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Morphological and Biometrical Comparisons of *Mesocricetus* Nehring, 1898 (Mammalia: Rodentia) species distributed in the Palaearctic Region

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Abstract: Currently, 4 species, *Mesocricetus auratus*, *Mesocricetus raddei*, *Mesocricetus newtoni*, and *Mesocricetus brandti* of the genus *Mesocricetus* are accepted as the valid taxa based on karyotype and morphologic features. A potential fifth species, *Mesocricetus nigriculus*, is under dispute and is currently listed as a subspecies of *M. raddei*, along with *Mesocricetus raddei raddei* and *Mesocricetus raddei avaricus*. UPGMA cluster analyses performed with biometrical measures confirm, only partially, the common separation of *Mesocricetus* hamsters into a Transcaucasian group with *Mesocricetus newtoni*, *Mesocricetus brandti*, and *Mesocricetus auratus*, and a Ciscaucasian group including the *M. raddei* subspecies. The status of *M. nigriculus* could not be resolved by these analyses. Biometric measurements group *M. nigriculus* and *M. auratus* together. *M. raddei* were found to be the most divergent species according to its biometrical characteristics. In addition to this, there are no morphologic or biometric differences in the subspecies level between *M. r. raddei* and *M. r. avaricus;* however, the differences among taxa might be explained by the fact that the species inhabits mountainous areas and that body measures and coloration reflect ecological adaptation more than true phylogenetic position. Morphometric data revealed an increasing similarity in *M. brandti* from the eastern to the western part of its range. *M. newtoni* proved to be an intermediary between *M. auratus* and *M. brandti*.

Key Words: *Mesocricetus* spp, morphology, UPGM cluster, Palaearctic region

Paleartik Bölgede Yayılış Yapan *Mesocricetus* Nehring, 1898 (Mammalia: Rodentia) Türlerinin Morfolojik ve Biyometrik Karşılaştırılması

Özet: Günümüzde bu *Mesocricetus* cinsinin 4 türü "*Mesocricetus auratus*, *Mesocricetus raddei*, *Mesocricetus newtoni* ve *Mesocricetus brandti*" karyolojik ve morfolojik özellikleri dikkate alınarak gecerli taksonlar olarak dikkate alınmaktadır. Cinsin beşinci türü "*Mesocricetus nigriculus*" tartışmalı olup *Mesocricetus raddei raddei* ve *Mesocricetus raddei avaricus*'la birlikte *M. raddei*'nin bir alttürü olarak değerlendirilmektedir. Biyometrik özellikler dikkate alınarak yaptığımız UPGMA küme analizi *Mesocricetus* türlerini, transkafkas grubu (*Mesocricetus newtoni*, *Mesocricetus brandti* ve *Mesocricetus auratus*) ve ciskafkas grubu (*M. raddei* ve alttürleri) olacak şekilde iki ana gruba ayırmıştır. *M. nigriculus*'un taksonomik durumunu bu biyometrik analizlerle tam olarak açığa çıkartılamamıştır. Buna karşın biyometrik ölçüler *M. nigriculus* 'la *M. auratus*'un birbirine en yakın iki tür olduğunu, *Mesocricetus* türleri içinde biyometrik olarak en farklılaşmış taksonun *M. raddei* olduğunu göstermiştir. Ayrıca *M. r. raddei* ve *M. r. avaricus* arasında alttür ayrımını sağlayacak seviyede biyometrik ve morfolojik farklılık bulunmamaktadır. Taksonlar arasındaki farklılıkların bazı türlerin dağlık alanda yaşaması gerçeğiyle ve ölçü ve renk farklılıklarının türlerin gerçek filogenetik pozisyonlarını açıklamaktan çok türlerin ekolojik uyumunu yansıttığı şeklinde de açıklana bilir. Bunun yanında morfolojik bulgular *M. brandti*'nin yayılış alanı içinde doğudan batıya doğru artan bir benzerlik gösterdiğini, *M. newtoni*'nin ise *M. auratus* ile *M. brandti* arasında arabir grup oluşturduğunu ortaya koymaktadır.

