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A new species of long-eared bat from Europe (Chiroptera: Vespertilionidae)

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A b s t r a c t . A new species of bat of the genus *Plecotus* from the Alps and other mountainous regions of Europe is described. *Plecotus alpinus* sp. nov. can be distinguished from other *Plecotus* species by its sequence of parts of the 16S and D-loop region of the mitochondrial DNA. *Plecotus alpinus* sp. nov. is genetically a close relative to *Plecotus auritus*, although in some morphological characters it shows a closer relation to *Plecotus austriacus*. *Plecotus alpinus* sp. nov. shares morphological similarities with *P. auritus* and *P. austriacus*, so in former studies it appeared as intermediate between *P. auritus* and *P. austriacus*. However, a combination of characteristic traits distinguishes *P. alpinus* sp. nov. clearly from its close related taxa.

K e y w o r d s . *Plecotus alpinus* sp. nov., systematics, Europe.

Introduction

Particular long ears (>25mm) are characteristic for all long-eared bats. They are widely distributed throughout the Northern Hemisphere and comprise the Palearctic genus *Plecotus* (Geoffroy, 1818) and the Nearctic genera *Corynorhinus*, *Idionycteris* and *Euderma*. The Nearctic taxa were included as subgenera in the genus *Plecotus* by Handley (1959). However, this view was rejected, based on cytogenetic (chromosome banding, e.g. Fedyk & Ruprecht 1983, Stock 1983, Qumsiyeh & Bickham 1993, Volleth & Heller 1994) and/or morphological data (Frost & Timm 1992, Bogdanowicz et al. 1998). Recently, Hofer & Bussche (2001) used mitochondrial DNA sequences to re-evaluate vespertilionid phylogeny. According to their analysis, long-eared bats represent a tribus of their own, the Plecotini. It includes the Nearctic *Corynorhinus*, *Idionycteris* and *Euderma*, and the Palearctic genera *Plecotus* and *Barbastella*.

In the past, species designation within the genus *Plecotus* have frequently changed. Linnaeus (1758) only recognised the brown long-eared bat, *Plecotus auritus*. Subsequently, several new species were described (e.g. Fischer 1829, Jenyns 1828, Koch 1860, Barrett-Hamilton 1907, Thomas 1911, see also Bree & Dulic 1963), but none of these was accepted until 1960. Bauer (1960) re-validated *Plecotus austriacus* (Fischer, 1829), formerly a variety of *P. auritus*. Since then, only two further subspecies, *Plecotus auritus begognae* (de Paz, 1990) and *P. austriacus kolombatovici* (Dulic, 1980) have been described from Europe.

Plecotus austriacus is widely distributed from the Cape Verde Islands, northern Africa, Central Europe, and the Arabian Peninsula to the Himalayas (Strelkov 1988,

1989, Swift 1998). *Plecotus auritus*, a more montane species, is widespread from Ireland through Central and northern Europe, the Ural and Caucasus Mountains, Mongolia to northeast China and Japan (Strelkov 1988, 1989, Corbet & Hill 1991, Swift 1998). However, the systematics and taxonomy of eastern Palearctic populations of both species still remain unclear (e.g. Strelkov 1988, 1989, Yoshiyuki 1991).

Recently, several *Plecotus* species have been recognized. *Plecotus teneriffae* (Barret-Hamilton, 1907), formerly a subspecies of *P. auritus*, is now treated as a species endemic to the Canary Islands (Ibáñez & Fernandez 1985). *Plecotus balensis* (Kruskop & Lavrenchenko, 2000) was newly discovered in the Bale Mountains, Ethiopia.

