Kırşehir Ahi Evran Üniversitesi Ziraat Fakültesi Dergisi
(Journal of Kırşehir Ahi Evran University Faculty of Agriculture)
Ahi Ziraat Der – J Ahi Agri
e-ISSN: 2791-9161
https://dergipark.org.tr/tr/pub/kuzfad
KUZ FAD

Research article

Examination of some cranial characteristics of *Mus domesticus* Linnaeus 1758 and *Mus macedonicus* Petrov & Ruzic 1983 (Mammalia: Rodentia) distributed in Turkey[a]

Güliz YAVUZ[1*]

[1] Kırşehir Ahi Evran University, Faculty of Agriculture, Department of Plant Protection, 40100, Bağbaşı, Kırşehir, Türkiye

* Sorumlu yazar (Corresponding author): gyavuz@ahievran.edu.tr

Makale alınış (Received): 18.06.2022 / Kabul (Accepted): 26.06.2022 /Yayınlanma (Published): 30.06.2022

ABSTRACT

It is known that species belonging to the subgenus *Mus* have common morphological characters and therefore their morphological differentiation is difficult. In this context, it was aimed to examine some skull characters as well as ZI, H+B/T values used as diagnostic criteria and the ventral edge of the parietal bone. While ZI values were found to vary between 0.24 and 0.52 in *Mus domesticus*, it was observed to vary between 0.49-1.33 in *M. macedonicus*. The H+B/T values were found to be between 0.74-1.1 in *M. domesticus* and between 0.81-1.77 in *M. macedonicus*. On the dorsal surface of the skull, it was observed that the frontal suture variations tended to be round shaped and the parietal suture variations tended to be v shaped. When the notch status of the upper incisors was examined, it was determined that the ratio of having non-notched and single-notched teeth was close to each other in both species. When the ventral edge of the parietal bone was examined, it was observed that while wavy and straight edges were found in close proportions in *M. domesticus*, straight edges were predominant in *M. macedonicus*. When the populations were evaluated according to geographical regions, no significant differences were observed between regions.

Keywords: House mouse, Macedonian mouse, morphological variation

[a] **Atıf bilgisi / Citation info:** Yavuz G (2022). Examination of some cranial characteristics of *Mus domesticus* Linnaeus 1758 and *Mus macedonicus* Petrov & Ruzic 1983 (Mammalia: Rodentia) distributed in Turkey. Ahi Ziraat Der/J Ahi Agri 2(1): 43-55

Araştırma makalesi

Türkiye'de yayılış gösteren *Mus domesticus* Linnaeus 1758 ve *Mus macedonicus* Petrov & Ruzic 1983 (Mammalia: Rodentia)'nın bazı kafatası özelliklerinin incelenmesi

ÖZ

Mus altcinsine ait türlerin ortak morfolojik karakterler taşıdıkları ve bu nedenle morfolojik olarak ayrımlarının zor olduğu bilinmektedir. Bu kapsamda teşhis kriteri olarak kullanılan ZI, H+B/T değerleri ve parietal kemiğin ventral durumunun yanında, bazı kafatası karakterlerinin incelenmesi amaçlandı. ZI değerlerinin *Mus domesticus*'ta 0,24-0,52 arasında değişkenlik gösterdiği tespit edilirken, *Mus macedonicus*'ta 0,49-1,33 arasında değiştiği gözlendi. H+B/T değerleri ise *M. domesticus*'ta 0,74-1,1 arasında, *M. macedonicus*'ta 0,81-1,77 arasında bulundu. Kafatasının dorsal yüzeyinde frontal sutur varyasyonlarının yuvarlak şekilli, parietal sutur varyasyonlarının v şeklinde olma eğiliminde olduğu görüldü. Üst kesici dişlerin çentik durumu incelendiğinde ise her iki türde de çentiksiz ve tek çentikli dişlere sahip olma oranının birbirine yakın olduğu tespit edildi. Parietal kemiğin ventral kenarının durumuna bakıldığında *M. domesticus*'ta dalgalı ve düz kenarlar birbirine yakın oranlarda bulunurken, *M. macedonicus*'ta düz kenarların ağırlıklı olduğu görüldü. Popülasyonlar coğrafi bölgelere göre değerlendirildiğinde ise bölgeler arası belirgin farklar gözlenmedi.

