The Bat Community of the Rabi Oil Field in the Gamba Complex of Protected Areas, Gabon

Rogelio M. RODRIGUEZ[1], Federico HOFFMANN[1, 2], Calvin A. PORTER[1, 3] and Robert BAKER[1]

1 Introduction

Bats are the focus of many research projects because they are unique among mammals and fulfill a diversity of ecological niches (Solari *et al.* 2001). Unlike other mammals, bats have true powered flight. They have a low reproductive rate, generally one or two young per year. Such a low level of fecundity is unusual for an animal their size. This makes them vulnerable to increased mortality. Bats are especially interesting to study because the ability of microbats to echolocate represents a unique evolutionary adaptation that allows for existence in a nocturnal environment. Bats are found on every continent (except Antarctica) and inhabit a variety of environments to the tree line. Bats include many functional groups, such as insectivores, frugivores, nectivores, sanguivores, piscivores, and carnivores (Ascorra and Wilson 1992). The majority of bat species are insectivorous; many species consume large numbers of insects and therefore play an important role in controlling insect populations. Frugivorous and nectivorous bats depend on plants for food and shelter. Concomitantly many plants depend on bats as pollinators or seed dispersers. For example, bats serve as the major pollinator of the baobab tree of eastern Africa. These unique interactions allow for interesting ecological associations between animals and plants (Thomas 1991).

The distribution of bats in west-central Africa is still poorly-known (Fahr and Ebigbo 2003). As a result of collaborative efforts between the Smithsonian Institution and Texas Tech University and with support from The Shell Foundation and Shell Gabon, a preliminary survey of the bat fauna was conducted in the Rabi oil field, within the Gamba Complex of Protected Areas, in Gabon, Africa. Gabon is located on the Atlantic coast of western Africa, on the Equator, between The Republic of the Congo, Cameroon, and Equatorial Guinea. It has a tropical, humid climate, with the rainy season extending from September to May. The Gamba Complex experiences an intense dry season (June-August) when rainfall totals approach zero (Lee *et al.* this volume). It is located in a species-rich zone for Old World fruit bats (Juste *et al.* 1999), as well as containing a diverse array of microchiropteran taxa. Thus, the current study builds onto a foundation for which future surveys and conservation assessments can be performed on this invaluable group of organisms.

2 Materials and Methods

Bats were mist netted at various localities throughout the Rabi oil field, in the Gamba Complex, with sampling efforts and net locations set to maximize diversity. The government of Gabon authorized the research and collection of vouchers specimens. Sampling was conducted in February and March 2002. Four basic stations were selected, and each was sampled two to three times, with additional nets placed in openings and around areas of human habitation. Some nets were placed within the forest, 50-500 meters (m) from the forest edge. Other nets were placed at the edge of the forest, either near natural clearings, or more often, along roads or near areas cleared for human activities. In both cases, nets were placed in potential flyways, either over water or across pathways in the forest. Mist nets were opened at dusk, and we generally collected bats until midnight or 0100h. Because of a relatively low capture rate, we were often able to leave nets open until dawn before closing or moving the nets. Bats were tentatively identified in the field and prepared as

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[1] Department of Biological Sciences, Texas Tech University, MS 43131, Lubbock TX 79401.
Emails: r_rod77@hotmail.com, rjbaker@TTU.EDU

[2] Present address: School of Biological Sciences, University of Nebraska, Lincoln, NE 68588.
Email: federico@unlserve.unl.edu

[3] Present address: Department of Biology, Xavier University of Louisiana, 1 Drexel Drive, New Orleans, LA 70125. Email: cporter@xula.edu

Table 1. Bat species, organized by family, recorded in the Gamba Complex, Gabon. The habitat and the period of night when captured were recorded, as well as whether tissue samples were taken.

