New records of bats (Mammalia: Chiroptera) and karyotypes from Guinean Mount Nimba (West Africa)

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Abstract

New bats were recorded from various habitats on the Guinean side of Mount Nimba during two surveys in 2008 and coupled with a cytotaxonomic survey. A total of 152 specimens comprising 15 species in 12 genera from five families were collected, of which 13 individuals were karyotyped. The most numerous species was *Rhinolophus guineensis* followed by four fruit bats (*Epomops buettikoferi*, *Lissonycteris angolensis*, *Roussettus aegyptiacus*, *Nanonycteris veldkampii*). We confirm the presence of *Hipposideros lamottei* in the mine adits at 1500 m as well as the exceptional diversity of this habitat. First standard karyotypes are provided for *Epomops buettikoferi* and *Nanonycteris intermedia*. We also document for the first time karyotypes for West African populations of *Mops thersites*, *Lissonycteris angolensis* and *Roussettus aegyptiacus*, and cytogenetical comparisons with the existing literature are provided. We add five new species to the list of Guinean Nimba and two to the whole Nimba list (including Liberian side), which now stands at 42 species. This confirms the importance of Mount Nimba as a hotspot of diversity and the necessity to protect it.

Keywords: *Chiroptera, Mount Nimba, West Africa, cytogenetics, diversity*

Introduction

Bats are the second most abundant order of mammals, representing 25% of its diversity in 1116 species (Wilson & Reeder 2005). This figure is steadily rising as many taxonomic studies, based on genetics, morphology and acoustic characteristics, have recently highlighted the existence of significant cryptic diversity in this taxon (Kingston et al. 2001; Vallo et al. 2008; Taylor et al. 2012; Monadjem et al. 2013).

The forests of tropical Africa are considered as hotspots of biodiversity (Myers et al. 2000; Olson et al. 2001). By acting as refugia during cold periods, they are considered as promoters of biodiversity in west central Africa (Nicolas et al. 2011; Missoup et al. 2012). Some studies demonstrated that diversity may also arise at the ecotone between forest and savanna (T.B. Smith et al. 2005; Fahr & Kalko 2011). Montane forests also play a role in shaping tropical African biodiversity by constituting terrestrial islands (White 1981; Kingdon 1990; Taylor et al. 2012), isolated by altitude and changes in habitat.

In tropical west and central Africa, different montane blocks are scattered in the lowland Guineo-Congolian forest but their mammalian fauna has attracted less attention than those of the Eastern Arc (Newmark 2002; Stanley & Goodman 2011) or Ethiopian highlands (Yalden & Largen 1992; Kasso et al. 2010). Prominent among the West African highlands is Mount Nimba, which straddles the borders of Guinea, Ivory Coast and Liberia. This mountain is considered as a prime hotspot for African

mammals (Olson et al. 2001; Mittermeier et al. 2005) and it was designated a UNESCO Biosphere Reserve in 1980. Mount Nimba harbours an exceptionally rich biological diversity, with numerous endemic taxa including the bat *Hipposideros lamottei* Brosset, 1984. Despite a rather low altitude [highest peak at 1768 m above sea level (asl)], the exceptional geology of the site has allowed the development of edaphic vegetation assemblages that are unique (Lamotte & Roy 1962). Extensive savannas occur at higher elevations, forming an island of montane grasslands interdigitated among blocks of Upper Guinean Forest.

Bat diversity in Mount Nimba has been documented in a number of previous studies, which have mostly focused on the Liberian side of the mountain (Coe 1975; Verschuren 1976; Hill 1982; Wolton et al. 1982), with fewer studies on the Guinean side (Lamotte 1942; Aellen 1963; Brosset 1985). In a review of the bats recorded from Guinean Mount Nimba, Brosset (2003) confirmed the occurrence of 39 species and suggested that this may be one of the most diverse bat communities on the African continent. Brosset (2003) also noted the exceptionally high number of Pteropodidae present at this site as well as the high diversity of bats from montane forest above 800 m asl. Furthermore, Monadjem et al. (2013) also reported a highly diverse assemblage of 10 species of pipistrelloid bats from the Liberian side of Mount Nimba.

This paper reports on a bat survey conducted as part of a global inventory on the small mammal fauna of Guinean Mount Nimba. The objectives are: (1) to document new records of bats from Guinean Mount Nimba and to provide a recent update of the bat diversity in the Nimba region, and (2) to report karyotypes for some of these species.

Study area

We captured bats in four different localities in Guinean Mount Nimba (Table I). The first locality was Seringbara (550–620 m asl), situated on the southwestern flank of the highest peak, "Richard Molard", 5 km east of Bossou station and covered by dense primary and secondary forest. The second site was Gbie (540–620 m asl). It consisted of enclosed savanna of anthropic origin within secondary forest on the northeastern flank of the mountain, about 6 km from Nzo village. The third locality was situated in the Societe des Mines de Fer de Guinea (SMFG) mining concession (1498 m asl). It is constituted of old mine adits in high altitude grasslands at "Pierre Richaud". Finally, bats were also captured adjacent to the SMFG mining camp (City I and II), between the Gouan and Zougue rivers at an intermediate altitude (800–1200 m asl).

