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ABSTRACT

From 1993 to 2000, observations were made of small to medium-sized mammals in seven poorly known submontane forest reserves and one village forest in the North Pare, South Pare, East Usambara and Nguu Mountains, Tanzania. Of 26 species recorded, three are Red-Listed as Threatened (Endangered: Zanj elephant shrew *Rhynchocyon petersi*; Vulnerable: red-bellied coast squirrel *Paraxerus palliatus*, and eastern tree hyrax *Dendrohyrax validus*) and five as Lower Risk (two dwarf galagos *Galagoides* spp., African buffalo *Syncerus caffer*, suni *Neotragus moschatus*, and Harvey's duiker *Cephalophus harveyi*). Most of our mammal records represent new distributions in the Eastern Arc Mountains, and one record of an unidentified squirrel in the Nguu Mountains is of conservation interest. Together with timber removal and cultivation, hunting appears to threaten the survival of mammals in these forests. There is an urgent need to establish long-term conservation programmes in these forests and more thorough surveys of mammals are necessary.

INTRODUCTION

The moist forests of eastern Tanzania harbour a number of endemic forest mammals, the ecology and conservation status of which are poorly known (Kingdon & Howell, 1993; Rathbun, 1995; Perkin *et al.*, 2002). Despite the biological importance of these forests (*e.g.*, Lovett & Wasser, 1993) they are at risk from high rates of deforestation (Hamilton, 1989; Rodgers, 1993; Newmark, 2002), conservation in Tanzania having focused more on the protection of the lowland savannah habitat and the large mammals it harbours (Rodgers, 1993). Apart from the recently

established Udzungwa Mountains National Park and Amani Nature Reserve, moist forest in eastern Tanzania is only protected as Forest Reserves (FRs), which does not adequately protect the forest from unsustainable exploitation and destruction (Rodgers, 1993).

We conducted surveys of various faunal groups in submontane forests in the North and South Pare Mountains, and in the East Usambara Mountains and Nguu Mountains between July 1993 and September 2000, with one previous excursion in 1984 (table 1) (figure 1). During these surveys, we documented all small to large mammals that were encountered. The impetus for this paper comes from the scarce information on the mammal fauna in the North and South Pares (Swynnerton & Hayman, 1949), Nilo FR in the East Usambaras (Allen & Loveridge, 1927), and the Nguu Mountains. Thus, in this paper we present our records of various mammal species in eight forests of the four Eastern Arc Mountains. We further provide notes on the ecology of poorly known, globally threatened forest mammals. Threats to their survival in these forests are briefly discussed.



Figure 1. Eastern Arc Mountains in Tanzania and Kenya. Mountains shaded in black are areas we surveyed.

STUDY SITES AND METHODS

We conducted fieldwork in seven Forest Reserves and one village forest: Kindoroko, Minja, Mramba, and Kamwalla II FRs, Kilambeni Village Forest (North Pares), Chome FR (South Pares), Nilo FR (East Usambaras), and Nguru North FR (Nguus) (table 1). Forest Reserves are managed by the central government whereas village forests are under the

Table 1. Summary of fieldwork effort, elevations sampled, and dates of fieldwork for the study sites.

