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Abstract: The primary aim of this study was to establish for the very first time the results on the rodent fauna gathered from the ongoing Neolithic excavations at the Tepecik-Çiftlik site in southern Cappadocia (Niğde, Turkey). So far, the fauna being study is represented by species of arvicolines (*Microtus* cf. *arvalis* and *Arvicola* cf. *amphibius*), murines (*Mus* cf. *musculus*), sousliks (*Spermophilus xanthoprymnus*), hamsters (*Mesocricetus brandti*) and mole-rats (*Spalax xanthodon*), and their remains are described in detail. Paleoenvironmental assumption based on common preferences of the fauna elements indicates, at first sight, a rather dry steppe environment with sparse plant cover or perennial short grasses. On the other hand, the presence of *Arvicola* cf. *amphibius* points out streams and marsh-like vegetation cover with bodies of water . The predation or burn marks observed on some specimens and the presence of subterraneous rodents raise questions concerning their taphonomy.

Keywords: Anatolia; Holocene; micromammals; paleoenvironment; Rodentia; systematics.

Introduction

Tepecik-Çiftlik is a mound-type human settlement site, known as ranging from the late Neolithic up to late Roman-Byzantine periods so far, according to five civilization occupational levels. It is located in the Çiftlik District of Niğde Province, in the southern part of Central Anatolia (Figure 1; for geomorphology of the environment, see Bıçakçı et al. 2017). Based on radiocarbon dating of the levels, the settlement age is *ca*. 5900–6650 cal. BC but the presence of a fifth level should indicate an earlier date of initiation of the settlement (Bıçakçı et al. 2012, 2017).

In the early 1960s, the site was first reported by Ian Todd who drew attention, especially to the importance of obsidian tools, for the Neolithic period of Central Anatolia (Todd 1966) although the main focus of excavations has been directed for many years towards other sites such as Çatalhöyük, Can Hasan and Yumuk Tepe-Cilicia (Figure 1; Garstang 1953, Mellaart 1962, French 1972, Bıçakçı et al. 2012, 2017). Thereafter, the pursuit of the obsidian material sources gave an importance to Tepecik-Çiftlik site as being closer to Göllü Dağ which is determined as the main obsidian source (Balkan-Atlı et al. 1998). Hence, the geographical position of Tepecik-Çiftlik holds a key to understand the Neolithic period in Central Anatolia on a broader scale. It is also crucial for the diffusion of obsidian material as regards the ancient civilization of Aşıklı Höyük (excavation initiated in 1989; Esin 1996) and Çatal Höyük which stand for the Aceramic Neolithic and Pottery Neolithic periods, respectively (see Bıçakçı et al. 2012, 2017).

Although the Tepecik-Çiftlik excavation was started in the early 2000s, attention was only paid to small mammals from 2014. Most specimens included in the present study were recorded from the recently opened trenches (Figure 2), in addition to some individual specimens (skulls, mandibles) that were collected during previous years. This is the first study dealing with rodents of the Tepecik-Çiftlik settlement.

Micromammals, because of the minute size of their remains, cannot be easily recorded during excavation than through the screen-washing of large amounts of sediment (Hillson 2005). Among micromammals, the rodents constitute the most abundant taxon.

For Turkey (and Cyprus), Krystufek and Vohralik (2001) cited 60 extant species, and this number is expected to increase with new discoveries or taxonomic enhancements.

Studies on micromammals in archeology contribute to our knowledge about the faunal environments of human settlements and their interactions (Jenkins 2012, Romaniuk et al. 2016). Also, micromammals are considered better proxies, compared to macromammals, for assumptions on paleoclimate and paleoenvironment as they are more sensitive to small variations in climate

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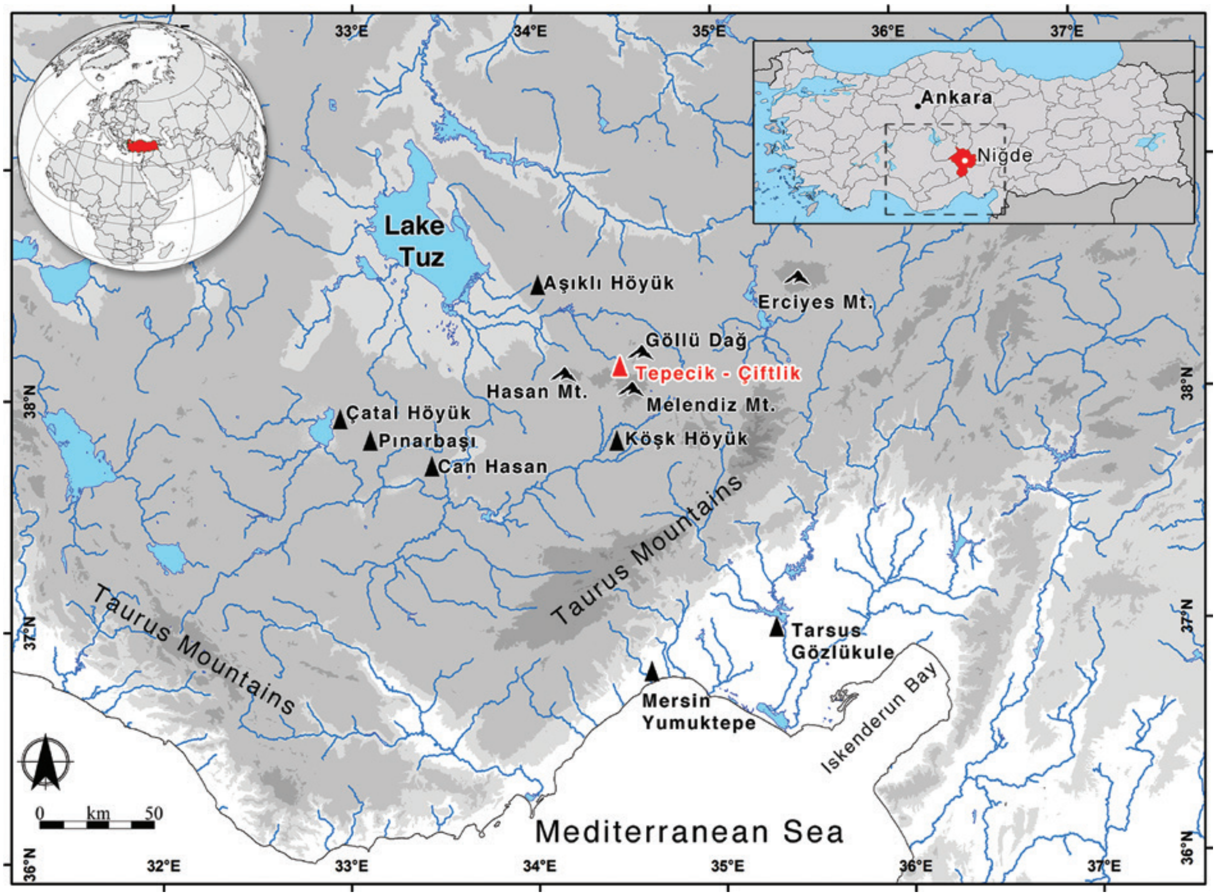

Figure 1: Location of the Tepecik-Çiftlik excavation site and other pottery Neolithic sites in Central Anatolia (modified after Godon 2010).

and have greater capacity to adapt to environmental changes thanks to their success in adaptive radiation (Renfrew and Bahn 2011).