Anahtar Sözcükler: *Mesocricetus* spp, morfoloji, UPGMA, Paleartik bölge

Introduction

The recent distribution of the genus *Mesocricetus* is confined to a particular area of the Palaearctic region stretching from northern Syria to the northern parts of the Caucasus Mountains and from the Balkans to Iran (Corbet, 1978; Niethammer 1982; Harrison and Bates, 1991; Wilson and Reeder, 1993). Four species have been accepted to date; *Mesocricetus raddei* (Nehring, 1894), *Mesocricetus newtoni* (Nehring, 1898), *Mesocricetus brandti* (Nehring, 1898), and *Mesocricetus auratus* (Waterhouse, 1839) (Raicu and Bratosin, 1966; Hamar and Schutowa, 1966; Lehman and Macperson, 1967; Lehmann, 1969; Felten et al., 1971; Sickenberg, 1972; Spitzenberger, 1972; Todd et al., 1972; Radjabli, 1975; Lyman and O'Brien, 1977; Popescu and Dipaolo, 1972; Doğramacı et al., 1994; Yiğit et al., 2000). *M. brandti* is the only species with a wide geographical range; the remaining species occur in limited areas. The species rank of most *Mesocricetus* species has long been debated (Nehring, 1898a; Argyropola, 1933; Neuhäuser, 1936; Steiner and Vauk, 1966; Corbet, 1978; Harrison and Bates, 1991). Still unresolved is the position of *Mesocricetus nigriculus* (Brandt, 1838), which is often considered a subspecies of *M. raddei* (Ellerman and Morrison-Scott, 1951). A key criterion for distinguishing *M. auratus* and *M. brandti* was their diploid chromosomes number (2n = 44 in *M. auratus*; 2n = 42 in *M. brandti*) (Todd et al. 1972; Radjabli 1975; Doğramacı et al. 1994), but Popescu and Dipaolo (1972) and Lyman and O'Brien (1977) reported the existence of 2 chromosomal variants (2n = 42 and 44) in *M. brandti* from populations in Central Anatolia. More recently, Yiğit et al. (2000) described a number of morphological characteristics separating *M. brandti* and *M. auratus*. The most differentiated karyotype (2n = 38) was found for *M. newtoni* by Raicu and Bratosin (1966). This species was reported to be closely associated with *M. brandti* (Hamar and Schutowa 1966). Hamar and Schutowa (1966) divided *Mesocricetus* hamsters into 2 geographically and evolutionarily distinct groups. Three species, *Mesocricetus newtoni*, *Mesocricetus brandti*, and *Mesocricetus auratus*, form a Transcaucasian line. The Ciscaucasian group is composed of the *M. raddei* complex, which consists of 3 subspecies. Two large forms, *Mesocricetus raddei raddei* and *Mesocricetus raddei avaricus*, were described from the plateaus of the Caucasus Mountains (Ognev and Heptener, 1927; Gromov and Erbajeva, 1995). A third smaller subspecies, *M. raddei nigriculus,* occupies the steppe habitats of the northern Caucasus region (Lukjanenko, 1954). *M. r. raddei* was separated from *M. r. avaricus* by variations in the black colour on the belly and differences at the rostrum, especially the nasal bones. Both subspecies can be distinguished from the smaller *M. r. nigriculus* by their diploid number of chromosomes (*M. r. raddei*, *M. r. avaricus* 2n = 44; *M. r. nigriculus* 2n = 42) (Gromov and Erbajeva, 1995). Nehring (1898 a,b) considered the morphological differences sufficient to accept *M. nigriculus* as a distinct species. Hamar and Schutowa (1966) also suggested the possibility that *M. nigriculus* represents a distinct species. To date, biometric evaluations of the genus *Mesocricetus* are quite scant, and the validity of some species is still uncertain. The aim of this study was to evaluate the taxonomic status of *Mesocricetus* hamsters by quantitative analysis of their metric and epigenetic parameters. We also review the current knowledge about their distribution and ecology.

Materials and Methods

Origin of animals

Golden hamsters (*Mesocricetus auratus)* from 2 main geographical regions were examined. Seven adult and 3 sub-adult animals came from Kilis, in southeastern Turkey, which forms the northern distribution edge. Fifteen adult specimens were caught at 3 sites close to the type of locality in Aleppo, Syria (collection at the Institute of Zoology, Martin-Luther-University Halle-Wittenberg, Germany; see also Gattermann et al., 2001). Two museum skins from Aleppo were investigated at the Naturkunde Museum, Berlin, Germany.

