

The Taxonomy and Karyology of *Rattus norvegicus* (Berkenhout, 1769) and *Rattus rattus* (Linnaeus, 1758) (Rodentia: Muridae) in Turkey

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Abstract: In this study, the Turkish population of *Rattus norvegicus* and *Rattus rattus* were studied with regard to external, cranial, phalli, bacula and tooth crown morphology and karyotype. External, internal and karyologic characteristics of *R. norvegicus* were found to be consistent with previously published results. Additionally, it was determined that there are striking color variations in the dorsal and ventral fur of *R. rattus* and that crown morphology is not a definitive characteristic distinguishing these species because of connected lobes in old specimens. According to the karyological studies, the diploid chromosome numbers and fundamental numbers of *R. norvegicus* and *R. rattus* were found to be 42, 38 and 64, 60, respectively.

Key Words: *Rattus norvegicus*, *Rattus rattus*, taxonomy, Turkey.

Türkiye'deki *Rattus norvegicus* (Berkenhout, 1769) and *Rattus rattus* (Linnaeus, 1758)'ün (Rodentia: Muridae) Taksonomisi ve Karyolojisi

Özet: Bu çalışmada, *Rattus norvegicus* ve *Rattus rattus*'ün Türkiye populasyonları eksternal, kranial, fallus, bakulum, diş morfolojileri ve karyolojileri dikkate alınarak araştırıldı. *R. norvegicus*'ün eksternal, internal ve karyolojik karakterlerinin literatüre tamamen uyduğu saptandı. Ayrıca *R. rattus*'ün dorsal ve ventral kürkünde çok değişik renk varyasyonların bulunduğu ve yaşlı örneklerde diş loblarının birleşmesi nedeniyle diş morfolojisinin bu iki türün ayırımında belirleyici bir karakter olmadığı belirlendi. Karyolojik çalışmalarda *R. norvegicus* ve *R. rattus*'ün diploid ve temel kromozom kol sayılarının sırasıyla 42, 38 ve 64, 60 olduğu bulundu.

Anahtar Sözcükler: *Rattus norvegicus*, *Rattus rattus*, taksonomi, Türkiye.

Introduction

The genus *Rattus* has been defined as a widely distributed and taxonomically mixed group including many species and subspecies throughout the world (1, 2, 3, 4). In the palaeartic region, Ellerman and Morrison-Scoott (1) identified three subspecies for *R. norvegicus* (Berkenhout, 1769) and 52 subspecies for *R. rattus* (Linn., 1758). Vinogradov and Argyropulo (2) stated that three species belonging to this genus, *R. norvegicus*, *R. rattus* and *R. turkestanicus* Satunin, 1902, range across Caucasia. In addition, according to Harrison and Bates (4), the only rats occupying Arabia are *R. norvegicus* and *R. rattus*. Apart from these reviews, several karyological studies on this genus have been conducted in eastern and south-eastern Asia by Yong (5), Yosida et al., (6), Yosida and Sagai (7), Yosida (8) and Cao and Tran (9), and in

Europe by the committee for the standardized karyotype of *R. norvegicus* (10), Vistorin et al., (11), Gamperl (12), Diaz de la Guardia et al., (13), Capanna et al., (14) Capanna and Civitelli (15) and Gropp et al. (16). In western Asia, however, karyological studies on this genus are very scanty. Only a few distribution records from Turkey exist, by Aharoni (17), Neuhauser (18) and Lehmann (19). Additionally, distribution records on *R. norvegicus* and *R. rattus* recorded from areas neighboring Turkey have been provided by Misonne (20), Bodenheimer (21), Hatt (22), Ondrias (23) and Lay (24). At present, data on the taxonomy and karyology of both species mentioned above is insufficient. In this preliminary study, the karyotypes, phalli and bacula of these species are described from Turkey for the first time. Thus, the aim of this study was to provide current

information on the distribution and karyological records and comparative materials on *R. norvegicus* and *R. rattus*, and to contribute to further investigations.

Material and Method

Specimens (14♂, 11♀) were collected from various localities in Turkey and examined with regard to morphological, biometrical and karyological characteristics. Specimens were caught with snap and Sherman live traps, and live specimens were transferred to the laboratory, where they were kept one to a cage for karyological studies. The localities of rats captured are shown in figure 1. External and cranial character measurements (mm) and weight (gr.) were taken for all specimens (nail length was included in hindfoot measurement), and all specimens were skinned in the standard museum manner. The skulls and bacula were carefully drawn under binoculars in order to examine and compare morphological structures. Karyological preparations were performed in accordance with Patton (25). A total of 10 to 20 slides were prepared for each rat specimen karyotyped, and at least 30 well-spread metaphase cells from each preparation were analyzed. The skins, skulls and karyotype preparations were deposited at the University of Ankara, Faculty of Science.