This study aims to present the results on the rodent fauna, studied for the first time, from the Tepecik-Çiftlik excavation. The treatment of collected sediments so far from different trenches and units has yielded some well-preserved specimens represented by skulls and mandibles as well as many isolated teeth which are described in detail in the next section. This study enhances our knowledge on the poorly known Quaternary, especially the Holocene micromammal fauna in Anatolia (Erdal 2017). Finally, the taphonomic context is discussed.

Materials and methods

The fossils were obtained (except for large cranial specimens found during excavation) using the wet-screening process of sedimentation. Metal sieves of different mesh size (0.5, 1 and 8 mm^2) were used in either a floatation tank when available (by avoiding any material that floated except for seeds or charcoal) or in broad plastic basins filled with water. The washed material trapped on different sized mesh was spread on a large canvas separately to be dried and then stored in different plastic bags labeled each with trench and unit number as well as the mesh size.

Dry samples were sorted using a binocular microscope (Leica EZ4 HD) (Leica Microsystems, Wetzlar, Germany) and any "bony" material found was carefully separated using a tweezers and stored separately. The skulls and mandibles were measured using a Vernier caliper; dental measurements were handled via the software provided by the Leica EZ4 HD and Dino-Lite USB microscopes; (AnMo Electronics Corporation, Taiwan) photographs were taken under the microscope for isolated specimens or with a Canon 600D (Canon Inc, Tokyo, Japan) for skulls and jaws; drawings were made using a camera lucida and thereafter enhanced by Macromedia Flash Professional v.8 and Adobe Illustrator CS5 (Adobe Systems, Inc., CA, USA). All the fossil material described in this paper will be stored at the Archaeology Department of Istanbul University.

The nomenclature and measurement methods follow for arvicolines van der Meulen (1973), Rekovets and

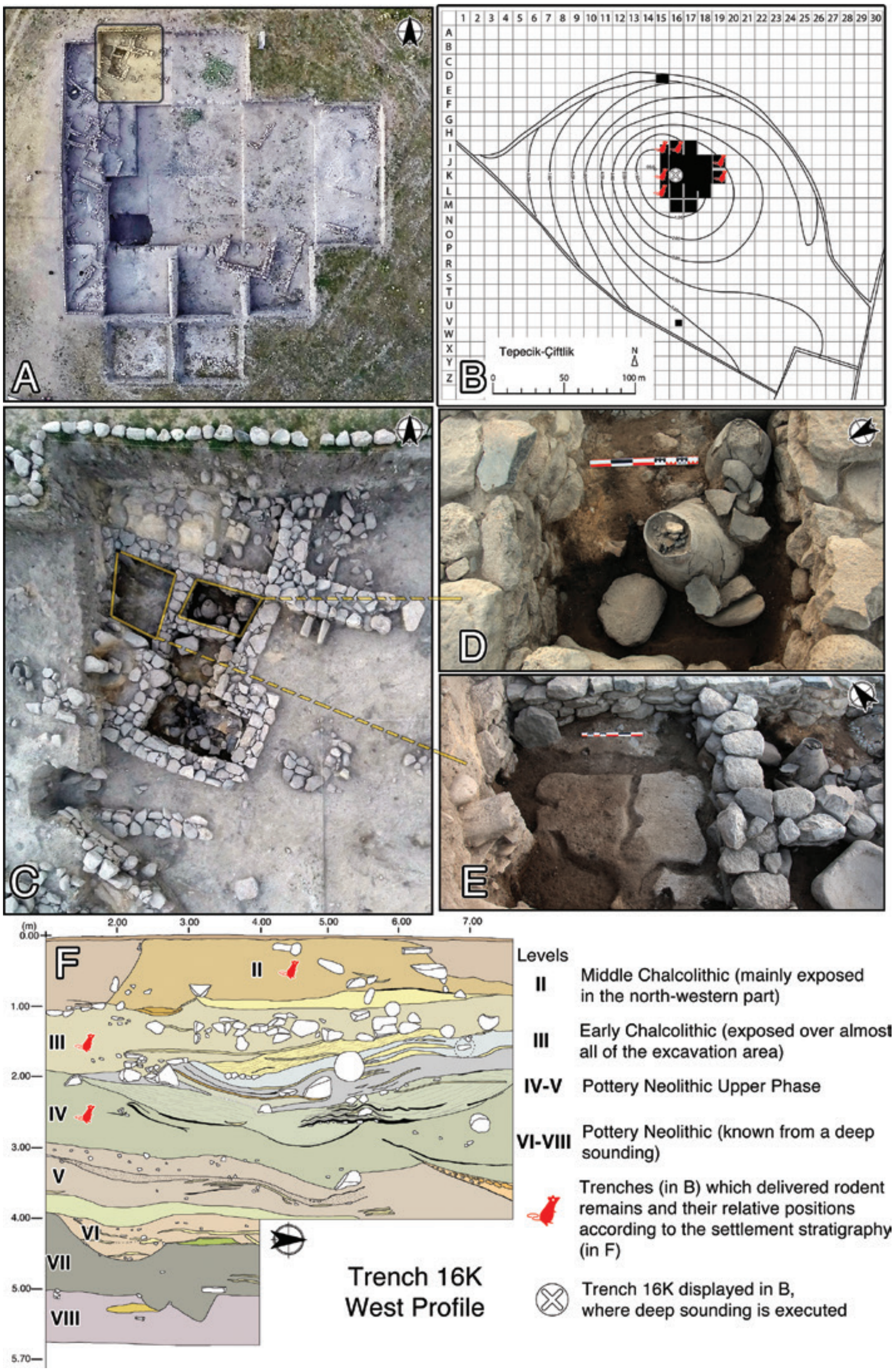

Figure 2: Photographs from the excavation area, topographic diagram and stratigraphic profile of the site.
(A) Aerial photograph of the site in 2015 (courtesy of Tepecik-Çiftlik Archives); (B) topography of the site within a diagram where the trenches opened so far are shown in black squares (modified after Bıçakçı et al. 2012); (C) aerial photograph of the trench 16I of which the context is the most certain; (D) a closer look at unit 84 and (E) 85 from the trench 16I, (F) stratigraphic profile of levels II–VIII established with deep soundings on the trench 16K (modified after Bıçakçı et al. 2012). Layer 1 is not included in the profile as it represents few tombs from the Late Roman–Early Byzantine periods, long after the mound was abandoned. Note that the filled square in A displays the location of the trench 16I among the study area, arrows indicate the north. Scale bar used in D and E is 50 cm. For context information see Table 1.

Nadachowski (1995) and Krystufek and Vohralik (2005); for murines Garcia-Alix et al. (2009); for sciurids Fling (1997); for cricetines López-Antonanzas et al. (2014); for spalacids Topachevskii (1969) and Sarıca and Sen (2003); for skull and mandibular measurements Krystufek and Vohralik (2005) and Helgen et al. (2009).

Abbreviations for teeth: all upper/lower incisors, premolars and molars are indicated as I/i, P/p, M/m, respectively, followed by a number for its position in molar series (anterior to posterior, 1–3); dext, dexter and sin, sinister.

Institutional abbreviations: İÜ, İstanbul University; İTÜ, İstanbul Technical University; SÜ, Sakarya University; HÜ, Hacettepe University; MNHN, Muséum National d'Histoire Naturelle (Paris). Abbreviations used for measurements are provided under the relevant tables. Note that "TP" in the labels of specimens means Tepecik, followed by a series of numbers indicating the year of excavation, trench number, unit, sample number (if present) and specimen number, respectively.

