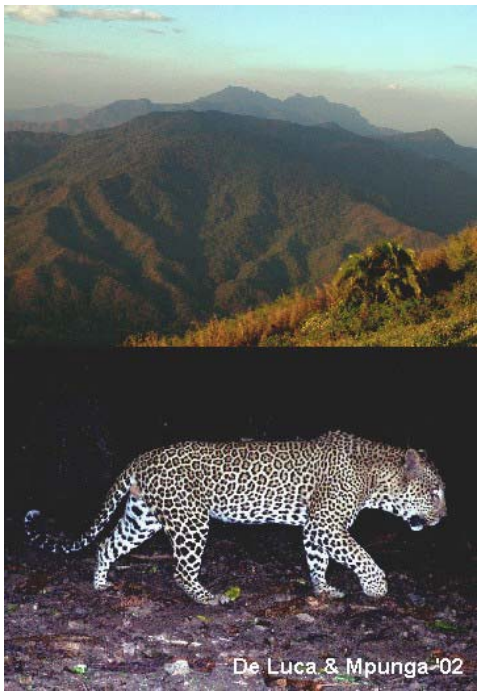
Carnivores of the Udzungwa Mountains

Presence, distributions and threats



Daniela W. De Luca
& Noah E. Mpunga

PO Box 1475
Mbeya, Tanzania
ddeluca@wcs.org

January 2005

Image resolutions:
In order to keep the PDF size as small as possible, images used in this report have been highly compressed. The quality of lower resolution images is inevitably poor. Higher resolution hard copies and images are available on request. Contact ddeluca@wcs.org.

Suggested citation:
De Luca, D.W. & Mpunga, N.E. 2005. Carnivores of the Udzungwa Mountains: presence, distributions and threats. Wildlife Conservation Society. Mbeya. pp 38.

Front cover:
Top; View from Mwanihana looking west (Photo by Daniela De Luca, 2002);
Bottom; Large male leopard photo trapped in Matundu near Ruipa (Photo by Daniela De Luca & Noah Mpunga, 2002).

Acknowledgments

This work was funded by the Wildlife Conservation Society (WCS). Considerable support was provided by the WCS Southern Highlands Conservation Programme. We are grateful to the Tanzania Commission for Science and Technology (COSTECH) and the Tanzania Wildlife Research Institute (TAWIRI) for providing permission to carry out the work. The authors wish to thank the Warden-in-Charge for Udzungwa Mountains National Park (M. Meoli), Park Ecologist (H. Dule), Community Conservation Officer (E. Changula), Warden Anti-poaching (O. Lazaro) and the various field assistants and rangers especially L. Kababa, S. Melchiorre and also S. Mtoka. We are very grateful to the people of the villages of Mkula, Msosa, Msolwa and Ruipa who welcomed us and collaborated so helpfully in the research; in particular to the village chairmen, E. Masolwa of Mkula, M. Mchambo of Msosa and M. Kassim of Mkula who also acted as a field guide. We are very grateful to H. Van Rompaey for much advice and comments on mongoose and genet identification, as well as R. Hurskainen, M. Taylor, F. Rovero, D. Hills, M. Kelly and T. Jones for their help, information and comments. Finally, we are especially grateful to T. Davenport for advice, discussion, editorial input and invaluable help with the photographs.

Summary

The mammalian carnivores of the Udzungwa Mountains National Park area were intensively investigated over a period of one year from November 2001 to November 2002. This was the first study in this area specifically targeting this important group of animals.

A combination of field methods: ecological inventories (rapid assessment surveys; scat, spoor and sign surveys; camera trapping) and socio-economic investigations (structured village interviews) were employed. Some 678kms of transect were walked; 10,608 camera-trap hours (884 trap-nights) were carried out, and 128 village interviews undertaken, across representative areas throughout the park and its buffer zones.

A total of 26 species of carnivore were confirmed for the UMNP and a further five species are 'probable'. This corresponds to at least 79% (or as many as 91%) of Tanzania's total number. These data show that UMNP is one of the richest protected areas (if not the *richest) for carnivores in Eastern Africa, as well as one of the most important.*

*The presence of Jackson's mongoose (*Bdeogale jacksoni*) was particularly significant. This little known and 'very vulnerable' species was formerly recorded only from two areas; in and around Mt Kenya and south of Mt Elgon. This, therefore, represents an important new record for Tanzania.*

*Other high-risk species recorded included Lowe's servaline genet (*Genetta servalina lowei*) known only from th Udzungwas. The 'endangered' African wild dog (*Lycaon pictus*) was confirmed as an occasional visitor to the park, and the 'vulnerable' cheetah (*Acinonyx jubatus*) and lion (*Panthera leo*) were also documented. Meller's mongoose (*Rhynchogale melleri*) and the bushy-tailed mongoose (*Bdeogale crassicauda*) meanwhile, are significant and very rarely recorded. The former may be a new record for this animal in terms of altitude and habitat type.*

*The leopard (*Panthera pardus*) was not uncommon in the sites studied, as also was the spotted hyaena (*Crocuta crocuta*), found even in montane forest, representing an unusual and interesting record for a species more commonly associated with lowland savanna. The aardwolf (*Proteles cristata*) meanwhile, recorded from a road kill may represent the most southerly record for the* P. c. septentrionalis *subspecies.*

*The Udzungwa carnivore community is rich and of considerable importance. Its status and complexity will depend much on the continued conservation of all Udzungwa habitats. Illegal hunting of carnivores still occurs in and around the UMNP area especially for traditional purposes. Species such as the Cape clawless otter (*Aonyx capensis*) are much trapped as a result. However, carnivores are not perceived as a major problem by local communities and thus not substantially persecuted in return. Continued law enforcement, education and community incentives should help to conserve this key carnivore site.*

Table of contents

List of Figures and Tables

1. Introduction

1.1 Background

Mammalian carnivores (comprising the Canids, Felids, Mustelids, Vivverids, Herpestids and Hyaenids) have adapted to a wide variety of environmental conditions, illustrating great ecological flexibility. Unfortunately however, their crucial ecological role is often poorly understood by both biologists and decision makers. Moreover, they are frequently perceived as competitors to humans and persecuted accordingly. Whilst their charismatic appeal is undeniable, it has not helped to slow down a rapid decline in their numbers, and some have thus become seriously threatened. Unfortunately, carnivore diversity and abundance is also increasingly reduced by land-use changes, prompted by rising human populations. Habitat degradation, fragmentation and loss, increased access and unsustainable levels of hunting of carnivores and their prey, have all decreased resilience and undermined survival.

Large gaps in knowledge still remain for the status of many carnivores; indeed the distribution details of most species remain sketchy. Surprisingly, this is very much the case in Tanzania, one of Africa's most biodiverse nations (Boitani et al., 1999, Mills et al., 2001). Up to now 34 species of carnivore have been recorded in Tanzania; more than any other African country. Many of the species are of global conservation concern. Amongst the larger species, the African wild dog (*Lycaon pictus*) is regarded by the IUCN Red List of Threatened Species (2004) as 'endangered', with increasingly isolated populations. Meanwhile the cheetah (*Acinonyx jubatus*) and the lion (*Panthera leo*) are listed as 'vulnerable', and the aardwolf (*Proteles cristata*) too poorly known.

Amongst the smaller carnivores many are little known and information about their ecology is severely lacking. Many species however, are considered to be under threat. For example, Lowe's servaline genet (*Genetta servalina lowei*) is regarded as 'highly endangered' and the Eastern Arc isolates of the palm civet (*Nandinia binotata arborea*) are considered to be very rare (Schreiber et al., 1989). Other species such as serval (*Leptailurus serval*), Meller's mongoose (*Rhynchogale melleri*), Cape clawless otter (*Aonyx capensis*), zorilla (*Ictonyx striatus*) and striped weasel (*Poecilogale albinucha*) are localised, poorly known and all vulnerable to land clearance and persecution. There are insufficient data to assess their distribution, population or degree of threat and thus appropriate intervention is difficult.

In Tanzania however, the vast majority of data come from the north of the country and the well-known national parks. In the more remote regions and across the South, the only information is often the documentation of Kingdon (1977; 1990; 1997) and the predictions of continental-scale databanks (Boitani et al., 1999). Tanzania's remarkable systems of mountains such as the Eastern Arcs and the Southern Highlands are important centres of biotic endemism, and many montane areas are seriously threatened by degradation and habitat modification. However as yet, very little carnivore research (and hence conservation action) has been carried out, especially on the smaller species.

Recommendations by IUCN specialist groups include the Eastern Arcs amongst those areas that need to be surveyed in order to properly address the specific needs of carnivores, and to develop suitable conservation initiatives.

The Udzungwa Mountains are a major component of the Eastern Arc Mountains hotspot and contain some of the most biologically important forests in Africa (Dinensen et al., 2001; Lovett & Wasser, 1993). The Udzungwa Mountain National Park (UMNP) area includes two of the richest forests of the Udzungwas in terms of the number of species of primates, duikers and birds; Mwanihana in the East and Luhomero in the West Kilombero Scarp, and they are cited as first conservation priority areas amongst all Udzungwa forests (Dinensen et al., 2001). Despite high levels of diversity and endemism and their associated importance for global biodiversity, these forests are also among the most threatened ecosystems in the world (Bakarr, 2000). Efforts to document existing biodiversity in the Udzungwas began relatively recently (see Rodgers & Homewood, 1982; Various authors, 1998; Ehardt *et al*., 1999; Dinesen *et al*., 2001) and have continued with botanical and zoological surveys by Frontier Tanzania (2001a; 2001b). However, up to now there have been no surveys specifically focusing on the carnivores of the Udzungwa Mountains area.

1.2 Objectives

In order to begin examining carnivore status across southern Tanzania and the impact of management regimes in the country's under-studied areas, we investigated the Udzungwa Mountains National Park and buffer zones from November 2001 to November 2002. Combining ecological and socio-economic investigations we sought to record carnivore presence and relative abundance, habitat preference and the factors limiting their abundance.

The work stems from a broader carnivore-based conservation project, the *Carnivores of the Rift* Project (now a component of the Wildlife Conservation Society's *Southern Highlands Conservation Programme*). The project seeks to examine carnivore distribution, abundance and threats, and provide conservation remedies and advice. The research component aims to collect new information from unexplored sites, and target areas of national (and global) significance by virtue of their biological diversity and endemism.

1.3 Specific aims

I. To produce a comprehensive and up-to-date carnivore list for the UMNP area.

II. To determine the level of carnivore exploitation and the source of human-carnivore conflict in the UMNP area.

III. To investigate causes of threat for each species in and around UMNP in order to provide information necessary for the implementation of conservation initiatives, including ecological monitoring.

1.4 Study area

The study area included the Udzungwa Mountain National Park (UMNP) and its buffer zones. The park covers almost one fifth (1,999 sq. km.) of the total range of the Udzungwa Mountains and lies between 7^0 30' - 8^0 15' S and 36^0 20' 36^0 55'E, between the towns of Mikumi, Iringa and Ifakara (Fig. 1). It embraces a variety of habitats including natural forest (lowland, submontane and montane) ranging from 280m to 2600m a.s.l. In addition, a corridor of wooded grassland and open and closed woodland lies between the two main forest blocks in the East and in the West. The broad vegetation types are illustrated in Figure 2. There is a longer variable dry season in the west (about 7 months) and shorter dry season in the east (about 5 months). The wet season runs between March and May, with a short peak in December. The precipitation amounts to approximately 2000mm per year in the east decreasing to 800-1000mm in the west (Hall, 1986).