Using mitochondrial DNA, Mayer & Helversen (2001) and Spitzenberger et al. (2001) recognized three *Plecotus* lineages in Europe, namely *P. auritus*, *P. austriacus* and *P. kolombatovici*. Both studies argued that *P. kolombatovici* is clearly differentiated at the species level. Surprisingly, Mayer & Helversen (2001) demonstrated a sister relationship of *P. kolombatovici* and *P. austriacus*, while Spitzenberger et al. (2001) found *P. auritus* to be the sister species of *P. kolombatovici*. As shown by Kiefer et al. (submitted), Spitzenberger et al. (2001) incorrectly assigned the name *P. kolombatovici* to a clade that obviously represented a fourth, currently unknown species (Fig. 1, Tab. 1). We here describe this new species and present preliminary data on its morphological variation.

Material and methods

All specimens of the new species were identified using parts of the mitochondrial 16S or D-loop genes (for details see Kiefer et al. submitted). A total of six specimens (four males, two females) was investigated. Five specimens were dry skins, one specimen is preserved in alcohol. We used five extracted skulls and two bacula for cranial and bacular morphology. Three voucher specimens are stored in the Zoologisches Forschungsinstitut und Museum Alexander Koenig, Bonn (ZFMK), one specimen in the Senckenberg Institute, Frankfurt (SMF) and one specimen is deposited in the private collection of O. von Helversen, Erlangen, Germany. For comparison we analysed specimens of all European *Plecotus* species which previously have been identified using DNA-sequencing.

We took the following measurements: FA = forearm length (with wrist), HF = hind foot length (without claws), TL = tragus length, TW = tragus width, TH = thumb length without claw, CL = claw length, TA = tail length, SL = skull length, CBL = condylobasal length, SH = skull height (with bullae), IOW = interorbital constriction width, M³-M³ = width across upper molars, C-M³ = length of maxillary tooththrow, C-M₃ = length of mandibular tooththrow, ML = mandible length, MW = mastoid width, CsupL = Length of upper canines, MBD = maximum bulla diameter, ZW = zygomatic width, MDB = minimal distance between bullae, 3MT = length of 3rd finger, 5MT = length of 5th finger, BL = length of baculum, BW = basal width of baculum, VHL = total ventral hair length, %WT = percentage of white tip in ventral hair length.

The bacula were obtained following the maceration procedure of Anderson (1960). They were photographed with a digital imaging unit (Leica DC 300) on a Leica photomicroscope and compared to published drawings of bacula of other *Plecotus* species. Two size parameters were scored for the Y-shaped bacula: LB – length of baculum and BW – basal width of baculum. We also analysed qualitative features of external and cranial morphology.

