SPECIES RICHNESS AND ABUNDANCE ESTIMATES OF SMALL MAMMALS IN ZARANINGE COASTAL FOREST IN TANZANIA

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ABSTRACT

A study on small mammals (<2 kg) was conducted in Zaraninge Forest, Coast Region, Tanzania, in the dry and wet seasons from 1994 to1996. The forest was found to harbour 11 small mammal species from 11 genera and seven families. There was high similarity in the number of species caught during the two seasons (Sørensen Coefficient (CCs)=0.92), implying there to be minimal migration of the species in the area. A total of 159 individuals were caught during the dry season, rodents accounting for 89.3% of the total catch and insectivores 10.7%. The most common species were Cricetomys gambianus *and* Grammomys dolichurus *that had trap successes of 2.83 and 1.11 respectively. During the wet season 185 animals were caught, rodents accounting for 92.4% of the total catch and insectivores 7.6%.* Cricetomys gambianus *was significantly more abundant during the dry season.* Graphiurus murinus *was not caught in this season and no trend in abundance was detected for the other species. Forest specialist species included* Paraxerus palliatus *and* Petrodromus petersi*. No species was endemic to the forest, near-endemic species that occur in coastal and Eastern Arc forests included* P. petersi *and* Beamys hindei. B. hindei *also occurs in a few other East African forests. Threatened species* are B. hindei and P. palliatus *that are vulnerable and* P. petersi *that is endangered*. Lepus capensis *is in Appendix I of CITES list and* Hystrix cristata *and* Mellivora capensis *in Appendix III. The forest, though small is in good health and fairly well protected, therefore the species are not in danger of being locally extinct in the near future.*

INTRODUCTION

In East Africa coastal forests consist of small remnant patches (1-50 km^2) (Burgess *et al*. 2000) of a once large pan-African forest block. These patches have been affected by different climatic conditions for over a million years and by human activities for over a century. The size and geographical location of these patches together with variable, erratic rainfall regimes contribute in making these patches more vulnerable to perturbations. As a result, coastal forest ecosystems are expected to be less complex; this would translate into lower numbers of flora and fauna species and abundance compared to equivalent forest patches in tropical rainforests.

However, these coastal forests are of global conservation importance because they support unique flora and fauna with a well-developed endemic element. Thus, the World Wide Fund for Nature, Royal Botanical Garden at Kew, Missouri Botanical Garden, the International Council for Bird Preservation and Wildlife Conservation of Tanzania have recently identified them as priorities for botanical, ornithological and entomological categorization.

Coastal forests are scientifically poorly known, as they have not received detailed studies especially on small mammals. Scientific contributions on this group are from brief surveys conducted by Frontier Tanzania and compiled by Burgess *et al.* (2000 and references there in). Zaraninge Forest harbours a number of resident mammal species, both large and small, including four antelopes, four primates, a few rodents, two elephant shrews, shrews and small carnivores (Clarke and Dickinson 1995). Small mammal species richness and

abundance in a habitat can be an important indicator of habitat quality and these parameters can be useful for monitoring habitat degradation (Bowland and Perring, 1994). Small mammals are also an important component of the food chain in an ecosystem; they feed on a variety of foodstuff including plant material, insects and worms and in turn are preyed upon by small carnivores, birds of prey and snakes (Delany 1971). Therefore, depending on their numbers, they could regulate populations of their prey and predators.

As several coastal forests have been adversely fragmented and degraded by uncontrolled anthropogenic activities, there is an urgent need to identify the status of the small mammals in the remaining patches, in order to provide baseline data for sound development of conservation strategies and for meaningful comparison with future data. Small and fragmented reserves may play an important role in preserving local endemism, especially for species with low area requirements (Terborgh 1974, Terborgh and Winter 1980) like small mammals, but the fragments must be properly protected and managed. Gilpin and Diamond (1980) argue that different species will tend to be preserved using different strategies; species with moderate to low area requirements can survive in small fragments, while species with large area requirements will only be found in larger fragments. Thus, meaningful conservation practice should depend not only on the ecology of individual species, but also on its value, such as threat of extinction, aesthetics, economics or endemism.