Turkish hamsters (*Mesocricetus brandti*) were collected at localities across the entire range in Turkey (n = 91). The examined material consisted of various museum specimens from Turkey (n = 4, Naturkunde Museum, Berlin, Germany), Georgia (n = 5, Severtzov's Institute of Ecology and Evolution, Moscow, Russia), Zanjan, Iran (n = 5), Azerbaijan (n = 1), and Dagestan (n = 1, Severtzov's Institute of Ecology and Evolution, Moscow, Russia).

Ten Romanian hamsters (*Mesocricetus newtoni*) were provided by the Naturkunde Museum, Berlin, Germany. One living adult female from Shumen (Bulgaria) was also studied.

Data describing all 3 subspecies of *Mesocricetus raddei* (*M. nigriculus*, n = 15 from Caucasia, Stawropol; *M. raddei*, n = 15 from Dagestan; *M. r. raddei*, n = 6; *M. r. avaricus*, n = 9) were obtained from collection material stored at the Naturkunde Museum, Berlin, and Severtzov's Institute of Ecology and Evolution, Moscow.

Measures and statistics

Museum specimens, as well as recently collected animals, were examined. Only adult hamsters were used for comparative statistics. Characters of adulthood in captured specimens were signs of lactation, pregnancy, embryos, and swollen testes. Collection material was classified as adult when molars M^3 and M_3 reached the levels of M^2 and M_2 (Yiğit, 2003).

External measures consisted of total body length (TBL), tail length (TL), hind foot length including nails (HFL), and ear length (EL). Additionally, we measured the body weights of the living animals. Fourteen metric cranial characteristics were scored; zygomatic breadth (ZB), interorbital constriction (IC), condylobasal length (CBL), occipitonasal length (ONL), basal length (BL), nasal length (NL), mastoid breadth (MAB), occipital width (OW), diatom length (DL), palatal length (PL), length of anterior palatine foramen (LAPF), height of braincase with bullae (HBC), mandible length (MAL), upper molar alveolar length (UML), and lower molar alveolar length (LML). The following non-metric skull parameters were considered: 1. V- or U-shaped palatine end; 2. broad braincase; 3. broad coronoid process; 4. pointed tip of anterior palatine foramen.

The metric characteristics were analysed using the NTSYS-pc version 2.1 computer program. First, all data were standardized (Sort: SS, Subt: Min) and the distance matrices were calculated by Manhattan coefficient. Similarity coefficients (distance matrix) and UPGMA clusters were also computed using NTSYS-pc, version 2.1 (Rohlf, 2000).

Results and Discussion

Mesocricetus auratus (Waterhouse, 1839)

Type locality: Aleppo, Syria

Habitat and Distribution: The main distribution area lies in the fertile, agricultural Aleppinian plateau in Syria and extends into the southern part of Turkey. The golden hamster lives mainly in fields of annual crops, i.e., weeds, barley, chickpea, lentil, and vegetables (Gattermann et al. 2001).

External Characteristics: Topotypes from Syria are slightly darker than Turkish animals. The dorsum is dark yellowish and becomes more yellowish and light brown around the head. The flanks have a warmer tone. There is a dark spot between the ears. The ears are covered with short whitish hairs. A demarcation line along the flanks is clearly visible. Ventral fur is whitish grey, and the chest patch is less pronounced and dull brownish. A dull blackish stripe marks the pouches. Our findings match the colour description given by Harrison and Bates (1991), but the reddish coloration on the dorsal fur was absent in sub-adult individuals.

Cranial Characteristics: Golden hamsters from Turkey and Syria are very similar with respect to cranial measures (see also Yiğit et al. 2000). The shape of the posterior end of the palatal bone distinguishes *M. auratus* from *M. brandti*; however, the *auratus* typical V-shape was only marked in adult specimens. Sub-adults and juveniles have a smoother V-shape or U-shape, which turns into a V-shape.

Mesocricetus raddei (Nehring, 1894)

Type locality: Samur River, Dagestan

Habitat and Distribution: *M. raddei* is found in grasslands and steppe areas. According to Hamar and Schutowa (1966), this species is distributed in north Azerbaijan and Dagestan (Figure 1).