Results

The collected sediments during the last 2 years at Tepecik-Çiftlik have so far yielded six species belonging to five rodent subfamilies with 119 total described remains (TDR). Considering molars and cranio-mandibular elements they represent 50 minimum numbers of individuals (MNI). These specimens are described below to show their morphological characters for identification. The common vole *Microtus arvalis* (Pallas 1778) is represented by one mandible and 27 molars (MNI = 22, TDR = 28); the water vole *Arvicola amphibius* (Linnaeus 1758) by only one upper third molar; the house mouse *Mus* cf. *musculus* (Linnaeus 1758) by eight mandibles and five maxillary fragments with 34 molars in total (MNI = 20, TDR = 47); Anatolian ground squirrel *Spermophilus xanthoprymnus* (Bennet 1835) by three skulls and one mandible with 20 molars (MNI = 3, TDR = 24); Turkish hamster *Mesocricetus brandti* (Nehring 1898) by one skull and mandible and nine very worn molars (MNI = 1, TDR = 11); Anatolian mole rat *Spalax xanthodon* (Nordmann 1840) by one skull and three mandibles with four molars (MNI = 3, TDR = 8). Note that cranial or mandibular specimens were collected in the excavation and isolated teeth using screen-washing. The additional information concerning the levels, periods, context of trenches and units as well as number of remains (NR), TDR and MNI for each species of each trenches and levels are provided in Table 1. The relevant views from the excavation site and its stratigraphic profile are illustrated in Figure 2.

Order **Rodentia** Bowditch 1821
Suborder **Myomorpha** Brandt 1855
Family **Cricetidae** Fischer 1817
Subfamily **Arvicolinae** Gray 1821
Genus ***Microtus*** Schrank 1798
Microtus cf. *arvalis* Pallas 1778
(Figure 3; Tables 2, 3)

Materials

Five isolated M1 (TP15: 16I-84-1493-001, 16I-85-1494-007, 014, 015 and 016); eight M2 (TP15: 15L-12-004, 005, 15L-23-007, 008 and 012); one M3 (TP15: 16I-85-1494-005); left mandible bearing incisor and m1–m3 (TP13-15K-1-19-1); four isolated m1 (TP15: 15L-12-001, 002, 15L-23-005 and 16I-85-1494-004) and four m2 (TP15: 15L-12-003, 15L-17-004, 16I-84-1493-002 and 1518-001), two m3 (TP15: 15L-12-006, 16I-85-1494-009).

Trenches and units

15K-1-19; 15L-12, 23, 17; 16I-84 and 85.

Context

Figure 2 and Table 1.

Description

Rootless and hyposodont upper molars are represented by five M1 of which two belong to younger individuals (Figures 3.2, 4), eight M2 with one juvenile (Figure 3.13) and one M3 (Figure 3.14). The M1 have an anterior lobe followed by four alternate triangles. The dentine field of triangles are not confluent except on juvenile ones. Buccal re-entrant folds are broader than lingual ones. The cement is absent on young individuals with shorter crown height contrary to adults. The enamel is thicker on trailing edge compared to leading ones and it is absent on the posterior margin of T4 on all M1; the enamel is lacking on the lateral sides of anterior lobe in one of five specimens (Figure 3.5). A variation is observable on the posterior or lateral prolongation of T4.

On the M2, the anterior lobe is followed by three alternating triangles where dentine fields are not confluent, except on the juvenile specimen (Figure 3.13). Re-entrant folds are filled with cement. Besides minor dissimilarity in the enamel, possibly due to the degree of wear or digestion by predators, which obscure the observation, the leading edges are thinner than trailing ones. In five of eight specimens (except 15L-23-012, 16I-85-1494-013 and 018; Figures 3.7, 10, 13), there is a tendency of formation of an additional LSA4, and

Table 1: Provenance of rodent remains in the successive horizons of the Tepecik-Çiftlik infill and relevant periods, absolute ages, trenches, units, their context information and studied material counts.

Level	Period[a]	Absolute age[a]	Trenches and units	Context	Micromammal remains	NR[b]	MNI	TDR[c]
II	Early Chalcolithic	5900–6100 cal. BC	15K-1-19	The filling contains ashes and carbonized plant remains.	*Microtus* cf. *arvalis*	1	1	4
			15K-39	A pit on the uppermost phase of level 2, filled with ashes	*Spalax xanthodon*	1	1	2
			15I-54	Open area; dark-colored filling containing ashes and carbonized plant remains under the fallen stones	*Spermophilus xanthoprymnus*	1	1	8
			15L-12	Pit filling	*Microtus* cf. *arvalis*;	6	3	6
					Mus cf. *musculus*	3	3	5
			15L-13C	Pit filling (trash pit?)	*Spermophilus xanthoprymnus*	2	1	7
			15L-17	Pit filling	*Microtus* cf. *arvalis*;	1	1	1
					Mus cf. *musculus*	4	3	8
			15L-23	Pit filling	*Microtus* cf. *arvalis*;	6	6	4
					Mus cf. *musculus;*	1	1	1
					Arvicola cf. *amphibius*	1	1	1
			15L-91	Open area	*Mus* cf. *musculus*	1	1	3
III	Late Neolithic	6100–6400 cal. BC	16I-84	Room "CL". It is a part of building complex containing two large jars and a cylindrical silo made of clay, both in purpose of storage	*Microtus* cf. *arvalis*;	3	3	3
					Mus cf. *musculus*	9	7	15
			16I-85	Room "CM". Carbonized plant remains and a grinding stone are recovered in the room. The west part of the room is not excavated	*Microtus* cf. *arvalis*	10	8	10
					Mus cf. *musculus*	9	5	15
IV	Pottery Neolithic	6400–6650 cal. BC	19J-89	Open area	*Mesocricetus brandti*	2	1	11
			19K-101	Open area	*Spermophilus xanthoprymnus*	1	1	9
			19K-158	Open area	*Spalax xanthodon*	1	1	2
?	?	?	16I-27	Problematic; recovered from the annually deposited sediment	*Spalax xanthodon*	2	1	4
					Total	65	50	119

NR, Number of remains; MNI, minimum number of individuals; TDR, total described remains. Note that only cranio-mandibular specimens are studied and counted.

[a] Absolute ages and periods from Bıçakçı et al. 2017. [b] *In situ* molars are counted with the cranio-mandibular element. [c] All material described are counted separately (i.e. *in situ* molars + mandible or maxillary).

consequently an additional triangle T5 in the postero-lingual direction, and it is broadly confluent with T4. Other variations that can be noted are the smaller size of one specimen (15L-23-012) and the lack of enamel on the lateral side of anterior lobe as well as on the buccal tip of T2 (16I-85-1494-013).

The only M3 of *Microtus* found so far (Figure 3.14) displays an anterior lobe, which lacks enamel on its buccal and lingual edges, and six salient angles (T2–T7). Hence, there are four buccal and four lingual re-entrant angles. Lingual re-entrant angles are deeper and broader than buccal ones except for BRA2. The dentine fields of T2–T4 are closed but T5 and T6 are broadly confluent as well as T7 and the posterior cap. The latter is short and wide. The enamel on the leading edges is thinner than on trailing ones. As to the morphotype, the M3 from Tepecik is closer to the "type IV", in other words, *forma variabilis sensu* Rörig and Börner (1905; fig. 92) and Rekovets and Nadachowski (1995; fig. 73). According to Markova et al. (2010) who studied the variability on the m1 and M3 in the *arvalis* group, such complexity would increase as a result of the dominance of a continental climate and increased aridity leading to more abrasive food consumption. As the "*variabilis*" type for M3 is considered complex, it would indicate the same climatic conditions for the region of Tepecik-Çiftlik. Also note that the complexity of M3 in the *arvalis* group increases by time in the fossil record (Rekovets and Nadachowski 1995, Markova et al. 2010).

