NOTE BRÈVE

BAT ASSEMBLAGES FROM EASTERN LAKE TURKANA, KENYA

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RÉSUMÉ. — *Les peuplements de chauves-souris de l'est du lac Turkana, Kénya*. — Les peuplements de chauves-souris ont été étudiés par piégeage sur sept sites sur la bordure Est du lac Turkana, Kénya, région où le statut et la distribution de ces mammifères demeuraient inconnus. Nous avons capturé 97 individus de 13 espèces appartenant à 6 familles : Mégadermatidés (*Cardioderma cor*), Rhinolophidés (*Rhinolophus clivosus*), Nyctéridés (*Nycteris hispida* et *N. thebaica*), Vespertilionidés (*Myotis tricolor, Nycticeinops schlieffeni, Pipistrellus kuhlii* et *Neoromicia nanus*), Molossidés (*Chaerephon pumila, Mops condylurus* et *M. demonstrator*), Emballonuridés (*Taphozous perforatus* et *Coleura afra*). *Lavia frons* (Mégadermatidés) a été observé mais non capturé. La présence de bâtiments autour des stations de piégeage a affecté de manière significative le succès du piégeage. L'abondance, la richesse et la diversité se sont avérées variables selon les sites, en relation avec des différences dans la structure écologique des habitats forestiers, semi-désertiques ou insulaires. La richesse et la diversité étaient plus fortes dans les sites protégés et non pâturés que dans ceux non protégés et surpâturés par le bétail. Le surpâturage aurait un effet néfaste sur les peuplements de mammifères, augmentant ainsi les risques de perte de biodiversité dans les zones sauvages.

Very little information is available on the small mammal fauna of the arid and semi arid regions of Northern Kenya, owing to poor access and difficult working conditions, although scanty records can be found in Kingdon (1971, 1974), Aggundey & Schlitter (1984), Canova & Fasola (1994). The eastern side of Lake Turkana is one of the remotest parts of Northeastern Kenya, with undeveloped infrastructure and a harsh climate. The communities of wild mammals of this region are relatively undisturbed, but their natural habitats could be rapidly threatened by the increasing drought and overgrazing by livestock. Ecology and conservation of Kenyan bats are poorly known, and most information relies on literature and museum collections (Webala *et al.,* 2006). Bats are difficult to survey thoroughly and apparent patterns might result more from sampling bias or fragmentary distributional information than from real differences in species richness across sub-regions (Lim & Engstrom, 2001). However, the identification of extant species is a basic requirement for detailed studies of their biology and for future conservation and management planning.

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The aim of this study is to report on the first survey of bat assemblages in the semi-arid eastern side of Lake Turkana, and to discuss the implications for the conservation of the natural assets of this region.

MATERIALS AND METHODS

Study area

Bat trapping was carried out at seven study sites on the eastern side of Lake Turkana, along the lake from Loiyangalani to Koobi Fora, and inland up to Mt Kulal Biosphere Reserve (details in Table I). The area is sparsely populated by natives who rely mainly on pastoralism, although hunting for wildlife and fishing are also important economic activities. Lake Turkana is the largest and most northerly of all the Rift Valley lakes, with mostly rocky or sandy shores and little vegetation (Fitzgerald, 1981). The climate is very hot, arid, and very windy. Air temperature ranges 19.2 – 39.9°C with a mean daily temperature range 31°C – 33°C (Kenya Wildlife Service, 1996 & 2001). The months from October to January are the warmest and driest, July and August the coolest. Total annual rainfall is <200mm and unpredictable, and rain may not fall 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. Despite the low carrying capacity of the area the fauna is relatively diverse, especially in breeding and migrant birds, and the lake is an important flyway for migrant waterbirds (Bennun & Fasola, 1996).