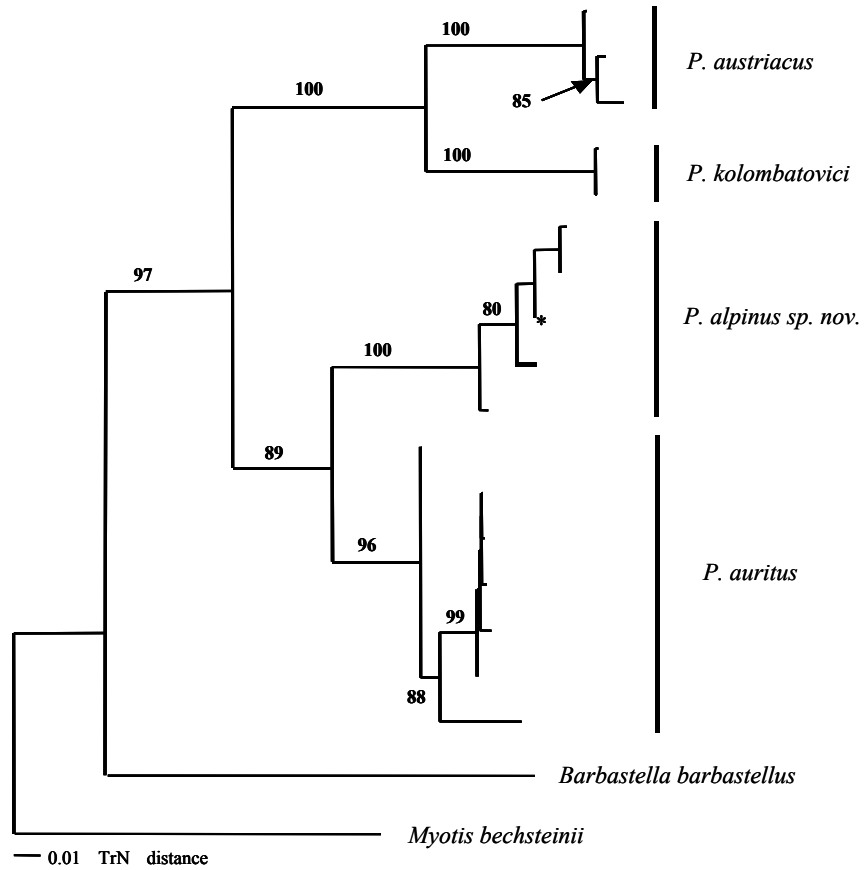


Fig. 1. Neighbor-joining tree of European *Plecotus* samples (modified after Kiefer et al. submitted), based on 1714 bp of mitochondrial 16S, ND1 and D-loop gene fragments (Tamura-Nei substitution model with I=0 and G=0.4826; for details see Kiefer et al. submitted). An asterisk indicates the position of a specimen with a D-loop sequence identical to the holotype.

Table. 1. Mean Tamura-Nei genetic distances within and among major European *Plecotus* lineages (modified after Kiefer et al. submitted).

lineage	(1)	(2)	(3)	(4)
(1) <i>P. auritus</i>	0.023	-	-	-
(2) <i>P. alpinus</i> sp. nov.	0.166	0.009	-	-
(3) <i>P. austriacus</i>	0.331	0.436	0.014	-
(4) <i>P. kolombatovici</i>	0.340	0.397	0.173	0.002

Results and description

Molecular data unambiguously separate the new *Plecotus* species from *P. auritus*, *P. austriacus* and *P. kolombatovici* and therefore constitute excellent characters for species determination, useful in species descriptions (e.g. Veith et al. 2001). The molecular differences are corroborated by the external, cranial and bacular morphology.

Plecotus alpinus sp. nov.

Holotype.

Adult male, ZFMK 2001.325; Ristolas, Haute-Alpes, France, 06°57' N, 44°46'E, 1600 m a.s.l., August 24, 2001; collected dead on road by Philippe Favre (Groupe Chiroptères de Provence); dry skin, skull and baculum, with carcass in alcohol (Figs 2, 3, 4).

