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Research Article

The Taxonomy and Distribution of *Apodemus agrarius* (Pallas, 1771) (Mammalia: Rodentia) in the European Part of Turkey

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Abstract: The morphological and karyological characteristics of 27 specimens of *Apodemus agrarius* (Pallas, 1771) from the European part of Turkey were studied in detail and compared with those in the literature in order to provide a wider perspective on the taxonomic status of *Apodemus agrarius* in Turkey. In all the samples examined, 2n = 48 karyotype was observed with FN = 56 and FNa = 54. The 2n = 48 karyotype includes three pairs of metacentric, one pair of submetacentric and 19 pairs of acrocentric autosomes. Of the sex chromosomes, the X is a large acrocentric and the Y is a small acrocentric. In addition, bacular characteristics, which are very important in the taxonomy of this species, were examined in samples from Turkish Thrace for the first time.

Key Words: *Apodemus agrarius*, Distribution, Taxonomy, Thrace, Turkey

Trakya'daki *Apodemus agrarius* (Pallas, 1771) (Mammalia: Rodentia)' un Taksonomisi ve Yayılışı

Özet: *Apodemus agrarius*'un Türkiye' deki taksonomik durumuna daha geniş bir perspektif sağlamak için, Trakya' dan 27 örneğin morfolojik ve karyolojik karakterleri, detaylı olarak çalışıldı ve bunlar literatürdeki verilerle karşılaştırıldı. İncelenen tüm örneklerde FN = 56 ve FNa = 54 olan 2n = 48 karyotip gözlendi. 2n = 48 karyotype üç çift metasentrik, bir çift submetasentrik ve 19 çift akrosentrik otozom içermektedir. Eşey kromozomlarından, X büyük bir akrosentrik ve Y küçük bir akrosentriktir. Ayrıca, bu türün taksonomisinde çok önemli olan bakulum karakterleri de Trakya örnekleri için ilk defa incelendi.

Anahtar Sözcükler: *Apodemus agrarius*, Yayılış, Taksonomi, Trakya, Türkiye

Introduction

The genus *Apodemus* Kaup, 1829 is one of the most widespread noncommensal rodent groups in the Palaearctic. Usually, the occurrence of six species of *Apodemus* has been credited to Turkey: *A. sylvaticus* Linnaeus, 1758; *A. agrarius* Pallas, 1771; *A. uralensis* Pallas, 1811; *A. flavicollis* Melchior, 1834; *A. mystacinus* Danford and Alston, 1877; and *A. hermonensis* Filippucci et al., 1989 (1). Although there have been other studies on Turkish *Apodemus* (1-4), little is known about the distribution and taxonomy of *Apodemus agrarius* in Turkey. The first record of *A. agrarius* in Turkey comes from the Belgrad Forest located on the European side of İstanbul (5). Subsequent studies revealed that the species is present in Kemerburgaz-İstanbul (6), İstanbul and Kırklareli (2) and İğneada-Kırklareli (7). According to reviews of mammals in this region, the species is common in Turkey (8,9).

Researchers mapping the distribution of *A. agrarius* in Europe stated that the species is receding from the western part of its distribution (10,11). On the other hand, zoogeographical studies from Greece and Bulgaria reported that the southern border of the distribution of *A. agrarius* suggests an expansion of the species towards

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Thessaloniki and surrounding areas where the River Nestos flows into the Aegean Sea (12). The same researchers have also suggested that this species might have a wider distribution in Bulgaria than was previously thought, and its distribution might extend into the European part of Turkey.

In this paper, we further analyse *A. agrarius* in the European part of Turkey. Our objectives are to describe the patterns of variation in external, skull, bacular and chromosomal characteristics using all available specimens of *A. agrarius* to provide a definitive statement concerning the taxonomic status of this species in Turkey and to contribute to the completion of the distribution map of Turkish populations.

Materials and Methods

This study was carried out on 27 specimens of *A. agrarius* collected between 1995 and 1996. The skins and bacula of the each specimen were prepared according to Mursaloğlu (13). Chromosome preparations were made on bone marrow according to Ford and Hamerton (14).

Chromosome identification was made directly under the microscope and chromosomes were recorded according to their sizes and shapes as outlined by Levan et al. (15). At least 50 cells were scored for chromosome number and at least 10 were fully analysed for precise chromosome composition.

