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On the Distribution, Taxonomy and Karyology of the Genus *Plecotus* (Chiroptera: Vespertilionidae) in Turkey

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Abstract: *Plecotus auritus* and *Plecotus austriacus* were recorded from 8 and 3 localities in the Asiatic part of Turkey, respectively. It was determined that the length of the first premolar, the shape of the zygomatic arches and baculum distinguish these taxa from each other. Apart from these morphological characteristics, the tibia length of *P. austriacus* was found to be significantly greater than that of *P. auritus* ($P < 0.05$). The diploid chromosome numbers were identical in both taxa ($2n = 32$). The number of chromosomal arms (FN = 54) and the number of autosomal chromosomal arms (FNa = 50) were the same as in previously published papers on *P. austriacus*.

Key Words: *Plecotus auritus*, *Plecotus austriacus*, Karyology, Turkey

Türkiye’de Yayılış Gösteren *Plecotus* (Chiroptera: Vespertilionidae) Cinsinin Yayılışı, Taksonomisi ve Karyolojisi Üzerine Bir Çalışma

Özet: *Plecotus auritus* sekiz ve *Plecotus austriacus* üç lokaliteden olmak üzere Anadolu’dan kaydedildi. İlk premolarların uzunluğu, zygomatik yayın ve bakulumun şeklinin bu taksonları birbirinden ayırdığı saptandı. Bu morfolojik karakterlerden başka, *P. austriacus*’un tibia uzunluğunun *P. auritus*’tan istatistiki olarak daha büyük olduğu belirlendi ($P < 0.05$). Diploid kromozom sayısı her iki taksonda benzer bir şekilde $2n = 32$ dir. *P. austriacus*’un kromozom kol sayılarının (FN = 54) ve otosomal kromozom kol sayılarının (FNa = 50) literatüre uygun olduğu bulundu.

Anahtar Sözcükler: *Plecotus auritus*, *Plecotus austriacus*, Karyoloji, Türkiye

Introduction

The genus *Plecotus* E. Geoffroy, 1818 is distributed in the Palaearctic and Nearctic regions (Koopman, 1994). Of these species, *Plecotus auritus* (Linnaeus, 1758), known as the brown long-eared bat, and *Plecotus austriacus* (Fischer, 1829), known as the grey long-eared bat, range across Turkey (Satunin, 1913; Kahmann and Çağlar, 1960; Hanák, 1966; DeBlase and Martin, 1973; Nader and Kock, 1983; Lanza and Finotello, 1985; Helvesen, 1989; Albayrak, 1990; Albayrak, 1993; Steiner and Gaisler, 1994; Benda and Horáček, 1998; Mitchell-Jones et al., 1999). *P. auritus* inhabits woodlands, and uses the roof space of houses and barns as well as tree holes in summer (Mitchell-Jones et al., 1999). Koopman (1994) recognised 4 subspecies of *P. auritus*, and the nominative subspecies, *auritus*, is

currently distributed from Western Europe to Central Siberia (Corbet, 1978; Koopman, 1994; Mitchell-Jones et al., 1999).

P. austriacus is essentially a cavern-dwelling bat in the Arabian Peninsula (Harrison and Bates, 1991). Mitchell-Jones et al. (1999) also noted that *P. austriacus* inhabits open and semi-covered areas and roosts primarily in rocky cavities in Europe. According to Koopman (1994), this species is represented by 8 subspecies in the world, and the formerly described *P. austriacus kolombatovici* Dulic, 1980, from Europe was reevaluated as new species *Plecotus kolombatovici* Spitzenberger et al., 2001. In addition 3 new *Plecotus* species have recently been described in Europe: *Plecotus alpinus* Kiefer and Veith, 2001; *Plecotus microdontus* Spitzenberger, Haring and Tvrtkovic, 2002; and *Plecotus sardus* Mucedda, Kiefer,

Pidinchedda and Veith, 2002 (Kiefer et al., 2002; Kiefer and Veith, 2001; Spitzenberger et al., 2001; Spitzenberger et al., 2002; Mucedda et al., 2002). Of these species, *P. microdontus* was later evaluated to be a synonym of *P. alpinus* (Kock, 2002).

