Diversity and dynamics in a community of small mammals in coastal Guinea, West Africa

Elisabeth Fichet-Calvet[1], Emilie Lecompte[2], Frederic Veyrunes[3], Patrick Barrière[4], Violaine Nicolas[5] & Kékoura Koulémou[6]

[1] **Evolutionary Biology Group, University of Antwerp, Antwerp, Belgium**
[2] **Evolution et Diversité Biologique, Université Paul Sabatier, Toulouse, France**
[3] **Institut des Sciences de l'Evolution, Université de Montpellier II, 34095 Montpellier Cedex 05, France**
[4] **AICA-CREG, Nessadiou BP37, 98870 Bourail, New Caledonia**
[5] **Systematics & Evolution, Museum National d'Histoire Naturelle, 55 rue Buffon, 75 005 Paris, France**
[6] **Projet de Recherches sur les Fièvres Hémorragiques en Guinée, Centre Hospitalier Donka, BP 5680, Conakry, Guinée**

Corresponding author : Elisabeth Fichet-Calvet: ecalvet@club-internet.fr

ABSTRACT. In order to investigate dynamics and reproduction in *Mastomys erythroleucus* inhabiting a high rainfall area in coastal Guinea, West Africa, a small mammal study was carried out through a 1-year longitudinal survey. Sampling was by standardized trapping in houses, cultivations, forest and savanna. Identification of the small mammals was based on morphology, and by molecular technique for sibling species. As a part of a larger survey on reservoirs of Lassa virus in Guinea, 106/289 specimens were screened for arenavirus and were found negative. The most abundant species was *M. erythroleucus* (46%) which occurred in all habitats, with a preference for savanna close to the cultivations. Its reproduction was seasonal and lasted for 8 months, beginning in the early rainy season and finishing in the early dry season. It was syntopic with *Lophuromys sikapusi* (13%) and *Praomys rostratus* (10%), which probably migrated from forest/orchards to cultivations in the late rainy season. Reproduction was high in many species in the late rainy season, but *P. rostratus* seemed to reproduce actively in the dry season, in contrast to *L. sikapusi*. Pygmy mice, *Mus (Nannomys*) spp., were abundant in the early rainy season only. The high species richness (14) is explained by the combined influence of Sudanian-Guinean-Congolian habitats. The role of the absence of bush fires is also debated in that context.

KEY WORDS : abundance, diversity, Lassa virus, *Lophuromys sikapusi*, *Mastomys erythroleucus*, *Mus* (*Nannomys*) spp., *Praomys rostratus*, reproduction, season.

INTRODUCTION

We carried out a terrestrial small mammal survey to investigate the reservoirs of Lassa virus in Guinea, West Africa. The human disease, Lassa Fever (LF) is definitely linked with the presence of *Mastomys natalensis* (Smith, 1834), which is absent in coastal Guinea (LECOMPTE et al., 2006). In that region, only *Mastomys erythroleucus* (Temminck, 1853) was present and it has never been found to be infected by Lassa virus, justifying the low endemic zone described by LUKASHEVICH et al., (1993). In Africa, *M. erythroleucus* is distributed from Senegal to Ethiopia, and from south Sahara to the Equator, partially overlapping with the distribution of *M. natalensis* (GRANJON et al., 1997). In Senegal particularly, numerous studies have been carried out during the last 30 years, describing many aspects of population ecology: abundance, reproduction, growth, diet, home range, behaviour and parasite infections (HUBERT et al., 1977; HUBERT, 1982; HUBERT & DEMARNE, 1981; HUBERT & ADAM, 1985; DUPLANTIER & GRANJON, 1988; DUPLANTIER et al., 1996; SÈNE et al., 1996; BROUAT et al., 2007). Our exploration was an opportunity to study the population ecology of *M. erythroleucus* in a more humid area than that of the earlier studies in Senegal. This area was chosen because of a similar habitat, here a Guinean forest-savanna mosaic (WHITE, 1983), to those investigated in a high endemic zone (FICHET-CALVET et al., 2007), which have a similar annual rainfall of around 1600-1900mm per year. In these climatic conditions, do the dynamics and demography vary seasonally as they do in drier zones where the rainy season is shorter? A study in 1936-37 in Freetown, Sierra Leone, showed an extensive reproductive period throughout the year in *M. erythroleucus* but many specimens trapped in the "native huts" and outside were included in the analysis, possibly showing a longer period of sexual activity due to increased food availability (BRAMBELL & DAVIS, 1941).

Because faunal assemblages could differ in relation to season, we present the diversity of this small mammal community, based on three sampling periods: two in the rainy season and one in the dry season. Through this one-year longitudinal survey, the spatio-temporal dynamics of the most abundant species accompanying *M. erythroleucus* were also investigated.

MATERIALS AND METHODS

Study site

The village of Gania (10°03'58"N, 12°32'27"W, 240m asl), prefecture of Kindia, was investigated in June 2004 (early rainy season), October 2004 (late rainy season) and February 2005 (dry season). The annual mean rainfall at Kindia, the closest station, was 1953mm between 1961 and 1990 (www.meteo-guinee-conakry.net, rainfall data not available during this study). The rainy season lasts from April to November.

Of the 3465 trapping nights during this period, 900 were in houses, 1545 in cultivations, 780 in forest and 240 in savanna. The cultivated land comprised crops of millet, maize, peanuts, ochras, cucumbers, sweet potatoes, cassava and rice fields, 1-year fallow lands, and pastures. Forest comprised orchards (bananas, mango, orange, guava) mixed with native trees (*Afzelia africana*, *Anosophyllea laurina*, *Ceïba pentandra*, *Cola acuminata*, *Combretum micranthum*, *C. paniculatum*, *Lophira lanceolata*, *Parkia biglobosa*, *Pterocarpus erynaceus*, *Sterculia tragacantha*). Savanna was a more open habitat, such as wooded fallow land and grassland. In each of these habitats, the traps (Sherman LFA live trap, H.B. Sherman Traps, Inc.) were set for three consecutive nights with 100 traps in houses, 160-180 traps in cultivations and 80 traps in forest and 20-40 in savanna. The sampled houses were distributed along a line through the village, with two traps set in each room. Usually, the houses are rectangular with a mud-brick wall delimiting several rooms, and covered with a roof of corrugated galvanized iron. A maximum of 12 traps per house were set. In cultivations, forest and savanna, the traps were set in lines of 100m with 20 traps placed singly, each 5m apart. Traps were baited with a mixture of peanuts, dry fish and wheat flour.