A nearly complete left mandible (Figures 3.26, 27) is only missing the apex of coronoid and angular processes. The coronoid process tends to direct slightly labially, relative to angular process. The corpus mandibulae is rather narrow but the masseteric ridge is robust. The mental foramen is situated mesial to the anterior end of masseteric ridge, slightly anterior to m1 and coincides with the

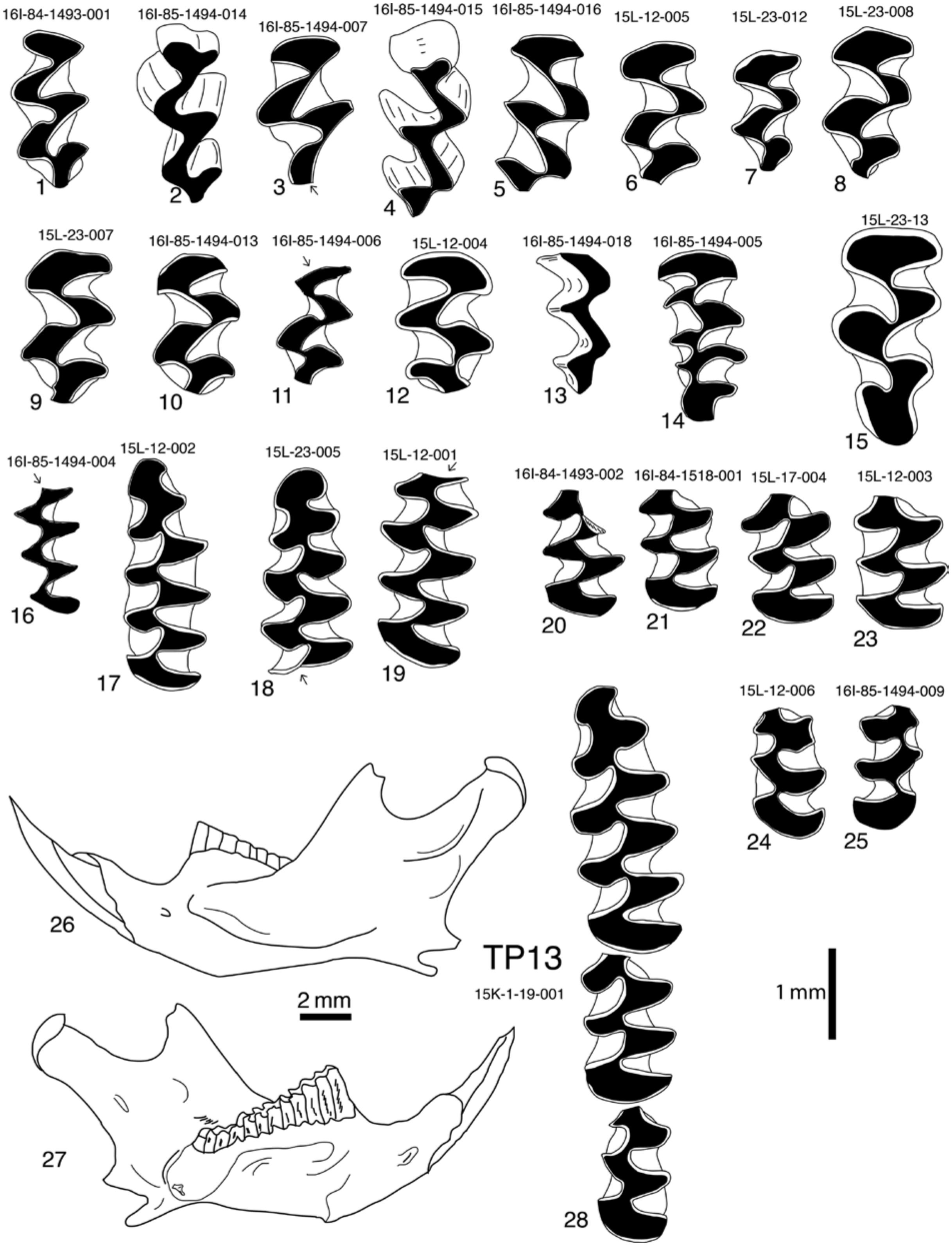

Figure 3: Arvicoline molars and mandible from trenches 15K–L and 16I.
Isolated molars: (1–5) M1, (6–13) M2, (14) M3 of *Microtus* cf. *arvalis*; (15) M3 sin. of *Arvicola* cf. *amphibius*; (16–19) m1, (20–23) m2, (24–25) m3 of *M.* cf. *arvalis*. The left mandible of *M.* cf. *arvalis* is displayed in (26) buccal and (27) lingual views with (28) *in situ* lower molars series, m1–m3 of the mandible. Note that all molars are sinester except 4–5, 12–14 and 25. The initial "TP13" is for mandible specimen only, the rest are TP15. Vertical scale is for molars, horizontal for mandible. Arrows indicate broken parts.

Table 2: Dental measurements of Tepecik-Çiftlik rodent species given in mm by minimum and maximum length and width.

Genus and species	Trench number	Tooth	N	Length		N	Width	
				Range	Mean		Range	Mean
Microtus cf. *arvalis*	TP13-15K-1-19; TP15-15L-12, 23, 17; TP15-16I-84-1493, 1518; TP15-16I-85-1494	M1	4	1.72–1.75	1.73	5	0.65–0.91	0.86
		M2	7	1.34–1.72	1.57	8	0.58–1.09	0.91
		M3	1	–	1.89	1	–	0.89
		m1	2(/5)	2.6–2.80	2.7	4(/5)	0.96–1.14	1.05
		m2	5	1.37–1.57	1.46	5	0.87–1.02	0.95
		m3	3	1.38–1.46	1.43	3	0.73-0.84	0.79
Arvicola cf. *amphibius*	TP15-15L-23	M3	1	–	2.6	1	–	1.23
Mus cf. *musculus*	TP15-15L-12;17;23;91; TP15-16I-84-1493; TP15-16I-84-1516; TP15-16I-84-1517; TP15-16I-84-1518; TP15-16I-85-1494	M1	10	1.52–1.82	1.65	10	0.91–1.19	1.09
		M2	3	0.96–1.11	1.04	3	0.93–0.97	0.95
		m1	14	1.45–1.55	1.5	14	0.87–0.98	0.92
		m2	7	0.95–1.12	1.01	7	0.88–0.95	0.92
Mesocricetus brandti	TP14-19J-89	M1	2	2.33–2.39	2.36	2	1.48–1.51	1.49
		M2	2	1.93–1.94	1.936	2	1.59–1.60	1.601
		M3	2	1.86–1.87	1.867	2	1.53–1.55	1.54
		m1	1	–	2.2	1	–	1.13
		m2	1	–	1.93	1	–	1.34
		m3	1	–	2.13	1	–	1.47
Spalax xanthodon	TP09-16I-27; TP14-19K-158C; TP13-15K-39	m1	3	2.64–2.93	2.78	3	2.29–2.49	2.37
		m3	1	–	2.239	1	–	2.213
Spermophilus xanthoprymnus	TP14-19K-101; TP15-15I-54; TP15-15L-13C	P4	3	1.99–2.09	2.04	3	2.4–2.57	2.52
		M1	4	2.18–2.26	2.25	4	2.9–2.97	2.93
		M2	6	2.18–2.41	2.3	6	2.9–3.12	2.99
		M3	5	2.71–2.83	2.76	5	2.81–2.94	2.82
		p4	1	–	2.129	1	–	2.035
		m3	1	–	3.502	1	–	2.748

N, Quantity of measured material.

