

A New Distribution Record and Some Bioecological Features of *Plecotus auritus* (Linnaeus, 1758) from Northwest Türkiye (Chiroptera: Vespertilionidae)

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Abstract: Species of the genus *Plecotus*, which have distinctive morphology with their long ears, are common in the Palearctic region. Its distribution area in Türkiye is seen as fragmented. In the present study, a new distribution record for *Plecotus auritus* (Linnaeus, 1758) from Bolu province is given. External characteristics, fur coloration, skull morphology, morphometric measurements, and some ecological characteristics of the specimen were also recorded. The greatest length of skull, condylobasal length, zygomatic breadth, skull height, and largest diameter of tympanic bulla values were measured as high when compared to the data of *Plecotus auritus* from Türkiye and Central Europe. It is noted that the species' diet includes *Galleria mellonella* from the order Lepidoptera. Additionally, call length (ms) (1.4- 4.9 mean= 3.4), max. frequency (kHz) (28.8-62.4 mean= 39.9), min. frequency (kHz) (16.8-36.4 mean= 24.3), and peak frequency (kHz) (22.8-35.6 mean= 28.7) acoustic parameters of *Plecotus auritus* were determined.

Keywords: Long-eared Brown bat, Türkiye, Bolu, bat calls, *Galleria mellonella*.

Türkiye'nin Kuzeybatısından *Plecotus auritus* (Linnaeus, 1758)'a Ait Yeni Bir Yayılış Kaydı ve Bazı Biyoeolojik Özellikleri (Chiroptera: Vespertilionidae)

Öz: Uzun kulakları ile ayırt edici bir morfolojiye sahip olan *Plecotus* cinsi türleri Palearktik bölgede yaygın olarak bulunmaktadır. Türkiye'deki yayılış alanı parçalı durumdadır. Bu çalışmada *Plecotus auritus* (Linnaeus, 1758) için Bolu ilinden yeni bir yayılış kaydı verilmiştir. Dış karakteristikler, kürk rengi, kafatası morfolojisi, morfometrik ölçümler ve bazı ekolojik karakteristikleri kaydedilmiştir. Türkiye ve Avrupa'dan *Plecotus auritus* için verilen ölçümlerle kıyaslandığında kafatasının en büyük uzunluğu, kondilobasal uzunluk, zigomatik genişlik, kafatası yüksekliği ve bullenin en büyük çapı uzunluğu bakımından daha yüksek değerler kaydedilmiştir. Bu türün diyetinde Lepidoptera takımından *Galleria mellonella* türünün olduğu tespit edilmiştir. Bununla beraber türün akustik parametreleri olarak: Çağrı uzunluğu (ms) (1.4-4.9 ort= 3.4), En yüksek frekans (kHz) (28.8-62.4 ort= 39.9), En düşük frekans (kHz) (16.8-36.4 ort= 24.3), and Tepe frekans (kHz) (22.8-35.6 ort= 28.7) tespit edilmiştir.

Anahtar kelimeler: Kahverengi uzun kulaklı yarasa, Türkiye, Bolu, Yarasa sesleri, *Galleria mellonella*.

1. Introduction

There are eight species in the world belonging to the genus *Plecotus* Geoffrey, 1818 (Long-eared bats) (Wilson & Reeder, 2005). These species are *Plecotus alpinus* Kiefer & Veith, 2002, *P. auritus* (Linnaeus, 1758), *P. austriacus* Fischer, 1829, *P. balensis* Kruskop & Lavrenchenko, 2000, *P. kolombatovici* Dulic, 1980, *P. sardus* Mucedda, Kiefer, Pidinchedda & Veith, 2002, *P. taivanus* Yoshiyuki, 1991 and *P. teneriffae* Barrett & Hamilton, 1907. The genus *Plecotus* includes at least 19 cryptic species and is very common in the Palearctic region (Swift, 1998; Spitzenberger et al., 2006). However, *P. alpinus* was considered as a synonym of *P. macrobullaris* Kuzyakin, 1965 (Spitzenberger et al., 2003, Piraccini, 2016). Currently, *Plecotus kozlovi* Bobrinskoj, 1926, *Plecotus ognevi* Kishida, 1927, *Plecotus sacrimontis* G.M. Allen, 1908, *Plecotus strelkovi* Spitzenberger, 2006, *Plecotus turkmenicus* Strelkov, 1988, and *Plecotus wardi* Thomas, 1911 are also evaluated in the genus *Plecotus* (Yoshiyuki, 1991; Spitzenberger et al., 2006; Huang et al., 2019; Kruskop & Fukui, 2019; Srinivasulu & Srinivasulu, 2020).