Anahtar Kelimeler: Ev faresi, sarı evfaresi, morfolojik varyasyon

Introduction

Turkey is a country rich in plant and animal diversity, and this species richness is caused by its continental location, different climate types it contains, and natural or man-made barriers that will cut off gene flow between populations. Turkey has many mammal species among which rodents are the predominant group in terms of species diversity. Rodents live in many different environments such as houses, fields, trees, and forests. One of the most interesting of these is the *Mus* (Linnaeus 1758) species that live in close contact with humans.

The evolutionary process of the genus *Mus* is complex, and many studies continue to be carried out to solve the problems of this genus. In parallel with the solution of taxonomic problems at the species and subgenus level, studies on the systematics and phylogenetic relationships among species of the genus have been carried out (e.g., Auffray et al. 1990; Berry and Scriven 2005; Guenet and Bonhomme 2003; Kishimoto et al. 2021; Krystufek and Macholan 1998). The genus includes 38 species distributed worldwide (Novak and Paradiso 1983; Wilson and Reeder 2005). However, the existence of many species defined in the genus *Mus* has brought along new taxonomic evaluations at the subgenus level.

Considering the large number of taxa defined recently at species and subspecies level, it is understood that the taxonomy of the genus *Mus* is not fully formed (Auffray and Britton-Davidian 2012) and detailed morphological studies are not sufficient for this genus, including geographical variations. In addition, investigating the morphological differentiation of *Mus domesticus* living together with humans and *M. macedonicus* living outside of human

settlements in different geographical areas is important in terms of evolutionary biology and systematic studies. In addition, although western Turkey is a region affected by human-induced habitat degradation, many geographical barriers such as straits, rivers, mountain ranges, and islands affect the populations living in this region (Helvacı et al. 2012). With all this background, this study aimed to investigate whether the diagnostic criteria of species of the genus *Mus* distributed in Turkey and whether some morphological characters in the skull differ according to geographical regions.

Material and Methods

In this study, some cranial morphology features of 562 *Mus* samples in the Ankara University Mammal Research Collection (AUMAC) were examined. Samples from a total of 40 localities (Figure 1) by looking at the ZI value (the ratio of the width of the malar ridge to the width of the antero-lateral part of the zygomatic arch) (Figure 2), the H+B/T value (the ratio of head-body length to tail length), and the ventral edge of the parietal bones (Figure 3) were diagnosed. In addition, 123 skull specimens were evaluated for frontal suture variations on the dorsal surface of the skull, 116 for parietal suture variations, 108 for upper incisor variations, and 107 for ventral edge variations of the parietal bone in *M. domesticus*. In *M. macedonicus*, 363 skull samples were analyzed for frontal suture variations on the dorsal surface of the skull, 364 for parietal suture variations, 323 for upper incisor variations, and 276 for ventral edge variations of the parietal bone. The number of samples examined differed according to whether the skull was damaged or not.

Figure 1. Localities of the examined samples

Results and Discussion

Mus domesticus and *M. macedonicus* species were identified by examining a total of 562 *Mus* specimens from 40 localities in western Turkey. In diagnosis, 154 specimens from *M. domesticus* and 408 specimens from *M. macedonicus* were examined. While ZI values were found to vary between 0.24 and 0.52 in *M. domesticus*, it was observed to vary between 0.49-

1.33 in *M. macedonicus*. The H+B/T values were found to be between 0.74-1.1 in *M. domesticus* and between 0.81-1.77 in *M. macedonicus* (Table 1).