Data collection and analysis

During the dry (February–March) and the wet (September–October) seasons of the year 2008, six 12-m mist nets with five shelves, 16-mm mesh and 110-denier thickness were set at the different sites. At each site, nets were set across potential flight paths of bats such as rivers and streams, swampy areas, paths through forest or at the ecotone between savanna and forest. They were also placed at the entrance of two mine adits for one night. The nets were opened for several hours from dusk till after midnight (generally 7:00 pm to 01:00 am). In the field, the following morphological measurements were taken from each captured bat: length of forearm (FA), length of the tibia (TIB), and length of ear (E).

Skulls were either prepared in the field (by Fode Kourouma) or at the Service of Osteological and Taxidermy Preparation (SPOT) in the Muséum d'Histoire Naturelle (MNHN), Paris, and measured using a pair of Mitutuyo calipers with a precision of 0.01 mm.

Thirteen specimens were kept for standard karyotypic analyses, which were conducted directly in the field by one of us (VA) (SER175, 179, 180,

Table I. Trapping effort at the various locations during the dry (February–March) and wet (September–October) seasons at Guinean Mount Nimba during 2008. See the text for a more detailed description of the habitat at each location.

Location	Habitat	Altitude (m)	Trap effort (net nights)		Total
			Dry season	Wet season	
Gbie	Savanna/forest ecotone	540 – 620	6	10	**16**
Gouan camp	Disturbed savanna/forest	800 – 1200	–	14	**14**
Pierre Richaud	Montane grassland	1498	2*	–	**2**
Seringbara	Lowland forest	550 – 600	30	17	**47**
Total			**38**	**41**	**79**

*These nets were set up at the entrance of mine adits and therefore only captured bats that were roosting in the adit.

181, 183, 189, 190; GBIE196, 197, 223, 245, 246, 255) and three specimens sequenced (NIMI123, NIM1108, NIM1110, cytochrome B; Monadjem et al. submitted). Metaphase chromosome preparations were obtained by the standard colchicine method following the protocol of M.R. Lee and Elder (1980).

All specimens have been deposited in the Mammal section of the MNHN collections. For identifications we compared our new specimens to voucher collections based on previous surveys (e.g. Brosset 1985, 2003) and housed in the MNHN.

Results

A total of 152 bats were netted during this study, comprising five families, 12 genera and 15 species. The single largest contribution by family was the Pteropodidae (69.7% of all captures) with an average capture rate of success of 0.37 bats per 12 m mist net hour (b/mh), vs 0.15 (b/mh) for insectivorous bats. The greatest capture of individual species was *Rhinolophus guineensis* (21.1% of all captures), *Nanonycteris veldkampii* (19.1%), *Epomops buettikoferi* (11.2%) and *Rousettus aegyptiacus* (10.5%). These proportions were similar between the wet and dry seasons except for *R. guineensis*, which was predominantly captured during the dry season (Table II). External measurements, standard karyotype (when available) and localities from which each species was collected in Guinean Mount Nimba are presented in Table III.

Family Pteropodidae Gray, 1821

Two males of *Hypsignathus monstrosus* Allen, 1861 were netted from Nimba: one during the dry season in the lowland forest of Seringbara and the other in the wet season in Gouan Camp. This is the largest species of bat recorded for this region.

Another Pteropodidae, *Epomops buettikoferi* (Matschie, 1899) was represented by 18 specimens; six (five males and one female) from Seringbara and 12 (four males and eight females) from Gbie and Gouan. It was present in a variety of habitats from forest to the savanna-forest ecotone. Four specimens were karyotyped (SER180, 181, 183, 190), all from lowland forest of Seringbara. The karyotype consisted of 34 autosomes and two (XX) or one (X0) gonosomes in females (2n = 36) and males (2n = 35), respectively. The autosomal set comprised 17 pairs of bi-armed chromosomes decreasing in size, thus resulting in NFa (Fundamental Number of autosomes) = 68 (Figure 1). The X chromosome was submetacentric of medium-sized.

A total of 16 specimens belonging to *Lissonycteris angolensis smithii* Thomas, 1908 was captured during this study; six (two males and four females) from lowland forest at Seringbara and 10 (five males and five females) from mine adits at Pierre Richaud (Table III). The chromosome set of the studied female from Seringbara consisted of 16 pairs of meta/submetacentric decreasing in size, one pair of very small acrocentric and two medium-sized submetacentric X chromosomes, resulting in 2n = 36 and NFa = 66 (Figure 2).

Nine representatives of *Megaloglossus woermanni* Pagenstecher, 1855 (two males and seven females) were collected, of which eight were in the dry season and one in the wet season, all from the lowland forest at Seringbara (Table III).