Autopsies, identification of the species and demographic parameters

Because this study was part of a larger survey on the reservoirs of LF in Guinea, trapped rodents and shrews were handled using P3 standard rules (MILLS et al., 1995) and killed by lethal dose of anesthetic (fluorane). To avoid any contamination of the field workers and the material, the autopsies were performed *in situ*, at a cleaned place under the trees and near the village. The rodents were described morphologically, weighed, measured (length of head and body, tail, hindfoot and ear) to enable a preliminary identification according to the keys published for West Africa (ROSEVEAR, 1969; DUPLANTIER & GRANJON, 1993). Individuals of *Lophuromys* were morphologically assigned to be *L. sikapusi* (Temminck, 1853) and the identity of six specimens was confirmed by cytochrome b (1140pb) sequence. According to the recent systematic revision of the genus *Praomys* (LECOMPTE et al., 2002a; NICOLAS et al., 2005; NICOLAS et al., 2008), two species exist in Guinea, the smaller form *P. tullbergi* (Thomas, 1894), and the larger form *P. rostratus* (Miller, 1900). Because the adult *Praomys sp.* in our study had measurements (weight: 49.0±12.0g, head and body: 127.5±10.1mm, tail: 152.9±13.0mm, hindfoot without claws: 25.0±1.0mm, n=44) consistent with those described for *P. rostratus* in Côte d'Ivoire (VAN DER STRAETEN & VERHEYEN, 1981), and also because molecular determination was confirmed by sequencing cytochrome b (1140pb) for four specimens, we consider all the specimens as belonging to that species in this study. *Mus* (*Nannomys*) is also a complex of morphologically very similar species living sometimes in sympatry, which thus has led to many mis-identifications. Hence, all trapped specimens were identified molecularly based on 490 pb of cytochrome b gene (VEYRUNES et al., 2005). Species identification of shrews was based on morphological and cranio-dental characters.

The weight of the desiccated eye lens ELW gives the best indication of age for small mammals (LORD, 1959; rev in MORRIS, 1971; HUBERT & ADAM, 1975). Eyes were removed and after preservation for a minimum of two weeks in 10% formalin, the lenses were extracted, dried for two hours at 100°C, and weighed to the nearest 0.1mg. Females were examined for the diameter of the uterus, the number of foetuses or uterine scars, and for indications of lactation. They were classified as sexually active if they were pregnant or lactating or had recent scars in a large uterus. Males were classified as sexually active if the seminal vesicles were swollen and more than 30mm^2 in *Mus* (*Nannomys*), 100mm^2 in *Mastomys*, *Lophuromys*, *Lemniscomys* and *Uranomys*, 110mm^2 in *Rattus*, 90mm^2 in *Praomys* (formerly *Myomys*) *daltoni*, 120mm^2 in *Praomys rostratus*, and 280mm^2 in *Gerbilliscus* (formerly *Tatera*) *guineae*, in surface (length x width).

Data analysis

The species richness S represents the number of species in the community, and is weighted by the Shannon index of diversity (H), calculated as $H=-\sum p_i \ln p_i$, where p_i=number of individuals for each species/total number of individuals SHANNON & WIENER, 1963. In theory, H increases with S, but practically does not exceed 5.0 in biological communities (KREBS, 1998). Evenness index (E) indicates how the species are distributed in the community, and is derived from H (E=H/lnS). The values range from 0 (one dominant species) to 1 (all species equally represented in the community). Here, S, H and E were calculated by habitat and season.

The abundance of the rodents was measured by abundance index (AI) calculated according to published methods as AI=∑(number of trapped rodents/length in m) x 100 (SPITZ et al., 1974; KREBS, 1998), and for each species by habitat. As control, AI was compared to a mean trapping success (TS=∑(number of trapped rodents/ ∑trapping nights) x 100) for three consecutive nights. The habitats analysed statistically were: houses, cultivations, (nearby and remote), forest/orchards (nearby and remote) and savanna (wooded fallow land and grassland). Remote cultivations were separated from the houses by a corridor of proximal forest requiring at least 15min of walking. Remote forest was close to remote cultivations.

The variations of abundance index (AI) and age structure (ELW) were analysed using ANOVA with AI or ELW as the dependent variable and season (early rainy, late rainy, dry), and habitat (cultivations, forest/orchards, savanna) as independent variables. A post-hoc test (Scheffe's) was made to identify which pairs of means are significantly different. This analysis was performed using the SuperAnova software (Abacus Concepts, 1989). The variation of sexual activity was analysed through a multiple regression, including the independent variables as for the ANOVA's.

The comparison of proportions, describing the occurrence of the species by habitat, was made using a Chi2 test. Logistic regression and Chi2 were performed through the software Statview 5 (SAS, Institute Inc. 1998).

RESULTS

Specific spatial distribution

We collected 289 small mammals of 14 species. These were: *Mastomys erythroleucus* (n=134), *Lophuromys sikapusi* (n=37), *Praomys rostratus* (n=28), *Rattus rattus* (Linnaeus, 1758) (n=28), *Gerbilliscus guineae* (Thomas, 1910) (n=15), *Uranomys ruddi* (Dollman, 1909) (n=10), *Mus* (*Nannomys*) *mattheyi* (Petter, 1969) (n=10), *M.* (*Nannomys*) *minutoides* (Smith, 1834) (n=6), *Lemniscomys striatus* (Linnaeus, 1758) (n=5), *Crocidura olivieri* (Lesson, 1827) (n=5), *C. buettikoferi* (Jentink, 1888) (n=4), *P. daltoni* (Thomas, 1892) (n=4), *Hylomyscus simus* (Allen & Coolidge, 1930) (n=2), and *L. linulus* (Thomas, 1910) (n=1). The Shannon index (H in Table 1) was 1.86 when the three seasons were taken into account, but varied according to season: 1.54 in June 2004, 1.66 in October 2004 and 1.83 in February 2005. Species richness and evenness indices were also calculated by season (Table 1).

In houses, the diversity and evenness indices were the lowest (H=0.99, E=0.61), because the commensal rodent community was mainly composed of *R. rattus* (68%, 28/41), which tends to evict the autochtonous species such as *M. erythroleucus*, *M. mattheyi*, *P. daltoni* and *H. simus* (Fig. 1). Conversely, cultivations were highly diversified (H=1.69), with 12 species more equally distributed than in houses (E=0.68) despite the predominance of *M. erythroleucus* (54%). In forests and orchards, the evenness index was highest (E=0.71) because the occurrence of *M. erythroleucus* decreased (42%), whereas those of *L. sikapusi* (30%) and *P. rostratus* (22%) increased. In savanna/fallow land, *M. erythroleucus* was highly representative (65%), with a significantly higher occurrence (p=0.02) than in forest/orchards. *L. sikapusi* and *P. rostratus* were not present in savanna/fallow land; however *U. ruddi*, *L. striatus*/*linulus* and *P. daltoni*, were present, so that a similar diversity index (H=1.28 and H=1.25) was evident in both habitats.