STUDY AREA AND METHODS

Study area

This study was conducted in Zaraninge Dry Evergreen Coastal Forest situated between $6^{0}04'$ and $6^{0}13'$S and $38^{0}35'$ and $38^{0}42'$E, in north-eastern Tanzania (Fig 1). The primary forest covers an area of about 20 km^2 on a plateau, which rises to an altitude of 300 metres above sea level (Clarke and Dickinson 1995). Within the forest, there is Kiwandi swamp, which covers an area of 2.5 km^2. Several small patches of evergreen forest and thickets surround the primary forest and thereafter follows mixed wooded grassland at the lowland of the plateau.

Zaraninge Forest is surrounded on its western, northern and southern boundaries by human settlements. Past disturbance derived from encroachment for arable land, settlements and need for forest products, including bush meat. Commercial logging took place between 1950s and 1980s, but it was stopped in 1985. To accommodate villagers' aspirations, the forest boundary was shifted whereby some forest patches were left under village management programmes and forest guards were employed to protect the remaining forest from further human disturbance. It is, therefore, reasonable to assume that the forest was accorded a good measure of protection. All these factors have combined to form the present structure and function of Zaraninge Forest ecosystem and the plant and animal species it harbours.

The climate of the study area is characterized by variable rainfall pattern controlled by the Inter-Tropical Convergent Zone (ITCZ). Normally, short rains from the northeast monsoons are received between October and December and long rains from the southwest monsoons between April and June. Mean annual rainfall ranges between 900 and 1400 mm (Hawthorne 1984, Clarke 2000).

