*Russian J. Theriol. 9(2):* 47–60 

# Mammals of the Babille Elephant Sanctuary (Eastern Ethiopia)

**Leonid A. Lavrenchenko, Sergei V. Kruskop, Afework Bekele, Gurja Belay, Petr N. Morozov, Yuri F. Ivlev & Andrei A. Warshavsky**

ABSTRACT. The paper presents the results of a first attempt to document the mammals of the Babille Elephant Sanctuary (Eastern Ethiopia). Four species (*Nycteris thebaica*, *Lavia frons*, *Mus tenellus*, *Helogale parvula*) were documented for the first time in the Sanctuary, two species (*Rhinolophus fumigatus*, *Mastomys awashensis*) were found new for eastern Ethiopia and the presence of another species (*Neoromicia zuluensis*) was confirmed for the first time within the limits of Ethiopia. Moreover, genetic and chromosomal characteristics of two rodents (*Acomys* sp. and *Gerbilliscus* cf. *robustus*) suggested new undescribed species. In total, according to our current estimate based on original data and previously published literature, the mammal fauna of the Sanctuary includes 59 species belonging to 11 orders, 30 families and 51 genera. The Babille Elephant Sanctuary has significant conservation value due to its high mammal species diversity and complex structure of the fauna including elements with different zoogeographic affinities.

KEY WORDS: mammals, Babille Elephant Sanctuary, Ethiopia, *Acomys*, *Gerbilliscus*, *Neoromicia*, new records.

*Leonid A. Lavrenchenko [lavrenchenko@sevin.ru], A.N. Severtsov Institute of Ecology and Evolution RAS, Leninskii pr. 33, Moscow 119071, Russia; Sergei V. Kruskop [kruskop@zmmu.msu.ru], Zoological Museum of Moscow State University, Ul. Bolshaya Nikitskaya 6, Moscow 125009, Russia; Afework Bekele [afeworkbekele@hotmail.com], Addis Ababa University, Biology Department, Addis Ababa 1176, Ethiopia; Gurja Belay [gurja_belay@yahoo.com], Addis Ababa University, Biology Department, Addis Ababa 1176, Ethiopia; Petr N. Morozov [pnmorozov@yandex.ru], A.N. Severtsov Institute of Ecology and Evolution RAS, Leninskii pr. 33, Moscow 119071, Russia; Yuri F. Ivlev [yuvertb@sevin.ru], A.N. Severtsov Institute of Ecology and Evolution RAS, Leninskii pr. 33, Moscow 119071, Russia; Andrei A. Warshavsky [warsh@yandex.ru], A.N. Severtsov Institute of Ecology and Evolution RAS, Leninskii pr. 33, Moscow 119071, Russia.*

# Млекопитающие слоновьего заказника Бабилле (Восточная Эфиопия)

**Л.А. Лавренченко, С.В. Крускоп, Афеворк Бекеле, Гурджа Белай, П.Н. Морозов, Ю.Ф. Ивлев, А.А. Варшавский**

РЕЗЮМЕ. Проведена инвентаризация фауны млекопитающих слоновьего заказника Бабилле (Восточная Эфиопия). В результате исследований обнаружены 4 новых для исследуемой территории вида (*Nycteris thebaica*, *Lavia frons*, *Mus tenellus*, *Helogale parvula*) и 2 вида – новых для восточной Эфиопии в целом (*Rhinolophus fumigatus*, *Mastomys awashensis*). Впервые для Эфиопии документально подтверждено обитание *Neoromicia zuluensis*. Кроме того, результаты молекулярно-генетических и цитогенетических анализов свидетельствуют об обитании на исследуемой территории двух пока не определенных форм грызунов (*Acomys* sp. и *Gerbilliscus* cf. *robustus*), возможно представляющих новые виды. Впервые составленный на основании как собственных, так и литературных данных, список млекопитающих заказника включает 59 видов, относящихся к 11 отрядам, 30 семействам и 51 роду. Природоохранное значение слоновьего заказника Бабилле определяется как высоким видовым богатством млекопитающих, так и общим разнообразием их зоогеографических связей.

КЛЮЧЕВЫЕ СЛОВА: млекопитающие, слоновий заказник Бабилле, Эфиопия, *Acomys*, *Gerbilliscus*, *Neoromicia*, новые находки.

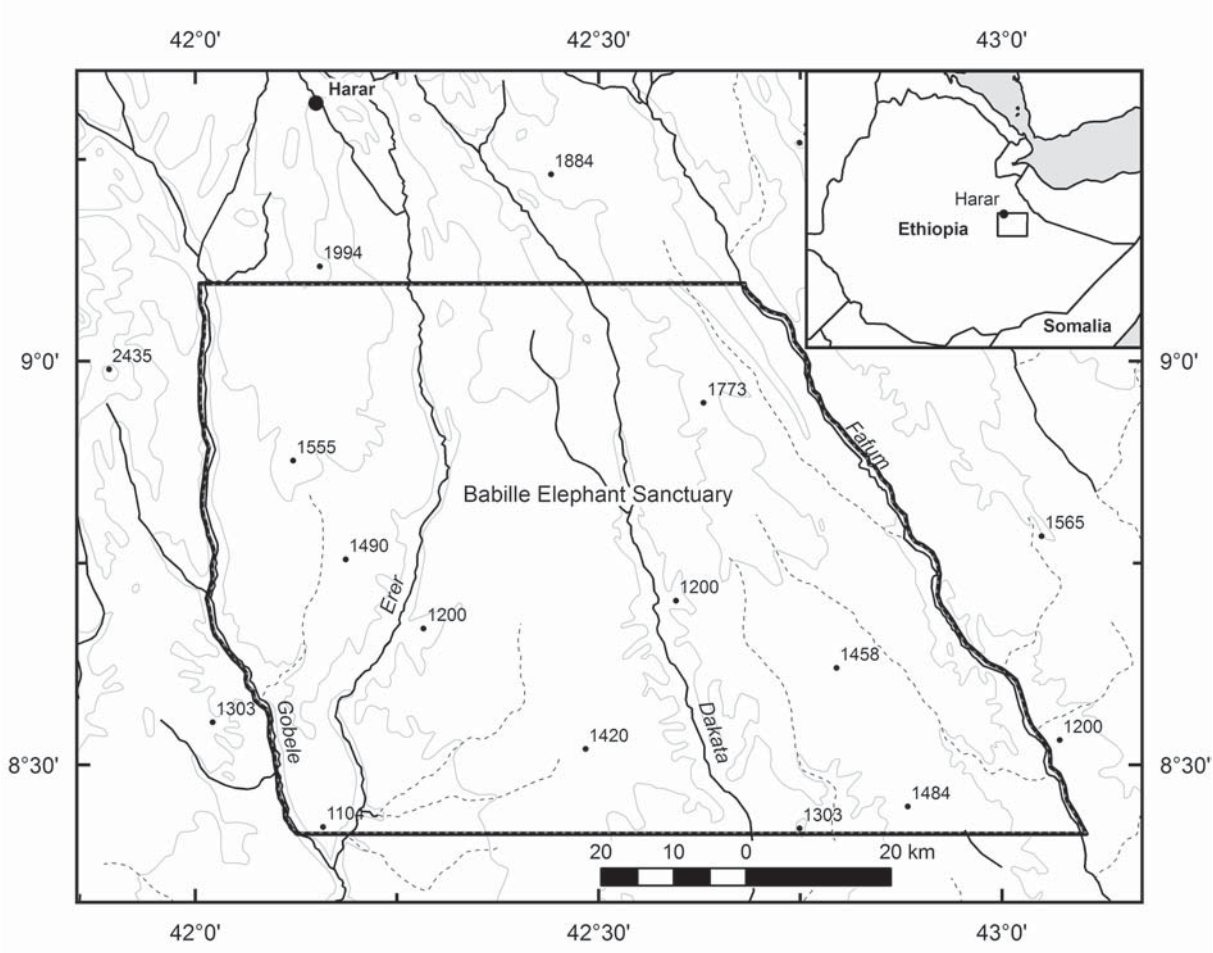


Figure 1. Map of Ethiopia showing the location of the Babille Elephant Sanctuary.

## Introduction

The Babille Elephant Sanctuary is situated at the boundary of the Oromiya and Somali Regions, about 560 km east of Addis Ababa, eastern Ethiopia, at 08°25′–09°08′N, 42°00'–43°06′E, 850–1785 m a.s.l. The Sanctuary contains four major rivers (Gobele, Erer, Dakata and Fafum) with many tributaries in dissected escarpments across each valley (Fig. 1). The Sanctuary's relief controls the directional flow of the rivers, which all flow south towards the Wabi Shebelle River. Generally, the vegetation of Babille falls into three major categories: scrub-mixed woodland, semi-desert bushland/scrubland and evergreen scrub. Moreover, there are narrow strips of *Acacia* forest in the valley bottoms. The Babille Elephant Sanctuary was nominally established in 1970 to protect the last surviving remnant of what may well be a distinctive Somali-arid subspecies of African elephant (*Loxodonta africana orleansi*), now probably numbering fewer than 100 animals (Yalden *et al*., 1996). No detailed diversity assessments have been undertaken of the mammals of the Sanctuary since its establishment. Therefore, our knowledge of mammals of this desert area is patchy and scarce. Any information on shrews, bats and rodents is practically absent throughout much of the region. In view the fast habitat destruction at the Babille region as a result of the activity of the German biodiesel company (Flora Eco-Power Holding AG), a complete inventory of the mammalian fauna of this nominally protected area is especially important and urgent. Here we report the results of a mammal survey of the northern part of the Sanctuary restricted to the upper Gobele, Erer and Dakata Valleys.

