Small carnivores of the Mt Rungwe–Kitulo landscape, southwest Tanzania: presence, distributions and threats

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Abstract

An ongoing multi-disciplinary research and conservation initiative examined the small carnivore community of the Mt Rungwe–Kitulo landscape in southwest Tanzania over an eight-year period. This key landscape's two contiguous protected areas (Mt Rungwe Nature Reserve and Kitulo National Park) had not, at the study's start, been formally managed for decades. We used sign survey, camera-trapping and interviews to assess small carnivore species richness and conservation status, and the causes of threat to each species, such as habitat degradation and hunting. Across the Mt Rungwe–Kitulo landscape 11 species of small carnivores were sighted, camera-trapped and/or recorded by hunted remains and/or signs (faeces and/or footprints). Species found in Mt Rungwe were detected also in Kitulo except for Egyptian Mongoose *Herpestes ichneumon*, which nevertheless is likely to inhabit the latter. Faeces records from 2003 to 2010 indicated broad distributions for genet(s) *Genetta* (at least some, Rusty-spotted Genet *G. maculata*), Zorilla *Ictonyx striatus* and African Striped Weasel *Poecilogale albinucha*, *Genetta* being the most commonly recorded 'species' in the landscape. Excepting Servaline Genet *G. servalina*, all species expected in the landscape were found. The recorded carnivore composition showed a prevalence of generalist species, probably resulting from the degraded habitat (and consequent invasion of the forest edge as it fragments) and a long history of hunting within the forest. Forest-dependent species are therefore at risk from isolation. Interviews demonstrated the importance of human perception and cultural values in responses to problem animal conflicts. Illegal hunting might be restraining some species' populations, particularly African Civet *Civettictis civetta* and Honey Badger *Mellivora capensis*. Local and broader conservation implications are discussed.

Keywords: habitat fragmentation, habitat use, medicinal uses, Southern Highlands

Petits carnivores de la région de Mt Rungwe–Kitulo, en Tanzanie sud-occidentale: présence, distributions et menaces

Résumé

Dans le cadre d'une recherche et d'une initiative de conservation multi-disciplinaires en cours, nous avons examiné la communauté de petits carnivores de la région de Mt Rungwe–Kitulo, au sud-ouest de la Tanzanie, sur une période de huit ans. Les deux aires protégées contiguës (la Réserve Naturelle de Mt Rungwe et le Parc National de Kitulo) de ce paysage clé, au début de l'étude, avaient été privées de toute gestion formelle pendant des décennies. Nous avons utilisé une enquête basée sur les signes de terrain, le photo-piégeage et des entretiens afin d'évaluer la richesse des espèces de petits carnivores et leur statut de conservation. En outre, nous avons étudié les causes de menace pour chaque espèce, telles que la dégradation de l'habitat et la chasse. À travers le paysage de Mt Rungwe–Kitulo, 11 espèces de petits carnivores ont été observées, prises en photo et/ou détectées par le biais de restes de chasse et/ou des indices (fèces et/ou empreintes). Les espèces trouvées au Mt Rungwe ont également été détectées à Kitulo, à l'exception de la Mangouste d'Égypte *Herpestes ichneumon*, qui est toutefois susceptible d'être aussi présente dans le parc national. Les données recueillies de 2003 à 2010 avec les excréments indiquèrent la large répartition des genettes *Genetta* (en tout cas quelques unes, comme la Genette pardine *Genetta maculata*), du Zorille commun *Ictonyx striatus* et de la Belette rayée d'Afrique *Poecilogale albinucha*, *Genetta* étant 'l'espèce' la plus couramment rencontrée dans l'ensemble de l'aire d'étude. À l'exception de la Genette servaline *G. servalina*, toutes les espèces attendues dans la région d'étude ont été enregistrées. La composition des carnivores de cette région présentait une prévalence d'espèces généralistes. Ceci est probablement le résultat de l'habitat dégradé (et de l'invasion consécutive de la lisière de la forêt au fur et à mesure qu'elle devient plus fragmentée), ainsi que d'une longue histoire de la chasse en zone forestière. Les espèces tributaires de la forêt encourent donc un risque d'isolement. Les données des enquêtes d'opinion ont démontré l'importance de la perception humaine et des valeurs culturelles dans les conflits avec les animaux qui posent problème. La chasse illégale pourrait restreindre les populations de certaines espèces, en particulier la Civette africaine *Civettictis civetta* et le Ratel *Mellivora capensis*. Les implications pour la conservation locale et en général sont discutées.

Mots clés: fragmentation de l'habitat, hauts-plateaux du sud (Tanzanie), utilisation de l'habitat, utilisations médicinales

Introduction

Throughout Tanzania environments are changing rapidly, protected ineffectively from the pressures of a growing human population. This is most obvious in areas of high human density, such as the montane highlands of the southwest. Inadequate land-use planning exacerbates the problem, as evinced by encroachment of the forests and grasslands of the Southern Highlands. Across the latter area, animal populations have been depleted (Davenport 2006, Davenport *et al*. 2008) and

those still persisting are at risk of local extinction if habitat fragmentation continues unabated.

Some mammalian carnivores are particularly vulnerable to local extinction in fragmented landscapes. Their low numbers and, often, nocturnal and cryptic nature make them difficult to study and monitor. Some carnivores tend to disappear from ecosystems with many people because their protein-rich diet often draws them into direct conflict with livestock keepers, resulting in retaliatory persecution and hunting. Some are also actively pursued for their skin or body parts, for use in traditional medicine (De Luca & Mpunga 2004, 2012). These threats may limit the possibility of recovery once a population has been depleted and present conservationists with unusual and difficult challenges (Sillero-Zubiri & Laurenson 2001, Treves & Karanth 2003).

As part of an ongoing multi-disciplinary research and conservation initiative run by the Wildlife Conservation Society (WCS), we examined the carnivore community of the Mt Rungwe–Kitulo landscape in south-western Tanzania over a period of eight years. The aims were to compile a comprehensive list of carnivore species in the landscape with information on the distribution and status of each, and to assess causes of threats. The goals were to provide conservation with a tool to mitigate threats to carnivores and to design a monitoring system for these newly protected areas. This paper presents the data for carnivores excluding dogs (Canidae), cats (Felidae) and hyaenas (Hyaenidae).

Despite being poorly known previously, the Mt Rungwe–Kitulo landscape has become celebrated for the discovery of a new genus of monkey, Kipunji *Rungwecebus kipunji* (Davenport 2005, Davenport *et al*. 2008) and for the endangered orchids in Kitulo (*Bustani ya Mungu*) which are harvested for food (Davenport & Ndangalasi 2001, 2003). However, lack of management for decades (especially in forest habitats) has allowed widespread unsanctioned extraction of forest products, including illegal hunting and logging (Machaga *et al*. 2005, Davenport 2006). Habitat degradation and fragmentation are therefore commonplace and affect forest connectivity and the persistence of many forest-dependent species (Davenport 2006). That said, species that thrive in mosaics and forest-edge habitats may be benefiting from these modifications.

We present data on small carnivore diversity, distribution and encounter rate, based on camera-trapping in Mt Rungwe and the Livingstone Mountains, which latter are now included within Kitulo National Park, and on interviews and sign surveys in both Mt Rungwe and Kitulo. Information on range, altitude and habitat use by small carnivore species is presented based on data collected from 2003 until 2010 across the Mt Rungwe–Kitulo landscape. Maps generated from faecal records suggest the extent of each species's distribution. The interviews investigated the conservation status of and threats to small carnivores, including the medicinal and traditional uses of their body parts, and killing as retaliation for domestic animal attacks.

Study area: the Mt Rungwe–Kitulo landscape

On Mt Rungwe, surveys were undertaken mainly within the boundaries of the now Mt Rungwe Nature Reserve (Mt Rungwe NR). This was gazetted in 2009, having previously been a district-managed Catchment Forest Reserve. It encompasses some 150 km^2 within 9°03–12′S, 33°35–45′E (Fig. 1). We also surveyed the southern buffer area around Mt Rungwe NR and the corridor between Mt Rungwe NR and Kitulo National Park (see Results, Fig. 3). The topography varies from hilly to steeply dissected, with elevation ranging from 1,500 to 2,981 m a.s.l. at the summit (Davenport 2006). Although there is rarely a month without rain, the drier season is between June and October; the mean annual rainfall between 1968 and 2008 was 2,133 mm (Davenport *et al*. 2010). The reserve comprises montane and upper-montane forest, bamboo and montane grassland, and smaller patches of bushland and heath at higher elevations (Davenport 2006, Gereau *et al*. 2012). The surrounding human population density is 210–400 people per km^2 (Machaga *et al*. 2005), with the highest human populations being in the west along the main Tukuyu road and around the tea plantations. Water catchment properties are considered high, with water courses feeding villages and towns from Kiwira and Tukuyu to the fertile Kyela valley and hence Lake Nyasa/Malawi.