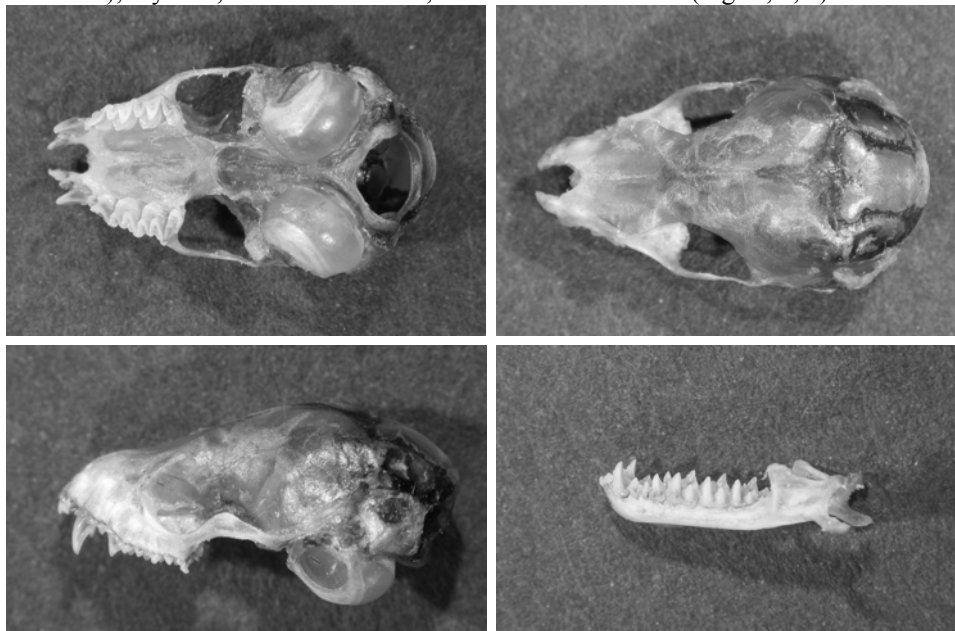


Fig. 2. Skull (lateral, ventral and dorsal view) and mandible of *Plecotus alpinus* sp. nov. (holotype, ZFMK 2001.325).

Other specimens studied.

Adult male, private collection of O. von Helversen, Tymphristos, Karpenissi, Greece, 38°55' N, 21°55'E, 1800 m a.s.l., June 12, 2001; collected by O. von Helversen; dry skin, skull and baculum, with carcass in alcohol.

Adult female, ZFMK 61.451, Schaan, Liechtenstein, 51°06' N, 06°28' E, August 23, 1961; collected by E. von Lehmann; skin and skull.

Adult female, ZFMK 2001.327, Fischertratten, Austria, 46°56' N, 13°31' E, 768 m a.s.l., May 15, 2000; collected by G. Reiter; skin and skull.

Adult male, SMF 44898, Ogulin, Lika, Croatia, 1972; collected by J. Gelencir; skin in alcohol with skull.

Juvenile male, ZFMK 2001.328, Duvin, Switzerland, 46°43' N, 09°12' E, 1080 m a.s.l., August 29, 2000; collected by Miriam Lutz; dry skin with skull.

Diagnosis.

Long-eared bat of medium to large size with a condylobasal length of 15.5 – 15.8 mm. The overall impression of the ventral fur is dense and more whitish than in all other European *Plecotus* species. Thumb, claw and forearm are comparative large and the tragus is remarkably long (>16 mm). Differs from all European *Plecotus* species in its DNA sequences of the 16S and D-loop mitochondrial genes.

16S; GenBank accession number AY081062 (homologous to positions 2215-2490 of the *Pipistrellus abramus* mitochondrial genome, GenBank accession number AB061528):

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gtattagaggcattgcctgccagtgactctagttaaacggccggtatcctgaccgtgcaaaggtagcataatcattgttctct
aaatagggactgtatgaatggcctcacgagggttaactgtcttactttaatcagtgaatgacactcccgtgaagaggcgg
gaatataaaaataagacgagaagaccctatggagctcaactaactataagtataataactaaagagacaaatcaa
actgactaagttaacaattgggtggggcgacctcggataaaaatcaactccgagatagatctactaagacctacaagtcaa
agttatctaccacacattgatcccaatgacgatcaacgaaacaagttaccctaggataacagcgcaatcctatfaagagcc
catatcgacaattagggttacgacctgatgttgatcaggacatcccaatggtgcagcagctattaatgttcgtttgtcaacg
attaaagtctacgtgatctgagt.
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D-Loop; GenBank accession number AY081061 (homologous to positions 16776-16926 of the *Pipistrellus abramus* mitochondrial genome, GenBank accession number AB061528):

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tcttgcaaacccccaaaacaagaagaataatattacgacacttatagacttaactcactctgcaccaaatctataacttttccc
accacaaagtacaccctctactttaagatacaatttccttagacagacatgtcctcagatctgcaaacgggccttcaacaca
acacgc.
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Description and comparison.