Especially in Western Europe, *P. auritus* and *P.*

austriacus are recorded as sympatric sibling species (Postawa et al., 2012). The distribution area for *P. auritus* in Türkiye is fragmented and the records are given from Thrace, the Mediterranean region, and Eastern Anatolia (Kahmann & Çağlar, 1960; Çağlar, 1965; de Blasé & Martin, 1973; Helverson, 1989; Albayrak, 1990; 1991; 1993; Steiner & Gaisler, 1994; Albayrak, 2003; Karataş et al., 2003; Toyran et al., 2017). *P. auritus* and *P. austriacus*, which are among the species found in Anatolia, are found as siblings and form colonies of 20-30 individuals in caves and cracks. *P. auritus* is categorized as "Least concern" (LC) on a global scale and it is also classified in Annex IV of the Habitats Directive 92/43/EC (Gazaryan et al., 2020).

The aim of this study is to advance the knowledge about *Plecotus auritus*'s some bioecological characteristics and geographic range in Türkiye.

2. Material and Methods

2.1. Material

A dead specimen of *P. auritus* was found on August 20, 2020 close to the Insect Production Laboratory on Bolu

Abant İzzet Baysal University campus (40°42'37.93" N, 31°30'51.51" E, altitude: 827 m.) (Fig. 1). The specimen's weight and standard external measurements were noted

and also pictures were taken. The specimen was prepared as a conventional museum type according to Mursaloğlu (1965).

