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A new species of long-eared bat (*Plecotus;* Vespertilionidae, Mammalia) from Ethiopia

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Abstract. A new species of *Plecotus* is described, based on several specimens from southern Ethiopia, the southernmost distribution record of the genus. The new species differs from all known species of *Plecotus* in size, cranial proportions and pelage coloration. In some metric and qualitative traits (skull size and face shape) it resembles *P. auritus.* The similarities between these two species may be convergent, though. The shape of the baculum of the new species is strikingly similar to that of the insular *P. teneriffae*. At present the phylogenetic relationships among the species of *Plecotus* remain unresolved.

Key words: *Plecotus,* new species, taxonomy, systematics, craniometry, Ethiopia.

Introduction

Plecotine bats are a rather small group within the family Vespertilionidae. Nevertheless, their taxonomy is unsettled and therefore has been the subject of several revisions (Fedyk & Ruprecht 1983, Frost & Timm 1992). The genus *Plecotus* E. Geoffroy, 1818 s. str. includes two to four currently recognized species but also many named taxa of uncertain rank (Yoshiyuki 1991). Most of these taxa are presently included in the polymorphous species *P. austriacus* (Fischer, 1829) which is widely distributed from Algeria and Central Europe to the Arabian peninsula and the Himalayas (Strelkov 1988). The characters in which it differs from the also widely distributed but more monomorphic *P. auritus* (Linnaeus, 1758) were described by Strelkov (1988). *Plecotus austriacus* was the only member of the genus known to occur in Africa (Corbet 1978), and the Ethiopian highlands were reported as the southernmost part of its distribution area there (Yalden et al. 1996). A third form, now treated as a full species, *Plecotus teneriffae* Barret-Hamilton, 1907, inhabits the Canary Islands (Ibanez & Fernandez 1985, de Paz 1994).

During fieldwork of the Joint Ethio-Russian Biological Expedition (JERBE) in the winter of 1995/96 some observations on *Plecotus* were made and one specimen was collected in the Bale Mountains National Park. Previously several specimens of long-eared bats had been collected by D. Yalden in 1986 in the same area (Yalden 1988), four of which are now deposited in British zoological collections. Comparison of the collection material shows certain morphological peculiarities that set

the Ethiopian long-eared bats apart from other forms currently included in *P. austnacus*. In our view the *Plecotus* from the Ethiopian mountain woodlands represents a distinct taxon which deserves specific rank. The description of this species is presented herein.

Materials and methods

Field work was carried out within the framework of the JERBE from December, 1995 to February, 1996. Observations were made in the ever-green tropical rain forest (locally known as the Harenna Forest) on the southern slope of the Sanetti Plateau, ca. 2500-3000 m ASL, with the help of an electric lantern and QMC-mini narrow band heterodyne ultrasound detector. The type individual, now preserved in the collection of the Zoological Museum of the Moscow State University, was captured in the *Shefflera-Hagema* forest belt by using nylon mist-net (7 x 1 8 m).

A total set of 8 specimens of the new form were investigated 5 alcohol specimens, 3 dry skins and 2 extracted skulls 65 specimens of *Plecotus austriacus* and *P. auritus* deposited in the collections of the Zoological Museum of the Moscow State University, the Zoological Museum of the St. Petersburg Zoological Institute and the Harrison Institute (Center for Systematics and Biodiversity Research), Sevenoaks (Kent), were studied as comparative material Collection numbers of these specimens are given in the Appendix.

15 cranial measurements were taken with electronic callipers to the nearest 0 01 mm with the help of a binocular microscope condylo-basal (CBL) and condylo-canine (CCL) length, width of the skull on mastoid level (W), height of the braincase posterior to the auditory bullae (BCH), mterorbital width (IOW), width and length of the rostrum (at the level of the preorbital foramina and from the preorbital foramen to the alveole of the inner incisor) (WR, LR), maximum length of auditory bullae (ABL), upper tooth row length (CM3), length of the upper canine base (Ñ), molanform row length (P4M3), canine and molar width (CC, M3M3), length of the lower jaw (LMD) and lower tooth row length (MCM3). 9 of these measurements which show greater distinctness between the new and the known species were chosen for further statistical analysis CBL, CCL, W, CM3, C, PM3, ABL, M3M3, LMD. These measurements were analysed by principal component analysis and stepwise discriminant function analysis using of the statistical package STATISTICA 5.0 (StatSoft, Inc.).

