

Species richness and habitat use of small carnivores in the Arusha National Park (Tanzania)

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Received 29 April 2004; accepted in revised form 12 October 2004

Key words: Arusha National Park, Carnivore community, Diet, Habitat use, Tanzania

Abstract. The carnivore community of Arusha National Park, Tanzania, was monitored using live trapping and diurnal and nocturnal visual counts and recording of tracks and signs along line transects. Nine carnivore species were recorded. Hyena (*Crocuta crocuta*), the most common large species, leopard (*Panthera pardus*) and African civet (*Civettictis civetta*) were detected along line transects, while the smaller species were counted and/or captured. *Mungos mungo*, *Galerella sanguinea*, and *Genetta maculata* were the most prevalent at transect counts, while *G. sanguinea*, *Bdeogale crassicauda*, and *G. maculata* were most frequently captured. *Ichneumia albicauda* and *Ictonyx striatus* were captured at only a single site. Carnivores selected natural habitat types, multilayered forest, open shrubs and herbaceous savannah, and were absent, or tended to avoid disturbed (man-made) habitats. Species of which sufficient data were gathered seemed to behave as habitat generalists (*C. crocuta*, *G. sanguinea*, *G. maculata*, *M. mungo* and *I. striatus*). The need for more detailed studies on small carnivore ecology and the importance of smaller protected areas for their conservation are discussed.

Introduction

The conservation of natural landscapes and their wildlife in Africa is closely linked to the institution of protected areas, often as national parks. Many of these have been set aside from human activities for the protection of large herbivores and carnivores, or landscape conservation (Pressey 1994; Caro 2001). However, it is still unclear whether variation between landscapes and protected areas in species richness of the large mammal fauna is associated with variation in species richness, abundance and diversity of small to medium-sized terrestrial mammals (e.g. Keesing 1998; Caro and O’Doherty 1999). Species (or community) responses to disturbance vary among mammal species, often in relation to body size and home range size (e.g. Isabirye-Basuta and Kasenene 1987; Laurance 1991; Andrén 1994; Decher and Bahrian 1999; Virgós and Garcia 2002) and with the type, duration and degree of disturbance (Jeffrey

1977; Andr  n 1994; Estrada et al. 1994). Moreover, interspecific competition among African carnivores and killing and/or predation of smaller by larger carnivores can have marked effects on distribution, habitat use and/or abundance of non-dominant species (reviewed by Caro and Stoner 2003).

The larger carnivores and herbivores are often lacking in relatively small protected areas prone to some degree of human disturbance and/or landscape fragmentation by agriculture activity or increasing human settlements (Gehring and Swihart 2003). However, such areas might host important populations of small to medium-sized mammals, either granivores or herbivores (rodents), and carnivores. In the past two decades, several studies have investigated rodent communities and/or dynamics in parks and surrounding agriculture habitats (see above) also in relation to crop-damaging rodents (e.g. *Mastomys natalensis*, Leirs et al. 1994, 1996). But very little is known about small carnivore distribution and relative abundance in the mildly disturbed landscapes of smaller protected areas, probably because studying these illusive species can be difficult and time consuming.

One such area is Arusha National Park, located near the Arusha Township, northern Tanzania, which covers 137 km² and lies in an area of a strongly increasing human population, where the need for land is high. Here we present the results of a survey of distribution, habitat use and relative abundance of small, and large, carnivores which allowed us to evaluate species richness of the carnivore community in and around the park, as part of a broader study, aimed to obtain unbiased estimates of local biodiversity. In a further step, the ecological parameters linked with carnivore distribution will be analysed in function of landscape and species conservation for future use by the park and wildlife managers. Two methods were used for monitoring carnivores: line transect counts for large carnivores; and capture-mark-recapture using live-traps for small carnivores.

