Diversity in small mammals from eastern Lake Turkana, Kenya

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Rodents and insectivores were surveyed, using live trapping, at seven sites on the eastern side of Lake Turkana, one of the remotest parts of Kenya, and at study areas of biological distinctiveness, such as Sibiloi National Park and the Mount Kulal Biosphere Reserve. A total of 191 individuals of 11 species were captured, but only two rodents (*Acomys percivali* Dollman 1911 and *A. wilsoni* Thomas 1982) were numerous at two sites. The presence of the lesser Egyptian gerbil *Gerbillus gerbillus* Olivier 1801 is a new record for Kenya. We were unable to arrive at a conclusive explanation of the differences in species richness and in habitat use that we recorded for the seven sites, because our samples were too limited. However, certain patterns suggest the influence of different factors, such as habitat diversity, ecological isolation (the forest of Mount Kulal), and geographic isolation (Central Island, in the lake). It is possible that the impact of livestock overgrazing is a major limiting factor for small mammal communities.

KEY WORDS: small mammals, communities, distribution, Lake Turkana, Kenya.

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INTRODUCTION

The eastern side of Lake Turkana, which is one of the remotest parts of Kenya due to its harsh climate and undeveloped infrastructure, is relatively undisturbed and includes areas of biological distinctiveness such as the Sibiloi National Park with the Central and Southern Islands and the Mount Kulal Biosphere Reserve. However, changes are impending, due to the fact that the local population is becoming more and more sedentary, there is increasing pressure against livestock grazing, and mounting droughts. Such changes may affect small mammal communities.

The taxonomy and ecology of small mammals in Kenya are fairly well known as regards the savannah and areas with high-potential agriculture (Aggundey & Schlitter 1984, Alibhai & Key 1985, Schwan 1986, Oguge et al. 2004, Corti et al. 2005, Odhiambo et al. 2005, Castiglia et al. 2006). In contrast, only scanty records are available for arid northern Kenya and specifically for eastern Lake Turkana (Kingdon 1971-1974a, 1971-1974b; Aggundey & Schlitter 1984; Canova & Fasola 1994). The aims of this paper are to describe the small mammal communities of eastern Lake Turkana, to provide basic information on their distribution and habitat use, and to hypothesize the implications of the ongoing habitat changes on small mammal communities in the region.

MATERIALS AND METHODS

We surveyed small mammals at seven sites throughout the eastern part of Lake Turkana (Fig. 1, Table 1): Loiyangalani, Derati, four sites within Sibiloi National Park (Allia Bay, Koobifora, Central Island, Southern Island), and the Mount Kulal Biosphere Reserve.

Lake Turkana is the largest and most northerly of the Rift Valley lakes. Central Island, which is a small active volcano, has three saline crater lakes, while Southern Island has none. The lake shores are mostly rocky or sandy with little vegetation (Fitzgerald 1981). The climate is very hot and arid, with air temperatures ranging from 19.2 to 39.9 °C, and with a mean daily temperature of 31-33 °C (Kenya Wildlife Service 1996, 2001). The months from October to January represent the warmest and driest period, while July and August are the coolest months. Strong south-easterly winds are frequent. Rainfall (< 200 mm/year) is unpredictable, and may not occur for years (International Lake Environment Committee 2002). On the grassy plains, yellow speargrass *Imperata cylindrica*, *Commiphora* spp., *Acacia tortilis*, *A. elatior* and other *Acacia* species predominate, along with desert date *Balanites aegyptiaca* and doum palm *Hyphaene coriacea* in sparse gallery woodlands. The *Salvadora persica* bush is found on Central Island and Southern Island. Despite the low carrying capacity of the area, its fauna is fairly diverse: the lake is an important flyway for water birds, and the region is recognized as an Important Bird Area, with over 350 bird species, as well as being a conservation priority (Bennun & Fasola 1996, Bennun & Njoroge 2001). Eastern Turkana, which is sparsely populated, is one of the economically poorest regions in Kenya. Pastoralism is its mainstay, although hunting for wildlife and fishing are also important economic activities. Hunting and pastoralism are prohibited inside the Sibiloi National Park, and livestock grazing is allowed there only during severe droughts, although some livestock herds may be present. Access to the forest of the Mount Kulal Biosphere Reserve is not restricted and, especially during periods of drought, thousands of livestock are driven into the forest to search for grass and water.