Lanza (1960), Bauer (1960), Harrison (1964), Corbet (1978) and Lanza and Finotello (1985) reported that *P. auritus* and *P. austriacus* are sibling species and occur sympatrically in Europe. These species were also sympatrically distributed in Turkey (Nader and Kock, 1983; Helversen, 1989; Albayrak, 1990; Albayrak, 1993; Benda and Horáček, 1998). Because of the very weak morphological differences between the species, populations of *P. auritus* from the Middle East were classified within *P. austriacus* by Atallah (1977), DeBlase (1980) and Harrison and Bates (1991). Later, it was revealed that these taxa live sympatrically in the Middle East (Lanza, 1959; Lanza, 1960; DeBlase, 1980). Up to now, there has been no karyological record on the genus *Plecotus* in Turkey, and *P. austriacus* especially was very rarely recorded from eastern Turkey (Strelkov, 1988; Benda and Horáček, 1998). The aim of this study is to contribute to the distribution and karyology of the genus *Plecotus*, and provide comparative materials for taxonomic studies.

Materials and Methods

In 1999 and 2001, specimens of *P. auritus* ($n = 12$) and *P. austriacus* ($n = 12$) were captured with mist nets and by hand in several localities in Asiatic Turkey (Fig. 1), and these specimens were examined with respect to their morphological and karyological characteristics. In addition ecological observations were also recorded in the field. Age determination was performed according to the criteria given by DeBlase (1980). External and cranial measurements (mm) and weight (g) were obtained from each animal (DeBlase, 1980; Harrison and Bates, 1991). Two males of both species were karyotyped based on the colchicine hypotonic citrate technique of Ford and Hamerton (1956). A total of 10 to 20 slides were prepared from each specimen, and at least 30 well-spread metaphase plates were analysed. The diploid number of chromosomes ($2n$), the total number of chromosomal arms (FN), and the number of autosomal arms (FNa) as well as the X and Y chromosomes were determined. Biometric characteristics of adults were compared by

using a t-test (Microsoft Excel t-test, two-sample assuming unequal variances). All specimens were deposited as skins and skulls at the Department of Biology, Faculty of Science and Art, Niğde University.

Abbreviations used in the text: TBL: Total body length, TL: Tail length, HFL: Hindfoot length, EL: Ear length, TrL: Tragus length, TrW: Tragus width, FAL: Forearm length, TiL: Tibia length, LFP: Length of first phalange without nail, WSL: Wingspan length, W: Weight, ZB: Zygomatic breadth, IC: Interorbital constriction, GLS: Greatest length of skull, CBL: Condylbasal length, RW: Rostrum width, MAB: Mastoid breadth, WB: Width of braincase, HB: Height of braincase, MAL: Mandible length, UML: Maxillary tooth row ($C-M_3$), LML: Mandibular tooth row ($C-M_3$).

Results and Discussion

Plecotus auritus (Linnaeus, 1758)