Fig. 1. *Map of the Udzungwa Mountains area showing boundaries and the location of 'interview' villages.*

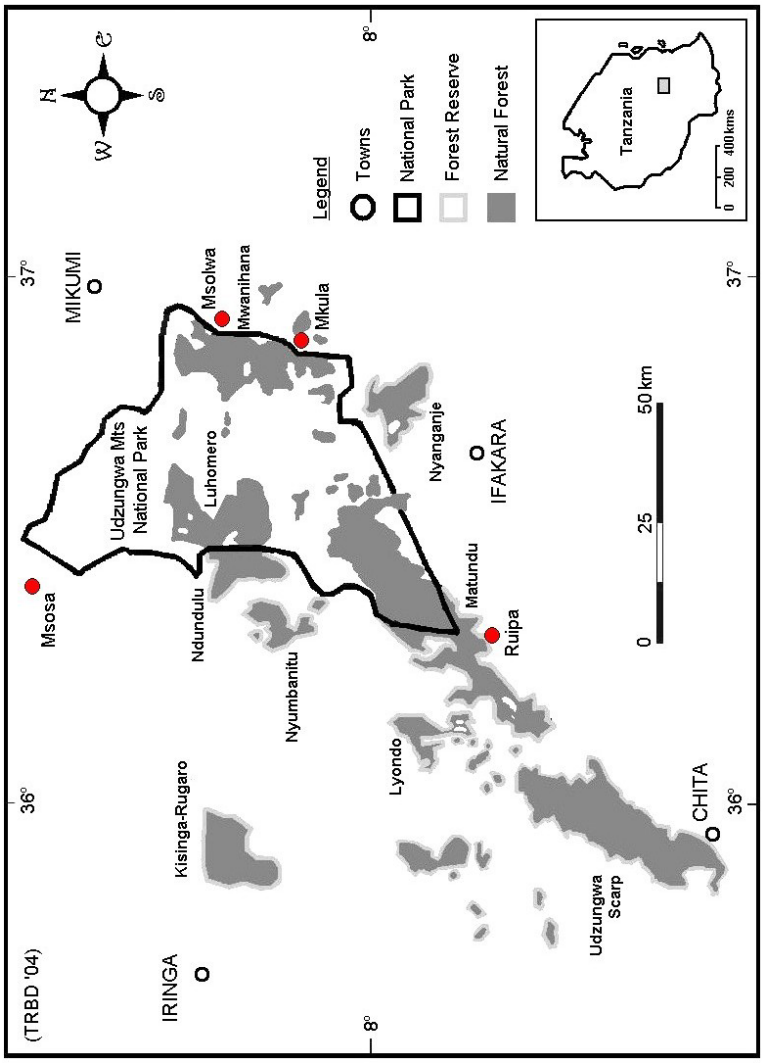
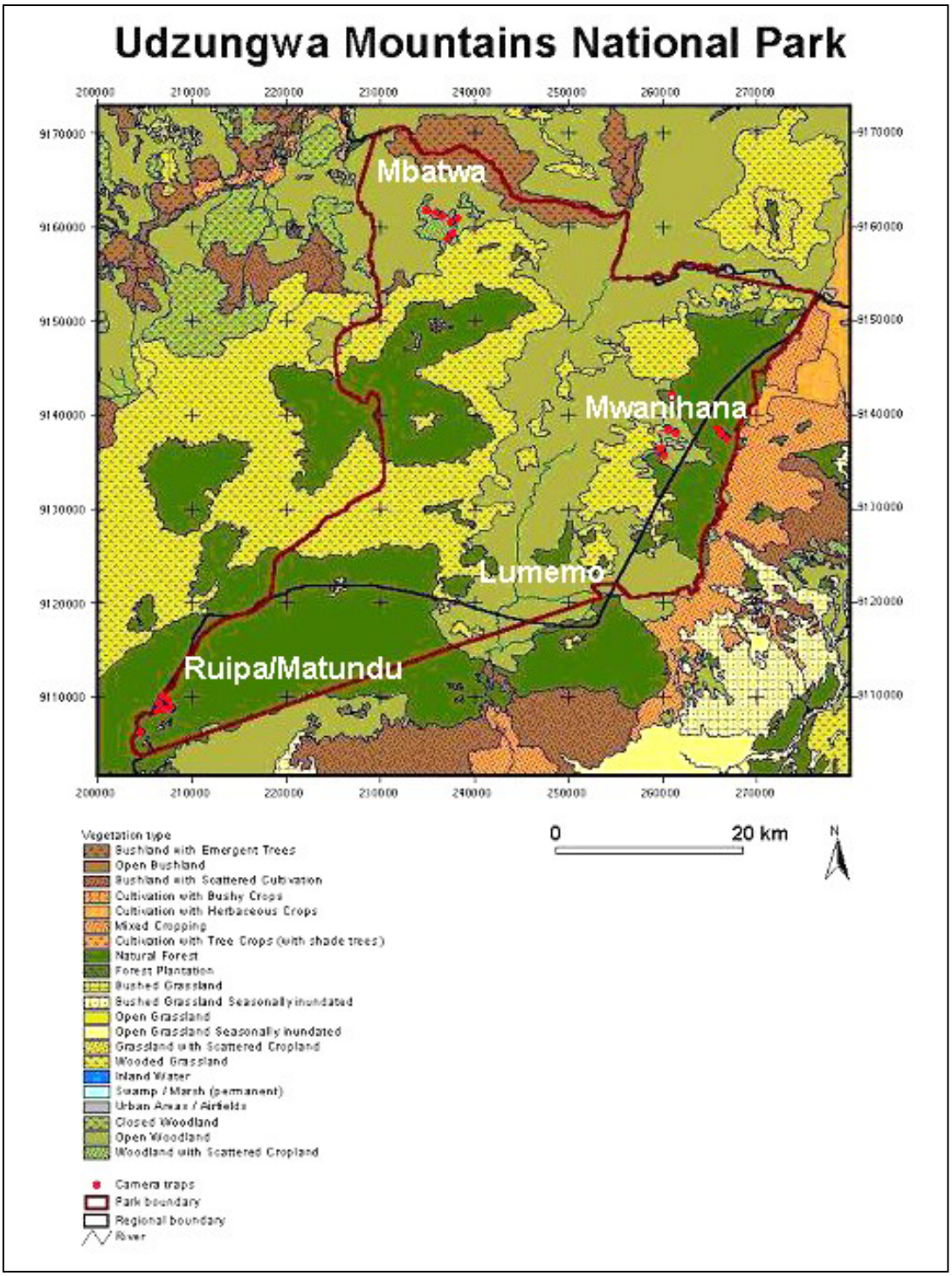


Fig. 2. *Map of the Udzungwa Mountains National Park area showing vegetation types and camera trap locations (in red).*



2. Methods

Fieldwork was carried out between November 2001 and November 2002. In order to determine the presence of carnivore species we used a combination of field methods: ecological inventories (sign surveys and camera trapping), and socio-economic investigations (village interviews). Initially however, we performed rapid assessment surveys across different areas in order to select appropriate sampling sites representative of the park's diverse habitats. During such surveys all carnivore signs were also noted.

2.1 Areas surveyed

The aim was to sample as far as possible the breadth of habitats, vegetation types, altitudes, rainfall conditions and human influence across the Udzungwa Mountains National Park (UMNP) and its buffer zones. To that end the six major vegetation communities (lowland forest, submontane forest, montane forest, open woodland, closed woodland, wooded grassland) from 280 to 2200m a.s.l. were all sampled (see Fig 2; Table 1). Within UMNP we surveyed a number of forest areas at different altitudinal ranges (Mwanihana/Sonjo, Sanje and Ruipa/Matundu). The Lumemo area was surveyed initially because it is characterised by open woodland far from villages. In the Mbatwa area meanwhile, the main habitat type is (open and closed) woodland, although it used to be a village surrounded by cultivation until 1977 when the population was removed.

***Table 1**. Areas and habitats sampled, and type and date of fieldwork carried out*

Area	Habitat	Type of work	Date
Mwanihana / Sonjo	Lowland forest; submontane forest; montane forest; open woodland; wooded grassland	Rapid Assess.	Nov. 01
Ruipa (Matundu)	Lowland forest	Rapid Assess.	Dec. 01
Lumemo	Open woodland	Rapid Assess.	Dec. 01
Mbatwa	Open woodland; closed woodland	Rapid Assess.	Feb. 02
Mkula	Lowland forest	Rapid Assess.	May. 02
Sanje / Kihulula	Submontane forest	Rapid Assess.	May. 02
Mwanihana / Sonjo	Lowland forest; submontane forest; montane forest; open woodland; wooded grassland	Camera Trap / Signs	Apr. May. Jun. Sept. 02
Mkula	Lowland forest	Camera Trap / Signs	Jun. 02
Ruipa (Matundu)	Lowland forest	Camera Trap / Signs	Jul. Aug. 02
Mbatwa	Open woodland; closed woodland	Camera Trap / Signs	Sept. Nov. 02
Mkula village	N/A	Interviews	Apr. 02
Msolwa village	N/A	Interviews	May. 02
Msosa village	N/A	Interviews	Jun. 02
Ruipa village	N/A	Interviews	Aug. 02

Following rapid assessment surveys, four areas were selected for the subsequent placement of camera traps. These areas covered different altitudinal ranges and vegetation types, although the prevalent type was lowland/ submontane forest. Camera traps were set on the Mwanihana track (lowland forest; submontane forest; open woodland; wooded grassland) and in the Mkula river/Sonjo area (lowland forest). These locations ranged between 400 and 1880m (Table 3). Camera traps were also set in lowland forest between 280 and 415m in Matundu Forest - the park's southern tip - in the Ruipa (old ranger post) area. We sampled the northern part of the park, Mbatwa, and traps were placed in open and closed woodland between 1127 and 1393m. Full details of camera trap locations including habitat types, altitudes, grid reference co-ordinates are all presented in Table 3.

2.2 Sign surveys - tracks, signs, scats

All carnivore sign and track was recorded at all times during fieldwork; during the initial rapid assessment phases; along selected transects and also during camera trap work. We routinely noted the location (grid reference co-ordinates), altitude and habitat type during surveys and camera trapping checks. The distances and co-ordinates of transects and walked daily, were recorded by handheld Garmin GPS III+ and later uploaded to our geographical information system (ArcView 3.2). Spoor was measured, identified and photographed, and data on all footprints, signs and scats were recorded on standard data sheets.

A total of 678kms of transect was walked during the survey, and the total lengths and locations of the transects are provided in Table 2. For subsequent analysis of scat data we introduced a factor of terrain roughness in the steep and undulating areas (x 1.3) in order to calibrate scat abundance representatively (Khorozyan, 2003)

***Table 2**. Transect lengths surveyed in each area*

Location		Surveyed distances (km)	With factor of terrain roughness (km)
Mwanihana	Mwanihana trail	264	343.2
	Kihululа	35	45.5
	Sanje	13	16.9
	Mkula	21	27.3
	Lower Mkula river	6	7.8
	Upper Mkula river	45	58.5
	Subtotal	*384*	*499.2*
Lumemo		20	26
Ruipa		198	198
Mbatwa		76	98.8
	Total	**678**	**822**

Carnivores scats were identified on the basis of field experience and criteria described in field guides (Walker, 1992; Stuart & Stuart, 2000) by observing and measuring the shape, segmentation, termini and length and diameter especially for large felids (e.g. leopard). We defined 'scat' as the cluster of individual faeces deposited in a single act of defecation. All scats were collected for subsequent identification and reference, and DNA samples were also collected and stored in 80% ethanol (in the WCS office in Mbeya) for future analysis. During sign surveys and routine checks of the camera traps (see later) we also surveyed repeatedly the same tracks/paths for leopard scats. Footprints were photographed in order to develop a computer protocol to identify species and individuals (to be reported elsewhere).

2.3 Camera trapping

Camera trapping was carried out in each of the pre-selected areas for a minimum of 210 trap-nights. A total of 10,608 camera-trap hours (884 trap-nights) were achieved in all areas. Between 5 and 13 camera traps were employed at any one time. Initially passive infrared units (Camtrakker^{TM}) were used, consisting of a weather–proof box containing a passive infrared heat-in-motion detector connected to a compact fully-automatic 35mm camera. When passing animals give off heat, a silent electronic switch engages the camera and a photograph is taken. The date and time of the 'event' is printed on the photograph.

Subsequently, the number of camera traps employed was increased by using active infrared monitors (Trailmaster^{TM}1500). These consist of a transmitter unit, a receiver, and a compact fully-automatic 32mm camera. In this case passing animals are detected and the camera is triggered when the infrared beam that can be set at different sensitivities, is broken. Each time the infrared beam was broken by a passing animal, an 'event', the date, the time were recorded automatically by the infrared monitor and the camera.

Placement locations (Table 3) were chosen to maximize capture rate. Carnivores prefer to follow animal trails therefore we placed most of the camera traps in the vicinity of such trails. All the traps were set to work at night between 7pm and 7am, and mounted on a pole at about 25-30cm from the ground. They were baited regularly and checked at regular intervals of 7-10days. A variety of baits were tested during an initial trial phase. These included dry fish, rotten eggs and blood, freshly dead poultry and cod liver oil. The most effective bait proved to be a liquid attractant (fresh cow's blood) suspended over the appropriate area, and this was routinely employed thereafter.