For small mammals (rodents and bats) the study was performed in the context of the "bar-coding taxon identification" (Blaxter, 2004), where specimens are defined by their unique nucleotide sequences of a mitochondrial gene and compared with known taxa and only then are they assigned to a known or new species. Moreover, for rodents our data also rely on non-ambiguous cytotaxonomic analysis: determinations at the specific level were assumed by the study of karyotypes. This technique constitutes a powerful tool for discriminating small mammals in general, and rodents in particular, as many cases of morphologically sibling but

karyotypically well-differentiated species have now been evidenced, especially among African genera.

## Material and methods

Fieldwork was undertaken from 28 November to18 December in 2008. The expedition base camp was situated on the right bank of the Erer River, near the Erer Integrated Rural Development Center (09°09′08″N, 42°15′25″E, 1252 m a.s.l.). Three localities were studied in the Erer Valley: riverine forest (09°03′53″N, 42°16′31″E, 1200 m a.s.l.), bushland (09°00′55″N, 42°16′11″E, 1200 m a.s.l.) and scrubland (09°03′36″N, 42°16′12″E, 1210 m a.s.l.). Additional data was obtained during one-day pilot trips into the Dakata (29 November) and Gobele (30 November) Valleys. All the cases of sighting of larger mammals were recorded and fixed, if possible, by two digital photo cameras (Sony Cyber-shot DSC-H2 and Panasonic Lumix FZ-50). Photographs, measurements and notes were made for any tracks, trails and droppings. Rodents were captured using live-traps baited with a piece of carrot and a piece of foam-rubber saturated with vegetable oil which was replaced every 2 days.

Bat observations were conducted visually with the help of an electric lantern, and acoustically by the use of narrow-band heterodyne ultrasound detector D100 (Pettersson Elektronik AB, Sweden). For reasons of safety, the space and time of bat observations and capture were restricted; all the observations were made on the fenced territory of the Erer Integrated Rural Development Center and on the section of the Erer River close to the Center. Bat individuals were captured using typical nylon mist-nets (size 6×3 and 10×4.5 m), erected in bat foraging sites and across flight paths (Kunz *et al*., 1996), and also by the mobile flap-trap (Borissenko, 1999). Total trapping effort of the mist nets amounted to about 56 hours/net.

Captured individuals were examined to determine sex, age and physiological condition. Standard external measurements were taken for each specimen, including length of head and body, tail length, length of hind foot, ear length, and weight. For bats, the forearm and tibia length were also measured. Voucher specimens of each species were taken for confirmation of the record and further investigation, including of verification of their taxonomic position and status. Except for voucher specimens, all trapped mammals were released after external examination in the places where they were captured. Voucher specimens were catalogued and deposited at the Zoological Museum of Moscow State University and Natural History Museum of Addis Ababa University. Collected specimens were preserved in 70% ethanol or prepared as a dry skin and skeleton. Tissue samples (pieces of muscles and liver if taken from fresh sacrificed specimens, or small pieces of wing membrane taken from some of released individuals) were preserved in 96% alcohol and stored in Eppendorf tubes for genetic analyses.

Bat specimens used for the morphological comparison are housed in Royal Ontario Museum (ROM, Toronto, Canada), Geneva Natural History Museum (GNHM, Geneva, Switzerland), Hungarian Natural History Museum (HNHM, Budapest, Hungary) and Zoological Institute of Russian Academy of Sciences (ZIN, St-Petersburg, Russia). Fourteen craniodental measurements were used in the further morphometric analysis to clarify the taxonomic position of *Neoromicia* sp.: condylocanine length (CCL), condylobasal length (CBL), mastoid width of the skull (MW), occipital height of the skull (OH), width of postorbital constriction (POC), rostral width at the level of the infraorbital foramina (RW), width across outer margins of upper canines (CC), crown width between outer margins of M3 (MM), C–M3 crown length (CM), length of the upper canine at the base of crown (C), palate length from anterior margins of canines to the tip of posterior palatal emargination (Pal), crown length of mandibular tooth row (cm), lower jaw length from alveolus of i1 to the articulated process condyle (MdL), and lower jaw height to the tip of coronoid process (MdH). These measurements were taken to the nearest 0.01 mm with electronic callipers in combination with a binocular microscope and then processed in Principal Component Analysis with the use of Statistica for Windows.

In establishing species identifications of bats, DNA barcodes (sequences of the 5'-fragment of *cox*-1 mitochondrial gene, up to 658 bp) were made for most of the processed specimens as part of the Barcoding of life project [http://barcodinglife.com], housed on the base of Biodiversity Institute of Ontario, Guelph University, Canada. A standard cocktail of primers acceptable for various mammalian species (Ivanova *et al*., 2007) was used to get PCR-products of the 5'-fragment of *cox*-1 (cytochrome c oxidase subunit 1) mitochondrial gene (up to 658 bp). Analogous data from Kenyan bats were used for comparison. Species identification of rodents was also confirmed by molecular data for a selected number of individuals. The entire cytochrome *b* gene (1140 bp) was amplified and sequenced following the method described in Lavrenchenko & Verheyen (2006). Homologous GenBank sequences of relevant rodent species were used for comparison.

For chromosomal analysis of rodents, somatic metaphases were prepared from bone marrow by the usual air-drying technique (Ford & Hamerton, 1956). Slides were stained with 4% Giemsa in phosphate buffer with pH = 7.0. C-banding was obtained according to Sumner (1972).

## Results

During this survey we documented the occurrence of 36 mammal species including one macroscelidid, one hyrax, one proboscidean, three primates, seven rodents, one lagomorph, eight bats, eight carnivores and six artiodactyls. All relevant data (taxonomic identifications, geographic range extensions, ecological con-

texts and other information) for each mammal species are summarized below. These species accounts add to our scarce knowledge of many poorly-known species, and provide the first major sketch of the mammal community of Babille as a whole. The nomenclature of mammals used here follows Grubb *et al*. (2003) [for primates] and Wilson & Reeder (2005) [for other groups] unless otherwise stated. We use the term "Babille" for the whole area within the limits of the Babille Elephant Sanctuary.

## SPECIES ACCOUNTS

Order Macroscelidea Butler, 1956
Family Macroscelididae Bonaparte, 1838
*Elephantulus rufescens* (Peters, 1878)

Elephant shrews are rather common in the bushland and scrubland habitats of the explored part of the Erer Valley. Animals crossing the road were seen in the morning (9.25, 3 December) and evening (18.20, 14 December) time. One animal was trapped by our assistants in the vicinity of the base camp.

Order Hyracoidea Huxley, 1869
Family Procaviidae Thomas, 1892
*Procavia capensis* (Pallas, 1766)

Many rock hyraces were seen and photographed on the rocky outcrops in the Dakata Valley on 29 November.

Order Proboscidea Illiger, 1811
Family Elephantidae Gray, 1821
*Loxodonta africana* (Blumenbach, 1797)

The Somali-arid subspecies of African elephant (*L. a. orleansi*) is the main object of protection in the Babille Elephant Sanctuary. Tracks and fresh droppings of the two groups of elephants were observed on 13–14 December in the Erer Valley. One animal, disturbed by local people, was seen nearby the Erer River on 14 December.

Order Primates Linnaeus, 1758
Family Galagidae Gray, 1825
*Galago senegalensis* E. Geoffroy, 1796

Two galago species might be expected to occur in the Sanctuary – the northern lesser galago, *G. senegalensis*, and the Somali lesser galago, *G. gallarum*. The former is widespread throughout most of Ethiopia (Yalden *et al*., 1977, 1996), the latter is one of Africa's least known primates. *G. gallarum* is highly specialized to specific habitats of the semi-arid thorn scrub and thorn scrub/woodland of eastern Kenya, southern Ethiopia, and Somalia where, in most places, it is the only small galago present (Butynski & De Jong, 2004). It is noteworthy that the distribution maps provided by Butynski & De Jong (2004) and Butynski *et al*. (2008) indicate the occurrence of *G. gallarum* in the northeastern corner of the Babille Elephant Sanctuary. However, this indication is not supported by any reference to collected specimens or recorded sightings. In general, although the limits of the geographic distribution of *G. gallarum* are poorly understood (Yalden *et al*., 1996; Butynski et al., 2008), in Ethiopia this species is not known to occur north of the Wabi Shebele River (Yalden *et al*., 1996).