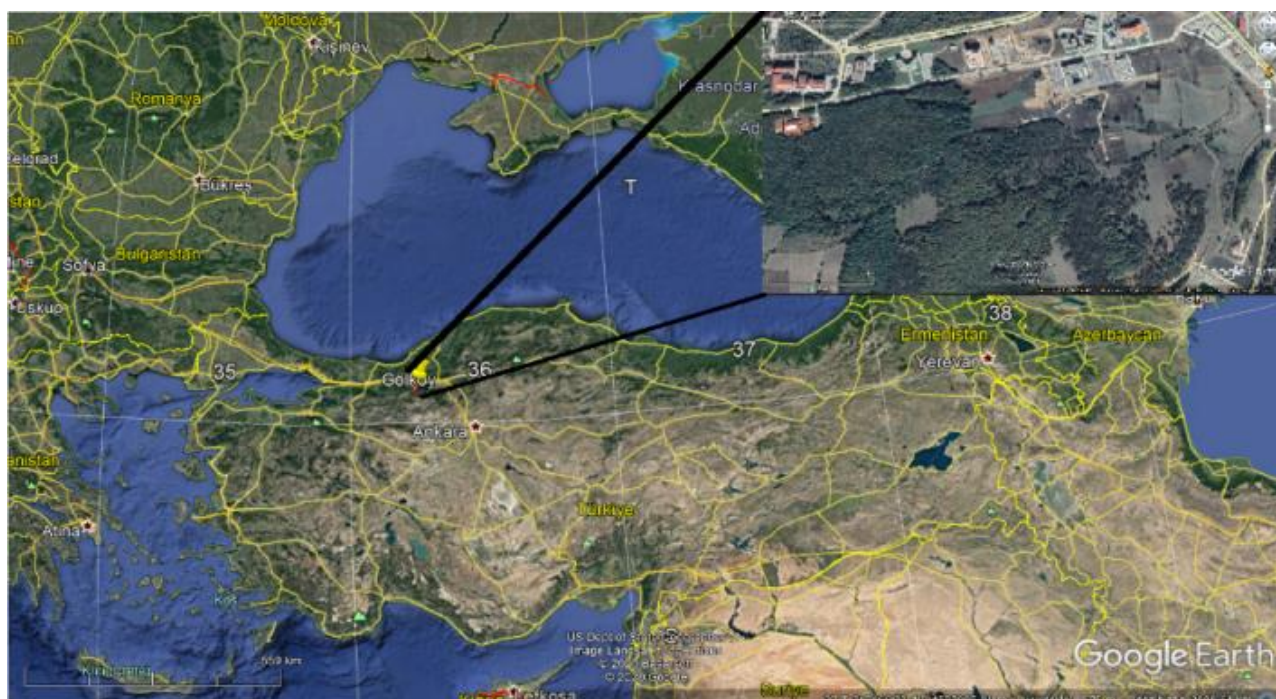


Figure 1. The location where *Plecotus auritus* was detected

2.2. Morphometric measurements

In order to take the morphometric measurements of the skull, the skull was heated in 10% ammonia solution in a 70 °C water bath in plastic boxes and cleaned. According to Dietz & Helverson (2004), in addition to weight following external measurements and according to Häussler & Brown (1991), 12 morphometric measurements of skulls were measured. Abbreviations for method: TBL=Total body length, TL= tail length, HF= hind foot length, EL= ear length, TrL= tragus length, TrW= tragus width, FL= forearm length (including carpals), ThL= thumb length, TiL= tibia length, D3= 3rd digit length D5= 5th digit length, CBL= condylobasal length, GLS= Greatest length of skull, IO= interorbital width, ZB= zygomatic breadth, SH= skull height (including tympanic bulla), MB= mastoid breadth, LBT= length (largest diameter) of tympanic bulla ML= Mandible length, CM³= maxillary toothrow length, CM₃= mandibular toothrow length, W= weight. Previously published studies (Stebbins, 1977; Albayrak, 1990; 1991; Benda & Horáček, 1998; Karataş et al., 2003; Dietz & von Helverson, 2004; Spitzenberger et al., 2006) were used for the identification of the specimen and for evaluations. The external standard measurements were measured with the steel scale and the morphometric measurements of the skull were measured using the open-source FIJI image program in the photographs taken (Schindelin et al., 2012). The study was conducted with the permission of the Republic of Türkiye, Ministry of Forestry and Water Affairs (Permit no. E-21264211-288.04-2256346). This permission also replaces the permission of the local ethics committee.

The stuffed museum specimen has been preserved in the Department of Wildlife Ecology and Management, BAİBÜ.

2.3. Recording and evaluation of bat calls

Bat calls recordings were taken between 20th May and 20th September 2020 with an Ultrasonic voice recorder (Pettersson D500x Pettersson GmbH). The device was fixed at a height of 7-10 meters from the ground near the building and in the wooded area and recordings were taken from dusk to sunrise. These recordings were evaluated in analysis softwares (Raven pro 1.6, Bat sound ver3 and Bat Explorer). In the analysis, four parameters were measured for each bat call: F_{max} (kHz) as the starting frequency at the onset of the call; F_{peak} (kHz) as the peak frequency or the frequency containing the most energy; F_{min} (kHz) as the final frequency measured at the end of the call and pulse duration or the call length (millisecond=ms) (Papadatou et al., 2008; Redgwell et al., 2009; Russ, 2012).

3. Results

Some taxonomic and ecological characteristics of an adult male *P. auritus* specimen were recorded (Fig. 2).