The Kitulo plateau is one of Tanzania's most important fire-climax montane grasslands. Kitulo National Park (Kitulo NP) includes the plateau and the Livingstone Forest. Kitulo NP, gazetted in 2002 (Davenport 2002a, 2002b), comprises some 273 km^2 of Afromontane and Afroalpine grassland at 2,600–2,960 m a.s.l. (Fig. 1). Located between the Kipengere Range and the Uporoto and Livingstone Mountains (9°00–16′S, 33°43′–34°03′E), Kitulo was formed over 2.5 million years ago from volcanic ash thrown out from the erupting Mt Rungwe a few kilometers to the west. Heavy rain often falls in convectional thunderstorms during one strict wet season from November to April. During the barren dry season, from May to October, nightly temperatures plummet, with frosts regular over many weeks in July and August. The resultant fertile and well-drained soils, as well as the high rainfall, temperate climate and its biogeographic location, all contribute to Kitulo being the largest and most important plateau grassland community in East Africa (Salter & Davenport 2011).

Kitulo NP and the contiguous Mt Rungwe NR are home to Kipunji and other important species including rare and restricted-range mammals (e.g. a newly discovered *Dendromus* mouse, and Africa's rarest forest antelope, Abbott's Duiker *Cephalophus spadix*; Salter & Davenport 2011) and birds (e.g. Blue Swallow *Hirundo atrocerulea*) that have contributed to Kitulo being designated as an Important Bird Area *sensu* BirdLife International (Baker & Baker 2002). Southern Reedbuck *Redunca arundinum*, Bush Duiker *Sylvicapra grimmia* and Klipspringer *Oreotragus oreotragus* are also found on the Kitulo plateau. In the 1950s the Rungwe–Kitulo landscape held African Buffalo *Syncerus caffer*, Burchell's Zebra *Equus quagga*, Common Eland *Taurotragus oryx*, African Elephant *Loxodonta africana*, Lion *Panthera leo*, Leopard *P. pardus*, Spotted Hyaena *Crocuta crocuta* and Striped Hyaena *Hyaena hyaena*: all are now either locally extinct or transient visitors. Large predators have been persecuted and mostly driven out of the Mt Rungwe–Kitulo landscape, with the exception of Leopards and very occasional Lions (De Luca & Mpunga 2004, DWDL & NEM own data).

Materials and methods

Sign surveys, camera-trapping and socio-economic interviews were employed to ascertain which species of carnivores inhab-

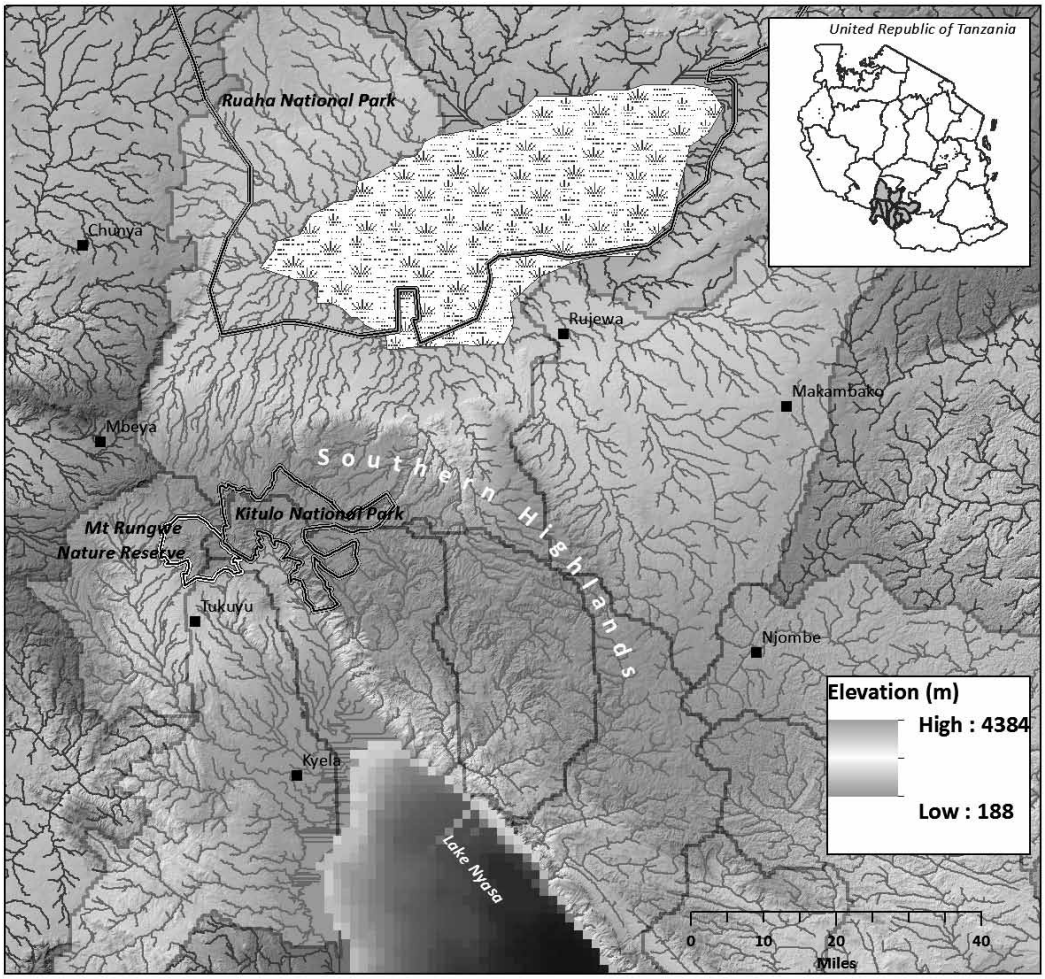

Fig. 1. The Southern Highlands in southwest Tanzania, showing the boundaries of the protected areas and river catchments (extracted from elevation data).

it Mt Rungwe–Kitulo and to investigate their status between 2003 and 2010. More detailed data on their habitats and altitude range were collected between February 2003 and December 2004 inclusive in Mt Rungwe, and during 2004 in Kitulo NP. Initial rapid assessments were carried out widely, to select appropriate sampling zones representative of all habitats and altitudes.

Ecological surveys

During all stages of fieldwork, the locations of all carnivore signs and tracks, and of all snares, loggers' huts and other human impacts, were recorded. Carnivore footprints were measured, identified and photographed. All faeces were collected for subsequent visual identification by one observer (NEM, at all times) using available field guides (Walker 1992, Stuart & Stuart 2000). Faecal identification was based on the inspection of the shape, the measurements, the colour and the food contents. Items were also compared with our reference collection of known museum specimens at the WCS office in Mbeya. The Mt Rungwe–Kitulo landscape receives the highest annual rainfall in Tanzania (Davenport *et al*. 2010), so only very rarely did we find old or dissociated faeces. These were not considered in the analysis. All sign records and camera-trap photographs were grid-referenced, using a Garmin GPS. Data on habitat type and altitude recorded in the field were fed into a Geographical Information System (GIS) (ArcView 3.2). The main survey took place from February 2003 to December 2004 in Mt Rungwe and in 2004 in Kitulo NP. From 2005 to 2010, the survey effort in Kitulo NP and Mt Rungwe varied between years and was generally lower than the initial years.

Appendix 1 shows for each transect route surveyed in Mt Rungwe in 2003 (only) and in Kitulo NP in 2004 (only) the length, the effort (i.e. the number of times it was walked), and its start, end and mean altitudes. In Mt Rungwe the mean (± SD) altitude of a transect route at its start was 1,855 ± 50 m a.s.l. (range: 1,350–1,800 m; n = 46), and 2,150 ± 400 m a.s.l. (range: 1,400–2,950 m; n = 46) at its end. In Kitulo NP, a plateau, the mean altitude of a transect route at its start was 2,500 ± 300 m a.s.l. (range: 1,700–2,850 m: n = 37) and 2,450 ± 300 m a.s.l. (range: 1,700–2,850 m; n = 37) at its end. To obtain altitude data where field records were not available, a point at each vertex of a transect route was generated, and values extracted from an ASTER GDEM Version 2 raster file. The 'VLOOKUP' function (Microsoft Excel) was used to link the transect routes to the dates they were surveyed.

In Mt Rungwe the faecal search effort was very high in 2003, 2004 and 2005 with 517 km, 461 km and 192 km, respectively. The distances walked between 2006 and 2010 ranged between 33 and 50 km. In 2003 the mean daily distance walked was 5.9 km (range, 2–8 km; 95% CI) and the total distance walked

through the year was distributed over 46 different transect routes. In Kitulo NP, annual faecal searching effort ranged from 18 km of transects in 2010, and 163 km in 2005, to 381 km in 2004 (Appendix 1). In 2004 the mean daily distance walked was 6.5 km (range 2.2–16.5 km; 95% CI) and the total distance walked was distributed over 37 transect routes. The number of faeces found per species and the percentage of transect routes with faeces give some indication how common was each species in the Mt Rungwe–Kitulo landscape. The 'faecal encounter rate' was defined as the number, *n*, of faeces/10 km walked. It was beyond the scope of this study to attempt to relate population density to faecal encounter rate (see Karanth *et al*. 2003).