External Characteristics: Dorsal fur appears dark grey. Yellowish and reddish colours become dominant towards head and flanks. Some specimens generally show a moderately yellowish tone. The belly is blackish, but a darker chest patch is clearly distinguished. Our colour description is consistent with those of other authors (Ognev and Heptener, 1927; Argyropola, 1933; Hamar and Schutowa, 1966; Gromov and Erbajeva, 1995).

Cranial Characteristics: The anterior of the nasal bone is approximately at the same level as the upper incisors. The rostrum is more broadened, and the braincase is posteriorly narrower than in other *Mesocricetus* species. The zygomatic arch is robust, and the maxillary part of the zygomatic arch is laterally widened. The braincase is moderately flattened, but slightly anteriorly curved. Parietal and ex-occipital ridges are marked. Occipital condyles are clearly visible from a dorsal viewpoint. The tip of the anterior palatal foramina

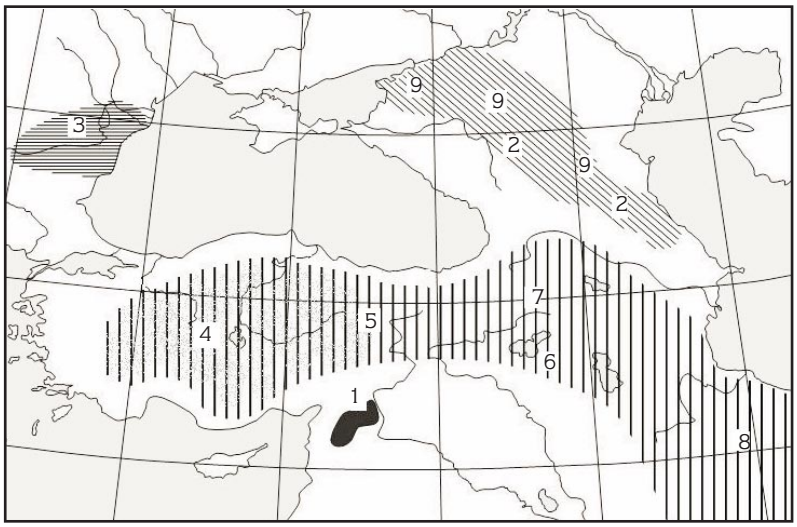

Figure 1. Map shows the study areas and recent distributions of *Mesocricetus* spp in the Palaearctic region; *M. auratus* (1), *M. brandti* (4, 5, 6, 7, 8), *M. raddei* (2) *M. nigriculus* (9), and *M. newtoni* (3).

is more triangular than in *M. brandti*. The posterior end of the palatal bone is U-shaped, as in *M. brandti.* In most specimens, there is a small crack. The mandible is larger and higher than in other *Mesocricetus*. The coronoid process is broad and well separated from the condyloid.

Mesocricetus newtoni (Nehring, 1898)

Type locality: Kolarovgrad, Bulgaria

Habitat and Distribution: According to Hamar and Schutowa (1966), *M. newtoni* lives in agricultural fields, mainly in Lucerne and other perennials, cereals, fallow land, and adjacent areas such as forest belts, and also in dry grassland and grassland. *M. newtoni* occurs only along the Danube River in northern Bulgaria and Romania (Figure 1).

External characteristics: General appearance of the dorsal fur is reminiscent of *M. brandti*. *M. newtoni* is less yellowish than specimens from central Anatolia, but with more grey on the back. In this respect, the investigated animals resemble *M. brandti* specimens from Kars and Ardahan in Turkey; however, the dorsal coloration is darker than that of *M. brandti*. The rostrum is yellowish. There is a dark stripe extending from the ears to the shoulder. Black stripes on the cheek pouches are very obvious. The black chest patch extends further behind the forearms than in *M. brandti*. The demarcation line along the flanks is distinct. The belly is also yellowish, but in some specimens it turns into a more greyish tone. The findings are consistent with those reported by Hamar and Schutowa (1966) and Niethammer and Krapp (1982).

Cranial Characteristics: In general, the cranial characteristics are similar to those of *M. brandti*. The anterior of the nasal bone slightly exceeds the upper incisors. Posterior of the nasal bone extends beyond the malar process of the zygomatic arch. The zygomatic arch is robustly-built. The braincase is narrow and dorsally flattened. Occipital condyles are visible from the dorsal. The posterior shape of the palatal bone is the same as in *M. brandti*. The coronoid process is curved and rather tiny. It has shown that the ridge of the parietal used by Hamar and Schutowa (1966) proved to be an invalid taxonomic character because it changes with age.