We recorded two lesser galagos just on the territory of the base camp almost every evening, usually between 18.30 and 23.00. Animals moved through the tree canopies, not coming down onto the ground. Several single animals were also recorded at dusk in various parts of the Erer Valley. Mating calls were recorded several times in the middle of December in the base camp, however coupling was not observed. Butynski & De Jong (2004) described striking difference in vocalisation between *G. senegalensis* and *G. gallarum*; nevertheless mating call of the Babille galagos was very similar to that heard by us in other parts of the country undoubtedly inhabited by *G. senegalensis*. Furthermore, the investigation of our photographs demonstrates that these animals possess some characters of external appearance distinguishing *G. senegalensis* from *G. gallarum* (according to Butynski & De Jong, 2004; De Jong & Butynski, 2004): greyish-brown (not white) face, greyish-brown (not black) ears and tail. All these characteristics allowed identification of the galagos from the Erer Valley as *G. senegalensis*.

Family Cercopithecidae Gray, 1821
*Cercopithecus aethiops* (Linnaeus, 1758)

This common Ethiopian species was several times observed nearby the Erer River. Groups of at least four grivets was observed even in the agricultural land near the base camp.

*Papio hamadryas* (Linnaeus, 1758)

Two family groups of hamadryas baboons, each of at least five adults, were observed during the pilot trip to the Dakata Valley on 29 November. Characteristic baboon vocalisation, very probably of that particular species, was registered also in the Erer Valley, about ten kilometres south of the base camp.

Order Rodentia Bowdich, 1821
Family Sciuridae Fischer, 1817
*Xerus rutilus* (Cretzschmar, 1828)

Pallid ground squirrels were observed and photographed multiple times in various parts of the Erer Valley, including close vicinity of the base camp, and also during pilot trips into the Gobele and Dakata Valleys. According to our observations, ground squirrels inhabit open bushy areas including highly overgrazed places, and are active during the day time, mainly between 10.00 and 14.00. The analysis of cytochrome *b* gene sequences including one from the specimen collected in the Erer Valley confirms the attribution of the Babille ground squirrels to *X. rutilus*. The karyotype of this specimen (male) was characterized by 2n=38, NF=76 and NFa=72. The X chromosome is a medium-


Figure 2. Giemsa stained karyotype of *Acomys* sp. (male) from Babille (2n=44, NFa=66).

sized submetacentric, and the Y chromosome is a smallest heterochromatic submetacentric. The morphology of the chromosomes is generally in agreement with those described for specimens of *X. rutilus* from Kenya by Nadler & Hoffmann (1974).

Family Muridae Illiger, 1811

*Acomys* sp.

Spiny mouse is rather common rodent of the bushland/scrubland habitats in the Erer Valley. Currently, six distinct *Acomys* species are known for Ethiopia: *A. cahirinus*, *A. cineraceus*, *A. kempi*, *A. mullah*, *A. percivali* and *A. wilsoni* (Musser & Carleton, 2005). Moreover, undescribed yet 68-chromosomal *Acomys* sp. (morphologically close to *Acomys cahirinus* s.str.) was found in the middle part of the Ethiopian Rift Valley (Sokolov *et al*., 1993). The karyotype (2n=44, NF=68, NFa=66) of two *Acomys* specimens (male and female) from Babille comprises 12 pairs of metacentrics / submetacentrics and 10 pairs of acrocentrics (including sex chromosomes) (Fig. 2). The X-chromosome is a large acrocentric; Y-chromosome is the smallest one. The studied chromosomal set is notably distinct from the karyotypes of *A. cahirinus* (2n=36, NF=68), *A. cineraceus* (2n=48–50), *A. mullah* (2n=68) and *A. wilsoni* (2n=62, NFa=76) but is quite similar to that of *A. chudeaui* from Morocco and Mauritania and *A. airensis* from Niger and Mali (2n=40–46, NFa=66) (Fadda *et al*., 2001; Dobigny *et al*., 2002; Corti *et al*., 2005; Musser, Carleton, 2005; Nicolas *et al*., 2009). Conspecificity of the two latter taxa was recently suggested (Nicolas et al., 2009). Moreover, karyotypes of other Ethiopian spiny mice, *A. kempi* and *A. percivali*, remain currently unknown. The analysis of the cytochrome *b* sequences revealed that four Babille spiny mice do not clearly belong to any of *Acomys* species, and separated from them by high genetic distances (from 11.7 to 19.9%). In particular, such distances between karyologically similar Babille *Acomys* and specimens from *A. chudeaui / airensis* clade range from 13.1 to 14.2%. Again, it is worth mentioning that any relevant cytochrome *b* data on two Ethiopian species, *A. kempi* and *A. percivali*, are currently not available. Thus, for the moment no taxonomic hypothesis for the specimens from Babille can be made. Therefore, they were provisionally named as *Acomys* sp. One possibility is that they represent a previously undiscovered spiny mouse species.

*Gerbilliscus* cf. *robustus* (Cretzschmar, 1826)

The gerbils were trapped both in the bushland/scrubland habitats and at the edge of the riverine forest in the Erer Valley. The external and cranial measurements of these animals correspond to those of *G. robustus*. Their karyotype is characterized by 2n=36, NF=72 and NFa=68. The X chromosome is a medium-sized submetacentric, and the Y chromosome is a small acrocentric. Such chromosomal formulae have been reported for *G. nigricaudus*, *G. vicinus* and *G. robustus* s.str.;

the monophyly of this evolutionary lineage, characterized by a high karyotypic stability, was supported by molecular phylogenetics (Colangelo *et al*., 2005). The analysis of the cytochrome *b* sequences revealed that the Babille gerbils clearly belong to the *G. robustus* species complex (sensu Colangelo *et al*., 2005, 2007). Within this complex they are phylogenetically close to *G. robustus* s.str. from Ethiopia (Zeway) and Chad, and a specimen from Kenya (Rongai), which was attributed supposedly to *G. phillipsi* by Colangelo *et al*. (2005), although separated by high genetic distances (11.8–14.8% and 10.6–10.8%, respectively). Such cytochrome *b* genetic distances correspond to the level usually recorded between allied species of rodents (Bradley & Baker, 2001). Therefore, it seems very likely that the *Gerbilliscus* specimens from Babille represent a new cryptic species.

*Mastomys awashensis* Lavrenchenko et al., 1998

Multimammate rats of the genus *Mastomys* were trapped only in the grasslands on the bank of the Erer River and were certainly absent in the bushland/scrubland habitats. Currently, 3 distinct *Mastomys* species are known for Ethiopia (*M. natalensis*, *M. erythroleucus* and *M. awashensis*), all of them would likely not be recognized without data from karyotypes, allozymes and DNA-sequencing. Both cytogenetic and cytochrome *b* sequencing analyses revealed that all seven *Mastomys* specimens collected in Babille clearly belong to *M. awashensis* which is endemic to Ethiopia. Their karyotype, composed of thee pairs of acrocentrics and 12 pairs of bi-armed chromosomes (2n=32, NF=58, NFa=54), is in agreement with those previously published (Lavrenchenko *et al*., 1998; Volobouev *et al*., 2002; Corti *et al*., 2005). This little-known species was initially described by us (Lavrenchenko *et al*., 1998) based on samples from two localities of the middle Awash Valley. Later, Corti *et al*. (2005) found *M. awashensis* in another adjacent locality near Zeway Lake. Because of the restricted distribution area (15000 km$^2$) the species was classified as "Vulnerable" in the IUCN Red List (Lavrenchenko & Corti, 2008). However, during the further trapping sessions the species was recorded in two additional localities (near Mekelle: Colangelo et al., 2010; southeastern lakeside of Tana Lake: our data) far to the north. Combined with our current finding of *M. awashensis* in Babille, the data demonstrate that its range extends well beyond the Ethiopian Rift Valley to regions both in the north and east of the country. Therefore, the conservation status of *M. awashensis* must be re-evaluated. The values of cytochrome *b* genetic distance between the specimens from Babille and their conspecifics from the Zeway, Tana and Mekelle areas are rather low (0.8–2.4%).

*Mus* (*Nannomys*) *tenellus* (Thomas, 1903)

A single specimen of pygmy mouse was trapped at the edge of the riverine *Acacia* forest in the Erer Valley. Unfortunately, the animal was found dead in a trap and karyotyping was not attempted. The external and cranial measurements of the mouse correspond to those of *Mus tenellus*. Molecular analysis supports this identification, the cytochrome *b* genetic divergence between the specimen from Babille and *Mus tenellus* from two localities of western Ethiopia (middle Godjeb Valley, Bebeka coffee farm) ranges from 2.8 to 3.3%. This is the first record of the species for the whole Babille area.