Habitat use analysis

Table 1 summarises the total occurrence of habitat types along the transect routes, extracted from GPS tracklogs in Mt Rungwe (2003 only) and Kitulo NP (2004 only). These were measured by using the 'Intersect' tool in Arcmap 10.0 to link the transect routes with vegetation types. The vegetation-type information was obtained from a Landcover class map that was generated from Landsat ETM+ image p169r066 (Southern Highlands of Tanzania), dated 26 September 2001 (Fig. 2). The 'Intersect' operation produced a new file that segmented all the transect routes by landcover classes. We calculated the length of each segment, using a 'calculate geometry, Length' function in ArcMap.

Following a standard approach on analysis of habitat use data (Neu *et al*. 1974), χ^2 goodness-of-fit tests were used to compare the distribution of small carnivore faeces between different habitat types with that expected assuming no selection, i.e. proportional to the availability of habitat types along the transects. In order to meet sample-size requirements for the χ^2 test (Sokal & Rohlf 1995), data were pooled for each protected area. Table 1 summarises the total occurrence of habitat types along the transect routes; in the analysis though, the habitat type frequencies were used per transect, that is they considered the number of times that each transect route was surveyed (Appendix 1). To estimate the habitat use : availability ratio (selection ratio) between the number of small carnivore faeces found and the number expected for each habitat type, only habitat types which had more that five observations were included in the analysis. Because the values of χ^2 were quite high, conclu-

Table 1. Total occurrence of habitat types along transect routes in Mt Rungwe Nature Reserve and Kitulo National Park, Tanzania.

Habitat type	Mt Rungwe, 2003 (km)	Kitulo NP, 2004 (km)
Forest Natural and Degraded	121.04	81.86
Woodland	39.69	76.17
Agriculture (All)	26.25	12.35
Grassland	12.40	127.83
Bamboo	8.41	15.67
Upper Ericaceae	4.77	9.36
Mountain Shadow	4.64	2.80
Lower Ericaceae	2.79	1.13
Cloud Shadow	2.46	0.33
Pine	2.08	2.67
Heath and Grass	1.97	0.76
Burned	0.00	4.61
Pyrethrum	0.00	0.19

Survey effort in other years is not incorporated.

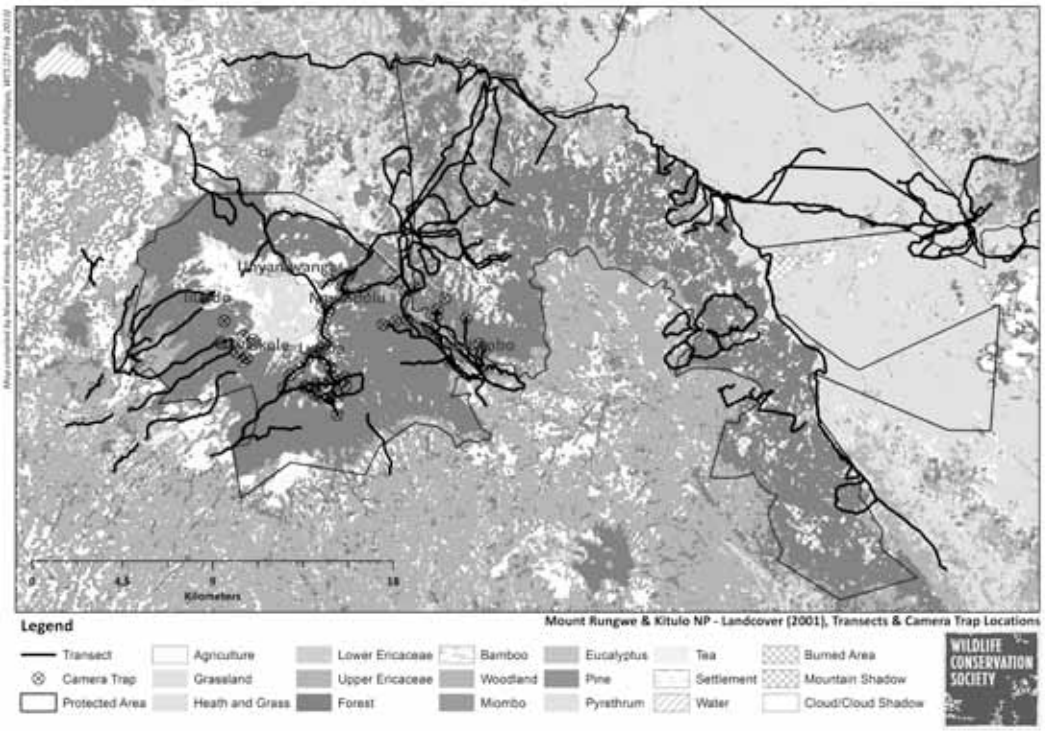

Fig. 2. Vegetation of the Mt Rungwe–Kitulo landscape, Tanzania, showing the extent of each habitat-type crossed by the transects (black line). Black rings show the camera-trap locations (around Lusiba, Mwaikole, Ilundo, Unyamwanga, Ngumbulu and Malambo) within the Mt Rungwe and Livingstone areas.

sions on habitat preference or avoidance were possible when the interval of values of observed habitat use did not overlap with the expected use values. When these intervals overlapped, there was considered to be no effect of selection or avoidance.

Camera-trapping in Mt Rungwe

Camera-trapping was conducted between February 2003 and December 2004 in six sectors in Mt Rungwe (Lusiba, Malambo, Mwaikole, Ngumbulu, Unyamwanga and Ilundo) (Fig. 2), using five passive weatherproof 35 mm Camtrak camera-traps (www.trailcam.com) and 15 weatherproof 35 mm cameras of which eight were Trailmaster TM55 passive infrared and seven were Trailmaster TM1550 active infrared (www.trailmaster.com). Camera-trap locations were concentrated along the forest edge, to document how often habitat generalists were entering forest. Locations were chosen to maximise photo-capture rates and were documented by GPS (Fig. 2). Taking into account Mt Rungwe's difficult terrain and that most carnivores tend to follow trails, most camera-traps were placed within 100 m of trails and/or near locations where faeces had previously been found. The typical distance between traps was 0.5–1 km. All traps were set to work continuously through the 24-hour cycle, with one camera-trap-night being 24 hours. They were mounted 25–30 cm above ground, assuming that large carnivore presence (which would suggest higher mounting for optimal recording) was unlikely. Cameras were programmed to print date and time on a 400 ISO film with a 1.5-minute delay between successive images. Notionally independent events were defined partly following O'Brien *et al*. (2003): namely, consecutive photographs of different conspecific individuals (no social groups were photographed) in cases where they were identifiable, and consecutive photographs of conspecifics and non-conspecifics more than one hour apart. Photographs without date and time printed were omitted from the analysis.

Information on the number of camera-trap-nights for which each camera-trap was functional was retrieved at intervals of 7–10 days. The Mt Rungwe area having intense human exploitation, camera-traps were baited to increase trapping success. Trials using a variety of baits found the most effective to be a suspended liquid blood attractant. This was routinely employed thereafter. The number of camera-trap locations in each of the six camera-trapped sectors of the Mt Rungwe–Kitulo landscape varied according to its size (Fig. 2). Cameras were usually deployed for a minimum of 21 days. Out of 82 camera-trap locations, 23% were in bamboo forest, 25.6% in grassland, 43.9% in montane forest, 4.9% in upper Ericaceae, and 2.4% in pine *Pinus* stands (Fig. 2).

Village interviews

To supplement information from camera-trapping and ecological surveys and to investigate illegal hunting, we interviewed, by structured questionnaire (Appendix 2), 126 people from six villages (Ilolo, Ilundo, Malambo, Unyamwanga, Ngumbulu, Syukula) around Mt Rungwe, between May and June 2003. Interviewees were selected based on their knowledge of the area and wider landscape. They comprised hunters and collectors of honey, firewood and medicinal plants, mostly 40–80 years old, although six were under 40. The interviews covered many issues including carnivore sightings (relating the species to a booklet of photographs), patterns of sightings by habitat-types, locations and vernacular names. People were asked when they last saw each species. Human–carnivore conflict and history of hunting activities were also ascertained. Data were collected on the frequency of problem-animal occurrences and the ways employed to prevent or reduce them. Information on carnivore exploitation such as consumptive use (traditional medicine, spiritual use) and cultural significance was gathered.