The locality of the specimen is near to forestry and agricultural lands. The main tree species in the area are *Quercus petrae*, *Q. pubescens*, *Q. robur*, *Carpinus betulus*, *Coryllus avellana*, *Cornus mas*, and *Pinus nigra* (Fig. 3). Following external and cranial measurements (mm) and weight (gr) of an adult *Plecotus auritus* (♂) was recorded as TBL= 84.0, TL= 46.0, HF=8.0, EL=37.0, TrL= 14.9, TrW= 4.1, FL= 38.0, ThL= 6.0, TiL= 18.8, CBL= 18.7, GLS= 19.7, IO= 4.1, ZB= 10.2, SH= 10.0, MB= 9.0, LBT= 5.0, D3= 47.0, D5= 51.0, ML= 10.3, CM³ = 6.7, CM₃= 5.7, W= 5.0 (Fig. 4). The dorsal fur color of the specimen was light brown and the ventral fur color was yellowish pale-brown. The demarcational line, between dorsal and ventral fur, was indistinguishable.



Figure 2. A male *Plecotus auritus* specimen (20th August 2020, BAİBÜ Campus)



Figure 3. Habitat of *Plecotus auritus* from BAİBÜ Campus

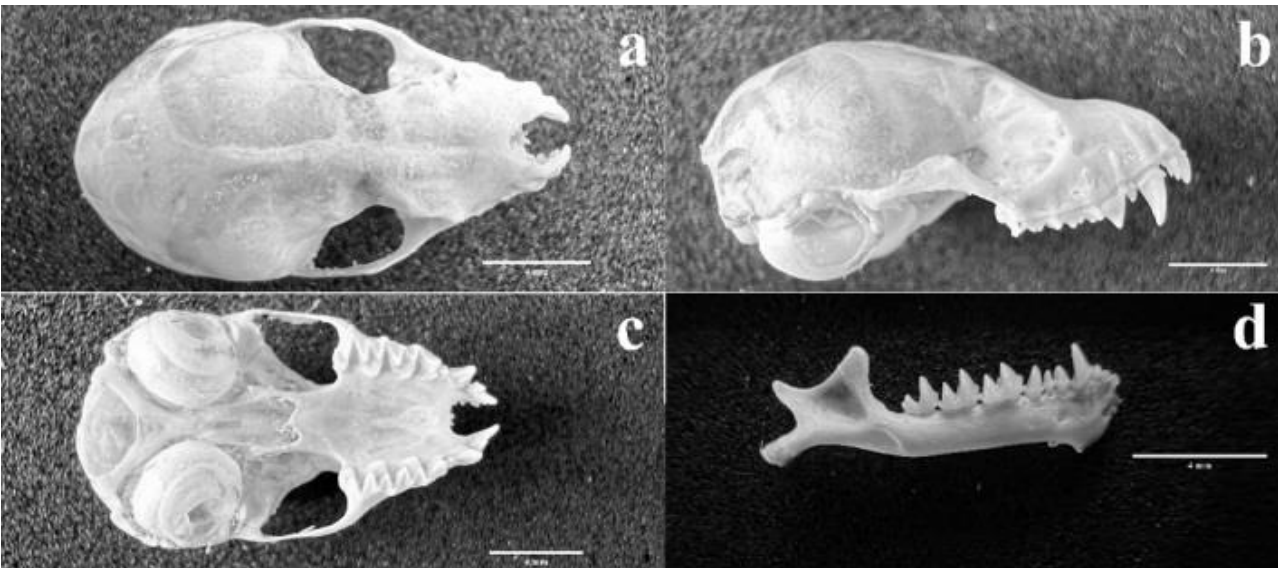


Figure 4. Skull of *Plecotus auritus* a) dorsal, b) lateral and c) ventral view d) mandibula

3.1. Evaluations of bat calls

As a result of the evaluation of the sound recordings, 41 calls, which likely belong to *P. auritus*, were detected. The image of the results obtained in the Bat Explorer program was presented (Fig. 5). The F_{max} , F_{peak} , F_{min} , and the call duration measurements are shown in Table 1. Call length (ms) (1.4- 4.9 mean= 3.4), max frequency (kHz) (28.8-62.4 mean= 39.9), min frequency (kHz) (16.8-36.4 mean= 24.3), peak frequency (kHz) (22.8-35.6 mean= 28.7).