Mesocricetus brandti (Nehring, 1898)

Type locality: Tbilisi, Georgia

Habitat and Distribution: *M. brandti* lives on the edges of crops and agricultural areas, and steppe and grassland with soft soil in Turkey. In Iran, we captured *M. brandti* in Trifolium gardens close to the natural steppe. *M. brandti* ranges from western Turkey to northeastern Iran (Figure 1) and is the most widely distributed *Mesocricetus* species.

External Characteristics: Animals from Ardahan and Kars (northeastern Turkey) are clearly differentiated

from other populations according to their darker greyish dorsal coloration. Specimens from Lake Van are the palest. A pale dorsal colour was also typical for animals collected in northeastern Iran. The dark greyish tone becomes greyish-yellowish when approaching western Anatolia. The chest patch was well marked in all specimens examined, but its posterior margin does not extend behind the forearms. The stripe on pouches is blackish with some geographical variation, being dark in northeast Anatolia and less pronounced in western Anatolia. The demarcation line is indistinct on the flank and the dorsal colour changes gradually into the ventral colour. The general external peculiarities of Turkish populations were described by Yiğit et al. (2000).

Cranial Characteristics: Skull morphology is similar to that of *M. auratus.* Interorbital constriction is wider in young specimens than in adults. In adult and old specimens, parietal ridges are clearly developed, as in *M. auratus*. In contrast to *M. auratus*, the posterior end of the palatal bone is U-shaped, while it is V-shaped in adult *M. auratus*. The cranial morphology and its age-dependent development were discussed by Yiğit et al. (2000) and Yiğit (2003).

Mesocricetus nigriculus (Brandt, 1838)

Type locality: Malka River, northern Caucasia, Dagestan

Habitat and Distribution: *M. nigriculus* lives in the Volga River Basin (Figure 1). This species is distributed in steppe areas across Azerbaijan, Dagestan, Chechnya, and Ukraine (Hamar and Schutowa, 1966).

External Characteristics: Dorsal coloration is pale grey, and similar to that of *M. brandti* specimens from Van (Turkey). Dorsal fur has hairs with black and yellow tips, and the hair is darker at the base than at the tip. The belly is entirely black. The black chest patch is not distinguishable, but the blackish stripe commences on each check posteriorly.

Cranial Characteristics: The skull is approximately the same size as that of *M. brandti*, but its morphology is more similar to that of *M. raddei.* The braincase is narrow and smooth. Occipital condyles are visible from the dorsal. The posterior end of the palatal bone is U-shaped. The tip of the anterior palatine foramen is pointed, as in *M. raddei.*

Biometrical Comparisons

We compared 4 external and 15 skull measurements to establish a phylogenetic tree for the genus *Mesocricetus* (Table 1). Four subgroups were identified: *M. auratus*, *M. nigriculus*, *M. brandti* (1. grey-yellowish specimens from Central Anatolia, 2. grey-blackish specimens from Kars-Ardahan.), and *M. newtoni* (Figure 2). *M. raddei* seems to be the most distinguished species among *Mesocricetus* spp. *M. newtoni* appeared to be an intermediary between *M. auratus-M. nigriculus* and *M. brandti* (Figure 2). *M. auratus* and *M. nigriculus* are in the same clade with a distance of 0.238; their similarity is almost the same as in *M. brandti* (1) and *M. brandti* (2) (D: 0.210).

Furthermore, populations of *M. brandti* were separated into 4 groups for comparison as follows: Central Anatolia (1), Sivas-Erzincan (2), Van (3), and Kars-Ardahan (4), and the Iranian population of *M. brandti* (5) was considered last. Their metric characteristics were analysed using the NTSYS–pc version 2.1 program. According to the UPGMA cluster, the Central Anatolia and Sivas-Erzincan populations of *M. brandti* were first clustered with a distance of 0.061, and other populations were gradually connected to this cluster from west to east (Figure 3). The Iranian population of *M. brandti*, which is at least 700 km from the nearest Turkish population, was connected to *M. brandti* (4) with the distance of 0.809.

The Kars-Ardahan and Iranian populations of *M. brandti* appeared the most divergent and ancestral populations. In addition, *M. brandti* (1) and *M. brandti* (2) seemed to be sister subpopulations by means of separating Central Anatolia and Sivas-Erzincan from the nominative subspecies *M. brandti* (4).