Table 1.

Study sites for small mammals on the eastern side of Lake Turkana, Kenya.

Study site	Coordinates	Dominant vegetation	Protection status	Grazing regime
Koobifora	3°57'N, 36°11'E	Arid to semi desert, with scattered *Acacia*, *Commiphora* and *balanites* trees and shrubs	Sibiloi National Park	Grazed by wild herbivores
Derati oasis	3°50'N, 36°31'E	Sparse gallery woodland with predominant, *Acacia tortilis*, *A. elatior* and other *Acacia* sp., desert date *Balanites aegyptiaca* and doum palm *Hyphaene coriacea,* and with *Imperata cylindrica* grass and *Commiphora* sp. bushes	Unprotected	Grazed by both livestock and wild herbivores
Allia Bay	3°39'-4°00'N, 36°11'-36°34'E	Arid to semi desert, C*ommiphora* woodland prevalent. Dry sand river beds lined with shady thorn trees intersect the landscape	Sibiloi National Park	Grazed by wild herbivores
Loiyangalani	2°45'N, 36°42'E	Doum palm *Hyphaene coriacea* in and around the town of Loiyangalani	Unprotected	Grazed by both livestock and wild herbivores
Southern Island	2°23'N, 36°44'E	*Salvadora persica* bush dominant. Mostly arid and rocky	Sibiloi National Park	No grazing
Central Island	3°30'N, 36°02'E	*Salvadora persica* bush dominant, with tall grass around the three crater lakes	Sibiloi National Park	No grazing
Mount Kulal forest	2°34'N, 36°55'E	Evergreen montane forest dominated by *Olea hochstetteri* — *Cassipourea malosana* and *Olea africana* — *Juniperus procera* at > 1,500 m asl (Schultka & Hilger 1983). At lower elevations very dense and tall vegetation, with *Acacia* dominant in drier parts	Biosphere Reserve, legally recognized but unprotected	Grazed by both livestock and wild herbivores

We conducted two intensive trapping sessions on terrestrial small mammals, rodents and shrews, one from 21 June to 8 July 2004 and the second from 23 December 2004 to 13 January 2005. Small mammals were captured in the various habitats that were present at each study site: rocks, sparse grassland, primary forest, secondary forest, and forest edge. We used live traps (aluminium, 230 × 95 × 80 mm, H.B. Sherman's Traps Inc., Tallahassee, FL, U.S.A.) baited with fried coconut smeared with a mixture of peanut butter and oats. The traps were inspected and re-baited each morning, and were operated for 5 consecutive nights at each site. Trapping was conducted both on transects, which enabled a rapid sampling of species composition, and also on square grids, which were used to estimate population size. Each transect consisted of 3-5 lines of 30 traps each, spaced 5-10 m apart, and positioned in places suitable for capture. Each grid had 49 traps set at 10-m intervals in a 7 × 7 grid, for 5 consecutive nights. Altogether, 564 trapping nights were operated on average (190-922) at each study site. The area in a radius of 5 m around each trap was described in terms of the percentages of cover by grass, shrubs and trees, and of cover by sand, soil and gravel and rocks.

Species identification followed Dollman (1915-1916), Meester & Setzer (1971), Delany (1975), Kingdon (1971-1974a, 1971-1974b, 1997), and was confirmed by comparisons with specimens at the National Museums of Kenya. The nomenclature is based on Wilson & Reeder (2005). Most mammals were released at the capture point, after being marked non-invasively by clipping fur in a unique, recognizable pattern (Cameron et al. 1997). Each specimen was identified, its sex,

Fig. 1. — Lake Turkana with detail of the seven study sites.

age, and reproductive condition were recorded; it was then measured for weight (to the nearest 0.5 g on a 100-g spring scale), head and body length, tail, hind foot, and ear length (to the nearest millimetre) (Nagorsen & Peterson 1980). Some shrews found dead in traps were retained for systematic studies of this incompletely known group (Decher et al. 1997), and are deposited at the National Museums of Kenya. In order to compare site productivity (Kasangaki et al. 2003), despite occasional differences in trapping efforts among the study sites, we calculated trap success as captures per 100 trap nights, i.e. Total catch / Trap nights × 100.