Family Bathyergidae Waterhouse, 1841

*Heterocephalus glaber* Ruppell, 1842

The naked mole-rat is a rather common species in most habitats in the Erer and Dakata Valleys. The characteristic soil mounds clearly indicated the location of subterranean colonies of this unique fossorial eusocial rodent. The process of constructing such mounds by the animals was repeatedly observed. One specimen (female) was obtained from a villager in the base camp. The specimen shows a lower cytochrome *b* genetic divergence (3.6%) from a conspecific from the nearby location in eastern Ethiopia (Diredawa) [separated from Babille by the Chercher Highlands] than from ones from southern Ethiopia (Dembalawachu), northern Kenya (Lerata) and southern Kenya (Mtito Andei) (10.3–11.2%). This high genetic differentiation at the intraspecific level reflects such characteristics of naked mole-rats as limited gene flow imposed by the subterranean lifestyle (their colonies are almost completely isolated breeding groups), the patchiness of suitable habitats, and a mating system promoting extreme inbreeding (Faulkes *et al*., 1997).

Family Hystricidae Fischer, 1817

*Hystrix cristata* Linnaeus, 1758

Characteristic spines of the crested porcupine were found near the fence surrounded the Erer Integrated Rural Development Center. No any other signs of this species were observed.

Order Lagomorpha Brandt, 1855

Family Leporidae Fischer, 1817

*Lepus habessinicus* Hemprich, Ehrenberg, 1832

Hares were twice seen and photographed in open bushy area in the Erer Valley. The lack of the prominent black tips on the posterior surface of the large ears allowed identification of these hares as *L. habessinicus*, which is wide-spread throughout northern and eastern Ethiopia (Yalden *et al*., 1986).

Order Chiroptera Blumenbach, 1779

Family Pteropodidae Gray, 1821

*Epomophorus minor* Dobson, 1879

Small epomophorine fruit bats were common on the territory of the Erer Integrated Rural Development Center, mainly in the *Acacia* woodland, but also observed over the Erer River. During the period of investigations these bats were frequently seen flying between the tree canopies and were the only chiropterans which were still active in the morning hours (when the air tempera-

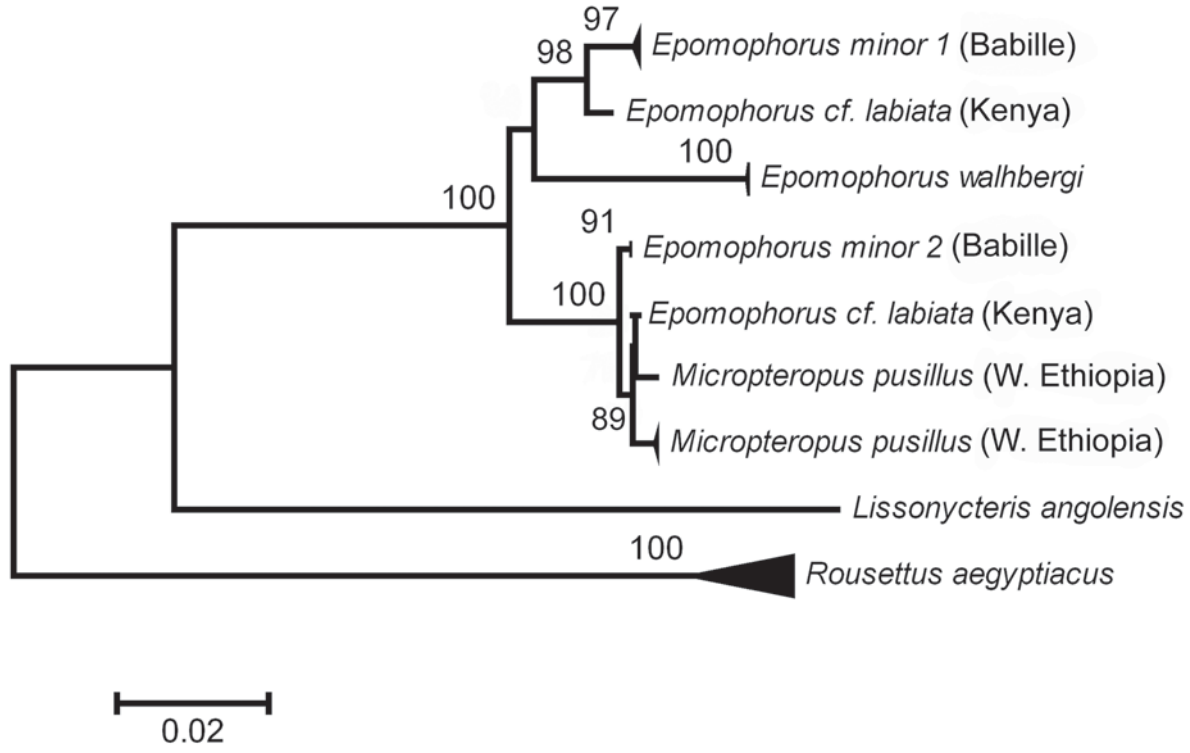


Figure 3. Kimura 2 parameter tree for the cytochrome-c oxidase (1 subunit) gene (*cox1*) sequences of the some East African epomophorine fruit bats; Angola and Egyptian fruit bats were taken as outgroups; bootstraps over 70% calculated from 1000 replicas are mentioned over appropriate branches.

ture was lowest, about 6–8°C). Roosting between the dry *Acacia* fruits was also recorded. Observed hunting by fan-tailed ravens (*Corvus ripidurus*) on the same bats testifies that in the Erer Valley *Epomophorus* can be a common prey for large animalivorous birds.

Measurements of all the captured specimens (forearm length 54.5–61.8 mm, body mass 26.8–41.5 g) lie well within the range of *Epomophorus minor* (or *E. minimus* sensu Claessen & De Vree, 1991; see also Bergmans, 1997). Skull shape and the structure of the palatal ridges well segregate the Babille specimens from similar sized *Micropteropus pusillus* (as described by Bergmans, 1997). Since there is no strict consensus about status of *E. minimus* and its relations with *E. minor*, here we accept Bergmans' (1997) point of view. Two different coloration types were observed: one of "traditional" greyish-brown coloration, with whitish belly and shoulders and pure white ear tufts; another of brownish-yellow coloration, with yellow belly and bright-yellow ear tufts. All the processed specimens were captured into the mist nets nearby the base camp; six of them — three males and three females — were taken as vouchers. Most of the captured bats of this species were immature reproductively inactive individuals. Bright yellow coloration, not previously reported for any Ethiopian epomophorines, came probably from the pollen of some plant on which bats were fed; later it has disappeared on the voucher specimens confirming the artificial and external genesis of the colour.

Provisional mtDNA analysis of the tissue samples indicated a very problematic situation. The tree represented on the Fig. 3, clearly demonstrates that the Babille sample is divided into two clusters, one independent and another mixed with *Micropteropus pusillus* from western Ethiopia and with one specimen of larger *E. labiatus* from Kenya. Distance between the two clusters slightly exceeds 4%. Since specimens in both clusters are physically almost identical, and the *cox*-1 gene sequences demonstrate no variation across all the analysed epomophorine individuals, the observing situation could be most plausibly explained by ancient hybridisation between both *E. labiatus* and *E. minor,* and further look to be closely related taxonomically to *M. pusillus.* This seems to have resulted in massive mtDNA introgression. Comparable cases of introgression of alien DNA were already described e.g. for Palaearctic *Eptesicus* (Artyushin *et al*., 2009) and for African *Scotophilus* (Trujillo *et al*., 2009), but not for any fruit bats. The final solution will require analysing more numerous and geographically diverse material and sequencing of some more genes, including nuclear ones. At the present stage it casts doubt on the status of the genus *Micropteropus,* which probably should be treated as a partial synonym of *Epomophorus*.

Family Rhinolophidae Gray, 1825

*Rhinolophus fumigatus* Ruppell, 1842

One specimen of this large (size of the European greater horseshoe bat, forearm length = 54.2 mm) *Rhinolophus* with a very characteristic pure grey coloration was captured in the mist net set above the bed of the Erer River. An identical specimen was observed some minutes later at the same place, which emitted loud CF echolocation calls at *ca*. 117 kHz. This horseshoe bat species was not previously reported from this part of Ethiopia (Largen *et al*., 1974; Yalden *et al*., 1996).

Family Hipposideridae Lydekker, 1891

*Hipposideros tephrus* Cabrera, 1906

Two adult males of the false horseshoe bat were captured on the Erer River over the water on 16 December, in the evening, about half an hour after sunset. Probably animals of the same species (indicated by small size, very manoeuvrable flight and absence of the tonal echolocation signal) were observed several times also on the Erer River and near the base camp.

The *Hipposideros caffer* complex is one of taxonomical nightmares; distributed throughout Sub-Saharan Africa (Koopman, 1994), it was for a long time divided into two main species — *H. caffer* and *H. ruber* (Hayman & Hill, 1971; Fenton, 1975; Yalden *et al*., 1996), demarcation between which was not always clear (Baeten *et al*., 1984; Lavrenchenko *et al*., 2004). Recent studies (Vallo *et al*., 2008) have demonstrate the presence of at least seven distinct species in the complex, of which three, namely *H. ruber* s.str., *H. centralis* and *H. tephrus*, — could be found in Ethiopia. Captured *Hipposideros* specimens demonstrate a morphotype resembling more "*caffer*" rather than "*ruber*", which, together with their extremely small size (forearm in both individuals was 44.2 mm), allocates them presumably to *H. tephrus*. The captured animals possess very bright colourful orange-golden coloration, not seen by us previously in any Ethiopian *Hipposideros*; however one specimen with similar coloration pattern was later found in the collection of the Natural History Museum of Addis Ababa University (No M1987. 133).