Table 3. *Locations and details of the camera trap placements*

CT No.	Sensor Type	Location name	Habitat type	Loc. S	Loc. E	Altitude
TM6	P	Mbatwa	Open/closed woodland	S 07 34 772	E 036 35 903	1127
TM3	A	Mbatwa	Open/closed woodland	S 07 34 903	E 036 36 489	1127
TM5	P	Mbatwa	Open/closed woodland	S 07 35 051	E 036 36 797	1127
TM7	P	Mbatwa	Open/closed woodland	S 07 35 298	E 036 37 658	1132
TM8	P	Mbatwa	Open/closed woodland	S 07 35 512	E 036 37 369	1164
TM4	A	Mbatwa	Open/closed woodland	S 07 36 216	E 036 37 369	1373
TM1	A	Mbatwa	Open/closed woodland	S 07 36 344	E 036 37 218	1393
CT2	P	Mkula river/Sonjo	Lowland forest	S 07 47 591	E 036 52 615	719
CT4	P	Mkula river/Sonjo	Lowland forest	S 07 47 684	E 036 52 798	495
CT1	P	Mkula river/Sonjo	Lowland forest	S 07 47 693	E 036 52 712	526
CT3	P	Mkula river/Sonjo	Lowland forest	S 07 47 838	E 036 52 918	484
TM2	A	Mkula	Lowland forest	S 07 47 925	E 036 53 129	430
CT4	P	Mkula	Lowland forest	S 07 48 014	E 036 53 164	450
CT1	P	Mkula	Lowland forest	S 07 48 028	E 036 53 204	450
CT3	P	Mkula (ex-NP)	Lowland forest	S 07 48 117	E 036 55 799	285
CT2	P	Mwanihana	Open woodland	S 07 45 626	E 036 50 097	950
CT3	P	Mwanihana	Open woodland	S 07 47 596	E 036 49 865	980
CT4	P	Mwanihana	Open woodland	S 07 45 807	E 036 50 265	?
CT1	P	Mwanihana	Montane forest	S 07 49 0??	E 036 49 5??	1800
CT3	P	Mwanihana	Open woodland	S 07 48 081	E 036 51 675	650
CT2	P	Mwanihana	Montane forest	S 07 49 002	E 036 49 533	1830
CT3	P	Mwanihana	Wooded grassland	S 07 48 554	E 036 49 454	1470
CT4	P	Mwanihana	Open woodland	S 07 47 479	E 036 49 809	950
CT1	P	Mwanihana	Open woodland	S 07 47 713	E 036 50 265	915
CT2	P	Ruipa	Lowland forest	S 08 02 858	E 036 20 513	317
CT1	P	Ruipa	Lowland forest	S 08 03 303	E 036 20 668	415
TM2	A	Ruipa	Lowland forest	S 08 04 876	E 036 19 258	330
CT1	P	Ruipa	Lowland forest	S 08 02 986	E 036 20 761	415
CT3	P	Ruipa	Lowland forest	S 08 03 472	E 036 21 080	394
CT3	P	Ruipa	Lowland forest	S 08 03 474	E 036 21 078	343
CT3	P	Ruipa	Lowland forest	S 08 03 601	E 036 20 550	368
CT4	P	Ruipa	Lowland forest	S 08 03 643	E 036 20 148	327
CT2	P	Ruipa	Lowland forest	S 08 03 324	E 036 20 164	280

2.4 Village interviews

To supplement the information from camera trapping and field surveys we interviewed 128 people in four villages located within the buffer zones around the National Park: Mkula and Msolwa to the east of Mwanihana, Ruipa village just outside Matundu forest in the extreme south, and Msosa near Mbatwa in the north (see Fig 1). Mkula and Msolwa lie on the eastern boundary at 5 and 10 km respectively from park headquarters at Mang'ula.

The village of Mkula was selected because the inhabitants used to live inside the area of the national park. People from Msolwa are relatively wealthier than those from Mkula, the village organization having been considered a 'village model' by the late President Nyerere. In the northern sector we chose Msosa also because some of the villagers used to live inside the area that is now the park and were therefore assumed to be knowledgeable about the area. Allegedly, many people 'moved' to Msosa in 1977 from Mbatwa during Ijumaa. Finally, in the south we selected Ruipa village, as it is of recent origin, people having moved to the area in the late 1980's. Ruipa is also considered to be poorer that other villages, due in part to its isolation and distance from the main Ifakara road.

The interviews employed structured questionnaires (available on request). Interviewees were selected based on their knowledge of the area and included hunters who used to trap in the area that now is the park, as well as collectors of firewood and medicinal plants. Summary profiles of all villages and interviewees are given in *Appendix 1*.

The interviews permitted the collection of data on a variety of related issues in the Udzungwas including carnivore sightings (facilitated by showing a purposely-prepared booklet of carnivore photographs), location, date, frequency of sightings, and the local vernacular names of the species in question.

Human-carnivore conflict and hunting was also ascertained and data were taken on the frequency of problem animal occurrences and the ways employed to prevent or reduce them. Information on carnivore exploitation such as consumptive uses (eg. traditional medicines, spiritual uses) was gathered, in order to assess the degree of threat. Information was also taken on the past and present occurrence and hunting of prey species. Finally general attitudes towards natural resources and protected areas and the level of awareness about the value of wildlife were investigated.

3. Results and discussion

We recorded a total of 26 carnivore species (confirmed) and another 5 species (probable) during this study in the UMNP area. Two further species were considered unlikely. An annotated checklist of these species with their means of record is given in Table 4. Of the 34 carnivore species recorded in Tanzania, we have confirmed the presence of at least 26 (and probably as many as 31) species in the Udzungwa area. The species total represents at least 76% (and probably as much as 91%) of the national total figure. This total is represented by species from six families; two (to four) canids, four mustelids, five viverrids, eight (or nine) herpestids, two (or three) hyaenids and five (or six) felids. Of particular specific interest are the records for Jackson's mongoose, Meller's mongoose, bushy-tailed mongoose, Lowe's servaline genet, wild dog and cheetah, and these are all discussed below.

The minimum figure (26) now known for UMNP is equal to the number of carnivore species found in Tanzania's largest national park the Serengeti (Sinclair, 1995), a park with an area of 13,000 km^2, and known for having one of the largest predator and prey biomass(es) in the world (Caro & Durant, 1995; Sinclair, 1995). With the exception of the spot-necked otter and the savannah dwarf mongoose which have not been recorded in either area, these two national parks are inhabited by all carnivore species found in Tanzania, and half of the number of species in Africa (Boitani et al., 1999; Mills et al., 2001). Udzungwa Mountains National Park itself however, can rightly be recognised as amongst the richest protected areas for carnivore diversity in East Africa, if not beyond. The rich assemblage of species in an area of 1,999km^2, can be explained by the diversity of habitat types and altitude range. The gazettement as a national park and consequent management over the last 12 years has, according to many of the people interviewed, improved the status of the forest particularly, and has probably contributed to the conservation of both carnivores and their prey.

Of the total recorded, 15 species were caught on film and an additional nine were from direct observations, scat, spoor or road kill. Two more species were claimed by at least 60% of interviewees from at least one village area, and the records accepted. The five species cited as probable were claimed by 25 – 50% of interviewees from at least one village area. Finally, two more species were claimed by a small percentage of interviewees but we consider these records unlikely.

Forest carnivores are notoriously difficult to study and can be easily overlooked (Ray, 2001); one of the reasons being that the finding of scats in forest litter is not easy, even by searching mainly along established paths. Despite the relatively low number of scats collected per species (Table 7), we identified three species that did not occur in the photo traps (wild dog, lion and jackal). They were also sighted by local people in the eastern villages crossing the road from Selous Game Reserve and entering the park. A fourth species, which was not caught on film but identified from footprints, was the striped weasel from Mbatwa. The sightings data from the interviewees (n=128) (Table 4) were also very helpful to understand the level of awareness and knowledge about carnivores in general, and in particular about endangered and vulnerable species (see below).

Table 4. *Checklist of carnivore species recorded in the UMNP area during this study*

	English name	Species	Kiswahili	Ph	Ob	Ac	Pr	% Mkula n=35	% Msolwa n=33	% Ruipa n=34	% Msosa n=30
		Canidae									
1	Side-striped Jackal	*Canis adustus*	Bweha		O			24.2	30.3	21.2	73.3
2	Black-backed Jackal	*Canis mesomelas*	Bweha Nyekundu				P	12.1	30.3	9.1	26.7
3	Bat-eared Fox	*Otocyon megalotis*	Bweha Masikio				P	12.0	15.2	18.2	26.7
4	Wild Dog	*Lycaon pictus*	Mbwa Mwitu		O			21.2	54.6	54.6	66.7
		Mustelidae									
5	African Clawless Otter	*Aonyx capensis*	Fisi Maji Kubwa		O			82.0	84.9	60.6	23.3
6	Zorilla	*Ictonyx striatus*	Kicheche			A		36.4	57.6	63.6	33.3
7	Striped Weasel	*Poecilogale albinucha*	Chororo		O			18.2	63.6	63.6	46.0
8	Honey Badger (Ratel)	*Mellivora capensis*	Nyegere	Ph				39.4	63.6	63.6	90.0
		Viverridae									
9	Common Genet	*Genetta genetta*	Kanu	Ph				15.2	42.4	78.8	46.7
10	Servaline Genet	*Genetta servalina*	Kanu	Ph				12.1	33.3	21.2	40.0
11	Large Spotted Genet	*Genetta maculata*	Kanu	Ph				9.1	30.3	24.2	0.0
12	African Civet	*Civettictis civetta*	Fungo	Ph				88.0	87.9	67.7	72.7
13	African Palm Civet	*Nandinia binotata*	Fungo	Ph				12.0	27.3	15.2	10.0
		Herpsetidae									
14	Egyptian Mongoose	*Herpestes ichneumon*	Nguchiro				P	21.2	27.3	18.2	30.0
15	Slender Mongoose	*Herpestes sanguinea*	Nguchiro		O			51.5	57.6	60.6	46.7
16	Dwarf Mongoose	*Helogale parvula*	Kitafe			A		48.5	42.4	54.6	80.0
17	Banded Mongoose	*Mungos mungo*	Nkuchiro		O			39.0	72.7	48.5	70.0
18	Marsh Mongoose	*Atilax paludinosus*	Nguchiro wa Maji	Ph				48.5	81.8	45.5	3.3
19	White-tailed Mongoose	*Ichneumia albicauda*	Karambago	Ph				0.0	6.1	0.0	80.0
20	Meller's Mongoose	*Rhynchogale melleri*	Nguchiro	Ph				0.0	0.0	0.0	6.7
21	Bushy-tailed Mongoose	*Bdeogale crassicauda*	Nguchiro	Ph				0.0	0.0	3.0	13.3
22	Jackson's Mongoose	*Bdeogale jacksoni*	Nguchiro	Ph				0.0	0.0	0.0	0.0
		Hyaenidae									
23	Striped Hyaena	*Hyaena hyaena*	Fisi				P	30.3	3.0	24.2	40.0
24	Spotted Hyaena	*Crocuta crocuta*	Nyangao / Fisi	Ph				36.4	33.3	24.2	33.3
25	Aardwolf	*Proteles cristatus*	Fisi ya Nkole		O			6.1	0.0	8.8	3.3
		Felidae									
26	Wild Cat	*Felis sylvestris*	Paka Mwitu		O			30.3	24.2	33.3	43.0
27	Serval	*Felis serval*	Mondo	Ph				24.2	21.2	54.6	50.0
28	Caracal	*Felis caracal*	Simba Mangu	Ph				9.1	3.0	3.0	23.3
29	Leopard	*Panthera pardus*	Chui	Ph				72.7	72.7	36.4	53.3
30	Lion	*Panthera leo*	Simba		O			45.5	51.5	42.4	23.3
31	Cheetah	*Acinonyx jubatus*	Duma				P	18.2	9.1	9.1	46.7
			TOTALS	15	9	2	5				
	Golden Jackal	*Canis aureus*	Bweha wa Mbuga					3.0	9.1	6.1	16.7
	Spot-necked Otter	*Lutra maculicollis*	Fisi Maji					3.0	9.1	0.0	0.0

Key: *Ph – Photo trapped; Ob – Observed / Scat / Spoor / road kill; Ac – Claimed by at least 60% of interviewees from at least one village area, and record accepted. Pr – Probable; claimed by 25 – 50% of interviewees from at least one village area.*

3.1 Camera trapping

Camera trapping is now widely recognised as a very effective tool in the investigation of presence, morphology, behaviour and movements of individuals and populations of animals. It is particularly valuable for investigating remote areas, difficult terrain or dense forested areas that often prevent direct observation. The technique freely allows the documentation of rare and/or elusive species believed to be (locally) extirpated (e.g. De Luca & Mpunga, 2002; Goldman & Winther-Hansen, 2003; Spalton, 2002).