Distribution and ecological remarks: *P. auritus* were recorded from 8 different localities (Fig. 1), and were also observed around Erzincan and Niğde provinces. Of these localities, Niğde, Eskişehir, Aksaray, and Kayseri were located in central Anatolia, but Erzincan, Rize and Hatay were in eastern, north-eastern and south-eastern Turkey, respectively. In addition to our distributional records, this species was previously recorded from Asiatic Turkey by Satunin (1913), Kahmann and Çağlar (1960), DeBlase and Martin (1973), Albayrak (1990, 1993), Steiner and Gaisler (1994) and Benda and Horáček (1998). The last point of distribution of *P. auritus* was reported by Bobrinskii et al. (1944) in eastern Turkey. We caught specimens in the crevices of historical castles, old buildings, ruins and ancient stone monasteries. We also found a summer roost with 7-8 individuals in the roof of an ancient stone monastery. According to our field observations, individuals commenced activity just before dusk, and flew at a height of 3-15 m. Their flying style is reminiscent of a butterfly. It was determined that they often come back to the roosting place during their activity. When resting, they keep their ears under their wings, and the tragi are markedly visible. The localities in central Anatolia were steppe-like, and trees were very rare, but the north-eastern and south-eastern localities were almost covered with trees. These findings show that this species has a wide habitat tolerance. Unlike our findings, Mitchell-Jones et al. (1999) stated that brown

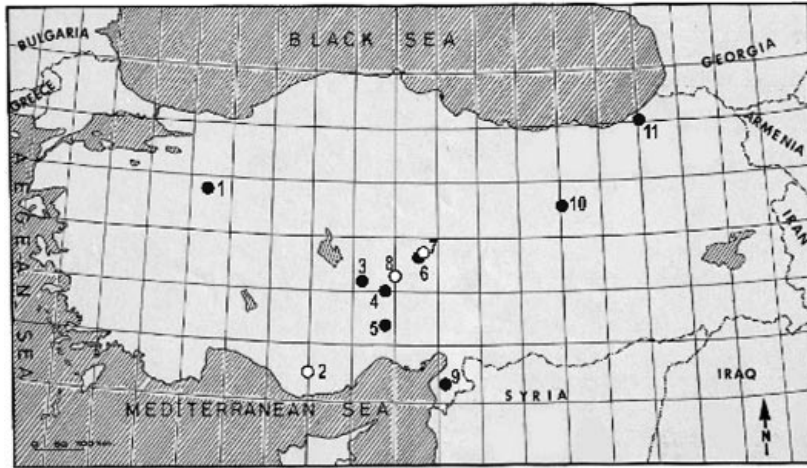


Figure 1. Recording localities of *Plecotus auritus* (●) and *Plecotus austriacus* (○), 1: Eskişehir, 2: Ermenek (Karaman), 3: Güzelyurt (Aksaray), 4: Niğde, 5: Ulukışla (Niğde), 6: Melikgazi (Kayseri), 7: Talas (Kayseri), 8: Yeşilhisar (Kayseri), 9: Belen (Hatay), 10: Kemâh (Erzincan), 11. Hemşin (Rize).

long-eared bats were a woodland species and used the roof space of houses, barns and churches as well as tree holes in summer.

External characteristics: Brown long-eared bats are a medium sized species with maximum TBL 102 mm among Vespertilionid bats. External measurements along with weights are given in Table 1. The dorsal fur is tricoloured, the base of hairs are blackish, the mid-zones are pale yellowish and their tips are light brown. Thus the general appearance of the dorsal fur is light brown, and the colours of the rostrum and the back of ear are somehow warmer and more yellowish than the dorsal fur. The ears are very long, up to 42 mm, and there are 22-24 horizontal ridges on their internal surfaces. The tragus at its widest point measured less than 5 mm and is long and transparent. The wings are long and highly pointed, enabling this bat manoeuvrable flight. The wing membranes are inserted on the tibia just above the ankle. The tail is almost enclosed within the uropatagium, but the tip of the tail slightly extends outside the uropatagium.

Cranial characteristics: The skull is elongated, and inflated upwards at the level of brain case (Fig. 2). The maximum length of the skull measured is 18.1 mm. The rostrum is short and narrow. The zygomatic arches do not extent laterally and are slender. There is a concavity upward with angles on the zygomatic arch. The first

premolar is present, and is also shorter than in *P. austriacus* (Fig. 2). The tip of the angular process in the mandible is pointed.