Plecotus alpinus sp. nov. is a medium to large-sized representative of the genus with a dense fur. The tip of the ventral hair is white, not grey as in *P. austriacus* or *P. kolombatovici* or yellowish-brown to creamy as in *P. auritus*. Its ventral fur appears more whitish than in all other European *Plecotus* since the white tips of the ventral fur cover more than 50% of total hair length (*P. auritus*: 33%, *P. kolombatovici*: 37%, *P. austriacus*: 51%) The total length of the ventral hair is with more than 9.5 mm much longer than in any other European *Plecotus* species. The dorsal fur is pale-grey with a black base, a whitish central part and darker tips and resembles that of *P. austriacus*. In the juvenile specimen the ventral fur is completely white, the darker base is absent.

The protuberances in front of the eyes are larger than in *P. austriacus* but smaller than in *P. auritus*. Forearm length is medium to large, thumb and claw are as big as in *P. auritus* (Dulic 1980, Häussler & Braun 1991, v. Helversen 1989). The hind foot is medium to large sized and covered with long patulous hairs like in *P. auritus* (v. Helversen 1989). The tragus is longer than in *P. auritus*, *P. austriacus* and *P.*

kolombatovici (Dulic 1980, v. Helversen 1989, Häussler & Braun 1991). The proximal part of the ear and the tragus is flesh-coloured, whereas the distal part of the tragus is dark as in *P. austriacus*.

The skull (Fig. 2) is medium-sized with a comparatively long rostrum and medium-sized tympanic bulla (Hának 1966, Dulic 1980, Häussler & Braun 1991). The processus angularis mandibulae has no well-marked horn like in *P. austriacus* and its end has no club-shaped widening like in *P. auritus* (Fig. 2, see Ruprecht 1965). Shape and size of the baculum (Fig. 3, Tab. 2) are intermediate between *P. auritus* and *P. austriacus* (Topál 1958, Lanza, 1960, Strelkov, 1988, 1989). In addition, Dulic (1980) herself pointed out that the baculum of a specimen from Lika is atypical for both *P. austriacus* and *P. auritus*.

Table 2. Individual measurements (mean and standard deviation, SD) of male (m) and female (f) adult specimens of *Plecotus alpinus* sp. nov., including the holotype (no. 1).

measurement	1 (m)	2 (m)	3 (f)	4 (f)	5 (m)	mean \pm SD
FA	40.5	39.7	39.7	39.8	42.2	40.38 \pm 1.07
HF	8.5	9.0	8.5	8.5	8.5	8.60 \pm 0.22
TL	16.0	18.0	17.0	17.0	-	17.00 \pm 0.82
TW	5.5	6.0	5.5	5.5	-	5.63 \pm 0.25
TH	7.0	7.0	7.0	6.5	6.8	6.86 \pm 0.22
CL	2.3	2.0	2.8	2.3	-	2.35 \pm 0.33
TA	-	-	-	-	53.5	
SL	16.8	16.8	16.8	16.9	16.8	16.80 \pm 0.07
CBL	15.8	15.5	15.7	15.8	15.5	15.67 \pm 0.17
SH	7.5	7.7	8.0	7.7	-	7.73 \pm 0.19
IOW	3.7	3.5	3.8	3.5	3.6	3.64 \pm 0.13
M ³ M ³	6.5	6.6	6.6	6.5	6.1	6.45 \pm 0.21
C-M ³	5.7	5.7	6.3	5.5	5.6	5.76 \pm 0.31
C-M ₃	6.2	6.0	6.2	6.5	6.0	6.18 \pm 0.20
ML	10.9	10.9	10.9	10.8	10.7	10.85 \pm 0.10
MW	9.1	9.1	8.9	9.1	9.0	9.03 \pm 0.07
CsupL	1.3	1.2	1.2	1.8	-	1.38 \pm 0.27
MBD	4.6	4.6	4.6	4.6	4.5	4.59 \pm 0.05
ZW	8.9	9.1	8.8	8.8	8.5	8.81 \pm 0.21
MDB	0.8	0.9	0.9	0.8	-	0.85 \pm 0.09
3 MT	64.0	67.0	62.0	64.0	-	64.25 \pm 2.06
5 MT	51.0	52.5	51.0	51.0	-	51.38 \pm 0.75
BL	0.61	0.51	-	-	-	0.56 \pm 0.07
BW	0.85	0.85	-	-	-	0.85 \pm 0.00
VHL	10.0	10.0	9.7	-	8.3	9.90 \pm 0.17
% WT	53	55	56	-	50	53.67 \pm 1.15