However, success rates can be very slow especially for carnivores (Jackson & Hillard, 1986; Carbone et al., 2001). Indeed, with the exception of the bushy-tailed mongoose and the marsh mongoose - the two species most commonly photo-trapped (Tables 5; 6) - our success rates for some species in the Udzungwas were relatively slow in terms of the number of trap-nights per picture (photo trapping rate).

Camera traps provide a good means of quantifying data through the analysis of results per unit effort. Not only can this indicate a relative index of abundance (see Table 6), but it can also help to highlight more significant areas or provide an approximation of relative diversity per site. Table 6 illustrates camera trap success in the four main locations studied. An examination of the number of species per unit effort indicates for example, that the lowland forest of Matundu and the medium altitude woodland of Mbatwa were the most diverse areas for carnivore species in respect of camera trap success per unit effort.

Table 5. *Photo-trapping rates per species (number of independent photos / the number of trap-nights in areas where species was expected), ranked according to trap success*

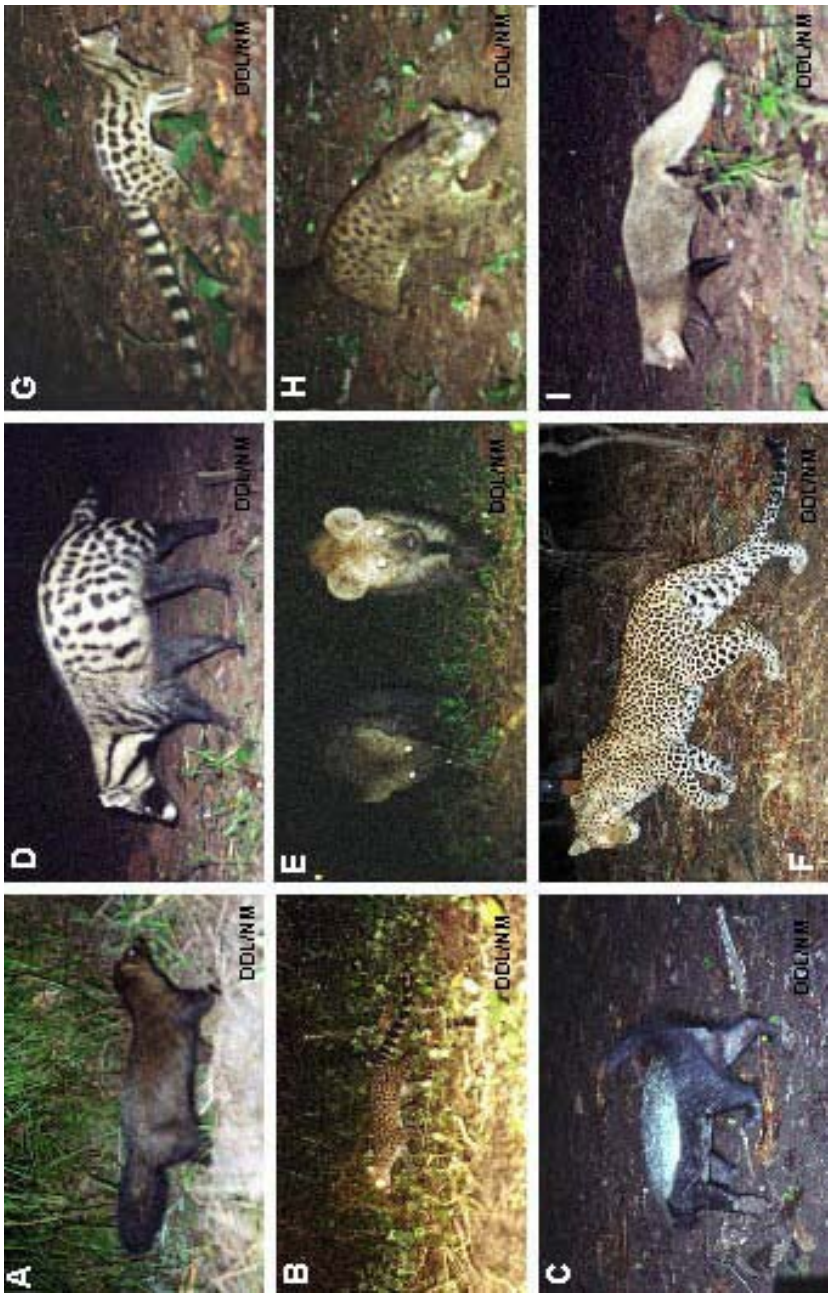
Carnivore Species	No. of pictures	No. of trap-nights	Photo trapping rate
Bushy-tailed mongoose	79	674	**8.53**
Marsh mongoose	32	674	**21.1**
Large spotted genet	15	637	**42.5**
Spotted hyaena	10	457	**45.7**
White-tailed mongoose	4	210	**52.5**
African civet	15	884	**58.9**
Meller's mongoose	8	688	**86.0**
Leopard	9	884	**126**
Common genet	3	460	**153**
Caracal	1	210	**210**
Jackson's mongoose	3	674	**225**
Honey badger	3	884	**295**
African palm civet	2	674	**337**
Servaline genet	2	674	**337**
Serval	1	688	**688**

Table 6. *Camera trap locations with altitude ranges (**Alt**.), number of trapping hours (7pm-7am) and trap nights, number of cameras per location (**CTs**), frequency (**F**; number of times animals were photographed including unidentified mongooses), number of species per site (**Spp**), number of species per unit effort (**Spp / Effort**), species photographed at each site.*

Location	**Alt. (m)**	**Trap hours (1900-0700)** **Trap nights**	**CTs**	**F**	**Spp**	**Spp / Effort**	**Species photographed**
Mwanihana	950-1850	2,964 247	9	92	6	0.0020	African civet, spotted hyaena, marsh mongoose, bushy-tailed mongoose, Lowe's servaline genet, Meller's mongoose
Mkula	300-750	2,772 231	8	78	4	0.0014	African civet, marsh mongoose, large spotted genet, bushy-tailed mongoose
Ruipa / Matundu	300-450	2,352 196	9	104	9	0.0038	Jackson's mongoose, leopard, honey badger, African palm civet, marsh mongoose, African civet, common genet, large spotted genet, bushy-tailed mongoose
Mbatwa	1150-1400	2,520 210	8	23	8	0.0032	African civet, leopard, serval, caracal, spotted hyaena, white-tailed mongoose, large spotted genet, honey badger

That notwithstanding, camera trapping was very effective in illustrating carnivore diversity in the UMNP area (see Table 4; Figs. 3 & 4). Many other species (non-carnivore) were also photo trapped and these will the subjects of another report.

Fig. 3. *Carnivore species photo trapped in the UMNP area (A - I)*



Key to Figs 3 & 4:
A- Bushy-tailed mongoose; B- Servaline genet; C- Honey badger; D- African civet; E- Spotted hyaena; F- Leopard; G- Large spotted genet; H- African palm civet; I- Jackson's mongoose; J- Meller's mongoose; K- Serval; L- Caracal; M- Marsh mongoose; N- Common genet; O- White-tailed mongoose.

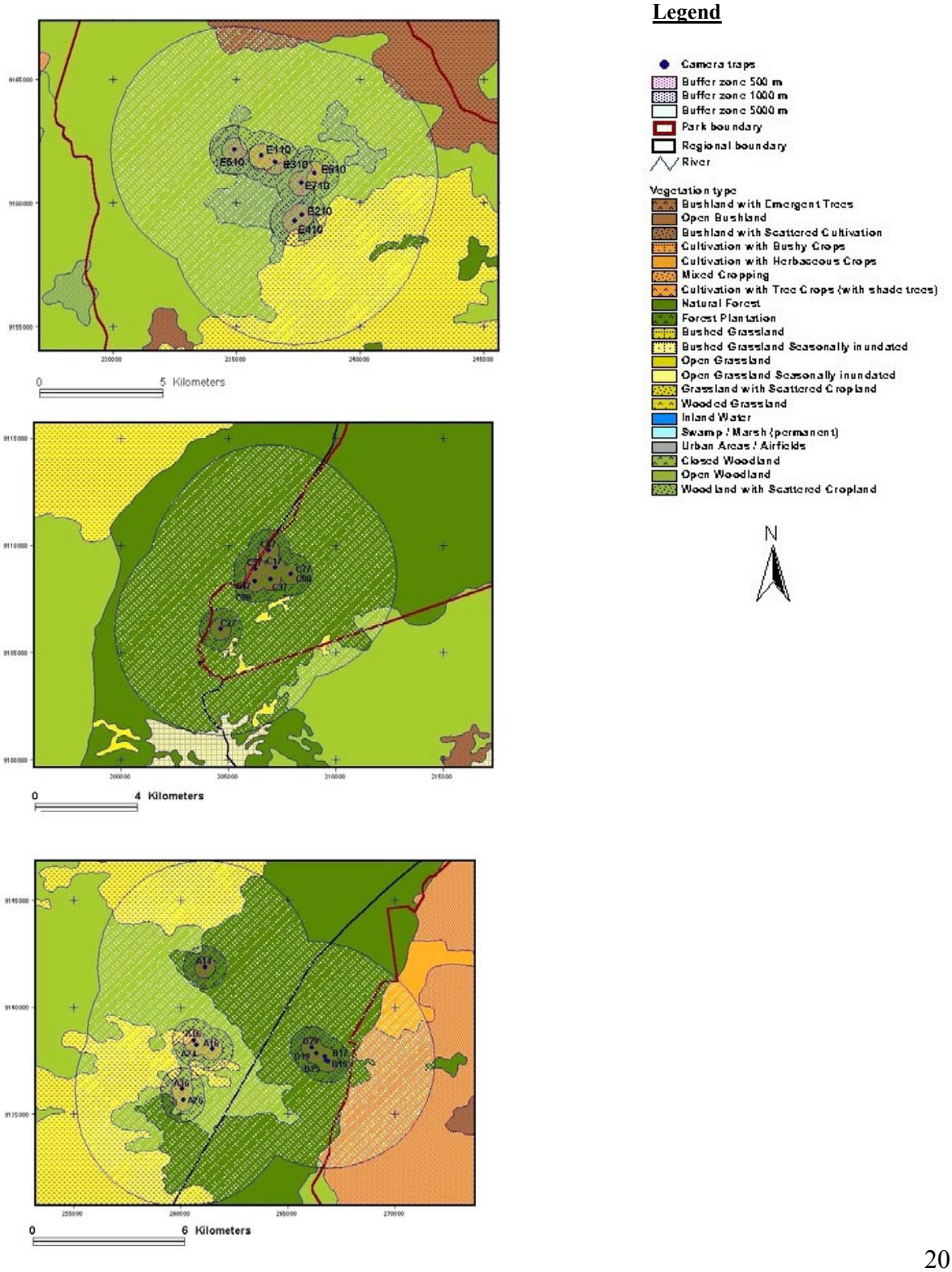
Fig. 4. *Carnivore species photo trapped in the UMNP area (J – O)*

3.2 Habitat sampled

Small, medium and large carnivore species generally have small, medium and larger home ranges. Whilst camera traps were placed at a fixed point within certain habitats (see Table 3), clearly it does not necessarily imply that those species trapped at that camera are found only in that habitat. Many species, though associated with a certain habitat, dwell within ecotones and near habitat boundaries.

In order to visualise the habitat sampled, and to illustrate the potential variety of habitats used by the species photo trapped, we constructed - using GIS ArcView 3.2 - buffers of 0.5km, 1km and 5km around every camera trap location. These buffers demonstrated the putative distances travelled by small, medium and large species respectively and thus the 'sample' area for each camera trap. These are illustrated in Figure 5.