For morphological comparisons, the criteria given by Doğramacı (2) were used to determine animal age, and four external and 11 skull characteristics were measured for all 27 adult specimens using watch-faced callipers with a sensitivity to one-tenth of a millimetre.

The stuffed skins, bacula and karyotype slides of all specimens examined in this study are now kept at the Biology Department of Arts and Sciences Faculty in Ondokuz Mayıs University.

Results

Apodemus agrarius (Pallas, 1771)

1771. *Mus agrarius* Pallas, Reise. Russ. Reichs, 1, s. 454.

Type locality: Simbirsky, edge of the River Volga, Russia.

Distribution in Turkey: See Figure 1.

Habitat in Turkey: Although it is mainly found in grassland and bush at the edge of damp forests, it is also found in the high grass by rivers and streams and within forests themselves.

Morphological Characteristics: Adult specimens of *A. agrarius* have upper parts that vary from yellowish brown to dark brown. A black line 1-2 cm in width stretches dorsally from just anterior to the ears to the base of the tail and is a defining character. The ventral side of the body is whitish smoky grey, but in young individuals the belly is blackish. There is a sharp demarcation line on flanks. The dorsal part of the tail is black and the ventral side is whitish with sparse hair, but these intergrade smoothly. The underside of the hind legs is black and bare

Figure 1. Collection localities in the European part of Turkey. 1: Kırklareli, İğneada; 2: Kırklareli, Demirköy; 3: İstanbul, Belgrad Forest and 4: İstanbul, Kemerburgaz. The dotted area shows the approximate distribution of *Apodemus agrarius* in the European part of Turkey.

and there are tubercules on each part of the foot where the nails project. The upper side of the hind legs is covered with hair similar to that on the underside of the body. Inside the ears the hair is similar in colour to that on the upper side of the body.

Baculum Characteristics: The baculum has an appearance of a knob when it is viewed dorsally and laterally, whereas it looks like a spoon with an inner hollow when it is viewed ventrally. The distal part of the baculum is broad in its dorsal, lateral and ventral aspects and gets thinner towards its proximal parts (Fig. 2).

Skull Characteristics: The skull is long and delicate. A bone extension starting from the point where interparietal and parietal bones join together makes an outward projection at the edge of the parietal and frontal bones. This fusion extends to the end of frontals. The weak zygomatic curves extend to the underside of the skull and pass the line of molar teeth. The front surface of the incisor teeth is wheat yellow and the back surface is white. The tympanic bullae are rather small. The measurements taken from the skulls are given in the Table.

Karyological Characteristics: The diploid chromosome number of our *A. agrarius* samples is 2n = 48. The fundamental chromosome arm number is FN = 56, while the autosome arm number is FNa = 54. Of the 23 pairs of autosomes, three are metacentric, one is submetacentric, and the remainder are acrocentric in different sizes. Of the sex chromosomes, the X is a large acrocentric and the Y is a small acrocentric (Fig. 3).

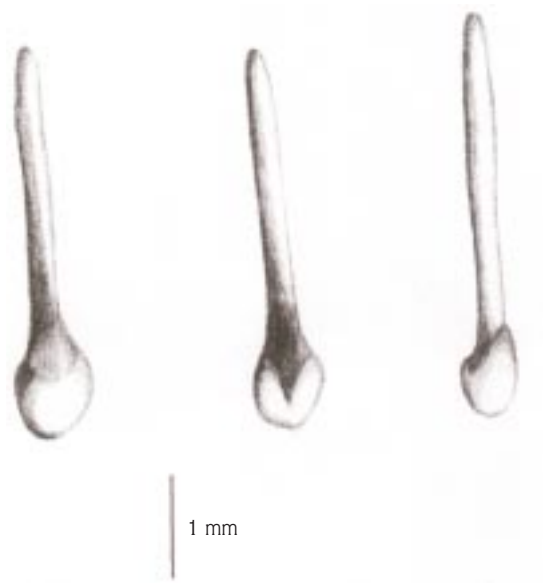

Figure 2. Baculum of *Apodemus agrarius* from İğneada a: dorsal view, b: ventral view, c: lateral view.