Evaluations of non-metric characteristics

Apart from biometric comparisons, the non-metric characteristics of 5 species considered valid taxa were evaluated with respect to the following phenetics: 1. V-shaped palatine end; 2. U-shaped palatine end; 3. Broad braincase; 4. Broad coronoid process; 5. Pointed anterior palatine foramen; 6. Grey-yellowish dorsal colour; 7. Yellowish-reddish dorsal colour; 8. Black belly. *M. brandti* was morphologically divided into 2 subpopulations; *M. brandti* (1), with grey-yellowish dorsal coloration, and *M. brandti* (2), with grey-blackish and yellowish dorsal coloration. The phenotypic similarity between *M. brandti*

Table 1. The average measurements of *Mesocricetus* species: 1. *M. auratus* (topotypes); 2. *M. raddei*; 3. *M. newtoni*; 4. *M. brandti* (Central Anatolia); 5. *M. brandti* (Sivas-Erzincan); 6. *M. brandti* (Van); 7. *M. brandti* (Kars-Ardahan); 8. *M. brandti* (Zanjan, Iran); 9. *M. nigriculus*.

Ch	1	2	3	4	5	6	7	8	9
TBL	168 n = 15	185.6 n = 10	150.6 n = 13	151.3 n = 63	158 n = 14	164 n = 13	170 n = 11	185.6 n = 5	168 n = 7
TL	21.8 n = 15	25.6 n = 10	20.7 n = 13	18.8 n = 63	19.7 n = 14	19.3 n = 13	21.1 n = 11	18.0 n = 5	22.6 n = 7
HFL	18.5 n = 15	26 n = 10	19 n = 13	21.1 n = 63	21.5 n = 14	20.6 n = 13	21.4 n = 11	21 n = 5	21.4 n = 7
EL	20.6 n = 15	25.2 n = 10	17.7 n = 13	21.8 n = 63	22.2 n = 14	23.1 n = 13	23.0 n = 11	25.6 n = 5	21.2 n = 7
ZB	19.8 n = 15	23.1 n = 15	18.9 n = 15	17.8 n = 63	17.9 n = 14	18.3 n = 13	18.4 n = 11	19.4 n = 5	20.1 n = 10
IC	4.7 n = 15	4.9 n = 15	2.8 n = 15	3.4 n = 63	3.5 n = 14	3.4 n = 13	3.3 n = 11	4.3 n = 5	4.5 n = 10
CBL	34.3 n = 15	41.2 n = 15	33.7 n = 15	32.2 n = 63	31.8 n = 14	32.4 n = 13	33.5 n = 11	34.9 n = 5	35.7 n = 10
ONL	34.6 n = 15	42 n = 15	34.0 n = 15	33.1 n = 63	32.8 n = 14	32.9 n = 13	34.6 n = 11	35.1 n = 5	36 n = 10
BL	32.5 n = 15	39.1 n = 15	32.2 n = 15	30.4 n = 63	29.9 n = 14	30.4 n = 13	31.6 n = 11	33.5 n = 5	33.8 n = 10
NL	14.7 n = 15	16.6 n = 15	13.7 n = 15	12.9 n = 63	12.7 n = 14	13.2 n = 13	13.6 n = 11	15.0 n = 5	14.2 n = 10
MAD	8.8 n = 15	12.5 n = 15	8.8 n = 15	10.0 n = 63	10.1 n = 14	10.3 n = 13	10.4 n = 11	9.2 n = 5	10.6 n = 10
OW	13.4 n = 15	16.7 n = 15	13.6 n = 15	13.3 n = 63	13.3 n = 14	13.6 n = 13	13.5 n = 11	14.3 n = 5	14.9 n = 10
DL	11.1 n = 15	13 n = 15	10.4 n = 15	9.4 n = 63	9.3 n = 14	9.7 n = 13	10.2 n = 11	10.8 n = 5	10.8 n = 10
PL	17.5 n = 15	21.6 n = 15	17.4 n = 15	16.2 n = 63	15.9 n = 14	15.9 n = 13	17.1 n = 11	17.6 n = 5	18.2 n = 10
LAPF	5.4 n = 15	6.4 n = 15	5.3 n = 15	5.4 n = 63	5.3 n = 14	5.4 n = 13	5.7 n = 11	7.2 n = 5	5.4 n = 10
HBC	13.0 n = 15	13.9 n = 15	11.7 n = 15	11.6 n = 63	11.9 n = 14	12.1 n = 13	12.4 n = 11	13.0 n = 5	12.4 n = 10
MAL	22.2 n = 15	25.6 n = 15	20.2 n = 15	20.6 n = 63	20.5 n = 14	20.9 n = 13	20.5 n = 11	22.7 n = 5	21.9 n = 10
UML	5.9 n = 15	7.4 n = 15	6.1 n = 15	6.3 n = 63	6.3 n = 14	6.3 n = 13	6.4 n = 11	7.0 n = 5	6.6 n = 10
LML	5.9 n = 15	7.4 n = 15	6.0 n =15	6.3 n = 63	6.4 n = 14	6.1 n = 13	6.2 n = 11	6.7 n = 5	6.5 n = 10