Qualitative features of external and cranial morphology, chromosomes (routine staining) and baculum shape were also investigated.

Results

The population of long-eared bats from Harenna Forest differs from all other taxa of the genus *Plecotus* in cranial measurements, pelage coloration and face shape. Here we describe this population as a new species which may be termed Ethiopian long-earedbat.

***Plecotus balensis* sp. nov.**

Holotype. Adult male No. S-164904 (collection of the Zoological Museum of the Moscow State University), Harenna Forest, Bale Mountains National Park, southern Ethiopia, 6°45' N, /39°44'E, 2760 m ASL, December, 29, 1995, collected by S. V. Kruskop. Dry skin, skull, and carcass m alcohol (Figs 1, 5, 7).

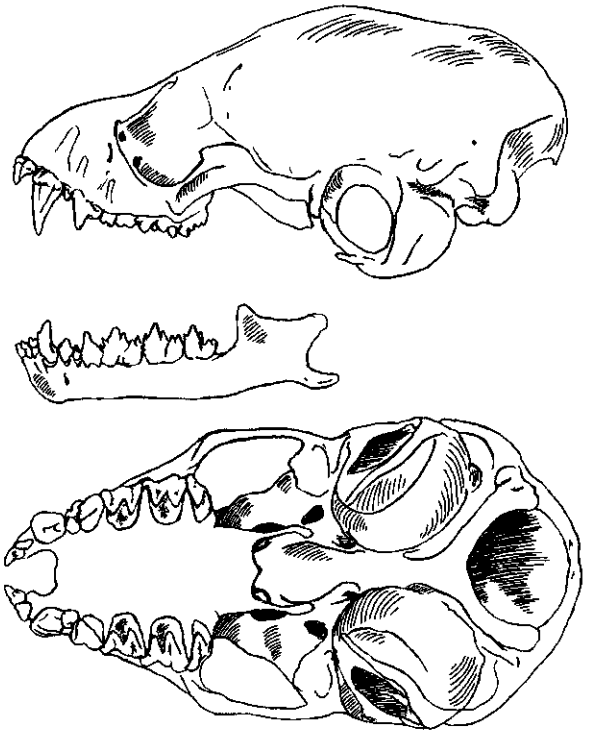

Fig. 1. Skull (lateral and ventral view) and mandible of *Plecotus balensis* sp. nov. (holotype, ZMMU S-164904).

Other specimens studied. Two adult males, Nos. 8825, 66732 (collection of the Zoological Institute, St. Petersburg), locality unknown ("Abissinia" = Ethiopia; probably vicinity of Addis-Ababa), specimens in alcohol; adult female, No. HFE 244 (collection of the Bale Mountains National Park), Harenna Forest, Bale Mountains National Park, southern Ethiopia, August, 15, 1986, collected by the Harenna Forest Expedition, skin only; two adult males and two females, Nos. LM.1986.212.61-64 (collection of the Liverpool Museum), same locality, August, 4-19, 1986, collected by HFE, three specimens in alcohol, one dry skin with skull.

Diagnosis. A typical medium-size representative of *Plecotus* s. str. Differs from all subspecies of *Plecotus austriacus* by dark-brownish coloration of fur, small skull size, relatively short rostrum, noticeably smaller and rounded tympanic bullae, inflated muzzle behind nostrils and baculum shape. *Plecotus balensis* differs from *Plecotus auritus* in having more inflated and slightly larger tympanic bullae, more

slender tooth row, narrower rostrum, small protuberances in front of eyes, smaller baculum, and absence of yellowish component in fur coloration.

Measurements of the holotype (in mm). External: body length - 45, tail length - 48, ear length - 37, tragus length - 15.2, tibia length - 17.4, foot length (without-/with claws) - 7.1/8.3, FA - 36.3, Dl (without-/with claws) - 5.4/7.0, Mc2 (metacarpal of the second digit) - 33.5, Mc3 - 35.0, Ph3.1 (first phalanx of the third digit) - 14.0, Ph3.2 - 12.8, Ph3.3 - 7.2, Mc4 - 34.4, Ph4.1 - 9.0, Ph4.2 - 10.5, Mc5 - 33.3, Ph5.1 - 9.0, Ph5.2 - 10.0. Skull: CBL - 15.21, CCL - 14.64, W - 8.92, BCH - 5.81, IOW - 3.71, WR - 4.13, LR - 3.38, CM3 - 5.42, C - 0.98, P4M3 - 4.18, CC - 3.54, M3M3 - 5.76, LMD - 10.15, MCM3 - 5.76, ABL - 4.28.

