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Research Article

Distribution of rodent species (Mammalia: Rodentia) in Zonguldak Province, Turkey

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Abstract

To know rodent species in an area is crucial in most scientific disciplines, such as wildlife management studies, forestry applications, conservation purposes, and public health studies. This study aimed to determine the rodent species and their distribution in Zonguldak and to provide detailed inventory data and distribution maps for further studies. Samples were collected mostly by Sherman traps, rarely by conventional cage-like traps, photo traps, or observed visually, from 33 localities representing different habitat types, between 2009 and 2016. A total of 427 specimens from 15 species were evaluated. These species are: *Sciurus anomalus*, *Myodes glareolus*, *Microtus subterraneus*, *M. mystacinus*, *Apodemus flavicollis*, *A. sylvaticus*, *A. uralensis*, *A. witherbyi*, *A. mystacinus*, *Rattus rattus*, *R. norvegicus*, *Mus musculus*, *M. macedonicus*, *Glis glis*, and *Muscardinus avellanarius*. Among them, *M. mystacinus*, *A. uralensis*, *M. macedonicus*, and *M. avellanarius* were recorded by primary data for the first time from Zonguldak. Among 33 localities investigated Kurtköy and Beldibi areas have the highest number of rodent species with each having 7. TNI (Trap Night Index) was calculated as 21.43 for seven of the localities studied. Some skull peculiarities and pelage morphology were used to identify *Apodemus* species, and karyology was used to identify *Microtus* and *Rattus* species. Morphological evaluations of *Apodemus* specimens verified the occurrence of *A. sylvaticus* in Asiatic Turkey.

Keywords: *Karyology, morphometry, ecology, zoogeography, taxonomy*

Introduction

The taxonomy and distribution of rodents have been investigated in Anatolia for several purposes, such preparing inventory lists (Yiğit et al., 2006; Kryštufek & Vohralík, 2009; Burgin et al., 2020), wildlife management (Gür, 2016; Çetintaş et al., 2017; Yiğit et al., 2021), collecting zoogeographical data (Yiğit & Çolak, 1998; Yiğit et al., 2003), making taxonomical evaluations (Albayrak and Arslan, 2006; Çolak et al., 2007), determining rodent-borne diseases (Çelebi et al., 2015; Polat et al., 2019, 2020; Usluca et al., 2019; Karakuş et al., 2020), and preparing distribution maps (Kryštufek & Vohralík, 2005, 2009; Yiğit et al., 2003, 2006), etc. According to such studies, 65 rodent species have been recorded in Turkey (Osborn, 1964; Felten et al., 1971; Kumerloeve, 1975; Doğramacı, 1989; Kurtonur et al., 1996; Özkan & Kryštufek, 1999; Gözcelioğlu et al., 2005; Kryštufek & Vohralík, 2005, 2009; Çolak et al., 1997, 1998, 2004, 2006; Yiğit et al., 2003, 2006, 2016; Özkurt & Bulut, 2020). Yiğit et al. (2006), and Kryštufek & Vohralík (2009) were listed 20 rodent species for Western Black Sea Region, and Kryštufek & Vohralík (2009) and Sözen & Karataş (2008) were listed 14 rodent species for Zonguldak Province. These studies have recorded very few and occasional records for the distribution of species, and some species were only been listed without giving any definite recording sites.

Though *Apodemus sylvaticus* has been recorded from Akçakoca and Çaycuma by Filippucci et al. (1996), Macholán et al. (2001) and Michaux et al. (2003) did not recognize *A. sylvaticus* among Anatolian *Apodemus* species. Çolak et al. (2007) stated that *A. sylvaticus* is not distributed in the Middle East. Additionally, Kryštufek & Vohralík (2009) examined a large sample (N = 171) of field mice from Bolu and Zonguldak, where *A. sylvaticus* has been recorded by Filippucci et al. (1996), but could not determine any animal matched the morphology of *A. sylvaticus*. Moreover, their examination of many more specimens from other localities in the Anatolian part of the Marmara region and the western Black Sea Mts. also failed to identify *A. sylvaticus*. Yiğit et al. (2006) mapped *A. sylvaticus* only for Thrace. Recently, Kryštufek & Vohralík (2009) conclude that the presence of *A. sylvaticus* in Anatolia requires further attention and additional supporting evidence.