FR	Site	Altitude (m)	Dates	Field-hours‡ day	night	Coverage §	Observers **
Kindoroko (885 ha)	(37°38'E, 3°44'S) several stations	1400–2100	8–22 Jul 1993	180	14	30 km, 50%	NC
Minja (520 ha)	(37°40'E, 3°35'S) several stations	1300–1750	15–25 Aug 1984	*	*	30 km, 60%	KH, CM
			26 Jul–2 Aug 1993	92	11		NC
Mramba (3355 ha)	(37°36'E, 3°34'S) several stations	1550–1750	2–6 Aug 1993	38	3	10 km, 40%	NC
Kamwalla II (293 ha)	(37°35'E, 3°43'S)	1550–1800	28–30 Jul 1994	31	2	3 km, 80%	NC
Kilambeni VF (unknown)	(37°41'E, 3°38'S)	1500	14–25 Aug 1984	*	*	4 km, 40%	KH, CM
Nilo (2720 ha)	Kilanga (38°40'E,4°55'S)	700–1050	20–31 Jul 1995	269	12	95 km, 60%	PMN
	Lutindi (38°39'E, 4°42'S)	600–1500	2–12 Aug 1994	119	7		NC
			4–31 Jul 1995	329	11		PMN
			9–10 Oct 1996	8	0		NC
			15-18 Oct 1998	4	18		AP
Chome (14282 ha)	Chome (37°50'E, 03°55'S)	1100-2000	10-12 Sept 2000	18	12	3 km, 20%	AP
			17-26 Jul 1993	*	*		WS
			20-27 Aug 1994	*	*		WS
Nguru North (14042 ha)	Gombero (37°28'E, 5°29'S)	1000–1550	11–25 Aug 1995	369	22	85 km, 40%	PMN
			28 Jul–16 Aug 2000				WS
	Luago (37°28'E, 5°36'S)	1000–1300	28 Aug–8 Sep 1995	317	18		PMN

‡ One field-hour is defined as one hour of field observations carried out by a single person or group of people working together.
§ Coverage represents a conservative estimate of survey length (km) and per cent of forest sampled in each of the forests (note that a few forest reserves include adjacent woodland as well).
* Observations at some forests were *ad hoc* and therefore sampling periods cannot be presented.
** *Key to observer names*: AP = Andrew Perkin, CM = Charles Msuya, KH = Kim Howell, NC = Norbert Cordeiro, PMN = Project Mount Nilo (see Seddon *et al.*, 1995, 1999a,b), WS = William Stanley

jurisdiction of local communities. Surveys were conducted at two sites in Nilo FR (Lutindi and Kilanga) and two sites in Nguru North FR (Gombero and Luago). For a detailed description of these forests see Hamilton & Bensted-Smith (1989), Lovett & Pócs (1993), Cordeiro & Kiure (1995), Stanley *et al.* (1996, 1998a), Cordeiro (1998) and Seddon *et al.* (1999a,b).

We made opportunistic observations of mammals when they were encountered while we surveyed birds and other fauna along hunter and animal paths that passed through a variety of forest microhabitats. For each mammal observation, the identity of the species, number of individuals, behaviour, altitude, location, and habitat were recorded. Nocturnal observations were made from well-defined footpaths with the aid of spotlights to detect eye-shine and to illuminate mammals for identification, mostly between 04:00–06:00 h and 19:00–24:00 h. Tape recordings were made (by AP in Chome FR and Nilo FR) on a Sony WM6 coupled to a Sennheiser K6-ME66 microphone. We also regularly checked stream banks and paths for tracks. We report on most mammals observed, including squirrels. Shrews, bats and smaller rodents are not discussed here as they have been more systematically sampled in many of the study areas and have been and will be reported on elsewhere (Stanley *et al.*, 1996, 1998a,b).

Species detectability or encounter rates vary according to habitat, behaviour relative to human presence and hunting intensity, and other factors associated with the nature of our opportunistic observations, including variability of observer experience with these animals. For the mammals we observed in each forest, we fully recognise that our sampling was inadequate to document the entire fauna and so we do not statistically compare species richness or encounter rates between and among forests.

To qualitatively assess potential threats to mammals, any evidence of mechanical logging, pit-sawing, pole collecting, cultivation within forests and hunting were documented. In addition, informal discussions with inhabitants of settlements adjacent to each forest provided information on the targets and relative frequency of mammal hunting in the forests and how people used the forest (*e.g.* for timber, fuel, food).

Taxonomy follows that of Kingdon (1997) and Grubb *et al.* (2003) (for primates). Threatened status is based on the 2003 IUCN Redlist (www.iucn.redlist.org).