We captured nine specimens (eight females and one male) of *Micropteropus pusillus* (Peters, 1868), one in savanna at Gbie and the rest at the Gouan mining camp (Table III).

A total of nine specimens (four females and five males) of *Myonycteris torquata* (Dobson, 1878) were captured, three from forest habitat at Seringbara in the dry season and the rest during the wet season at Gouan mining camp (Table III).

We netted 29 specimens (16 males and 13 females) belonging to *Nanonycteris veldkampii* (Jentink, 1888) during both wet and dry seasons, all in forest habitat at Seringbara (Table III).

One of the most abundant species in our nets was *Rousettus aegyptiacus unicolor* (E. Geoffroy, 1810), with 17 specimens captured, of which three individuals (two females and one male) were from savanna at Gbie and 14 (nine males and five females) from forest at Seringbara (Table III). Four specimens (three females, GBI197, GBI245 and GBI246, and one male, GBI255) from our study showed karyotype 2n = 36, NFa = 66 (Figure 3). Despite sharing similar diploid and fundamental numbers, and X chromosomes, with *Lissonycteris angolensis*, the karyotype of these two species showed some differences. The autosomes of *R. aegyptiacus* consist of 12 metacentric pairs (*L. angolensis* has 11 pairs, two submetacentric pairs (*L. angolensis* has three pairs), two subtelocentric pairs and one small acrocentric pair. The Y chromosome is the smallest chromosome in the complement.

Family Rhinolophidae Gray, 1825

A total of 40 specimens (11 females and 29 males) of *Rhinolophus guineensis* Eisentraut, 1969 were

Table II. Bat diversity, trap effort, number of individuals, relative abundance and abundance in the different habitat types sampled at Guinea forest region. CR, critically endangered; VU, vulnerable; LC, least concern; DD, data deficient. b/mh: bat per 12 m mist net hour; DST, dry season trapping; WST, wet season trapping; TT, total trapping.

Species	Dry season	DST (b/mh)	Wet season	WST (b/mh)	Total	TT (b/mh)	Relative abundance (%)	RED LIST
Trapping effort		0.15		0.12		0.27		
Pteropodidae								
Epomops buettikoferi (Mastchie, 1899)	7	0.19	10	0.28	17	0.47	11.18	LC
Hypsignathus monstrosus H. Allen, 1861	1	0.03	1	0.03	2	0.06	1.32	LC
Lissonycteris angolensis smithii (Thomas, 1908)	11	0.31	4	0.11	15	0.42	9.87	LC
Megaloglossus woermanni Pagenstecher, 1885	8	0.22	1	0.03	9	0.25	5.92	LC
Micropteropus pusillus (Peters, 1867)	1	0.03	8	0.22	9	0.25	5.92	LC
Myonycteris torquata (Dobson, 1878)	3	0.08	6	0.17	9	0.25	5.92	LC
Nanonycteris veldkampii (Jentink, 1888)	11	0.31	18	0.50	29	0.81	19.08	LC
Rousettus aegyptiacus unicolor (Gray, 1870)	10	0.28	6	0.17	16	0.44	10.53	LC
TOTAL MEGACHIROPTERA					**106**	**0.37**	**69.74**	
Rhinolophidae								
Rhinolophus guineensis Einsentraut, 1960	24	0.66	8	0.17	32	0.84	21.05	VU
Rhinolophus simulator alticolus Sanborn, 1960	2	0.05	0	0.00	2	0.05	1.3	LC
					34	0.00	**22.38**	
Nycteridae								
Nycteris intermedia Aellen, 1959	0	0.00	1	0.03	1	0.03	0.66	LC
					1		**0.66**	
Hipposideridae								
Hipposideros cf.ruber Noack, 1893	1	0.03	5	0.14	6	0.17	3.95	LC
Hipposideros lamottei Brosset, 1984	3	0.08	0	0.00	3	0.08	1.97	CR
					9		**5.92**	
Molossidae								
Mops thersites (Thomas, 1903)	0	0.00	1	0.03	1	0.03	0.66	LC
Mops brachypterus leonis (Thomas, 1908)	1	0.03	0	0.00	1	0.03	0.66	LC
					2		**1.32**	
TOTAL MICROCHIROPTERA					**46**	**0.15**	**29.61**	
TOTAL DATA	**83**		**69**		**152**	**0.27**	**100.00**	

captured during the dry season from adit Galery 1 (Pierre Richaud) and Gouan village II in the wet season (Table III).

Two males identified as *Rhinolophus simulator alticolus* Sanborn, 1936 were captured at the entrance of an adit at Pierre Richaud during the dry season (Table III).