We aimed to provide an inventory list and a distribution map of rodents in Zonguldak Province to make it accessible in necessary cases such as taxonomic studies, public health problems, management studies, conservation studies, and multi-functional forestry applications, etc.

Materials and Methods

Between 2010 and 2016, rodent samples were collected from 33 localities throughout Zonguldak Province.

Samples were generally collected by Sherman traps and traditional cage-like traps. During trapping, traps were set on transects by about 90 traps spaced at about 10 m intervals and were baited by bread coated with chocolate or peanut butter. Traps were left two consecutive nights at each study site. Additionally, photo traps were also used to determine some species such as squirrel and dormouse. Photo traps were set and fixed on tree trunks as 30 to 50 cm above ground level. A total of 427 specimens were recorded; among them, 6 were visually observed, 99 were photographed by camera traps, and 321 were trapped by either Sherman traps or traditional traps. Sampling localities are shown in Figure 1.

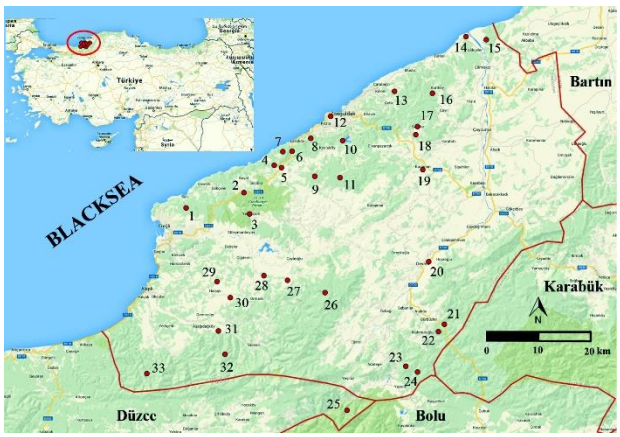

Fig. 1. Localities studied in Zonguldak Province. The numbers of localities are the same as in Table 1.

Species identification was made according to Harrison & Bates (1991), Kryštufek & Vohralík (2005, 2009), and Yiğit et al. (2006). External and cranial character measurements (mm) and weight (gr.) were taken for all specimens, and nail length was included in hindfoot measurements (Harrison & Bates, 1991).

Since *Apodemus* species are externally very similar, a detailed morphological and biometric study was performed for these specimens to determine species correctly. Morphological characteristics such as the pectoral spot expressions, the posterior end of the palatal bone, pterygoid process, fronto-parietal suture, and upper molar crown patterns given by Filippucci et al. (1996), Kryštufek (2002), and Kryštufek & Vohralík (2009) were used. Additionally, the identification key given by Barciova & Macholán (2009) was used to separate *A. sylvaticus* and *A. flavicollis*. A total of 33 cranial and dental, and four external measurements were taken from adult *Apodemus* specimens, and these measurements were used in morphometric analysis to compare the five species. Principal Component Analysis (PCA), and Discriminant Function Analysis (DFA) were used to separate *Apodemus* species. Statistical analyses were performed by SPSS 19.0 software (SPSS LEAD Inc., USA).

Karyotype was done to identify some morphologically similar species. Chromosome preparations were made from bone marrow according to Ford & Hamerton (1956).
Trap Night Index (TNI) was calculated for seven localities which were studied by definite trap numbers according to Gurnell & Flowerdew (2006), as the number of samples caught per trap-night or per 100 trap-nights. Burgin et al. (2020) was fallowed for species names and taxonomy.
The stuffed specimens and skulls examined were deposited in the Department of Biology, the Faculty of Art and Science, Zonguldak Bülent Ecevit University.