Diversity was assessed using three indicators: the Shannon-Weiner index of diversity *H'*, the Evenness index *J'*, and the Simpson's D diversity (calculated as in Krebs 1989). Since Evenness *J'* is weighted towards common species, the modified inverse of the Simpson diversity of concentration for equally abundant species was also calculated (Dunstan & Fox 1996), as $D = 1/(\Sigma p_i^{\,2})$, where p_i is the proportion of species i in the community. We estimated population size only for Percival's Spiny Mouse *Acomys percivali* Dollman 1911 and Wilson's Spiny Mouse *A. wilsoni* Thomas 1982 at Derati and at Southern Island, where they were caught in sufficient numbers to enable us to make these estimates.

Habitat preferences, which are based on the data regarding soil and vegetation cover, were first investigated using a Bray-Curtis similarity measure, and the resulting matrix used for cluster analyses and semi-strong multidimensional scaling ordination, with stress = 0. Two sites, Central Island and Kulal, which were very dissimilar in cluster analysis and MDS ordination both from each other and from all the other sites in terms of trap success, were excluded from further analyses, and we aimed to identify relationships among the remaining five sites. We applied BEST analysis (Biota and/or Environment matching in the BIOENV algorithm) with a standard Spearman Rank correlation, in order to examine the relationships between species occurrence and habitat characteristics. All analyses were conducted on square-root transformed data, using Primer 6.1.6 (Primer-E 2005).

RESULTS AND DISCUSSION

Small mammal communities and populations

A total of 191 small mammals were trapped during 3406 trap-nights (Table 2), belonging to 11 species, mostly Rodentia (9 species and 187 individuals) with very few Soricomorpha (2 species and 4 individuals). Of these 191 captures, 31 were rodent recaptures from two sites only: Derati and Southern Island. Since we performed only live trapping, in order to minimize animal deaths, shrews were definitely underrepresented in our sample. Various species of rodents and shrews were selectively trapped, depending on the type of trap and capture technique (Pucek 1969, O'Farrell et al. 1994). Most captures belonged to only two species, *Acomys percivali* (61%) and *Acomys wilsoni* (12%). Therefore, we were not able to calculate the abundance of the other 7 species, which were caught in small numbers ($n < 5$) and restricted to particular sites. *Acomys percivali* was very abundant at Southern Island (an estimated density of 530.1 individuals/ha), and much more so than at Derati (78.1 individuals/ha). *Acomys wilsoni* at Derati was less numerous (68.57 individuals/ha) than the former species.

Table 2.

Summary of trapping results for rodents and shrews: no. = number of captures, % = trap success in percentage of trap-nights with captures.

Species	Koobifora		Derati		Allia		Mt Kulal		Loiyangalani		Southern Island		Central Island		Total
	no.	%	no.	%	no.	%	no.	%	no.	%	no.	%	no.	%	
Taterillus emini	3	0.33	—	—	—	—	—	—	—	—	—	—	—	—	3
Acomys wilsoni	1	0.12	15	2.00	6	0.87	—	—	2	10.00	—	—	—	—	24
Acomys percivali	—	—	24	3.20	—	—	—	—	1	5.00	118	42.29	—	—	143
Tatera robusta	—	—	—	—	2	0.29	—	—	—	—	—	—	—	—	2
Tatera vicina	—	—	—	—	3	0.44	—	—	—	—	—	—	—	—	3
Grammomys dolichurus	—	—	—	—	—	—	3	0.54	—	—	—	—	—	—	3
Mastomys natalensis	—	—	—	—	—	—	—	—	—	—	—	—	4	2.11	4
Arvicanthis niloticus	—	—	—	—	—	—	—	—	—	—	—	—	4	1.58	4
Gerbillus gerbillus	—	—	—	—	1	0.15	—	—	—	—	—	—	—	—	1
Crocidura hildegardeae	—	—	—	—	—	—	2	0.36	—	—	—	—	—	—	2
Crocidura hirta	—	—	—	—	—	—	—	—	—	—	—	—	2	1.05	2
Total captures	4		39		12		5		3		118		10		191
Trap-nights	922		749		687		559		20		279		190		3406
Trap success (%)	0.43		5.21		1.75		0.89		15.00		42.29		11.00		5.46
Species richness	2		2		4		2		2		1		3		16
Shannon's diversity index (H')	0.56		0.67		1.20		0.67		0.64		0		1.06		
Evenness $J' = H'/H'_{Max}$	0.81		0.96		0.87		0.97		0.92		0		0.96		
Simpson's diversity index (D)	1.6		1.9		2.9		1.9		1.8				2.8		