Table 1. Parameters of *Plecotus auritus* calls (n=41)

Measurements	Mean	Range	±Std deviation
Call length (ms)	3.4	1.4- 4.9	1.2
Max Frequency (kHz)	39.9	28.8-62.4	7.9
Min Frequency (kHz)	24.3	16.8-36.4	3.8
Peak frequency (kHz)	28.7	22.8-35.6	2.7

4. Discussion

The taxonomical status of *Plecotus* species is quite complex due to the existence of sibling and cryptic species in the genus *Plecotus*. At the beginning of the current millennium, three new species, *P. balensis*, *P.*

sardus, and *P. alpinus* (= *P. microdontus* Spitzenberger, 2002), were described. In the previous version of the records, the genus *Plecotus* from Europe was used to be attributed to *P. auritus* and *P. austriacus* (Paz, 1994; Schober & Grimmberger, 1998; Mitchell Jones et al., 1999). However, *Plecotus kolombatovici*, which was previously accepted as a subspecies of *P. austriacus*, determined as a separate species and its taxonomic status was updated (Mucedda et al., 2002). It is noteworthy to mention that *Plecotus auritus* and *P. austriacus* can be found sympatrically (Albayrak & Aşan, 1999; Postawa et al., 2012). It is important to define the boundaries of the species' own distribution areas. In the present study, *P. auritus* specimens were identified only in a relatively small area; thus, no data could be interpreted as to whether *P. auritus* and *P. austriacus* are sympatric or not.

4.1. Ecological data

Plecotus auritus distribution records from Türkiye were made, indicating that these animals frequented caves, old stone monasteries, old buildings, old ruins, and the roofs of buildings. *P. auritus* habitats in Central Anatolia were steppe-like; however, the habitats in Northeastern and

Southeastern of Türkiye have mostly trees (Albayrak, 1991; Karataş et al., 2003) (Fig. 6). In the present study is consistent with Horáček (1975), Mitchell Jones et al. (1999), Flückiger & Beck (1995), Horáček & Uhrin, (2010), and Starik et al. (2021) in terms of *P. auritus* calls recorded in the mixed and deciduous forest and the specimen was found in the building close to the woodland. According to Benda and Ivanova's (2003) taxonomic and distributional review of the genus *Plecotus* in Bulgaria and central Europe, *P. auritus* prefers to live in mountainous locations at elevations of at least 1000 meters. In the present study, our *P. auritus* specimen was

found at 872 m a.s.l. close to the deciduous forest.

P. auritus is an insectivorous bat species. Swift (1991) reported that the orders Lepidoptera and Coleoptera comprise nearly 70% of the diet of *P. auritus*. In addition, *Plecotus auritus* feeds on Diptera and Lepidoptera and occasionally on Arachnida (Rydell, 1989; Taake, 1992; Swift & Racey, 2002; Starik et al., 2021). The fact that the specimen used in the present study was obtained from the *Galleria mellonella* (Linnaeus, 1758) (The Greater Wax Moth) production laboratory indicates that *Plecotus auritus* was fed with a species from the order Lepidoptera.