Baculum: The baculum is composed of 2 main parts: the shaft and base. The shaft is in the shape of a stick, and the baculum has a bifurcated base and are not parallel to each other. The maximum length and width of the baculums measured were 1 mm and 0.6 mm, respectively. The shape of the baculum distinguishes *P. auritus* from *P. austriacus*; this difference comes from the pattern of arms of the baculum base in both species. This finding was consistent with Topál (1958), Lanza (1959, 1960), Hanák (1966), Qumsiyeh (1985), Hill and Harrison (1987), and Albayrak (1990, 1993).

Karyology: The diploid number of chromosomes is $2n = 32$, autosomes consist of 20 metacentric or submetacentric and 10 acrocentric chromosomes. The X is large metacentric, and the Y chromosome is small acrocentric. The NF and NFa are 54 and 50, respectively (Fig. 3).

According to Zima and Král (1984), the karyotype of *P. auratus* is composed of 10 pairs of metacentric and submetacentric, 3 pairs acrocentric and 2 pairs of dot-like chromosomes ($2n = 32$, FNa = 50). They also stated that one of the dot-like chromosomes is sometimes regarded as biarmed and so FNa is 52. These karyotypic peculiarities were supported by Bovey (1949) in

Table 1. The external, cranial measurements (mm) and weight (g) of adult specimens of *Plecotus auritus* (n = 12) and *Plecotus austriacus* (n = 9).

Characters	<i>P. auritus</i>		<i>P. austriacus</i>	
	Mean	(min. – max.)	Mean	(min. – max.)
TBL	93.5	(73.9 – 102)	94.6	(88 – 107)
TL	47	(30 – 53)	49.6	(45 – 56)
HFL	9.6	(8.5 – 11)	9.7	(8.5 – 11)
EL	37.4	(30.8 – 42)	38.2	(37 – 40)
TrL	17.3	(15.3 – 20)	17.9	(17 – 19)
TrW	5	(4.5 – 5.5)	5.4	(5.0 – 5.5)
FAL	40	(35.2 – 42.9)	41	(38 – 43.5)
TiL	18.8	(15.8 – 20.5)	21.2	(20.5 – 21.5)
LFP	6.3	(5.0 – 6.5)	6.7	(6.5 – 7.0)
WSL	270	(260 – 280)	260.5	(232 – 290)
W	6.1	(4.7 – 8.7)	5.8	(5 – 7)
IC	3.7	(3.4 – 4.1)	3.5	(3.4 – 3.5)
ZB	8.8	(8.6 – 9.1)	8.7	(8.5 – 8.8)
GLS	17.3	(16.6 – 18.1)	17.0	(16.3 – 17.4)
CBL	15.9	(15.2 – 16.7)	15.6	(15.2 – 16.0)
RW	4.2	(4.5 – 4.7)	3.8	(3.7 – 3.9)
MAB	8.3	(7.1 – 9.2)	9.2	(9.0 – 9.5)
WB	8.4	(8.2 – 8.8)	8.1	(8.1 – 8.2)
HB	8.1	(7.4 – 8.6)	7.8	(7.7 – 8.0)
MAL	11.1	(10.7 – 11.4)	11.0	(10.8 – 11.4)
UML	5.6	(5.4 – 6.0)	5.5	(5.3 – 5.8)
LML	6.2	(5.9 – 6.1)	6.1	(6.1 – 6.2)

