SCIENTIFIC CONTRIBUTIONS

African Bat Conservation News publishes brief notes concerning the biology of bats, new geographical distributions (preferably at least 100 km from the nearest previously published record), sparsely annotated species lists resulting from local surveys including roost counts and echolocation and sonograms of bat species occurring on the African continent and adjacent regions, including the Arabian peninsula, Madagascar, and other surrounding islands in the Indian and Atlantic oceans.

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A CHIROPTERAN SURVEY OF THE LAC KINKONY-MAHAVAVY AREA IN WESTERN MADAGASCAR

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Although bats form a large component of tropical biodiversity (e.g. HUTSON *et al.* 2001; SIMMONS 2005) they were omitted from many of the vertebrate surveys conducted in Madagascar during the 1990s, which were designed to assess the biodiversity of sites of potential conservation importance. Only recently have surveys on the island started to uncover the true diversity of the chiropteran fauna (e.g. GOODMAN *et al.* 2005b, 2006) and to compile detailed information on the bats from protected areas (GOODMAN *et al.* 2005a). Associated with its karstic geology, the west of Madagascar is reported to be particularly important for bat diversity and, as this region received less attention from biologists than the humid east, additional surveys are required.

As part of a multi-disciplinary team organized by Birdlife International Madagascar Programme, we surveyed the bats of the Lac Kinkony-Mahavavy forest-wetland complex (Province de Mahajanga) during February and March 2006. Although noted for its wetland bird community, this unprotected area also has important areas of deciduous dry forest. There was no prior information available about the bats of this specific area, although sites to the north and south have been surveyed (GOODMAN *et al.* 2005a).

Materials and Methods

We surveyed forests and caves in four areas (Analamanitra, Antsilaiza-Anjahamena, Marofandroboka and Anjohibe) within the Lac Kinkony-Mahavavy forest-wetland complex. We conducted 5, 4, 4, and 3 trapping nights at these sites, respectively. According to the availability of sites to place mist nets our effort varied between 21 and 30 m of mist nets per night. All nets were either 6 m or 9 m in length and were set close to the ground in forest gaps, along forest trails and edges, and near water. Nets were checked regularly and extracted bats were stored in cloth bags for a short period before processing. We also visited all reported or potential bat roosts based on information from local people and our own field observations. Voucher specimens were identified using keys and taxonomic descriptions (GOODMAN *et al.* 2005b, GOODMAN 2006, PETERSON *et al.* 1995) and were deposited in the Département de Biologie Animale, Université d'Antananarivo (Appendix I). *Scotophilus* were identified using external measurements; with *Scotophilus marovaza* Goodman, Ratrimomanarivo and Randrianandrianina, 2006, the smallest species (forearm length < 45 mm).

Results

In total, nine bat species were found during the survey, two Megachiroptera and seven Microchiroptera. Two *Pteropus rufus* E. Geffroy St.-Hilaire, 1803 day roosts were discovered in small groves; one on an island in a freshwater lake (Maroandravy), and the other (Ambatomaraha) on a rocky outcrop. The roost at Ambatomaraha consisted of approximately 1,000 bats whilst the population at Maroandravy was estimated to be around 400 individuals. Local people reported regular movement of bats between the two sites. Informal conversations with people who were familiar with the *P. rufus* at Ambatomaraha reported that a group of eight men visit the roost for periods of two to three nights and use canopy nets to capture the bats. Up to 100 are reportedly caught on each visit and taken to nearby markets and sold for USD 0.5 each to local restaurants.

A single cave roost of the small fruit bat *Rousettus madagascariensis* G. Grandidier, 1929 was discovered in Madiromasina and was estimated to contain over 5,000 individuals.

A total of 189 bats of eight species were mist netted whilst active at night (Table 1). *Rousettus madagascariensis* was the most commonly caught species and represented 32% of all captures. A single *Triaenops furculus* Trouessart, 1906 was netted. Species richness varied from six to eight per site. *Rousettus madagascariensis* and *Hipposideros commersoni* (E. Geoffroy St.-Hilaire, 1813) were captured at all areas surveyed.

Captures of *R. madagascariensis*, *Myotis goudoti* (A. Smith, 1834), *Triaenops* spp. and *Miniopterus manavi* Thomas, 1906 were higher in forest than village or savanna habitats (Table 2). *Myotis goudoti* and *T. furculus* were the only species that were not trapped outside of forest habitats. *Myzopoda schliemanni* Goodman, Rakotondraparany and Kofoky, 2007 was captured most frequently in degraded forest. For *R. madagascariensis*, high capture rates appeared to be related to the proximity of the cave roost (Table 2). Approximately half of the *S. marovaza* and *H. commersoni* captures were from sites near trees in the vicinity of villages.