Table 3: Mandibular measurements in mm of available material from Tepecik-Çiftlik.

	Microtus* cf. *arvalis **TP13-15K-1-19**	***Spermophilus xanthoprymnus*** **TP15-15L-13C-002**	***Mesocricetus brandti*** **TP14-19J-89-002**	***Spalax xanthodon*** **TP13-15K-39-001**	***Spalax xanthodon*** **TP09-16I-27-002**	***Spalax xanthodon*** **TP14-19K-158C-001**
LTR	5.977	9.4	6.1	8.3	8.3	9.5
DD	4.431	6	5.75	7.8	10.4	8.6
DL	12.353 min	?	?	?	30 min	28.7
LCP	9.241	11.5	9.8	?	16.5	14.4
LDL	3.83	6.1	6.2	6.5 min	8.4	6.4

LTR, Lower tooth row length; DD, dentary depth; DL, dentary length; LCP, length of condyloid process; LDL, lower diastema length; min, minimum.

outline where the diastema reaches its ventral optimum curve. The chin process forms a faint angle but is distinct. The mylohyoid line on the lingual side of the mandible rises at the posterior part of the first molar and curves postero-ventrally at the third molar level.

Lower molars are also rootless and hypsodont with alternating triangles ("prismatic" shape) and positive enamel differentiation ("*Microtus*-type"). The cement is present in re-entrant angles (Figures 3.17–25, 28). Note that on the broken juvenile lower first molar, the cement is barely present on lingual angles and the enamel differentiation is not achieved (Figure 3.16). On the other m1s (Figures 3.17–19), there are four re-entrant angles on the buccal side and five on the lingual side. The secondary wing (T6–T7 *sensu* Repenning 1992) is present and confluent contrary to the primary wing (T4–T5). The anteroconid complex is rather simple, the enamel is very thin on the mesial apex of anteroconid cap and, triangles T8–T9 are not fully formed except in one specimen, 15L-23-005 (Figure 3.18). On the latter, LRA5 is much deeper and narrower which causes a wider anterior cap, in other words, T9 is more prominent. On the other hand, worn and partly eroded occlusal surface morphology as well as very short crown height (the shortest is 1.71 mm) would suggest that this tooth was subjected to digestion. Also, one of the first lower molars lacks the anterior cap (Figure 3.19), which makes its identification ambiguous. The posterior loop clearly lacks enamel on the buccal and lingual sides of m1.

On the m2, none of the triangles are confluent, T4 is mesially short, lingual re-entrant angles are deeper than buccal ones (Figures 3.20–23). The two major variations observed on the m2 sample are that enamel, although "*Microtus*-type", is thicker on specimens from trench 15L compared to that of 16I and it is clearly absent on the lateral sides of the posterior lobe on specimens from trench 16I.

On the m3, all triangles are confluent and inclined postero-lingually. One of the isolated m3 (Figure 3.24) differs from the others in the morphology of LSA3 (or T3) in having a shallow cavity on the lingual side. Note that this cavity forms a groove throughout the crown in the lateral view. Another variation on one m3 is the enamel occurrence is nearly undistinguishable on the posterior edge of the tooth (Figure 3.25).

In Turkey, 13 biological species of *Microtus* have been identified (Krystufek and Vohralik 2009, Yiğit et al. 2016b) and their identification as well as nomenclature history are thoroughly discussed in Krystufek and Vohralik (2005), with some nomenclature corrections added afterwards in Krystufek and Vohralik (2009: 13–28). Unlike the identification of a palaeontological species, many authors mainly based differences between species on karyotype analyses in addition to some morphological characters (e.g. fur color, tail length, nipples, etc.). Such characters cannot be handled for fossil remains. It is a known issue that generally lower first molars and upper third molars bear key features that can be distinguished at the genus or species level among arvicolines. However, these teeth display great morphological variations and need abundant material for safe species identification.

Nonetheless, the Tepecik-Çiftlik specimens display morphological similarities with the extant species *Microtus guentheri* known in Turkey from the social voles group (see Krystufek and Vohralik 2005) as well as in the middle Pleistocene of Qesem Cave in Israel (Maul et al. 2011). Also, many similarities and minor differences exist between the Tepecik-Çiftlik material and the two members of the *arvalis* group from Anatolia: *Microtus levis* (=*rossiaemeridionalis*) and *Microtus arvalis* (=*obscurus*) (Krystufek and Vohralik 2005, 2009, Musser and Carleton 2005).

Microtus guentheri is greater in the length of m1 (minimum 3.14 mm contra maximum 2.80 mm in the Tepecik specimens), although the mean values of the A/L index are close to 55.72–52.7 of Tepecik arvicoline. According to Markov et al. (2012) who compared *Microtus arvalis* and *Microtus levis* from Hungary by means of craniomandibular measurements, the mandible from Tepecik is rather closer to the mean values of *M. arvalis* than that of *M. levis* (Markov et al. 2012, table 1, characters V22–25). Likewise, the m1s from Tepecik are within the size range of *M. arvalis* from Pleistocene of Ukraine (Rekovets and Nadachowski 1995), from the Late Pleistocene of North Eastern Iberia (Luzi et al. 2017) and from the late Quaternary of Poland (Nadachowski 1982).

Although the highly individual intraspecific variations but slight interspecific differences in the *arvalis* group (Krystufek and Vohralik 2005) would muddle pinpointing the species identification, it is still possible to compare Tepecik-Çiftlik arvicoline with *Microtus levis* and *Microtus arvalis*. For instance, the formation of T5 on M2 is frequently observed on the Tepecik material found so far but it is exceptionally present on *M. levis*, and absent on *M. arvalis*. On the other hand, some shared characters between the Tepecik arvicoline, *M. levis* and *M. arvalis* can be cited as four buccal and lingual re-entrant angles on M3 (rare condition in *M. levis* and *M. arvalis*), the presence of BRA4, alternating T4–T5, T6–T7 confluent with anterior cap, five lingual and four buccal re-entrant angles on m1. In summary, the Tepecik-Çiftlik specimens are well in concordance with their closed dentine of T4 on M3 and buccal triangles smaller than the lingual ones on m1 with *M. arvalis*, and mostly fit the type "C" of morphological variations provided by Luzi et al. (2017): T6–7 and AC confluent, with small incipient BSA5 and LSA6 (Luzi et al. 2017: 499). Therefore, the arvicoline specimens found at Tepecik-Çiftlik are cautiously referred to as *M. arvalis* (=*obscurus*), in accordance with general morphology, measurements and complex morphotype of M3 as previously mentioned.

Genus ***Arvicola*** Lacépède 1799
Arvicola cf. *amphibius* Linnaeus 1758
(Figure 3.15, Table 2)

Material

One isolated M3 (TP15-15L-23-013).

Trench and unit

15L-23.

Context

Table 1.