Family Megadermatidae Allen, 1864

*Lavia frons* (E. Geoffroy, 1810)

A single adult male of the yellow-winged false vampire bat was captured in a mist net set between the bushes in the vicinity of the base camp. The same specimen was also observed several times in the same area, flying slow and manoeuvring close to the ground and to the base of bushes. Our record was made at least 200 km north-west from the closest previously published locality (Sassabane) of the species in Ethiopia (Largen *et al*., 1974).

Family Nycteridae Hoeven, 1855

*Nycteris thebaica* E. Geoffroy, 1813

The Egyptian slit-faced bat is one of the most ecologically flexible members of the Nycteridae, widely distributed throughout Africa and Arabia (Gray *et al*., 1999). A single adult female was captured in the mist net on the border of bush growth and *Acacia* woodland on the territory of the Erer Integrated Rural Development Center. Previous to this capture, this bat (very probably this concrete individual) was several times seen flying manoeuvrable very close to bushes and to the ground surface, which is corresponds to known foraging behaviour of the slit-faced bats (Seamark & Boganowicz, 2002). This is the first record of the species for the whole Babille area.

Family Molossidae Gervais, 1856

*Chaerephon pumillus* (Cretzschmar, 1830)

About twenty small molossids from the genus *Chaerephon* were captured in the mist nets set into the Erer River bed though some of them were released immediately after capture. Five specimens (one male and four females) were taken as vouchers while the rest were released after observation and measuring. All the individuals examined were reproductively inactive. It is very probable that the captured bats came to the Erer River and flew lowly over the river bed for the purpose of drinking, while their normal foraging flight occurs distinctly higher. Readily audible social calls of presumably the same species were heard abundantly over the Erer Integrated Rural Development Center.

Identification of the small African free-tailed bats is highly problematic, since about 15 taxa have been described within this size class of the genus (Van Cakenberghe *et al*., 1999) and taxonomic borders even of the most common species, *Ch. pumilus*, are still uncertain (Lavrenchenko *et al*., 2004). Our vouchers were compared with a set of *Chaerephon* specimens preserving in the Royal Ontario Museum, Canada, including six *C. nigeriae* from Ethiopia, twelve *C. leucogaster* from Ethiopia and Madagascar, three *C. chapini* and eleven *C. pumila* from Kenya. According to these comparisons, our specimens are distinctly smaller than *C. nigeriae* and somewhat larger than *C. leucogaster* and *C. chapini*, corresponding *C. pumilus*. High variability of the underside coloration pattern in both *C. leucogaster* and especially *C. pumilus* reduces the taxonomic value of this feature.

Family Vespertilionidae Gray, 1821

*Neoromicia zuluensis* (Roberts, 1924)

Small serotines from the genus *Neoromicia* were multiply observed flying around the buildings of the Erer Integrated Rural Development Center and in its vicinity under and above the canopies of *Acacia* trees. Foraging flight relatively swift and manoeuvrable, animals emit tonal FM echolocation calls at 30–45 kHz (maximum energy at about 37–40 kHz). Two adult reproductively inactive males were captured into mist net while they emerged from the building, which depict this species as at least partially synanthropic.

The only *Neoromicia* species previously reported from this part of Ethiopia is *N. somalicus* (Largen *et al*.,

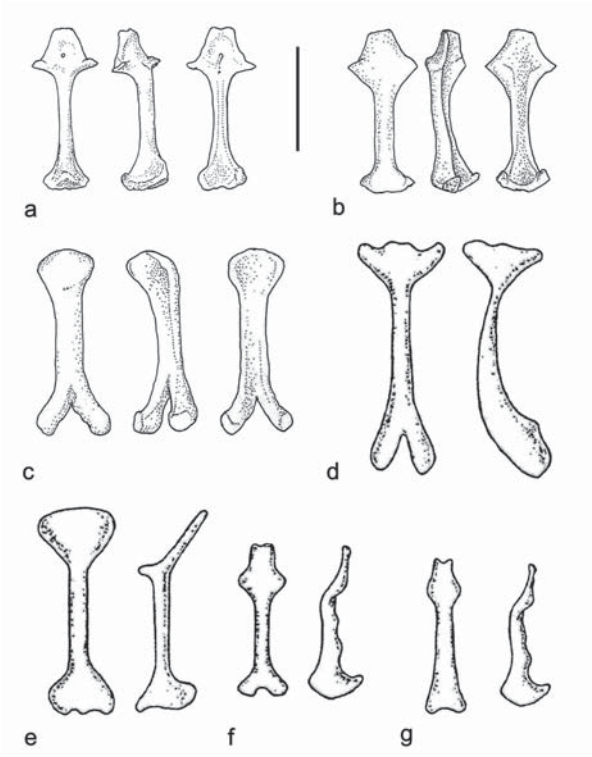


Figure 4. Penial bones (bacula) of some *Neoromicia* species: a — *Neoromicia cf. zuluensis* from the Erer Valley (upper, left and ventral views); b — *N. guineensis* (upper, right and ventral views); c — *N. nanus* (upper, left-ventral and ventral views); d — *N. tenuipinnis* (upper and right views); e — *N. capensis* (upper and right views); f — *N. somalicus* (upper and right views); g — *N. zuluensis* (upper and right views); a–c original, d–g — after Hill & Harrison (1987). Scale bar = 1 mm.

1974) and that was the provisional identification of our specimens. However, further analysis of their mtDNA set Babille *Neoromicia* well apart from the specimen of *N. somalicus* from Bahir Dahr. Bacular shape of Babille serotines is typical for *Neoromicia* (Fig. 4), precisely dividing them from all other vespertilionids and also from *N. nanus*, *N. rendalli* and *N. tenuipinnis*. The latter species, though being similar in size to the Babille specimens, clearly differs by its wider and shorter tragus and by its characteristic white-winged coloration pattern.

Principal Component Analysis based on fourteen craniodental measurements of 70 individuals, representing eight *Neoromicia* species (specimens are stored in the collections of ROM, GNHM, HNHM and ZIN), associates the Babille specimen with *N. guineensis* and *N. zuluensis* equally in the space of the two first Principal Components (Fig. 5), however the third PC (positively correlated with the occiput height) clearly divided it from *N. guineensis*. This also corresponds with provisional data of DNA analysis. Unfortunately we have no molecular data on *N. zuluensis* and thus cannot test our material in this respect. According to Peterson *et al*. (1995), *N. zuluensis* should be considered a species, separated from *N. somalicus*, with a distribution stretching from Ethiopia to South Africa. However, no

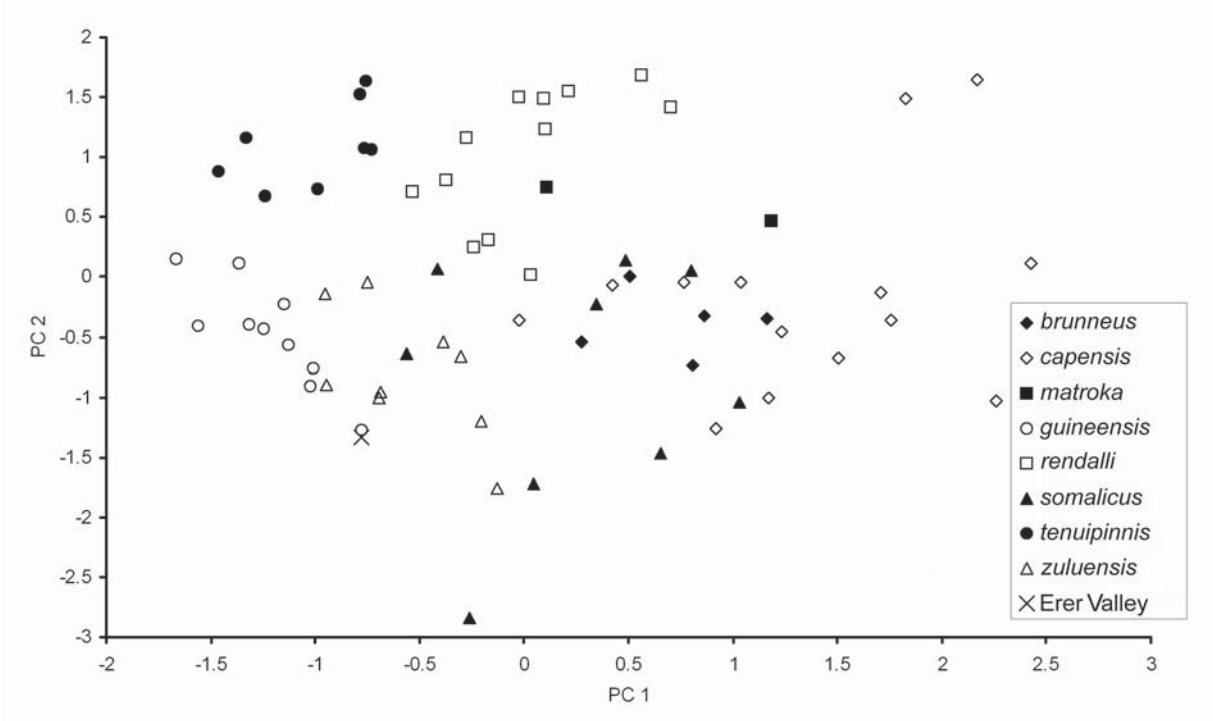


Figure 5. Bivariate scatterplot for the Principal Component Analysis of 14 craniodental measurements of eight *Neoromicia* species. PC 1 (eigenvalue = 10.37; % of total variance = 79.77) has correlations with overall size, and PC 2 (eigenvalue = 1.27; % of total variance = 9.77) positively correlated with postorbital constriction.

exact localities were identified in their work, and this species was not even mentioned by Yalden *et al*. (1996). Thus our record in Babille is the first confirmed from Ethiopia for *N. zuluensis*.