Results

We determined 4 families, 8 genera, and 15 species of rodents (Table 1), and a total of 427 samples were recorded throughout 33 localities in Zonguldak Province (Figure 1). Rodent samples were obtained from different habitats such as pure or mixed forests of beech, oak, pine, chestnut, also hazelnut orchards, predominantly rocky areas, caves, and agricultural fields.

Rodent species determined

Family: Sciuridae G. Fischer, 1817
Sciurus anomalus Gmelin, 1778
Records of the *S. anomalus* were directly seen (localities 10, 19, and 31), determined by photo traps (localities 1, 7, 12, 15, 16, 21, 26, 32, and 33), and one was found near the motorway as dead because of being hit by a vehicle (locality 20) (Table 1). Habitat preference of the *S. anomalus* is oak, beech, black pine, and chestnut mixed forests.
Family: Gliridae Muirhead, 1819
Glis glis (Linnaeus, 1766)
Specimens of the *G. glis* were recorded from nine localities as indicated in Table 1. A specimen was caught in locality 22 (1 ♀); and 57 specimens photo trapped in localities 7, 10, 13, 16, 17, 18, 32, and 33. Habitat preference of the *G. glis* is beech forest and black pine forests and chestnut groves. Also, a colony of the species was observed going in and out of the Sofular cave near a deciduous forest.
Muscardinus avellanarius (Linnaeus, 1758)
Specimens of the *M. avellanarius* were recorded from four localities; two were caught in localities 2 and 27, two were photo trapped in locality 10, and two were seen in locality 11 (Table 1). Habitat preference of the *M. avellanarius* is pure forests of chestnut and beech, as well as mixed forests, and hazelnut gardens.

Family: Cricetidae G. Fischer, 1817
Myodes glareolus (Schreber, 1780)
63 samples of the *M. glareolus* were recorded by Sherman traps from eight localities in Zonguldak (Table 1). Habitat preference of the *M. glareolus* is mixed forests of beech, oak, torch pine, and Scots pine.
Microtus subterraneus (de Selys Longchamps, 1836)
Five specimens of the *M. subterraneus* were collected from 3 localities; 6, 22, and 29 (Figure 1). The karyotype of the specimens contains 2n = 52, NFa = 56 and NF = 60. The autosomal chromosomes were 22 acrocentric pairs, a large subtelocentric pair, a submetacentric pair, and a small metacentric pair. The X chromosome is a medium-sized metacentric and the Y chromosome is a small metacentric. Habitat preference of the *M. subterraneus* is meadows among fir forests, agricultural fields, and hazelnut groves.

Table 1. Localities, sample size and species animals examined.