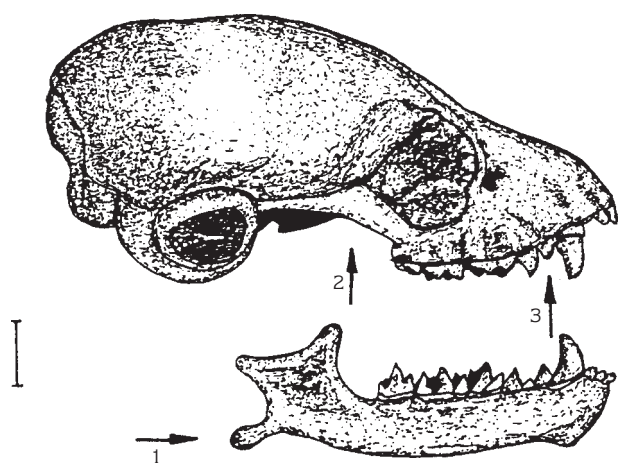


Figure 2. The skull of *Plecotus auritus*, lateral view. 1. the tip of angular process, 2. zygomatic arch, 3. first premolar (scale: 2 mm).

Switzerland, Vorontsov et al. (1969) in Russia, Fedyk and Fedyk (1971) in Poland, and Zima (1982) in Czechoslovakia. In addition to this, the same karyotype was reported by Harada (1973) in Japan. These karyologic reports are consistent with those of Turkish specimens, and also show that there is no geographical variation in the karyotype of *P. auritus*.

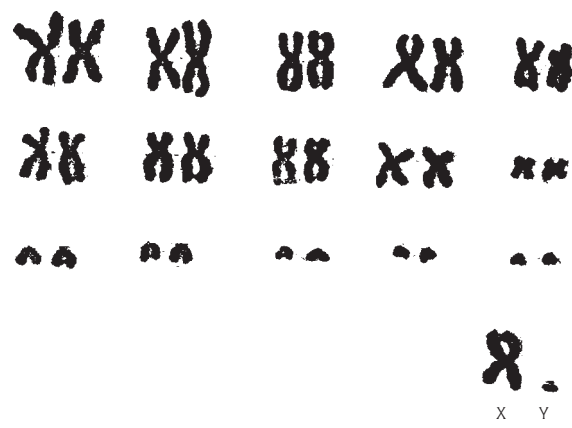


Figure 3. Karyotype of *Plecotus auritus* (male), 2n = 32, FN = 54, FN_a = 50.

Specimens examined: Aksaray (Güzelyurt, Ihlara Valley), 19 May 2001: 1 ♂ adult, Eskişehir (Campus of Osmangazi University), 01 July 1999: 1 ♀ adult, Erzincan (Kemâh, Kemâh Castle), 11 July 2002: 1 adult (observation), Hatay (Belen, Bakras Castle), 22 July 1998: 1 ♂ adult, Kayseri (Melikgazi, Başakpınar, Örenönü), 13 July 2001: 1 ♂ adult, Niğde (Gümüşler), 10 August 1999: colony with 10-15 individuals (observation), Niğde (Gümüşler, Gümüşler stone monastery), 20 July 1996: 1 ♂ adult, 2 ♀♀ adults, Niğde (Ulukışla, Maden Village, Bolkar mines), 27 June 2001: 1 ♂ adult, Rize (Hemşin, Akyamaç Village), 25 August 2001: 2 ♂♂, 2 ♀♀ adults.

Plecotus austriacus (Fischer, 1829)

Distribution and ecological remarks: The grey long-eared bat was recorded from Görmeli village of Karaman and Kayseri province (Fig. 1). Its distribution through Anatolia was widened by Nader and Kock (1983), Helversen (1989), Albayrak (1993) and Benda and Horáček (1998). In addition, Mitchell-Jones et al. (1999) included Turkish Thrace in the distribution areas of *P. austriacus*. This species was found in a cave with 3 roosting clusters of 3-5 individuals in September. It was found that the same cave was also shared by *Rhinolophus* spp. When they were roosting in the cave, their ears were laid down back, and their tragi were visible. Their flying styles was somewhat similar to that of a butterfly.

External characteristics: The maximum total length measured is 107 mm (Table 1). The dorsal colour is evidently darker than previous species, the difference in coloration is especially marked on the facial region. The ears are long as those of *P. auritus*, the tragus is relatively long, and extends to half of the ear. Its widest point was 6 mm. In addition to these, the tibia length from 20.5 mm to 21.5 mm was found to be statistically different from those of the former species. The other morphological characteristics are very close to the previous species.