*Scotophilus* cf. *dinganii* (A. Smith, 1833)

Specimens of *Scotophilus* were observed on almost all working nights, usually soon after sunset, foraging along the forest border, tree lines, Erer River bed and over the roofs of buildings at heights of 3 to 15 meters from the ground and higher. Flight is fast, rectilinear and not manoeuvrable. Echolocation calls are very loud, FM, with maximum energy at about 30–32 kHz, which is characteristic of the genus. Five individuals were captured by the flap-trap on the territory of the Erer Integrated Rural Development Center and in the mist net set across the Erer River; one adult reproductively inactive male was taken as a voucher. In general appearance and size (forearm length 48.6, upper tooth row 6.7 mm) it resembles *S. dinganii*, the most common Ethiopian species, however being somewhat paler in coloration than specimens from the west of the country. Very probably, this coloration difference reflects some age or geographic variety. Meantime, the presence of several genetic lineages inside *S. dinganii* was already shown including possible traces of the past interspecies hybridisation (Trujillo *et al*., 2009), so the question of diversity in this species needs further investigation.

Order Carnivora Bowdich, 1821
Family Felidae Fischer, 1817
*Caracal caracal* (Schreber, 1776)

Single caracals were twice observed in the Erer Valley. One record was made in the evening time (13 December), another one during the day time (2 December).

*Panthera pardus* (Linnaeus, 1758)

Leopard tracks were several times observed on the trails in the Sanctuary and even nearby the Erer Integrated Rural Development Center. One animal was seen near the Erer River in the evening on 14 December.

*Panthera leo* (Linnaeus, 1758)

Lion is supposed to be a common predator in the observed area. Tracks of lions (mainly immature) were seen in different parts of the Sanctuary. Tracks of a lioness with cubs were seen and photographed on the trail in the Dakata Valley, about one kilometre south of the road Harar-Jigjiga.

Family Viverridae Gray, 1821
*Genetta maculata* (Gray, 1830)

One large-spotted genet was several times observed directly near the base camp.

Family Herpestidae Bonaparte, 1845
*Ichneumia albicauda* (G. Cuvier, 1829)

Several white-tailed mongooses (probably one or two adults and two immatures) were regularly observed just in the base camp. One animal was seen on the Erer River. Footprints of mongooses of this size class were frequently observed in various parts of the Erer Valley.

*Helogale parvula* (Sundevall, 1846)

One dead dwarf mongoose (immature female) was obtained from the villagers near the Erer River. This is the first record of the species within the borders of the Sanctuary.

Family Hyaenidae Gray, 1821
*Crocuta crocuta* (Erxleben, 1777)

Calling of spotted hyena was heard in the vicinity of base camp almost continuously every night. Animals themselves were seen and photographed three times after sunset in the Erer Valley; one animal was observed carrying prey (probably a dik-dik).

Family Canidae Fischer, 1817
*Canis mesomelas* Schreber, 1775

Black-backed jackals were twice observed in the Erer Valley.

Order Artiodactyla Owen, 1848
Family Suidae Gray, 1821
*Phacochoerus africanus* (Gmelin, 1788)

Groups of warthogs were several times observed and photographed in different parts of the Erer Valley, both in the Sanctuary and out of it. Special interest of these animals was the proposition that the Babille area could be inhabited not only by widespread common warthog, *Ph. africanus*, but also by the rare desert warthog, *Ph. aethiopicus* (d'Huart & Grubb, 2001; d'Huart *et al*., 2008). The examination of our photographs demonstrates that there are really warthogs of different coloration types in Babille, including individuals with a very pale mane and dorsal crest, which is supposed to one of characteristics of *Ph. aethiopicus* (d'Huart & Grubb, 2001). It is worth mentioning, however, that any field identification of warthog species is rather doubtful because of high level of geographical variation in external appearance of widespread *Ph. africanus*, which is still poorly understood (Grubb, 1993). Despite intensive search for warthog skulls, only one (deposited currently at the Natural History Museum of Addis Ababa University) was found in the bushes. The presence of clear traces of the alveoli of two incisors in the upper jaw and the lack of a spherical hollow knob (formed by internal sinuses) in the front part of the zygomatic arch allowed identification of this skull as *Ph. africanus*. So, the presence of the *Ph. aethiopicus* in the Sanctuary could not be confirmed.

Family Bovidae Gray, 1821
*Madoqua guentheri* Thomas, 1894

Guenther's dik-diks were seen and photographed many times in variably disturbed bushy areas, mainly inside the Sanctuary. Animals were usually observed soon after sunset, alone or in small groups up to three individuals.

*Madoqua saltiana* (De Blainville, 1816)

Phillips's dik-dik was several times seen in various parts of the Erer Valley. One animal was seen in Dakata Valley on 29 November. Large part of observations was made in the day time.

*Tragelaphus imberbis* (Blyth, 1869)

Lesser kudu were twice seen in the bushland/scrubland of the Erer Valley in the day time: one adult male and one female. Both animals were seen at almost the same place; footprints and droppings most probably of the same species were observed in the same area.

*Tragelaphus scriptus* (Pallas, 1766)

One bushbuck was repeatedly seen at the edge of the riverine *Acacia* forest in the Erer Valley.

*Sylvicapra grimmia* (Linnaeus, 1758)

One bush duiker was seen in bushy area in the Erer Valley on territory of the Sanctuary.

## Discussion

The results of our mammal survey at the Babille Elephant Sanctuary are just one more step in a continuing effort by the authors to document and describe the diversity and distributions of Ethiopian mammals. The current survey has significantly increased our knowledge of the local mammal fauna. Four species (*Nycteris thebaica*, *Lavia frons*, *Mus tenellus*, *Helogale parvula*) were detected for the first time in the Sanctuary, two species (*Rhinolophus fumigatus*, *Mastomys awashensis*) were new for eastern Ethiopia and the presence of another species (*Neoromicia zuluensis*) was confirmed for the first time within the limits of Ethiopia. It is even more important that genetic and chromosomal characteristics of two rodents (*Acomys* sp. and *Gerbilliscus* cf. *robustus*) possibly indicate new yet undescribed species. Clearly, extensive comparisons with type material using a multidisciplinary approach are needed to investigate the status of these potentially new taxa (the study is in progress).

However, the actual taxonomic diversity of the Babille mammal fauna is undoubtedly larger than we documented. Our failure to record some species of larger mammals reported for the area previously (*Heterohyrax brucei*, *Orycteropus afer*, *Mellivora capensis*, *Otocyon megalotis*, *Canis aureus*, *Civettictis civetta*, *Genetta genetta*, *Galerella sanguinea*, *Hyaena hyaena*, *Felis silvestris*, *Leptailurus serval*, *Oreotragus oreotragus*, *Litocranius walleri* and *Tragelaphus strepsiceros*) (Yalden *et al*., 1980, 1984, 1986) can be attributed to the short fieldwork time of our survey. Two large carnivores (*Lycaon pictus* and *Acinonyx jubatus*) reported from the Erer and Dakata Valleys during 1960–70s (Yalden *et al*., 1980) have experienced dramatic reductions in numbers and geographic range in recent decades (Malcolm & Sillero-Zubiri, 2001; Ray *et al*., 2005; Durant *et al*., 2008; McNutt *et al*., 2008) and have probably disappeared from the area. Furthermore, it is highly likely that the failure to detect the three bats (*Taphozous perforatus*, *Miniopterus africanus*, *Chaerephon bivittatus*), two shrews (*Crocidura olivieri*, *C. smithii*) and one rodent (*Myomyscus brockmani*) known for the area previously (Largen *et al*., 1974; Yalden *et al*., 1976) can probably be attributed to insufficient trapping efforts during our survey. Finally, another rodent species, *Pectinator spekei*, was found previously only in the south-western sector of the Sanctuary (Daletti, 08°33′N 42°07′E, Yalden *et al*., 1976) which was not visited by us during the survey. In total, according to our current estimate, the mammal fauna of the Sanctuary includes 59 species belonging to 11 orders, 30 families and 51 genera. Obviously, this list is not complete. It is highly likely that four additional species of bats (*Rousettus aegyptiacus*, *Rhinolophus clivosus*, *Rh. blasii*, *Cardioderma cor*), two rodent species (*Taterillus emini*, *Arvicanthis* sp.), and one carnivore (*Atilax paludinosus*) recorded in the vicinities of the Sanctuary (see Largen *et al*., 1974; Yalden *et al*., 1980, 1996) occur also in its area. Although we failed to detect *Galago gallarum* and *Phacochoerus aethiopicus delamerei* it is quite possible that these distinctive Somali-arid endemics may occur in the southern part of the Sanctuary.