Results

Eleven small carnivore species from four families were recorded in the landscape by direct sighting, camera-trapping, pelts and/or their signs (Table 2). All species found in Mt Rungwe

Table 2. Small carnivore species of the Mt Rungwe–Kitulo landscape, Tanzania.

English name	Scientific name	Mt Rungwe	Kitulo NP
Mustelidae			
African Clawless Otter	*Aonyx capensis*	CT*,F,S	F
Zorilla	*Ictonyx striatus*	F,S	F
African Striped Weasel	*Poecilogale albinucha*	F,S	F
Honey Badger	*Mellivora capensis*	F	F
Nandiniidae			
African Palm Civet	*Nandinia binotata*	VO,CT,S	VO,F
Viverridae			
Large-spotted Genet	*Genetta maculata*	CT,VO,S,F	CT**,F,VO
African Civet	*Civettictis civetta*	F	F
Herpestidae			
Marsh Mongoose	*Atilax paludinosus*	F	F
Egyptian Mongoose	*Herpestes ichneumon*	VO,S	
Common Slender Mongoose	*Herpestes sanguineus*	CT,VO,F,S	VO,F
Banded Mongoose	*Mungos mungo*	VO	VO

CT = camera-trapped; F = faeces; S = skin; VO = visual observation.

* Faeces in 2003; camera-trap in 2010.

** Camera-trapped within the Mt Rungwe session in 2003 in the Livingstone Mountains which were later included in Kitulo NP.

were found also in Kitulo NP except for Egyptian Mongoose *Herpestes ichneumon*, although it is likely to be there too.

Mt Rungwe–Kitulo landscape faeces survey 2003–2004

Faecal encounter rates in Kitulo NP in 2004 (Table 3) suggested that the most common carnivores there were genet(s) *Genetta* (perhaps Rusty-spotted Genet *G. maculata*) and Zorilla *Ictonyx striatus*, followed by mongooses *Herpestes* (possibly Common Slender Mongoose *Herpestes sanguineus*). *Genetta*, African Striped Weasel *Poecilogale albinucha*, *I. striatus* and African Civet *Civettictis civetta* preferred mostly the cultivation matrix, but *Herpestes* mongooses showed a weaker such preference. Except for the mongoose, all the preceding species significantly selected the bamboo forest, while *Genetta* and *I. striatus* avoided the natural forest. No *P. albinucha* or *Herpestes* faeces were found in this habitat and results were not conclusive for *C. civetta* (Table 4). Only *Herpestes* preferred extensively the planted pine forest and the grassland in part; results on grassland habitat preference or avoidance for *Genetta*, *I. striatus* and *C. civetta* were inconclusive (Table 4). The altitudinal distribution of faeces found in Kitulo NP is shown in Table 5. *Genetta* faeces were found in equal numbers between 2,000–2,500 m and 2,500–3,000 m, whilst *I. striatus* and *Herpestes* (*H. sanguineus*?) faeces were found mainly between 2,500 and 3,000 m.

Table 3. Faecal encounter rates of small carnivores in Kitulo National Park, Tanzania, in 2004.

Species name[1]	Number of faeces	% routes with faeces	Faecal encounter rate[2]
Genetta[3]	186	66.70	4.52
Ictonyx striatus	126	68.25	3.06
Herpestes[3]	63	31.75	1.53
Poecilogale albinucha	32	31.75	0.78
Civettictis civetta	20	6.35	0.49
Atilax paludinosus	7	7.93	0.17
Aonyx capensis	5	4.76	0.12
Mellivora capensis	4	4.76	0.10

[1] English names are given in Table 2.
[2] Number faeces/10 km walked.
[3] Some *G. maculata* and *H. sanguineus* were identified by other methods (see text).

The faecal encounter rates in Mt Rungwe in 2003 (Table 6) suggested that the most common carnivores there were *Genetta* and African Clawless Otter *Aonyx capensis*. *Ictonyx striatus* and *Herpestes* seemed less common than in Kitulo NP, whilst *P. albinucha*, Honey Badger *Mellivora capensis*, Marsh Mongoose *Atilax paludinosus* and *C. civetta* faeces were found only rarely. In 2003 *P. albinucha* and *I. striatus* showed a high preference for the cultivation matrix, while the forest was actively avoided by *Genetta* and *P. albinucha*; *Genetta* and, less so, *I. striatus*, preferred grassland (Table 4). The altitudinal distribution of faeces found in Mt Rungwe is shown in Table 7. *Genetta* faeces were found in equal numbers within 1,500–2,000 m and within 2,000–2,500 m. Faeces of *P. albinucha* and *M. capensis* were found mainly between 2,000 and 2,500 m.

The distribution maps (Fig. 3) distinguish faeces found during 2003–2005 from those found during 2006–2010. Over 2003–2010, *Genetta* (Fig. 3a), *I. striatus* (Fig. 3b) and *P. albinu-*

Table 4. Habitat selection ratios[1] for each small carnivore species in Mt Rungwe and Kitulo National Park, Tanzania.

Species[2]	*G.*	*P. a.*	*I. s.*	*G.*	*P. a.*	*I. s.*	*H.*	*C. c.*
Habitat type	**Mt Rungwe, 2003**			**Kitulo NP, 2004**				
Agriculture		7.93 (pref.)	7.44 (pref.)	5.97 (pref.)	9.18 (pref.)	10.12 (pref.)	6.7 (pref.)	11.60 (pref.)
Bamboo				3 (pref.)	7 (pref.)	3 (pref.)		6.88 (pref.)
Forest Natural and Degraded	0.64 (avoid)	0.6 (avoid)		0.7 (avoid)		0.53 (avoid)		1.04 (nc)
Grassland	5.75 (pref.)		3.34 (pref.)	1.3 (nc)	0.92 (nc)	1.06 (nc)	1.41 (pref.)	
Heath and Grass								
Lower Ericaceae								
Pine							39.5 (pref.)	
Upper Ericaceae								
Woodland								
χ^2 **value**[3]	214.05	61.9	62.87	112.67	97.4	326.15	538.67	103.00
	df = 1	*df* = 1	*df* = 1	*df* = 3	*df* = 2	*df* = 3	*df* = 2	*df* = 2
***P* value**[3]	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

[1] Number of observed faeces frequency/expected frequency per habitat type. In parentheses, conclusions on positive preference ('pref.'), avoidance ('avoid') or no effect ('nc') from analysis of observed use (see text).
[2] *G.* = Genet *Genetta* (some *G. maculata* were identified by other methods; see text); *I. s.* = Zorilla *Ictonyx striatus*; *H.*= Mongoose *Herpestes* (some *H. sanguineus* were identified by other methods; see text); *P. a.* = African Striped Weasel *Poecilogale albinucha*; *C. c.* = African Civet *Civettictis civetta*.
[3] χ^2 and *P* values from goodness-of-fit tests of observed versus expected distributions of small carnivore faeces per habitat.

Table 5. Kitulo National Park, Tanzania: altitude distribution of small carnivore faeces in 2004, and minimum and maximum altitudes where each species's faeces were found during 2004–2010.

Species[1]	Altitude intervals (m)			Min. altitude (m)	Max. altitude (m)
	1,501–2,000	2,001–2,500	2,501–3,000		
Civettictis civetta	12	0	7	1,990	2,550
Genetta[2]	23	86	77	1,660	2,900
Atilax paludinosus	7	1	4	1,640	2,820
Aonyx capensis	4	0	1	1,610	2,550
Poecilogale albinucha	6	9	17	1,830	2,830
Ictonyx striatus	30	38	58	1,570	2,875
Herpestes[2]	10	10	38	1,660	2,850
Mellivora capensis	4	0	0	1,635	1,945
Total number of faeces	**96**	**144**	**202**		

[1] English names are given in Table 2.
[2] Some *G. maculata* and *H. sanguineus* were identified by other methods (see text).

Table 6. Faecal encounter rate of small carnivore species in Mt Rungwe Nature Reserve, Tanzania, in 2003.

Species name[1]	Number of faeces	% routes with faeces	Faecal encounter rate[2]
Genetta[3]	71	45.45	1.03
Aonyx capensis	32	11.36	0.46
Ictonyx striatus	15	11.36	0.22
Herpestes[3]	15	11.36	0.22
Poecilogale albinucha	12	11.36	0.17
Mellivora capensis	6	13.64	0.09
Atilax paludinosus	5	11.36	0.07
Civettictis civetta	1	2.27	0.01

[1] English names are given in Table 2.
[2] Number faeces/10 km walked.
[3] Some *G. maculata* and *H. sanguineus* were identified by other methods (see text).

cha (Fig. 3c) seemed the most widespread species across the Mt Rungwe–Kitulo landscape. The distribution of *A. capensis* (Fig. 3e) will be reported elsewhere (De Luca *et al*. in prep.).