Ch = Characteristics, n = number of specimens).

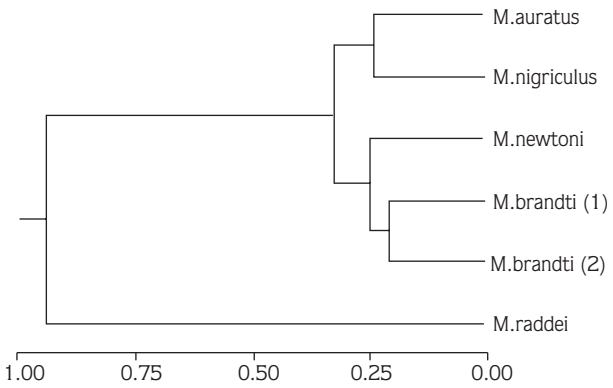

Figure 2. UPGMA cluster showing the distance between *Mesocricetus* spp. 1: grey-yellowish form; 2: grey-blackish form.

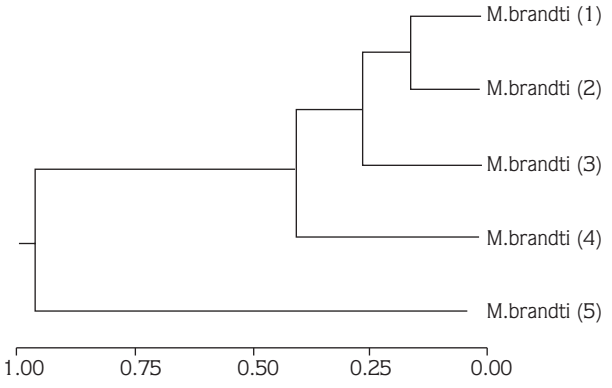

Figure 3. UPGMA cluster showing the distance among intra-populations of *M. brandti*. 1: Central Anatolia; 2: Sivas-Erzincan; 3: Van; 4: Kars-Ardahan; 5: Zanjan (Iran).

and *M. newtoni* supported the geographic approaches of Hamar and Schutowa (1966), who stated that *M. newtoni* had originated from *M. brandti* that passed through the Bosphorus to the Balkans. *M. auratus* seems to be a separate or intermediate group between *M. brandti-M. newtoni* and *M. raddei-M. nigriculus*. The phenetic data is mostly consistent with the morphometric data. In both biometric and morphologic comparisons, *M. newtoni* appeared to be an intermediate group. Apart from the postulations of Hamar and Schutowa (1966), Hosey (1982) also stated that sea level was sufficiently low for the establishment of a land bridge across the Bosphorus at the end of the Pleistocene. This finding explains how *M. newtoni* became distributed in the Balkans.