Species	Habitat	Period of Capture	Tissue Samples
Pteropodidae			
Epomops franqueti	Relatively open environment	Shortly after dark	Yes
Hypsignathus monstrosus	Over a small pool of water at the edge of the forest near human habitations	Dawn	Yes
Megaloglossus woermanni	Opened and closed areas	Shortly after dark, until midnight	Yes
Myonycteris torquata	Deep and forest edges	Shortly after dark, until midnight	Yes
Scotonycteris zenkeri	Deep in forest	Well after sunset	Yes
Vespertilionidae			
Glauconycteris beatrix	Deep in forest	Late at night	Yes
Glauconycteris poensis	Deep in forest	Late at night	Yes
Neoromicia brunneus	Deep in forest	Late at night	Yes
Kerivoula phalaena			No
Nycteridae			
Nycteris arge	Deep in forest	Late at night	No
Nycteris grandis	Deep in forest	Late at night	No
Rhinolophidae			
Hipposideros gigas	Deep in forest	Late at night	Yes
Hipposideros caffer	Deep in forest	Late at night	Yes

museum specimens (either as skin, skull, and skeleton or preserved in fluids). Tissue samples of liver, kidney, and heart were taken and stored in lysis buffer (Longmire *et al.* 1997) and ethanol 95%. Specimens have been desposited in the Gabon Biodiversity Program in Gamba, and the Smithsonian Institution, and the tissue samples at the Natural Science Research Laboratory at Texas Tech University.

Standard external measurements such as body length, tail length, hind foot length, ear length, tragus length and forearm length were taken in the field. An additional nine cranial measurements were taken with digital calipers to the nearest 0.01 millimeter (mm): *greatest skull length* (GSL), least distance from posterior border of supraoccipitals to anteriormost projection of the premaxillae; *condylobasal length* (CBL), least distance from posterior margin of occipital condyles to anteriormost projection of the premaxillae; *zygomatic breadth* (ZB), greatest distance across zygomatic arches perpendicular to the longitudinal axis of cranium; *interorbital breadth* (IOB), least distance across frontal bones; *braincase breadth* (BB), greatest distance across braincase; *mastoid breadth* (MB), greatest distance between mastoid processes; *maxillary toothrow length* (MxTL), distance from anterior margin of upper canine alveolus to posterior margin of last upper-molar alveolus; *mandibular toothrow length* (MnTL), distance from anterior margin of lower canine alveolus to posterior margin of last lower-molar alveolus, and width of the upper tooth row; *maxillary toothrow width* (MxTW), greatest distance across the external margins of the alveoli of the upper-molar toothrow (Table 2).

In addition, we sequenced a 400 bp fragment of the 5' end of the mitochondrial cytochrome-*b* gene in order to validate field identifications. Total genomic DNA was isolated following the phenol extraction protocol according to Longmire *et al.* (1997). The target sequence was amplified using primers L14724 and H15149 (Kocher *et al.* 1989, Edwards *et al.* 1991) via the polymerase chain reaction (PCR). PCR trials were run for 35 cycles of denaturating at 95°C, annealing at 50°C, extension 72°C each at 40 seconds, and a final cycle of extension at 72°C for 30 minutes. Amplicons were purified using a QIAquick PCR Purification Kit (QIAGEN Inc., Valencia, CA) following the manufacturer's protocol. Samples were cycle sequenced using BigDye terminator chemistry and electrophoresed in an ABI 377 sequencer. Sequences were checked and aligned using the program Sequencher Version 3.0 (Gene Codes Corporation Inc., Ann Arbor, MI).

Table 2. Summary of selected measurements from a collection of bats from the Gamba Complex, Gabon. Data presented as mean in millimeters (min-max). Abbreviations are: sample size (N) greatest skull length (GSL), condylobasal length (CBL), zygomatic breadth (ZB), mastoid breadth (MB), braincase breadth (BB), interorbital breadth (IOB), maxillary toothrow length (MxTL), mandibular toothrow length (MnTL), maxillary toothrow width (MxTW), and total length (TL). Tail length, hindleg length and ear measurements are also presented.