Table 1. ZI index and H+B/T index values used in the diagnosis of *Mus domesticus* and *Mus macedonicus*

		M. domesticus	***M. macedonicus***
ZI	Mean	0,42	0,75
	Minimum	0,24	0,49
	Maximum	0,52	1,33
H+B/T	Mean	0,95	1,21
	Minimum	0,74	0,81
	Maximum	1,1	1,77

Frontal Suture

Among 123 *M. domesticus* specimens, frontal suture variations were examined on the dorsal surface of the skull, 18% were angular, 68% were round-shaped, and 14% were "v" shaped (Figure 4). While it was determined that the samples belonging to the Mediterranean Region population had all three variations, 71% of the Aegean Region population was determined to have the rounded frontal suture variation. It was observed that 65% of the Central Anatolian Region population had rounded frontal sutures. While all three variation types were detected in Ankara samples specific to this geographical region, it was striking that Eskişehir samples had only angular frontal suture variation, while Kayseri samples had only round shaped frontal suture variation. When the Black Sea Region population was examined, 85% of them were found to have round-shaped frontal sutures. Within the scope of this geographical region, it was observed that the Bolu and Düzce samples had angular and rounded variations, while the Zonguldak samples had round-shaped and "v" shaped variations. It was found that 61% of the Marmara Region population had rounded frontal sutures. When the island populations were examined, it was determined that the Marmara Island population had all three variations, while the Bozcaada population showed a round and "v" shaped frontal suture variation (Table 2).

Table 2. Distribution of cranial and tooth characters according to localities in *Mus domesticus* (a: Mediterranean Region, b: Aegean Region, c: Central Anatolia Region, d: Black Sea Region, e: Marmara Region)

Locality	Frontal Suture			Parietal Suture		Upper Incisor			Ventral Edge of Parietal Bone	
	angle	rounded	V	straight	V	straight	1 notch	2 notches	zigzag	straight
Adana[a]	1	-	-	1	-	-	1	-	1	-
Mersin[a]	-	-	1	1	-	-	1	-	1	-
Hatay[a]	-	2	-	-	1	-	-	1	1	-
Afyon[b]	1	2	-	-	3	-	2	-	2	-
Manisa[b]	-	-	1	-	1	1	-	-	1	-
İzmir[b]	-	1	-	-	1	-	-	1	-	1
Muğla[b]	-	1	-	1	-	1	-	-	-	1
Uşak[b]	-	1	-	-	1	1	-	-	-	1
Ankara[c]	8	29	4	3	38	22	19	-	26	15
Eskişehir[c]	4	-	-	-	4	-	3	1	-	3
Kayseri[c]	-	2	-	-	2	-	-	1	1	2
Bartın[d]	2	8	-	2	7	1	6	-	5	5
Bolu[d]	1	2	-	2	2	2	2	-	1	2
Düzce[d]	-	7	-	-	7	5	-	-	1	4
Ordu[d]	-	2	-	2	-	-	1	1	1	1
Samsun[d]	-	2	-	-	2	-	2	-	2	-
Zonguldak[d]	-	3	1	-	4	1	-	1	-	3
Kırklareli[e]	1	3	-	-	1	1	-	-	-	3
Edirne[e]	1	2	4	2	4	3	2	1	3	2
İstanbul[e]	1	2	1	2	3	3	2	-	4	1
Marmara Adası[e]	1	5	3	-	8	6	3	-	-	9
Bozcaada[e]	-	11	3	-	15	-	11	3	2	7
Çanakkale[e]	-	1	-	-	1	-	1	-	-	1

Of the 363 *M. macedonicus* specimens whose frontal suture variations were examined, 94% were found to be round-shaped and 6% were found to be "v" shaped (Figure 5). “V” shaped frontal suture was found only in Hatay locality in the Mediterranean Region population, and only in Uşak in the Aegean Region population. Almost all the specimens from the Central Anatolian Region had a round-shaped frontal suture, while in the Black Sea Region population, all specimens except Bartın locality, and in the Marmara Region population, all specimens except Edirne and İstanbul localities had round-shaped frontal sutures (Table 3).