Material and methods

The study site

Arusha National Park is the core of Mount Meru (36  45' E–3  15' S) natural system, Tanzania (Figure 1). Rainfall and temperature data show two rainy seasons: the short rains of November–December and the long rains of February–June (rainfall on the lakes approximately 1000 mm per year, semi-arid grassland and savannah at lower elevations 250–500 mm per year). The park boundaries are delimited by rural villages, and some Masaai settlements, while a quarry for the extraction of phosphate close to Minjiingu is an important industrial site near the study area. Agriculture is becoming more and more intensive, with cultivations of beans and corn, extracting land from wild fauna and cattle. Traditional livestock raising by the Masaai (sheep and goats) is decreasing and important revenue comes from organised hunting (Mount

Meru Conservation Project 2002). No human activity is allowed within the Park, apart from tourism, which is concentrated on alpinism at Mount Meru and guided tours for viewing wildlife (Mount Meru Conservation Project 2002). Hence, tourism is considered to create little or no disturbance to vertebrate communities.

The study area comprised Arusha National Park and a 10 km buffer zone around its boundaries. The landscape is very heterogeneous, and we determined 13 different habitat types. Shrubland (open shrubs, 17.5% of available habitat, closed shrubs 0.8%, shrubs on temporarily flooded land 0.03%), forest (multilayered forest 12.1%, closed forest 1.2%, open forest 0.9%) and herbaceous dry (17.5%) or temporarily flooded savannah (0.7%) are the major natural habitats. Bare land (0.8%) associated with volcano peaks and water bodies (0.2%) are scarce. Scattered agricultural land and shrub crops (41.6%) and forest plantations or tree crops (14.5%) are the most important mildly disturbed and altered habitats, while urban, rural and industrial areas comprise only 0.13% of the study area.

Line transect counts

Line transects were distributed across the various habitat types, proportionally to their relative abundance within the study area (Figure 1). Transect counts were carried out to collect data of observations, signs and tracks of large carnivore species, and to investigate their habitat use, and

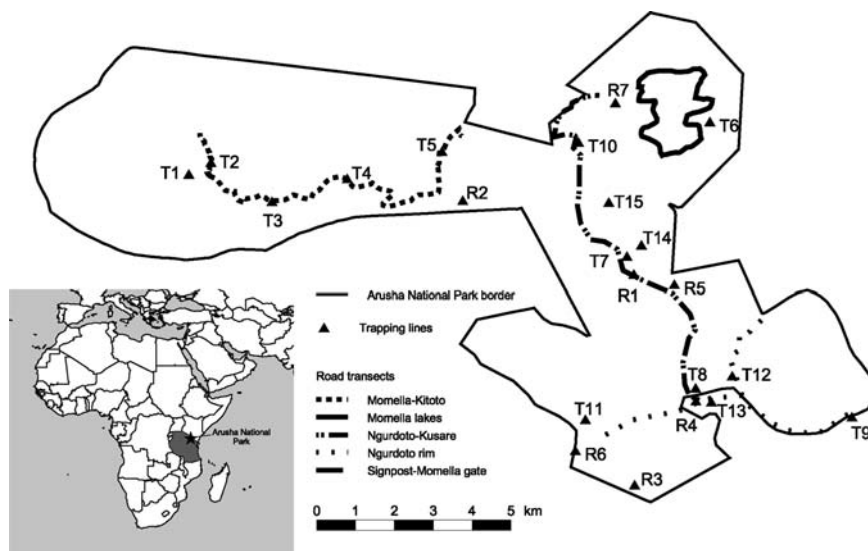


Figure 1. Location of the five road transects and 21 trapping lines in Arusha National Park, Tanzania.

relative abundance. Five transects, between 9 and 11 km long, were surveyed by car, at a speed ranging between 5 and 15 km h⁻¹, between March and August 2001. Each transect was checked 10 times: for an entire week (five times) during day-time and for one week (five times) at night using spotlights. At each census, all carnivore species detected were recorded, and the locations were determined using a GPS. Additional sightings, tracks or signs of large carnivores were also used to increase sample size. In areas with a network of dustroads and paths, transect counts are a suitable method for determining the presence of medium-sized and large carnivores such as aardwolf (*Proteles cristatus*), spotted hyena (*Crocuta crocuta*), lion (*Panthera leo*), leopard (*Panthera pardus*), cheetah (*Acinonyx jubatus*), serval (*Leptailurus serval*), caracal (*Caracal caracal*), black-backed jackal (*Canis mesomelas*), side-striped jackal (*Canis adustus*), bat-eared fox (*Otocyon megalotis*), and African wild dog (*Lycaon pictus*) (e.g. Sliwa and Richardson 1998; Rasmussen 1999).