Fig. 5. *Sampling locations and habitats, showing 'buffers' around each camera trap employed. From top to bottom; Mbatwa, Matundu and Mwanihana.*



3.3 Species accounts

Despite their expense, problematical nature and the considerable effort required, the value of camera trapping for investigating the presence of species otherwise difficult to assess, was more than confirmed in this study. This was particularly true for the smaller and more cryptic carnivores such as the mongooses and genets.

In Matundu forest we caught on film a mongoose that we have identified as **Jackson's mongoose** (*Bdeogale jacksoni*). The shape of the ears, the intense yellow on the side of the neck and throat, and the white bushy tail are distinctive (Fig. 3.). This represents a new species record for Tanzania. This little known and highly localised species was formerly known only from montane and bamboo forest on Mt Kenya and lowland forest near Mt Elgon (Kingdon, 1997). Its status is classified as 'very vulnerable' by IUCN (2004). The animal has since also been photo trapped in the same area by F. Rovero (*pers. com*.), and collaboration on the subject is planned.

Jackson's mongoose is similar to the **white-tailed mongoose** (*Ichneumia albicauda*) but the latter has leaner legs, no yellow tints on the neck and throat and has five toes (Kingdon, 1997). The white-tailed mongoose was caught on film only in Mbatwa in the drier north of UMNP (Fig. 4).

Meller's mongoose (*Rhynchogale melleri*) was photographed in the Mwanihana montane bamboo forest at 1850m (Fig. 4). The colour of the pelage, the dark legs and tail and the distinctive upturned shape of the muzzle are all indicative of this species. The species is normally associated with woodland up to approximately 1500m (Kingdon, 1997) and its status is regarded as being 'indeterminate' (IUCN, 2004) being too poorly known. It is possible that this is the first record for this species in such a habitat and altitude.

The **bushy-tailed mongoose** (*Bdeogale crassicauda*) was the most photographed species in UMNP (Fig. 3) with the highest photo-trapping rate (Table 5). The subspecies occurring in this region is *puisa* (Schreiber et al., 1989). Despite records that associate this species to wooded grassland rather than forest (Kingdon, 1977), our data show that it can be found (sometimes in pairs) in montane forest up to 1850m, and lowland forest between 300 and 750m (Table 6). The only location where the species was not photographed was in Mbatwa, a dry thicket woodland. It is nowhere considered common.

The **marsh mongoose** (*Atilax paludinosus*) meanwhile, was the second most photographed species (Table 5). The subspecies occurring in East Africa is *robustus* (Kingdon, 1997). It was photographed (Fig. 4), except for the dry woodland of Mbatwa, in all habitats sampled from 300m up to 1850m in the montane bamboo area of Mwanihana where a pair was caught a few times. Its presence however, seemed to be linked to the vicinity of watercourses; it was not recorded more than 2 km away from rivers.

Other more common mongooses recorded in the UMNP area were the **slender mongoose** (*Herpestes sanguinea*), seen near park headquarters, Sonjo and Mbatwa, the **banded mongoose** (*Mungos mungo*) observed in the Mwanihana area near Mkula, and the **dwarf mongoose** (*Helogale parvula*); a common and unmistakable species whose presence was claimed by 60% of all interviewees and 80% of those in Msosa. Finally the presence of the **Egyptian mongoose** (*Herpestes ichneumon*), a common and widespread carnivore, is considered probable based on the interview data.

Lowe's servaline genet (*Genetta servalina lowei*) is an uncommon and little-known forest arboreal species, described from a skin found in the Dabaga area in 1932 by Willoughby Lowe (Kingdon, 1977; Brink et al., 2002; De Luca & Mpunga, 2002). This species was photographed in the Mwanihana area (980m) in habitat described by Rodgers & Homewood (1982) as intermediate rain forest, as well as in montane forest bordering bamboo at 1830m (Fig. 3; Table 6). These data suggest that in Tanzania the species itself is a forest animal as in West Africa (Ray, 2001; van Rompaey, 1998).

Surprisingly, the **common genet** (*Genetta genetta*) was photographed only in lowland forest at Matundu (Fig. 3), but not in the drier habitat of Mbatwa where we expected to find it. The subspecies occurring in this region is *dongolana* (Kingdon, 1997). In Matundu forest however, the common genet was sympatric with the **large spotted genet** (*Genetta maculata*), where most likely ecological separation is achieved by different use of the forest habitat (Ray, 2001). The large spotted genet (Fig. 4) and the **African civet** (*Civettictis civetta*) were present in various habitats (lowland forest, open and closed woodland) and across a broad altitudinal range (280-1470m.a.s.l). However, the large spotted genet was not photographed in the montane forest or woodland of Mwanihana (Table 6). It is possible that the large spotted genet is in competition with the servaline genet, and/or that its distribution does not extend to higher elevations (Kingdon, 1997).

Together with the servaline genet and the serval, the **African palm civet** (*Nandinia binotata*) showed the lowest photo-trapping rate (Table 5). African palm civets are mainly arboreal but do come to ground to forage (Rosevear, 1974) or to seek water (Sanderson, 1940). With our camera traps set on the ground, this could explain the relatively low number of pictures. However, our current work in the Southern Highlands (*in prep*) has shown that this species is also easily photo trapped on the forest floor. The individual photographed in Matundu does not show the narrower stripes on the neck typical of *N. b. gerrardi* (Fig. 3), but has narrow poorly defined rings on the tail like *N. b. arborea* (van Rompaey & Ray, in prep). This could suggest that Udzungwa is the area of overlap between the two subspecies (assuming that is, that these subspecies are valid).

In East Africa palm civets are chiefly associated with fragmented forest up to 2000m (Kingdon, 1997). However, they are also found in lowland forest (such as Matundu), deciduous, gallery and riverine forests and savanna woodlands, as well as in cultivated mosaic forest and fields bordering forest edges (Charles-Dominique, 1978; Happold, 1987; Skinner & Smithers, 1990).

Between 60 and 91% of people interviewed were familiar with the **African clawless otter** (*Aonyx capensis*). Even though we carried out a census along the Mkula River, we did not trap the animal on film. On one occasion, however, we saw an individual during the daytime. Furthermore, the ecologist of the park photo-trapped an individual in Lumemo at 1400 hrs (H. Dule *pers. com.*), which would suggest they are active during daylight and not at night when our camera traps were usually activated.

Otter scats were found in several locations around the Mwanihana/Sonjo river area. Their scats are quite distinct from the marsh mongoose, usually consisting completely of crab remains or fish and generally deposited in the proximity of water. The marsh mongoose, however, tends to scatter legs and pieces of crab carapace widely. In Congo's Dzanga-Sangha reserve, marsh mongoose and Congo clawless otter (*Aonyx congica*) do not frequent the same small streams within the forest (Ray, 1997). The same could be true in the Udzungwas, or it could be that competition is avoided temporally, with the mongoose active by night and the otter by day (see above). Only a more thorough investigation on the repartition of watercourse habitat and the activity patterns between the two species would answer this question. The Cape clawless otter is particularly targeted by hunters (see below).

The **honey badger** (*Mellivora capensis*) was photographed in both Mbatwa and Matundu/Ruipa confirming its versatility in adapting to both wetter and drier conditions (Fig. 3; Table 6). Spoor of the **striped weasel** (*Poecilogale albinucha*) was observed in Mbatwa although the interview data suggests it is widespread. The **zorilla** (*Ictonyx striatus*) meanwhile, also a widespread animal was acknowledged by 63% of interviewees in Ruipa.

Both **serval** (*Felis serval*) and **caracal** (*Felis caracal*) were photographed only once each in the Mbatwa area (Fig. 4; Table 6), a dry woodland as expected for caracal. Serval often occurs also along the margins of forest galleries, subalpine and montane mosaic moorland (Kingdon, 1997) and so its distribution in UMNP is probably much wider. Half buried scat of the **wild cat** (*Felis sylvestris*) a little known animal, was found on the Mwanihana trail.

Individual **leopards** (*Panthera pardus*) were photographed in two different locations within the park, Ruipa/Matundu and Mbatwa (Figs 3; 4; Table 6). As some of pictures are quite clear, they can be used for individual identification through analysis of spot patterns and therefore park monitoring purposes (see later). Leopards are not uncommon in the UMNP area despite considerable persecution in the past.

Lions (*Panthera leo*), despite not being photographed, were recorded by scats. They were also repeatedly seen by people in the villages on the eastern side of the park, and have also been encountered by other researchers in the area of Mizimu camp (T. Jones *pers. com*.). The time of the year of the scats suggest that they may only be in the park seasonally when prey tend to move from Selous towards the rivers of the Udzungwas.

According to interviewees, **cheetah** (*Acinonyx jubatus*) occurred in the northern sector (Msosa/Mbatwa area) at least up to the 1980's (as did wild dog). After this time, however,

they were sighted very rarely. Some people mentioned a disease that might have wiped out both species. No pictures of cheetahs were taken by photo traps and no scat was found, and their current status in UMNP is unclear.

Between 55 and 70% of people interviewed claimed to have seen packs of **wild dogs** (*Lycaon pictus*) moving in the surroundings of Mkula in the east. These animals most likely were coming from the Selous Game Reserve. No pictures were taken by camera trap but we found a scat in wooded grassland at the edge of the Mwanihana bamboo forest. This may be the first confirmation that wild dog use the UMNP. Wild dogs are endangered throughout Africa, but the Udzungwas are bordering the Selous, which hosts about a fifth of the continent's population (Fanshawe, et al.1997; Creel & Creel, 2002). Given the conservation significance of the species and its need for big home ranges, this record is an important one.

The scats of the **side-striped jackal** (*Canis adustus*) were found in three different sites within Mwanihana forest as well as in montane grassland between 1200 and 1400m. No species of jackals were photo-trapped in UMNP despite their nocturnal habits, however the **black-backed jackal** (*C. mesomelas*) is probably also present having been widely claimed in both Msolwa and Msosa villages.

The **aardwolf** (*Proteles cristata*) was recorded from a road kill near Mbatwa in 2002 and this may represent the most southerly record for the *P. c. septentrionalis* subspecies. Meanwhile, **spotted hyaenas** (*Crocuta crocuta*) were photographed in all habitats sampled, including the forest at Mwanihana where they were attracted by abundant prey such as bushy-tailed and marsh mongooses and red duikers (Figs. 3; 4; Table 6).

Our pictures prove beyond any doubt the occurrence of spotted hyaenas in the UMNP and in high altitude montane forest, despite being previously considered not to occur in the park (Mills & Hofer, 1998). Their presence in high forest is unusual, although they have also been recorded up to 4000m in Kenya (Kruuk, 1972). Spotted hyaenas most likely are resident in the UMNP area given that the pictures were taken in the wet season. This is in contrast to lions that may enter the forest seasonally from the neighbouring Selous in search of water and prey in the dry season.

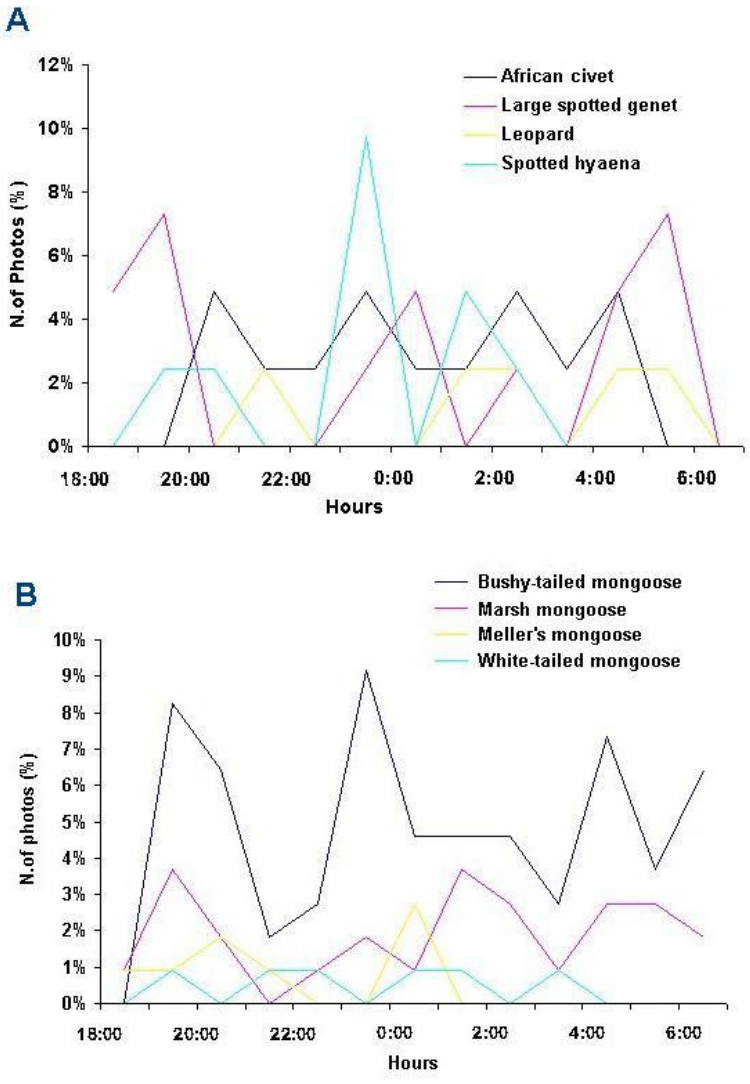
The frequency of pictures of leopards and spotted hyaenas in the Mbatwa area compared to the few photographs of serval and caracal suggest that intraguild competition may favour the larger species. Nonetheless, the presence of many carnivores in this area shows that niche separation probably occurs at activity pattern and prey size levels (Ray, 2001).