Six microchiropteran roosting sites were discovered during the survey. At Analamanitra, 57 *T. rufus* Milne-Edwards, 1881 were netted as they emerged from Anjohikalanoro Cave. Further exploration of this roost was not possible due to local taboos associated with the site. At Marofandroboka, we netted eight *Miniopterus manavi* at Ambohibory Cave and estimated there were approximately 150 individuals inside. In four caves at Anjohibe, colonies of *M. manavi* ranged in size from 20 to 1000 individuals.

Table 1. Results of mist netting at four forest sites in the Kinkony-Mahavavy forest-wetland complex in western Madagascar during February-March 2006.

Species	Number of individuals caught			
	Analamanitra (126 net m)	**Antsilaiza (111 net m)**	**Marofandroboka (114 net m)**	**Anjohibe (75 net m)**
Rousettus madagascariensis	10	6	6	60
Hipposideros commersoni	6	5	3	1
Triaenops rufus	3	2	20	13
Triaenops furculus	0	0	0	1
Scotophilus marovaza	12	6	2	0
Myotis goudoti	1	0	9	4
Miniopterus manavi	0	0	2	1
Myzopoda schliemanni	5	5	6	0
Total bats caught	37	24	48	80
Bats/net meter	0.29	0.22	0.42	1.01
Species richness	6	5	5	6

Table 2. Results of mist netting in five different habitat types from four forest sites at the Kinkony-Mahavavy forest-wetland complex in western Madagascar during February-March 2004.

Species	Bat captures				
	Village (51 net m)	**Savannah (15 net m)**	**Degraded forest (231 net m)**	**Relatively intact forest (75 net m)**	**Riparian forest (54 net m)**
Rousettus madagascariensis	2	5	12	40	23
Hipposideros commersoni	6	1	2	1	1
Triaenops rufus	5	1	19	6	8
Triaenops furculus	0	0	0	1	0
Scotophilus marovaza	9	1	8	0	2
Myotis goudoti	0	0	8	4	1
Miniopterus manavi	1	0	1	1	0
Myzopoda schliemanni	1	1	12	0	2
Total bats caught	24	9	62	53	37
Bats/net meter	0.47	0.60	0.27	0.71	0.69
Species richness	6	5	7	6	6

Discussion

Nine bat species were recorded from the Kinkony-Mahavavy forest-wetland complex representing a unique community composition for Madagascar. Although the species richness was lower than other sites on karstic substrate in western Madagascar, considerably greater survey effort was used during previous surveys (GOODMAN *et al.* 2005a) and it is likely that repeat visits to the Mahavavy-Kinkony complex will reveal previously unrecorded species. In particular, given the presence of limestone caves, bats such as *Otomops madagascariensis* (Dorst, 1953) and *Emballonura tiavato* Goodman, Cardiff, Ranivo, Russell, and Yoder, 2006 would be expected to occur at the site.

In terms of conservation, the Kinkony-Mahavavy complex appears to be important for bats. Although there is debate as to the extent to which Malagasy bats require intact forest habitats for their survival (GOODMAN *et al.* 2005), our results reported here and from other studies (e.g. KOFOKY *et al.* in press; RANDRIANANADRIANANINA *et al.* 2006) indicate that some species do have a close association with forest vegetation. Our results suggest that *Myotis goudoti* and *T. furculus*, two cave-roosting species, are associated with forest habitats and the forests of the Kinkony-Mahavavy complex provide important feeding areas for bats.

Myzopoda schliemanni is a recently described species (GOODMAN *et al.* 2007) and its conservation status is unknown. However, it appears to have a restricted distribution within western Madagascar and all captures are from sites that have native forest (GOODMAN *et al.* 2007). Capture rates of *M. schliemanni* in our survey are the highest reported and forested wetland habitats, such as at Kinkony-Mahavavy, may represent important habitats for this species.

Other species of conservation interest include *P. rufus*, *R. madagascariensis* and *H. commersoni* as all are threatened by hunting in Madagascar (GOLDEN 2005, GOODMAN 2006, MACKINNON *et al.* 2003). *Pteropus rufus* is listed as vulnerable on the IUCN Red List and is threatened across its range (MACKINNON *et al.* 2003). These bats play important

roles in maintaining forest ecosystems in Madagascar (BOLLEN and DONATI 2006; BOLLEN and VAN ELSACKER 2002) but populations are subject to heavy and sustained hunting. Roosts, such as Ambatomaraha, with a thousand *Pteropus* are becoming less common in Madagascar and such sites need to be conserved to preserve the bats and the ecological services they provide. Fruit bats can be legally hunted in Madagascar between May and September and their meat is a popular and important source of protein in the west. More information is needed on the dynamics of the bat-bushmeat trade in this region to ensure that any conservation plans are developed in an appropriate socio-economic context.