Camera-trapping survey

Between February 2003 and December 2004, camera-traps were set at 85 locations, within six sectors of Mt Rungwe and the Livingstone mountains part of Kitulo NP (Fig. 2). Some 31 'independent' photographs of small carnivores were recorded from 3,938 camera-trap-nights (Table 8). The highest camera-trapping rate of small carnivores was in Mwaikole, in southern Mt Rungwe (Table 8). In this southern part *G. maculata*, the most commonly photographed species of small carnivore during the survey, was photographed in Mwaikole, Malambo and Lusiba. African Palm Civet *Nandinia binotata* was photographed in Mwaikole and Malambo. *Herpestes sanguineus* was only photographed in Lusiba. No small carnivore was camera-trapped in the three northern sectors of Mt Rungwe NR: Ngumbulu, Ilundo and Unyamwanga (Fig. 2; Table 8). Lusiba in the southeast and Ngumbulu in the north of Mt Rungwe had more trap-nights per camera because of a Serval *Leptailurus serval* survey in 2004.

Direct sightings of live and dead animals

Herpestes ichneumon was sighted at the forest edge around the villages of Malambo (in Rungwe East) and Ngumbulu (in Rungwe North). A skin found was from Kibisi (in South West Rungwe). Banded Mongoose *Mungos mungo* was seen at the forest edge in Nkuka Forest (Southern Rungwe) and around the village of Ngumbulu (Rungwe North); and in Numbe Valley (North-east of Kitulo NP). *Nandinia binotata* was sighted in Nkuka Forest (Southern Rungwe) and in the Livingstone Forest, Numbe (within Kitulo NP), while a skin was seen from the Malambo area (Rungwe East). *Genetta maculata* was sighted widely within Mt Rungwe NR (18 sightings). All six genet skins

Table 7. Mt Rungwe Nature Reserve, Tanzania: altitude distribution of small carnivore faeces in 2003, and minimum and maximum altitudes where the species were found during 2003–2010.

Species[1]	Altitude intervals (m)			Min. altitude (m)	Max. altitude (m)
	1,501–2,000	2,001–2,500	2,501–3,000		
Civettictis civetta	1	0	0	1,517	2,471
Genetta[2]	38	38	8	1,538	2,887
Atilax paludinosus	1	1	0	1,680	2,354
Aonyx capensis	26	3	0	1,559	2,430
Poecilogale albinucha	1	7	2	1,562	2,625
Ictonyx striatus	5	4	0	1,600	2,480
Herpestes[2]	5	1	1	1,520	2,887
Mellivora capensis	1	5	0	1,617	2,390
Totals number of faeces	**78**	**59**	**11**		

[1] English names are given in Table 2.
[2] Some *G. maculata* and *H. sanguineus* were identified by other methods (see text).

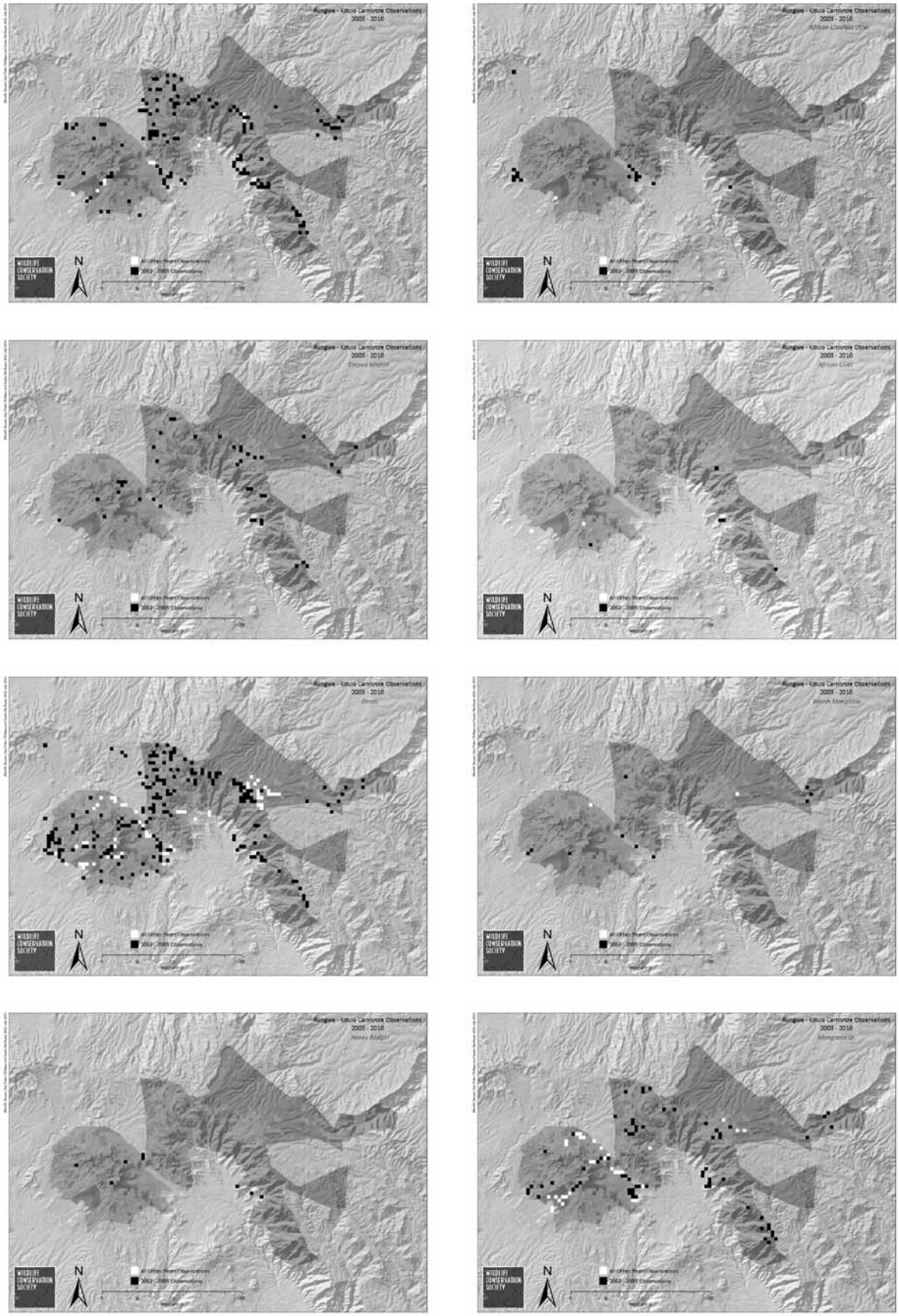

Fig. 3. Distributions of small carnivores in the Mt Rungwe–Kitulo landscape, as determined by records of faeces, in 2003–2010. (a) Zorilla *Ictonyx striatus*; (b) African Striped Weasel *Poecilogale albinucha*; (c) unidentified genet(s) *Genetta*; (d) Honey Badger *Mellivora capensis*; (e) African Clawless Otter *Aonyx capensis* (preliminary); (f) African Civet *Civettictis civetta*; (g) Marsh Mongoose *Atilax paludinosus*; (h) unidentified mongoose(s) *Herpestes*. The total coverage of survey points as background (light grey) indicates the extent of survey. The black squares indicate the faeces locations in 2003–2005. The white squares indicate faeces locations in 2006–2010. The dark grey represents the extent of the protected areas: Mt Rungwe Nature Reserve and Kitulo National Park.

Table 8. Encounter rates and the number of camera-trap locations where each of the three small carnivore species camera-trapped were recorded in six sectors of Mt Rungwe and the Livingstone mountains, Tanzania.

	Species	Mwaikole	Ngumbulu	Malambo	Lusiba	Ilundo	Unyamanga	TOTAL
Total camera-trap-nights		408	740	488	2,145	78	79	3,938
Mean number camera-trap-nights per camera-trap		31.4	52.85	40.66	48.75	78	79	330.66
Working cameras		13	14	12	44	1	1	85
Number of 'independent' photographs	*G. maculata*	5	0	5	10	0	0	20
	N. binotata	4	0	3	0	0	0	7
	H. sanguineus	0	0	0	4	0	0	4
Total of small carnivore 'independent' photographs		**9**	**0**	**8**	**14**	**0**	**0**	**31**
Number camera-trap locations where photographed	*G. maculata*	5	*	5	9	*	*	19
	N. binotata	4	*	3	*	*	*	7
	H. sanguineus	*	*	*	4	*	*	4

*No photographs were taken.
English names are given in Table 2.

Table 9. Carnivore sightings reported by villagers (*n* = 126) in the Mt Rungwe–Kitulo landscape, Tanzania, with habitat location and approximate years of sighting.