Methods

We conducted two surveys, one 21 June-8 July 2004, and a second during 23 December 2004-13 January 2005. Bats were caught using a harp trap (Austbat, Victoria, Australia) and mist nets of various lengths (2.6x6, 2.6x12, and 2.6x18-m) and mesh size, erected at ground level in potential flyways. Sampling for bats was done opportunistically from sites such as near buildings and in areas of tall trees such as laggas that had potential bat flyways. At Kulal, the harp trap and the mist nets were set on tracks and forest gaps. The mist nets were operated for two consecutive trapping nights from 18.30 to 22.00, before moving them to a new location. The harp trap was left open throughout the night for two consecutive nights. Additionally, accessible caves, water tanks and buildings were searched for bat occupation.

The identification of bats follows Meester & Setzer (1971), Kingdon (1971, 1997) and comparison with specimens at the National Museums of Kenya. The nomenclature is based on Wilson & Reeder (2005). Each specimen was identified, its sex, age, and reproductive condition were recorded, and it was measured for: weight to the nearest 0.5g using a 100g spring scale, and length of head plus body, tail, hind foot, forearm and ear to the nearest millimetre (Nagorsen & Peterson, 1980).

Data analyses

Diversity was assessed using two indicators, calculated as in Krebs (1992). The Shannon-Weiner index of diversity: $H' = - \Sigma p_i \ln p_i$ where p_i is the proportion of the total sample belonging to the i^{th} species and Evenness index: $J' = H'/H'_{Max}$, where H' is the Shannon-Wiener index and $H'_{Max} = \ln S$, where S = species richness which equals to the total number of species in a community. This index relates H' relative to the maximum value of H' when all species in the sample are perfectly even with 1 individual per species (Ludwig & Reynolds, 1988). Evenness values indicate how the species are distributed in a community. When the evenness is high, the mammal fauna is diverse and the species are equally abundant (Magurran, 1988). Euclidean similarity was calculated on log transformed data, and dendrogram was obtained by the UPGMA clustering method, using MVSP 3.1 and Primer 6 demo package.

In order to standardize data for all sites despite the differing trap effort, trap success was calculated as overall trappability for bats, defined as the number of bats trapped per mist net and harp trap hours, an indication of the productivity of the communities sampled in that trap success depends on habitat productivity (Kasangaki *et al.* 2003).

Several habitat variables were measured around a 50 meters circle surrounding the trapping station, including distance of infrastructures and building (meters), trees and rocks; since only building distance significantly affected bat trappability (see Results) other details are not provided here.

RESULTS AND DISCUSSION

We caught 97 individuals of 13 species and six families of bats (Table II). None of the species was recorded at all study sites, and most species were recorded only at one or two sites. *Lavia frons* (Megadermatidae) was observed but not captured within Sibiloi National Park. Sibiloi, Koobi-Fora and Kulal sites had the highest number of bat species and the highest capture success while Derati, Loyangalani and Central Islands had the lowest richness, and Southern Island had no record (Table II). Richness and diversity were higher on the sites

TABLE I

Description of the seven trapping sites and their vegetation

Name	Coordinates	Environment	Protection status	Grazing regime by livestock
Koobi Fora	3°57'N, 36°11'E	Arid to semi desert, with scattered *Acacia*, *Commiphora* and *Balanites* trees and shrubs	Sibiloi National Park	Low
Derati	3°50'N, 36°31'E	Sparse gallery woodland with predominant *Acacia tortilis*, *A. elatior* and doum palm *Hyphaene coriacea* and *Commiphora* sp.	Unprotected	High
Sibiloi	3°39'-4°00'N and 36°11'-36°34'E	Arid to semi desert, *Commiphora* woodland prevalent. Dry sand river beds lined with shady thorn trees intersect the landscape	Sibiloi National Park	Low
Loiyangalani	2°45'N, 36°42'E	Doum palm *Hyphaene coriacea* in and around Loiyangalani town	Unprotected	High
Southern Island	2°23'N, 36°44'E	*Salvadora persica* bush dominant. Mostly arid and rocky	Sibiloi National Park	None
Central Island	3°30'N, 36°02'E	*Salvadora persica* bush dominant, with tall grass around the three crater lakes	Sibiloi National Park	None
Mt Kulal	2°34'N, 36°55'E	Evergreen montane forest dominated by *Olea hochstetteri – Cassipourea malosana* and *Olea africana – Juniperus procera* at altitudes >1,500 m. At lower elevations very dense and tall vegetation, with *Acacia* dominant in drier parts	Biosphere Reserve, legally recognized but unprotected	Occasionally high