Family Nycteridae Van der Hoeven, 1855

A single female attributed to *Nycteris intermedia* Aellen, 1939, was captured at Gbie during the wet season (Table III). The karyotype of the single female (GBIE 223) was 2n = 34, NFa = 62 and had 15 pairs of large to small metacentric and

Table III. The range (minimum–maximum) in external standard measurements (mm) of the bats collected during this survey: N, sample size; FA, forearm length; TIB, tibia length; E, ear length; 2N, diploid number of chromosomes; aFN, autosome fundamental number. Abbreviations for the localities: SER, Seringbara; GC, Gouan Camp; GBI, Gbie; GC, Gouan City I and II; PR, mine adit in Pierre Richaud; NA, karyotype not available.

Species	N	FA: Min–Max	TIB	E	localities	2N, aFN
Hypsignathus monstrosus	2	131–137.7	56.6–59.9	31–32	SER,GC	NA
Epomops buettikoferi	18	79.9–98.6	27.6–42.9	19–28	SER,GBI,GC	36, 68
Lissonycteris angolensis	16	70.3–73.8	28.3–33.7	15–20	SER,PR	36, 66
Megaloglossus woermanni	9	40.2–42.3	12.2–19.3	12–19	SER	NA
Micropteropus pusillus	9	50.4–53.4	20.8–23.5	13–16	GBI,GC	NA
Myonycteris torquata	9	42.1–62.2	17.6–25.6	12–16	SER,GC	NA
Nanonycteris veldkampii	29	40.4–53.2	13.7–22	12–19	SER	NA
Roussettus aegyptiacus	17	84.4–100	31.2–46.2	19–22	GBI,SER	36, 66
Rhinolophus guineensis	41	44.4–47.8	19.9–22.8	13–19	PR, GCI	NA
Rhinolophus simulator alticolus	1	43.2	17.3–18.3	19	PR	NA
Nycteris intermedia	1	35.5	21.0	20	GBI	34, 62
Hipposideros cf.ruber	6	49.9–53.8	19.6–22	12–15	SER,GCI	32, 60
Hipposideros lamottei	3	55–56.3	22–25	11–15	PR	NA
Mops thersites	1	41.0	15.3	14	GBI	48, 70
Mops brachypterus leonis	1	39.0	12.2	16	SER	NA

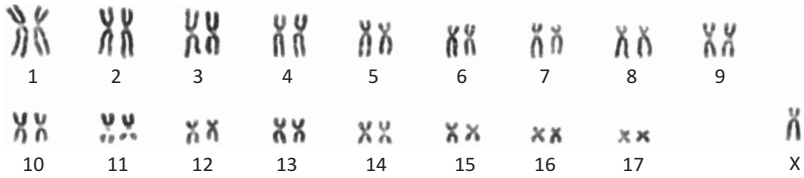

Figure 1. Standard karyotype of male *Epomops buettikoferi* (SER 190) 2n = 35, NFa = 68.

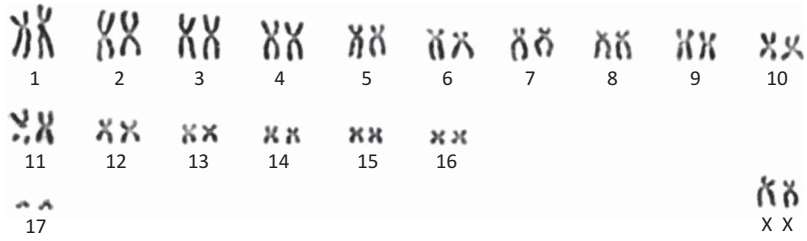

Figure 2. Standard karyotype of female of *Lissonycteris angolensis smithii* (SER 179) 2n = 36, NFa = 66.

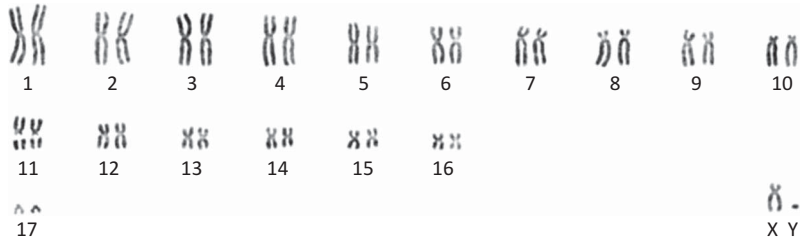

Figure 3. Standard karyotype of male *Rousettus aegyptiacus unicolor* (GBIE 255) 2n = 36, NFa = 66.

submetacentric chromosomes and one middle-sized acrocentric pair (Figure 4). The X chromosome was a submetacentric similar in size to the acrocentric autosomes.

Family Hipposideridae Lyddeker, 1891

A total of six specimens attributed to *Hipposideros* cf. *ruber* (Noack, 1893) were captured in the Nimba Mount slopes. Two of them (one male and

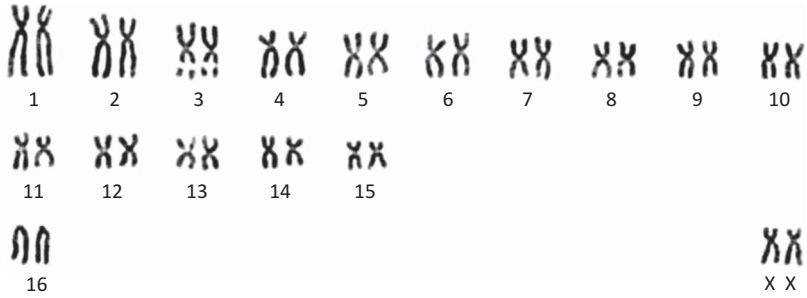

Figure 4. Standard karyotype of female *Nycteris intermedia* (GBIE 223) 2n = 34, NFa = 62.