The seasonal variation in abundance and in reproduction is analysed below in detail for the four most common species, *M. erythroleucus* (46.4%), *L. sikapusi* (12.8%), *P. rostratus* (9.7%) and *R. rattus* (9.7%), and globally for the remaining ones.

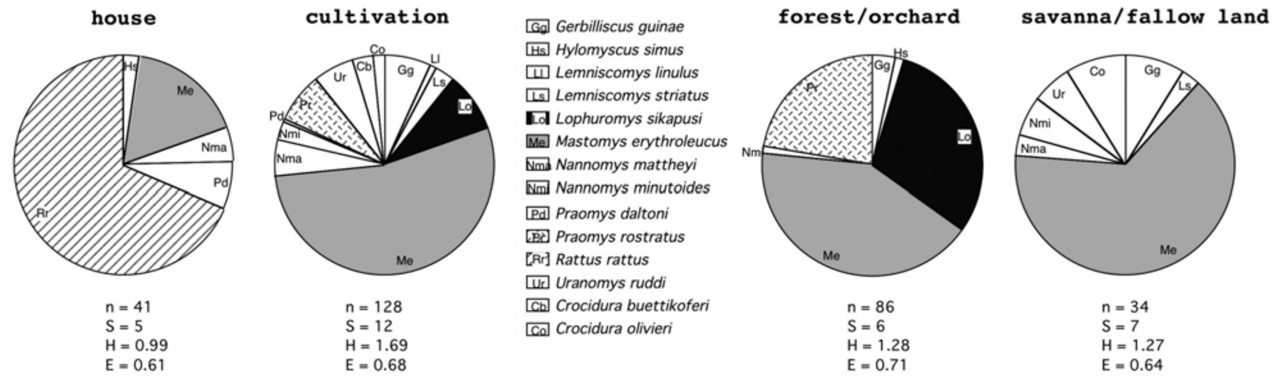

Fig. 1. – Distribution by habitat of the 14 species recorded at Gania. N, S, H and E correspond to sample size, species richness, species diversity and species evenness indices respectively (see material and method for definitions).

TABLE 1

Distribution of the small mammal community by season and by detailed habitat in Gania. Muridae: Gg=*Gerbilliscus* (*Tatera*) *guineae*, Hs=*Hylomyscus simus*, Ll=*Lemniscomys linulus*, Ls=*L. striatus*, Lo=*Lophuromys sikapusi*, Me=*Mastomys erythroleucus*, Nma=*Mus* (*Nannomys*) *mattheyi*, Nmi=*Mus* (*Nannomys*) *minutoides*, Pd=*Praomys* (*Myomys*) *daltoni*, Pr=*P. rostratus*, Rr=*Rattus rattus*, Ur=*Uranomys ruddi*; Soricidae: Cb=*Crocidura buettikoferi*, Co=*C. olivieri*. Sample size (N), species richness (S), diversity (H) and evenness (E) were calculated for each trapping session (see material and method for definitions). Italic values in brackets indicate the numbers of animals screened for Lassa virus.

Season	**Houses**	**Nearby cultivations**	**Nearby forest/ orchard**	**Wooded fallow land**	**Grass-land**	**Remote cultiva-tions**	**Remote forest/ orchard**	**N**	**S**	**H**	**E**
Early rainy (Jun 2004)	1 Me *(1)* 1 Nma (*1*) 5 Rr *(5)*	5 Gg *(5)* 3 Ls *(3)* 27 Me *(26)* 7 Nma *(6)* 3 Nmi *(3)* 6 Ur *(5)*	2 Gg *(2)* 1 Lo *(1)* 6 Me *(6)* 1 Nmi *(1)* 1 Pr *(1)*	1 Gg *(1)* 4 Me *(4)* 1 Nma *(1)* 2 Nmi *(2)*			9 Me *(9)*	**86**	**9**	**1.54**	**0.70**
Late rainy (Oct 2004)	1 Hs 5 Me 18 Rr *(3)*	1 Gg 8 Lo 28 Me *(2)* 1 Pd 2 Pr 1 Ur 2 Co	1 Gg 9 Lo *(1)* 7 Me 2 Pr *(1)*	7 Me 1 Ur	1 Ls 8 Me *(3)* 1 Ur *(1)* 2 Co *(1)*	1 Lo 1 Ls 2 Me 7 Pr 2 Cb	1 Lo 1 Me 8 Pr *(5)*	**129**	**11**	**1.66**	**0.69**
Dry (Feb 2005)	1 Me *(1)* 1 Nma 3 Pd 5 Rr	3 Gg 1 Ll 1 Lo 7 Me *(1)* 1 Ur 1 Cb	2 Lo 2 Me 3 Pr		2 Gg 3 Me 1 Co	1 Lo 5 Me *(2)* 1 Cb	1 Hs 13 Lo 11 Me *(1)* 5 Pr	**74**	**12**	**1.83**	**0.74**

TABLE 2

Mean trapping success (TS) and abundance index (AI) in % by species, habitat and season.

		mean TS			**AI**		
Species	**Habitat**	**Early rainy** (Jun 04)	**Late rainy** (Oct 04)	**Dry** (Feb 05)	**Early rainy** (Jun 04)	**Late rainy** (Oct 04)	**Dry** (Feb 05)
M. erythroleucus	Houses	0.3	1.7	0.3	0.6	2.2	0.5
	Cultivations	5.0	5.6	2.5	3.0	3.3	1.5
	Forest	5.0	4.4	4.3	3.0	2.7	2.6
	Savanna	6.7	12.5	5.0	4.0	7.5	3.0
L. sikapusi	Cultivations	0.0	1.7	0.4	0.0	1.0	0.3
	Forest	0.3	5.6	5.4	0.2	3.3	3.0
P. rostratus	Cultivations	0.0	1.7	0.0	0.0	1.0	0.0
	Forest	0.3	5.6	2.7	0.2	3.3	1.6
R. rattus	Houses	1.7	6.0	1.7	3.1	7.8	2.6

Spatio-temporal abundance and reproduction

Abundance index and mean trapping success by species and season are summarized in Table 2 in which June 2004, October 2004 and February 2005 correspond to early rainy, late rainy and dry season respectively.