Capture-mark-recapture

Trapping was performed once at each of the 14 transect lines (5–6 traps, 200 m apart), situated in the different major habitat types of Arusha National Park, in July and August 2001. Single traps were also set near seven ranger posts. Each trapping session consisted of one week pre-baiting, using also rice to attract rodents, the carnivores' natural prey, followed by 3–5 nights trapping. Wooden cage traps (30 × 30 × 120 cm) baited with pieces of meat or chicken, were placed opportunistically in favourable micro-habitats for small carnivores to improve trapping success. The traps were checked early in the morning and shortly before dusk. When an animal was captured, it was transported, inside the trap, to the laboratory, where it was marked and handled with the help of a veterinary. Each captured animal was transferred into a smaller confinement cage where it was anaesthetised with ketamine (100 mg/ml, dose between 1–3 I.U. per 100 g body mass), and the following data were recorded: species, sex, age (juvenile, subadult, adult), reproductive condition (anoestrus, pregnant, or lactating for females; testes position for males), head and body length (mm), tail length (mm), ear length (mm), anal–genital distance (mm), fore-foot length (mm), hind-foot length (mm), body mass (g), and tooth formula. Finally, of each captured carnivore, hair samples were collected, a skin biopsy was taken from the ear, and, if present, external parasites were collected. After manipulation, the animal was put back into the trap where it remained to recover completely from the anaesthetic. It was released at sunset near the place it had been trapped.

Skin biopsies were used for mitochondrial DNA analysis to determine animals of the genus *Genetta* at species level, since overlapping morphological variation between closely related genet species turns difficult an ascertained species ID in the field.

DNA was extracted from samples of ten different individuals using a commercial kit (DNeasy Tissue Kit, Qiagen) and following the manufacturer's protocol. Fragments, with an average size of 200 bp, of three mitochondrial regions (cytochrome *b* gene, *ND-5* gene and control region) were amplified via PCR with genet-specific primers (Fernandes et al., in prep.). Amplification took place in 25 μ l (containing 2–5 μ l of DNA) using *Taq* DNA Polymerase (Invitrogen) for one cycle in 94 °C for 3 min, followed by 35 cycles in 94 °C for 30 s, 50–55 °C (depending on the primer pair) for 45 s and 72 °C for 1 min. The final extension at the end of the profile was 72 °C for 7 min. Negative controls were carried along the PCR reactions to detect contamination. Amplified PCR product was purified with the GeneClean Turbo Kit (Bio 101, Q-Biogene), following the manufacturer's instructions. Sequencing was carried out using the ABI Prism Dye Terminator cycle sequencing ready reaction kit (Perkin–Elmer) for ABI 377 DNA sequencer following the recommendations of the manufacturer. The sequences obtained were aligned, edited, and assembled, using Sequencher™ 3.0 (Gene Codes Corporation Inc.) software. Forward and reverse sequences were aligned for each individual. Replicates coming from different extractions and/or amplifications were performed for all individuals in order to authenticate the respective sequences.

Species identification of each genet specimen was achieved by sequence comparison with a comprehensive, both taxonomically and geographically, genet sequences database kept by one of us (C. Fernandes) and applying clustering algorithms implemented in the software PAUP version 4.0b10 (Swofford 2002). Additionally, sequences were assessed against the available information for genets in GenBank, which in terms of mitochondrial DNA is currently restricted to the cytochrome *b* gene (Gaubert et al. 2004), using the program Blast (Altschul et al. 1997).

Habitat use analysis

We used Ivlev's electivity index (Jacobs 1974) to investigate habitat selection by the different carnivore species, including all records from captures and observations. For each species, the Ivlev's index E_i for habitat *i* is calculated with the formula: $E_i = (u_i - a_i)/(u_i + a_i)$, where u_i is the proportion of observations in habitat *i* (habitat utilised) of that species, and a_i is the proportion of habitat *i* available in the study area.