Etymology. The name *balensis* is derived from the Bale Mountains, the area from where the type specimen originated.

Description. Medium-sized *Plecotus,* noticeably smaller than typical *Plecotus austriacus* and *Plecotus teneriffae.* Average forearm length is 38.5 mm (n=6) which is less than in all forms of the *Plecotus austriacus* complex and in *Plecotus teneriffae,* and agrees with measurements of European *Plecotus auritus.* Skull on the whole (Fig. 1) and tooth-row visibly smaller than in European and North African specimens of *Plecotus austriacus.*

The most important skull features are the size and shape of the auditory bullae. In the two measured skulls from Harenna forest they have a maximum length of 4.28 and 4.16 mm which is less than in any *Plecotus austriacus* subspecies. In this species the maximum length of bullae according to Strelkov (1988) is never less than 4.3 mm (4.41 mm is the minimum among specimens measured for this study). In two specimens of *Plecotus austriacus christiei* from Israel (HZM.1.3511) and Egypt (ZIN.8822), the bullae have a length of 4.88 and 4.62 mm. Thus, the size of the auditory bullae of the new form seems to be more similar to *Plecotus auritus* than to *Plecotus austriacus* (Fig.2). However, the bullae of *Plecotus balensis* look more inflated than those of *Plecotus auritus* and some specimens of *Plecotus austriacus.*

The rostrum looks slightly shortened compared to the of the typical *Plecotus austriacus.* Small premolar displaced lingually from the midline of the tooth-row but not reduced in size. All teeth, including the canines, look relatively less robust than in *Plecotus austriacus* and in this respect are similar to those of *Plecotus auritus* and *Plecotus teneriffae* (Ibanez & Fernandez 1985).

The scatter plot of the first two principal components (Fig. 3) shows that *Plecotus austriacus* and *Plecotus auritus* are clearly separated, whereas the two specimens of the new species are obviously closer to *Plecotus auritus,* lying on the periphery of its range.

The two "large" species of long-eared bats are well segregated by the stepwise discriminant function analysis. Based on the 9 metric cranial parameters chosen, 100% of *Plecotus austriacus* and 98% of *Plecotus auritus* were allocated correctly. In respect of cranial shape on the whole, the specimens from Bale associate closer with the latter species but are still far from its centroid (Fig. 4).

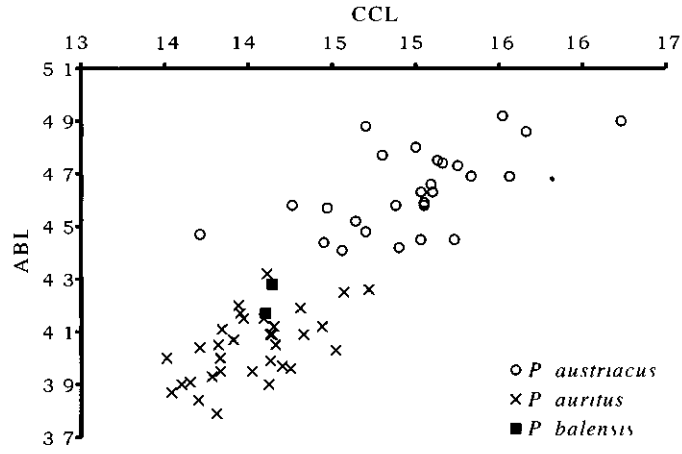

Fig. 2. Bivanate scatterplot of two skull measurements, condylocanine length (CCL) and auditory bulla length (ABL) of *Plecotus auritus, P. austriacus* and *P. balensis* sp. nov.