Mastomys erythroleucus

The abundance index AI, analysed through an ANOVA, varied significantly by season (p<0.0001), *M. erythroleucus* being more abundant at the end of the rainy season (AI=4.4±1.9 ind/100m, n=53) than at the start (AI=3.0±0.3 ind/100m, n=46) or in the dry season (AI=2.2±0.6 ind/100m, n=28). AI also varied significantly by habitat (p<0.0001, Table 2), *M. erythroleucus* being more often trapped in the savanna/fallow land (AI=6.2±1.9 ind/100m, n=22) than in cultivations (AI=2.8±0.6 ind/100m, n=69) or in forest/orchards (AI=2.8±0.2 ind/100m, n=36). The two-way interaction "habitat x season" is significant (p<0.0001), suggesting that many rodents explored the savanna/fallow land at the end of the rainy season (Fig. 2). The age structure, based on eye lens weight ELW did not vary by habitat (ANOVA ns) but varied significantly by season (p<0.0001), revealing a younger population in the dry season (ELW=18.4±3.2mg, n=29), compared to the rainy season. Mean ELW values were similar in early (ELW=28.1±1.9mg, n=47) and late (ELW=27.9±9.9mg, n=58) rainy season, but the population sampled at the end of the rainy season (October 2004) was constituted by two cohorts, the old and the young, separated by only a few individuals in the intermediate ELW classes (Fig. 3). Reproduction, analysed through a multiple logistic regression, showed that sexual activity was significantly higher in the late rainy season (p=0.0001), than in the early rainy or the dry seasons. This analysis was made including sex and age (ELW) since these intrinsic variables are known to have a high influence on sexual activity (p<0.0001 for both). Here, high activity was mainly due to a higher rate in males (76%, 22/29) than in females (14%, 4/29), because the analysis in females alone did not show significant differences in sexual activity between the three trapping sessions. Habitat had no influence on sexual activity (Chi2 NS). In the dry season, the sex ratio was biased towards males (6 females vs 23 males). Litter size, here based on the number of foetuses, was 9.8 (range: 5-13, n=5).

Lophuromys sikapusi and *Praomys rostratus*

Season had a significant effect on abundance index in the two species (p<0.0001 for both), leading to higher abundances in the late rainy season (*L. sikapusi* and *P. rostratus*: AI=2.2±1.2 ind/100m, n=19) and in the dry season (*L. sikapusi*: AI=2.7±0.9 ind/100m, n=17; *P. rostratus*: AI=1.6ind/100m, n=8) than in the early rainy season (*L. sikapusi* and *P. rostratus*: AI=0.2ind/100m, n=1, Fig. 2). In the dry season, individuals of *L. sikapusi* were found deep in the forest (13/17 in remote forest/orchards), in contrast to the previous season where many of them were found in nearby cultivations and forest/orchards (17/19, Table 1). Habitat also had a significant effect (p<0.0001) for both species because these rodents were more abundant in forest/orchards (*L. sikapusi*: AI=3.0±0.6 ind/100m, n=26; *P. rostratus*: AI=2.4±1.0, n=19) than in cultivations (*L. sikapusi*: AI=0.9±0.3 ind/100m, n=11; *P. rostratus*: AI=1.0 ind/100m, n=9).

As for *M. erythroleucus*, the age structure in *L. sikapusi* varied seasonally (p=0.01), with the population older in the dry season (ELW=6.9±1.5mg, n=17) than in the late rainy season (ELW=5.5±1.9mg, n=19) (Fig. 3). At this period, sexual activity in both sexes was high (38%, 8/21) and then declined in the dry season (6%, 1/17). Conversely, the age structure in *P. rostratus* did not vary by season (ANOVA ns) and reproduction also continued in the dry season. Statistics for *L. sikapusi* and *P. rostratus* were based only on the samples from the late rainy and dry seasons, as the sample from the early rainy season was too small to be included (n=1 for each species in June 2004). The litter sizes were 3.5 (range: 3-4, n=4) in *L. sikapusi* and 4.1 (range: 3-5, n=7) in *P. rostratus*.

Rattus rattus

As for the rodents described above, the main commensal rodent, *R. rattus* was more abundant in houses in the late rainy season. Reproduction occurred during the rainy season and seemed to have ceased by the dry season. The sample sizes in June 2004 (n=5) and February 2005 (n=5) were too small to allow statistical analyses for abundance and age structure, and also to be sure of an absence of reproduction (Fig. 3).

Other species

Combining the two species of *Mus*, it is valuable to note that most of them (15/16) were trapped in the early rainy season. They were not detected in the other seasons, despite a similar trapping effort in the same habitats. Only one of 15 *M*us was sexually active in June 2004. In October 2004, two of two *G. guineae* (females), one of one *H. simus* (male), one of one *L. striatus* (male), one of one *P. daltoni* (female), three of three *U. ruddi* (one female, two males) and one of four *C. olivieri* (female) were sexually active. In February 2005, only three of five *G. guineae* (one female, two males) and one of one *H. simus* (female) were sexually active.

Detection of Lassa virus

In coastal Guinea, none of the animals was found to be infected with Lassa virus (LECOMPTE et al., 2006), nevertheless the specimens caught in Gania and examined for arenavirus infection are listed in Table 1 (for details in RT-PCR screening, see VIETH et al., 2007; LECOMPTE et al., 2006 and FICHET-CALVET et al., 2007). Of 289 small mammals collected, 106 were screened, distributed over all species and habitats.