Results

Genus *Rattus* Fischer, 1803

1803. *Rattus* Fischer, Das National-mus. Naturg. Paris.2: 128.

Key to Turkish species of The Genus *Rattus*

1. The tail is always shorter than head and body length, ears do not reach the eyes when laid forwards. Temporal ridges on braincase are almost parallel. The occipital condyles are the most posteriorly projecting point of the skull. The diploid chromosome number is 42.

..... *Rattus norvegicus*, Norway rat, Brown rat.

2. The tail length is always greater than head and body length. When the ears are drawn forward, they reach the eyes and usually cover them. The temporal ridge is almost convex. The median occipital ridge is the most posteriorly projecting point of skull.

The diploid chromosome number is 38.

..... *Rattus rattus*, Black rat.

Rattus norvegicus (Berkenhout, 1769)

1769. *Mus norvegicus* Berkenhout, Outlines Nat. Hist. Great Britain and Ireland, 1: 5. Great Britain.

External characteristics: This species is generally robust and heavily built. The tail length is always less than head and body length in adult specimens, and sometimes equal to head and body length in young specimens. The ear is short and, when drawn forward, does not reach the eyes. External measurements are shown in Table 1. Dorsal fur color varies slightly from dark brownish to ochre, and the dorsal hair bases are grayish. Tail slightly bicolored and covered with short, sparse, dirty, whitish hairs. The outer and inner surfaces of ears are covered with short, sparse, blackish hairs. The upper sides of both

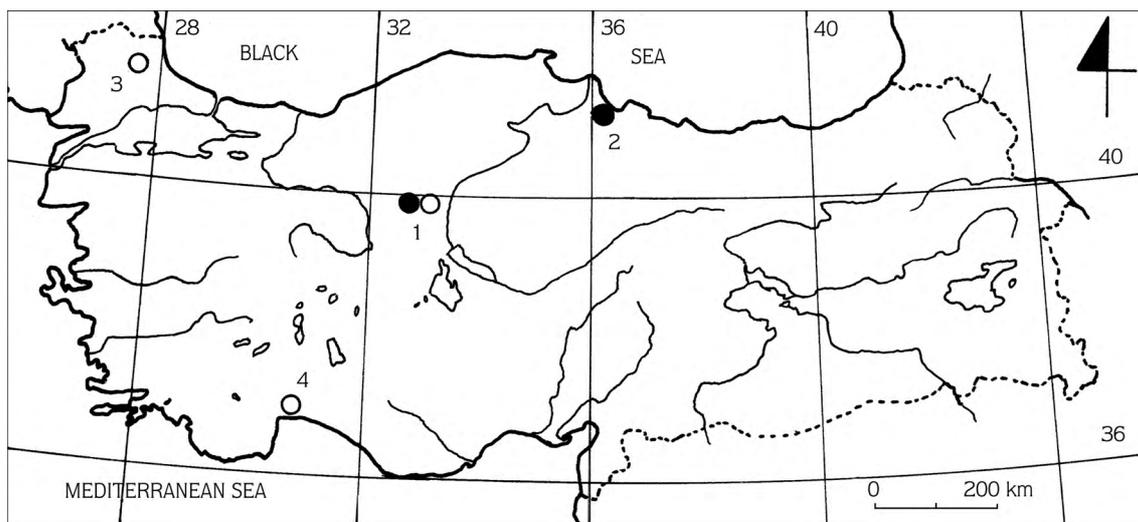


Figure 1. Collecting localities of *R. norvegicus* (●) and *R. rattus* (○) in Turkey. 1. Ankara., 2. Samsun, 3. Demirköy/Kırklareli, 4. Akseki/Antalya.

the fove and hind feet are covered with tiny whitish hairs, the nail is pigmented, and the soles of the fore and hind feet are completely naked.

The hairs on ventral fur are white but the bases are grayish. The line of demarcation along the flanks is fairly distinct. *Rattus norvegicus* has 12 mammae (2 pairs pectoral, 1 pair abdominal, 3 pairs inguinal).

Cranial characteristics: The skull is considerably robust, the braincase is narrow and elongated. The rostrum is moderately long and the nasals are rounded off posteriorly. The cranial measurements are given in Table 1. The parietals and interparietal are bordered by ridges which are straight and almost parallel (Fig. 2a). The squamosal and maxillary process of the zygomatic arc

are laterally widened. The lacrimals project slightly from behind the infraorbital foramen, which is laterally and vertically broadened. The supraoccipital is nearly vertical, and the exoccipital condyles form the most posteriorly projecting point of the skull in this species (Fig. 2a). The incisiva foramina is of moderate size, just reaching the front of M¹, and the post-palatal foramina is point-sized. The tip of pterygoid process does not closely touch the anterior parts of tympanic bullae. The posterior margin of the palate is situated considerably posterior to the line connecting the posterior margin of M³ (Fig. 2b). The mandible is also robust and its coronoid process is markedly separated from the condyloid process. Upper incisors are straight, and the anterior surfaces are smooth without any grooves and colored orange. The

Table 1. External and cranial character measurements of *R. norvegicus* and *R. rattus* (adults), SD: Standart deviation.