Diet composition

All carnivore faeces (scats) found were collected. The presence of guard hairs, ingested during grooming by most carnivore species, was compared with a reference collection and used to identify the species that produced the scat. Diet

analysis was carried out according to the method described by Kruuk and Parish (1981). Relative frequency of food item a (Fr_a) was calculated by dividing number of scats containing item a by total number of scats collected. Volume of food item a (Vm_a) was defined as the average volume of item a (sum of bulk-scores containing item a divided by total number of scats, Kruuk and Parish 1981). Undigested remains in carnivore faecal samples were identified by comparison with reference collections made with specimens collected inside the study area. We relied on comparison with reference atlases (Debrot et al. 1982; Teerink 1991) for hair identification of mammal at order-level, considering scale pattern and observing the composition and structure of the medulla in cross-section. Fruit consumption was determined based on the remains of undigested seeds and parts of the fruit cuticle appearing in the scats. Reference collections were used for identification of insect remains (order or family level) and seed or fruit remains.

Results

DNA identification of genet specimens

Sequences were obtained for the three targeted genes and submitted to GenBank (Accession Nos. AY751466–AY751489). The ten sampled animals were determined as rusty-spotted genets – *Genetta maculata*, accordingly with the most recent nomenclatural proposal for this species, still highly debated and under revision by other experts in *Genetta* taxonomy (Gaubert et al. 2002, 2003).

Trapping and transect counts

A total of 218 records of nine different carnivore species were collected: 35 captures and 183 observations or signs (tracks) during transect counts. Leopard (3 observations), spotted hyena (68 observations) and African civet (*Civettictis civetta*, 3 observations) were only encountered during transect counts (Table 1). Thirty-one different individuals belonging to six species of small carnivores: one, the zorilla (*Ictonyx striatus*), belonging to the family *Mustelidae*, four species of the family *Herpestidae* (according to McKenna and Bell 1997), and one rusty-spotted genet (*Genetta maculata* Gray 1830; Gaubert et al. 2002, 2003), of the family *Viverridae*, were captured (Tables 1 and 2). Two animals, a zorilla and a bushy-tailed mongoose (*Bdeogale crassicauda*), were recaptured once, while a melanistic rusty-spotted genet was recaptured twice, for a total of 35 captures and recaptures in 337 trap-nights (overall trapping success 10.4%, Table 2). Trapping success [(number of captures/number of traps $\times$ nights) $\times$ 100] varied from 0 to 17% along the 14 transects, and from 0 to 100% at the ranger posts (Table 2).

Table 1. Total number of contacts (captures, observations, signs, tracks) per species and habitat and the percentage of contacts within each of the habitat types per species.

Habitat type	<i>B. crassicauda</i>	<i>C. civetta</i>	<i>C. crocuta</i>	<i>G. sanguinea</i>	<i>G. maculata</i>	<i>I. albicauda</i>	<i>I. striatus</i>	<i>M. mungos</i>	<i>P. pardus</i>	Total
Multilayered forest	85.7	33.3	22.1	37.0	19.4		44.4	37.9	33.3	68
Open forest			14.7	11.1	16.1	25.0			33.3	20
Closed shrub			2.9				33.3			5
Open shrub	14.3	66.7	46.5	18.5	51.6	25.0	11.1	56.1		96
Herbaceous savannah			11.8	25.9	12.9	50.0	11.1	4.5	33.3	26
Scattered agriculture								1.5		1
Water bodies				7.4						2
N. of contacts/species	7	3	68	27	31	4	9	66	3	218
Captures	6	0	0	10	13	1	4	1	0	35
Observations	1	3	68	17	18	3	5	65	3	183

No contacts in: closed forest, shrubs on temporarily flooded land, herbaceous savannah on temporarily flooded land, forest plantations and tree crops, urban, rural or industrialised areas, and bare land.

Table 2. Trapping effort, trapping success and species captured at 14 transect lines and 7 ranger posts (see Figure 1 for position of trap lines and ranger posts).