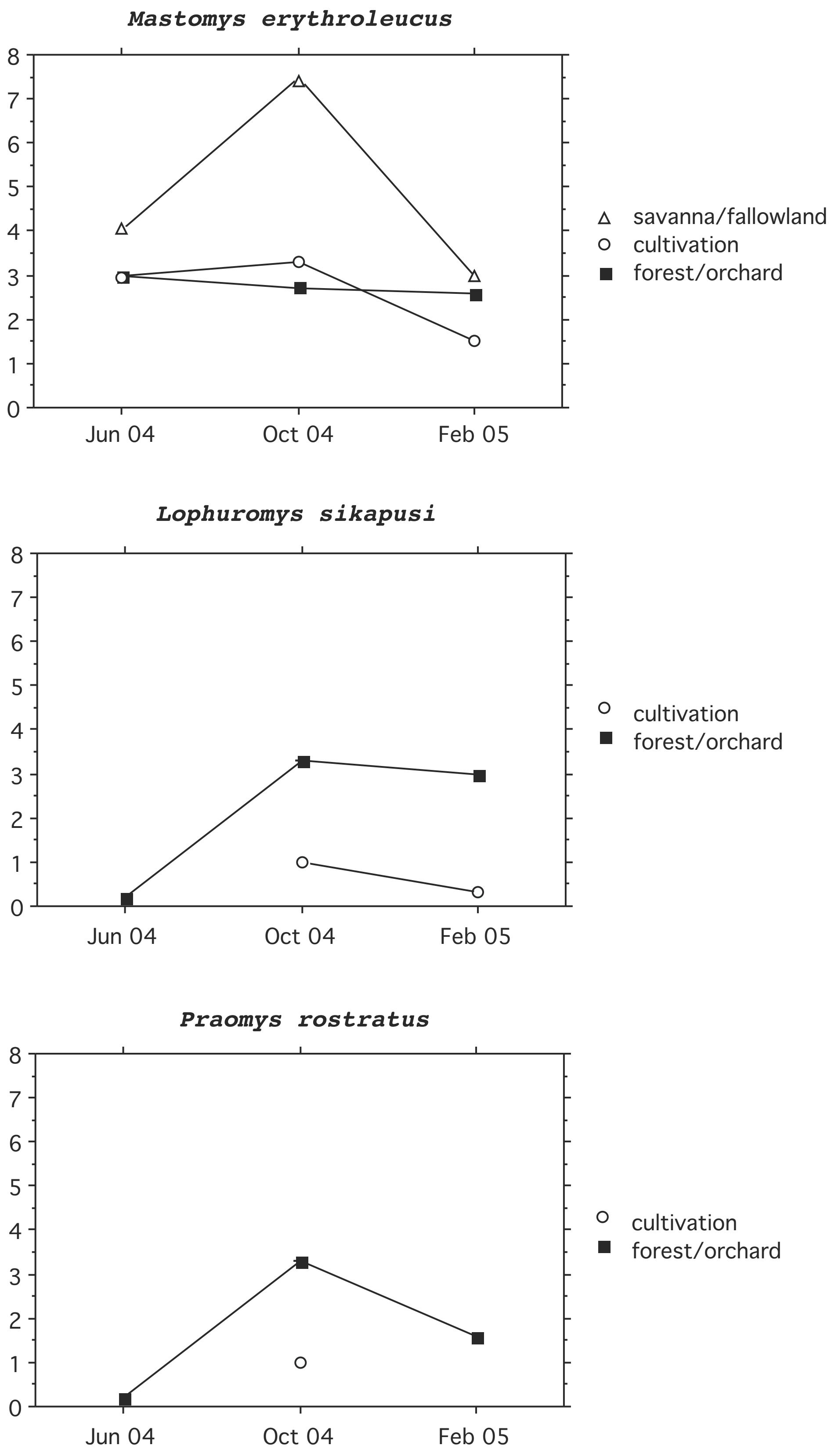

Fig. 2. – Abundance index (individuals/100m) in *Mastomys erythroleucus*, *Lophuromys sikapusi* and *Praomys rostratus* by habitat and by month of collection.

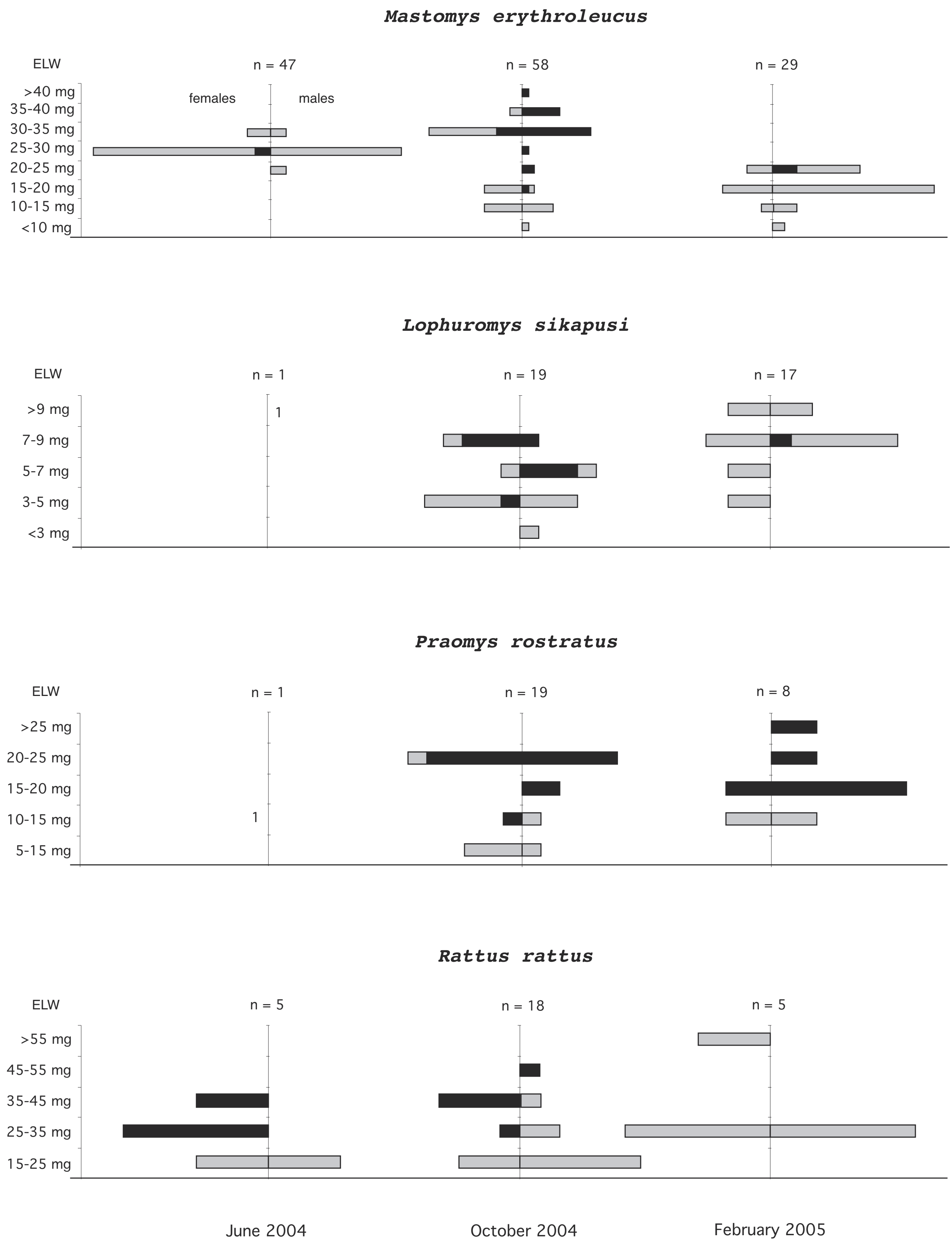

Fig. 3. – Distribution of sexual activity in *Mastomys erythroleucus*, *Lophuromys sikapusi*, *Praomys rostratus* and *Rattus rattus* by age (ELW: eye lens weight), sex and season. Each pyramid corresponds to the proportion of females (left) and males (right) sampled at each session (shaded area) in which the proportion of sexually active individuals is included (black area). To equalize the pyramid surface between small and large samples, the length of each horizontal bar reflects the proportion of individuals in each collection (total length of bars in each collection=1). n: sample size for each session.