Characters (mm)	Rattus rattus									
	Rattus norvegicus		Blackish Ankara		Brownish Ankara		Brownish Demirköy		Brownish Antaya	
	n	Mean ± SD	n	Mean ± SD	n	Mean ± SD	n	Mean ± SD	n	Mean ± SD
Total length	8	405±54.70	5	365±23.7	4	344.5±22.29	4	372.5±2.88	4	418.3±40.10
Head and body	8	217.25±41.43	5	168.2±0.78	4	171.75±8.18	4	181.7±3.30	4	190±18.00
Tail length	8	187.37±22.32	5	199.8±14.8	4	192.75±17.23	4	190.7±0.95	4	228.3±22.18
Hind foot	8	43.00±3.07	5	35.0±1	4	35.25±2.87	4	35.75±0.95	4	38.3±3.2
Ear length	8	22.25±0.70	5	23.2±1.09	4	22.5±0.57	4	22.5±0.57	4	23.3±3.51
Weight (g)	8	259±85.2	5	116.2±10.08	4	117.25±12.25	4	125±38.72	4	159.±52.08
Zygomatic breadth	8	23.75±2.46	5	18.94±0.53	4	18.7±0.6	4	19.62±1.35	4	21.26±1.68
Interorbital constriction	8	5.55±0.54	5	5.18±0.42	4	5.32±0.27	4	5.7±0.14	4	5.73±0.77
Condylobasal length	8	45.52±3.21	5	37.36±0.61	4	37.5±0.98	4	37.7±1.80	4	42.25±3.04
Occipitonasal length	8	47.61±3.46	5	39.48±0.72	4	39.6±0.92	4	39.4±1.85	4	44.2±3.25
Basal length	8	42.63±3.31	5	35.18±0.70	4	34.7±1.13	4	35.0±1.97	4	39.6±3.39
Nasal length	8	18.23±1.56	5	14.3±0.32	4	14.2±0.16	4	14.2±1.19	4	15.2±1.20
Frontal length	8	15.21±1.60	5	12.9±0.72	4	13.4±0.14	4	12.5±0.77	4	13.93±1.28
Parietal length	8	7.66±0.88	5	7.34±0.43	4	7.42±0.05	4	7.1±0.24	4	8.36±1.67
Length of facial region	8	24.93±1.60	5	20.98±0.61	4	21.37±0.17	4	20.85±1.21	4	21.8±0.79
Length of brain case	8	21.4±1.47	5	17.82±0.60	4	18.37±0.37	4	17.17±1.12	4	20.2±0.95
Mastoid breadth	8	14.72±1.07	5	11.96±0.40	4	12.2±0.80	4	11.5±0.34	4	12.7±0.36
Skull height	8	14.76±0.82	5	12.8±0.38	4	12.8±0.29	4	13.42±0.67	4	13.53±6.18
Occipital width	8	18.43±1.11	5	15.6±0.29	4	15.37±0.37	4	16.02±0.78	4	16.96±0.89
Braincase width	8	16.73±0.51	5	16.02±0.66	4	15.95±0.23	4	16.5±0.42	4	17.16±0.66
Diastema length	8	13.68±1.13	5	10.66±0.79	4	10.3±0.42	4	10.77±0.74	4	11.66±0.80
Palatal length	8	22.22±1.18	5	17.92±0.63	4	17.55±0.53	4	18.07±0.96	4	19.26±1.17
Foraman incisiva	8	7.68±0.66	5	7.16±0.61	4	6.72±0.23	4	7.17±0.28	4	7.86±0.05
Length of tympanic bulae	8	7.46±0.45	5	6.94±0.31	4	6.87±0.15	4	6.87±0.15	4	7.26±0.56
Width of tympanic bullae	8	6.03±0.21	5	6.2±0.29	4	6.15±0.05	4	5.95±0.44	4	6.36±0.25
Mandible	8	28.13±2.25	5	22.62±1.16	4	22.62±0.51	4	22.7±1.31	4	24.13±3.85
Maxillary tooth row	8	7.35±0.6	5	6.62±0.19	4	6.72±0.09	4	6.72±0.25	4	7.1±0.5
Mandibular tooth row	8	7.26±0.32	5	6.48±0.27	4	6.47±0.20	4	6.2±0.11	4	6.66±0.11