Transect	Trap-nights	Number of captures (% trapping success)	Species captured
T1	15	0 (0%)	
T2	15	1 (7%)	<i>Genetta maculata</i>
T3	15	1 (7%)	<i>Genetta maculata</i>
T4	15	0 (0%)	
T5	25	4 (16%)	<i>Ictonyx striatus</i>
T6	30	3 (10%)	<i>Mungos mungo</i> <i>Genetta maculata</i>
T7	30	2 (7%)	<i>Galerella sanguinea</i>
T8	30	3 (10%)	<i>Galerella sanguinea</i>
T9	24	0 (0%)	
T10	24	2 (8%)	<i>Galerella sanguinea</i> <i>Ichneumia albicauda</i>
T11	24	2 (8%)	<i>Genetta maculata</i> <i>Bdeogale crassicauda</i>
T12	24	4 (17%)	<i>Genetta maculata</i> <i>Bdeogale crassicauda</i>
T13	24	2 (8%)	<i>Bdeogale crassicauda</i> <i>Galerella sanguinea</i>
T14	24	4 (17%)	<i>Genetta maculata</i> <i>Bdeogale crassicauda</i> <i>Galerella sanguinea</i>
<i>Ranger posts</i>			
R1	5	0 (0%)	
R2	1	1 (100%)	<i>Genetta maculata</i>
R3	2	1 (50%)	<i>Genetta maculata</i>
R4	2	2 (100%)	<i>Genetta maculata</i> <i>Galerella sanguinea</i>
R5	2	2 (100%)	<i>Genetta maculata</i> <i>Galerella sanguinea</i>
R6	4	0 (0%)	
R7	2	1 (50%)	<i>Genetta maculata</i>

The most common species, based on their frequency of occurrence among the trapped animals, were rusty-spotted genet (11 individuals), slender mongoose (*Galerella sanguinea*, 10 different animals), and bushy-tailed mongoose (5 individuals). Three zorillas, one banded mongoose (*Mungos mungo*) and one white-tailed mongoose (*Ichneumia albicauda*) were also captured. Rusty-spotted genets showed a marked sexual dimorphism, with males significantly larger and heavier than females (Table 3). This was not the case for slender and bushy-tailed mongoose (Table 3). Three species showed rare morphological anomalies. The anal glands were missing in all three zorillas, two adult males and a subadult male, that were captured at transect T6. All 10 slender mongoose (5 males, 5 females) showed asymmetry in tooth formula: the first upper premolar was present on only one side of the upper jaw. Finally, two *G. maculata* were melanistic.

Table 3. Sex, age-category and body measurements of small carnivores captured at Arusha National Park. Sex M = male, F = female; age J = juvenile, S = subadult, A = adult.

Species	Sex	Age	Head-body length (mm)	Tail-length (mm)	Foot-length (mm)	Body mass (g)
<i>Genetta maculata</i>	M	S	480	355	79.9	1160
	M	A	460	365	83.3	1900
	M	S	415	315	77	1000
	M	A	490	410	75.3	1310
	M	J	380	400	72.6	710
	M	J	470	390	76.3	1150
	Males (mean $\pm$ SD)		449 $\pm$ 43	373 $\pm$ 35	77.4 $\pm$ 3.7	1205 $\pm$ 397
	F	A	470	380	75.5	1100
	F	J	390	395	72.1	910
	F	J	390	345	57.5	510
<i>Mungos mungos</i>	F	J	360	340	63.9	550
	F	A	440	400	74.8	1000
	Females (mean $\pm$ SD)		410 $\pm$ 44	372 $\pm$ 28	68.8 $\pm$ 7.8	814 $\pm$ 268
	F	J	285	140	68.7	410
	M	J	260	180	55.2	320
	M	A	325	245	57.6	500
<i>Galerella sanguinea</i>	M	A	335	315	57.2	520
	M	A	345	220	61.4	550
	M	S	330	310	58.8	510
	Males (mean $\pm$ SD)		319 $\pm$ 33	254 $\pm$ 58	58.0 $\pm$ 2.3	480 $\pm$ 91
	F	A	330	270	55.8	450
	F	S	265	235	53.4	320
	F	A	250	305	57.2	550
	F	J	320	315	59.3	500
	F	A	280	240	55.2	470
	Females (mean $\pm$ SD)		289 $\pm$ 35	273 $\pm$ 37	56.2 $\pm$ 2.2	458 $\pm$ 86
<i>Ichneumia albicauda</i>	F	J	450	410	111	1900
<i>Bdeogale crassicauda</i>	M	A	420	240	77.3	1600
	M	A	410	220	78.8	1120
	M	A	390	230	77	1100
	Males (mean $\pm$ SD)		407 $\pm$ 15	230 $\pm$ 10	77.7 $\pm$ 1.0	1273 $\pm$ 283
	F	A	385	220	74.6	1100
	F	A	380	240	75.2	1500
	Females (mean $\pm$ SD)		383 $\pm$ 4	230 $\pm$ 14	74.9 $\pm$ 0.4	1300 $\pm$ 283
<i>Ictonyx striatus</i>	M	J	300	165	56.2	600
	M	A	300	170	56.6	550
	M	A	310	175	56.6	550
	Males (mean $\pm$ SD)		303 $\pm$ 6	170 $\pm$ 5	56.2 $\pm$ 0.2	567 $\pm$ 29