Taxonomic Remarks

The distribution of *M. auratus* is known to be confined to northern Syria and southeastern Turkey (Harrison and Bates, 1991; Doğramacı et al. 1994; Yiğit et al. 2000; Gattermann et al. 2001). According to our morphological and biometrical comparisons, there are no differences between the topotypes and the Turkish population, except for a slight colour difference, becoming less yellowish-reddish towards Turkey. There is also no geographical barrier separating recent populations. In this respect, all populations of *M. auratus* distributed in the given area were considered to represent the nominative subspecies. The non-metric cranial peculiarities of *M. auratus* are also very similar to those of *M. newtoni* and *M. brandti*, but its V-shaped palatal end distinguishes *M. auratus* from *M. brandti*. *M. newtoni* is another monotypic taxon in the genus *Mesocricetus*. Its distribution is also confined to north-east Bulgaria and south-east Romania, and apparently did not extend too far. Because of its limited distribution, the *M. newtoni* population was considered the nominative subspecies. *M. brandti* is one of the most confusing taxa within the genus *Mesocricetus*. Its distribution area extends from western Turkey to north-eastern Iran. As indicated by Yiğit et al. (2000), there are 2 marked colour morphs in the population; grey-yellowish and grey-blackish. The former colour morph is commonly distributed in Turkey and Iran, but the latter is only recorded from Kars-Ardahan in north-east Turkey. The second dark-coloured population was also biometrically distinguishable from other grey-yellowish populations, and was partly separated from other populations by geographical barriers. This dark-coloured population is the nominative subspecies of *M. brandti*. Another colour morph extending from western Anatolia to Iran shows true morphological and biometrical peculiarities for sub-specification, but its validity is not supported by partial mitochondrial D-loop or 16S rRNA (unpublished data) DNA sequence data. In the same area as the nominative subspecies, *Mesocricetus koenigi* was first described in Gaz Koparan (Göle/Kars, Turkey) by Satunin (1900). We compared specimens of *M. brandti* from the same area with the skins of *M. koenigi* in the museum of Severtzov's Institute of Ecology and Evolution in Moscow, and found that the 2 forms have the same morphological characteristics. Therefore, *M. koenigi* was considered a synonym of *M. brandti* in accordance with the priority rule.

M. raddei, distributed in Dagestan, is known as the black-bellied hamster. This species is very clearly distinguishable from the other 4 species by means of its larger biometric characteristics. Apart from the nominative subspecies, *Mesocricetus raddei avaricus* was first described by Ognev and Heptener (1927). According to their descriptions, *M. r. avaricus* has a very black belly, distinctly projecting forward ossa nasalia, and narrowed zygomatic arches, anteriorly. They also stated that although the differences in the fur colour are easily noticeable, this cannot be considered a taxonomic characteristic. When checking the skull drawings of both subspecies given by the author above, the drawings seem to belong to different age groups, and acceptable evidence for its validity as a subspecies characteristic is insufficient. In addition, the skull drawing given by Argyropola (1933) for *M. r. avaricus* is identical to the skull figured by Ognev and Heptner (1927) for the nominative subspecies. We also studied the specimens of *M. raddei* in the Museum of Severtzov's Institute of Ecology and Evolution in Moscow, and determined that there are no sub-specific morphological characteristics separating *M. raddei raddei* from *M. r. avaricus*. These results showed that *M. raddei* is a monotypic species.

The specific status of *M. nigriculus* is still under discussion, and this species has been considered a subspecies of *M. raddei* by Argyropola (1933), Hamar and Schutowa (1966), Corbet (1978), Gromov and Erbajeva (1995), and Wilson and Reeder (1993). According to our examinations, the biometric characteristics (body and skull measurements) of *M. nigriculus* are markedly shorter than those in *M. raddei*, and the coloration on the rostrum and belly show some differences among these taxa. In addition, their distribution areas partially overlap and there are no well-marked geographical barriers between the populations of the 2 species. Gromov and Erbajeva (1995) stated that there was a karyological difference between *M. raddei* and *M. nigriculus*. According to these morphological and biometrical criteria, *M. nigriculus* seems to be a valid species, as indicated by Nehring (1898 b).

In addition to the validity of *Mesocricetus* spp, cluster analyses performed with metric data gave some clues as to their geographical distribution. In clusters, *M. raddei* seems to be the most divergent and earliest-split species among the taxa. In the first cluster, *M. raddei* was located on a single branch, and was connected to the clades of *M. auratus-M. nigriculus* and *M. newtoni-M. brandti* (Figure 2). A close relationship was shown between *M. auratus* and *M. nigriculus*. In the phylogeographical approach, it was suggested that *M. raddei*, *M. nigriculus*, and *M. newtoni* originated from the group of *M. auratus* and *M. brandti* (Hamar and Schutowa 1966). During the Pleistocene, *M. brandti* spread across to the Balkans via the Bosphorus and evolved into *M. newtoni.* In such a phylogeographical concept, the validity of our assumption needs further support from molecular evidence.

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