Discussion

The first report of *A. agrarius* in Turkey involved data collected by Kahmann (5) from Belgrad Forest. In contrast, Malec and Storch (16) suggested that these samples belong to *Apodemus agrarius kahmanni* Malec and Storch, 1963. In a later study, Osborn (6) collected some specimens from Kemerburgaz and assigned them to *A. agrarius*. Doğramacı (2), who has done the most detailed research on Turkish *Apodemus*, compared six external and 11 internal characteristics of nine *A. agrarius* specimens collected from İstanbul and Kırklareli with those given by Kahmann (5) and Osborn (6) and found no difference. Furthermore, when Doğramacı (2) compared his morphological data both with those given by Malec and Storch (16) for the type and the paratype specimens of *A. a. kahmanni* and with those of Ondrias (17) for Greek *A. a. kahmanni* samples, he concluded that the Turkish samples were morphologically similar. This finding led him to suggest that *A. a. kahmanni* is distributed in Turkey.

Table. Measurements of cranial and external characters of *Apodemus agrarius* (n = 27).

Measurements taken	Min-Max	Mean	Standard deviation
Head and body length	107-126	115.70	5.32
Total length	178-207	195.05	8.70
Tail length	68-85	78.10	4.50
Hind foot length	19-22	20.85	0.68
Ear length	13-15	13.75	0.60
Weight (g)	33-45	39.20	2.85
Upper left molar length	3.90-4.65	4.35	0.11
Occipitonasal length	25.65-28.05	27.55	0.45
Palatal foramen length	4.05-4.70	4.55	0.15
Basilar length	21.10-22.00	21.55	0.26
Zygomatic breadth	12.95-13.55	13.15	0.35
Interorbital breadth	4.35-4.55	4.40	0.18
Palatiler length	11.85-12.05	11.80	0.24
Condylobasal length	25.80-26.50	25.75	0.35
Diastema length	7.45-7.75	7.60	0.14
Baculum length	3.65-3.75	3.72	0.04

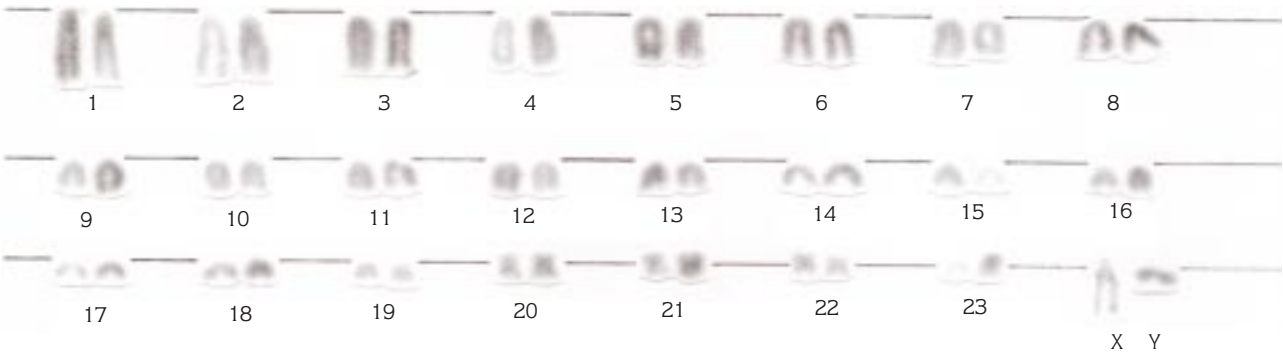

Figure 3. Karyotype of male *Apodemus agrarius* collected in İğneada-Kırklareli (2n = 48).

When *A. agrarius* samples collected from the localities in Figure 1 were compared both among themselves and with data from the literature, no significant statistical difference was found, suggesting that *A. agrarius* (i.e. *A. a. kahmanni*) occurs in the European part of Turkey.