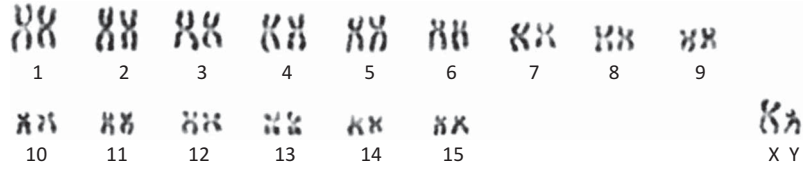

Figure 5. Standard karyotype of male *Hipposideros* cf *ruber* (SER 189) 2n = 32, NFa = 60.

one female) came from Gbie at the ecotone secondary forest/enclosed savanna, two (both males) from Seringbara in forest and the remaining two (both females) from Camp Cité II (Table III). One male (SER189) was karyotyped, with 2n = 32 and NFa = 60 (Figure 5). This karyotype consisted of 15 pairs of meta/submetacentric chromosomes gradually decreasing in size. The X chromosome was a middle-sized submetacentric and the Y chromosome a small subtelocentric.

Three specimens (two females and one male) of the Mount Nimba endemic *Hipposideros lamottei* Brosset, 1985 were all caught during the dry season at an adit at Pierre Richaud at an altitude of 1498 m asl (Table III). No karyotype was obtained for this species, but the Cyt. *b* gene was sequenced and the specimens were compared directly with the type series to confirm the species taxonomic validity (Monadjem et al. submitted).

Family Molossidae Gervais, 1856

A single female attributed to *Mops thersites* (Thomas, 1903) was captured at Gbie during the wet season (Table III). The karyotype comprised four pairs of metacentric (of which the first pair was the largest of the set), eight pairs of subtelocentric, 11 pairs of acrocentric autosomes decreasing in size and a middle-sized submetacentric X chromosome, thus giving 2n = 48 and NFa = 70 (Figure 6).

Another female molossid was captured during the dry season in a nocturnal butterfly light trap in the Seringbara forest. Its morphology and external measurements (Table III) allowed us to attribute it to *Mops brachypterus leonis* (Peters, 1852).

Discussion

Taxonomic notes and morphological comparisons

For some species, identifications based upon external morphological grounds were not easy. By comparison, the size range of our new specimens of *Rhinolophus guineensis* (FA: 44.4–47.8 mm, TIB: 19.9–22.8 mm, Table III) fits well with previous records of Côte d'Ivoire and Guinea. For example, Fahr et al. (2002) trapped a single specimen from the Man region (Côte d'Ivoire) whose measurements were: FA: 45.8 mm, TIB: 20.5 mm, *E* = 21 mm. At the Simandou range (Guinea), Fahr and Ebigbo (2003) reported the following measurements for *R. guineensis*: FA: 46.8–47.4 (*N* = 7). And finally, on the Fouta Djallon mountains (Guinea), the measurements were FA: 44.3–46.9 mm, TIB: 19.9–22 mm, E: 16.5–20.2 mm (Weber & Fahr 2007).

Similarly, the skull measurements of *Nycteris intermedia* were GSKL (greatest skull length): 17.40 mm; CCL (condylo-canine length) = 15.00 mm; Zygomatic width = 10.30 mm; MAST (mastoid width) = 7.55 mm; C–M3 (upper teeth row length) = 6.00 mm; C–C (inter canine width) = 4.20 mm; M3–M3 (inter third upper molar width) = 6.45 mm, fit within the known range for this species and confirmed the identification.

Concerning the old MNHN Lamotte collections that were examined by one of us (AM), we confirmed all previous identifications and discovered an overlooked specimen of *Neoromicia* cf *somalica* specimen (MNHN1977-559) that had been collected from "Mt. Nimba" in 1942. This specimen was not mentioned in the review of Brosset (2003). It has a GSKL of 12 mm, the anterior premolar is absent,