Harita No	Species	Coordinate	Altitude (m)	*Sciurus anomalus*	*Glis glis*	*Muscardinus avellanarius*	*Myodes glareolus*	*Microtus subterraneus*	*Microtus mystacinus*	*Apodemus sylvaticus*	*Apodemus flavicollis*	*Apodemus witherbyi*	*Apodemus uralensis*	*Apodemus mystacinus*	*Rattus rattus*	*Rattus norvegicus*	*Mus musculus*	*Mus macedonicus*	Total
1	Balı	N 41.308370°, E 31.465790°	307	2															2
2	Bayat	N 41.331949, E 31.585228°	363			1													1
3	Yalnızçam	N 41.299102°, E31.596599°	436				1				5			1					7
4	Çalcaköyü	N 41.374417°, E 31.647459°	208				9			2	33	6	5						55
5	Seyfetlerköyü	N 41.370418°, E 31.662475°	228						1										1
6	Ilıksu1	N 41.395633°, E 31.684856°	69				1	1		1	15		9						27
7	Ilıksu2	N 41.395280°, E 31.665420°	182	2	5														7
8	Değirmenağzı	N 41.416098°, 31.722716°	146								2			5					7
9	Aşağıçayır	N 41.357420°, E 31.731264°	546				1				3								4
10	Ulutan	N 41.412366°, E 31.789242°	260	1	12	2													15
11	Dağlıca	N 41.355400°, E 31.783153°	544			2	20				1		18						41
12	İncivez	N 41.449705°, E 31.764265°	93	1											14	12	6		33
13	Cumayanı	N 41.488670°, E 31.896195°	186		5														5
14	Sefercikköyü	N 41.572843°, E 32.043897°	15												8	3			11
15	Sazköy	N 41.568230°, E 32.085600°	168	8															8
16	Kurtköy	N 41.485450°, E 31.974344°	315	6	4		27			5	17	12	20						91
17	Sofular	N 41.433896°, E 31.943639°	312		5														5
18	Çayır Mağarası	N 41.421711°, E 31.939967°	395		18									4					22
19	Karaman	N 41.367732°, E 31.954254°	300	1															1
20	Devrek centrum	N 41.225376°, E 31.967120°	556	1															1
21	Devrek Wood Storage	N 41.127936°, E 31.998970°	360	3															3
22	Beldibi	N 41.116515°, E 31.987009°	574		1		3	2			10	2	3						21
23	Yazıcık1	N 41.062686°, E 31.919682°	545										1						1
24	Yazıcık2	N 41.053942°, E 31.943421°	745								1								1
25	Karadere	N 40.994397°, E 31.798072°	602				1			3		2	3						9
26	Sütlüce	N 41.177070°, E 31.752270°	841	10															10
27	Davutlar	N 41.196162°, E 31.674661°	445			1													1
28	Hasankahyalar	N 41.203444°, E 31.625989°	223						1		3								4
29	Işıklıköy	N 41.194006°, E 31.529399°	170					2			5							3	10
30	Çamlıbelköyü	N 41.169496°, E 31.557050°	293								4								4
31	Aydınyayla	N 41.117517°, E 31.532133°	120	2															2
32	Gümeli	N 41.081288°, E 31.545850°	693	4	3														7
33	Belen	N 41.051214°, E 31.384559°	270	5	5														10
		Total		46	58	6	63	5	2	11	99	22	59	10	22	15	6	2	427

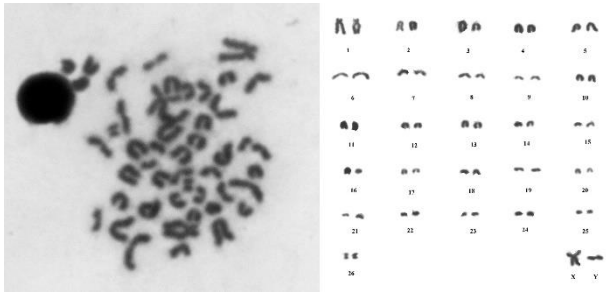

Fig. 2. The karyotype of a male *Microtus subterraneus*.

Microtus mystacinus (De Filippi, 1865)
Specimens of the *M. mystacinus* were collected from meadowlands, agricultural fields, and hazelnut groves. Two specimens were collected from localities 5 and 28 (Table 1). The karyotype of the species was 2n = 54, NFa = 54 and NF = 56 (Figure 3). All autosomal chromosomes are acrocentric except for a small metacentric pair. The X chromosome is the largest acrocentric in the set and the Y chromosome is small acrocentric.

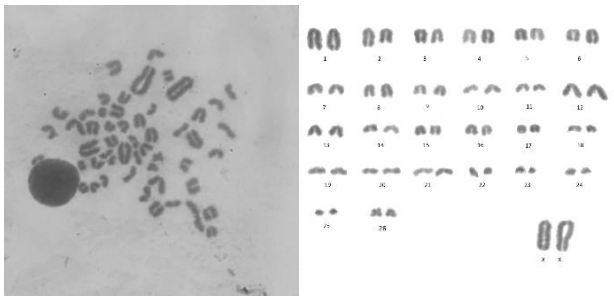

Fig. 3. The karyotype of a female *Microtus mystacinus*.