Cranial characteristics: The general aspect of the skull is almost the same as that of *P. auritus*. But the shape of the zygomatic arch and the length of the first premolar are the major differences along with the baculum's shape. The zygomatic arch is gently curved upwardly, and the first premolar is relatively long. The angular process of the mandible is rounded, not pointed (Fig. 4).

Baculum: In general, the baculum is the same as in the previous species, but the arms of the baculum base are somehow shorter, broader and slightly parallel. Our results were similar to the findings of Topál (1958), Qumsiyeh (1985) and Strelkov (1988).

Karyology: Only 2 specimens were karyotyped. Because of unseparated chromosomal arms in the preparations, the number of chromosome arms was not determined. But the diploid numbers of chromosomes were found to be similar to the former species. The diploid numbers of chromosomes were similar to those reported by Fedyk and Fedyk (1971) in Poland, Baker et al. (1974) in Tunisia and Zima (1982) in Czechoslovakia.

Specimens examined: Karaman (Ermenek, Üçbölük Village) 17 September 1999: 3 ♀♀ adults, Kayseri (Talas, 2 km north-west of Gürpınar), 13 July 2001: 2 ♂♂ adults, 1 ♀ adult, Kayseri (Yeşilhisar, Soğanlı), 6 July 2001: 3 ♂ juveniles, 3 ♀♀ adult (lactating).

Taxonomic remarks and comparisons: Although Hanák (1966) evaluated *P. auritus* and *P. austriacus* as sibling species, and these taxa were considered conspecific for a long time in the Middle East (Atallah, 1977; DeBlase, 1980; Harrison and Bates, 1991). According to differences in the baculum shape, the validity of these sibling species was confirmed by Topál (1958), Lanza (1959, 1960), Qumsiyeh (1985), Strelkov (1988) and Hill and Harrison (1987). In addition to this, Muceda et al. (2002) considered the baculum shape as a diagnostic characteristic for separating *P. auritus*, *P. austriacus*, *P. sardus*, *P. alpinus*, *P. teneriffae* and *P. kolombatovici*. Muceda et al. (2002) also suggested that *P. sardus* was clearly distinguishable from other European *Plecotus* species by its mitochondrial 16S rRNA. Kiefer and Veith (2001) reported that *P. alpinus* shared morphological similarities with *P. auritus* and *P. austriacus*. Apart from this, Bauer (1960) stated that *P. austriacus* tend to have a larger size, relatively larger tympanic bullae, relatively shorts thumbs, and less brownish colour than *P. auritus*. When comparing the characteristics of each taxon, it was determined that the external, cranial measurements and weight of *P. auritus* were in the range of *P. austriacus* ($P > 0.05$) with the exception of TiL ($P < 0.05$). The measurements and weight of *P. auritus* were also found to be similar to those reported by Albayrak (1990, 1993). Apart from these, the LML of both taxa was found to be significantly higher than the UML ($P < 0.05$). Additionally, the lengths of the first upper incisor and upper canine, the shape of