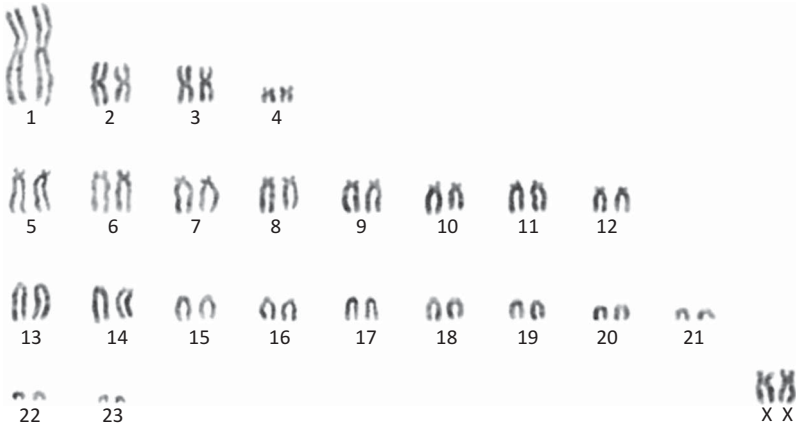

Figure 6. Standard karyotype of female *Mops thersites* (GBI 196) 2n = 48, NFa = 70.

and the outer upper incisor is half the length of the inner one and is bifid.

Cytogenetic comparisons

In this paper we provide karyotypes for the first time for two species: *Epomops buettikoferi* and *Nycteris intermedia*. We also provide for the first time karyotypes for the West African populations of *Mops thersites, Lissonycteris angolensis smithii* and *Roussettus aegyptiacus unicolor*. The standard karyotype of *E. buettikofferi* is characterized by 2n = 36 (female XX), 2n = 35 (male X0) and NFa = 68, which is close to that published for *E. franqueti* (Peterson & Nagorsen 1975; Haiduk et al. 1980; Primus et al. 2006), with some variation in the sex chromosome systems of males of *E. franqueti*. The karyotype of a male *E. franqueti* (2n = 36) from Cameroon was characterized by standard XY sex chromosome (Haiduk et al. 1980). The chromosome complement of a male (2n = 35) from Gabon was characterized by X0 sex chromosome. Cells in the diakinesis stage of meiosis have 18 elements, one of which appears to be an X chromosome univalent (Primus et al. 2006). Previously, the XX/X0 sex chromosome system was described only in *E. crypturus* and *E. gambianus* (Peterson & Nagorsen 1975).

The karyotype of *Nycteris intermedia* recorded in this study (2n = 34, NFa = 62) was different from any other reported species of the genus. Peterson and Nagorsen (1975) and Rautenbach et al. (1993) both described a 2n = 42, NFa = 78 karyotype from specimens of *N. thebaica* collected in Zimbabwe (Rhodesia) and southern Africa. The karyotypes with 2n = 42 are also known for *N. woodi* (Rautenbach et al. 1993), *N. hispida* (T.E. Lee et al. 1989) and *N. grandis* (Porter et al. 2010).

The karyotype of *Mops thersites* recorded in this study (2n = 48, NFa = 70) was different in the fundamental number (NFa) from eight other congeneric African molossid species: *M. midas* (Somalia), *M. condylurus* (Somalia, Senegal), *M. spurrelli* (Cameroon), *M. brachypterus leonis* (Cameroon), *M. petersoni* (Cameroon), *M. demonstrator* (Cameroon), *M. nanulus* (Cameroon) and *M. thersites* from Cameroon (S.A. Smith et al. 1986; Sreepada et al. 2008). All these species were characterized by a diploid number of 48 and NFa ranged from 54 to 66. The autosomal complement of *M. thersites* from Cameroon includes one pair of large metacentric, three pairs of medium metacentric, three pairs of medium subtelocentric, one pair of small subtelocentric and 15 medium to small acrocentric chromosomes, which clearly differs from the *M. thersites* from Mount Nimba. In general, all species have a similar structure of karyotype. The differences may be the result of pericentric inversions and heterochromatic autosomal arm additions/deletions.

In addition, we also present the first karyotype for the west African taxon *Lissonycteris angolensis smithii*. Our results show that this taxon has a similar karyotype to that of *L. angolensis angolensis* (type locality is Angola) reported from Cameroon (Haiduk et al. 1980, 1981).

Rousettus aegyptiacus was initially described from Egypt but this species has populations scattered across Africa and Eurasia. The taxon present in west Africa is *R. aegyptiacus unicolor* (Rosevear 1965) and our documentation of its karyotype from Mount Nimba (2n = 36, NFa = 66) corresponds to *R. aegyptiacus* described from east Africa (Đulic & Mutere 1973, 1977) and from South Africa (Haiduk et al. 1981, 1983). The karyotype of *R. aegyptiacus* from Egypt was characterised by 2n = 36, NFa = 68

(Sayed 2011). This karyotype is composed of nine pairs of metacentric, four pairs of submetacentric and four pairs of subtelocentric. The X chromosome was a middle-sized submetacentric and the Y chromosome a minute acrocentric. The autosomes of *R. aegyptiacus* described by Đulic and Mutere (1973) consist of 12 metacentric pairs, two submetacentric pairs, two subtelocentric pairs and one acrocentric pair. This difference in almost identical karyotypes results from difficulty in distinguishing between some pairs of autosomes, which may be considered as metacentric or submetacentric, as well as some other pairs of autosomes which may be considered as submetacentric or subtelocentric. Such difficulties in determining the morphology of the chromosomes are common to many other species of African bats. In our study we adhere to the terms of Đulic and Mutere (1973). The slight differences in the NFa number results from varying morphology of the small pair of chromosome number 17 that we, in the present work, considered as acrocentric but which was biarmed from Egyptian specimens.