Family: Muridae Illiger, 1811
Apodemus sylvaticus (Linnaeus, 1758)
Specimens of the *A. sylvaticus* were collected mostly from pure beech forests, mixed forests and along streams. 11 specimens were captured from localities 4, 6, 11, 16, 22, and 25 (Table 1).

Apodemus flavicollis (Melchior, 1834)
Specimens of the *A. flavicollis* were captured from every habitat type, but, especially from the black pine forests. A total of 76 samples were recorded from 6 localities; 4, 6, 11, 22, 23, and 16 (Table 1). Habitat preference of the *A. flavicollis* is pure or mixed beech, oak, fir, torch pine, and chestnut forests, hazelnut groves, agricultural fields, and open areas.

Apodemus uralensis (Pallas, 1811)
Specimens of the *A. uralensis* were captured from generally pure beech and beech-oak mixed forests. 67 samples were collected from 6 localities (6, 11, 16, 22, 24, and 25) (Table 1).

Apodemus witherbyi (Thomas, 1902)
Records of the *A. witherbyi* were taken from torch pine, oak, fir, and beech mixed forest. 21 specimens were captured from 4 localities (4, 22, 25, and 16).

Apodemus mystacinus (Danford and Alston, 1877)
Specimens of the *A. mystacinus* were sampled from generally rocky areas inside forests. This species has been recorded from three localities; 8 samples were collected from localities 8 and 10, and seen inside the Çayır cave.

Rattus rattus (Linnaeus, 1758)
Specimens of the *R. rattus* were captured from gardens near human settlements, and beech forests along the Filyos River. A total of 20 samples were collected from two localities; 12 and 14 (Table 1). The karyotype of the species was 2n=38, NFa=58 and NF=60.

Rattus norvegicus (Berkenheut, 1769)
Specimens of the *R. norvegicus* were collected near settlements and reed beds among the rivers, it is also common inside the city centrum. 12 individuals of this species were collected from two localities; 12 and 14 (Table 1). The karyotype of the species was 2n=42, NFa=62 and NF=64.

Mus musculus (Linnaeus, 1758)
Specimens of the *M. musculus* were captured from settlements. Six samples of this species were sampled from locality 12 (Table 1). Traps were set only inside buildings in this locality.

Mus macedonicus Petrov &Ružić, 1982
Specimens of the *M. macedonicus* were captured from open areas, inside and around hazelnut groves in Işıklı village (locality 20, Table 1).

Trap Night Index (TNI)
According to methodological trapping by 100 Sherman traps in seven localities, the most caught rodent species are *A. flavicollis* (6.96 number of catch/100 TN), *M. glareolus* (5.59 number of catch/100 TN), and *A. uralensis* (5.40 number of catch/100 TN) respectively. Trapping results for Sherman traps in seven localities were given in Table 2.

For 7 localities, the total number of trap nights was 1092 and the overall trap success for rodents caught was 21.43 per 100 TN. Among the 81 rodent samples, the majority was from Kurtköy (44.02%) and Çalca (28.65%), followed by Dağlıca (20.53%), Ilıksu (14.06%), Karadere (11.25%), Beldibi (11.05%), and Kurdeşe (3.13%).

Morphological identification of *Apodemus sylvaticus*
A small spot on a specimen, a faint stain on a specimen, a big spot on a specimen, and nothing on the other specimens on the throat were detected in *A. sylvaticus* specimens. The shape of the fronto-parietal suture differs among the specimens of this species. While in 7 specimens are angled, 5 are curved. The posterior margin of incisive foramen only exceeds posteriorly the line connecting the anterior alveolar margins of 1st molars in 2 specimens, slightly bypassing the line in 3 specimens, and does not approach the line in the other specimens. The shape of the posterior margin of the hard palate is rounded in 4 out of 12 (33.33%) specimens.