1 = ZFMK 2001.325 (holotype); 2 = Tymphristos; 3 = ZFMK 61.451 (Schaan); 4 = ZFMK 2001.327 (Fischertratten); 5 = SMF 44898 (Ogulin, data from Kock 1974).

Specimens examined for comparison.

Plecotus auritus: ZFMK 2.001.329 (m); ZFMK 2.001.330; ZFMK 2.001.331 (f), ZFMK 2.001.332; ZFMK 2.001.333 (f); ZFMK 2.001.334 (f); ZFMK 2.001.335; ZFMK 2.001.336; ZFMK 2.001.337; ZFMK 2.001.338; *Plecotus austriacus*: ZFMK 77.49; ZFMK 77.50; ZFMK 2.001.339 (f); ZFMK 2.001.340; ZFMK (f); ZFMK 2.001.341 (f); ZFMK 2.001.342 (f). *Plecotus kolombatovici*: ZFMK 79.214 (m).

Etymology.

Named after the alpine region, where the new species is regularly found. We suggest the following vernacular names: Alpine long-eared bat (English), Alpenlangohr (German), Oreillard des Alpes (French).

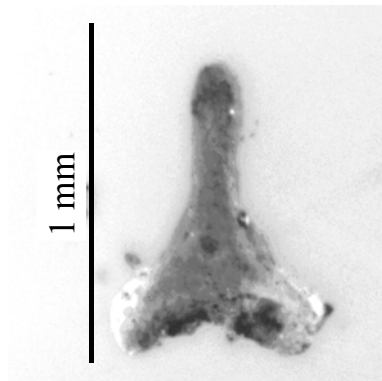


Fig. 3. Baculum of *Plecotus alpinus* sp. nov. (dorsal view; holotype, ZFMK 2001.325).

Distribution and life history.

Plecotus alpinus sp. nov. is currently known from the Alps (France, Austria, Liechtenstein, Switzerland, Italy, Slovenia), the Dinarian Mountains (Croatia), and the Pindos Mountains in Greece (Kiefer et al. submitted). It occurs at altitudes above 800 m a.s.l., with only one known exception from Italy (Pesina, province of Verona, 480 m a.s.l., see Fig. 4). However, these specimens were caught directly at the foot of the Monte Baldo massif.

Discussion

Plecotus alpinus sp. nov. is an alpine sister species of the brown long-eared bat, *P. auritus*. The new species can unambiguously be distinguished from other European *Plecotus* species based on molecular data (Fig. 1). It shares morphological similarities with *P. auritus* and *P. austriacus*, although being well distinct from either species in several traits. However, its combination of characteristic traits makes the species to look like an intermediate between *P. auritus* and *P. austriacus*. This is probably the reason

why it has not been discovered until recently. In fact, "intermediates" between known *Plecotus* species have been described from the distribution range of the Alpine long-eared bat (e.g., Dulic 1980), one of which proved to represent a specimen of *P. alpinus* sp. nov. (from Ogulin, Lika, Croatia; see Kiefer et al. submitted).

Aellen (1961) caught bats at the Col de Bretolet at the French-Swiss border at ca. 2000 m a.s.l. One of these, a very large female *Plecotus*, was examined by Bauer (in Aellen 1961) who suggested that it was a hybrid between *P. auritus* and *P. austriacus*. From its external characters (except the forearm length), it represented a large *P. auritus* whereas its skull was more typical for *P. austriacus*. However, an introgression between *P. auritus* and *P. austriacus* could not be proved (Moretti et al. 1993). High altitude populations of long-eared bats were described from the Alps which were difficult to assign either to *P. auritus* or to *P. austriacus* based on morphological characters (e.g. Spitzenberger & Mayer 1988). These populations probably represent *P. alpinus* sp. nov. as well.