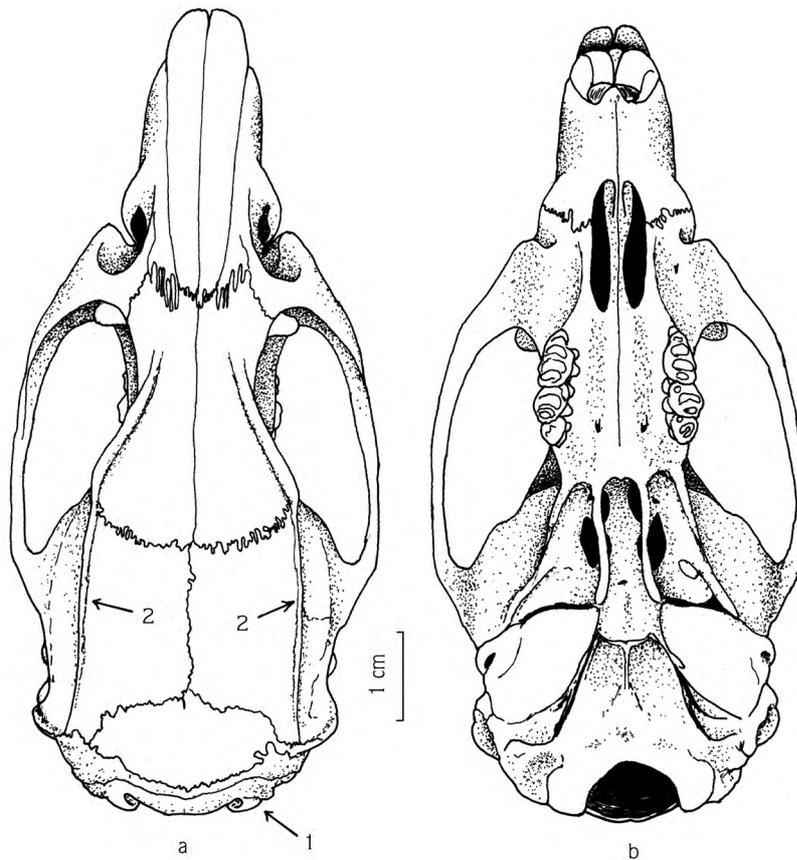


Figure 2. The skull of *R. norvegicus*. a. Dorsal view, b. Ventral view, 1. Occipital condyles, 2. Parietal and interparietal ridges.

molar surfaces are highly variable according to age. In young and adult specimens, the main lobes of the molar surfaces are in M^1 with 3; M_1 with 4; M^2 and M_2 with 3; M^3 with 3; M_3 with 2. These lobes might connect with each other during the aging process, and the external tubercle on the first lobe of M^1 is absent (Fig. 3 a, b, c). M^1 and M_1 molars have five roots, M^2 and M_2 molars have four, and M^3 and M_3 molars have three.

Phallus: Stick-shaped and covered with small spines (Fig. 4 a, b, c).

Baculum: Composed of two main parts, distal and proximal. The distal part is cartilaginous, usually deformed by preparation, and the proximal is osseous. The osseous baculum is also composed of two parts, the first being the base, which is triangular, with deep debris on its underside, and the second being the shaft (Fig. 5 a, b, c, d).

Karyology: The diploid number of chromosomes is $2n=42$. Autosomes consist of 18 metacentric, submetacentric, 4 subtelocentric and 20 acrocentric chromosomes. The X and the Y chromosomes are acrocentric. The fundamental number (FN) is 64 (Fig 6).

Specimens examined: Ankara 6 (4 ♂, 2 ♀), Samsun 2 (1 ♀, 1 ♂).

Rattus rattus (Linnaeus, 1758)

1758. *Mus rattus* Linnaeus, Systema Naturae 10 th ed., 1: 61., Sweden.

External characters: This rat is slenderly built and has sharp color variations in both dorsal and ventral furs. The tail always exceeds the head and body in length. The external measurements are presented in Table 1. When the ear is drawn forward, it reaches the eyes and usually exceeds them. The dorsal colors are extremely variable, from dark, bright blackish to dark brownish speckled with black and white hairs. In this study, we determined four main colorations in this species. The first type, has a dark, slate blackish dorsal fur and grayish ventral fur, and is also referred to as *R. rattus rattus*. The second type, has dark brownish dorsal fur with yellowish white ventral fur, and is known as *R. rattus elaxandrinus*. The first and the second types coexistently occur in the province of Ankara. The third type, caught in Demirköy in European Turkey, is dorsally the same as in the second type, but the

