquatrix*	25. 9	M
Mountain buzzard	*Buteo tachardus*	25. 9 (adult with juv. nesting in *Polyscias fulva* tree), 18. 9, 2. 11	M
Livingstone's turaco	*Tauraco livingstonii*	Regularly seen and heard on most outings in Malenga area	M, K
White-chested alethe	*Alethe fuelleborni*	28. 9	M
Yellow-mantled widowbird	*Euplectes macrourus*	Sept-Nov 2000	M
White-tailed crested flycatcher	*Trochocercus albonotatus*	28. 9	M
Purple-crested turaco	*Tauraco porphyreolophus*	5. 11	I

* Key to locations: C = cultivation near to main Malenga Makali camp, 15 = caught in snare trap in plot 15 (found during vegetation survey in 1999), -4 = transect line '–4' in southern part of the reserve, M = Malenga Makali area inside central part of the reserve, K = Kinyonga camp (near to trapsite 1) inside northern boundary of reserve, I = cultivation near Ilamba village, L = Lusinga village.

Appendix 7.8A. Forest dependent reptile species known from the Udzungwa Mountains (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.

Appendix 7.10A. List of mollusc morpho-species recorded for each of the sites surveyed.
Trapsites 1-5 are in natural forest areas within New Dabaga/Ulangambi Forest Reserve. Trapsite A is in natural forest outside the forest reserve, trapsite B and C are plantation forests (pine and black wattle respectively) and trapsite D is in a fallow field.

Morpho-species	Trap site 1	Trap site 2	Trap site 3	Trap site 4	Trap site 5	Trap site A	Trap site B	Trap site C	Trap site D
A				X	X				
B		X	X	X	X	X			X
C	X	X	X	X	X				X
D	X	X		X	X				
E	X			X					
F			X	X					
G	X	X	X	X	X	X	X	X	
H	X	X	X	X	X				
I			X	X	X				
J	X	X	X	X	X	X	X	X	X
K				X					
L	X		X	X		X			
M	X	X	X	X	X	X			
N	X	X		X					
O	X	X	X	X		X			
P	X		X	X	X				
Q		X	X		X				
R	X		X						
S	X	X			X	X		X	X
W	X								
X					X		X		
Y									X
Z									X
AB									X
AC									X
AD									X
AF									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 (**Table 7.11A**).

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 species	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".