The trapping area is located in UTM zone 37M.

Distribution and habitat preferences

The community of carnivores of Arusha National Park did not use the different habitats randomly, but showed strong avoidance for some habitat

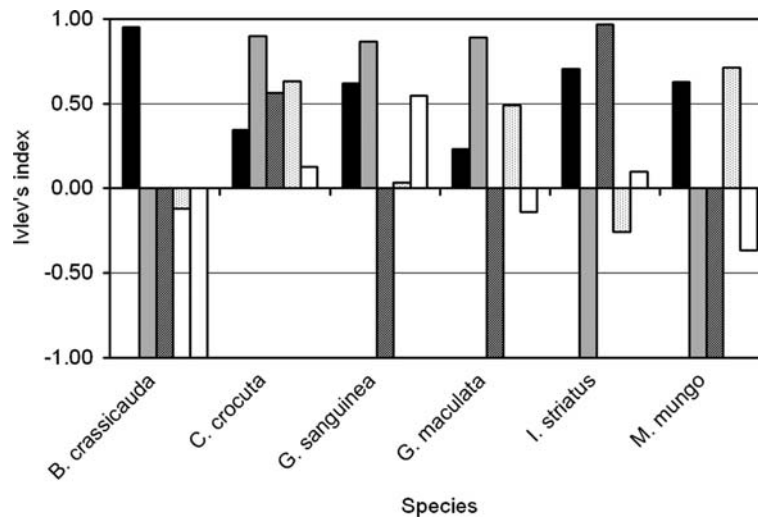


Figure 2. Ivlev's electivity index indicating habitat selection (positive values) or avoidance (negative values) for six carnivore species. Species-code: bde_cra = *Bdeogale crassicauda*, cro_cro = *Crocuta crocuta*, gal_san = *Galerella sanguinea*, gen_mac = *Genetta maculata*, ict_str = *Ictonyx striatus*, mun_mun = *Mungos mungo*. Multilayered forest = dark shaded bars; open forest = grey shaded bars; closed shrubs = hatched bars; open shrubs = dotted bars; herbaceous savannah = open bars.

types, and positively selected others. We observed no signs of presence of carnivores in urban, rural and industrial areas, agriculture areas, plantations and bare land, while only one species, the slender mongoose, was found near water bodies (Table 1). Temporary flooded shrubland was avoided by all species, at least during the study period. Also closed shrub and closed forest resulted avoided by carnivores, with the exception of zorilla and spotted hyena (Table 1, Figure 2). The habitat with the highest species-richness, thus used more than expected by chance by most species, was the multilayered forest: it was positively selected by all species except white-tailed mongoose, which was regularly observed in savannah (Table 1, Figure 2). Also slender mongoose and leopard commonly used herbaceous savannah (Table 1, Figure 2). Leopards, or their tracks, were also observed in open and multilayered forest (Table 1). Open forest was intensively used by rusty-spotted genet, slender mongoose and spotted hyena (Table 1, Figure 2). Open shrubland was used more than expected by the majority of small carnivores, but apparently avoided by zorilla and leopard (Figure 2, Table 1). The spotted hyena appeared to use most of the available, natural habitats, probably related to the species having large home ranges (Henschel and Skinner 1991; Boydston et al. 2003).