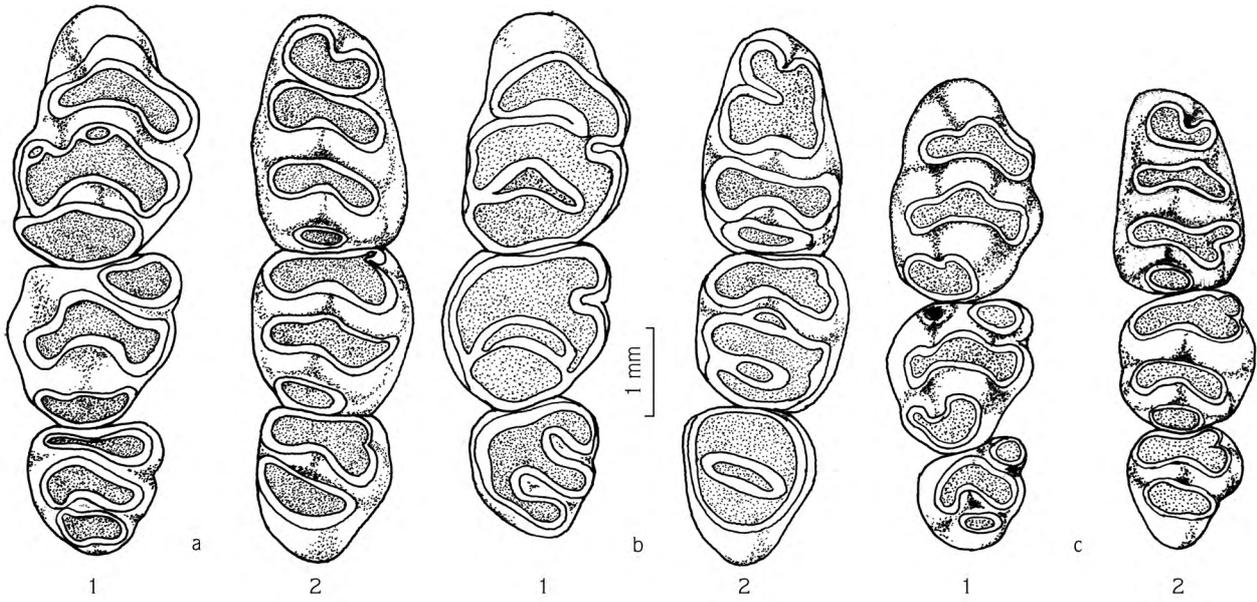


Figure 3. The molar surface of *R. norvegicus* and *R. rattus*. a. *R. norvegicus* (adult), b. *R. norvegicus* (old), c. *R. rattus* (adult). 1. Upper molar row, 2. Lower molar row.

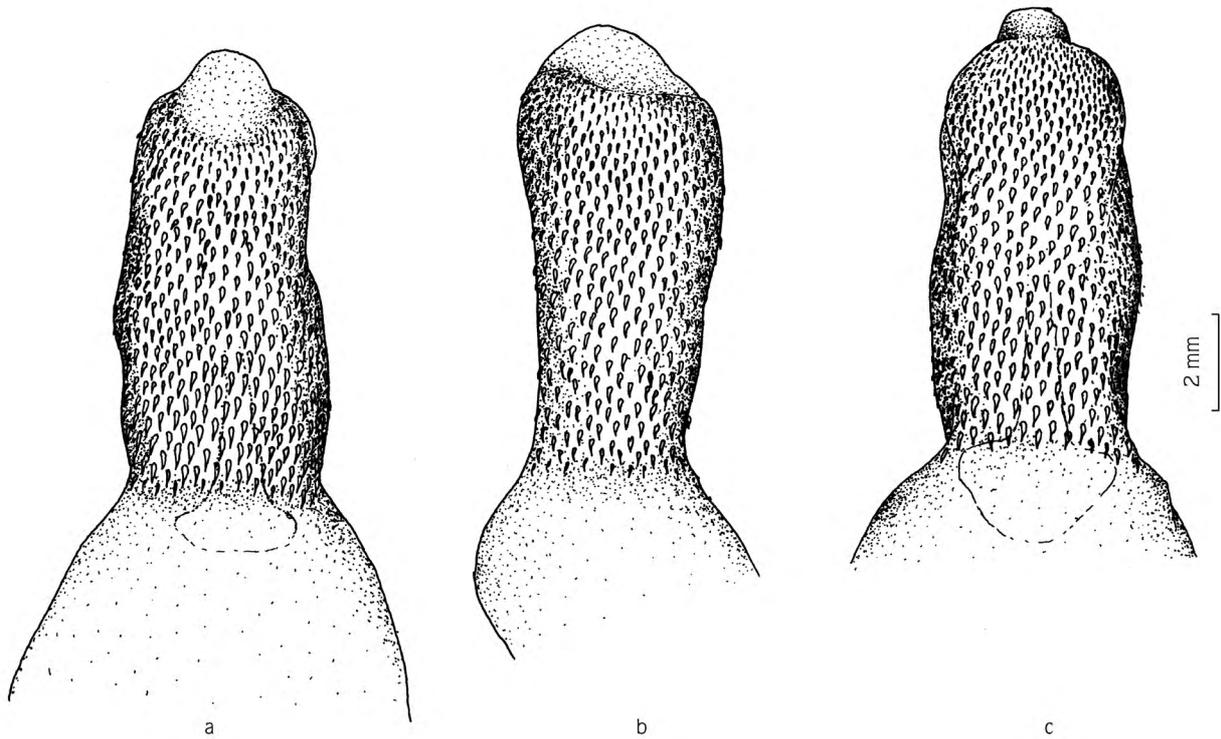


Figure 4. The phallus of *R. norvegicus*. a. Dorsal view, b. Lateral view, c. Ventral view.