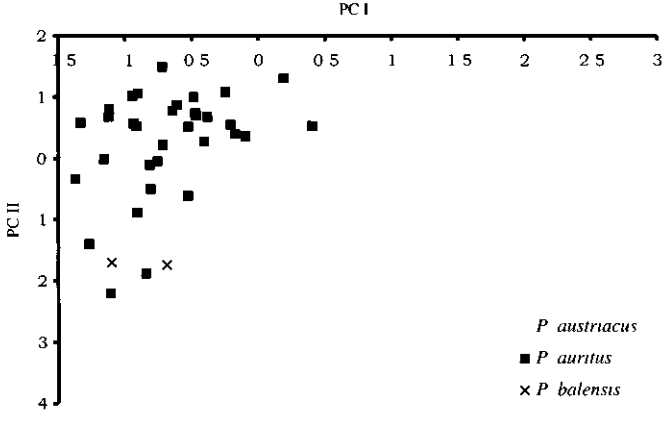

Fig. 3. Bivariate scatterplot of the first two principal components, based on the analysis of cranial measurements of *Plecotus auritus, P. austriacus* and *P. balensis* sp. nov. First principal component (eigenvalue 7 04773 % of total variance 78 30811) correlates with general size, second (0 833959 9 26621) mainly with the molar width of the skull (M3M3)

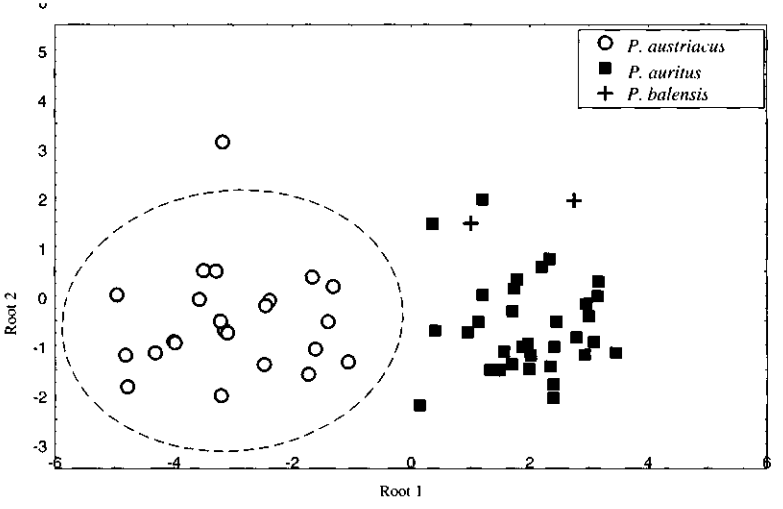

Fig. 4. Bivariate scatterplot of the two discriminant functions, based on the cranial measurements of *Plecotus auritus, P. austriacus* and *P. balensis* sp. nov. ABL and C contribute most significantly to Root 1, M3M3 to Root 2.

Externally the new form shows features somewhat intermediate between the two Palaearctic species. Protuberances in front of the eyes are relatively small, the distance between them in all specimens seen is more than three times their diameter which is characteristic of *P. austriacus.* The frontal part of the muzzle is thinly covered with hairs. Like in *P. auritus* (Strelkov 1985, 1988; Fig. 5), the muzzle behind the nostrils is noticeably inflated. Thumb length without claw (ca. 5.8 mm) is similar to that of *P. austriacus* (both *austriacus* and *christiei*; 4.7-6.3) and distinctly smaller than in Mediterranean *P. auritus* and *P. teneriffae* (5.9-7.6; 6.0-6.5) (dePaz 1994).

Coloration of *balensis* is noticeably darker than in all North African, Arabian and European forms of *P. austriacus* (Fig. 6). Dorsal hairs have dark brown bases, covering more than half of their length, a pale ring in the upper third and a brownish-grey tip, visibly darker than in specimens of *P. austriacus* from Israel, Algeria and southern Europe. Ventral hairs have long whitish or pale greyish tips and dark greyish bases. As in *P. austriacus,* there is practically no brownish component in the fur coloration, in contrast to that of *P. auritus.* Wing membranes and hairless parts of the head are brown; fingers, arms and hind feet are dark blackish brown. It should be noted that relatively dark-coloured subspecies of *P. austriacus* are known only from Asian mountain areas, while the closest neighbour of the Ethiopian form is *P. austriacus christiei* which has a very pale coloration and almost colourless membranes and naked body parts.

The karyotype of the new form (2N=32, NF=50) shows no differences to Palaearctic long-eared bats (Fedyk & Fedyk 1971).