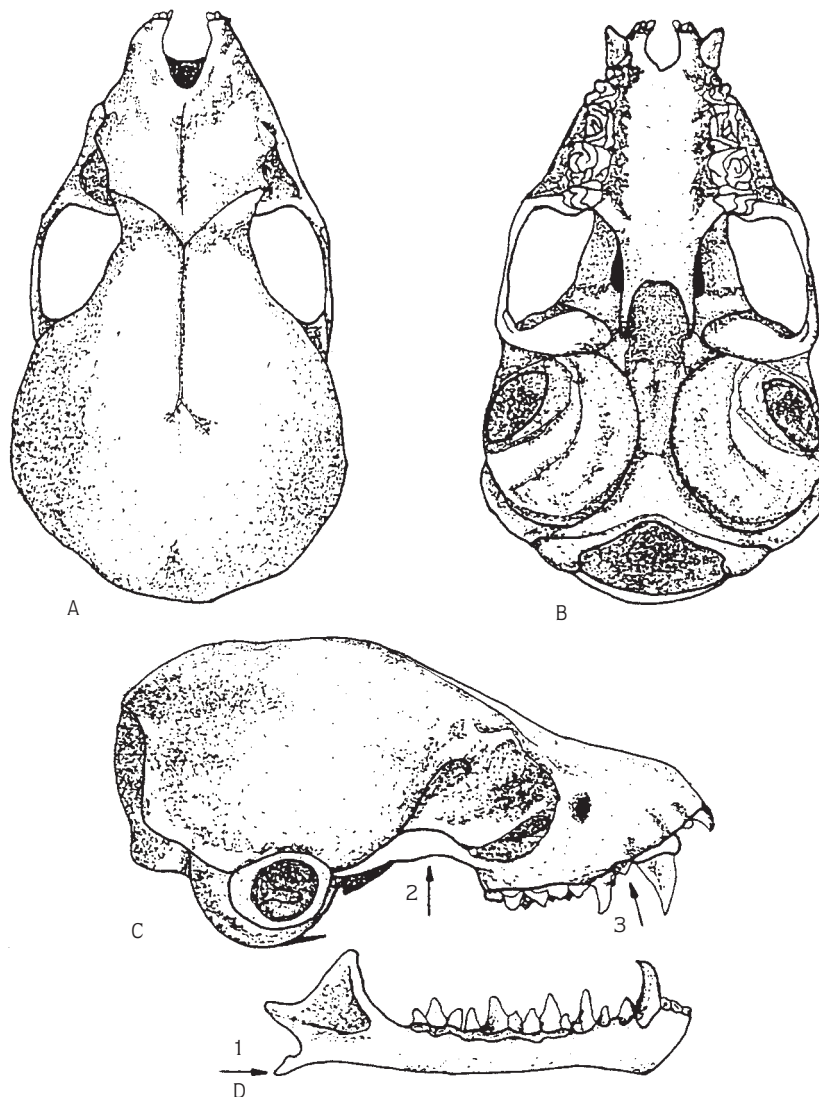


Figure 4. The skull of *Plecotus austriacus*. A: dorsal, B: ventral, C: lateral, D: the lateral view of mandible. 1. the tip of the angular process, 2. zygomatic arch, 3. first premolar (scale: 2 mm).

the thumb, thumb claw and feet, the facial part of the head from lateral view, lower lip and chin, and some morphological peculiarities of the skull were used to distinguish *Plecotus* species such as *P. auritus*, *P. austriacus*, *P. microdontus* and *P. kolombatovici* by Spitzenberger et al. (2002). Most of these characteristics were also found in Turkish specimens. The specimens examined in this study were evaluated with respect to the criteria given for *P. kolombatovici*, *P. alpinus* and *P. sardus* by Kiefer and Veith (2001), Spitzenberger et al. (2001, 2002), and Mucedda et al. (2002), and it was determined that Turkish specimens of *Plecotus* belong to *P. auritus* and *P. austriacus*. Turkish specimens of *P.*

auritus were included in the nominative subspecies (Corbet, 1978; Benda and Horáček, 1998; Koopman, 1994). Apart from *P. auritus*, the morphological measurements of *P. austriacus* for European specimens were found to be larger than those of Turkish specimens, which are similar in this respect to Egyptian specimens (Qumsiyeh, 1985; Harrison and Bates, 1991). We conclude that Turkish specimens of *P. austriacus* belong to *Plecotus austriacus cristiei* Gray, 1838. However, this conclusion is only tentative because of the small number of specimens examined. Further material should be collected to enlighten the specific and subspecific status of Turkish *Plecotus* populations.

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