Description

This molar is large sized, hypsodont, cemented and rootless. The enamel differentiation is not significant except at the posterior part of the tooth. Following the anterior loop, there are three alternating angles (T2–T4) and T5 is broadly confluent with T4 forming a simple posterior cap. There are two deep lingual and buccal re-entrant folds (LRA2–3 and BRA1–2); the third buccal one (BRA3) is shallower and wider. T6 and T7 are absent. Based on occlusal morphology and the size range of M3 (Özkurt et al. 1999, Krystufek and Vohralik 2005, Kalthoff et al. 2007), this specimen is closer to *Arvicola amphibius*. Note that excavations and residue sorting will be pursued, thus the record of this arvicoline species is expected to increase. For nomenclature priority of *Arvicola terrestris* over *A. amphibius*, see Musser and Carleton (2005) and Krystufek and Vohralik (2009).

Family **Muridae** Illiger 1811
Subfamily **Murinae** Illiger 1811
Mus cf. *musculus* Linnaeus 1758
(Figure 4, Table 2)

Material

Three maxillary fragments bearing M1–M2 (from trenches 16I-84 and 85) and two bearing only M1 (from trenche 16I-85); five isolated M1 (two from trenches 15L-17, three from trenches 16I-84 and 85); isolated six m1 and two m2 (from 16I-84; 16I-85 and 15L-23); one left mandible fragment with m1–m2 (from 16I-85, not illustrated); one left and right mandibulary fragment with m1 each (from 16I-84, not illustrated); three left mandible fragments of which the first bears incisor and m1–m2 (TP15-15L-17-003), the second with incisor and m1 (TP15-15L-12-013), the third with m1–m2 (TP15-15L-12-012); two right mandible fragments bearing worn m1–m2 (TP15-15L-17-002 and TP15-15L-91-003). Note that only some selected specimens with given catalogue numbers are illustrated in Figure 4.

Trenches and units

15L-17, 23, 12 and 91; 16I-84 and 85.

Context

Figure 2 and Table 1.

Description

Relatively small to medium sized molars display morphological similarities especially with *Mus musculus* among the extant species of *Mus* in Turkey, in having two tubercles on the lingual side of the M1 (t1 and t4) and two roots on m1. Some authors (Krystufek and Vohralik 2009 and references therein) distinguish Eastern European house mouse populations as a different species, *Mus domesticus*, based on some morphological and anatomical features. This can hardly be done on the fossil material. In this group, two extant species are recognized in Turkey, *M. musculus* (or *domesticus*) and *Mus macedonicus* (Musser and Carleton 2005, Krystufek and Vohralik 2009 and references therein). As discussed by Maul et al. (2011), the key feature to differentiate *M. musculus* from *M. macedonicus* is the thickness of the malar process on the zygomatic arch (thicker in *M. macedonicus*), and this characters cannot be observed on the available material from Tepecik. On the other hand, Zagorodnyuk (2002) and Krystufek and Vohralik (2009) note that the anterior root of M1 in *M. musculus* is slanting, possibly labially as seen in the Tepecik specimens contrary that of *M. macedonicus* where it is more or less straight. Also, Çolak et al. (2006; figs. 3–4) highlighted some interesting features concerning the lower and upper molars of both species: some *M. macedonicus* specimens display a mesial cusp on the M1 (which is absent in all the Tepecik specimens; Figure 4A–C) and the labial anterocone (t3 or anterolabial cusp) is missing or faint on the M1 of *M. musculus*, while it is prominent on the M1 of Tepecik murines. The latter is illustrated as distinct in Krystufek and Vohralik (2009: 154) *contra* Çolak et al. (2006).

On the M1, cusps on the lingual side are situated more posteriorly than on the labial side; labial anterocone (t3) is rather small; instead of posterostyle (t7) a weak enamel ridge is present; connection between enterostyle, protocone and paracone (t4–t5–t6, respectively) is well established; posteroloph (t12) is absent and hypocone (t8) is well positioned at the posterior edge with the metacone (t9). Two labial and one lingual roots are present.

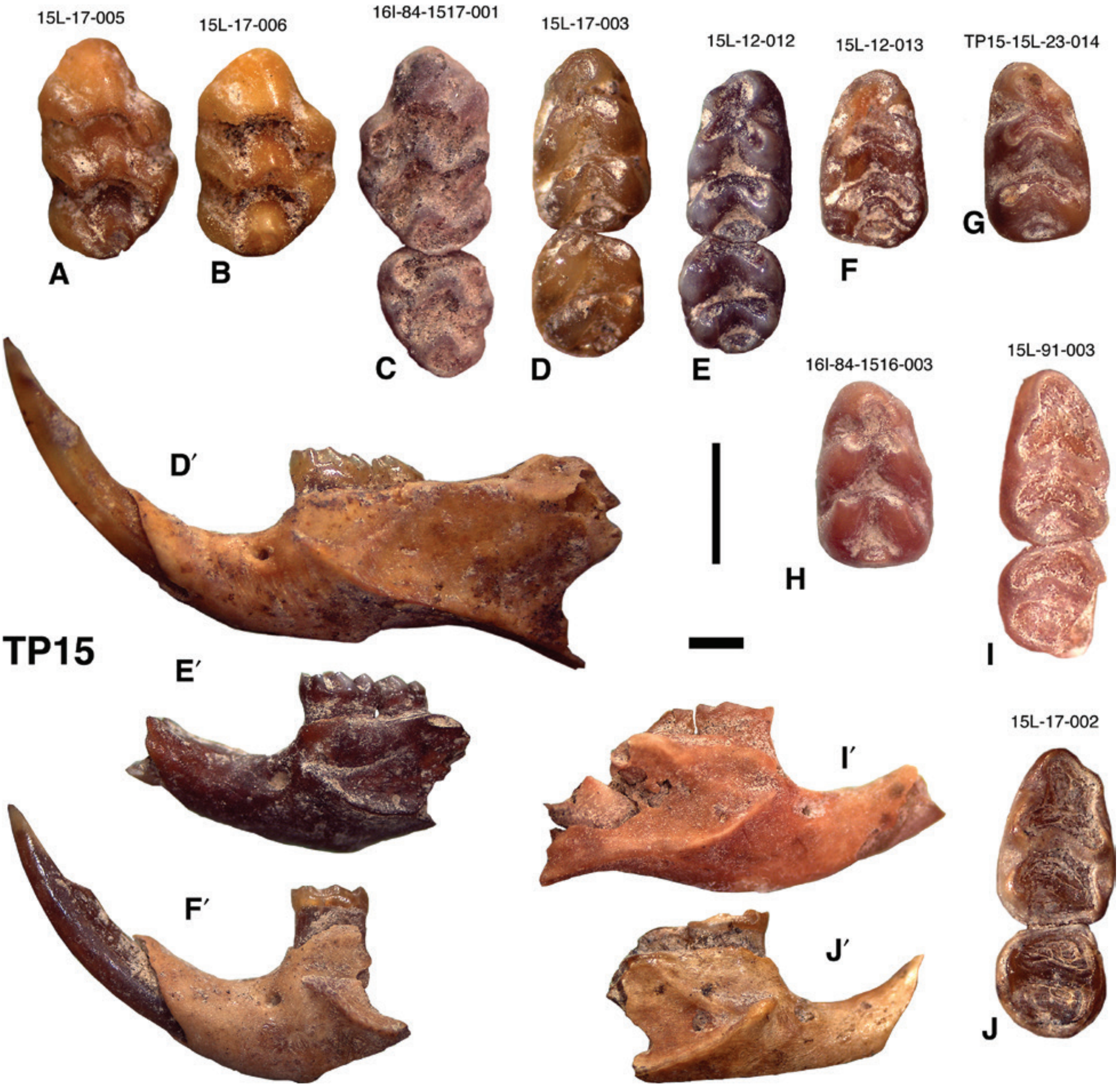

Figure 4: Upper and lower molars of *Mus* cf. *musculus* from trenches 15L and 16I with five mandible fragments in the labial view. Lower m1–m2 series are displayed to the right of the relevant mandible fragments. (A–B) M1 dext.; (C) M1–M2 sin. on the maxillary fragment; (D′–F′) left mandibles bearing (D) incisors and m1–m2, (E) m1–m2, (F) i and m1, respectively; (I′–J′) right mandibles bearing (I and J) m1–m2; (G–H) two isolated m1 dext. Note that vertical scale is for molars, lateral is for mandibles. Scale bars are for 1 mm.