RESULTS, NOTES ON THREATENED SPECIES, AND THREATS

Survey effort and coverage of the eight forests was variable, with Nilo, Nguru North and Kamwala II FRs being more extensively surveyed than the others (table 1). Nonetheless, 26 mammal species were recorded in the eight forests (table 2, note: dwarf galagos are counted as two and not three species as some of the unidentified galagos are probably mountain dwarf galago *Galagoides orinus* Lawrence & Washburn). The forest within and adjacent to Nilo FR supports at least 18 of the mammal species that are the focus of this paper, six of which are of conservation concern (table 2). In Nguru North FR, a total of at least 18 mammal species were recorded, including eight of conservation concern. In the North Pares, 17 species were recorded, including five of conservation concern (Kindoroko, Minja, Mramba, Kamwalla II, Kilambeni: 9, 13, 9, 6 and 10 species, respectively). In the South Pares, 14 species were recorded, including four of conservation interest. We provide notes and brief discussions of the Threatened and Lower Risk species below.

Dwarf galagos *Galagoides* spp.

The taxonomy of this group has recently been extensively revised primarily on the basis of

Table 2. Mammal species recorded in the eight Eastern Arc Mountains forests (altitudes of animal observations are summarised for entire forests based on information collated by all observers; elevations are in parentheses)*

Species	Status[a]	Kindoroko FR	Minja FR	Mramba FR	Kamwalla II FR	Kilamben VF	Mount Nilo FR	Chome FR	Nguru North FR
Angolan pied colobus *Colobus angolensis palliatus*		–	–	–	–	–	(900–1500)[d]	(1500–1700)	–
Yellow baboon *Papio cynocephalus*		–	(1400, edge)	(1500, edge)	–	–	(900–1500)	–	(1200)
Sykes's monkey *Cercopithecus mitis*		(1500–2100)	(1400–1750)	(1500–1750)	(1500–1800)	(1500)	(800–1500)	(1100–1400)[d]	(1100–1400)
Small-eared galago *Otolemur garnettii*		(1500–1800)	(1400–1600)	(1700)	(1600)	(1600)	(1100–1200)	(1500–1700)[d]	(1100–1200)
[Dwarf galagos *Galagoides* spp.]	LR/dd	–	–	–	–	–	(1000–1500)	(1500–1700)	(1100–1300)
[Zanzibar galago *Galagoides zanzibaricus*]	LR/nt	–	–	–	–	–	?	–	(1150–1350)
Mountain galago *Galagoides orinus*	LR/dd	–	–	–	–	–	(800–1500)	–	–
Zanj elephant shrew *Rhynchocyon petersi*	T(EN)	(1500–1900)	(1400–1700)	(1600–1750)	(1600–1750)	(1500)	(1050–1250)	(1100)	(1100–1300)
Tanganyikan mountain squirrel *Paraxerus lucifer*		(1500–2100)	(1600–1750)	(1600–1750)	–	–	(1000–1500)[d]	(1500–1700)	(1100–1300)
Red-bellied coast squirrel *Paraxerus palliatus*	T(VU)	–	–	–	–	–	–	–	(1100–1350)
[Bush squirrel sp. *Paraxerus* sp.]	?	–	–	–	–	–	–	–	(1100–1250)
Zanj sun squirrel *Heliosciurus undulatus*		(1400–1900)	(1400–1750)	(1500–1750)	(1500–1750)	–	(800–1400)	(1100)[e]	(1100–1300)
Ochre bush squirrel *Paraxerus ochraceous*		–	–	–	–	–	–	(edge, 1100)[e]	–
Lord Derby's anomalure *Anomalurus derbianus*		–	–	–	–	–	(1200)	–	–
Porcupine *Hystrix* sp.		–	–	–	–	–	quill (1230)[c]	quill (1500–1700)[c]	–