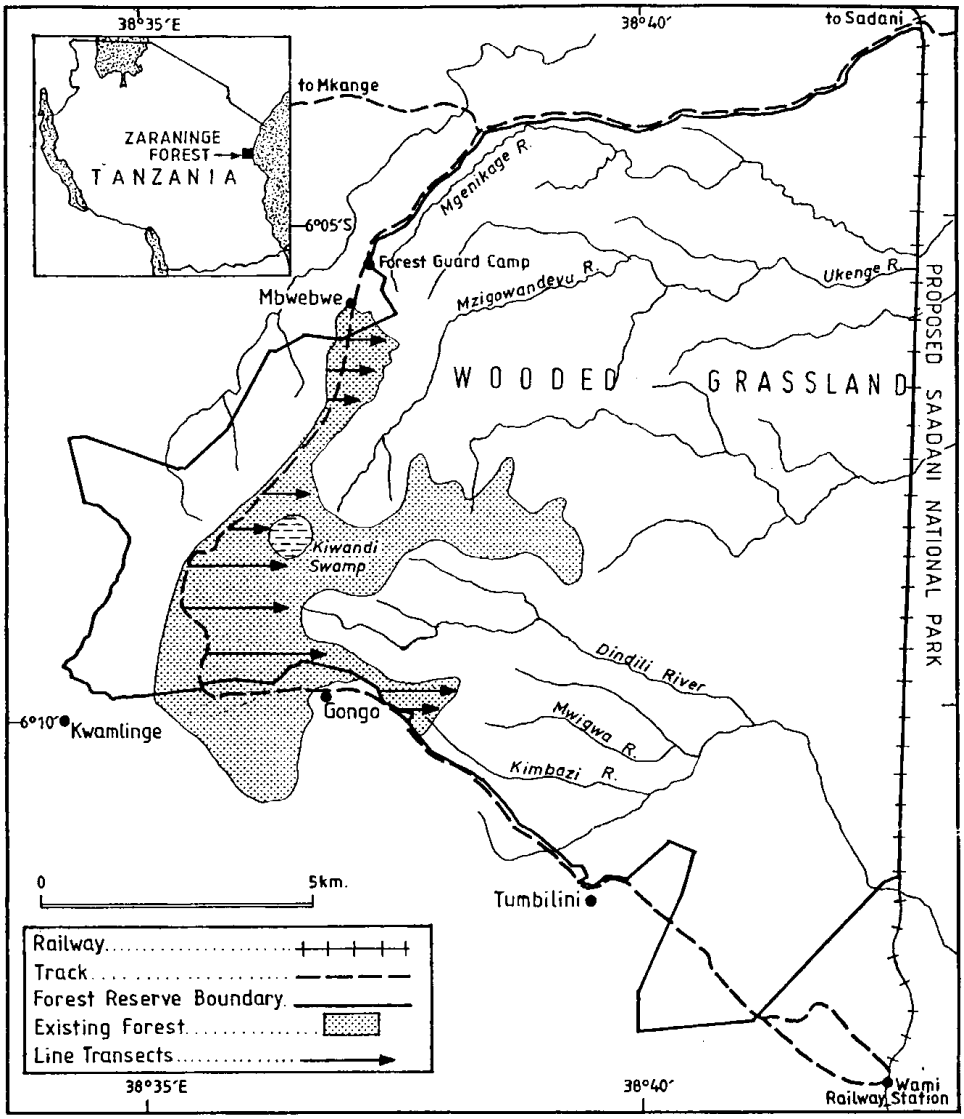

Figure 1: Map of Zaraninge Forest showing the trapline transects (Source – Forest Division Boundary map 1999).

METHODS

Small mammals were sampled from ten demarcated 1 m line transects in the primary forest. All transects ran due east starting from the main road from Mbwebwe to Tumbilini villages (Fig. 1). Trappable species (< 2 kg in body mass) varied considerably in size and behaviour, thus traps of different types and sizes were used in order to sample as many species as possible. Sherman live traps of two sizes (33*8*8 cm & 16*5*5 cm) and snap traps

(16*9 cm) were used for capturing animals below 100 g and to accommodate for the heavier species (200 g - 2 kg), Tomahawk live traps of two sizes (79*23*23 cm & 59*15*15 cm) were used.

Trap line method

Trap lines were set along the demarcated transects. Each trap line consisted a total of 108 to 112 (62 snap + 40 Sherman) traps and 18-20 Tomahawk traps. Sampling was conducted using a combination of all types of traps. All traps were set on the ground at 5 m interval and red plastic straps were tied on branches over each trap station for ease of locating. For the heavier species such as *Cricetomys gambianus* and *Petrodromus tetradactylus*, Tomahawk live traps were set along their feeding trails.

Only one type of trap was set at each trap station. Traps were checked twice daily, immediately after sunrise (0630-0730-hrs) and in late afternoon (1730-1830-hrs). Traps were baited daily in late afternoon with freshly fried coconut pieces smeared with peanut butter. Trapping was conducted for six to seven consecutive days on each transect before being shifted to another. Trapping efforts were 57 and 60 days in the dry and wet seasons respectively.

Standard museum records taken from caught animals included the species name, head and body length, tail length, hind foot length (claw not included), ear length, sex and body mass (DeBlase and Martin 1974, Delany 1971). Live caught animals were identified, sexed, weighed and marked on tails using a waterproof marker pen before being released into the field. Most of the animals killed by snap traps were preserved in 10% formalin. Only a few were skinned and prepared as voucher specimens.

Data analysis

Species richness was compiled from the list of caught animals, casual encounters and animal signs. Sϕrensen Coefficient (CCs) was used to determine the similarity of animal species between wet and dry seasons based on binary (present-absent) data (Wolda 1981, Brower *et al*. 1990).
The coefficient was calculated as follows:

$$CC_s = \frac{2c}{(s_1 + s_2)}$$

where s_1 and s_2 = the number of species caught in dry and wet seasons, respectively and c = the number of species common to both seasons. The value of CCs ranges from 0 (when no species are found in both seasons) to 1.0 (when all species are found in both seasons).