Table 2. Trapping results for Shermann traps in 7 localities

Localities	Number of Sherman traps	*M. glareolus* number of catch, TNI		*A. flavicollis* number of catch, TNI		*A. sylvaticus* number of catch, TN		*A. uralensis* number of catch, TNI		*A. witherbyi* number of catch, TNI		*M. subterraneus* Number of catch, TNI		*G. glis* Number of catch, TNI		For localities Total catch number, TNI
Kurtköy	184	27	14.67	17	9.24	5	2.72	20	10.87	12	6.52	0	0	0	0	44.02
Çalca	192	9	4.69	33	17.19	2	1.04	5	2.60	6	3.13	0	0	0	0	28.65
Beldibi	190	3	1.58	10	5.26	0	0	3	1.58	2	1.05	2	1.05	1	0.52	11.05
Dağlıca	190	20	10.53	1	0.53	0	0	18	9.47	0	0	0	0	0	0	20.53
Ilıksu1	192	1	0.52	15	7.81	1	0.52	9	4.69	0	0	1	0.52	0	0	14.06
Karadere	80	1	1.25	0	0	3	3.75	3	3.75	2	2.50	0	0	0	0	11.25
Kurdeşe	64	0	0	1	1.56	0	0	1	1.56	0	0	0	0	0	0	3.13
TOTAL	1092	61	5.59	77	7.05	11	1.01	59	5.40	22	2.01	3	0.27	1	0.09	21.43

Table 3. The mean and range of body and skull measurements of A. *sylvaticus*.

Characters	**N**	**Mean (mm)**	**Min. (mm)**	**Max. (mm)**	**SD ±**
Head and body	11	81.62	72	91.88	7.51
Tail	11	91,37	78.12	110	9.33
Hind foot	12	21.91	20	23	1.37
Ear	12	13.25	12	15	1.13
Weight	12	17	12	26	4.41
Condylobasal length	12	22.2	21.08	23.25	0.61
Zygomatic breadth	12	12.47	12.2	13	0.28
Length of Maxillary tooth-row	12	3.55	3.33	3.81	0.14
Length of mandible tooth row	12	3.62	3.45	3.89	0.12
Bulla length	12	4.43	4.09	4.87	0.21

The specimens of *A. sylvaticus* were found to be different from other *Apodemus* species by connections between t4-t5-t6-t7-t8-t9 in M^2. Tubercle t7 on the 2^{nd} molar is always cusp-like in the specimens. *A. sylvaticus* is different from *A. witherbyi* by the absence of connections bridges between t1 and t5 in M^1. Also, in the samples of the *A. sylvaticus*, 3^{rd} molar labial folds were not usually evident (66.66%), while *A. witherbyi* samples generally showed a deep labial fold. The mean and range of body and skull measurements (mm) of *A. sylvaticus* were given in Table 3.

Morphometric analyses of *Apodemus* spp.

Six *Apodemus* species are known to distribute in Turkey, and five of them were recorded from Zonguldak by this study: *A. mystacinus*, *A. sylvaticus*, *A. flavicollis*, *A. witherbyi*, and *A. uralensis*. According to Principal Component Analysis (PCA), *Apodemus* species were found as significantly different from each other ($p<0.05$). The results of KMO and Barlett's sphericity tests, PCA enforceability was accepted ($P<0.05$). The first three components explain 78.93% of the variance in PCA (Table 4). Two-dimensional distribution canonical discriminant chart was created in discriminant function analysis for five *Apodemus* species. All five *Apodemus* species were separated from each other according to discriminant function analysis ($p<0.05$). *A. sylvaticus* and *A. flavicollis* were found to be very close to each other. *A. witherbyi* and *A. uralensis* were also close, while *A. mystacinus* was clearly distinct from the other four species. According to our study, pelage and skull morphology (pectoral spot expressions, the posterior end of the palatal bone, pterygoid process, fronto-parietal suture, and upper molar crown patterns) can be used to identify *Apodemus* species in Zonguldak. However, since these characters may show inter- and intraspecific variations, all these characters should be evaluated together to determine the species of each sample.