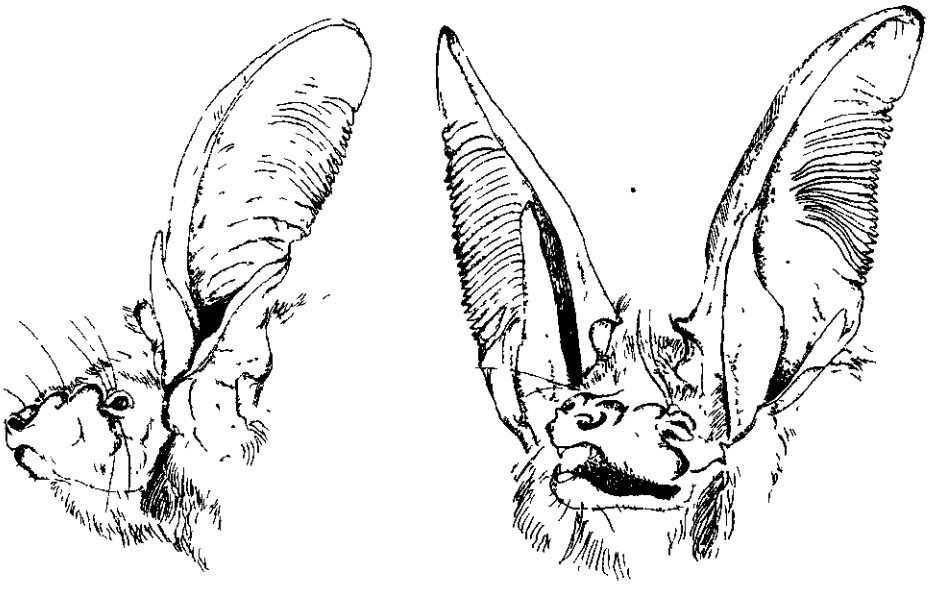

Fig. 5. Head of the Ethiopian long-eared bat, *Plecotus balensis* sp. nov. (holotype, ZMMU S-164904).

The shape of the baculum is considered as a good diagnostic trait distinguishing *P. auritus* and *P. austriacus* (Topal 1958, Strelkov 1988, 1989). The baculum of *P. balensis* to some extent combines characters of *P. austriacus* and *P. auritus.* Its general shape looks more similar to that of *P. teneriffae* (Ibanez & Fernandez 1985). It is noticeably more slender than the baculum of *P. austriacus.* Lateral projections on its proximal end are relatively thin with slightly bulbous tips, similar to those of *P. auritus,* but proportionally longer than in both *P. auritus* and *P. austriacus.* Thus, maximum width of the baculum of *P. balensis* is subequal to its maximum length (Fig. 7). The last feature is similar to the baculum of *P. teneriffae.* The basal projections in the latter, however, are thin, while in *P. balensis* they are thicker than the main portion. Another specific feature of the *P. balensis* penial bone is a perforation of its distal portion, not present in other *Plecotus.* Size of the baculum of the new species (0.9 mm) is noticeably smaller than in *P. auritus* (1.02-1.47 mm; Strelkov 1988) and slightly larger than in European *P. austriacus* (0.7-0.85 mm; Strelkov 1988) and *P. teneriffae* (0.8 mm; Ibanez & Fernandez 1985).

Distribution and remarks on natural history. The Ethiopian long-eared bat was reported by Largen et al. (1974) from only two localities. The Eritrean specimen may be *P. austriacus christiei,* and the second record has no exact locality ("Shoa"). Specimens deposited in St. Petersburg also have no precise geographical data, and probably came from somewhere on the Ethiopian upland north or north-west of