Table 3. Distribution of cranial and tooth characters according to localities in *Mus macedonicus* (a: Mediterranean Region, b: Aegean Region, c: Central Anatolia Region, d: Black Sea Region, e: Marmara Region)

Locality	Frontal Suture		Parietal Suture		Upper Incisor			Ventral Edge of Parietal Bone	
	rounded	V	straight	V	straight	1 notch	2 notches	zigzag	straight
Adana[a]	1	-	4	2	6	1	-	-	7
Antalya[a]	1	-	-	2	1	-	-	-	3
Burdur[a]	4	-	2	2	2	2	-	-	4
Isparta[a]	1	-	1	-	-	1	-	-	1
Hatay[a]	4	12	3	12	11	3	-	-	11
Mersin[a]	5	-	2	2	1	-	2	-	3
Afyon[b]	4	-	-	3	1	-	1	-	2
İzmir[b]	6	-	-	6	2	3	2	-	7
Muğla[b]	6	-	-	6	5	-	-	-	6
Uşak[b]	-	1	-	1	1	-	-	-	1
Manisa[b]	11	-	-	12	2	8	-	-	8
Denizli[b]	16	-	5	13	1	9	-	-	13
Kütahya[b]	1	-	-	1	1	-	-	-	-
Ankara[c]	28	2	-	25	19	7	1	6	19
Kayseri[c]	7	-	-	7	5	1	-	-	5
Çorum[c]	29	-	6	22	2	18	9	-	24
Kırşehir[c]	2	-	-	4	4	-	-	-	4
Konya[c]	17	-	1	16	7	9	1	-	15
Amasya[d]	3	-	-	2	-	2	-	-	2
Bartın[d]	-	1	-	1	-	1	-	-	-

Bolu[d]	10	-	-	10	5	2	1	1	4
Düzce[d]	7	-	2	4	4	2	-	-	4
Ordu[d]	9	-	1	8	1	3	4	-	8
Samsun[d]	18	-	5	13	2	13	-	1	14
Tokat[d]	9	-	-	10	-	8	-	-	7
Adapazarı[e]	2	-	-	1	-	1	-	-	1
Kırklareli[e]	38	-	3	36	23	8	3	-	25
Edirne[e]	11	6	2	15	10	2	3	3	11
Tekirdağ[e]	1	-	-	1	1	-	-	-	1
Marmara Adası[e]	4	-	3	1	2	-	2	-	3
Bozcaada[e]	4	-	-	1	-	1	-	-	1
Gökçeada[e]	20	-	-	19	13	4	-	-	20
Balıkesir[e]	11	-	2	9	7	3	-	-	9
Bilecik[e]	12	-	-	12	3	7	1	-	10
Bursa[e]	10	-	5	17	3	12	-	-	16
İstanbul[e]	-	1	-	1	1	-	-	-	1
Çanakkale[e]	13	-	2	14	9	4	1	-	16
Kocaeli[e]	6	-	1	8	4	-	-	-	3

Parietal Suture

Parietal suture variations on the dorsal surface of the skulls were examined, and 13% of 116 *M. domesticus* specimens were found to be straight and 87% to be "v" shaped (Figure 6). It was determined that Adana and Mersin samples in the Mediterranean Region population were straight shaped, while the Hatay sample had a “v” shaped parietal suture. While 85% of the Aegean Region population exhibited a "v" shaped variation, only the Muğla specimen was found to have a straight parietal suture in this geographical region. While "v" shaped parietal sutures were detected in 93% of the Central Anatolian Region population, it was observed that Ankara samples had both variations in this geographical region, while only "v" shaped parietal sutures were present in Eskişehir and Kayseri samples. It was observed that 78% of the Black Sea Region population had a "v" shaped variation. Within this population, only the straight parietal suture of Ordu specimens; It was noteworthy that Düzce, Samsun and Zonguldak samples had only "v" shaped parietal sutures. When the Marmara Region population was examined, it was seen that 88% of this population had a "v" shaped parietal suture. Bozcaada and Marmara Island populations were all found to exhibit “v” shaped parietal suture variation (Table 2).