All three M2 appear to be heavily worn or digested and thus, many features are not obviously displayed. Nonetheless, it is safe to indicate that all specimens possess a labial anterocone (t3) which is smaller than the lingual anterocone (t1; Figure 4C). According to Krystufek and Vohralik (2009), extant specimens of *Mus domesticus* lack labial anterocone and it is rarely present in *Mus macedonicus*.

As to the lower molars, the slight difference between *Mus musculus* and *Mus macedonicus* is that the former has a weaker labial anteroconid whereas it is individualized and mesio-labially oriented in *M. macedonicus*. Therefore, it forms a deeper valley between labial anteroconid and the protoconid. That feature of *M. macedonicus* is more or less observable on some Tepecik m1 specimens (Figure 4F, H) which is variable on others (Figure 4D–E, I). That valley disappears by increasing wear degree and thereafter labial anteroconid fuses within other cuspids (Figure 4J).

Overall, upper molars of Tepecik murines tend to be closer to that of *Mus musculus*. By means of measurements, specimens are within the range of *Mus* cf.

musculus from the middle Pleistocene Qesem Cave, Israel and generally smaller than *Mus macedonicus* from the palaeolithic Üçağızlı Cave, Hatay-Turkey (Maul et al. 2011, Suata-Alpaslan 2011). Therefore, the Tepecik specimens are cautiously attributed to *Mus* cf. *musculus*. It will be necessary to increase the sample size to obtain robust morphological and biometric data for a better definition of this taxon.

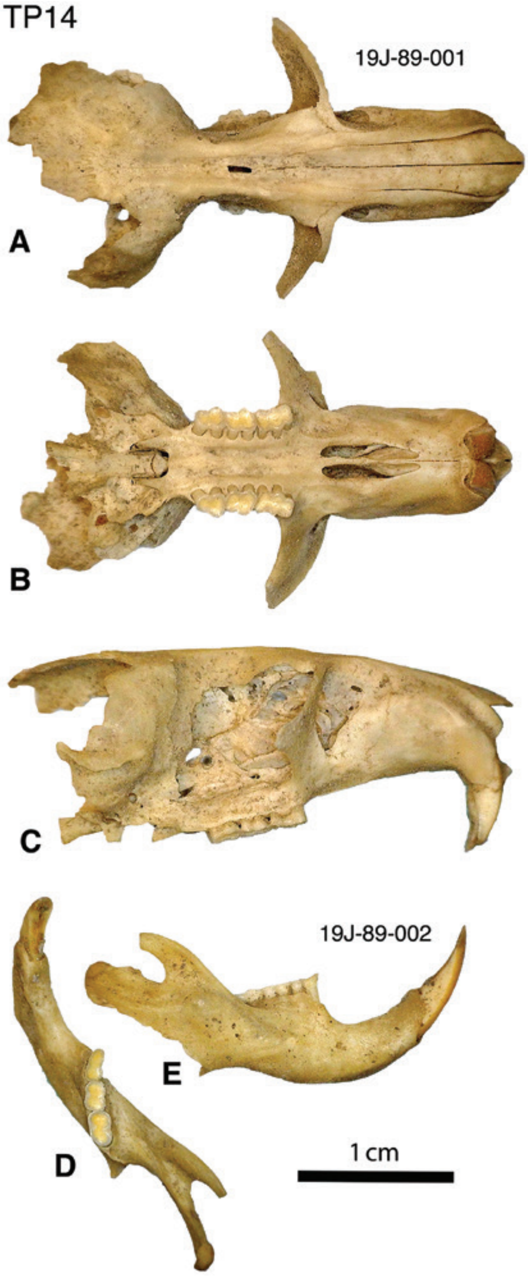

Figure 5: Skull and right mandible of *Mesocricetus brandti* from the trench 19J.
Skull in (A) dorsal, (B) ventral, (C) lateral views; mandible in (D) occlusal and (E) lateral views.

Family **Cricetidae** Fischer 1817
Subfamily **Cricetinae** Fischer 1817
Mesocricetus brandti Nehring 1898
(Figure 5; Tables 2–4)

Material

A skull with missing basicranium (TP14-19J-89-001) bears left and right molar series and incisors; right mandible with complete molar set and incisor (TP14-19J-89-002).

Trenches and units

19J-89.

Context

Table 1.

Description

Medium sized rodent with a long but laterally narrow and dorso-ventrally deep rostrum (Figure 5A). The incisive foramen is long, moderately wide and terminates without reaching the level of M1. The suture between the long nasal and frontal bones reaches the level of mid-M1s. The palatine foramen is situated at the level of the anterior root of M3 and is somewhat in a faint groove (Figure 5B). The supraorbital crests rise anteriorly in continuum with the posterior portion of the premaxillary. They are high and strong, forming a deep but narrow medial groove on the frontals. Finally, they turn into faint crests and appear to diverge laterally on parietals. The infraorbital foramen is laterally narrow but longitudinally extended. The masseteric plate is wide antero-posteriorly. The mesial flank of the upper and lower incisors is orange in color rather than yellow. The M1–M2 has four and M3 has three roots whereas all lower molars have two. The mandible is more or less robust, moderately deep with well-developed processes (the angular process and the tip of coronoid process are missing).

These specimens possibly belong to the same individual, of very old in age, as the degree of high wear of teeth is identical on the upper and lower molars and their occlusal surfaces perfectly match. Due to advanced wear, cusps and crests are lost, and consequently, the morphological features of molars are not accessible. However, all

Table 4: Cranial measurements in mm of *Spermophilus*, *Mesocricetus* and *Spalax* species from Tepecik.

	Spermophilus* cf. *xanthoprymnus **TP14-19K-101-001**	***Spermophilus xanthoprymnus*** **TP15-15I-54-001**	***Spermophilus xanthoprymnus*** **TP15-15L-13C-001**	***Mesocricetus brandti*** **TP14-19J-89-001**	***Spalax xanthodon*** **TP09-16I-27-001**
MTR	10.516	10.504	9.7	6.1	8.5
RL	22.8	23.5	22.2	18.8	31.3
CL	41.2 min	41	40.2	?	49.8
OL	43.2 min	?	?	?	53
IFL	2.6	2.7	2.6	5.85	4.1
IFW	1.7	2.4	1.5	2.3	1.7
BU	?	9	9.3	?	11.8
IC	9.7	9	8.4	4.15	7.7
BW	?	21.45	?	?	27.8
ZW	?	25.4 approx.	?	?	39.65
BL	20.2 min	20	19.1	?	21.4
RH	10.8	10.2	10.3	9.3	17.7
BH	14.6	14.2	14.8	11.8	21.5
PL	16.1	15.9	16.1	9.2	16.2
MDL	10.1	10.7	10.2 approx.	10.5	18.8

MTR, Maxillary tooth row length; RL, rostrum length; CL, condylobasal length of skull; OL, occipito-nasal length of skull; IFL, incisive foramen length; IFW, incisive foramen width; BU, bullae length; IC, interorbital constriction; BW, braincase width; ZW, zygomatic width of skull; BL, braincase length; RH, rostrum height; BH, braincase height; PL, palatal length; MDL, maxillary diastema length; min, minimum; approx, approximately.

the characters of the skull and mandible, as well as the outline and alignment of those brachyodont molars point to the family Cricetidae.