DISCUSSION

The species richness, diversity and evenness indices (N=14, H=1.9 and E=0.7) were higher at Gania than at Kedougou, Senegal (N=12, H=1.5 and E=0.6 in Ba, 2002). These studies are, nevertheless, comparable in time because several seasons were pooled, in space because trapping was performed inside and outside, and in methodology because the same kind of trap was used. Lower records of species by season in our study,– 10, 11 and 12 in early rainy, late rainy and dry seasons respectively –, than the 14 recorded globally, are probably a function of a cumulative effect from three trapping seasons instead of one only investigated in the other studies such as in Guinea or in Chad where species richness did not exceed 9 (Granjon et al., 2004; Denys et al., 2005). This suggests that studies on biodiversity should take into account the time scale for accurate estimations. Consequently, diversity in Gania, located between 12°W and 13°W in the transition zone (White, 1983), but 280km south of Kedougou, indicates the Sudanian, Guinean and Congolian influences are remarkable for the combination of faunas from savannas and forests.

In our one-year survey, *M. erythroleucus* showed seasonal variations in abundance, the maximal abundance being in late rainy season. These variations were linked with the annual cycle in reproduction, which occurs principally during the rainy season, as was previously reported in Côte d'Ivoire, Senegal and Ethiopia (Gautun, 1975; Hubert, 1982; Duplantier et al., 1996; Bekele & Leirs, 1997). The young, born in the rainy season were able to breed in the season of their birth, and thus assisted in increasing population density, producing a double age pyramid in late rainy season (October). As the population structure was young in the dry season, February, with the presence of ±30 days old individuals (ELW correspondence in Hubert & Adam, 1975), we suspect that reproduction was continuing in the early dry season as well (November to January). Then, from late dry season (February) to early rainy season (June), reproduction probably ceased, as evidenced by the lack of young age classes in the early rainy season (June). Consequently, reproduction in *M. erythroleucus* would probably continue for eight months of the year, from June to January in Gania, whereas in Freetown, Sierra Leone, it was continuous throughout the year with a peak from May to January (Brambell & Davis, 1941). The lower values recorded in February-April could be due to commensal individuals. In the western zone of Senegal, at Bandia, reproduction lasted five months, from July to November during the dry years ±300mm, but extended to seven months during the rainy years (±600mm) (Hubert, 1982). The timing of reproduction is then, largely flexible in this species, according to climatic conditions and underlying food availability.

The abundance index analysed here by habitat showed higher values in savanna/fallow land (3 to 7.5 ind/100m) than in nearby cultivations (1.5 to 3.3 ind/100m), suggesting that savanna/fallow land could serve as a source for rodent dispersal into cultivations. In Gania, *M. erythroleucus* also inhabits the forest/orchards, remaining stable through the year (2.6 to 3.0 ind/100m). Complementary to studies in Senegal and Guinea (Ba, 2002; Denys et al., 2005), we show here that *M. erythroleucus* is well adapted to live in the wooded habitats, sharing space with *L. sikapusi* and *P. rostratus*.

The latter species occurred in many trap lines at Gania, probably because of a well-preserved forest. *L. sikapusi* was more abundant in October 2004 and February 2005 than in June 2004. Such variations have already been observed in Gambari forest, Nigeria, where these rodents were abundant during one of three studied years (Happold, 1977). In our study, *L. sikapusi* was also more abundant than in primary rainforest such as in Gambari forest or in Makokou forest in Gabon (Duplantier, 1989), and also occurred in cultivations, which offered at the end of the rainy season a dense herbaceous coverage made by cucumbers and sweet potatoes. Our observations in Guinea confirm the preference of this species towards the habitats of secondary forest and moist cultivations. Reproduction seems to decrease (1/17) in the dry season, as was also observed in Nigeria (Happold, 1977).

The systematics of *Praomys* was recently amended from molecular studies (Lecompte et al., 2002b; Nicolas et al., 2005; Nicolas et al., 2008). As no data are available for *P. rostratus* dynamics, we here compare our results to those available for closely related species *P. tullbergi* and *P. misonnei* (formely *tullbergi*) (Nicolas et al., 2005). In Guinea, this species occurred in secondary forests mixed with orchards, hedgerows and cultivations, and also in semi-evergreen forest such as the Park of Upper Niger (Ziegler et al., 2002). As for *L. sikapusi*, its abundance was higher in forest habitats (0.2 to 3.3 ind/100m) than in cultivations (0 to1 ind/100m), but never reached the level of densities of *P. tullbergi* in primary forests in Nigeria (15 to 20/ha in Happold, 1977), or of *P. misonnei* in Gabon (4 to 20/ha in Duplantier, 1989). Here, reproduction persisted in the dry season, similarly to observations made in Côte d'Ivoire (Lim & Coeverden de Groot, 1997), in Nigeria for *P. tullbergi* (Happold, 1978), and in Gabon for *P. misonnei* (Nicolas & Colyn, 2003).

Pygmy mice, *Mus* spp, were either numerous, or were not caught at the other times. This binary variation "all or nothing" has already been recorded by Monadjem, 1999 in Swaziland, where *M. minutoides* was captured in relatively large numbers in winter, and then almost completely disappeared from samples in summer and autumn. In agreement with this author, we speculate that *Mus* spp. did not "disappear" from the study area but simply stopped visiting traps in the late rainy season and dry season when natural food was abundant. As for many species that were sexually active, the late rainy season also corresponds to the peak reproductive season, leading many species to move for mating, breeding and dispersing, which could cause the pygmy mice to not enter the traps. Nevertheless, their abundance at the start of the rainy season is congruent with the longitudinal survey realised on the "Leggada" populations (the former name of *Mus* (*Nannomys*)) in Côte d'Ivoire in 1969-1971 (Bellier, 1974). That study noted increased numbers in June and July, subsequent to the recruitment of young between February and April. Moreover, the systematics of *Mus* (*Nannomys*) species is unsatisfactory owing to the lack of discriminating morphological characters, and it is further confounded by the sympatric coexistence of sibling species (JOTTERAND-BELLOMO, 1988; VEYRUNES et al., 2004). Here, we found two species in a small sample, *M. mattheyi* and *M. minutoides* even being trapped on the same trap lines; these results suggest the need for caution in interpretation of previous studies on *Mus* (those without a molecular or karyotypic identification), as an amalgam of these morphologically-similar species is strongly suspected.