3.4 Nocturnal activity patterns

The frequency of independent photos for species with more than 5 pictures taken was plotted in order to show their nocturnal activity patterns (Fig. 6). Unfortunately not all the pictures could be included in this analysis as about a third were taken without a time, due to technical problems with the equipment.

The mongoose species, given their high numbers of photos (and thus sample size) were grouped separately. The bushy-tailed mongoose and the marsh mongoose occupying the same habitat showed similar activity patterns during the night, with peaks of activity at 19:00, 23:00 and 4:00 in the morning, while the Meller's mongoose was most active at 1:00 in the morning; a time of decreased activity for the other two species. Meller's mongoose was caught in open wooded grassland above the forest of Mwanihana at 1850m, higher than the altitude recorded by Kingdon (1997). The activity pattern of the other species showed that whilst the African civet was active throughout the night, the large spotted genet avoided the times when the spotted hyaenas were particularly active (at around 23:00hrs). Interestingly also, the bushy-tailed mongoose activity peaked at around 23:00hrs. At this time we photographed a spotted hyaena with a bushy-tailed mongoose in its mouth.

Fig. 6. *Activity pattern of carnivore species (trapped > 4 times) in the UMNP area; A-Larger species; B-Four spp of mongoose*



3.5 Spot pattern identification

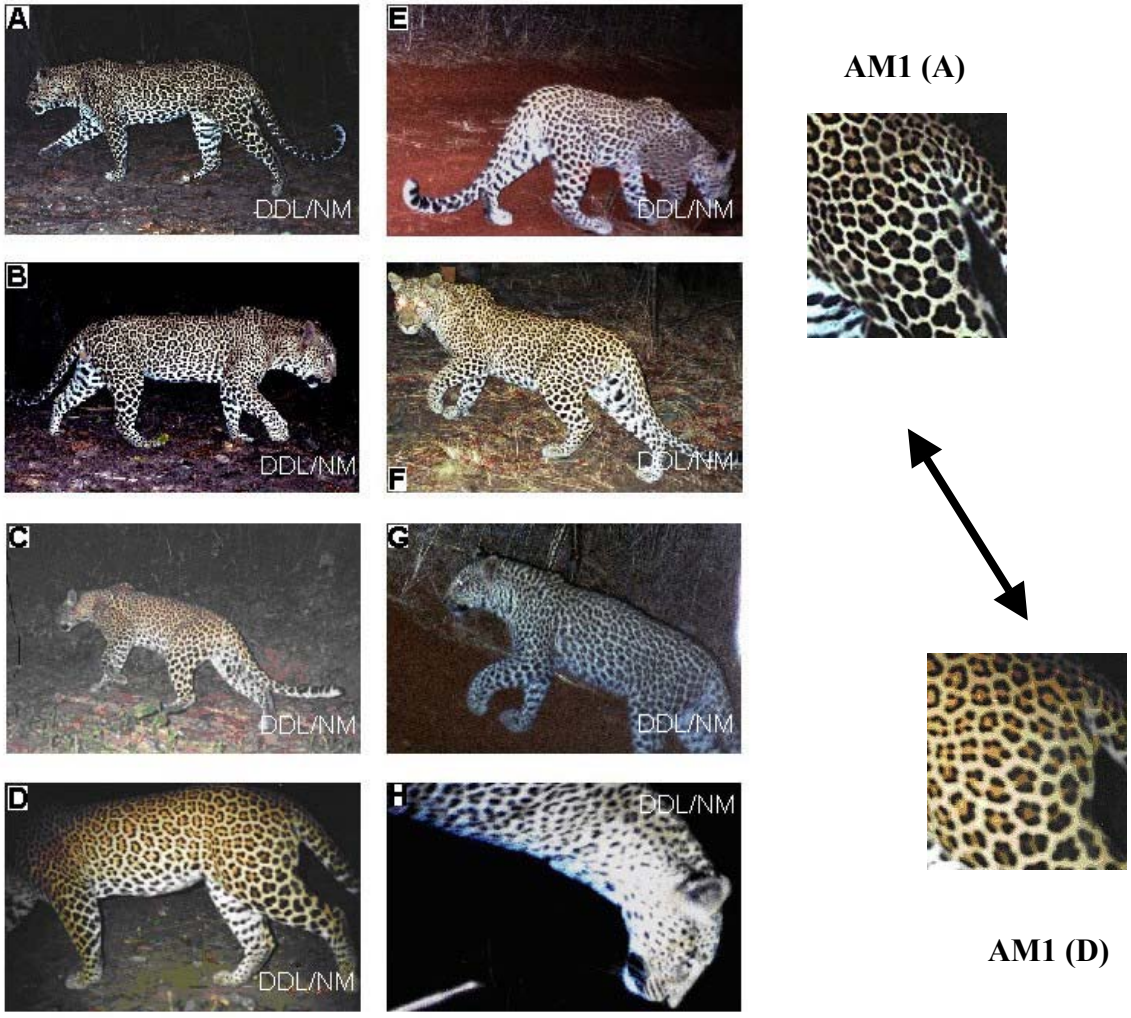
Identification of naturally marked animals through photographs is a powerful and non-intrusive technique for investigating basic aspects of population ecology, size and behaviour of many animals. An increasing number of long-term studies of mammals have used markings to identify individuals of many long-lived species, by building a photographic index (see Schaller, 1972; Douglas-Hamilton, 1973; Frame et al., 1979; Caro, 1994). Building a photographic index of leopards the top predator of the Udzungwas would increase knowledge about the species ecology, habitat use, movements and reproductive patterns. Such an understanding would be of value in promoting conservation initiatives regarding UMNP predators and prey. Kelly (2001) describes photograph-matching software developed to reduce the probability of misidentifying individuals in such a situation.

Our cameras were not placed in stereo as would be recommended, as our survey did not specifically target leopards. However, two leopard photographs from Ruipa/Matundu at different locations are the same animal, a large male, AM1 (Fig. 7; A;D). It is not clear whether a third image AM1? (Fig. 7; B) is the same animal as the photograph was on the other flank. This animal appears heavier and wider in the neck and head. In another location, we have a picture of a female AF1 (Fig. 7; C). This individual is leaner than AM1. Adult male leopards are larger than females (Schaller, 1972; Bertram, 1976) and can be up to 58% heavier and 21% larger in head-width (Miththpala et al., 1989).

Individuals photographed in Mbatwa proved more difficult to identify. Individual AF2 was a female (Fig. 7; F), while another individual (not shown) trapped 2 kms away could be the same female, although confirmation is not possible due to the poor quality of the picture. The other individuals photographed were a female AF3? (Fig. 7; H) and males AM2 and AM3 (Fig. 7; E;G). AM3 may be a young individual, while AM2 is adult, as evidenced by the size and body shape. It is interesting to note that these two individuals were caught just 8 minutes apart, which could suggest that this area might be an overlapping zone within respective home ranges. We were not able to confirm the identity of AF3? as it showed only the head. Similarly other photographs were not appropriate for individual recognition.

If our identifications are correct then there were 3 individual adults photographed in 210 trap-nights in the Matundu /Ruipa area, and another 3 (possibly 4) individual adults in the Mbatwa area; a total of 7 individuals within these two areas. However, in the Mwanihana area, where we found almost half of the scats, we did not manage to take any leopard pictures. This suggests that a figure for leopard density of 0.35ind per 100km^2, based on individual identification from photo traps is probably an underestimate. Given the highly cryptic nature of leopards, we believe that this number is a small fraction of the true figure despite the fact that leopards were hunted for a long time before the area became a national park. That said, it would seem that leopard density is still low compared to other Afrotropical forests (Martin & de Meulenaer, 1988; Jenny, 1996; Ray & Sunquist 2001).

Fig. 7. *Examples of individual leopards identified by camera traps in two locations; Matundu forest (A-D) and Mbatwa woodland (E-H). Close-up (at right) of left rear flank of images A and D showing spot recognition.*



Key:

A. AM1 *(male); 08^0 04' 876"S, 36^0 19' 258"E; 330m; 19/7-30/8/02;*
B. AM1*? (male); 08^0 04' 876"S, 36^0 19' 258"E; 330m; 19/7-30/8/02;*
C. AF1 *(female); 08^0 03' 601"S, 36^0 20' 550"E; 368m; 18/7/02;*
D. AM1 *(male); 08^0 03' 643"S, 36^0 20' 148"E; 327m; 10/8/02;*
E. AM3 *(juv? male); 07^0 35' 512"S, 36^0 37' 369"E; 1164m; 26/10/02;*
F. AF2 *(female); 07^0 36' 216"S, 36^0 37' 369"E; 1373m; 16/10/02;*
G. AM2 *(male); 07^0 35' 512"S, 36^0 37' 369"E; 1164m; 26/10/02;*
H. AF3*? (female?); 07^0 35' 512"S, 36^0 37' 369"E; 1164m; 23/10/02.*

3.6 Scat counts

For future monitoring purpose we present Table 7 to illustrate the number of scats found per species, and their faecal index of relative abundance (fRAI, number of scats per 10km of transect walked; Khorozyan, 2003; Karanth et al., 2003).

Regular collection of carnivore scats along established paths can provide a relatively simple method of monitoring variation in relative abundance. However, it is important that a monotonic linear relationship between data of faecal relative abundance and actual density is previously established (Karanth et al., 2003). Whilst some of these data are probably invalid statistically, they are all presented here as a possible baseline for future comparison and monitoring purposes.

Table 7. *The faecal index of relative abundance of carnivore species recorded in the UMNP area. Transect length and location details are provided in Table 2.*

	Mwanihana area		**Ruipa area**		**Mbatwa area**		**Lumemo area**		**Total**	
Species	Freq.	fRAI	Freq.	fRAI	Freq.	fRAI	Freq.	fRAI	Freq.	fRAI
Wild dog	1	*	0	*	0	*	0	*	1	*
Jackal	5	0.1	1	*	0	*	0	*	6	0.073
Leopard	11	0.22	9	0.455	7	0.709	1	*	28	0.341
Lion	1	*	8	0.404	1	*	0	*	10	0.122
Serval	0	*	2	*	1	*	0	*	3	0.036
Caracal	0	*	0	*	3	0.304	0	*	3	0.036
Wild cat	1	*	0	*	0	*	0	*	1	*
Genet sp.	5	0.1	1	*	1	*	0	*	7	0.085
African civet	0	*	0	*	2	0.202	0	*	2	0.024
Honey badger	1	*	1	*	2	0.202	0	*	4	0.049
Cape cl. otter	9	0.18	0	*	1	*	0	*	10	0.122
Spotted hyaena	3	0.06	2	0.101	2	0.202	1	*	8	0.097
Marsh mongoose	4	0.08	1	*	1	*	0	*	6	0.073
Mongoose sp.	4	0.08	4	0.202	0	*	1	*	9	0.109

3.7 Threats

3.7.1 Carnivore exploitation: consumptive use of carnivores

The interview data showed that despite park management, education and community initiatives, there is still specific exploitation of some carnivore species in UMNP. This is most notably of cape clawless otters, but also occasionally leopards and lions.