Concerning *Hipposideros cf ruber*, our Nimba specimen has the same standard formula as documented by Koubínová et al. (2010), who reported on seven females from Senegal, $2n = 32$, NFa = 60. The autosomes of this species included four pairs of metacentric, eight pairs of submetacentric and three pairs of subtelocentic (considered here as submetacentric). The standard karyotype of *H. ruber* is also identical to *H. tephrus* and *H. jonesi* but it is different from the karyotype of *H. cyclops* (2n = 36, NFa = 62) and *H. gigas* (2n = 52, NFa = 60). The large variation in diploid number (2n) and the similar fundamental numbers of chromosomal arms (NFa) indicate that the Robertsonian rearrangements are a probable source of karyotype variation among these species (Koubínová et al. 2010). Porter et al. (2010) noted that one specimen of *H. caffer* from Gabon had a 2n = 32 (NFa not indicated) karyotype similar to most other congeneric species with 2n = 32. In our opinion, this karyotype differs in the morphology of some pairs of autosomes (see Figure 1C of Porter et al. 2010) and demands more research. We note that the *H. ruber*/*caffer* complex consists of several cryptic species (Vallo et al. 2008, 2011) of which at least two species occur at Mount Nimba (Monadjem et al. submitted).

Mount Nimba bat community diversity and conservation

Brosset (2003) provided a list of 39 species recorded from Mount Nimba, many of which were only known from the Liberian side of the mountain. The total number of species recorded from Guinean Nimba prior to this study was 23 (see Table IV for references). During our field work, we collected a total of 15 species from the Guinean side. The updated list for this side of the mount, provided in Table IV, is based on this new data, to which we added the taxa previously reported by Lamotte (1942), Aellen (1963), Verschuren (1976), Brosset (1985), Fahr et al. (2006) and more recently by Monadjem et al. (2013). This allows us to report the presence of a total of 29 species of bats for Guinean Mount Nimba in 12 localities (Table V). Five of these species are documented here for the first time: *Hypsignathus monstrosus, Nanonycteris veldkampii, Micropteropus pusillus, Mops brachypterus leonis* and *Mops thersites* (Table IV). Of these, *H. monstrosus, N. veldkampii*, *Mops thersites* and *Neoromicia somalica* have already been recorded from Liberian Mount Nimba (Coe 1975; Verschuren 1976; Wolton et al. 1982; Monadjem et al. 2013). The other two species (*Mops brachypterus leonis* and *Micropteropus pusillus*) are new to the whole mountain, taking the total number of bats known from the Guinean Mount Nimba up to 29 species and for the entire mountain up to 42 species. Recent surveys of bats on the Liberian side of Mount Nimba have unearthed yet more species new to the mountain (Monadjem & Denys in prep.), underscoring the exceptional diversity of this region.

The fruit bat *Nanonycteris veldkampii* is known to be a migratory species in west Africa (Marshall & MacWilliam 1982; Thomas 1983), moving to Mount Nimba at the end of the wet season (October) and possibly departing in April (Coe 1975; Wolton et al. 1982). We captured this species during both our wet and dry season sampling sessions, but we did not survey during the critical period June–September when this species is suspected to have migrated out of this region.

Most of the bat diversity at Guinean Mount Nimba is derived from lowland forest elements, as highlighted by Brosset (2003). However, the montane grasslands which are only present on the Guinean side of Mount Nimba have an interesting assemblage of cave-roosting bats that have occupied the mine adits > 1400 m asl. Of foremost concern is *Hipposideros lamottei*, which is endemic to Mount Nimba, and its entire roosting population is known from a handful of adits in the Pierre Richaud region (Monadjem et al. submitted). This area is under threat of mining for iron ore (IUCN 2012) making this species critically endangered (IUCN 2012). Despite extensive surveys on the Liberian side of the mountain, this species has not been captured beyond the borders of Guinean Mount Nimba (Monadjem

Table IV. Bat species checklist for Guinean Nimba listing 29 species recorded from this area. The reference refers to the first publication recording the species from that locality.