The houses in Gania had a surprisingly low infestation of rodents in the dry season (mean TS for all species =3.3%), regardless of their trend to migrate inside at this season. Higher levels of infestation have been observed in other study sites in Senegal and Guinea (BA, 2002, FICHET-CALVET et al., 2007). This could be due to rodent management, regularly initiated by villagers, but also to the absence of bush fires, which were forbidden in Gania village. Such management could preserve seeds and shelters for rodents in natural habitats, hence removing the necessity to enter houses for food and shelter. Preservation of natural habitats such as savanna and forest, and anthropized ones, such as wooded fallow land, may allow a high species diversity, in contrast to places where farmland is burned (PAPILLON et al., 2006).

ACKNOWLEDGEMENTS

The study was supported by the European Community (INCO-DEV grant ICA4-CT2002-10050), a Marie Curie Intra-European Fellowships (FP6, No. MEIF-CT2003-506686) and the Howard Hughes Medical Institute. We are indebted to J. ter Meulen for his financial support (grant HHMI), to S. Daffis for work in P4 lab and to A. Doré, F. Kourouma, B. Soropogui, and O. Sylla, (Projet des Fièvres Hémorragiques de Guinée) for assistance in the field work. We are also grateful to L. Koivogui for facilitating the Guinean logistics, to C. Denys who manages the specimens collection at MNHN and to P. Chevret for molecular facilities at Montpellier University. Thanks to JM Duplantier and D.C.D. Happold who revised the manuscript. Rodent trapping was authorized by the Ministry of Public Health, Republic of Guinea permission no. 2003/PFHG/05/GUI.

REFERENCES

BA K (2002). Systématique, écologie et dynamique de populations de petits rongeurs potentiellement réservoirs ou hôtes de virus au Sénégal, Montpellier 126 pp.

BEKELE A & LEIRS H (1997). Population ecology of rodents of maize fields and grassland in central Ethiopia. Belgian Journal of Zoology, 127:39-48.

BELLIER L (1974). Applications de l'analyse des données à l'écologie des rongeurs de la savane de Lamto (RCI). Thèse de doctorat, Paris VI, Paris 600 pp.

BRAMBELL RFW & DAVIS DHS (1941). Reproduction of the multimammate mouse (*Mastomys erythroleucus* Temm.) of Sierra Leone. Proceedings of the Zoological Society of London. Series B, 111:1-11.

BROUAT C, KANE M, DIOUF M, BA K, SALL-DRAME R & DUPLANTIER J-M (2007). Host ecology and variation in helminth community structure in *Mastomys* rodents from Senegal. Parasitology, 134:437-450.

DENYS C, LECOMPTE E, CALVET E, CAMARA MD, DORÉ A, KOULÉMOU K, KOUROUMA F, SOROPOGUI B, SYLLA O, ALLALI BK, KOUASSI S, AKOUA-KOFFI C, TER MEULEN J & KOIVOGUI L (2005). Community analysis of Muridae (Mammalia, Rodentia) diversity in Guinea: a special emphasis on *Mastomys* species and Lassa fever distributions. In: HUBER BA (ed), African Biodiversity. Springer: 339-350.

DUPLANTIER J-M (1989). Les rongeurs myomorphes forestiers du nord-est du Gabon: structure du peuplement, démographie, domaines vitaux. Revue d'Ecologie (la Terre et la Vie), 44:329-346.

DUPLANTIER J-M & GRANJON L (1988). Occupation et utilisation de l'espace par des populations du genre *Mastomys* au Sénégal: étude à trois niveaux de perception. Sciences et Techniques de l'animal de Laboratoire, 13:129-133.

DUPLANTIER J-M & GRANJON L (1993). Les rongeurs du Sénégal: clé de détermination et critères d'identification. ORSTOM, Dakar, 33 pp.

DUPLANTIER J-M, GRANJON L & BOUGANALY H (1996). Reproductive characteristics of three sympatric species of *Mastomys* in Senegal, as observed in the field and in captivity. Mammalia, 60:629-638.

FICHET-CALVET E, LECOMPTE E, KOIVOGUI L, SOROPOGUI B, DORÉ A, KOUROUMA F, SYLLA O, DAFFIS S, KOULÉMOU K & TER MEULEN J (2007). Fluctuation of abundance and Lassa virus prevalence in *Mastomys natalensis* in Guinea, West Africa. Vector-Borne Zoonotic Diseases, 119-128.

GAUTUN JC (1975). Periodicité de la reproduction de quelques rongeurs d'une savane preforestière du centre de la Cote d'Ivoire. Revue d'Ecologie (la Terre et la Vie), 29:265-287.

GRANJON L, DUPLANTIER J-M, CATALAN J & BRITTON-DAVIDIAN J (1997). Evolutionary systematics in the genus *Mastomys* (Thomas, 1905) (Rodentia: Muridae): a review. Belgian Journal of Zoology, 127:7-18.

GRANJON L, HOUSSIN C, LECOMPTE E, ANGAYA M, CESAR J, CORNETTE R, DOBIGNY G & DENYS C (2004). Community ecology of the terrestrial small mammals of Zakouma National Park, Chad. Acta Theriologica, 49:215-234.

HAPPOLD DCD (1977). A population study on small rodents in the tropical rain forest of Nigeria. Revue d'Ecologie (la Terre et la Vie), 31:385-458.

HAPPOLD DCD (1978). Reproduction, growth and development of a West African forest mouse, *Praomys tullbergi* (Thomas). Mammalia, 42:73-95.

HUBERT B (1982). Dynamique des populations de deux espèces de rongeurs du Sénégal, *Mastomys erythroleucus* et *Taterillus gracillis* (Rodentia, Muridae et Gerbillidae): I. Etude démographique. Mammalia, 46:137-166.

HUBERT B & ADAM F (1975). Reproduction et croissance en élevage de quatre espèces de rongeurs sénégalais. Mammalia, 39:57-73.