Otter body parts are routinely sought for traditional medicine. For example, the skin, penis, fur, head and vocal cords are used to treat a variety of ailments (sexual problems, convulsions, burns, neck pain, tuberculosis and earache), as well as for spiritual purposes. Some interviewees mentioned that the body parts are used for protection from evil spirits, and to increase boys' strength and aggression. Otter parts are also used in burial ceremonies, to stop children crying and for decorative purposes in belts and hats.

Fig. 8. *Unusual otter skin from Mkula*

The fact that we did not find any sign of otters along the Mkula River may be linked to hunting from the nearby village. Indeed in Mkula we acquired the skin of an otter that had been caught locally (Fig. 8). The pelage exhibited a very unusual colouration, the skin is completely chocolate brown, without the white under throat and belly typical of *Aonyx capensis*, and the feet are unwebbed. A similar animal was found also in Lake Naivasha, Kenya (D. Hills, *pers. com.* Natural History Museum, London).

The most common trapping method mentioned was snares usually laid in the rainy season. It would seem that otters are now caught not within the park but in the Kilombero Valley. Perhaps this is because it is now illegal and in the park itself the animals have already been heavily hunted and/or because they are less abundant there.

3.7.2 Source of human-carnivore conflict: problem animals

Interview data revealed that carnivores are not considered to be a major problem in the UMNP surroundings, at least according to the people of Mkula, Msolwa, Msosa and Ruipa. Lions occasionally pass through the villages from Selous Game Reserve, but rarely stay or attack people or livestock. That said, there have been isolated incidents. For example, in the villages of Mkula and Msolwa, in the Kilombero side of the Park, in 1985 villagers

endeavoured to hunt a lion that had attacked a woman and a pig. In Ruipa meanwhile, a relatively new village, lions allegedly attacked a whole family in 1995.

According to park records between 1999 and 2001, one person was killed by a lion in both Sagamaganga and Lugongole-Kilama. Livestock were attacked by lions in 2000 in Kibaoni-Ifakara and in 2001 in the area between Sonjo and Mkula a lion threatened a person. In some cases, the Community Conservation Unit of UMNP reported that the park authorities were called to deal with these and other problem animals (Changula *pers. com.*)

Generally, however the most common attacks by wildlife cited by the interviewees were by elephants, on people working the fields. Interviewees were aware of neighbouring village reports, therefore usually avoided walking at night as a preventative measure.

In the northern sector, the Msosa/Mbatwa area, our interview data showed that spotted hyaenas, leopards and black-backed jackals were occasionally reported to take goats. However, people did not think of carnivores generally as a problem affecting their livelihoods. The problem animals mentioned most often were baboons, elephants and crocodiles. Generally people seemed unaware of methods to deal with problem animals and were seeking advice from us on the issue. In Ruipa interviewees complained about the fact that game wardens were not reacting promptly to their request for dealing with problem animals such as crocodiles and elephants.

Park authorities find it difficult to estimate the magnitude of the problem animals cause, often because the episodes are not reported regularly. Based on our discussions and interviews, we recommend that one person in each village (such as the *Mwenyekiti*) should be in charge of recording all problem-animal events and then report regularly to park authorities. There are ways of dealing with destructive/problem animals and these are presumably known to TANAPA staff. For example, building thorny fences for cattle has proven very effective in repelling carnivores in Laikipia, Kenya; digging ditches around fields, and planting and spraying of chilli pepper can prevent elephants destroying sugar cane; and planting tea as a buffer immediately around the forest edge has helped keep baboons from crop raiding in western Uganda (Davenport, *pers. com*.).

3.7.3 Past and present hunting pressure on predators

Through questions relating to past and present hunting we learned which species used to be in the area, which species were not really known and whether certain species were hunted frequently or rarely. It is important to note that we suspect that some interviewees confused their answers by referring to current illegal hunting activities. Therefore data may also give an indication of these activities too. That said people were sometimes (and understandably) reluctant to discuss current illegal activities openly.

UMNP was gazetted in 1992 and included land from various forest reserves; Mwanihana, part of the west Kilombero Scarp, Iwonde, Nyanganje and Matundu. On the Mwanihana

side, where two of our focal villages are located (Mkula and Msolwa), according to respondents only the game warden was entitled to hunt and distribute game to the people between 1959 and 1992. Nevertheless, many people entered the forest reserve to cut trees and hunting in this period was common (see also Rogers & Homewood, 1982).

Our data show that hunting was mainly for personal use for food, however hunters coming from outside the villages used to hunt for traditional and commercial purposes (eg. leopard skin). More than 50% of people interviewed claimed that carnivores were not hunted purposely. However in Msosa, 30% of respondents admitted that leopard were hunted in large numbers, while in the same village 47%, 43.33% and 40% said that leopards, spotted hyaenas and jackals respectively, were all hunted but in small numbers. Similarly, 35% of interviewees stated that leopards were hunted in Ruipa and Msolwa, and small numbers of lions, wild cats and honey badgers also in Ruipa. While in Msolwa and Mkula 35% of people mentioned that small numbers of African clawless otters used to be hunted in the forest reserve (now the park). It clearly appears that although carnivores were not always the main targets, they were frequently hunted and caught.

3.7.4 Past hunting pressure on prey species

It is clear from the interview data that hunting used to target ungulates. All duiker species were (and perhaps still are) heavily hunted, including blue and Abbott's duikers especially in the south in Ruipa/Matundu. The impact on carnivore abundance, especially the larger species (leopard, lion, spotted hyaena, serval and caracal) cannot be determined here, although it was undoubtedly significant. That said, species such as the blue duiker have a fast reproductive rate and have been shown to be one of the few ungulates that can be sustainably hunted (WCS, 1996). Coupled with the flexible diet of species such as the leopard, hunting might not have affected abundance excessively. However, without data on hunting off take this remains speculation.

A third of interviewees in Msosa mentioned that the sable antelope was hunted in large numbers. Other species said to have been hunted in large numbers were bush pigs, buffaloes and elephants. Among primates the red colobus, black and white colobus and Sanje mangabey were generally not hunted but in Ruipa about 30% and 27% admitted that some red colobus and black and white colobus were (or still are) hunted. Forty-four percent of respondents mentioned that Sykes monkeys are heavily hunted. In all the villages baboons and vervets were/are hunted because they damage crops. The gazettement of the National Park has reduced hunting, nevertheless illegal hunting continues.

3.7.5 Community attitudes towards conservation

The community's attitude towards the conservation of natural resources is fundamental for the successful implementation of research and conservation activities. In the villages sampled, people responded positively to our research in general and they were particularly keen to participate to the retrieval of carnivore names in local tribal languages. We collected

names of carnivores in nine local languages: Hehe, Sagara, Pogoro, Ngindo, Bena, Ndamba, Gogo, Ndewe (data in preparation). Through this exercise we gained an insight into the way people perceive carnivore images and behaviours and therefore their attitude towards the value of wildlife and the neighbouring protected area.

When people where asked how they see the co-existence of people and the park, in all the 4 villages approximately 70% of respondents said that it is good to have the park nearby, because its presence has increased rainfall, acted as a water catchment helping agriculture, and provided more firewood. Among other positive opinions, the social services provided by TANAPA and the financial benefits of tourism were mentioned.

The remaining 30% of people complained about dangerous animals coming too close to people, and villagers not being able to legally prevent this. In Ruipa people complained also that rangers do not know the park boundaries. When we asked whether they could see any benefit for the villagers from the presence of the park, around 80% of people in three villages (Mkula, Msolwa and Msosa) repeated that yes there were many benefits including heritage for future generations. However, 73% of people from Ruipa saw no benefits for the villagers or the country.

3.7.6 Overview of threat for carnivores in the UMNP area

It has been stated that the major threats for carnivores and indeed for wildlife in general within the UMNP area are habitat degrading activities such as illegal logging, excessive firewood collection, uncontrolled fire, uncontrolled medicinal plant collection, hunting and trapping of prey species (Bakarr, 2000). These are the result of increased population pressure on the natural resources of the area, in particular of the forest within the last few decades. This increased pressure on natural resources is the result of immigration and internal human population growth. As a consequence the communities' attitudes towards conservation has been eroded because of the greater needs. The demand for arable land and infrastructure development has created barriers for wildlife dispersal, by interrupting the habitat matrix that connects different habitat patches, (for example the road along the eastern side of the park separating it from Selous Game Reserve, and the case of Magombera forest). Inadequate land use planning has not helped the problems caused by increased demand on natural resources.

To quantify the impact of the threats listed above on certain carnivores species requires long-term research and monitoring, particularly looking at how species use their habitat in relation to different kinds of edges, the size of habitat openings, responses to disturbances such as logging, roads, the impact on prey species and direct exploitation from hunting, and movements and dispersal across heterogeneous landscapes (Sunquist & Sunquist, 2001).

This study was a first step towards this, by documenting first the species composition and distribution of carnivore communities in UMNP, which includes rare and threatened species of global significance. We investigated the terms of co-existence with local people and

identified the source of exploitation such as hunting and consumptive use. The persistence of the carnivore community will depend on how the specialist and generalist species respond to landscape changes such as available habitat size and the persistence of connections between habitat patches.

Roads and human activities have already interrupted corridors for large home range species in the area (eg. wild dogs and cheetahs) as it has in many other areas (Woodroffe & Ginsberg, 1998). Forest conservation initiatives are likely to help the survival of forest dependent species. However, as habitat degrades or the matrix breaks, a change in species composition would occur with an increase in generalist species which are more successful at adapting to human modified habitats (Terborgh et al., 1997).

4. Conclusions

We have recorded at least 26 species from 6 families of mammalian carnivore from the Udzungwa Mountains National Park area, corresponding to 79% of Tanzania's total. The real number may be as high as 31 species corresponding to 91% the national figure. On the basis of these data, UMNP must be considered as amongst the richest protected areas for carnivore diversity in East Africa (if not beyond), and certainly one of the most important.

The presence of Jackson's Mongoose (*Bdeogale jacksoni*) is particularly significant. This little known, highly localised and 'very vulnerable' (Kingdon, 1997) species was formerly known only from montane forest on Mt Kenya and lowland forest near Mt Elgon. This represents a new record for Tanzania, thus taking the national total to 35 species.

Amongst the carnivores recorded, many are little known and information about their ecology is severely lacking, although many are believed to be under threat. For example, the distinct subspecies of servaline genet (*Genetta servalina lowei*) was known only from one specimen and classified by IUCN as 'highly endangered'. This animal only occurs in the Udzungwa Mountains (Brink et al., 2002; De Luca & Mpunga, 2002). Other species highlighted by IUCN and recorded in this survey were the 'endangered' African wild dog (*Lycaon pictus*), and the 'vulnerable' cheetah (*Acinonyx jubatus*) and lion (*Panthera leo*). The wild dog is still using the park seasonally, entering from the nearby Selous. Whether the cheetah is still found in the north remains to be confirmed, although it was there until relatively recently. Meller's mongoose (*Rhynchogale melleri*) meanwhile, is considered 'indeterminate' being too poorly known and the bushy-tailed mongoose (*Bdeogale crassicauda*) is nowhere common and the data for UMNP may represent a novel habitat record.

The leopard (*Panthera pardus*) whilst not considered globally threatened, continues to be persecuted for its skin and for attacking livestock, a behaviour that presumably increases due to degradation of habitat where their prey live (Nowell & Jackson, 1996). It was found in all sites studied, as also was the spotted hyaena (*Crocuta crocuta*), the latter even in montane forest, representing an unusual and interesting record for a species usually associated with lowland savanna. Meanwhile, the aardwolf (*Proteles cristata*) was recorded from a road kill and this may represent the most southerly record for the *P. c. septentrionalis* subspecies.

The Udzungwa carnivore community is rich and important both in terms of its global significance and its local ecological value. Its status and complexity will depend much on the preservation of lower levels of the ecological pyramid, and the tackling of the causes of threat. Illegal hunting still occurs in and around the UMNP area both for food and for traditional purposes. The high demand of medicines and spiritual uses is having an impact on species such as the Cape clawless otter (*Aonyx capensis*). However, carnivores are not perceived as real problem by local communities and thus not substantially persecuted in return. Law enforcement, education and incentives offered to local communities would all help to curb illegal activities and promote this key area's conservation.

5. References

Bakarr, M.I. (Ed). 2000. Biodiversity conservation and forest resource management in the Udzungwa Mountains, Tanzania. Technical Report of Workshop held on October 23-24, 2000, Udzungwa Mountains National Park Headquarters, Mang'ula, Tanzania.