Species	Status [a]	Kindoroko FR	Minja FR	Mramba FR	Kamwalla II FR	Kilambeni VF	Mount Nilo FR	Chome FR	Nguru North FR
Clawless otter *Aonyx capensis*		–	–	–	–	–	–	–	(1200) [b]
African civet *Civettictis civetta*		–	–	–	–	(1500)	–	–	–
African palm civet *Nandinia binotata*		–	(1450)	–	–	–	(1100)	(1100–1700) [f]	(1100–1350)
Blotched genet *Genetta tigrina*		–	–	–	–	(1500)	– [d]	(1500–1700)	–
Banded mongoose *Mungos mungo*		–	–	–	–	(1500)	(1200)	–	–
Leopard *Panthera pardus*		–	(1300)	–	–	–	–	–	(1100–1250)
Eastern tree hyrax *Dendrohyrax validus*	T(VU)	(1500–2000) [d]	(1400–1750)	(1750)	(1600)	(1500)	(900–1500)	(1500–1700) [d]	(1100–1300)
Bush pig *Potamochoerus larvatus*		(1500–2100)	(1400–1750)	(1500–1750)	(1750)	(1500)	(1500)	(1500–1700)	(1100–1350)
African buffalo *Syncerus caffer*	LR/cd	–	–	–	–	–	–	–	(1450)
Bushbuck *Tragelaphus scriptus*		–	(1600–1700)	–	–	–	(900–1500)	(1500–1700)	–
Suni *Neotragus moschatus*	LR/cd	(1500–2100)	(1400–1750)	(1750)	–	(1500)	(1000)	–	(1140)
Harvey's duiker *Cephalophus harveyi*	LR/cd	(1400–2100)	(1400–1750)	–	–	(1500)	(1300)	(1500–1700)	(1150–1350)

* Due to the nature of our collective observations, elevational ranges of each species are incomplete for each forest.

[a] Conservation status according to the 2003 IUCN Redlist (www.iucn.redlist.org): T = threatened, LR = lower risk, (EN) = endangered, (VU) = vulnerable, cd = conservation dependent, (nt) = near-threatened, (dd) = data deficient.

[b] Record of Michel Menegon (pers. obs.) in Nguru North FR along a stream bank (37°28'31"E, 5°28'49"S), February 2002.

[c] *H. cristata or H. africaeaustralis*

[d] Old records in Swynnerton & Hayman, (1949)

[e] Records published in Stanley *et al.*, (1996, 1998a).

[f] Three individuals were snared by local villagers in Chome FR and brought to WS as specimens (now at the Field Museum and University of Dar es Salaam).

molecular studies, penile structure, pelage and vocalisations. Several species of *Galagoides* are now recognised but these have not all been described (Bearder *et al.*, 1995; Bearder, 1999; Perkin *et al.*, 2002; Grubb *et al.*, 2003). All known species of *Galagoides* are believed to be restricted to forest, including riparian strips (Grubb *et al.*, 2003). On the basis of the advertisement vocalisations described below, we believe that all individuals recorded belong in *Galagoides*. There are three species of *Galagoides* known to occur in the Eastern Arc Mountains and an additional undescribed form (Perkin *et al.*, 2002; Grubb *et al.*, 2003).

Dwarf galagos occurred at the three sites where these primates were specifically looked for: Chome FR, Nilo and Nguru North FR; they were not looked for in the North Pare forests, nor were they observed opportunistically. All visual records were of individuals or pairs, swiftly scampering or leaping through the canopy and subcanopy of mature trees in intact submontane forest. At Chome FR three individuals of a *Galagoides* spp. were seen on two consecutive nights. The vocalisations were heard briefly and only partially recorded. These calls lasted for less than 5 s and they sounded similar to the advertising calls of the as yet unidentified *Galagoides* sp. from the Taita Hills (Perkin *et al.*, 2002; similar observations in Chome FR were made by T. Butynski and C. Ehardt in 2000, pers. comm. 2004). At Nilo FR, one dwarf galago call comprised a loud, high pitched, slightly staccato bark repeated at diminishing intervals 10–15 times before an explosive burst of rapid clicks rising in pitch, akin to machine-gun fire. One of us (AP), who has confirmed mountain dwarf galago in Nilo F+R from previous visits, diagnoses this call as a type of alarm call 'grunt shrieks and rapid yaps' uttered by a mountain dwarf *orinus* type galago.