Parietal suture variations of 364 *M. macedonicus* specimens were examined, 87% of them showed indented variation in the form of the letter "v" and 13% showed a straight suture variation (Figure 7). 63% of the samples in the Mediterranean Region population had a "v" shaped parietal suture. A “v” shaped parietal suture was detected in 89% of the Aegean Region population, 91% of the Central Anatolian Region population and 88% of the Marmara Region population. Looking at the island populations, while no straight parietal suture was found in the Bozcaada and Gökçeada populations, both variations were observed in the Marmara Island population (Table 3).

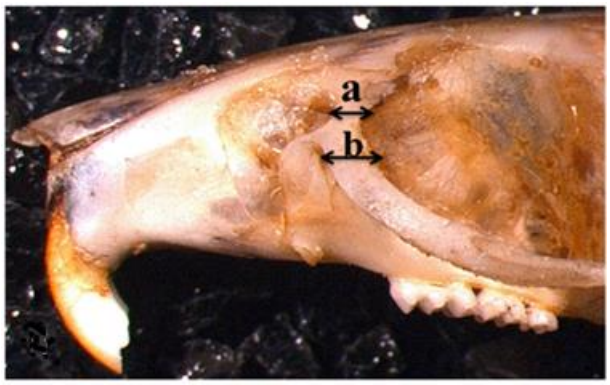

Figure 2. Zygomatic index in *Mus* (a: width of the malar ridge, b: width of the antero-lateral part of the zygomatic arch)

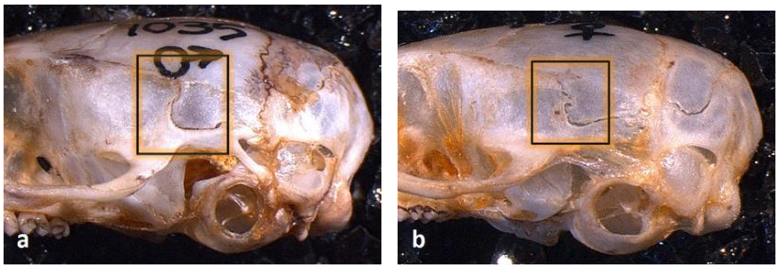

Figure 3. Ventral of parietal bones in *Mus macedonicus* (a) and *Mus domesticus* (b)

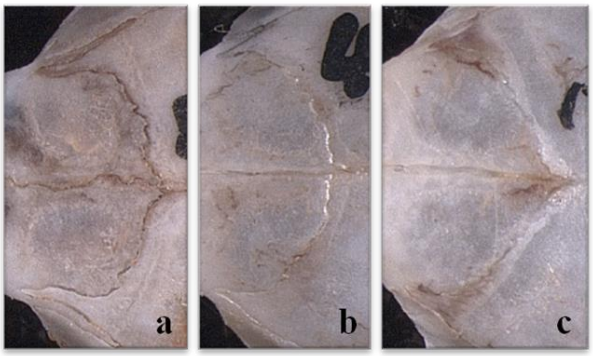

Figure 4. Frontal suture variations *in Mus domesticus* (a: angular, b: rounded, c: “v” shaped)

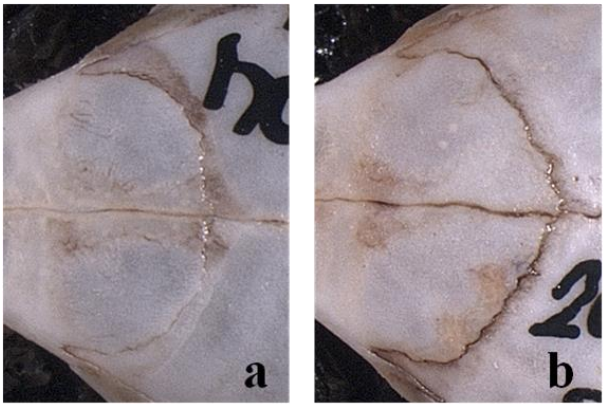

Figure 5. Frontal suture variations in *Mus macedonicus* (a: rounded, b: "v" shaped)