Among the localized species, we report the first record for Kenya with the presence of the lesser Egyptian gerbil *Gerbillus gerbillus* Olivier 1801, a North African species with its southern limit hitherto recorded in northern Sudan but also occurring in southwest Asia and Arabia (Harrison & Bates 1991). The species is a habitat specialist that is limited to sandy habitats, although it is also found on solidified sand flats (Zahavi & Wahrman 1957). The presence of other rodents (that are not included in our analyses) was also established from signs or observations: the unstriped ground squirrel *Xerus rutilus* (Cretzschmar 1828) at Allia, and the crested porcupine *Hystrix cristata* (L. 1758) at Kulal.

An overall low trap success (5.46%), which probably reflected a low carrying capacity, was observed during our study. At Southern Island and Derati, for example, the abundant captures produced only one and two species, respectively (Fig. 2). At other sites, i.e. Koobifora, Allia, Kulal, and Central

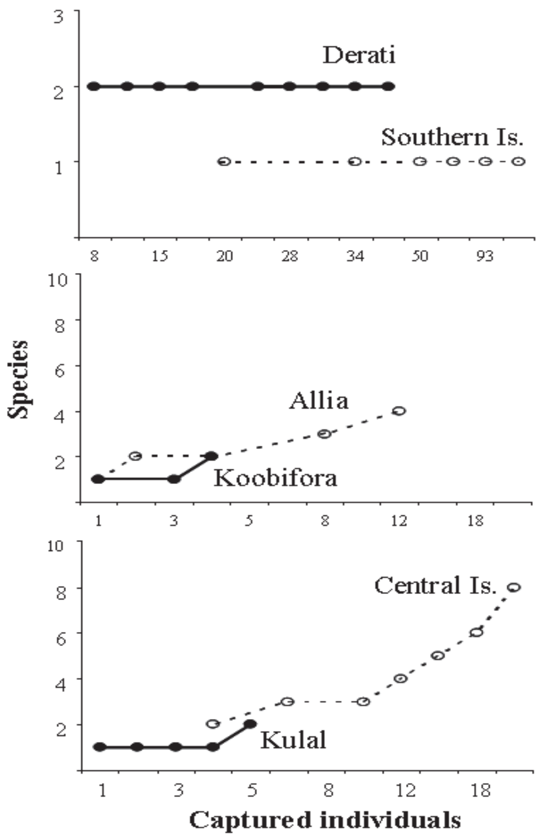

Fig. 2. — Accumulation rates of species of rodents and insectivores for six study sites on the eastern side Lake Turkana. At Loyengalani, captures were too few to be depicted.

Island, the number of species increased with the increase in captures, and the plot of species accumulation did not reach an asymptote. Further trapping could, therefore, have added new species, and our inventory could have been incomplete.

Ecological factors

Although the size of our sample for most species was too small for a conclusive discussion of differences in species richness and in habitat use, some patterns suggest the relevance of different factors.