Trap success, usually expressed as the number of animals caught per 100 trap nights, was used to determine the relative abundance of the caught species (Stanley *et al*. 1996, Barnett *et al*. 2002). Trap success (TS) was calculated using the formula:
TS (%) = Tc / Tn * 100,
where Tc = Total catch = the total number of animals of species *i* caught and Tn = Trap nights = a product of the number of traps used and trapping effort (trapping effort =number of days of trapping or effective trapping nights). A trap in use for a 24-hour period from sunrise to sunrise is referred to as a trap night.

RESULTS AND DISCUSSION

Eleven species from eleven genera and seven families were recorded (Table 1). Family Muridae dominated with three species accounting for 27.3% of all the species recorded in the forest, followed in abundance by families Cricetidae and Macroscelididae with two species each, while the remaining families had one species each.

The eleven species caught ranging in size from 30 gm (*Crocidura hirta*) to 1.8 kg (*Cricetomys gambianus*) in this study amount to 24.4% of the total number (45) of small mammal species (excluding bats) recorded in the Eastern African coastal forests (Burgess *et al*. 2000). Rodents alone

account for 20.8% of all rodent species recorded in the Eastern African coastal forests (Burgess *et al.*, 2000). There are 15 species and 33 subspecies of elephant shrews in sub-Saharan Africa, and all are endemic to the continent (Nicoll and Rathbun 1990). In South Africa there are eight species whereas Tanzania has five, two of which inhabit Zaraninge Forest.

Table 1: Small mammals (< 2 kg) caught or seen in Zaraninge Forest, Coast Region, Tanzania (1994 – 1996).

Fanily	**Species**	**Common name**
CRICETIDAE	*Beamys hindei* *	Lesser pouched rat
	Cricetomys gambianus *	Forest pouched rat
HERPESTIDAE	*Herpestes sanguineus* +	Slender mongoose
MACROSCELIDIDAE	*Petrodromus tetradactylus**	Four-toed elephant shrew
	Rhynchocyon petersi +	Black-and-rufous elephant shrew
MURIDAE	*Grammomys dolichurus* *	Common thicket rat
	Mus minutoides *	Pygmy mouse
	Rattus rattus *	Black rat
MYOXIDAE	*Graphiurus murinus* *	African common dormouse
SCIURIDAE	*Paraxerus palliatus* +	Red bush squirrel
SORICIDAE	*Crocidura hirta* *	Shrew
Families (7)	**Genera (11) Species (11)**	

Key: * =mammals caught in traps; + =mammals seen but not caught.

Table 2: Dry and Wet season trap successes for the most common small mammals caught in Zaraninge Forest, Coast Region, Tanzania (1994-1996).

Season	**DRY SEASON**			**WET SEASON**		
Species	Number of animals	Trap nights	Trap success (%)	Number of animals	Trap nights	Trap success (%)
Cricetomys gambianus	29	1026	2.83	61	1080	5.65
Grammomys dolichurus	68	6156	1.11	63	6720	0.94
Beamys hindei	29	6156	0.47	45	6720	0.67
Petrodromus tetradactylus	16	5244	0.31	10	5760	0.17
Graphiurus murinus	15	6156	0.24	0	6720	0.00
Rattus rattus	1	6156	0.02	4	6720	0.06
Crocidura hirta	1	6156	0.02	2	6720	0.03
TOTAL	**159**			**185**		

Seven species were caught in the forest in the dry season compared to six species in the wet season. The Sørensen Coefficient (CCs) was 0.92, revealing a high similarity in the number of species caught during the two seasons. The observed high similarity suggests that migration of the species between the forest and surrounding habitats is minimal. This also indicates that the forest is in good health and that most of the small mammal species are forest dependent.

In the dry season a total of 159 animals were caught (Table 2). Rodents accounted for 89.3% of the total catch and insectivores 10.7%. During the wet season, 185 animals

were caught (Table 2) where rodents accounted for 92.4% of the total catch and insectivores 7.6%. *Rattus rattus* is a house rat, but a few individuals were found in one locality in the forest that was over 2 km from the nearest village. House rat, the only small mammal species found on Songo Songo Island, inhabits both houses and thickets (Kiwia and Msuya 2001).