ventral fur is light grayish and the upper sides of the feet are pale brownish, and it is referred to as *R. r. alexandrinus*. In these three types, the hair bases of dorsal and ventral furs are grayish. The fourth type,

which is dorsally similar to the second and the third types, has ventral fur that is pure white, was caught in the coastal areas of southern Turkey, and is referred to as *R. rattus frugivorus*. In the first type, the tail and the ear are

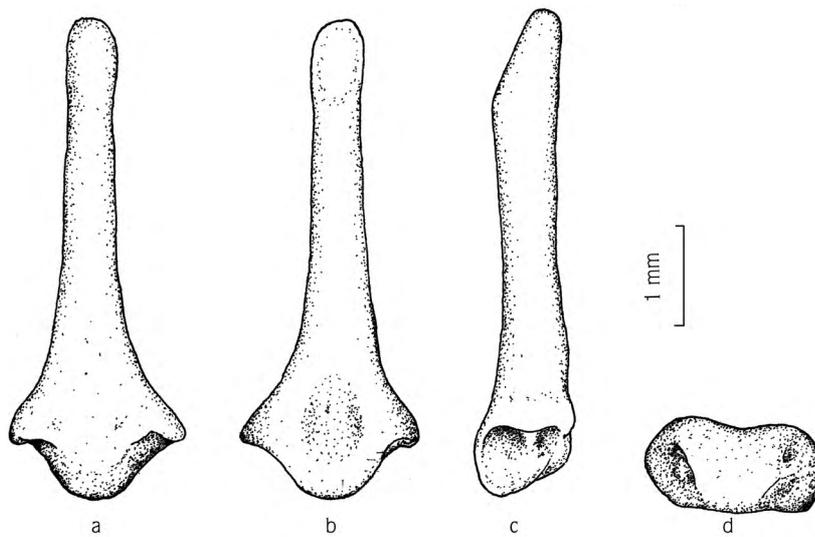


Figure 5. The baculum of *R. norvegicus*. a. Dorsal view, b. Ventral view, c. Lateral view, d. Basal view.



Figure 6. The karyotype of *R. norvegicus* (male). $2n=42$, FN=64.

uniformly covered with short, sparse blackish hairs, the dorsal color grows paler toward the flanks, but the line of demarcation along the flanks is not very distinct. The upper sides of both fore and hind feet are covered with tiny whitish and brownish hairs, and the soles are completely naked. In the second type, the median line on the dorsal fur is darker than the flanks, which are yellowish gray, the tail is sparsely covered with tiny whitish hairs, and the fore and hind feet are the same as in the first type. Unlike in the first type, the line of demarcation along the flanks is distinct in the second and the third types. In the fourth type, the tail is same as in the second type, and the upper parts of fore and hind feet are covered with tiny pale prawnish hairs. The line of

demarcation along the flanks is fairly distinct.

Cranial characteristics: There is no difference in cranial characteristics among specimens in Asiatic and European Turkey. The skull is of intermediate size and the braincase is slightly broad. The general features are the same as in *R. norvegicus*, but the parietal and the interparietal bones are bordered by ridges which are almost convex. The braincase is not smooth, and is rounded and downward-curved laterally, and posteriorly at the level of the parietal and the interparietal bones. The median ridge on the supraoccipital bone protrudes forward and the exoccipital condyles are behind the supraoccipital, which is why the posterior tip of the occipital condyles is not seen in the planar view of the

skull (Fig. 7a). The foramen incisiva is relatively longer than in *R. norvegicus*, but the post foramen incisiva is the same as in previous species. The tip of pterygoid process does not touch the anterior tip of the tympanic bullae (Fig. 7b). The upper incisors are straight, and the anterior surfaces are smooth and colored orange. The molar morphology varies from young to old specimens. Depending on the tooth wear, the lobes are generally not well marked, and are connected, especially in aged specimens. Molar morphology is usually similar to that of *R. norvegicus*, with a few slight differences. The only difference is the presence of an anterior tubercle on the first cup of M¹. The roots are the same as in the previous species.

Phallus: The phallus is similar to that of *R. norvegicus* (Fig. 4 a, b, c).

Baculum: The baculum is generally the same as in *R. norvegicus*, the base distinctly protrudes laterally, and there is a deep depression in its under side (Fig. 8 a, b, c, d).