Family/Genus	Species	Location	Reference
Hipposideridae			
Hipposideros	cf *ruber*	Gbie	This study
		Grotte de Blande	Aellen (1963)
		Keoulenta	Aellen (1963)
		Seringbara	This study
		Ziela	Aellen (1963)
		Zouguepo	Aellen (1963)
Hipposideros	*lamottei*	Gbie/Seringbara	This study
		Grotte de Blande	Brosset (1985)
		Pierre Richaud	Brosset (1985)
Hipposideros	*marisae*	Gouan river	Aellen (1963)
Molossidae			
Mops	*brachypterus leonis*	Seringbara	This study
Mops	*spurrelli*	Mt Nimba	Lamotte (1942)
Mops	*thersites*	Gbie	This study
Nycteridae			
Nycteris	*grandis*	Ziela	Aellen (1963)
Nycteris	*hispida*	Ziela	Aellen (1963)
		Zouguepo	Aellen (1963)
Nycteris	*intermedia*	Ziela	Fahr et al. (2006)
		Gbie	This study
Nycteris	*major*	Ziela	Fahr et al. (2006)
Pteropodidae			
Eidolon	*helvum*	Mt Nimba, NE	Aellen (1963)
Epomops	*buettikoferi*	Gbie	Bergmans (1975)
		Gouan Camp	This study
		Mt Nimba	This study
		Seringbara	This study
Hypsignathus	*monstrosus*	Gouan camp	This study
		Seringbara	This study
Lissonycteris	*angolensis smithii*	Pierre Richaud	Brosset (1985)
		Richard Molard	Verschuren (1976)
		Seringbara	This study
Megaloglossus	*woermanni*	Gbie	Aellen (1963)
		Seringbara	This study
Micropteropus	*pusillus*	Ziela	This study
		Gouan camp	This study
Myonycteris	*torquata*	Gouan camp	Verschuren (1976)
		Richard Molard	This study
		Seringbara	This study
Nanonycteris	*veldkampii*	Seringbara	This study
Rousettus	*aegyptiacus unicolor*	Gbie	Lamotte & Roy (1998)
		Grotte de Blande	Lamotte & Roy (1998)
		Grotte de Zie	This study
		Seringbara	This study
Rhinolophidae			
Rhinolophus	*guineensis*	Pierre Richaud	Brosset (1985)
		Seringbara	This study
Rhinolophus	*hillorum*	Pierre Richaud	Fahr et al. (2006)
Rhinolophus	*simulator alticolus*	Pierre Richaud	Brosset (1985)
Vespertilionidae			
Kerivoula	*lanosa*	Ziela	Aellen (1963)
Mimetillus	*moloneyi*	Ziela	Fahr et al. (2006)
Neoromicia	cf *somalica*	Mt Nimba	Monadjem et al. (2013)
Neoromicia	*guineensis*	Ziela	Fahr et al. (2006)
		Zouguepo	Aellen (1963)
Neoromicia	*nana*	Ziela	Fahr et al. (2006)
Neoromicia	*tenuipinnis*	Ziela	Aellen (1963)
Scotophilus	?	Zouguepo	Aellen (1963)

Table V. Gazetteer of collecting localities for bats in the Guinean Nimba.

Location	Latitude	Longitude	Altitude (m)
Gbie	7.65	−8.30	540–620
Gouan camp	7.69	−8.39	800–1200
Grotte de Blande	7.72	−8.35	520
Grotte de Zie	7.71	−8.36	520
Keoulenta	7.68	−8.31	450
Mt Nimba	7.68	−8.35	c. 500–900
Mt Nimba, NE	7.68	−8.35	500–700
Pierre Richaud	7.66	−8.37	1350–1600
Richard Molard	7.62	−8.42	1350
Seringbara	7.63	−8.46	550–600
Ziela	7.71	−8.36	520
Zouguepo	7.72	−8.39	510

et al. in prep.). Other bats that use the highland grasslands (at least for roosting) include the vulnerable *Rhinolophus guineensis* and *R. simulator alticolus*; the latter may represent a separate species (Monadjem & Fahr 2007). Both taxa are endemic to the Upper Guinean Forest zone and are known from only a few localities (Koopman 1989; Koopman et al. 1995; Fahr et al. 2002; Fahr & Ebigbo 2004).

Conclusions

During this survey of the Guinean side of Mount Nimba we confirmed the exceptional bat biodiversity of the area. Added to that, the presence of other endemic micro-mammals (like the otter-shrew *Micropotamogale lamottei* Heim de Balsac, 1954 or the Nimba shrews *Crocidura nimbae* Heim de Balsac, 1956, *Crocidura goliath nimbasilvanus* Hutterer, 2003, and the recent description of *Dendromus lachaisei* Denys & Aniskine, 2012) further corroborate the importance of the Biosphere Reserve of the Nimba Mount and the need to protect all its endemics. We were able to recover living specimens of the critically endangered *Hipposideros lamottei* in old mine adits at high altitude, but outside the perimeter of the biosphere reserve. Since mining exploitation is due to start in the Pierre Richaud zone at the only location where *Hipposideros lamottei* is known to roost, the situation for the species is very serious. Excavations will lead to the reduction of the edaphic savanna above 1200 m, which constitutes the main habitat of *Hipposideros lamottei,* and this will certainly affect the species whose population size is not yet known. We note here that the species was not very abundant in our survey. With this supplementary threat, this species may become extinct in an alarmingly short period of time in the absence of any further conservation management decisions.

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