Comparison of trap successes of different species within a locality or calculating diversity indices based on trap successes should be employed with caution because virtually all trapping methods are biased towards some species and against others. The biases are caused by factors such as diet preferences, vertical microhabitat use, body size and type of trap used that play a key role in determining trap successes of different species (Benjamin *et al*. 1984, Laurance 1992). However, differences in the number of species between different locations or seasons may be detected if the trapping regimes, and thus the biases, are similar on all sites (Benjamin *et al*. 1984). Therefore, in this study, Shannon-Wiener diversity index (H') was not calculated, instead trap success was used for comparison of the abundance of each species between seasons.

Since the seasonal trap nights for caught animals were not significantly different (Mann-Whitney U-test; U=11; n_1=7; n_2=6; p=ns), the actual numbers of individuals of each species caught in dry and wet seasons were compared to see if they differed significantly. No trend in abundance was detected except for *C. gambianus* and *Graphiurus murinus* species. For *C. gambianus* the Fisher's Exact Test detected it's abundance to be significantly higher during the wet season (p=0.023; df=1) whereas *G. murinus* was only caught during the dry season.

Cricetomys gambianus is widespread in the forest and surrounding habitats. The species showed equal preference for the forest and farmland habitats where it was most common (Kiwia 2005). Being an omnivore it eats wild fruits, seeds and invertebrates from the forest and from the farmland; it raids cultivated fruits (pineapples), cassava roots and maize seeds (Ajayi 1977). In this study, its trap success in the forest was higher during the wet season because its food was plentiful whereas during the dry season it had to visit the farmland more frequently to raid food crops.

Graphiurus murinus is predominantly arboreal where it nests in either tree holes or rock crevices (Delany 1971, Wirminghaus and Perrin 1993) and feeds on insects and seeds (Vesey-Fitzgerald 1966). None was caught in the wet season possibly because its population in the forest was low coupled with the possibility that it only occasionally descended from the canopy where insects and seeds were readily available. In the dry season it possibly had to spend more time on the ground searching for leaf litter insects, therefore, increasing the probability of being caught.

Populations of small mammals in the forest were very low, with trap successes for all species ranging from 0.02 to 2.8% during the dry season and 0.00 to 5.7% in the wet season. In South Africa, Rowe-Rowe and Lowry (1982) also recorded a lower trap success (5.0%) in a forest compared to peaks recorded in most other habitats, including tall grassland (10.8%) and woodland (20.0%). In Taiwan, Adler (1995) found sites with well-developed grass cover and low densities of shrubs and trees to harbour the highest overall rodent densities and species richness. In Transvaal, South Africa, Mendelson (1982) also recorded trap successes ranging between 17.2% and 29.7% in wooded grasslands. Likewise, in Natal Rowe-Rowe and Meester (1982) and Wirminghaus and Perrin (1993) recorded fewer small mammal species with lower trap successes in moist forests than in other habitats, possibly because the forests were devoid of grass or herbaceous undergrowth.

Species classified as being forest specialists, endemic and threatened are shown in Table 3. *Beamys hindei* was the only forest specialist species. Christensen (1996) describes it as a forest dwelling rodent whereas FitzGibbon *et al*. (1995) describes it as essentially a coastal forest species occurring at low densities in all evergreen or slightly deciduous forests and on sandy soils, which it uses for construction of burrows. According to FitzGibbon *et al.* (1995), food caching by the species is an adaptation to seasonally dry forests where food is in short supply during the dry season. In Tanzania and Kenya it has been recorded in more than ten and three coastal forests respectively (FitzGibbon *et al.* 1995).

Table 3: Small mammal species caught or seen that are forest specialist, endemic, and threatened in Zaraninge Forest, Coast Region, Tanzania (1994-1996).