Generally, the mammal fauna of the Sanctuary is dominated by savanna and xerophilous forms but they have different zoogeographic affinities. Among the 59 mammal species recorded 43 can be assigned to one of the following zoogeographic categories (sensu Yalden *et al*., 1996): Pan-African savanna (16 species), Somali-arid (12 species), East African savanna (9 species), West African savanna (3 species), Saharo-Sindian (2 species) and endemic to Ethiopia (1 species). Such a complex structure of the fauna can be associated with the location of the Sanctuary where species characteristic of the East African savannas, of the sub-Saharan savanna belt and of the Somali-arid zone meet and mingle. It is noteworthy that some species achieve their extreme south-eastern (*Cercopithecus aethiops*), north-eastern (*Neoromicia zuluensis*) or eastern (*Crocidura olivieri*, *Rhinolophus fumigatus*, *Miniopterus africanus*, *Chaerephon bivittatus*, *Mus tenellus*) limits in area of the Sanctuary. Therefore, the Babille Elephant Sanctuary has a considerable conservation significance due to its high mammal species diversity and rather distinctive composition and structure of the mammalian fauna.

ACKNOWLEDGEMENTS.

We are indebted to the Ethiopian Wildlife Conservation Authority for permission to work in the Babille Elephant Sanctuary. We thank the Manager and staff of the Erer Integrated Rural Development Center for the use of the Center buildings and equipment. We are grateful to Mrs. Dronov Alexey, Yohannes Dernersessian and Yihew Biru for their invaluable assistance during all stages of the expedition. We are indebted to Dr. Yirmed Demeke (Wildlife for Sustainable Devel-

opment) for his very useful advice on organization of the field investigation. We are especially indebted to our Project Coordinators Dr. Andrei Darkov (Joint Ethiopian-Russian Biological Expedition, Second Phase — JERBE III) and Ato Girma Yosef (Ethiopian Ministry of Science and Technology) for management of the expedition in the field and in Addis Ababa. We are sincerely grateful to Dr. Alex Borissenko, Dr. Nataly Ivanova and the director of Canadian Centre for DNA Barcoding (Guelph, Canada), Dr. Paul Hebert, for preliminary molecular analysis of Babille bats. Drs. Nina Sh. Bulatova and Rena S. Nadjafova (Severtsov Institute of Ecology and Evolution, RAS) made an inestimable contribution to the karyological part of this study. Study of the comparative material was held with the support of the special grant of Geneva Natural History Museum and under the kind help of Dr. Judith Eger (Canada), Dr. Manuel Ruedi (Switzerland) and Dr. Gabor Csorba (Hungary). We appreciate Dr. Derek Yalden (UK) for kind reviewing of the manuscript. At the final stage this work was supported by the Russian Foundation for Basic Research (projects Nos. 11-04-00443 and 10-04-00683-a).

## References

Artyushin I.V., Bannikova A.A., Lebedev V.S. & Kruskop S.V. 2009. Mitochondrial DNA relationships among North Palaearctic *Eptesicus* (Vespertilionidae, Chiroptera) and past hybridization between common serotine and northern bat // Zootaxa. No.2262. P.40–52.

Baeten B., Van Cakenberghe V. & De Vree F. 1984. An annotated inventory of a collection of bats from Rwanda (Chiroptera) // Revue zoologique Africaine. Vol.98. P.183–196.

Bergmans W. 1997. Taxonomy and biogeography of African fruit bats (Mammalia, Megachiroptera). 5. The genera *Lissonycteris* Andersen, 1912, *Myonycteris* Matschie, 1899 and *Megaloglossus* Pagenstecher, 1885; general remarks and conclusions; annex; key to all species // Beaufortia. Vol.47. No.2. P.11–90.

Blaxter M.L. 2004. The promise of a DNA taxonomy // Philosophical Transactions of the Royal Society of London. Ser. B. Vol.259. P.669–679.

Borissenko A.V. 1999. A mobile trap for bats // Plecotus et al. Vol.2. P.1–10.

Bradley R.D. & Baker R.J. 2001. A test of the genetic species concept: cytochrome *b* sequences and mammals // Journal of Mammalogy. Vol.82. No.4. P.960–973.

Butynski T.M. & De Jong Y.A. 2004. Natural history of the Somali lesser galago (*Galago gallarum*) // Journal of East African Natural History. Vol.93. P.23–38.

Butynski T.M., De Jong Y. & Bearder S. 2008. *Galago gallarum* // IUCN 2010. IUCN Red List of Threatened Species. Version 2010.4. <http://www.iucnredlist.org/>.

Claessen C. J. & De Vree F. 1991. Systematic and taxonomic notes on the *Epomophorus anurus-labiatus-minor* complex with the description of a new species (Mammalia: Chiroptera: Pteropodidae) // Senckenbergiana Biologica. Vol.71. No.4/6. P.209–238.

Colangelo P., Corti M., Verheyen E., Annesi F., Oguge N., Makundi R.H. & Verheyen W. 2005. Mitochondrial phylogeny reveals differential modes of chromosomal evolution in the genus *Tatera* (Rodentia: Gerbillinae) in Africa // Molecular Phylogenetics and Evolution. Vol.35. P.556–568.

Colangelo P., Granjon L., Taylor P.J. & Corti M. 2007. Evolutionary systematics in African gerbilline rodents of the genus *Gerbilliscus*: inference from mitochondrial genes // Molecular Phylogenetics and Evolution. Vol.42. P.797–806.

Colangelo P., Leirs H., Castiglia R., D'aes M., Meheretu Y. & Verheyen E. 2010. New data on the distribution and phylogenetic position of *Mastomys awashensis* (Rodentia, Muridae) // Mammalian Biology. Vol.75. No.5. P.459–462.

Corti M., Castiglia R., Colangelo P., Capanna E., Beolchini F., Bekele A., Oguge N.O., Makundi R.H., Sichilima A.M., Leirs H., Verheyen W. & Verhagen R. 2005. Cytotaxonomy of rodent species from Ethiopia, Kenya, Tanzania and Zambia // Belgian Journal of Zoology. Vol.135 (suppl.). P.197–216.

d'Huart J.-P., Butynski T.M. & De Jong Y. 2008. *Phacochoerus aethiopicus* // IUCN 2010. IUCN Red List of Threatened Species. Version 2010.4. <http://www.iucnredlist.org/>.

d'Huart J.-P. & Grubb P. 2001. Distribution of the common warthog (*Phacochoerus africanus*) and the desert warthog (*Phacochoerus aethiopicus*) in the Horn of Africa // African Journal of Ecology. Vol.39. P.156–169.

De Jong Y.A. & Butynski T.M. 2004. Survey of the Somali lesser bushbaby (*Galago gallarum*) and northern lesser bushbaby (*Galago senegalensis*) in Kenya and Ethiopia. Unpublished report to Primate Action Fund and Primate Conservation Inc., Washington, D.C. P.1–21.

Dobigny G., Nomao A. & Gautun J.C. 2002. A cytotaxonomic survey of rodents from Niger: implications for systematics, biodiversity and biogeography // Mammalia. Vol.66. P.459–523.

Durant S., Marker L., Purchase N., Belbachir F., Hunter L., Packer C., Breitenmoser-Wursten C., Sogbohossou E. & Bauer H. 2008. *Acinonyx jubatus* // IUCN 2010. IUCN Red List of Threatened Species. Version 2010.4. <http://www.iucnredlist.org/>.

Fadda C., Castiglia R., Colangelo P., Corti M., Machang'u R., Makundi R., Scanzani A., Tesha P., Verheyen W. & Capanna E. 2001. The rodent fauna of Tanzania: a cytotaxonomic report from the Maasai Steppe (1999) // Rendiconti Fisiche Accademia Lincei. Ser.9. Vol.12. P.29–49.

Faulkes C.G., Abbott D.H., O'Brien H.P., Lau L., Roy M.R., Wayne R.K. & Bruford M.W. 1997. Micro- and macrogeographic genetic structure of colonies of naked molerats, *Heterocephalus glaber* // Molecular Ecology. Vol.6. P.615–628.