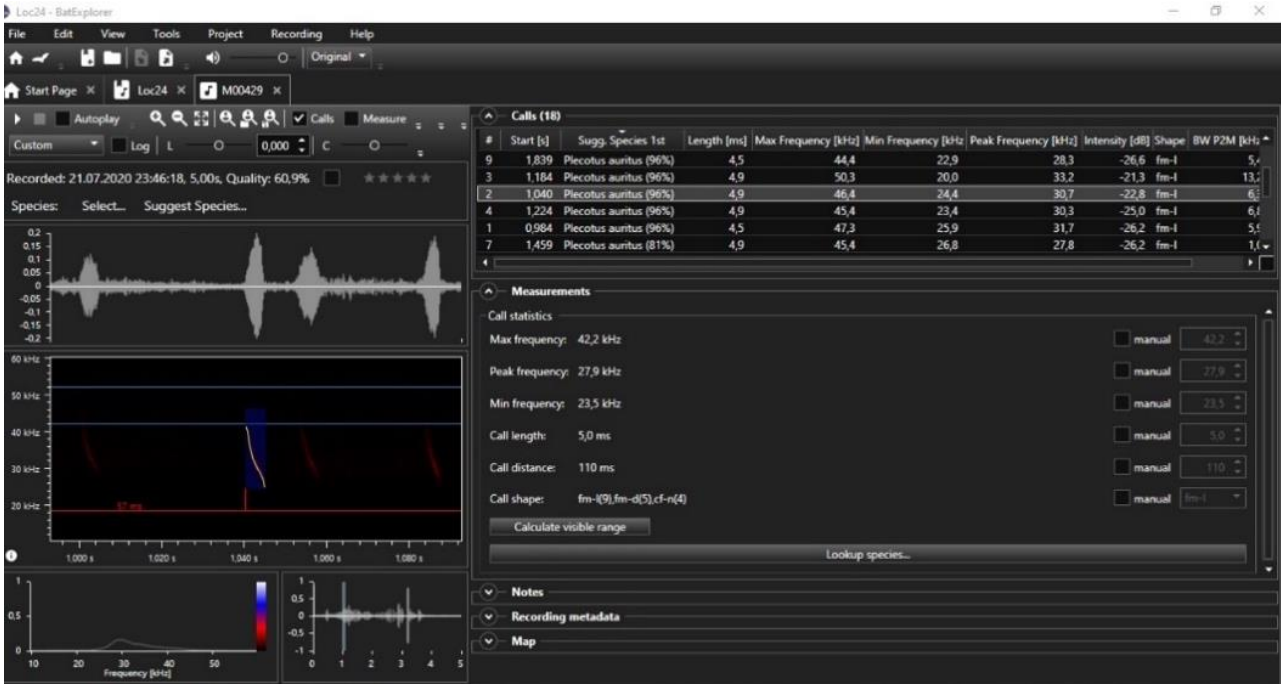


Figure 5. Spectrogram and call parameters of *Plecotus auritus*



Figure 6. Studies on *Plecotus auritus* from Türkiye. Numbers in brackets denotes studies about *Plecotus auritus* distribution (1) Satunin (1913); (2) Kahman and Çağlar (1960), (3) Çağlar (1965), (4) de Blase and Martin (1973), (5) Helverson (1989), (6) Albayrak (1990), (7) Albayrak (1991), (8) Albayrak (1993), (9) Steiner and Gaisler (1994), (10) Benda and Horáček (1998), (11) Albayrak and Aşan (1999), (12) Karataş et al. (2003), (13) Toyran et al. (2017), and (14) the present study

When deciduous forests and coniferous forests are compared in terms of insect species diversity, deciduous species, especially *Quercus* spp., host many insect species including the Lepidoptera (Southwood, 1961; Kennedy & Southwood, 1984; Patočka et al., 1999). In the study area wherein *P. auritus* was detected, the oak species are the dominant trees as mentioned above.

4.2. Taxonomical data

The dorsal fur color of *Plecotus auritus* ranges from light brown, brown, to reddish brown (Dietz & von Helverson, 2004), pale yellowish gray-brown (Albayrak, 1991), light brown (Karataş et al., 2003), to light buff or brown to gray (Swift, 1998). Ventral fur color can vary from yellowish-brown (Dietz & von Helverson, 2004) to whitish gray or whitish straw gray (Albayrak, 1991). The boundary between dorsal and ventral coloration in the flanks is absent (Dietz & von Helverson, 2004). The present study

revealed similar fur color peculiarities for *P. auritus* as reported by Dietz & von Helverson (2004).