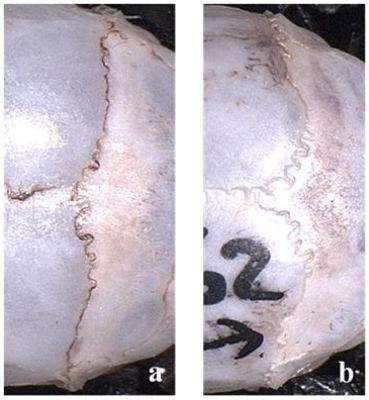

Figure 6. Parietal suture variations in *Mus domesticus* (a: straight, b: "v" shaped)

Upper Incisors

In terms of upper incisor morphology, 41% of 108 samples belonging to *M. domesticus* populations were unnotched, 50% single-notched, and 9% double-notched (Figure 8). While no notched upper incisors were found in the Mediterranean Region population, all three variation types were detected in the Aegean Region population. It was determined that the variation of non-notched and single-notched teeth was equal in the Central Anatolian Region population. While all three variation types were found in the Black Sea Region population, unnotched and single notched variations were found equally in the Marmara Region population. However, there were no double-notched upper incisors in the Marmara Island population and no notched upper incisors in the Bozcaada population (Table 2).

It was determined that the upper incisors of 323 specimens belonging to *M. macedonicus* populations were 49% non-notched, 42% single-notched, and 9% double-notched (Figure 9). In the Mediterranean Region population, predominantly non-notched and single-notched upper incisors were found. While all three types of variations were found in the Aegean Region population, it was observed that the one-notch variation was predominant. It was determined that the ratios of non-notched and single-notched teeth were close to each other in the Central Anatolian Region population. It was observed that the number of single-notched teeth was

higher in the Black Sea Region population, and the non-notched teeth were higher in the Marmara Region population. However, single-notched upper incisors were not found in the Marmara Island population and double-notched upper incisors in the Gökçeada population. One specimen from the Bozcaada population was found to have a single-notched upper incisor (Table 3).

Ventral Edge of Parietal Bone

Of the 107 *M. domesticus* specimens examined for variations of the ventral edge of the parietal bone, 42% had wavy/zigzag edges and 58% had straight edges (Figure 10). While wavy/zigzag variation was observed in the entire Mediterranean Region population, straight variation was found in half of the Aegean Region population samples. Wavy/zigzag ventral edge was detected in 40% of the Black Sea Region population. It was found that 28% of the Marmara Region population had wavy/zigzag variation. In addition, Marmara Island and Bozcaada populations were found to have mostly straight ventral edges (Table 2). As a result of the examination of 276 *M. macedonicus* specimens in terms of variations of the ventral edge of the parietal bone, it was determined that 96% of the specimens had straight ventral margins (Figure 11 and Table 3).

The zygomatic index (ZI) value used in the diagnosis of the genus *Mus* species was found between 0.24-0.52 for *M. domesticus* and between 0.49-1.33 for *M. macedonicus* in this study. The ZI scores of island populations was 0.40-0.50 for *M. domesticus*; It was found between 0.51-0.98 for *M. macedonicus*. Gözcelioğlu et al. (2005), on the other hand, while the ZI value varied between 0.25-0.46 in *M. domesticus*, this change was found as 0.63-0.83 in *M. macedonicus*. Krystufek and Vohralik (2009) determined the ZI value between 0.37-0.62 in their study with 81 *M. domesticus* samples, and between 0.52-1.42 in their study with 111 *M. macedonicus* samples. While the ZI values measured in this study were in agreement with the literature for *M. domesticus*, Gözcelioğlu et al. (2005) measured in a wider range than in the study. This may be due to the high number of samples and localities.