In Nguru North FR two distinctly different dwarf galago calls were heard and tape-recorded, although the identity of the callers was not confirmed visually. One call comprised a series of medium to high pitched 'yaks' repeated at regular intervals 20–30 times per bout, interrupted by a short screech or 'queet' that rose in pitch at the end, or by a longer squeal. The other call comprised a series of frequency-modulated notes repeated at regular intervals interspersed with high-pitched cackles and squeals. These two calls are both alarm calls probably responding to two different types of stimuli. It is possible that these calls were given by two different species, although good views were only obtained of one which closely fits the description given in the literature for Zanzibar galago *Galagoides zanzibaricus* (Matschie): brown above with tinges of chestnut on the head, back and thighs, cream suffused with grey below, a uniform grey-brown medium-thick tail with no black tip, two broad black rings around the dark red eyes, and a white stripe from the snout to the forehead. It appeared slightly larger than the dwarf galagos briefly observed at Nilo FR.

Dwarf galagos remain poorly understood, and given the presence of an unidentified dwarf galago species in the Taita Hills in Kenya (Perkin *et al.*, 2002), it is essential to look for these species in the nearby North and South Pare Mountains as well as other mountains. Further south, dwarf galagos seen and recorded in the Rubeho (Doggart *et al.*, in press), Uluguru Mountains (Perkin, 2000) and Udzungwa Mountains (Butynski *et al.*, 1998; Perkin, 2001) were confirmed as mountain dwarf galago. The interpopulation differences in vocal repertoires and the morphology of mountain dwarf galago in other long-isolated Eastern Arc Mountains forests require further study.

Zanj elephant shrew (or sengi) *Rhynchocyon petersi* (Bocage)

This species was encountered infrequently in all the forests. Zanj elephant shrews were observed chiefly within intact submontane forest habitat within and adjacent to the forests, but one of us (CAM, pers. obs.) has also seen them in small traditional forests in the North Pares. Kingdon (1984) notes that giant elephant shrews (*Rhynchocyon*) require a deep, dry

leaf litter for nesting and foraging, as documented for *R. chrysopygus* Günther (Rathbun 1979). Most sightings in Nilo and Nguru North FRs were brief and of lone individuals (81.6%, n=38) fleeing through dense undergrowth in their typical 'bounding' gait [see Rathbun (1979) for *R. chrysopygus*]. On 11 occasions we observed sengis foraging in the leaf litter, once in the open, and at other times in the dense forest understorey. Kingdon (1984) notes that this species is generally solitary and forages alone. However, on one of the few occasions when two individuals fed together, one slightly smaller than the other, we observed one scent-marking by dragging the perianal region on a fallen tree-trunk. Biometrics for specimens obtained in the Chome FR are given by Stanley *et al.* (1996).

Red-bellied coast squirrel *Paraxerus palliatus* (Peters)

This squirrel was not recorded at any of the North Pare forests, nor Nilo FR, but it was present in Nguru North FR. While not recorded from the upper elevations of Nilo FR, this rodent also inhabits forest and dense woodland in the adjacent lower Bombo Valley (Cordeiro & Githiru, 2000). This squirrel usually inhabits the canopy of mature trees (Nowak, 1991), and because it was not recorded in degraded habitat, this suggests that the presence of mature trees in dense woodland or forest habitats may be important for its long-term survival. It was distinguished from other squirrels by its red to orange belly and tail. It was observed throughout the day in intact submontane forest and was frequently observed in pairs (40% of records, n=20), often performing an aggressive display, which involved tail-flicking towards, and barking at, conspecifics and observers.

Bush squirrel *Paraxerus* sp.