Bertram, B.C.R. 1976. Kin selection in lions and in evolution. In: Growing Points in Ethology: 281-301. Bateson, P.P.G & Hinde, R.A. (Eds). Cambridge University Press.

Boitani, L., Corsi, F., De Biase, A., D'Inzillo Carranza, I., Ravagli, M., Reggiani, G., Sinibaldi, I. & Trapanese, P. 1999. A databank for the conservation and management of the African Mammals. EC-Directorate General for Development and IEA, Istituto di Ecologia Applicata.

Brink, H., Topp-Jorgensen, J.E. & Marshall, A.R. 2002. First record in 68 years of Lowe's servaline genet, *Oryx* 36: 323-327.

Carbone, C., Christie, S., Conforti, K., Coulson, T., Franklin, N., Ginsberg, J.R., Griffiths, M., Holden, J., Kawanishi, K., Kinnaird, M., Laidlaw, R., Lynam, A., Macdonald, D.W., Martyr, D., McDougal, C., Nath, L., O'Brien, T., Seidensticker, J., Smith, D.J.L., Sunquist, M., Tilson, R., Wan Shahruddin, W.N. 2001. The use of photographic rates to estimate densities of tigers and other cryptic mammals. *Animal Cons* 4: 75-79.

Caro, T.M. 1994. Cheetahs of the Serengeti Plains. University of Chicago Press. Chicago & Lond pp 478.

Caro, T.M. & Durant, S.M. 1995. The importance of behavioural ecology for conservation biology: examples from Serengeti carnivores 451-472. In: Sinclair A.R.E. & P. Arcese (Eds) Serengeti II: Dynamics, Management and Conservation of an Ecosystem. Chicago Univ. Press.

Charles-Dominique, P. 1978. Ecologie et vie sociale de *Nadinia binotata* (Carnivores, Viverridae): comparison avec les prosimiens sympatriques du Gabon. *Terre et Vie* 32: 477-528.

Creel S. & Creel N.M. 2002. The African Wild Dog: Behavior, Ecology, and Conservation. Princeton University Press. pp 341.

De Luca, D.W. & Mpunga, N.E. 2002. Preliminary observations of Lowe's Servaline Genet (*Genetta servalina lowei*) from Udzungwa Mountains National Park, Tanzania. *Small Carnivore Cons.* 27: 17-18.

Dinesen, L., Lehmberg, T., Rahner, M. and Fjeldså, J. 2001. Conservation priorities for the forests of the Udzungwa Mountains, Tanzania, based on primates, duikers and birds. *Biol. Cons.* 99: 223-226.

Douglas-Hamilton, I. 1973. On the ecology and behaviour of the Lake Manyara elephants. *E Afr. Wildl. J.* 11: 401-403.

Ehardt, C., Struhsaker, T.H. & Butynski, T. 1999. Conservation of the endangered endemic primates of the Udzungwa Mountains, Tanzania: Surveys, habitat assessment and long-term monitoring. Unpublished Report to Margot Marsh Biodiversity Fund & WWF Tanzania.

Fanshawe, J.H., Ginsberg, J.R., Sillero-Zubiri, C. & Woodroffe, R. 1997. The status and distribution of roaming wild dog populations. In: The African Wild Dog: Status Survey and a Conservation Action Plan. Woodroffe, R. Ginseberg, J.R. & Macdonald, D.W. IUCN. 11-57.

Frame, L.H., Malcolm J.R., Frame G.W. & Van Lawick, H. 1979. Social organization of African wild dogs (*Lycaon pictus*) on the Serengeti Plains, Tanzania (1967 - 1978*). Zeitschrift Fur Tierpsychologie* 224 - 249

Frontier Tanzania (2001a). New Dabaga / Ulangambi Forest Reserve - Zoological Report. Doody, K.Z, Howell. K.M. & Fanning, E. (Eds) Report for the Udzungwa Mountains Forest Management & Biodiversity Conservation Project, MEMA, Iringa, Tanzania. pp 160.

Frontier Tanzania (2001b). West Kilombero Scarp Forest Reserve - Zoological Report. Doody, K.Z, Howell. K.M. & Fanning, E. (Eds) Report for the Udzungwa Mountains Forest Management & Biodiversity Conservation Project, MEMA, Iringa, Tanzania. pp 191.

Goldman, H.V. & Winther-Hansen, J. 2003. The small carnivores of Unguja: results of a photo-trapping survey in Jozani Forest Reserve, Zanzibar, Tanzania. pp 32.

Happold, D.C.D. 1987. The Mammals of Nigeria. Clarendon Press. Oxford, England.

IUCN. 2004. IUCN Red List of Threatened Species. www.redlist.org Downloaded Dec, 2004.

Karanth, K.U., Nichols, J.D., Seidensticker, J., Dinerstein, E., Smith, J.L. McDougal, C., Johnsingh, A.J.T., Chundawat, R.S. & Thapar, V. 2003. Science deficiency in conservation practice: the monitoring of tiger populations in India. *Animal Conservation* 6: 1-10.

Kelly, M.J. 2001. Computer-aided photograph matching in studies using individual identification: an example from Serengeti cheetahs. *Journal of Mammalogy* 82 (2): 440 –449.

Khorozyan, I. 2003. Camera photo-trapping of the endangered leopards (*Panthera pardus*) in Armenia: a key element of species status assessment. Report for the People's Trust for Endangered Species. pp 37.

Kingdon, J. 1977. East African Mammals, Vol. IIIa. Academic Press Inc., London.

Kingdon, J. 1990. Island Africa. Collins Sons & Co. Ltd. London. pp 287.

Kingdon, J. 1997. The Kingdon Field Guide to African Mammals. A & C Black Publishers Ltd. London pp 464.

Kruuk, H. 1972. The Spotted Hyena: A Study of Predation and Social Behavior. The University of Chicago Press. Chicago & London. pp 335.

Jenny, D. 1996. Spatial organisation of leopards Panthera pardus in Tai National Park, Ivory Coast: is rainforest habitat a 'tropical haven'? *J. Zool. (Lond)* 240:427-440

Hall, J.B. 1986. Luhombero Massif, Iringa Region, Tanzania. Reconnaissance vegetation survey in August 1985. Department of Forestry and Wood Science, University College of North Wales, Bangor, UK. pp 93.

Lovett, J.C. & Wasser, S.K. (Eds) (1993). Biogeography & Ecology of the Rainforests of Eastern Africa. Cambridge University Press. Cambridge. pp 341.

Maffei, L., Cuellar, E. & Noss, A. 2004. One thousand jaguars *(Panthera onca)* in Bolivia's Chaco? Camera trapping in the Kaa-Iya National Park. *J. Zool. (Lond)* 262: 295-304

Martin, R.B. & de Meulenaer, T. 1988. Survey of the status of the leopard (*Panthera pardus*) in sub-saharan Africa. CITES. Lausanne.

Mills, G.M., Freigtag, S. & Van Jaarsveld, A.S. 2001. Geographic priorities for carnivore conservation in Africa. In: Gittleman J.L., Funk S.M., Macdonald D.& Wayne, R.K. (Eds). Carnivore Conservation. Cambridge University Press. 467-483.

Mills, G. & Hofer, H., 1998. Hyaenas Status Survey and Conservation Action Plan. IUCN. Gland, Switzerland and Cambrige, UK. pp 154.

Miththapala, S., Seidensticker, J., Phillips L.G. Fernando, S.B.U. & Smallwood, J.A. 1989. Identification of individual leopards (*Panthera pardus kotiya*) using spot pattern variation. *J. Zool. (Lond)* 218: 527 - 536

Nowell, K. & Jackson, P. (1996). Wild Cats: Status Survey and Conservation Action Plan. IUCN. Gland, Switzerland.

Ray, J.C. 1997. Comparative ecology of the two African forest mongooses, *Herpestes naso* and *Atilax paludinosus Afr. J. Ecol.* 35: 237-253.

Ray, J.C. 2001. Carnivore biogeography and conservation in the African Forest: a community perspective. In: Weber, W., White, L. & Noughton-Treves, L. (Eds). African Rainforest Ecology and Conservation. Yale University Press. 214-232.

Ray J.C. & Sunguist, M.E. 2001.Trophic relations in a community of Africa rainforest carnivores. *Oecologia* 127: 395-408.

Rodgers, W.A. & Homewood, K.M. 1982. Biological values and conservation prospects for the forests and primate populations of the Udzungwa Mountains, Tanzania. *Biol. Cons.* 24: 285-304.

Rosevear, D.R. 1974. The Carnivores of West Africa. British Museum of Natural History. London. pp 548.

Sanderson, I.T. 1940. The mammals of the north Cameroons forest area, being the results of the Percy Sladen Expedition to the Mamfe Division of the British Cameroons. *Trans. Zool. Soc. Lond*. 24: 623-725.

Schaller, G.B. 1972. The Serengeti Lion. University of Chicago Press. Chicago.

Schreiber, A., Wirth R., Riffel M., & Van Rompaey, H. 1989. Weasels, Civets, Mongooses and their Relatives. An action plan for the conservation of Mustelids and Viverrids. IUCN/SSC Mustelid and Viverrid Specialist Group. pp 100.

Sinclair, A.R.E. 1995. Serengeti past & present. In: Sinclair A.R.E. & Arcese P. (Eds.) Serengeti II: Dynamics, Management & Conservation of an Ecosystem. University of Chicago. 3-30.

Skinner, J.D. & Smithers R.H.N. 1990. The mammals of Southern Africa Univ. Pretoria. pp 769.

Spalton, A. 2002. Chasing the leopard's tail. *BBC Wildlife* Aug 2002: 28-34.

Stuart, C. & Stuart, T. 2000. A Fieldguide to the Tracks and Signs of the Southern and East African Wildlife. Struik. Cape Town. pp 310.

Sunquist, M.E. & Sunquist, F. 2001. Changing landscapes: consequences for carnivores. In: Gittleman, J.L., Funk, S.M., Wayne, R. & Macdonald D.W. (Eds) Carnivore Conservation. Cambridge University Press. Cambridge. 399-418.

Van Rompaey, H. & Colyn, M. 1998. A new servaline genet (Carnivora, Viverridae) from Zanzibar island. *S. Afr. J. Ecol.* 33: 42-46.

Van Rompaey, H. & Ray, J.C. (In prep). *Nandinia binotata* (Gray). Two spotted palm civet - African palm civet. African Mammals.

Various Authors. 1998. Special Issue of the *J. East Afr. Nat.Hist.* 87: Parts 1 & 2.

Walker, C. 1992. Signs of the Wild: Field Guide to the Spoor and Signs of the Mammals of Southern Africa. Struik. Cape Town. pp 228.

WCS. 1996. The Lobeke Forest, Southeast Cameroon. Summary of activities period 1988-1995. *Wildlife Conservation Society*. pp 217.

Woodroffe, R.B., Ginsberg, J.R. & D.W. Macdonald. 1997. The African Wild Dogs: Status Survey and a Conservation Action Plan. IUCN. Gland. Switzerland:

Woodroffe, R.B. & Ginsberg, J.R. 1998. Edge effects and the extinction of populations inside protected areas. *Science* 280: 2126-2128.

Terborgh, J., Lopez, L., Tello, J., Yu. & Bruni, A.R. 1997. Transitory states in relaxing ecosystems of landbridge islands. In: W.F.Laurence & R.O. Bierregaard (Eds). Tropical Forest Remnants: Ecology Management & Conservation of Fragmented Communities. Chicago Univ. Press. 256-274.

Appendix 1. *General profile of the villages and people interviewed in them:*

	Mkula n=33	**Msolwa n=33**	**Ruipa n=34**	**Msosa n=30**
Mean age	51	55.6	49.6	53.4
Mean family size	7.5	9.45	5.35	8
Mean no. of children	5.5	6.12	2.9	4.8
Main problems perceived	Disease, Water quality	Disease, Overpopulation, Poverty	Problem animals (esp. crocodiles), Disease	Lack of land, No agriculture facilities, Disease
Tribal composition	Ngindo, Hehe, Damba, Dwewe, Ngoni, Nyamwezi, Pare, Pogoro, Rangi, Sagara, Sambaa, Zarimo	Bena, Gogo, Hehe, Ndengereko, Pogoro, Sagara	Bena, Gogo, Hehe, Ndwewe, Ngoni, Pogoro, Nyakyusa	Sagara