Fig. 4. *Plecotus alpinus* sp. nov. (Pesina, Italy). Note the nearly white ventral fur and the colour of the tragus (photo A. Kiefer; specimen released after capture).

Available names

Several Central Asian and African *Plecotus* species have been described (e.g., *Plecotus wardi* Thomas, 1911, *Plecotus cristiei* Gray, 1838, *Plecotus balensis* Kruskop & Lavrenchenko, 2000) during the last two centuries. All of them live far out of the range of

Plecotus alpinus sp. nov. and are morphologically well distinct. We therefore can exclude them as potentially conspecific with the Alpine long-eared bat.

Several names are available from Europe (see Lanza 1959, 1960 and Bree & Dulic 1963 for a comprehensive list). Most of them are not available for the Alpine long-eared bats since they represent either nomina nuda (e.g. *Macrotus europaeus* Leach, 1816, *Plecotus bonapartii* Gray, 1838) or were described from areas where *Plecotus alpinus* sp. nov. does not occur (e.g. *Vespertilio otus* Boie, 1825, *P. brevimanus* Jenyns, 1828, *Plecotus cornutus* Faber, 1826, *Plecotus homochrous* Hodgson, 1847). Only the following names must be discussed in more detail.

Plecotus communis Lesson, 1827 and *Plecotus vulgaris* Desmarest, 1829: The holotypes of these two species are lost, probably during the 19th century (M. Tranier, pers. comm.), and the brief descriptions of these two taxa do not diagnose a specific species of long-eared bat.

Schinz (1840) mentioned *Plecotus mogalatos* Brehm as a synonym of *P. auritus* (later in this paper spelled *P. megalotos*), which had been described by "Herrn Brehm". This most likely was Christian Ludwig Brehm, an ornithologist from Saxony, Germany. To the best of our knowledge, neither a formal description nor a holotype exists for *Plecotus mogalatos/megalotos*. In the checklist of Ellerman & Morrison-Scott (1966) this synonym is mentioned as "*Plecotus megalotos* Schinz, 1840". We therefore regard *Plecotus megalotos* a nomen nudum, too.

Plecotus auritus meridionalis was described by Martino & Martino (1940) from Slovenia. Based on their description, this species is clearly distinguishable from *Plecotus alpinus* sp. nov. in the condylobasal-length and the length of the bulla. Their data on cranial morphology even indicate that *P. auritus meridionalis* may be identical with *P. austriacus* (Bauer 1960). In addition, they mentioned "... specimens from Switzerland and N. Italy [which] are probably intermediate forms" of *Plecotus auritus meridionalis* and *P. auritus auritus*. This perfectly corresponds to the "intermediate" individuals mentioned by Dulic (1980), which now turned out to be *Plecotus alpinus* sp. nov. (Kiefer et al. submitted).

Plecotus auritus hispanicus (Bauer 1957) was thought to be an endemic of the Iberian Peninsula. Bauer (1960) himself re-defined it as a local race of *P. austriacus*.

Koch (1862/63) mentioned three variations of *Plecotus*. His *Plecotus brevipes* (= *Plecotus kirschbaumii* in Koch, 1860) clearly is *Plecotus austriacus*. His *Plecotus* var. *typus* is medium-sized, grey-brown and found in the lowlands. His *Plecotus* var. *montanus* is smaller and reddish-brown. We agree with Kock (1994) that the two latter forms are within the variation of *Plecotus auritus*.

Ongoing research on morphological and echolocation characteristics of *Plecotus alpinus* sp. nov. will show whether it will be possible to identify the four European *Plecotus* species in the field.

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