However, in the present study, GLS, CBL, ZB, and SH values were measured as high when compared to the data of *P. auritus* samples from Türkiye and Central Europe (Table 2). Benda and Ivanova (2003) noted that CM³ and LBT values were distinctive measurements for *Plecotus* species (small specimens, CM³ < 5.7 mm and LBT < 4.25 mm belong to *P. auritus*). Although the CM³ value is consistent with the current investigation, our specimen's LBT value was 5.0 mm in comparison. In contrast to the current study, Starik et al. (2021) found that the value of D3 was higher than our result (compare 4.47 and 64.0 – 67.0 mm in Table 2). The specimen used in the present study differs from Karataş et al. (2003) in that there is no protrusion in the interparietal region of the skull in the lateral view.

Table 2. Comparing *Plecotus auritus* external measurements, skull morphometric measurements (mm), and weight (g) with published studies

	Stebbing (1977)	Schober & Grimmberger (1989)	Albayrak (1991)	Häussler & Braun (1991)	Spitzenberger et al. (2002)	Benda & Ivanova (2003) (Central Europa)	Benda & Ivanova (2003) (Bulgaria)	Karataş et al. (2003)	Starik et al. (2021)	This study
TBL								73.9-102		84.0
TL								30.0-53.0		46.0
HF			10.0-13.0	8.2-8.9				8.5-11.0	6.9-10.6	8.0
EL			36.0-40.0	35-38	26.2-40.4			30.8-42	26.2-38.5	37.0
TRL								15.3-20	14.9-6.2	14.9
TRW								4.5-5.5	4.2-5.5	4.1
FL	<39		39.4-43.2	37.5-39.7	35.1-43.5	35.6-42.8		35.2-42.9	35.1-43.2	38.0
THL		6.5-8.4	4.1-5.3			6.5-7.8			5.5-7.1	6.0
TİL								15.8-20.5		18.8
GLS						15.42-16.90	16.78-18.12			19.7
CBL			15.7-16.4			14.32-15.68	15.67-16.88	15.2-16.7		18.7
IO			3.5-3.7					3.4-4.1		4.1
ZB			8.6-9.3			8.12-9.26	8.85-9.68	8.6-9.1		10.2
SH			7.7-8.0			6.82-7.58	7.20-8.27	7.4-8.6		10.0
LBT						3.88-4.24	4.48- 4.96			5.0
MB								7.1-9.2		9.0
D3									64.0-67.0	47.0
D5									49.0-55.0	51.0
ML			10.8-11.3			9.68-10.83		10.7-11.4		10.3
CM ³			5.6-5.8	5.3-5.5	4.8-5.6	5.02-5.65	5.73-6.23	5.4-6.0		5.6
CM ₃			6.0-6.4	5.8-6.0	5.4-6.0	5.45-6.12	6.21-6.76	5.9-6.1		5.7
W								4.7-8.7	6.9-10.8	5.0

4.3. *Plecotus auritus* call records

Plecotus auritus is a bat species that is referred to as "the whispering bat" because of its extremely faint echolocation calls. *P. auritus* echolocation calls are described by Ahlen (1981) as weak, brief FM scans that last for around 2 ms and feature distinct second harmonics. The use of silent calls reduces the possibility of the bat being noticed by the prey while hunting. The frequency of the *P. auritus* call is usually 83-26 kHz but sometimes louder at 42-12 kHz. There is an accordance

between the parameters of bat calls when comparing our results to the published data (Ahlen, 1981; Masing, 2008).

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Ethics committee approval: The study was conducted with the permission of Republic of Türkiye, Ministry of Forestry and Water Affairs (Permit no. E-21264211-288.04-2256346). This permission also replaces the permission of the local ethics committee.

Conflict of interest: The author declare that there is no conflict of interest.

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