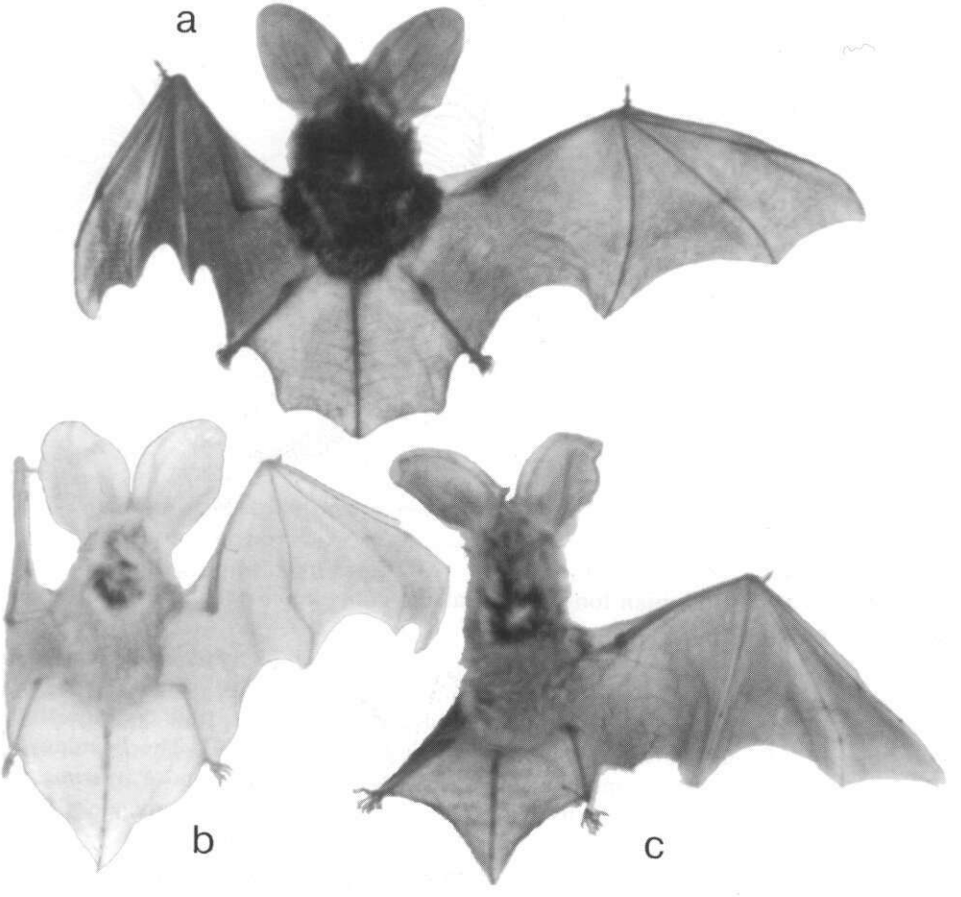

Fig. 6. Coloration of the dorsal pelage of *Plecotus balensis* sp. nov. (a; LM-1986-212-64,X), in comparison with *P. austriacus christiei* (b; HZM-1 3511) and *P. austriacus austriacus* (c; HZM-12.22271). Specimens are in slightly different scale.

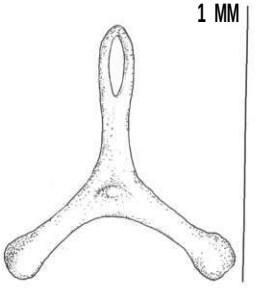

Fig. 7 (left). Baculum of *Plecotus balensis* sp. nov. (holotype, ZMMU S-164904).

Addis-Ababa. The only fully documented records of the new species are from the Harenna Forest, Bale Massif (Yalden et al. 1996; our data) and represent the southernmost point of the known distribution of the genus. According to the available data, *P. balensis* is confined to the upper belts of the Harenna Forest, Bale Mts. It is possible that the new species occurs also in some other forested areas of Ethiopia. Nevertheless, we failed to find any *Plecotus* in two other humid Afromontane forests on the opposite side of the Ethiopian Rift Valley (western plateau): the Beletta Forest (07°32'N 36°33'E, 2250 m ASL) and the Sheko Forest (07°04'N 35°30'E, 1930 m ASL).