Table 4. Diet composition of slender mongoose and rusty-spotted genet based on prey remains determined from scats.

Prey species (group)	Slender mongoose		Rusty-spotted genet	
	Relative frequency (Fr%)	Mean volume estimates (Vm%)	Relative frequency (Fr%)	Mean volume estimates (Vm%)
Mammals	24.3	38.0	25.6	38.0
Insectivora	2.4	3.0	2.5	3.0
Rodentia	14.6	15.5	15.3	38.0
Undetermined	7.3	15.5	7.6	15.5
Birds	9.7	3	17.9	15.5
<i>Gallus domesticus</i>	9.7	3	5.1	15.5
Other species	—	—	12.8	15.5
Insects	36.5	63	33.3	15.5
Orthoptera	4.8	3	2.5	0.5
Coleoptera	29.2	38	14.5	15.5
Tenebrionidae	—	—	2.5	0.5
Scarabeidae	29.2	38	12.8	15.5
Dermaptera	2.4	3	—	—
Heteroptera	—	—	5.1	3.0
Hymenoptera	—	—	2.5	0.5
Formicidae	—	—	2.5	0.5
Undet. Insects	—	—	5.1	3.0
Mollusca	4.8	0.5	—	—
Gasteropodidae	4.8	0.5	—	—
Vegetative matter	24.3	3.0	23.0	15.5
Fruits	9.7	3.0	12.8	15.5
Graminaceae	14.1	3.0	10.2	0.5

Prey remains determined at different taxonomical levels.

Food choice

We collected sufficient scats of *G. maculata* ($n = 17$) and slender mongoose ($n = 20$) for a quantitative analysis of their diet (Table 4). Slender mongoose were primarily insectivorous, but took also frequently small mammals, in particular rodents. Insects belonging to the Scarabeidae were among the most important prey of slender mongoose, while remains of other insect groups occurred much less frequently (Table 4). Grass was frequently eaten but in small quantities and is probably not a real food source but serves to improve digestion. Fruits were eaten occasionally (Table 4). In contrast, genets had a more carnivorous diet, taking often rodents, and also regularly birds (Table 4). Insects are taken frequently, but their volume was less important than for mongoose: genets probably eat insects when they encounter them but do not actively search for insect prey, except maybe for Scarabeidae. Fruits are regularly consumed and in important quantities (Table 4). Thus, both species appear to be generalist carnivores, feeding on small mammals, birds and insects, but also regularly consuming fruits. Moreover, they were captured at (Table 2), and visited ranger posts to prey on chickens.

Discussion

The conservation of the carnivore community of Arusha National Park faces two major problems: the limited size of the protected area where most natural habitats are still intact; and increasing human pressure on the areas immediately outside the park boundaries, causing loss and fragmentation of natural habitats. Nevertheless, for the moment, Arusha National Park still hosts a rich community of small carnivores. In the present study, four species of Herpestidae, one of Viverridae, and one of Mustelidae were captured using live-trapping. In addition, observations were made of two species of large carnivores: the leopard and the spotted hyena, and of the medium-sized African civet. Although the black-backed jackal was common in agriculture land and open shrubs around the park (Galanti and Kilewo, pers. obs.) it was not detected inside the park during the study period. No observations were made and no tracks or signs were found of aardwolf, or of African wild dog, although the latter has been signalled before in Arusha NP (Scheuerlein et al. 1997). Since these species have a high probability of encounter with transect counts, we feel confident they are absent from the park and the surrounding man-made habitats that were sampled (McNutt 1996; Sliwa and Richardson 1998; Rasmussen 1999).

Species richness of small carnivores in Arusha National Park was comparable to other protected areas (Waser 1980; Maddock and Perrin 1993; Ray and Sunquist 2001; Admasu et al. 2004a, b). Leopards and hyenas, the latter common in Arusha National Park, feed mainly on medium-sized to large mammals, and thus will have little effect on viverrids and mustelids. Serval, caracal and canid predators, that might directly kill smaller carnivores (Caro and Stoner 2003), were considered absent, since no signs of their presence had been recorded during the past 10 years (Galanti, unpublished data). In general, species-richness of the Herpestidae–Viverridae clade is not related to their (small) body size (Gittleman and Purvis 1998). Thus, more detailed studies will be necessary to test whether species richness of these small carnivores is actually related to the absence of canids and medium-sized fields.