According to the H+B/T value, which is one of the taxonomic characters used in the separation of *M. domesticus* and *M. macedonicus*, those whose tail length are equal to or shorter than the head-body length are identified as *M. macedonicus*, and those that are equal or longer as *M. domesticus*. In this study, the H+B/T value was calculated between 0.74-1.1 (mean 0.95) for *M. domesticus*, while it was calculated between 0.81-1.77 (mean 1.21) for *M. macedonicus*. The H+B/T values of island populations were found to be between 0.79-0.98 for *M. domesticus* and between 0.96-1.4 for *M. macedonicus*. Gözcelioğlu et al. (2005) found the H+B/T value between 0.73-1.0 for *M. domesticus* and 0.76-1.46 for *M. macedonicus*.

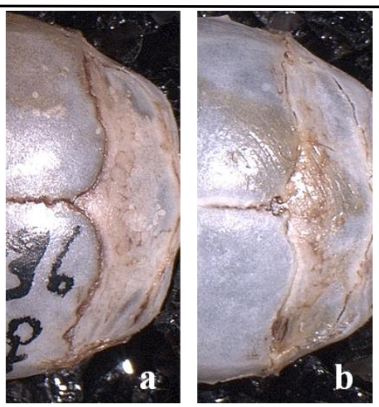

Figure 7. Parietal suture variations in *Mus macedonicus* (a: "v" shaped, b: straight)

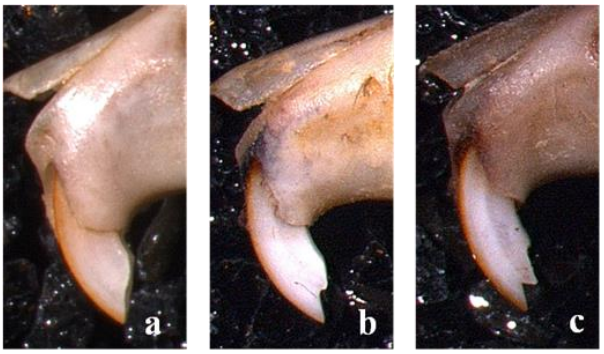

Figure 8. Variations of the upper incisors in *Mus domesticus* (a: unnotched, b: single-notched, c: double-notched)

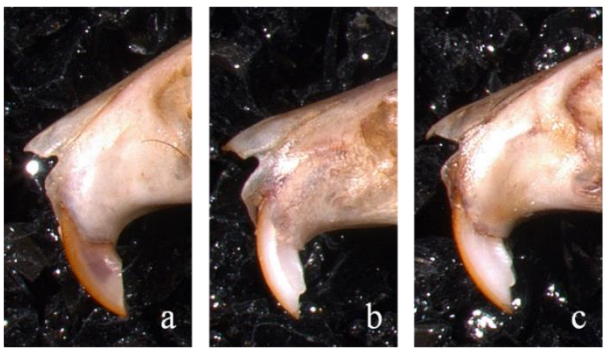

Figure 9. Variations of the upper incisors in *Mus macedonicus* (a: unnotched, b: single-notched, c: double-notched)

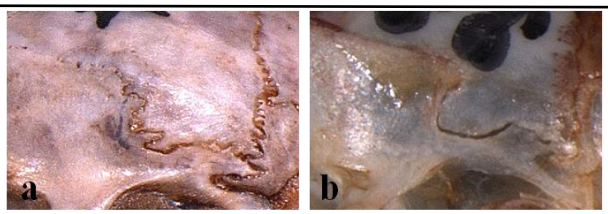

Figure 10. Variations of the ventral edge of the parietal bone in *Mus domesticus* (a: wavy/zigzag, b: straight)