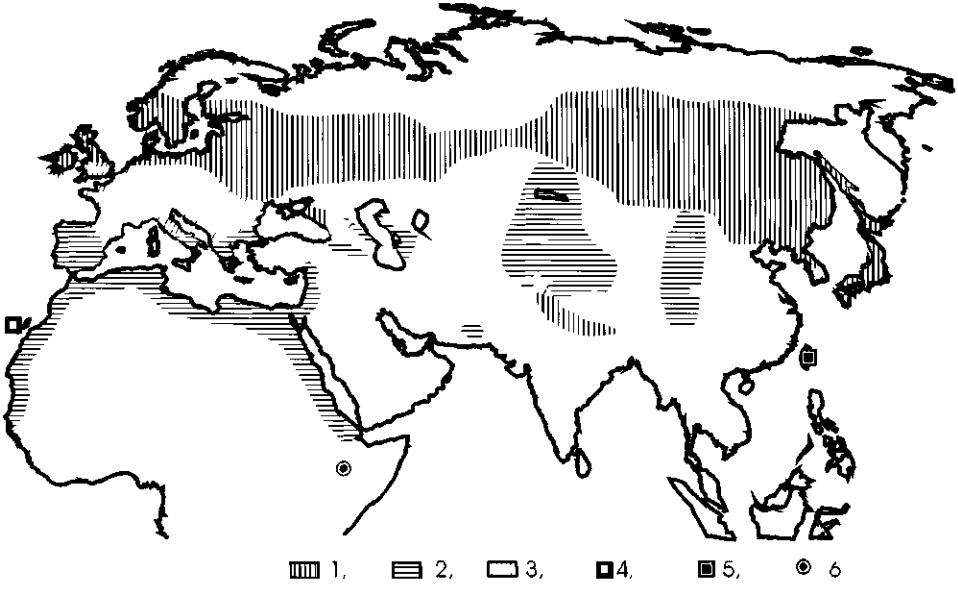

Fig. 8. Schematic map of the geographic distribution of the Old-world long-eared bats of the genus *Plecotus* s. str. 1 *P. auritus,* 2 *P. austriacus,* 3 areas of sympatry of 1 and 2, 4 *P. teneriffae,* 5 *P. taivanus, 6 P. balensis* sp. nov.

According to our observations, the long-eared bat in the Bale Mountains inhabits humid forest belts at elevations from about 2500 - 3000 m ASL and seems to be a relatively common species. The preferred foraging places are open parts of forests or edges of clearings where both perch hunting and aerial hunting activity were observed. Although the bats emitted audible (social?) calls, we failed to detect their echolocation signals with a QMC-mini narrow-band heterodyne detector, suggesting that the signals are of very low intensity, a characteristic of *P. auritus* hunting in cluttered spaces.

Discussion

At present, 32 mammalian species endemic to Ethiopia are known (Yalden et al. 1996; Lavrenchenko et al. 1998a, 1998b). Most of them have evolved from Afrotropical ancestors (Yalden & Largen 1992). Only three endemic species *(Capra walie, Lepus starcki* and *Canis simensis)* are putative derivatives of Palaearctic lineages (Yalden et al. 1996). It is obvious that *Plecotus balensis,* being a member of the essentially Palaearctic species complex, belongs to the latter group of endemics.

Within *Plecotus* s. str., *P. austriacus* is the most widely distributed species. It inhabits a wide range of habitats which results in a high level of variation among populations. Such variation concerns coloration, which is whitish or pale-grey in desert and semi-desert forms, and darker in specimens from mountain areas or from the European forest zone. However, *P. austriacus* seems to be less a forest inhabitant than *P. auritus* and its coloration is generally paler. Differences in rostrum proportions, bulla size and shape of muzzle are probably connected to the habits of the species; *P. austriacus* is reported to be mainly an aerial forager, while *P. auritus* is a typical gleaner (Andersen & Racey 1991, Kruskop 1999). Inflations behind the nostrils as well as the smaller size of bullae characteristic of *P. auritus* may be associated with some parameters of the echolocation signals used during foraging in highly cluttered space. While one would expect similar transformations in populations of the *P. austriacus* group confined to forested areas, the only population which shows such modifications is the Ethiopian long-eared bat, which is probably a derivative of the *P. austriacus* lineage.