	Epomops franqueti	*Myonycteris torquata*		*Megaloglossus woermanni*		*Scotonycteris zenkeri*		*Hypsignathus monstrosus*
Sex	Male	Male	Female	Male	Female	Male	Female	Female
N	1	1	16	6	1	1	1	1
GSL	47.8	33.5	30.7 (25.5–33.0)	27.2 (35.7–46.6)	27.56	25.2	24.3	59.8
CBL	47.2	32	29.5 (26.0–32.1)	26.1 (34.4–45.2)	26.08	23.9	22.9	59.5
ZB	26.3	20.2	18.7 (15.8–20.5)	13.8 (20.7–25.6)	13.69	15.5	14.7	32.2
MB	17.6	12.4	11.5 (10.8–12.4)	9.7 (16.0–18.0)	9.3	10	9.6	21.4
BB	16.7	13.6	13.2 (12.3–13.7)	11.2 (16.1–17.5)	10.76	11	11.3	20.6
IOB	7.1	5.7	5.2 (4.5–6.3)	4.3 (6.0–7.5)	4.14	4.7	4.9	12
MxTL	16.2	12.3	11.5 (9.9–12.5)	8.9 (12.8–15.3)	9.05	8.1	7.7	20.33
MnTL	18.7	13.2	12.5 (11.0-13.6)	10.1 (14.4–17.9)	10.2	9.1	9	26.03
MxTW	15.4	8.3	8.8 (8.2–9.5)	6.3 (11.8–13.2)	6.41	7.5	6.7	18.85
TL	162	112	105.1	72.3 (112–146)	72	70	70	210
Tail		7	9.9	-		-	-	
Hindfoot	20	16	14.4	11.7 (20–23)	11	11	13	35
Ear	29	20	18	15.7 (23–29)	16	14	15	36

	Nycteris arge	*Nycteris grandis*	*Hipposideros caffer*	*Neoromicia brunneus*		*Glauconycteris poensis*
Sex	Male	Male	Male	Male	Female	Male
N	1	1	2	2	1	1
GSL	19.29	25.11	17.2 (17.0 – 17.4)	14.3 (14.2 – 14.4)	11.23	11.85
CBL	17.06	21.61	14.9 (14.8 – 15.0)	13.9 (13.7 – 14.2)	10.81	11.27
ZB	11.26	15.75	9.7 (9.6 – 9.7)	9.6 (9.2 – 9.9)	8.41	8.48
MB	7.58	10.62	7.9 (7.2 – 8.8)	7.1 (6.0 – 8.2)	7.37	7.34
BB	8.47	10.68	8.9 (8.8 – 8.9)	7.6 (7.5 – 7.7)	7.33	7.03
IOB	5.01	8.06	3 (2.9 – 3.1)	4 (4.0 – 4.0)	4.29	4.1
MxTL	6.88	9.25	5.3 (5.1 - 5.5)	5 (4.9 – 5.2)	4	4.07
MnTL	7.48	9.73	6.6 (6.4 – 6.7)	5.6 (5.5 – 5.7)	4.35	4.19
MxTW	7.43	10.56	6.5 (6.3 – 6.7)	6.4 (6.1 – 6.7)	5.75	5.42
TL	105	139	78	92	102	78
Tail	54	66	28.5	38.5	51	35
Hindfoot	10	15	8	8.5	7	7
Ear	27	32	16	13.5	11	10

3 Results and Discussion

We recorded 13 species of bats in the area. Six Megachiroptera (family Pteropodidae; five of which are in the subfamily Pteropodinae and one in the subfamily Macroglossinae) captured in the study include *Epomops, Hypsignathus, Megaloglossus, Myonycteris,* and *Scotonycteris.* Eight Microchiroptera (four in the family Vespertilionidae, two in the family Nycteridae, and two in the family Rhinolophidae) include *Glauconycteris, Neoromicia, Kerivoula*, *Hipposideros*, and *Nycteris* (Table 1).

We captured a larger number of fruit bats, with *Myonycteris*, *Epomops* and *Megaloglossus* as the genera most frequently found in the nets. Microchiropteran taxa were scarce in number (less than 15 specimens in over 20 nights of netting), with captures restricted to the forested areas, whereas fruit bats were also obtained in more open habitats. *Megaloglossus woermanni* and *Myonycteris torquata* were the most abundant species captured, followed by *Epomops franqueti*. A note of caution should be exercised when interpreting these results, since mist nets are biased towards catching fruit bats, which rely mostly on their sight, as opposed to microchiropterans, which rely on echolocation for their orientation. Fruit-eating species in the family Phyllostomidae (Microchiroptera) are the ones most commonly caught in the Neotropical rainforests (Solari *et al.* 2001). Lower capture rates among insectivorous species is probably due to more advanced echolocation in insect-eating microchiropteran families, as suggested by Patterson *et al.* (1996) and Voss and Emmons (1996). Our personal observation would seem to corroborate this; we saw several microchiropterans flying along the pathways in the rainforest with no difficulties in avoiding the nets. A brief taxonomic account follows, and a summary of the measurements is presented in Table 2.