Species		Habitat types				Period		
	n	**Village %**	**Field %**	**Forest %**	**River %**	**2000s%**	**1990s%**	**1980s%**
Mellivora capensis	109	6.42	1.83	**90.83**	0.92	**88.07**	5.50	6.42
Ictonyx striatus	106	**88.68**	5.66	5.66	0.00	**88.68**	3.77	7.55
Poecilogale albinucha	98	**98.98**	1.02	0.00	0.00	**97.96**	1.02	1.02
Aonyx capensis	81	2.47	0.00	0.00	**97.53**	**71.60**	17.28	11.11
Civettictis civetta	80	20.00	15.00	**48.75**	16.25	**76.25**	7.50	16.25
Herpestes sanguineus	75	**94.67**	1.33	2.67	1.33	**98.67**	0.00	1.33
Genetta[1]	71	47.89	7.04	45.07	0.00	**95.77**	2.82	1.41
Atilax paludinosus	32	0.00	17.24	3.45	**79.31**	**81.25**	0.00	18.75
Herpestes ichneumon	27	**81.48**	0.00	11.11	7.41	**92.59**	7.41	0.00
Nandinia binotata	16	12.50	6.25	**75.00**	6.25	**93.75**	6.25	0.00
Mungos mungo	7	**42.86**	14.29	28.57	14.29	**100.00**	0.00	0.00

[1] Some *G. maculata* were identified by other methods; see text.
n: number of people reporting sightings.
Habitat types: % of people reporting sighting of each species in the various habitat types. Each person reported only one habitat per species.
Period: % of people reporting their last memory of sighting each species as in the 2000s, 1990s or 1980s.
The highest value for each species concerning habitat use and period of sighting is emboldened.

collected from hunters, from Ilundo (West Rungwe), and from Malambo (East Rungwe), were confirmed as *G. maculata* (P. Gaubert verbally 2012), despite their great variation in fur coloration and pattern. This was consistent with camera-trap photographs (see above). Within the rest of Kitulo NP genets were neither camera-trapped nor recorded as skins, and other genet species might thus occur. *Herpestes sanguineus* was sighted nine times close to the forest edge within Mt Rungwe NR; always close to the forest edge, near the villages of Kikondo and Usalama (both in the north of Kitulo Plateau); and near the village of Missiwa (in the south of Kitulo Plateau) (12 sightings). Two *H. sanguineus* skins were found, from Malambo (East Rungwe). The single skins of *P. albinucha* and *I. striatus* were each from the Unyamwanga area (West Rungwe).

Carnivore sightings reported by villagers in Mt Rungwe

Amongst 126 interviewees, most people reported their most recent sightings of most species to be within the previous three years; fewer people had last seen any species in the 1990s or 1980s (Table 9). The species reported by most interviewees in and around villages were *P. albinucha*, *I. striatus*, *Herpestes sanguineus* and *H. ichneumon*. *Genetta* was reportedly equally seen in the village and in the forest, while *M. capensis*, *C. civetta* and *N. binotata* were reportedly most sighted in the forest. *Aonyx capensis* and *Atilax paludinosus* were mainly reported from near rivers. Vernacular names for species collected during the interviews are presented in Appendix 3, in Kiswahili, the official Tanzanian language; Kinyankyusa, spoken widely in the area of Mt Rungwe NR; and Kinga, spoken in the area of Kitulo NP.

Threats

Are carnivores considered a problem around Mt Rungwe?

Of the 121 people (96% of those interviewed) in the villages who answered whether they considered carnivores to be a problem, 92%, 38% and 78%, respectively, considered *I. striatus*, *Genetta* and *H. sanguineus* to be problematic. Although *P.*

albinucha is considered a blessing to have around because of its perceived magical powers, the species is also considered a problem because it catches chickens. Between 11% and 24% of interviewees claimed to have seen *H. ichneumon*, *A. paludinosus* and *C. civetta* attacking poultry. Amongst the 121 respondents, 40–64% claimed that *I. striatus*, *Genetta* and *Herpestes sanguineus* attack chickens, while *P. albinucha* was reportedly sighted by 28% of interviewees destroying crops such as maize. The same number of people stated that they had seen *M. capensis* attacking beehives. The reported timing of attacks on livestock varied between species, with *I. striatus* attacking equally at all times during the 24-hr period, *Genetta* mostly by night (19h00–07h00; 61% of answers), and *Herpestes sanguineus* and *H. ichneumon* overwhelmingly by day. All people asked what they do about the attacks stated that they react by chasing with spears, sticks and dogs to kill the animals. It was unclear how often they succeed.

Carnivore hunting on Mt Rungwe

Of the 126 people interviewed, 56 (44.4%) answered about hunting. Of these 56, 41% considered that carnivore hunting occurred in the 1970s but according to 52% it did not. The respective figures for the 1980s were 48% and 50%, and for the 1990s, 21.4% and 78.6%. Finally, for the interval 2000–2003, 98% of the respondents denied the occurrence of carnivore hunting. All respondents stated that hunting was for food, with almost no hunting specifically for skins or other parts. The most common hunting methods were dogs and traps; snares and other methods were also reported. According to 83%, 64% and 50% of interviewees, *A. capensis*, *M. capensis* and *P. albinucha*, respectively, were hunted with log traps. Poison was said to be rarely employed.

Carnivore use on Mt Rungwe

It was difficult to distinguish whether animals were caught for food, medicinal/witchcraft purposes or a combination of both. Most likely is that any carnivore caught while hunting or in retaliation served both purposes. All carnivore parts used were valued for medicinal and/or witchcraft uses if not eaten, but some species had more uses than others. The scent glands of *C. civetta* are used to treat 'mental illnesses' in children (most likely to be epilepsy) and the skin to treat neck pain. People also attributed magical effects to this animal including powers of resuscitation, protection from witchcraft, and the stopping of children from crying. *Aonyx capensis* skin is used to treat neck and back pain, epilepsy, convulsions and mental illnesses in the young. Its blood is believed to increase fighting strength. Until the 1980s, members of some royal clans used to be buried in otter skins. *Genetta* skins are used to cure neck pains and mental illness, but at the same time their skins increase magical powers, and are used in fortune-telling and for protection from witchcraft. It is believed that a cow's fertility can be augmented if the cow jumps over a genet skin. Thus, most people with a cow also own a genet skin. *Mellivora capensis* skin is said to cure pains and mental trauma, the brains to treat headaches, the whole body to increase fighting abilities; its nose is used by local medicine men for various purposes. The greatest magical power of all is attributed to *P. albinucha*. Its skin is used to cure back pain, protect from witchcraft and to pay respects to the deceased; and the whole body gives the owner magical powers to steal crops, yet protects his own fields from thieves.

Discussion and conclusions

This, the first inventory of carnivores in Mt Rungwe NR and Kitulo NP, recorded 18 carnivore species (De Luca & Mpunga 2012), 11 of which were small carnivores, i.e. excluding Felidae, Canidae and Hyaenidae. The combination of ecological and sociological investigations provided a diverse list of species from the landscape, concomitant with the size, type and status of the habitat. Indeed, the diversity is perhaps surprising given the extent of long-term hunting and habitat damage from logging and encroachment.

In the Mt Rungwe–Kitulo landscape, there are two forest-associated small carnivores, *M. capensis* and *G. maculata*, that also use more open habitats (Kingdon 1997), one forest-dependent (*N. binotata*), two linked to water (*Atilax paludinosus* and *Aonyx capensis*), and one that we found predominantly around forest edge and secondary growth, *P. albinucha*. Elsewhere, this is also reported in uplands with extensive grassland (Kingdon 1997). All but three species (*N. binotata*, *A. paludinosus, A. capensis*) are habitat generalists often found near human-dominated habitats; these species tend to exploit ecotones as the forest is fragmented. However even generalists often widespread and abundant (e.g. *C. civetta* and *M. capensis*), at least in Tanzania (authors' own obs), seemed uncommon or locally rare (Figs 3d, 3f), despite, according to 90% of interviews with local people, the occurrence of *M. capensis* in the forest. Similarly, almost 50% of people interviewed mentioned *C. civetta* as encountered in the forest, but we recorded little evidence of it there or indeed elsewhere. Perhaps it is mostly in forests near villages; we did not survey village surroundings in detail. This information from Mt Rungwe and Kitulo NP is largely consistent with habitat use already reported (e.g. Kingdon 1997). Species generally not dependent on forest such as *G. maculata*, *I. striatus* and *P. albinucha* apparently avoided the forest, being recorded, at least in Mt Rungwe, mostly in grassland and the cultivated matrix, areas which are probably food-rich ecotones. The grassland in Kitulo NP can be quite disturbed by agricultural encroachment (Salter & Davenport 2011) perhaps confining these species to other habitats such as in bamboo forest, a habitat preferred by *Genetta*, *I. striatus*, *P. albinucha* and *C. civetta* (Table 4). Finally *Herpestes* (apparently *H. sanguineus*) also was recorded mostly in human-derived habitats such as the cultivated matrix and pine stands in Kitulo NP.