A bush squirrel that does not precisely fit any description in the current literature was infrequently encountered in intact submontane forest at the Luago site in Nguru North FR. Six individuals were observed closely and resembled the Tanganyika mountain squirrel race *P. lucifer lucifer* (Thomas) race: they were a rich cinnamon rufous above, slightly olive on the head, uniformly cream below; they had a dark brown dorsal patch, and a conspicuously thick, red bushy tails with no obvious bars; and they appeared to be slightly larger than *P.l. lucifer*. This squirrel was recorded throughout the day, often in pairs, and barked and flicked its tail at observers and conspecifics. Further work on the taxonomic position of this squirrel is needed before any conclusions can be made as to its status.

Eastern tree hyrax *Dendrohyrax validus* (True)

This species was recorded in Kindoroko, Minja and Kamwalla II FRs and Kilambeni Village forest, but may have been overlooked in Mramba FR where steep terrain prevented adequate exploration of the entire forest expanse. It was common in Nilo FR and uncommon in Nguru North FR. There were no sight records of this species, only aural records made at 19:00–21:00h and 04:00–06:00h in intact submontane forest. In Nilo FR this species seemed most common in forest at lower elevations (900–1300 m) where 10–14 individuals, possibly territorial males (Estes, 1992), were heard calling nightly. It was rarer in stunted forest on ridges and at 1500 m, where only 4–6 individuals were heard. Here the absence of large, mature trees for nest holes may have been a limiting factor. Similarly, at Kindoroko FR, it was commonly heard at 1500–1800 m, but less so above these elevations. In Minja and Kamwalla II FRs it was uncommon, whereas in Nguru North FR, eastern tree hyrax appeared to be more common in an area of submontane forest at 1300 m where 4–6 individuals were heard calling, compared to 2–3 elsewhere. This area was characterised by larger trees, including *Albizia gummifera* (J.F.Gmel.) C.A.Sm., more so than elsewhere (modal dbh: 30

cm *vs.* 20 cm, maximum dbh: 160 cm *vs.* 130 cm). Hyraxes mainly called at dawn and dusk although on three occasions they were heard during the day when apparently disturbed by Sykes's monkeys *Cercopithecus mitis* (Sykes). Eastern tree hyraxes den in large, mature trees (Kuendaeli, 1976) and large rocks and boulders, and all our records were from intact forest.

Suni *Neotragus moschatus* (Von Dueben)
This antelope was rarely encountered at all sites, and it is likely to have been overlooked and under recorded due to its elusiveness. At least one individual was flushed at 1200 m in Nilo FR. Droppings believed to be of this species were seen at Kindoroko and Minja FR. While local hunters reported its presence in the North Pare sites, it was not observed by us there, but was encountered in Kilambeni Village forest in 1984, and in traditional sacred forests near Kilambeni in 2000 (CM). In Nguru North FR, two individuals were briefly observed together at 22:30 h in the dense undergrowth of intact submontane forest.

Harvey's duiker *Cephalophus harveyi* (Thomas)
The red duikers we were able to identify in these forests most closely resembled Harvey's duiker in size and colouration. This duiker was recorded at Nilo, Kindoroko, Minja, and Nguru North FR and Kilambeni Village forest. An individual was seen at the edge of Kindoroko FR, and fleeing individuals were rarely encountered in Nilo and Minja FRs. It was recorded in intact submontane forest in Nguru North FR; seven of the eight records were of single individuals moving rapidly through the undergrowth in full daylight. On one occasion, two duikers were observed foraging for 10 minutes during which time they gave soft, barking contact calls. We also made poorer observations of smaller and duller red duikers moving rapidly through the undergrowth, which may suggest the presence of Natal duiker *C. natalensis* in some of the sites visited. This remains to be confirmed.