HUBERT B & ADAM F (1985). Outbreaks of *Mastomys erythroleucus* and *Taterillus gracilis* in the Sahelo-Sudanian zone in Senegal. Acta Zoologica Fennica, 173:113-117.

HUBERT B & DEMARNE Y (1981). Le cycle saisonnier des lipides de réserve chez deux espèces de rongeurs du Sénégal. Revue d'Ecologie (la Terre et la Vie), 35:55-72.

HUBERT B, LEPRUN JC & POULET A (1977). Importance écologique des facteurs édaphiques dans la répartition spatiale de quelques rongeurs au Sénégal. Mammalia, 41:35-59.

JOTTERAND-BELLOMO M (1988). Chromosome analysis of five specimens of *Mus bufo*-triton (Muridae) from Burundi (Africa): three cytogenetic entities, a special type of chromosomal sex determination, taxonomy, and phylogeny. Cytogenetics and Cell Genetics, 48:88-91.

KREBS JC (1998). Ecological methodology, 2nd Edition edn. Harper & Row, New York, 620 pp.

LECOMPTE E, FICHET-CALVET E, DAFFIS S, KOULÉMOU K, SYLLA O, KOUROUMA F, DORÉ A, SOROPOGUI B, ANISKINE V, ALLALI B, KOUASSI KAN S, LALIS A, KOIVOGUI L, GÜNTHER S, DENYS C & TER MEULEN J (2006). *Mastomys natalensis* and Lassa fever, West Africa. Emerging Infectious Diseases, 12:1971-1974.

LECOMPTE E, GRANJON L & DENYS C (2002a). The phylogeny of the *Praomys* complex (Rodentia: Muridae) and its phylogeographic implications. Journal of Zoology, Systematics and Evolution Research, 40:8-25.

LECOMPTE E, GRANJON L, KERBIS PETERHANS J & DENYS C (2002b). Cytochrome-b based phylogeny of the *Praomys* group (Rodentia: Murinae): a new African radiation? Compte Rendus Biologies, 325:827-840.

LIM BK & COEVERDEN DE GROOT PJ (1997). Taxonomic report of small mammals from Côte d'Ivoire. Bonner Zoologische Beiträge, 32:249-264.

LORD RD (1959). The lens as an indicator of age in cottontail rabbits. Journal of Wildlife Management, 23:359-360.

LUKASHEVICH LS, CLEGG JC & SIDIBE K (1993). Lassa virus activity in Guinea: distribution of human antiviral antibody defined using enzyme-linked immunosorbent assay with recombinant antigen. Journal of Medical Virology, 40:210-217.

MILLS JN, CHILDS J, KSIAZEK TG, PETERS CJ & VELLECA WM (1995). Methods for trapping and sampling small mammals for virologic testing. Centers dor Disease Control and Prevention, Atlanta, 61 pp.

MONADJEM A (1999). Population dynamics of *Mus minutoides* and *Steatomys pratensis* (Muridae: Rodentia) in a subtropical grassland in Swaziland. African Journal of Ecology, 37:202-210.

MORRIS P (1971). A review of mammalian age determination methods. Mammal Review, 2:69-104.

NICOLAS V & COLYN M (2003). Seasonal variations in population and community structure of small rodents in a tropical forest of Gabon. Canadian Journal of Zoology, 81:1034-1046.

NICOLAS V, VERHEYEN E, VERHEYEN W, HULSELMANS J, DILLEN M, AKPATOU B, DUDU A, WENDELEN W & COLYN M (2005). Systematics of African lowland rainforest *Praomys* (Rodentia, Muridae) based on molecular and craniometrical data. Zoological Journal of the Linnean Society, 145:539-553.

NICOLAS V, BRYJA J, AKPATOU B, KONECNY A, LECOMPTE E, COLYN M, LALIS A, COULOUX A, DENYS C & GRANJON L (2008). Comparative phylogeography of two sibling species of forest-dwelling rodent (*Praomys rostratus* and *P. tullbergi*) in West Africa: different reactions to past forest fragmentation. Molecular Ecology, 17:5118-5134.

PAPILLON Y, GODRON M & DELATTRE P (2006). Changes in a Sudano-Sahelian rodent community after slash-and-burn farming (Gonsé Forest,Burkina Faso). African Journal of Ecology, 44:379-387.

ROSEVEAR DR (1969). The rodents of West Africa Trustees of the British Museum (Natural History), London, 604 pp.

SÈNE M, DUPLANTIER J-M, MARCHAND B & HERVÉ J-P (1996). Susceptibility of rodents to infection with *Schistosoma mansoni* in Richard-Toll (Senegal). Parasite, 4:321-326.

SHANNON CE & WIENER W (1963). The mathematical theory of communication. University of Illinois Press, Urbana, pp.

SPITZ F, LE LOUARN H, POULET A & DASSONVILLE B (1974). Standardisation des piégeages en ligne pour quelques espèces de rongeurs. Revue Ecologie (Terre et Vie), 24:564-578.

VAN DER STRAETEN E & VERHEYEN W (1981). Etude biométrique du genre *Praomys* en Côte d'Ivoire. Bonner Zoologische Beiträge, 32:249-264.

VEYRUNES F, BRITTON-DAVIDIAN J, ROBINSON TJ, CALVET E, DENYS C & CHEVRET P (2005). Molecular phylogeny of the African pygmy mice, subgenus *Nannomys* (Rodentia, Murinae, Mus): implications for chromosomal evolution. Molecular Phylogenetics and Evolution, 36:358-369.

VEYRUNES F, CATALAN J, SICARD B, ROBINSON TJ, DUPLANTIER J-M, GRANJON L, DOBIGNY G & BRITTON-DAVIDIAN J (2004). Autosome and sex chromosome diversity among the African pygmy mice, subgenus *Nannomys* (Muridae; Mus). Chromosome Research, 12:369-382.

VIETH S, DROSTEN C, LENZ O, VINCENT M, OMILABU S, HASS M, BECKER-ZIAJA B, TER MEULEN J, NICHOL ST, SCHMITZ H & GUNTHER S (2007). A reverse transcription PCR assay for detection of Lassa virus and related Old World arenaviruses targeting the L gene. Transactions of the Royal Society of Tropical Medicine and Hygiene, 1253-1264.

WHITE F (1983). The vegetation of Africa UNESCO, 356 pp.

ZIEGLER S, NIKOLAUS G & HUTTERER R (2002). High mammalian diversity in the newly established National Park of Upper Niger, Republic of Guinea. Oryx, 36:73-80.

Received: June 7, 2007
Accepted: July 10, 2009