It is surprising that only one species of genet was recorded. Habitat analysis (Gaubert *et al*. 2006) and camera-trap records in other montane forests of Tanzania (De Luca & Mpunga 2002, Rovero *et al*. 2006) suggest that Servaline Genet *Genetta servalina* might be expected in Mt Rungwe. Because other genet species might be present, faecal records are here identified only to genus. Only methods like DNA analysis and thin-layer chromatography (Ray & Sunquist 2001) would identify genet faeces to species.

Signs of two species in the Mt Rungwe–Kitulo landscape were identified at higher altitude than they have been reported before: *P. albinucha* above 2,200 m and *I. striatus* up to 2,990 m on Mt Rungwe. Meanwhile, records of *Herpestes* (*H. sanguineus*, most likely) on Mt Rungwe up to 2,900 m, *A. paludinosus* at 2,800 m and *N. binotata* at 2,300 m all corroborate these species' ecological adaptability.

Of the 11 small carnivore species recorded on Mt Rungwe, those not captured by camera-trap probably are either localised and occur where we did not place traps (see Fig. 2) such as around villages and along rivers, or are rare and thus more likely to be found by longer-lasting camera-trapping surveys. The mustelids (excepting otters), *C. civetta* and *Atilax paludinosus* were recorded only by skins and faeces. There were too few camera-traps along rivers to ensure photographs of *Aonyx capensis* (or *Atilax paludinosus*) in this study, but *A. capensis* was camera-trapped later (De Luca *et al*. in prep.). Camera-trapping did record, but gave an unrealistic distribution of, one of Africa's most common mongooses, *H. sanguineus*: substantial effort generated just four pictures, but direct sightings (Fig. 3h) suggested it was common, as did village reports and widespread records of faeces probably of this species. The camera-trapping recorded three species of small carnivores out of the 11 that could have been photographed during the 3,938 trap-nights, indicating its limitations as a sole tool for monitoring mammalian carnivores (Tobler *et al*. 2008).

Nevertheless camera-traps can record species rarely observed directly (Rovero *et al*. 2005) or clarify the range of potentially threatened species (De Luca & Mpunga 2002, De Luca & Rovero 2006). Here, camera-trapping confirmed *N. binotata* in the Mt Rungwe–Kitulo landscape, as well as a skin being found; it has subsequently been observed several times on Mt Rungwe (T. Davenport verbally 2008). Large survey effort is needed to register some species (e.g. Tobler *et al*. 2008), such as those at very low densities (Nichols & Karanth 2002), so investigators must evaluate according to each study's aim and conditions, the relative merits of long-term camera-trapping with many traps, regular sign transects, a combination of these, or other methods.

Interviews suggested that the small carnivore encountered by most people is *M. capensis*, followed by *P. albinucha*. More than 50% of interviewees claimed to have seen most of the species listed including *C. civetta*. Only 13% of interviewees claimed to have seen *N. binotata*, although it may have been under-recorded because of its nocturnal and arboreal habits.

Threats and conservation

Many people perceived small carnivores as problematic, especially *I. striatus* and *Genetta*, because they attacked free-ranging chickens. The number of chickens kept per person in each village averages only between 1 and 3.7. Chickens are not a primary source of protein, but are valued for special occasions. Thus, material damage inflicted by small carnivores is not substantial but the cultural importance attached to the ownership of chickens affected people's perception, and therefore the likelihood of retaliation. Similarly, *P. albinucha*, despite being seen as a problem animal, was tolerated somewhat because of its perceived magical powers, although was still killed for use of its body parts. Local beliefs were responsible for the great number of *P. albinucha*, *C. civetta* and *A. capensis* reportedly killed in the past, according to interviews.

Civettictis civetta is one of the most common and widespread small carnivores in Africa (Ray *et al*. 2005), and was widely reported by local people (Table 9). However, we did not camera-trap it, and found its signs only rarely: a few faecal records within the PAs, and a few latrines near village areas close to PA boundaries. Investigation of the species's current local status is warranted, because the high percentage of interviewees reporting it might be based on a few animals scavenging at village rubbish-dumps. Interviewees reported that *C. civetta* was highly hunted in the past for the valuable musk produced in the anal gland. Apart from *Aonyx capensis*, this species had the lowest proportion of sightings in the 2000s among people who had sighted it at all (Table 9): it may thus recently have been more widely distributed than at present. Its catholic diet allows *C. civetta* to survive close to human-dominated environments but it seems to require thick cover near watercourses (Kingdon 1997), which might have decreased in heavily degraded forest. Intense hunting pressure, heavy selective logging, and increased habitat fragmentation all might keep population densities low.

African Clawless Otters (for their skins), African Striped Weasels (for their 'magical' powers) and Honey Badgers (for their considerable impact on beehives: see Begg & Begg 2002), have been persecuted or hunted extensively over time across Mt Rungwe–Kitulo, as suggested by the low number of faeces found (Fig 3). *Aonyx capensis* and *P. albinucha* both have relatively short spans of reproduction (Kingdon 1997, Weigl 2005), while *M. capensis* has a low annual birth rate (Begg *et al*. 2005, Weigl 2005). These attributes make them more vulnerable than otherwise similar species to over-harvesting, and may inhibit population recovery after exposure to over-harvesting or to any other cause of high mortality. Only detailed study could ascertain whether this is the case in Mt Rungwe. However, *A. capensis* turns out to be more abundant than previously expected, especially at lower altitudes, outside Mt Rungwe Nature Reserve (De Luca *et al*. in prep.).

Heavy illegal hunting during 1960–2000 (before the start of conservation management, in 2002) coupled with increasing habitat fragmentation by fire and illegal logging (Davenport & Patterson 2002, Machaga 2009) might have compromised small carnivores' and other mammals' opportunities of immigration into, or re-colonisation of, the affected areas. In Mt Rungwe, the species with narrower habitat-use are at risk of isolation and thus local extinction. The forest/grassland corridor that connects Mt Rungwe to Kitulo has been severely degraded (Davenport 2006) but remains vital for preventing isolation of the Mt Rungwe carnivores and other animals. There are grounds for optimism, with the recent establishment of Mt Rungwe as a Nature Reserve and the collaboration of Tanzania National Parks in Kitulo.

Fuller survey and long-term monitoring of these species across the whole Mt Rungwe–Kitulo ecosystem would further clarify their conservation status and needs. Even so, it seem already clear that the sources of human disturbances like fire, hunting, illegal logging and charcoal burning in the area need to be much reduced.

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Appendix 1. Transect length, effort (total km walked), and starting, ending and mean altitudes, in Mt Rungwe Nature Reserve (2003 only) and Kitulo National Park (2004 only), Tanzania.