Discussion and Conclusion

We recorded 15 rodent species from Zonguldak and among them, *M. mystacinus*, *M. avellanarius*, *A. uralensis*, and *M. macedonicus* were recorded for the first time from Zonguldak. Though these species were indicated in distribution maps (e.g., Kryštufek & Vohralík, 2005, 2009; Yiğit et al., 2007) as possibly distributed in Zonguldak, their occurrence was proven by primary data in this study.

Helvacı et al. (2012), Selçuk et al. (2012) and Arslan et al. (2013) recorded *G. glis* from Zonguldak. We supplied here 9 additional localities for this species.

M. avellanarius has been recorded from Bolu (Kıvanç, 1983; Yiğit et al., 2003) and from Tosya (Yiğit et al., 2003), but there was not any record between these two cities. Zonguldak is located between these two localities and our records filled a big gap in the distribution of this species in the Western Black Sea region.

Macholán et al. (2001) recorded *M. subterraneus* from Çaycuma. We recorded this species from 3 additional localities (Figure 1).

A. mystacinus has been recorded from Çaycuma by Zima & Macholán (1995), from Çayır by Kryštufek & Vohralík (2008), and from Zonguldak by Olgun Karacan et al. (2015). We recorded the species from additional 10 localities and showed that this species is widespread in Zonguldak.

The karyotypes of *R. rattus* and *R. norvegicus* were similar to those given by Yiğit et al. (1997), *M. subterraneus* to given by Çolak et al. (1998), and *M. mystacinus* to given by Kefelioğlu (1995).

A. sylvaticus has been recorded from Akçakoca and 5 km south of Çaycuma by Filippucci et al. (1996) based on morphology and electrophoretic analysis of 38 protein loci. Later, the occurrence of the species in the same localities was verified by the mitochondrial cytochrome b gene by Michaux et al. (2003). However, Macholán et al. (2001) did not recognize *A. sylvaticus* among Turkish *Apodemus* species. Kryštufek & Vohralík (2009) examined a large sample (N = 171) of field mice from Bolu and Zonguldak, where *A. sylvaticus* has been recorded by Filippucci et al. (1996), but could not determine any animal similar to the morphology of this species. Moreover, their examination of many more specimens from other localities in the Anatolian part of the Marmara region and the Western Black Sea Mts. also failed to identify *A. sylvaticus*. Filippucci et al. (1996) provided the drawings of the ventral side of the skull and both molar rows of the *A. sylvaticus* specimen from Akçakoca. Kryštufek & Vohralík (2009) indicated that this animal clearly differs from their Thracian sample by its short incisive foramen. By depending on these studies, Kryštufek & Vohralík (2009) concluded that the presence of *A. sylvaticus* in Anatolia requires further attention and additional supporting evidence. On the other hand, recently Yiğit et al. (2006) mapped *A. sylvaticus* only for Thrace.In this study, we examined a large sample (n=201) of *Apodemus* species from Zonguldak, and confirmed the presence of *A. sylvaticus* by using main characters that distinguish *Apodemus* species. We compared the characteristics of *A. sylvaticus* samples from Zonguldak with the characters given by Filippucci et al. (1996), Kryštufek (2002), Barciova & Macholán (2009), and Kryštufek & Vohralík (2009). The measurements of the length of thw mandibular tooth row, condylobasal length, and bulla length of *A. sylvaticus* specimens from Zonguldak were placed in the range given by Barciova & Macholán (2009). The means of body and skull measurements of *A. sylvaticus* are less than the measurements given by Filippucci et al. (1996) and Kryštufek & Vohralík (2009), except for hind foot length, ear length, and zygomatic breadth (Table 3 and 4). This shows that the body size of the samples from Zonguldak was smaller than European samples. The other important difference in morphology is the position of incisive foramina. In *A. sylvaticus* samples from Turkish Thrace (n= 32), the morphotype foramen length relative to the anterior margin of the 1st molar's alveoli