OBSERVATIONS ON THREATS TO MAMMALS AND FORESTS

We did not observe any signs nor obtain any reports of hunting or trapping designed specifically for elephant shrews, dwarf galagos and squirrels in any of the forests visited. However, specimens of both squirrel and elephant shrew were caught in snares in the Chome FR and delivered to WS (Stanley *et al.*, 1996). In contrast, the eastern tree hyrax, suni and Harvey's duiker were much sought after in all forests, but apparently less so in the Nguu Mts. One of us (WS) obtained two adult eastern tree hyraxes that were snared at the forest edge in Nguru North FR, and CM notes that this hyrax is often snared or hunted with dogs in the North Pares. Small hunting parties using dogs were noted in nearly all forests, where Harvey's duiker and suni were primary prey, but other targeted species included other antelope, bushpig and tree hyrax. Hunting with dogs was frequently evident or readily reported by villagers in Nilo FR and the forest reserves in the North Pares. Men with dogs and catapults were observed on six occasions, more than 15 old pit traps for antelopes were found well within these forest reserves, and several small baited traps for cane rats *Thryonomys* spp. and giant rats *Cricetomys gambianus* Waterhouse were found in and adjacent to Nilo FR. There was scant evidence of similar levels of hunting in Nguru North FR in 1995, but more signs (snares for large mammals) were prevalent in 2000.

Habitat loss and degradation were commonly encountered in all the forests visited. Forest loss was observed in Nilo, Kilambeni and Minja FRs in particular, where forest fires from neighbouring *shambas* encroached well into the forest edge. Degradation of forests, on the

other hand, was frequently observed in all forests, but especially Nilo and Minja FRs, where overgrazing by cows, sheep and goats in the forest understorey was rampant during our visits. In severe cases, the forest understorey was often devoid of dense vegetation, heavily trampled and thereby encouraged invasion of grasses. All forests also experienced some level of timber removal from pit-sewers, with large mature trees being cut in Kilambeni, Minja, Nilo and Nguru North FRs. Timber removal, along with cultivation of crops such as marijuana and cardamom found in Nilo FR, often create large gaps that can lead to the invasion of non-indigenous herbs and shrubs, including the highly invasive *Lantana* shrub.

DISCUSSION

Distribution records and sampling

Most mountains we visited represented new localities for a number of forest-dependent mammals, including globally threatened species. The threatened species located in these mountains were Zanj elephant shrew (Endangered), red-bellied coast squirrel (Vulnerable), eastern tree hyrax (Vulnerable) and five others classified as Lower Risk (two dwarf galagos *Galagoides* spp., African buffalo, suni, and Harvey's duiker). Because of the variation in both sampling effort and observer experience, we recognise that our data prevents a direct comparison of species richness and abundance among forests and mountains. However, based on our observations, we predict that the Nguru North FR harbours a more diverse mammal fauna (that has suffered less human impact) than Nilo and Chome FRs, and all four North Pare FRs. In Nilo FR, the mammal species we documented was similar to the number observed in Nguru North FR; however, based on direct observations and spoor by the same observers (unpublished data, PMN) abundances were lower in Nilo FR. We observed fewer species in the forests of the North and South Pares. Much lower survey effort may explain the fewer species recorded in Chome FR (see table 1); however, we discuss other possible reasons for this trend in the North Pare forests as well as Chome FR below.

Threats to mammals and forests

Multiple and varied levels of human activities have impacted the forests we surveyed and the populations of large mammals they harbour. The long-term survival of forest mammals in these reserves may be jeopardised by habitat loss, degradation and hunting. Below, we discuss the potential effects of each of these inter-related threats on this fauna.

Hunting and snaring threatens eastern tree hyrax and small antelope but apparently not dwarf galagos and red-bellied coast squirrels in these forests. Zanj elephant shrew populations are likely impacted by opportunistic snaring in certain areas. Scant observations or signs of bush pigs *Potamochoerus larvatus* Cuvier and small antelope were made in most of the forests, but especially so in Nilo and Chome FRs, and the North Pare forests. Judging from much larger flight-distances, small antelope and bushpig were less shy in Nguru North FR than in the other forests surveyed, suggesting that by 2000, hunting was apparently less severe there. In contrast, elephant shrews and forest squirrels were not reported to be the targets of specific hunting in our Eastern Arc forests, compared to, for example, coastal forests in south-eastern Kenya where they are directly pursued for meat (Rathbun, 1995; FitzGibbon *et al.*, 1995). Elephant shrews and forest squirrels may get caught during attempts to capture other mammals in pit falls, snares, and other kinds of traps. However, because WTS obtained four adult specimens of Zanj elephant shrew and two squirrel species in Chome FR from villagers who snared them along forest trails (table 1), it may be that

capturing these animals, at least in portions of the Pare Mountains, may be more prevalent than our observations and discussions with local villagers suggested.