Fenton M. B. 1975. Observation on the biology of some Rhodesian bats, including a key to the Chiroptera of Rhodesia // Life Sciences Contribution, Royal Ontario Museum. Vol.104. P.1–27.

Ford C.E. & Hamerton J.L. 1956. A colchicine hypotonic citrate, squash sequence for mammalian chromosomes // Stain Technology. Vol.31. P.247–251.

Gray P.A., Fenton M.B. & Van Cakenberghe V. 1999. *Nycteris thebaica* // Mammalian species. Vol.612. P.1–8.

Grubb P. 1993. The Afrotropical suids, *Potamochoerus*, *Hylochoerus* and *Phacochoerus*: taxonomy and description // Oliver W.L.R. (ed.). Pigs, Peccaries and Hippos. Status Survey and Conservation Action Plan. IUCN/SSC, Gland, Switzerland. P.66–75.

Grubb P., Butynski T.M., Oates J.F., Bearder S.K., Disotell T.R., Groves C.P. & Struhsaker T.T. 2003. Assessment of the diversity of African primates // International Journal of Primatology. Vol.24. No.6. P.1301–1357.

Hayman R.W. & Hill J.E. 1971. Order Chiroptera // Meester J. & Setzer H.W. (eds.) The Mammals of Africa. An Identification Manual. Part 2. Washington: Smithsonian Institution Press. P.1–73.

Hill J.E. & Harrison D.L. 1987. The baculum in the Vespertilioninae (Chiroptera: Vespertilionidae) with a systematic review, a synopsis of *Pipistrellus* and *Eptesicus*, and the description of a new genus and subgenus // Bulletin of the British Museum (Natural History), Zoology. Vol.52. P.225–305.

Ivanova N.V., Zemlak T.S., Hanner R.H. & Hebert P.D.N. 2007. Universal primer cocktails for fish DNA barcoding // Molecular Ecology Notes. Vol.7. P.544–548.

Koopman K.F. 1994. Chiroptera: Systematics. Handbuch der Zoology. Mammalia. Part. 60. Berlin: Walter de Gruyter. 217 p.

Kunz T.H., Thomas D.W., Richards G.C., Tidemann C.R., Pierson E.D. & Racey P.A. 1996. Observational techniques for bats // Wilson D.E., Cole F.R., Nichols J.D., Rasanayagam R. & Foster M.S. (eds.). Measuring and Monitoring Biological Diversity. Standard Methods for Mammals. Washington and London: Smithsonian Institution Press. P.105–155.

Largen M.J., Kock D. & Yalden D.W. 1974. Catalogue of the mammals of Ethiopia. I. Chiroptera // Monitore Zoologico Italiano. N.S. Supplemento. Vol.16. P.221–298.

Lavrenchenko L. & Corti M. 2008. *Mastomys awashensis* // IUCN 2010. IUCN Red List of Threatened Species. Version 2010.4. <http://www.iucnredlist.org/>.

Lavrenchenko L.A., Kruskop S.V. & Morozov P.N. 2004. Notes on the bats (Chiroptera) collected by the Joint Ethiopian-Russian Biological Expedition, with remarks on their systematics, distribution and ecology // Bonner Zoologische Beitrage. Vol.52. No.1/2. P.127–147.

Lavrenchenko L.A., Likhnova O.P., Baskevich M.I. & Afework Bekele. 1998. Systematics and distribution of *Mastomys* (Muridae, Rodentia) from Ethiopia, with the description of a new species // Zeitschrift fur Zaugetierkunde. Vol.63. No.1. P.37–51.

Lavrenchenko L.A. & Verheyen E., 2006. Evolutionary relationships among narrow-headed rats (genus *Stenocephalemys*, Muridae, Rodentia) inferred from complete cytochrome b gene sequences // Russian Journal of Genetics. Vol.42. No.4. P.439–446.

Malcolm J.R. & Sillero-Zubiri C. 2001. Recent records of African wild dogs (*Lycaon pictus*) from Ethiopia // Canid News. Vol.4. No.1. P.1–5.

McNutt J.W., Mills M.G.L., McCreery K., Rasmussen G., Robbins R. & Woodroffe R. 2008. *Lycaon pictus* // IUCN 2010. IUCN Red List of Threatened Species. Version 2010.4. <http://www.iucnredlist.org/>.

Musser G.G. & Carleton M.D. 2005. Superfamily Muroidea // Wilson D.E. & Reeder D.M. (eds.). Mammal Species of the World. A Taxonomic and Geographic Reference. Third Edition. Vol.2. Baltimore: Johns Hopkins University Press. P.894–1531.

Nadler C.F. & Hoffmann R.S. 1974. Chromosomes of the African ground squirrel, *Xerus rutilus* (Rodentia: Sciuridae) // Experientia. Vol.30. No.8. P.889–891.

Nicolas V., Granjon L., Duplantier J.-M., Cruaud C. & Dobigny G. 2009. Phylogeography of spiny mice (genus *Acomys*, Rodentia: Muridae) from the south-western margin of the Sahara with taxonomic implications // Biological Journal of the Linnean Society. Vol.98. No.1. P.29–46.

Peterson R.L., Eger J.L. & Mitchell L. 1995. Chiroptères // Faune de Madagascar. Vol.84. P.1–204.

Ray J.C., Hunter L. & Zigouris J. 2005. Setting conservation and research priorities for larger African carnivores // Working Paper No.24, New York, Wildlife Conservation Society. P. 1–203.

Seamark E.C.J. & Bogdanowicz W. 2002. Feeding ecology of the common slit-faced bat (*Nycteris thebaica*) in KwaZulu-Natal, South Africa // Acta Chiropterologica. Vol.4. No.1. P.49–54.

Sokolov V.E., Orlov V.N., Baskevich M.I., Afework Bekele & Assefa Mebrate. 1993. A karyological study of the spiny mouse *Acomys* Geoffroy 1838 (Rodentia, Muridae) along the Ethiopian Rift Valley // Tropical Zoology. Vol.6. P.227–235.

Sumner A.T. 1972. A simple technique for demonstrating centromeric heterochromatin // Experimental Cell Research. Vol.75. P.304–306.

Trujillo R.G., Patton J.C., Schlitter D.A. & Bickham J.W. 2009. Molecular phylogenetics of the bat genus *Scotophilus* (Chiroptera: Vespertilionidae): Perspectives from paternally and maternally inherited genomes // Journal of Mammalogy. Vol.90. No.3. P.548–560.

Vallo P., Guillen-Servent A., Benda P., Pires D.B. & Koubek P. 2008. Variation of mitochondrial DNA in the *Hipposideros caffer* complex (Chiroptera: Hipposideridae) and its taxonomic implications // Acta Chiropterologica. Vol.10. No.2. P.193–206.

Van Cakenberghe V., de Vree F. & Leirs H. 1999. On a collection of bats (Chiroptera) from Kikwit, Democratic Republic of the Congo // Mammalia. Vol.63. P.291–322.

Volobouev V.T., Aniskin V.M., Lecompte E. & Ducroz J.-F. 2002. Patterns of karyotype evolution in complexes of sibling species within three genera of African muroid rodents inferred from comparison of cytogenetic and molecular data // Cytogenetic and Genome Research. Vol.96. P.261–275.

Wilson D.E. & Reeder D.M. (eds.) 2005. Mammal Species of the World. A Taxonomic and Geographic Reference. Third edition. Baltimore: Johns Hopkins University Press. 2142 p.

Yalden D.W., Largen M.J. & Kock D. 1976. Catalogue of the mammals of Ethiopia. 2. Insectivora and Rodentia // Monitore Zoologico Italiano (N.S.), Supplemento. Vol.8. No.1. P.1–118.

Yalden D.W., Largen M.J. & Kock D. 1977. Catalogue of the mammals of Ethiopia. 3. Primates // Monitore Zoologico Italiano (N.S.), Supplemento. Vol.9. No.1. P.1–52.

Yalden D.W., Largen M.J. & Kock D. 1980. Catalogue of the mammals of Ethiopia. 4. Carnivora // Monitore Zoologico Italiano (N.S.), Supplemento. Vol.13. No.8. P.168–272.

Yalden D.W., Largen M.J. & Kock D. 1984. Catalogue of the mammals of Ethiopia. 5. Artiodactyla // Monitore Zoologico Italiano (N.S.), Supplemento. Vol.19. No.4. P.67–22l.

Yalden D.W., Largen M.J. & Kock D. 1986. Catalogue of the mammals of Ethiopia. 6. Perissodactyla, Proboscidea, Hyracoidea, Lagomorpha, Tubulidentata, Sirenia and Cetacea // Monitore Zoologico Italiano (N.S.), Supplemento. Vol.21. No.4. P.31–103.

Yalden D.W., Largen M.J., Kock D. & Hillman J.C. 1996. Catalogue of the mammals of Ethiopia and Eritrea. 7. Revised checklist, zoogeography and conservation // Tropical Zoology. Vol.9. P.73–164.