Carnivores did not use all landscape types in the Park, but clearly avoided all man-disturbed landscapes that are mainly situated just outside the park boundaries. This avoidance does not appear to be caused by direct human disturbance, but by alteration of the original habitat into landscapes that offer less shelter and, possibly, have a lower biomass (and diversity) of food resources. We must admit that the methods used to monitor carnivore habitat use, need to be interpreted with care, and current indices of habitat selection, or avoidance, might be related to differences in the probability of contact amongst different habitat types for at least some of the smaller species.

Three of the six small carnivore species that were captured and closely examined showed rare morphological anomalies. The anal glands were missing

in all three zorillas, two adult males and a subadult male, which were also smaller (head-body length, and tail length) and weighed less than animals recorded in Zimbabwe (Smithers 1983). All 10 slender mongoose (5 males, 5 females) showed asymmetry in tooth formula: the first upper premolar was present on only one side of the upper jaw. In other studies, this anatomical characteristic was documented to occur only rarely (9% of 181 skulls investigated by Skinner and Smithers 1990). Also, mean body mass of females from Arusha National Park was comparable with that of females from Zimbabwe, but males from Arusha weighed less (on average 150 g, see Smithers and Wilson 1979, for comparison). Finally, two rusty-spotted genets were melanistic. It is unclear why carnivores from Arusha National Park had some rare morphological traits. Although we did not take measurements on both sides of the body, the asymmetry in the number of premolars is indicative for the occurrence of fluctuating asymmetry (random deviations from perfect symmetry in bilaterally paired traits), which has been shown to increase with environmental and/or genetic stress (Palmer and Strobeck 1986; Lens and van Dongen 1999).

As in other parts of their range, slender mongoose in Arusha National Park mainly preyed upon small mammals and Scarabeidae, the latter easily found on or near dung of large herbivores, but, in contrast with some literature data, did not show a preference for snakes (Taylor 1975; Smithers and Wilson 1979). Likewise, the generalist diet of rusty-spotted genet, with primarily rodents, some birds and insects, but also fruits, has been found in most studies of the genus *Genetta* (Smithers and Wilson 1979; Virgos et al. 1999; Rosalino and Santos-Reis 2002).

The data presented here indicate that the small carnivores occurring in Arusha National Park strongly select the undisturbed and protected natural habitats within the park boundaries, in particular the multilayered and open forests, open shrubs and herbaceous savannah. They seem to avoid the nearby mildly disturbed areas, such as scattered agricultural fields and crops, man-made plantations and tree crops, although some rodent species, and thus potential prey biomass, might be more common there (e.g. Caro 2001). Although crepuscular or night-active, the small carnivores might select hunting habitats more in function of available shelters than of prey biomass. Therefore, projects including the near Mt. Meru Forest Reserve and Ngurdoto Forest Reserve to safeguard the forest habitats and species will be important for long-term conservation of the carnivore community.

We recommend that future studies should combine capture-mark-recapture methods of both carnivores and their prey (rodents, some important insect orders) in the different natural (undisturbed or slightly disturbed) and altered habitat types that occur in and around protected areas. Such monitoring should be combined with measurements of asymmetry of phenotypic traits, and intensive radio-tracking of some target species to obtain a better knowledge of their habitat use and home range size in relation to landscape structure and composition (e.g. Admasu et al. 2004a, b).

Acknowledgements

We thank Rossella Rossi, Archibald Temu and Rosemary Kileo for logistic support. Marta Treves, and the park rangers helped with the fieldwork. We are also grateful to the Tanzania National Parks for the permission to capture and study carnivores in Arusha National Park, and to N.N. Mafuro, Warden In Charge, and Albert Mzirai, Ecologist of the Arusha National Park for their collaboration. Authors are also grateful to Fabrizio Rigato (Milan Natural History Museum) for insects determination. The project was funded by the European Union (Project Reference Number B7-6200/99-07/DEV/ENV).

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