Quantification of harvesting levels was not performed by us; however, further research in this area is essential to determine what species are harvested unsustainably (see FitzGibbon *et al.*, 1995). Our qualitative evidence suggests that some of the larger, conspicuous species are quite rare in some of the large forests such as Kindoroko and Nilo FR. Rarity of these conspicuous species is probably attributable to over-harvesting, and if continued unabated, could lead to extirpation. For example, lack of records of conspicuous species like Angola pied colobus *Colobus angolensis palliatus* Peters in the North Pares (see also Rodgers, 1981) is peculiar, as there are previous reports of its potential occurrence from Kindoroko FR in the past (F. Mturi, pers. comm.), and skins of this species were used in ceremonies of the Pare people (CM, pers. obs.). We are uncertain whether this colobus still exists in small numbers, ever did occur (see Rodgers, 1981), or if it really was extirpated in the North Pares. Similar questions about the levels of harvesting need to be addressed for smaller antelope like suni, Harvey's duiker and eastern tree hyrax, especially in the forests where hunting appeared more prevalent.

Apart from hunting, forest loss and degradation threaten populations of many of the mammal species (Newmark, 2002). Pit-sawing, cultivation at the forest edge or within forests, and livestock grazing posed the most serious threats to the forest mammals in Nilo FR and North Pare forests; in Nguru North FR, pit-sawing and mechanical logging were already degrading the forest and are likely to increase in frequency in the near future due to the construction of a new road close to Luago and recent gold-mining activities in the Eastern Arc Mountains (Seddon *et al.*, 1999b; Doggart *et al.*, 2004). The removal of large mature trees and alteration of forest structure through cultivation, gold-mining and logging is likely to detrimentally impact most of the threatened species. Our observations, together with those of other authors (*e.g.* Kuendaeli, 1976; Nowak, 1991; Hanna and Anderson, 1994; Rathbun, 1995; Kingdon, 1997), indicate that Zanj elephant shrews, dwarf galagos, suni, Harvey's duiker and red-bellied coast squirrels prefer intact, undisturbed forests and dense woodland. With increased habitat disturbance or loss, complete extirpation of these species can occur, as appears to be the case for the Zanj elephant shrew in the Pangani area of Tanzania (Rathbun & Ribble, 2003).

Conclusion

Concurring with Rodgers (1993), we note that forest reserve status does not adequately protect the forests or wildlife of the targeted area. Given the varied threats to mammals and the presence of Threatened and Lower Risk mammal species, as well as a number of other mammal, bird, and herptile species of conservation importance (Cordeiro & Kiure, 1995; Stanley *et al.*, 1996; Stanley *et al.*, 1998a,b; Cordeiro, 1998; Seddon *et al.*, 1999a,b; Perkin, *et al.*, 2002; Spawls *et al.*, 2002; Menegon *et al.*, 2004), we conclude that there is an urgent need for an effective, long-term conservation programme in these forests. Informal discussions with local people indicated a growing concern over the rate and extent of forest loss and a willingness to become involved with conservation of habitats and biodiversity conservation (see also Mwihomeke *et al.*, 1998). Conservation programmes should therefore take advantage of this interest. Finally, we also recommend that more thorough, standardised sampling of mammal fauna, including small mammals and bats, be conducted in these forests. This work should be carried out in other FRs in the Nguus (*e.g.*, Kilindi and Derema FRs), and in the North Pares, areas that may hold other important populations of mammals of conservation interest.

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