Family	**Species**	**FF**	**En**	**Th**
CRICETIDAE	*Beamys hindei*	+	***	VU
SCIURIDAE	*Paraxerus palliatus*	-	-	VU
MACROCELIDIDAE	*Rhynchocyon petersi*	-	**	EN
Total		**1**	**2**	**3**

Key: FF=Forest specialist; En=Endemic; Th=Threatened; EN=Endangered; VU=Vulnerable; ** Near endemic to coastal forests and Eastern Arc forests; *** Near endemic to coastal forests, Eastern Arc forests and a few other tropical forests. Data source: Burgess *et al*. (2000); Hilton-Taylor (2000).

Near endemic species in the forest included *Rhynchocyon petersi* and *B. hindei* that occur in coastal and Eastern Arc forests. *Beamys hindei* also occurs in a few other East African forests (Burgess *et al*. 2000). In the Eastern African coastal forests there are only two small mammal species that are known to be endemic; the golden-rumped elephant shrew (*Rhynchocyon chrysopygus*) in Arabuko-Sokoke forest, Kenya (Corbet 1971, FitzGibbon 1994) and the Pemba fruit bat (*Pteropus voeltzkowi*) on Pemba Island (Burgess *et al*. 2000). Threatened species in Zaraninge Forest included *B. hindei* and *Paraxerus palliatus* that are Vulnerable (VU) and *R. petersi* that is Endangered (EN) Hilton-Taylor (2000).

Affiliation between mammal species in the coastal forests and the Eastern Arc forests is very close, especially for small mammals such as elephant shrews (*Rhynchocyon and Petrodromus*), bats and pouched rats (*Beamys* and *Cricetomys*). However, coastal forests are renowned for harbouring a bigger number (5) of elephant shrew species than the three species in the Eastern Arc forests (Nicoll and Rathbun 1990). Some of the important genera in these two forests like *Rhynchocyon* and *Beamys* are regarded as being primitive and possibly ancient relics (Kingdon and Howell 1993).

In tropical forests, vertebrates are commonly rare, patchily distributed and ecologically specialized such that some of them are especially vulnerable to habitat fragmentation (Diamond 1980, Laurance 1991). Species most susceptible to effects of fragmentation include habitat specialist mammals (Laurance 1990) and species with large home ranges (Terborgh 1974) that are incapable of inter-patch migration (Noss 1987). Most small mammals are adapted to life in undisturbed forests, being incapable of surviving in non-forest habitats. These species are all threatened to some extent by the rapid rate of forest destruction as observed in most Eastern African coastal forests, in addition to being isolated from one another by agricultural land (Struhsaker 1981, Chiarello and de Melo 2001).

Conservation of these mammals, especially the forest specialist species, deals essentially with the conservation of their habitat, the forest ecosystems (Struhsaker 1981).

The diversity of small mammals is used as an indicator of disturbance in natural ecosystems and some studies have shown a correlation between the presence or absence of small mammal indicator species and disturbance in natural habitats (Noss 1990, Avenant 2000). *Mastomys* species that was found to be at higher proportion in Willem Pretorius Nature Reserve was taken to be an indication of a high level of disturbance in the reserve (Avenant 2000). *Mastomys* species occur in the woodland and farmland that surround Zaraninge primary forest and also in the swamp that is wholly surrounded by the forest (Kiwia 2005), but none was encountered in the forest interior, suggesting that the primary forest is in fairly good condition.

CONCLUSSION

This study showed species richness and trap successes in the forest to be very low, but the results are consistence with studies conducted elsewhere, notably in Natal South Africa by Wirminghaus and Perrin (1993) and Taiwan by Adler (1995), which also showed both values to be lower in forests than in woodlands and grasslands. The absence of species that prefer habitats dominated by grass undergrowth like *M. natalensis* and *Lemniscomys striatus* in the forest interior indicates that the forest is good condition and although it is small, if managed properly it will be able to preserve the forest specialist and near endemic small mammal species that require small home ranges. Zaraninge Forest was fairly well protected even before in became part of the newly gazetted Saadani National Park, thus severe degradation of the forest by the local people is not expected. This implies that the small mammals are not expected to be extinct in the near future.

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