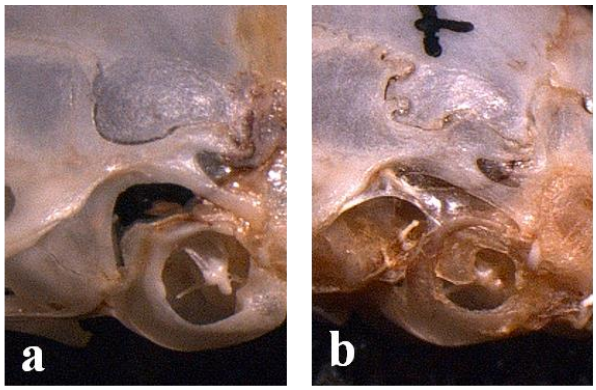

Figure 11. Variations of the ventral edge of the parietal bone in *Mus macedonicus* (a: straight, b: wavy/zigzag)

Conclusion

In the diagnosis of the genus *Mus* species, the diagnosis is made by looking at the ZI value, H+B/T value and the ventral state of the parietal bone. According to the results obtained in this study, it was seen that ZI value and H+B/T value were successful as diagnostic characters, but the ventral state of the parietal bone was not a reliable criterion. When the status of the frontal suture, parietal suture, and upper incisors, which are the other characters examined in the skull, were examined, no significant difference was determined in both interspecies and intraspecies variations.

Acknowledgements

This article was produced from a part of Güliz Yavuz's PhD thesis. I would like to thank my advisor Prof. Dr. Ercüment Çolak for his contributions.

Conflict of Interest

No known or potential conflict of interest exist for any author.

References

Auffray J C and Britton-Davidian J (2012). The house mouse and its relatives: systematics and taxonomy. In: M Macholan, S J E Baird, P Munclinger, J Pialek (Eds.), Cambridge Series in Morphology and Molecules, Cambridge University Press, pp. 1-35

Auffray J C, Marshall J T, Thaler L, Bonhomme F (1990). Focus on the nomenclature of European species of *Mus*. Mouse Genome 88: 7-8

Berry R J and Scriven P N (2005). The house mouse: a model and motor for evolutionary understanding. Biological Journal of the Linnean Society 84: 335–347

Gözcelioğlu B, Çolak R, Çolak E, Yiğit N (2005). A study on *Mus domesticus* Rutty, 1772 and *Mus macedonicus* Petrov and Ruzic, 1983 (Mammalia: Rodentia) distributed along the line of Ankara, Bolu and Zonguldak. Turkish Journal of Zoology 29: 133-140

Guenet J L and Bonhomme F (2003). Wild mice: an ever-increasing contribution to a popular mammalian model. Trends in Genetics 19: 24–31

Helvacı Z, Renaud S, Ledevin R, Adriaens D, Michaux J, Çolak R, Kankılıç T, Kandemir İ, Yiğit N, Çolak E (2012). Morphometric and genetic structure of the edible dormouse (*Glis glis*): a consequence of forest fragmentation in Turkey Biological Journal of the Linnean Society 107(3): 611-623

Kishimoto M, Kato M, Suzuki H (2021). Morphological and molecular recharacterization of the rodent genus *Mus* from Nepal based on museum specimens. Mammal Study 46: 297-308

Krystufek B and Macholan M (1998). Morphological differentiation in *Mus spicilegus* and the taxonomic status of mound-building mice from the Adriatic coast of Yugoslavia. Journal of Zoology 245: 185-196

Krystufek B and Vohralik V (2009). Mammals of Turkey and Cyprus Rodentia II: Cricetinae, Muridae, Spalacidae, Calomyscidae, Capromyidae, Hystricidae, Castoridae. Knjiznica Annales Majora

Novak R N and Paradiso J L (1983). Walker's Mammals of The World. Baltimore and London

Wilson D E and Reeder D M (2005). Mammal Species of the World. A Taxonomic and Geographic Reference, John Hopkins University Press