Karyology: The diploid chromosome number is $2n=38$ in specimens from both Asiatic and European Turkey. The karyotype is composed of 18 metacentric/submetacentric, 4 subtelocentric and 16 acrocentric chromosomes. The X and the Y chromosomes are acrocentric. The fundamental number (FN) is 60 (Fig. 9).

Specimens examined: Ankara 9 (4♂, 5♀); Demirköy/Kırklareli 4 (3♂, 1♀); Akseki/Antalya 4 (2♂, 2♀).

Discussion

R. norvegicus: In the present study, both external and cranial character measurements are mostly consistent with Miller (26), Vinogradov and Argyropulo (2), Ondrias (23), Corbet (3), Harrison (27) and Harrison and Bates (4). Additionally, Harrison (27) stated that the exoccipital condyles form the most posteriorly projecting point of the skull. This feature was similarly found in Turkish specimens, and it was declared to be one of the most important cranial characters distinguishing *R. norvegicus* from *R. rattus*. Yong (5) and Yosida (8) found that the diploid number of *R. norvegicus* is 42, and is composed of 4 pairs of submetacentric, 7 pairs of metacentrics and 10 pairs of acrocentrics, and that the X and the Y chromosomes are acrocentric. Our karyological findings are consistent with findings reported by the Committee for a standardized karyotype of *Rattus norvegicus* (10), Yong (5), Diaz de la Guardia (13), Yosida (8), Gamperl (12) and Cao and Tran (9).

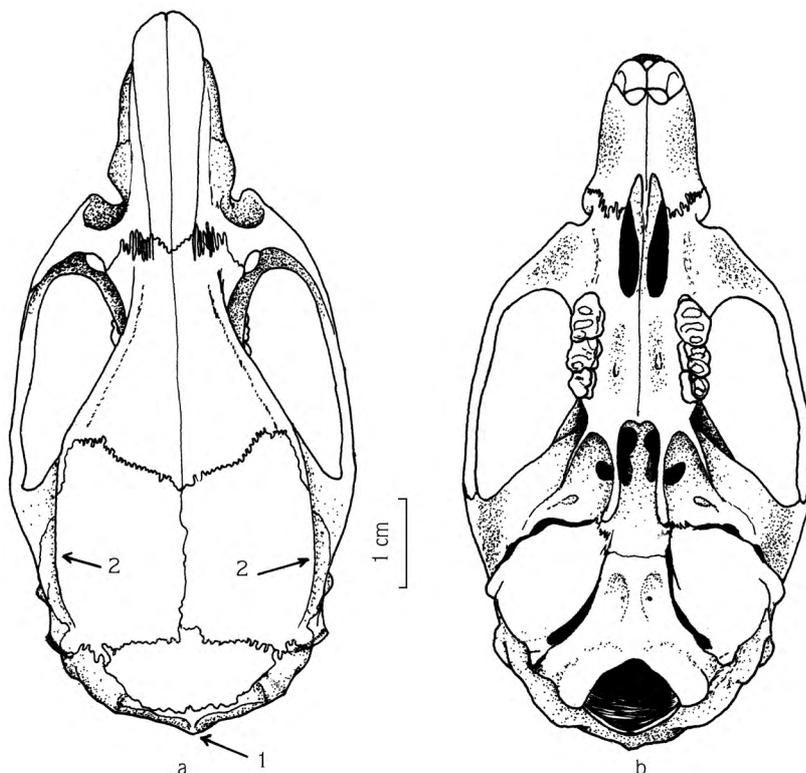


Figure 7. The skull of *R. rattus*. a. Dorsal view, b. Ventral view. 1. Supraoccipital ridges, 2. parietal and interparietal ridges.

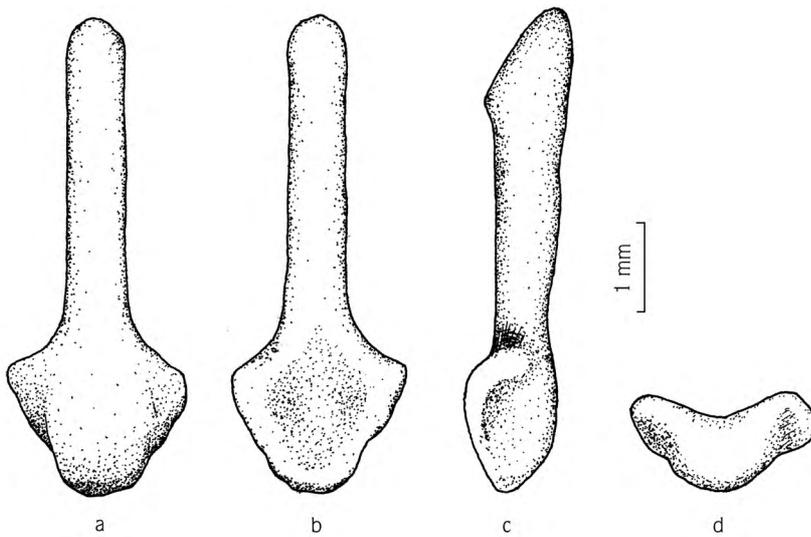


Figure 8. The baculum of *R. rattus*. a. Dorsal view, b. Ventral view, c. Lateral view, d. Basal view.