is mostly FI long type 87.5%, followed by 6.3% FI medium and 6.3% FI short type (Kryštufek & Vohralík, 2009). However, the proportions in samples from Zonguldak are mostly different as 58.3% FI short, 25% FI medium, and 16.7% long type (Table 4). This shows that the position of incisive foramina in samples from European and Asian parts of Turkey shows differences, and is not a diagnostic character alone.

Table 4. Discriminant function analysis; Eigen value scores. Total variance explained in 6 functions.

	Eigenvalues		
Component	Total	Variance %	Cumulative %
1	26.71	70.29	70.29
2	1.98	5.21	75.50
3	1.30	3.43	78.93
4	1.01	2.66	81.59
5	0.94	2.46	84.05
6	0.79	2.07	86.12

The connections of tubercles on molars are important to distinguish *Apodemus* species. The specimens of *A. sylvaticus* were found to be mostly different from other *Apodemus* species by connections between t4-t5-t6-t7-t8-t9 in M^2. However, the same connection pattern was seen on 9 out of 83 *A. flavicollis* samples and on 4 out of 20 *A. witherbyi* specimens. This situation again indicates that to distinguish *Apodemus* species several characters should be used in combination. A specimen of *A. sylvaticus* also differed from the other species of *Apodemus* by connections between t1, t4, and t8 in M^3. *A. sylvaticus* differed from *A. witherbyi* by the absence of connection bridges between t1 and t5 in M^1. Also, in the samples of the *A. sylvaticus*, labial folds were not evident in M^3, while *A. witherbyi* samples generally showed a deep one. All these results and the comparison given in Table 4 confirmed the presence of *A. sylvaticus* in Zonguldak.

According to Kryštufek & Vohralík (2009), *A. sylvaticus* is widespread in Turkish Thrace, restricted mainly to lowland habitats below 300 m a.s.1. We collected this species in pure torch pine forests (altitude 248 m), mixed forests (altitude 310 m), and along a stream (altitude 566 m). Our records showed that the distribution of this species may be reached up to about 600 meters a.s.l. in Zonguldak.

Species diversity was found richer in natural and old mixed forest areas such as Kurtköy and Beldibi, and lower in altered habitats such as cultivated areas, pine plantations and settlements (Table 1). The native habitat type of the Zonguldak area is mixed deciduous forests, and keeping the original vegetation type during forestry applications seems to be important to maintain mammalian diversity. Related to the mixed deciduous forest type seen in the Zonguldak area, the most common rodent species are found to be *S. anomalus* (from 13 localities), *A. flavicollis* (from 12 localities), and *G. glis* (from 9 localities). While planning forestry applications, taking into account the mammal species and their ecological peculiarities is important.

Some species of *Rattus*, *Mus*, *Microtus*, *Myodes*, and *Apodemus* are known as transmitters for some rodent-borne diseases, such as hantaviruses, lymphatic choriomeningitis virus, leptospirosis, rat-bite fever, salmonellosis, toxoplasmosis, hymenolepiasis, and trichinosis (Davis, 2005; Gratz, 2006; Sözen, 2011). Some of these rodents are also reservoirs of some other diseases such as tularemia (Çelebi et al., 2006; Polat et al., 2019? or long-lasting bacteremia (Çelebi et al., 2015). Some of these diseases were recorded around Zonguldak, ie. tularemia (Çelebi et al., 2006), hantaviruses (Öktem et al., 2014), bartonellosis (Çelebi et al., 2015). That is why knowing rodent species and their population trends in an area is important for public health studies to evaluate possible risks and take precautions.

This study presents distribution records of 15 rodent species and offers convincing morphological data on the presence of *A. sylvaticus* in Zonguldak.

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