TABLE II

Bats recorded at the seven trapping sites on the eastern Lake Turkana

		Number of individuals captured by site							
Family	Species	Koobi Fora	Derati	Sibiloi	Kulal	Loiyangalani	S. Island	C. Island	Total
Megadermatidae	*Cardioderma cor*	5	0	0	0	0	0	0	5
Rhinolophidae	*Rhinolophus clivosus*	0	0	0	2	0	0	0	2
Vespertilionidae	*Myotis tricolor*	0	0	0	1	0	0	0	1
	Nycticeinops schlieffeni	8	0	3	0	0	0	0	11
	Pipistrellus kuhlii	0	0	0	3	0	0	0	3
	Neoromicia nanus	0	1	0	0	2	0	0	3
Nycteridae	*Nycteris hispida*	0	0	0	0	0	0	1	1
	Nycteris thebaica	1	0	0	0	0	0	0	1
Molossidae	*Chaerephon pumila*	0	0	16	0	0	0	0	16
	Mops condylurus	0	0	37	0	0	0	0	37
	Mops cf. demonstrator	0	0	8	0	0	0	0	8
Emballonuridae	*Taphozous perforatus*	1	0	0	0	0	0	0	1
	Coleura afra	0	0	8	0	0	0	0	8
	Total (no. individuals)	15	1	72	6	2	0	1	97
	Mist net and harp trap (h)	72	108	264	264	48	72	108	936
	Capture success (bats per mist net/harp trap hour)	0.21	0.01	0.27	0.23	0.04	0	0.01	0.18
	Observed species richness	4	1	5	3	1	0	1	13
	Diversity	0.46	0	0.56	0.44	0	0	0	-
	Evenness	0.76	0	0.81	0.92	0	0	0	-

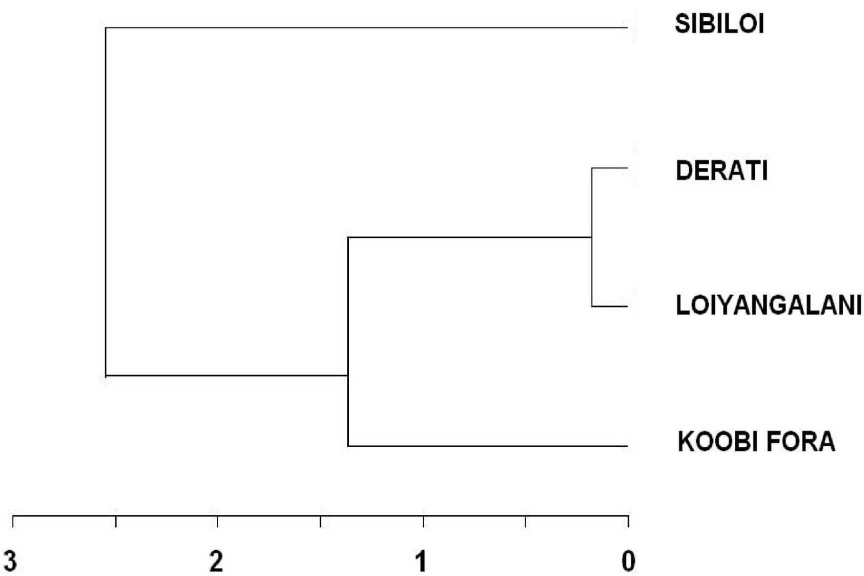

Figure 1. — Similarity in bat assemblages. Figures are Euclidean distance on a log transformed similarity matrix.

characterized by higher habitat complexity, like the forested habitat of Mt. Kulal, or general condition of higher wilderness as in Sibiloi and Koobi Fora. On the contrary, only 4 individuals of two species were captured at the other sites, characterized by less natural conditions (overpopulation and high concentration of livestock in Derati and Loiyangalani), or by isolated conditions (the two islands).