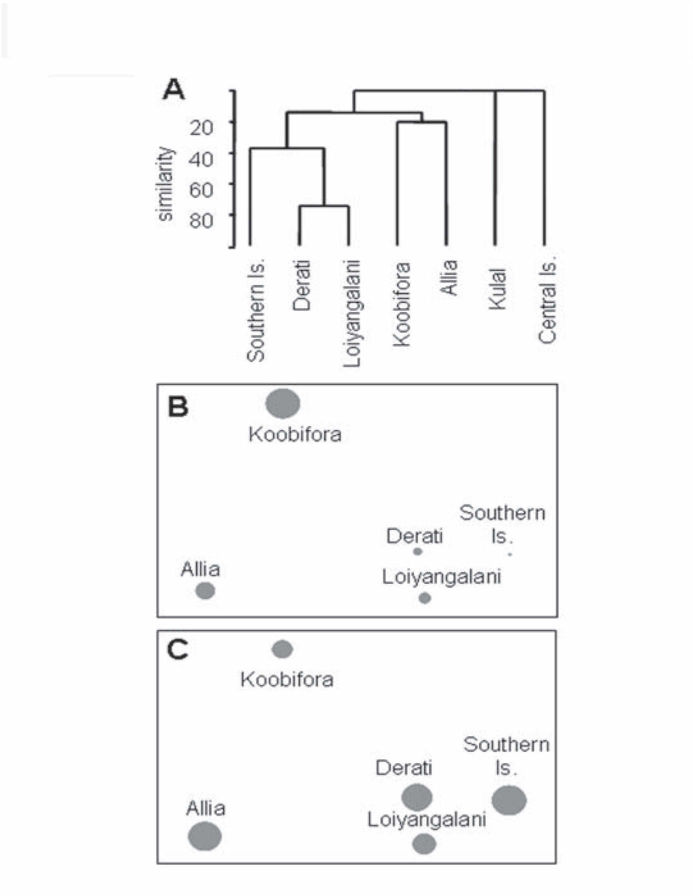

Fig. 3. — Multidimensional scaling ordination of the study sites for their small mammal communities. (A) Cluster ordination for sites in terms of trap success. Influence on the cover of sand (B) and of grass (C) on trap success. The size of the circles is proportional to the influence of either sand or grass.

A first factor of the variation observed in species richness and diversity among the sites (Table 2) could be habitat diversity. Species richness was lowest at Southern Island which is mostly bare and has limited vegetation, and where only one species (*Acomys percivali*) was recorded, albeit with the highest number of trapped animals). On the contrary, high richness and diversity were recorded at Central Island and at Allia, which offer a wide array of habitats, from rocks to grasslands, *Commiphora* woodlands, and gallery vegetation. Trap success was strongly correlated to percentage grass and sand cover, which explained the 83% variation (r^2 = 0.756). Sand cover had the greatest influence at Koobifora (see Fig. 3B, with larger circles corresponding to greater influence), as compared to the other sites, while trap success was strongly related to grass cover at Southern Island and at Allia sites relative to other sites (Fig. 3B-C). Other characteristics, such as the presence of rocks, trees and shrubs, were found to be unimportant. Loose sand probably provides food and important microhabitat for digging animals, while grass cover is a food source and enhances protection from predators. In this study of the drylands of northern Kenya, habitat structural complexity seems to be more important than vegetation composition for the occurrence of small mammals, as has resulted in other studies (e.g. Edge et al. 1995, Bergstrom 2004).

A second factor affecting species diversity could be isolation. At Kulal, only five animals of one shrew species, *Crocidura hildegardeae* Thomas 1904, and of one rodent, *Grammomys dolichurus* (Smuts 1832), were recorded during 559 trap nights, despite the complexity of the forest habitat, and in contrast with other African forests (e.g., Cameron 1996, Cameron et al. 1997, Kasangaki et al. 2003, Webala et al. 2006). Kulal and Central Island were dissimilar in trap success. However, the rodent species were also different, and these two sites also differed from the other ones (Fig. 3A). Such dissimilarities may be related to the isolation of the two sites. Kulal is a forest fragment isolated by hundreds of kilometers of arid landscapes from the nearest forests, and Central Island is isolated by 20 km of lake. Isolation of this kind can lead to loss of genetic diversity, a high probability of extinction (Keller & Waller 2002), and small wildlife populations.

An additional factor that may have affected small mammals is the impact of livestock grazing. The relatively high richness and diversity on Central Island might be related to the absence of the impact by large herbivores, in addition to a habitat that is suitable for highly-tolerant and opportunistic species, such as the Natal multimammate mouse *Mastomys natalensis* (Smith 1834) and Nile rat *Arvicanthis niloticus* (É. Geoffrey 1803). Southern Island lacked livestock as well; however, it had only one species, *Acomys percivali*, albeit at high densities, possibly because this species prefers the rocky habitats with little vegetation that predominate on the island (Schlitter 2004). At Kulal, the relatively low mammal richness could be related to forest degradation by livestock, that reduces herbaceous and shrubby vegetation and exposes large surfaces of soil (Reed & Clokie 2000).

While our findings are only preliminary, they suggest the importance of habitat structural complexity in the conservation of small mammals in the drylands of northeastern Kenya. This study also highlights the uneven distribution of small mammals between the drier habitats and the wet Mount Kulal zone, and suggests that overgrazing could be a major limiting factor for small mammal communities.

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