In all studies on the karyology of *A. agrarius* from Yugoslavia (18), Czechoslovakia, Poland and Hungary (19,20), Romania (21,22), and Siberia and the Far East (23,24), the diploid chromosome number, fundamental chromosome arm number and autosome arm number were reported to be 2n = 48, FN = 56 and FNa = 54, respectively. A standard karyotype consisting of 19 pairs of acrocentric and four pairs of biarmed autosomes was also reported. Both sex chromosomes, X being bigger, were described as acrocentric in these studies. The basic common finding in these studies is that four pairs of biarmed autosomes are always found in the karyotype despite the fact that a karyotype with three pairs of biarmed chromosomes and 20 pairs of acrocentric chromosomes (FNa = 52) was reported for populations from Bosnia (18) and Moldovia (21). Furthermore, Yiğit et al. (7) reported a karyotype with one pair of subtelocentric, four pairs of metacentric and 18 pairs of acrocentric chromosomes (FNa = 56) for populations from İğneada-Kırklareli, Turkey.

When the karyotype of *A. agrarius* in Figure 3 is compared with those given for specimens from the countries mentioned above, it is apparent that our result is in agreement with those previously presented, with the exceptions of the karyotypes reported from Bosnia and Moldovia and for that given for İğneada-Kırklareli populations. Considering the karyotype of *A. a. kahmanni*, which is distributed in Yugoslavia and Romania, the reason for the karyotypic difference observed in populations from Bosnia and Moldovia may reflect karyotypic polymorphism or polytypy. Moreover, some discrepancy in the autosome morphology is observed between the karyotype given here and that described in a hand-drawn ideogram for İğneada-Kırklareli populations by Yiğit et al. (7), who distinguished the biggest chromosome in Figure 3 as biarmed and reported NFa = 56. None of the animals, including 10 individuals from İğneada-Kırklareli, examined in the present study had this biarmed chromosome in their karyotypes. Given that karyotypic variability within the genus *Apodemus* is well documented, such that all species carry 48 chromosomes but differ in NFa number due to pericentric inversions (19,25,26), the karyotype given by Yiğit et al. (7) may be representative of one of the karyological forms of *A. agrarius* in Turkey. In order to make a correct interpretation of the chromosomal evolution in Turkish *Apodemus* populations, comparative banded chromosome analysis is needed.

The distribution of *A. agrarius* in Europe has receded at its western border apparently due to habitat destruction by humans, although there is no such problem in areas around the eastern border of the species (10,11). Kahmann (5) has stated that *A. agrarius* is distributed in the damp forest areas of Thrace facing the Black Sea. Özkan (27) has stated that the species does not exist in Edirne and its surroundings due to a lack of suitable habitats. The researchers studying the distribution of *A. agrarius* in Greece and Bulgaria (12,28) have suggested that the southern border of the species is the area where the River Nestos (Greece) flows into the Aegean Sea, and that the species, which is widely distributed in Bulgaria, might also exist both on the Bulgarian and Turkish sides of the River Tunca (Tundza).

Our current knowledge based on field trips over all the recorded distribution areas of *A. agrarius* in Turkey supports the suggestion by Özkan (27) that this species has a restricted distribution area and is only found in specific habitats in the European part of Turkey.

The fact that *A. agrarius* is distributed in the area between the Caspian Sea and Caucasus Mountains (8) suggests the idea that this species may exist in Asian Turkey. However, some eastern localities, such as Artvin, Ardanuç, Hopa and Kars, which are located near the Caucasus, have also been visited on two occasions and no trace of *A. agrarius* has been found in these places. The absence of *A. agrarius* in Asian Turkey is consistent with Filippucci et al. (1) and Macholan et al. (4), who collected data from seven and 11 localities in Asian Turkey, respectively. Thus, it has become evident that *A. agrarius* has a limited distribution only in Turkish Thrace and any attempt to increase its western and eastern range through Anatolia has been hindered by the Bosphorous in the west and by the Caucasus Mountains in the east. To the east, the Caucasus barrier is thought to be an important factor in structuring and limiting the distributions of many other species, including the crested newt (*Triturus karelini*) (29), the Caucasian salamander (*Mertensiella caucasica*) (30) and the white-breasted hedgehog (*Erinaceus concolor*) (31).

Specimens examined (n), with localities and coordinates: Kırklareli: İğneada, 4 km S. (n = 10, lat 41°53'N, long 27°59'E), Kırklareli: Demirköy (n = 5, lat 41°49'N long 27°47'E), İstanbul: Belgrad Forest (n = 7, lat 41°22'N, long 28°22'E) and İstanbul: Kemerburgaz (n = 5, lat 41°10'N, long 28°55'E).

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