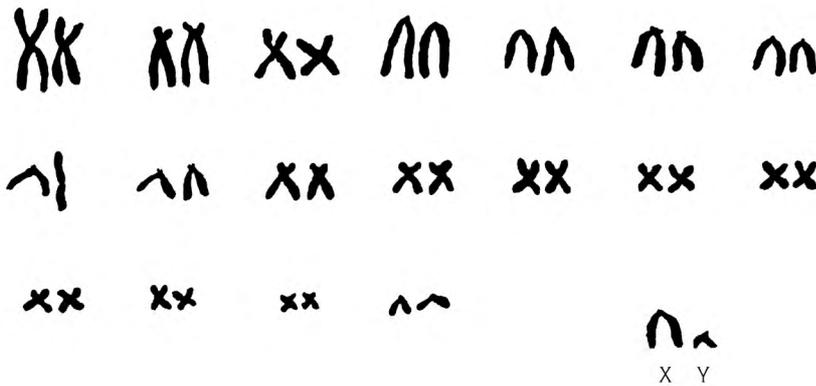


Figure 9. The karyotype of *R. rattus* (male). $2n=38$, $F=60$.

R. rattus: Miller (26) stated that there are two main color types in *R. rattus*: the first is *R. r. rattus*, which is dark slaty, turning almost blackish on back, and the second is *R. r. alexandrinus*, which is light brown above. However, these color types are assigned to different subspecies of *R. rattus*, and all intermediate stages exist between the two color types. These findings have been described by Vinogradov and Argyropulo (2), Ondrias (23), Harrison (27) and Harrison and Bates (4). These two main dorsal colors were similarly detected in Turkish specimens. Additionally, Ondrias (23) described two subspecies form Greece as *R. r. alexandrinus* and *R. r. frugivorus*. Our specimens from European Turkey are consistent with *R. r. alexandrinus* with respect to dorsal and ventral coloration, being dorsally dark gray to brown and ventrally grayish or slate grayish, as described by Miller (26) and Ondrias (23). On the other hand, Harrison and Bates (4) have suggested that specimens of *R. r. alexandrinus* from Arabia have whitish gray or yellowish ventral coloration. These descriptions are the same as in

specimens (the second type) from Asiatic Turkey. These findings show that specimens with two different color variations on ventral fur are assigned to the same subspecies, *R. r. alexandrinus*. Harrison and Bates (4) suggested that all these forms are color phases, and rejecting subspecies in this taxon. Unlike Miller (26), we did not find intermediate stages in our specimens comprising both color types. In addition to these two main dorsal color types, four different ventral fur colors were found in Turkish specimens. The fourth type, ventrally pure white, has been previously recorded from the same region in a separate taxon as *R. frugivorus* by Neuhauser (18). This taxon was considered to be a subspecies of *R. rattus* in reviews by Ellerman and Morrison-Scoot (1), Ondrias (23), Harrison (27) and Corbet (3). Our descriptions of the dorsal fur coloration of *R. r. frugivorus* are exactly consistent with Harrison (27). In this study, these specimens were considered to be a valid subspecies. The subspecies statuses of the first and the second types are unclear because of their coexistent

occurrence. According to Yosida et al. (6), there are two different karyotypic morphologies in *Rattus rattus*: the first, with $2n=38$, occurs in west India, west Asia, Europe, north and south America and Australia, and the second, with $2n=42$, ranges to East and Southeast Asia. Yosida et al. (6) called the first karyologic type Oceanian. Capanna and Civitelli (15) stated that the Australian and South-American populations, with 38 chromosomes, originated from an invasion of black rats from the European continent via sea traffic. Capanna et al. (14), Capanna and Civitelli (15), Gropp et al. (16) and Vistorin et al. (11) stated that the diploid number of chromosomes is 38, and that the autosomal set contains 9 metacentric, 2 subtelocentric and 7 acrocentric pairs,

and that both sex chromosomes are acrocentric in the *R. rattus* population occurring in Europe. Yosida et al. (6) found that Oceanic types are characterized by the presence of two large metacentric pairs. Yosida and Sagai (7) suggested that these two large metacentric pairs were derived by Robertsonian fusion of acrocentrics. The two large metacentric chromosome pairs were similarly found in the *R. rattus* population occurring in both Asiatic and European Turkey. Additionally, the autosomal set and sex chromosomes in Turkish populations are consistent with the findings of the above researchers.

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