3.1 Megachiroptera

Epomops franqueti
We captured 12 specimens of this species. Most were caught shortly after dark, and in a relatively open environment.

Hypsignathus monstrosus
The single specimen of *H. monstrosus* was captured over a small pool of water at the edge of the forest near human habitations. The bat was taken from the net at dawn.

Megaloglossus woermanni
This small nectar and pollen-feeding species was one of the most commonly found bats at Rabi. Unlike some other species, we found substantial numbers of both males and females. This species was most commonly captured in open areas, but was also found in the forest. Fahr and Ebigbo (2003) reported *M. woermanni* as a forest species in Guinea.

Myonycteris torquata
We identified in the field three different morphologic variants of the genus *Myonycteris*: a large, brown group, a medium-sized red group and a small grey group. These three groups were tentatively identified in the field as distinct species. However, analyses of their DNA sequences did not support these morphological groups. The pelage and size differences were probably associated with age. DNA sequence comparisons between these three morphotypes were on average below 2%, and suggest they are conspecific. This species appears to be well adapted to both deep and forest edges. *Myonycteris torquata* and *Scotonycteris zenkeri* were the only megachiropterans collected deep in the forest. These species are the smallest megachiropterans collected at Rabi. *Myonycteris. torquata* is extremely abundant at Rabi.

Scotonycteris zenkeri
Two specimens (one male and one female) of the species were captured and preserved, both in forested areas and collected well after sunset.

3.2 Microchiroptera

We recorded two species of the genus *Nycteris,* two of *Hipposideros*, two of *Glauconycteris* and one species of the genera *Miniopterus, Neoromicia and Kerivoula* most of these represented by a single specimen. Thus, morphologic and morphometric comparisons are not feasible. Microchiropteran captures occurred deeper in the forest and later in the night, as opposed to megachiropterans.

The only microchiropteran genus for which we have genetic data is *Nycteris*. The family Nycteridae contains 14 species all in the genus *Nycteris* (Gray *et al.* 1999). Genetic divergence between the two species of *Nycteris* we found in Gabon was high (p distance 17.1 %). *Nycteris* from Gabon showed an average genetic distance of 19.15% (18.39% -

20.05%) compared to *N. thebaica* and an average of 21.03% (20.21% - 21.59%) divergence from *N. macrotis*. Specimens of both species feigned death upon being touched in the nets.

3.3 Ecology

As is the case in similar sites in South America, frugivorous bats show the highest relative abundance (Solari *et al*. 2001, Ascorra and Wilson 1992), albeit the sampling strategy is likely to account for some of this pattern. As already noted, the lower number of insectivorous bats obtained might have something to do with their ability to detect and avoid nets. A further comparison with Neotropical bat faunas suggests that the forests of Gabon harbor fewer species than a comparable forest in the New World. We captured 13 different species throughout a 30 day period, whereas equivalent efforts in the rainforests of South America have generally produced over 30 species (see Solari *et al*. 2001, Table 2, modified from Voss and Emmons 1996). Additionally, the number of individuals captured was also considerably less at Rabi than is typical for similar methods in Latin America (C. A. Porter, pers. obs.). It is possible that different collecting methods (such as harp traps and netting in the canopy) may reveal additional diversity in the bat fauna of Rabi.

3.4 Conservation

Bats in Central Africa hold an exceptional conservation value due to their ecological roles among the Mega- and Microchiroptera. Current maintenance and future sustainability of the tropical forests of the region depend in part on the role of frugivorous bats. Megabats, such *Epomops franqueti*, serve as major pollinators and seed dispersers of tropical plants. Plants like papaya, guava, cashew, and neem rely on *E. franqueti* for prolonged reproductive success. In fact, fruitbats have been shown to contribute to over 90% of the seed dispersion in tropical and savanna habitats of Africa (Thomas 1991). This seed dispersion capability contributes considerably to the rate of forest regrowth in natural tree fall gaps and forest openings.

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