The range of the Ethiopian long-eared bats is separated from the European forest subspecies *P. austriacus austriacus* by the "belt" of *P. austriacus christiei,* a pale semi-desert subspecies with greatly inflated bullae and no inflations on the muzzle. That subspecies occurs in Egypt, Syria and Israel (Harrison & Bates 1991) and has also been reported from Eritrea (Largen et al. 1974) and Sudan (Koopman 1975). Possibly the ancestor of the Ethiopian *Plecotus* belonged to a lineage of *P. austriacus* which penetrated into montane Ethiopia in one of the inter-glacial periods, when the climate of northern Africa was more humid and the vegetation more abundant. There this population evolved in partial or complete isolation. The closest sibling *(christiei)* evolved in a different habitat, bordering the Ethiopian uplands from Mediterranea, Europe and West Asia. It has been suggested (Lavrenchenko 2000) that the small mammal fauna of the Harenna Forest was formed rather recently and mainly through a recruitment of species from adjacent altitudinal zones with their subsequent adaptive speciation. Apparently, this process was prompted both by an ecological vacuum in the forest communities and the relative richness of the non-forest Ethiopian fauna. According to this hypothesis, the ancestor of *P. balensis* must have come from savanna or any other arid habitat. The forest island conditions shaped the Ethiopian long-eared bat to a typical forest species including some features which are convergent to *P. auritus.* A parallel exist in another island population, *P. teneriffae,* which also inhabits relatively humid woodlands in the Canary Islands (Ibanez & Fernandez 1985).

An alternative hypothesis would assume that the craniometric similarity between the Ethiopian long-eared bat and *P. auritus* is accounted for by phylogenetic proximity rather than parallelism. In this case we may suppose that the range of the immediate ancestor of the latter species was much wider in the past covering areas adjacent to Ethiopian highlands but later underwent substantial reduction. As *P. austriacus* replaced *P. auritus* in North Africa, some isolated populations of the latter could remain in peripheral refuges giving origin to *P. balensis*. In the framework of the considered hypothesis an analogous scenario might be suggested for the three other forms, similar to *P. auritus* and separated from the mam distribution area of the latter (Fig. 8): *P. tenenffae, P. "auritus" homochrous* Hodgson, 1847 (with the synonym *puck* Barrett-Hamilton, 1907, shown in fig. 8 as Himalayan section of *P. auritus*) and the recently described *P. taivanus* (Yoshiyuki 1991).

A third hypothesis may suppose that *P. balensis* is a pre-glacial relict, a sister group of the common ancestor of both *P. auritus* and *P. austriacus* which has survived at the periphery of the core distribution of the genus This view is supported by the "intermediate" morphology of this species It is important to notice that intermediate characters exist not only in external or cranial traits which may be a result of adaptive evolution, but also in those (baculum) not known to be affected by environmental factors The similarity of the baculum between *P. balensis* and *P. teneriffae* may also be interpreted as a shared relict character To test these three competing hypotheses additional studies using molecular techniques will be necessary.

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Appendix. List of comparative material

ZMMU collection of the Zoological Museum of the Moscow State University, ZIN collection of the Zoological Museum of the St. Petersburg Zoological Institute, HZM collection of the Harrison Zoological Museum (Harrison Institute), Sevenoaks.

Plecotus austriacus. - Former Yugoslavia: ZIN-35067 (♂), 35068 (♂), 35069 (♀), 35070 (♀), 35071 (♀), 35168 (♂), 50234 (♂), ZMMU-42774 (♀). Bulgaria: ZIN-48069, 48070, 48071, (♂♂); 48143 (?). Czech Republic: ZIN-50233 (?), ZMMU-74643 (♀), 74644 (?).
France: ZMMU-101868 (♀). Ukraine: ZMMU-53272 (?). Kazachstan: ZMMU-19587 (?), 58154 (♀). Kirgizstan: ZMMU-33435, 33436, 33437, 33438, 33440, 33441, 33443 (??). Algeria: HZM-11.21812, 12.22270, 12.2271, (♂♂). Egypt: ZIN-8822 (♀). Israel: HZM-1.3511 (♀).

Plecotus auritus. - Former Yugoslavia: ZIN-35072, 35073 (??). Czech Republic: ZMMU-74645 (?), 74646 (♀). Belarus: ZMMU-53748 (♂). Moldovia: ZMMU-91353 (♀). Russia, European part: ZMMU-2344 (♂), 2345 (♂), 2347 (♂), 2348 (♀), 2349 (♀), 2350 (♀), 4192 (?), 15449 (?), 29103 (♀), 29105 (?), 29379 (?), 29402 (?), 29404 (?), 29429 (?), 77227 (♀), 84116 (♂), 84117 (♀), 94127 (♂), 100808 (?), 104736 (♂), 105481 (♂), 105482 (♀), 105483 (♀), 157987 (♂), 162779 (♀), 167242 (♀). Mongolia: ZMMU-122846 (♂), 134647 (?).