Measures to conserve the roosts at Ambatomaraha and Maroadravy could focus on establishing sustainable hunting practices in the former and reinforcing protection through the sacred taboos in the latter. Local people reported that the Maroadravy roost often contains over 1,000 bats when hunters are present at the Ambatomaraha roost. This highlights that local taboos can provide effective refuges for *P. rufus* and this may be particularly important as this species rarely roosts within existing protected areas. In addition, movement between Ambatomaraha and Maroadravy illustrates roost lability in *P. rufus* and conservation measures should include all known roosting and foraging sites within a given region.

Rousettus madagascariensis is regularly netted in the forests of western Madagascar (GOODMAN *et al.* 2005a) but very few roost sites are known to biologists (MACKINNON *et al.* 2003). The cave near the Anjohibe forest is the only reported roost site between Parc National Tsingy de Bemaraha and Anjohibe (Mahajanga), a distance of 370 km, and appears to be one of the largest roosting colonies known for the island. Although no evidence of hunting was found at this site, presumably because the cave is protected by local taboos, this species is subject to hunting pressure elsewhere in Madagascar (e.g. GOLDEN 2005).

Bats may use a variety of roosting sites in western Madagascar, including caves (KOFOKY *et al.*, 2006), tree cavities (ANDRIAFIDISON *et al.* 2006) and houses (GOODMAN *et al*. 2006). *Scotophilus marovaza* has been reported roosting in roofs constructed of *Bismarckia nobilis* leaves (GOODMAN *et al.* 2006). This species was never caught in relatively intact forest but was the most frequently trapped bat in and around villages. The roosting preferences of *Myzopoda* spp. remain a mystery and there are only two published observations under natural conditions, one from the leaves of *Ravenala madagascariensis* in the east (cited in SCHLIEMANN and MAAS 1978) and the other from a cave in the west (KOFOKY *et al.* 2006). More information is needed on the precise roosting requirements of the bats in the Kinkony-Mahavavy complex so that important sites can be protected and managed.

Bat conservation priorities in the Kinkony-Mahavavy are therefore as follows:

(i) Monitor the occupancy and population size of *P. rufus* roosts
(ii) Consider developing a sustainable approach to hunting at the Ambatomaraha *P. rufus* roost,
(iii) Assist the local community to protect the Maroandravy *P. rufus* roost and give due credit to the existing taboos as effective conservation measures,
(iv) Conduct a more detailed bat survey of the caves,
(v) Encourage vigilance at the Madiromasina 1 Cave against the commencement of hunting *Rousettus*,
(vi) Conserve the essential feeding and roosting habitats/features used by bats.

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Appendix 1: Voucher specimens collected during survey.

Species	Field Number	Sex	Capture location
Hipposideros commersoni	RBJ 253	M	S 16°03'11.7'' E 045°48'47.4''
Miniopterus manavi	RBJ 261	F	S 16°05'34.4'' E 045°51'39.9''
Miniopterus manavi	RBJ 264	F	S 16°01'18.2'' E 046°00'42.7''
Myotis goudoti	RBJ 259	M	S 16°02'39.5'' E 045°48'14.8''
Myotis goudoti	RBJ 262	F	S 16°05'09.9'' E 045°52'24.8''
Myzopoda schliemanni	RBJ 258	M	S 16°02'39.5'' E 045°48'14.8'
Myzopoda schliemanni	RBJ 260	F	S 16°02'43.4'' E 045°54'18.0''
Myzopoda schliemanni	RBJ 254	M	S 16°03'11.7'' E 045°48'47.4''
Rousettus madagascariensis	RBJ 251	F	S 16°03'11.7'' E 045°48'47.4''
Scotophilus marovaza	RBJ 247	M	S 16°03'11.7'' E 045°48'47.4''
Scotophilus marovaza	RBJ 248	F	S 16°03'11.7'' E 045°48'47.4''
Scotophilus marovaza	RBJ 249	F	S 16°03'11.7'' E 045°48'47.4''
Scotophilus marovaza	RBJ 250	F	S 16°03'11.7'' E 045°48'47.4''
Triaenops furculus	RBJ 263	F	S 16°01'56.6'' E 046°00'23.0'
Triaenops rufus	RBJ 252	F	S 16°03'11.7'' E 045°48'47.4''
Triaenops rufus	RBJ 255	F	S 16°03'44.4'' E 045°47'35.3''
Triaenops rufus	RBJ 256	F	S 16°03'44.4'' E 045°47'35.3''
Triaenops rufus	RBJ 257	M	S 16°03'44.4'' E 045°47'35.3''

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