Transect name	Transect length (km)	Total effort (km)	Start altitude (m)	End altitude (m)	Mean altitude (m)
Mt Rungwe					
Bamboo–Peak	4.82	33.72	2,419	2,943	2,681
Dry Lake–East Ward	4.29	4.29	2,368	2,372	2,370
Dry Lake–Peak/Crater	5.56	11.12	2,799	2,359	2,579
Ilundo–Mwaikole	6.90	6.90	1,539	2,019	1,779
Ilundo area	4.65	4.65	1,584	2,062	1,823
Ilundo East	1.73	1.73	1,400	1,455	1,427.5
Ilundo–Forest 1	8.50	8.50	1,540	2,132	1,836
Ilundo–Forest 2	1.94	1.94	1,691	1,759	1,725
Ilundo–Ndaga	5.08	5.08	1,539	1,825	1,682
Ilundo West Forest	1.21	2.42	1,617	1,622	1,619.5
Kabale–Lusiba	3.47	3.47	1,532	1,878	1,705
Kabwe Area	0.69	0.69	1,563	1,576	1,569.5
Katalalifu River	2.30	2.30	1,343	1,414	1,378.5
Kipoke River	2.67	2.67	1,354	1,411	1,382.5
Lake Lusiba–Rungwe Peak	4.94	4.94	2,151	2,943	2,547
Lower Camp–Dry Lake	3.35	3.35	2,147	2,359	2,253
Lower Camp–Lusiba	3.69	3.69	2,147	2,147	2,147
Lower Malambo–Forest	4.40	39.59	1,722	2,169	1,945.5
Lower Malambo–Livingstone 1	3.79	34.10	1,753	1,976	1,864.5
Lower Malambo–Livingstone 2	5.13	5.13	1,789	1,963	1,876
Lower Malambo–Jembajemba	2.12	2.12	1,722	1,777	1,749.5
Lower Malambo–Kapela	1.92	1.92	1,722	1,846	1,784
Lower Malambo–Ngumbulu	7.29	7.29	2,223	1,711	1,967
Lower Malambo–Upper Malambo	3.81	3.81	1,692	1,974	1,833
Lower Malambo–West Ward	2.55	5.09	1,722	1,911	1,816.5
Mwaikole–Mission	6.88	55.00	1,440	2,019	1,729.5
Mwaikole via Volcanic Stone	6.81	6.81	1,438	1,981	1,709.5
Mwatisi River	3.23	3.23	1,712	1,911	1,811.5
Ndala River	3.23	3.23	1,689	1,909	1,799
Ngumbulu–Peak/Crater	9.29	18.59	2,215	2,943	2,579
Ngumbulu–Livingstone	7.14	7.14	2,218	2,372	2,295
Syukula–Peak/Crater	8.19	8.19	1,622	2,944	2,283
Syukula–Dry Lake	6.78	33.90	1,681	2,359	2,020
Syukula–Lupoto	3.81	3.81	1,706	2,002	1,854
Syukula–Lusiba	7.19	7.19	1,704	2,151	1,927.5
Syukula–Rungwe Way	6.86	6.86	1,618	2,599	2,108.5
Trap check at Ngumbulu	6.23	74.80	2,197	2,740	2,468.5
Unyamwanga–Mbeye One	6.85	6.85	1,936	1,992	1,964
Unyamwanga–Ngumbulu	6.92	13.84	2,287	2,222	2,254.5
Unyamwanga–Ntokela	11.68	11.68	1,989	2,634	2,311.5
Unyamwanga–Peak/Crater	7.55	15.09	2,342	2,944	2,643
Upper Camp–Lusiba	2.37	18.96	2,453	2,147	2,300
Upper Camp–Peak	3.36	3.36	2,147	2,887	2,517
Upper Malambo–Livingstone	2.29	2.29	1,975	1,941	1,958
Upper Malambo–Mzee Samson	6.46	6.46	1,908	2,217	2,062.5
Upper Malambo inside the forest	2.32	9.26	1,957	2,183	2,070
Kitulo NP					
Kitulo Plateau 1	14.38	14.38	2,788	2,538	2,663
Kitulo Plateau 2	18.67	18.67	2,615	2,713	2,664
Kitulo Plateau 3	14.98	14.98	2,454	2,846	2,650
Kitulo Plateau 4	5.28	5.28	2,538	2,572	2,555
Livingstone East 1	3.80	3.80	2,838	2,490	2,664

Transect name	Transect length (km)	Total effort (km)	Start altitude (m)	End altitude (m)	Mean altitude (m)
Livingstone East 2	4.98	4.98	2,739	2,409	2,574
Livingstone East 3	6.46	6.46	2,839	2,755	2,797
Livingstone East 4	6.27	6.27	2,856	2,642	2,749
Livingstone East 5	5.54	5.54	2,838	2,781	2,809.5
NE Livingstone Near Usalama 1	2.96	5.92	2,570	2,860	2,715
NE Livingstone Near Usalama 2	4.65	4.65	2,501	2,824	2,662.5
North East 1	6.02	6.02	2,563	2,867	2,715
North Livingstone 1	20.15	20.15	2,313	2,650	2,481.5
North Livingstone 2	5.92	5.92	2,420	2,634	2,527
North Livingstone 3	16.72	16.72	2,657	2,183	2,420
North Livingstone 4	7.96	7.96	2,304	2,571	2,437.5
Numbe 1	9.62	9.62	2,535	2,490	2,512.5
Numbe 2	3.61	3.61	2,594	2,487	2,540.5
Numbe 3	7.55	7.55	2,445	2,537	2,491
Numbe 4	11.25	22.51	2,571	2,556	2,563.5
Numbe 5	9.62	9.62	2,541	2,726	2,633.5
Numbe 6	9.50	9.50	2,558	2,604	2,581
Numbe 9	11.71	11.71	2,571	2,587	2,579
South East 1	16.46	16.46	2,787	2,332	2,559.5
South East 2	7.24	7.24	2,337	2,289	2,313
South East 3	6.48	6.48	2,579	2,583	2,581
South East 4	4.85	4.85	2,579	2,597	2,588
South East 5	4.75	4.75	2,570	2,596	2,583
South West 1	4.67	4.67	1,707	1,928	1,817.5
South West 2	2.10	2.10	1,706	1,885	1,795.5
South West 3	6.70	6.70	2,753	1,826	2,289.5
South West 4	17.13	17.13	2,694	2,334	2,514
West Livingstone 2	10.12	10.12	1,911	1,782	1,846.5
West Livingstone 3	14.66	29.32	2,428	2,228	2,328
West Livingstone 4	10.67	21.33	2,291	2,247	2,269
West Livingstone 5	16.38	16.38	2,218	2,170	2,194
West Livingstone 7	5.88	11.76	1,698	1,687	1,692.5

Mt Rungwe Nature Reserve and surrounds (*n* [the number of transect routes] = 46); Kitulo National Park in 2004 (*n* = 37). Survey effort in other years is not incorporated.

Appendix 2. Interview questionnaire.

Interview N. Date

Village name……GPS location…….

1) Name of respondent:……1.1) Tribe……

2) Age: 2.1) Were you born here ? 2.2) If not, when did you arrive?

3) Do you keep livestock? y/n

3.1) which one?

3.2) how many?

4) Show the animal picture in the booklet and ask the questions:

ID N.	English	Kiswhaili	Kinyachusa/ Kikinga	Seen in Rungwe? (y/n)	Where? Habitat type/ name of location	What time of the day?	When? Year (00s, 90s, 80s)	Season?	N. of ind?	Activity of animal
1	African Clawless Otter	Fisi Maji Kubwa								
2	Zorilla	Kicheche								
3	Striped Weasel	Chororo								
4	Ratel (Honey Badger)	Nyegere								
5	Large Spotted Genet	Kanu								
6	Servaline Genet	Kanu								

7	African Civet	Fungo								
8	African Palm Civet									
9	Egyptian Mongoose	Nguchiro								
10	Common Slender Mongoose	Nguchiro?								
11	Banded Mongoose	Nkuchiro								
12	Marsh Mongoose	Nguchiro wa Maji								

RISK PERCEPTION and problem animals

5.1) Is wildlife bothering the people of the village? y/n

5.2) Why?

5.3) Is any of the following species a PROBLEM?

Genet
Zorilla
Striped Weasel
Common Slender Mongoose
Banded Mongoose
Egyptian Mongoose
African Clawless Otter
Ratel
Others

If YES, when do they attack? Night/Evening/Afternoon/Morning

Do people use some protection measures against problem animals?

What do they do?

HUNTING PRESENT AND PAST

7.1) Do villagers use to hunt in the area of Mt Rungwe? Yes/No

7.1.1) When?

7.2) What were the most common species hunted?

7.3) Do villagers hunt now? Yes/No

7.4) Do villagers hunt for? Food/Culture/tradition/trade/business

7.5) Are the hunters coming from outside your village? Yes/No

7.6) If they do, do hunters coming from outside hunt for? Food/Culture/Tradition/ Trade/Business

7.7) Do villagers hunt to sell the skin of the animal or the body parts? Y/N

CONSUMPTIVE USE OF CARNIVORE PARTS

8.1) Do people use the parts of carnivores for local medicines?

8.2) Which carnivores people prefer?

8.3) What part do people use?

8.3a) And what for?

8.4) Is it easy to catch?

8.5) How do they hunt them?

8.6) When is the best time to hunt them?

8.7) Do you know anybody that knows how to catch it?

8.8) Do they catch it often? One per week, one per month, 1 per 6months/ 1 per 12months.

Appendix 3. Vernacular names of small carnivore species collected around Mt Rungwe NR in 2003*.

English Name	Species	Kiswahili	Kinyakyusa	Kinga
Zorilla	*Ictonyx striatus*	Kicheche	Mole	Ekenyelechi
African Striped Weasel	*Poecilogale albinucha*	Chororo	Inyagisi	-
Cape Clawless Otter	*Aonyx capensis*	Fisi maji	Mbago	-
Honey Badger	*Mellivora capensis*	Nyegere	Mbukula	Amadunungu
African Palm Civet	*Nandinia binotata*	Fungo	Efungo	Lifungo lyamwinyasi
Large-spotted Genet	*Genetta maculata*	Kanu	Lwengwe	-

English Name	Species	Kiswahili	Kinyakyusa	Kinga
African Civet	*Civettictis civetta*	Fungo	Efungo	Lifungo lyamwinyasi
Marsh Mongoose	*Atilax paludinosus*	Nguchiro wa Maji	Nsyesyi / Ngalang'asa	Kimwelelo
Egyptian Mongoose	*Herpestes ichneumon*	Nguchiro	Isanga	Kimwelelo
Common Slender Mongoose	*Herpestes sanguineus*	Nguchiro	Nsyesyi / Ngalang'asa	Kimwelelo
Banded Mongoose	*Mungos mungo*	Nguchiro	Nsyesyi / Ngalang'asa	Kimwelelo

*Information from 126 interviewees.