There was a marginally significant positive relationship between overall trappability for bats and the presence of infrastructure, mainly buildings (2-tailed Pearson Correlation, R = 0.55, P = 0.07). For any of the other habitat variables we considered, no significant associations with bat trappability were found. There was no significant difference in capture success among species, except for *Nycticeinops schlieffenii* (F = 33.64, P = 0.002), that was captured more frequently at two sites than any other bat species.

We compared richness and diversity indices for the two homogeneous protected sites (Sibiloi and Koobi Fora) characterized by a low degree of grazing by domestic livestock, and two unprotected settlements (Derati and Loiyangalani) that are affected by very high grazing pressure. Other sites were excluded from analysis due to habitat differences (Kulal) or genuine richness reduction as in Central and Southern Islands. A higher richness (R = 8) and diversity (H' =0.49) of bat assemblages resulted for the sites included in protected areas, compared to the overgrazed ones (R = 1), thus suggesting that ecological pressures by domestic grazers can indirectly influence bat assemblage composition. The clustering confirmed a strong similarity of unprotected and overgrazed sites that appeared well segregated by protected and ungrazed ones (Fig. 1).

Capture success was generally low and none of the species accumulation curves for bats at Sibiloi, Mount Kulal and Koobi Fora reached an asymptote, suggesting that this species list may only be a portion of the bats present on the eastern Lake Turkana. Even under the most favourable circumstances, standard methods adequately sample only part of local bat faunas. Survey of bats at ground level underestimates the presence of many open space aerial insectivores such as Molossids that fly so high above the ground or canopy that they are out of reach of mist nets and harp traps (Rautenbach *et al.,* 1996; Fenton & Griffin, 1997; Kalko, 1997). Mist nets can also under-represent some species known to be adept fliers, such as Vespertilionids (Aldridge & Rauntenbach, 1987; Rauntenbach *et al.,* 1996; Kalko, 1997) and Emballonurids (Kalko, 1997). Indeed, except for *Taphozous perforatus,* which was caught by hand, all the

Molossids and Emballonurids in the present study were caught at exit points around roost sites in buildings and caves (*Mops* sp., *Chaerephon*, *Coleura afra*). These data can reflect a failure of standard methods (mist nets and harp traps) as tools for conducting inventories for bats in open habitats, as reported by O'Farrell & Gannon (1999). In our study areas, the natural flyways, that constitute potential trapping sites for bats, were generally lacking outside Kulal forest and few isolated cases. At Kulal, the disposal of nets at ground and undestorey level probably reduced the trappability of the guild of 'background cluttered space aerial insectivores' (Schnitzler *et al.,* 2003) thus explaining the absence of these species at those sites. The presence of *Lavia frons*, which was occasionally observed but never trapped in *Acacia* woodlands, attests to the partial inadequacy of sampling methods. The aim of most surveys is to record a comprehensive inventory of bat species in minimal time using minimal effort; we adopted the capture schemes recommended by Mills *et al.* (1996) and at each site we increased trap number instead of trapping for additional nights, in order to reduce trap avoidance behaviour. A higher variability of sampling methods, such as use of nets of differing mesh sizes or length, was also suggested by O'Farrell & Gannon 1999 as a useful tool to improve trappability. However, a methodological bias, besides a genuine low abundance of bats in our study areas, may partially explain our low trapping success. In order to achieve comprehensive inventories of bats during short term survey in harsh environmental conditions, the use of a combination of methods such as canopy mistnetting and harp traps in forests, acoustic monitoring by ultrasound detectors and searches for roost sites, is probably crucial for completeness of research, as suggested by Fenton (1997), O'Farrell & Gannon (1999) and Flaquer *et al.* (2007).

While these findings are only preliminary, our study suggests that ecological stress as overgrazing can directly or indirectly influence bat assemblages in our study areas, an impact well know on African small mammals and larger wildlife (Bergstrom, 2004). This impact can have detrimental effects on mammal assemblages still largely unknown, then increasing the risk of biodiversity losses in wild areas.

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