Among the seven genera and 18 species of Palaearctic, occurrence of the Cricetidae (Musser and Carleton 2005), hamsters are represented in Turkey by only two genera (*Cricetulus* and *Mesocricetus*) with three extant species (*Cricetulus migratorious*, *Mesocricetus auratus* and *Mesocricetus brandti*; Krystufek and Vohralik 2009).

The main distinction between *Cricetulus* and *Mesocricetus* is pointed out by Krystufek and Vohralik (2009) as being skull size (i.e. >30 mm in *Mesocricetus*) and therefore, the specimens from Tepecik represent the genus *Mesocricetus* accordingly to the greater condylobasal length even in the absence of a braincase (>31 mm; only a minor portion of parietals are preserved). On the other hand, *Cricetulus migratorius* differs from Tepecik cricetine in having nasal bones with rounded anterior edges and extending well anterior to the incisors, a faint protuberance on the premaxillary formed throughout the line of incisors root in the lateral and dorsal views, a palatal bone terminating just posterior to the level of M3 and finally, a less deep mandible (body).

As to *Mesocricetus* spp., the key characters for identification of Turkish species are the coloration of the fur and the molecular evidence (Ellerman 1948, Neumann et al. 2006) in contrast to very similar cranio-mandibular characters (Krystufek and Vohralik 2009). Nevertheless, Yiğit et al. (2000) strongly point out the difference on the shape of the mesopterygoid fossa and the orientation of pterygoids at the posterior end of the palatal bone; U-shaped in *Mesocricetus brandti* and V-shaped in *Mesocricetus auratus*. The former state of that feature fits the Tepecik specimen and overall comparisons here stated lead to ascribe the Tepecik specimens to *M. brandti*.

The mandible has a coronoid process weaker than in *Mesocricetus auratus* and curved posteriorly, almost in parallel with the articular process, and the angle between those two processes is somewhat narrower than in *M. auratus*.

Finally, the comparison of the size (upper and lower molars as well as tooth row and available cranio-mandibular measurements) shows that *Mesocricetus* from Tepecik displays mostly greater sizes compared to *Mesocricetus auratus* (see Hir 1992, Shehab et al. 1999, Yiğit et al. 2000, Krystufek and Vohralik 2009) and all measurements are within the range of *Mesocricetus brandti* (Yiğit et al. 2000, Yiğit 2003, Krystufek and Vohralik 2009, Suata-Alpaslan 2011).

Family **Spalacidae** Gray 1821
Subfamily **Spalacinae** Gray 1821
Spalax xanthodon Nordmann 1840
(=*S. nehringi* Satunin 1898)
(Figure 6; Tables 2–4)

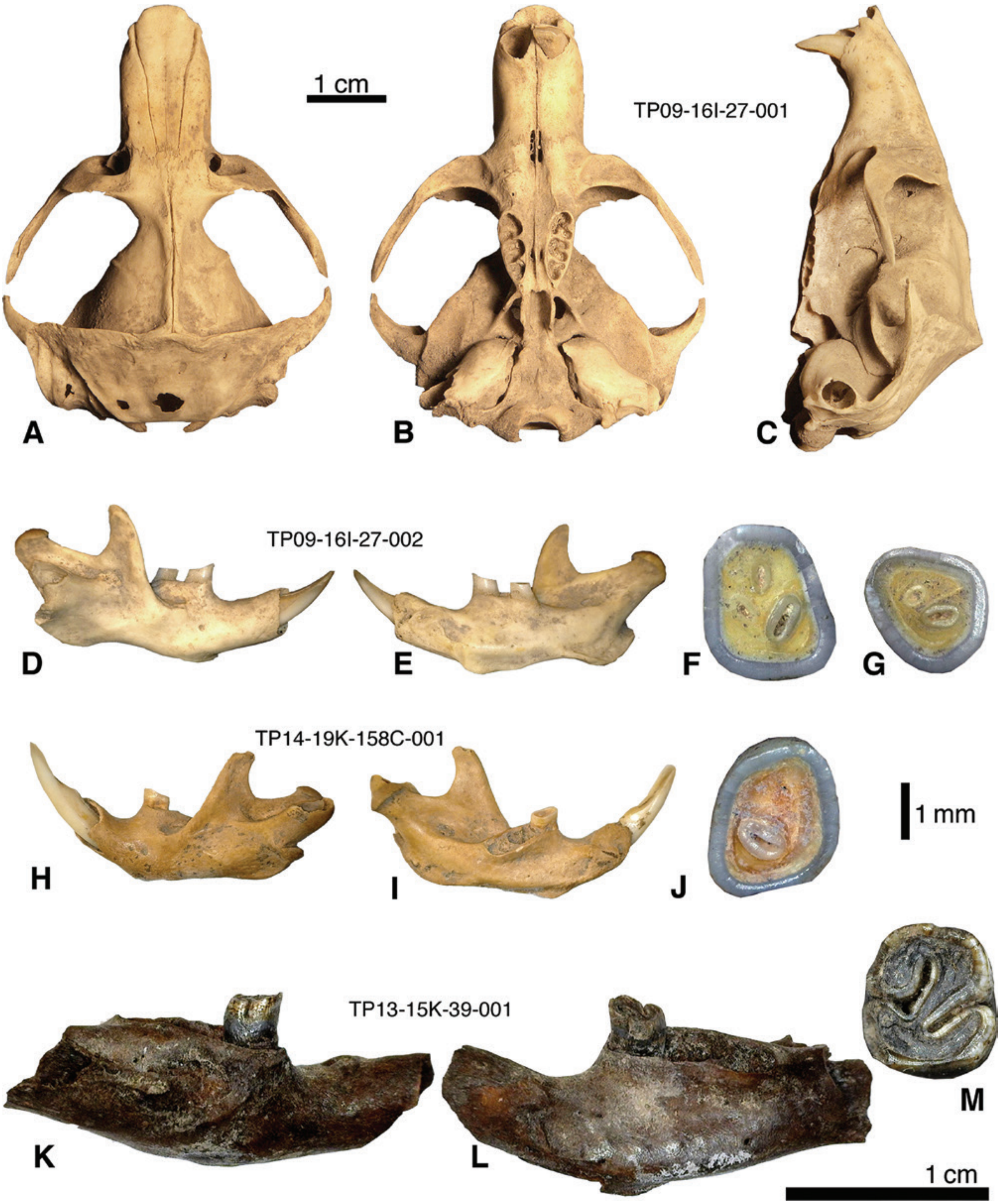

Figure 6: One skull without molars and three mandibles of *Spalax xanthodon* from trenches 15K, 19K and 16I. The skull in (A) dorsal, (B) ventral, (C) lateral views. Mandibles (D–E, H–I and K–L) are displayed in the labial and lingual views on the left and right, respectively. The molars *in situ* are demonstrated in the occlusal view to the right of the relevant mandible: (F–G) m1 and m3 dext., (J) m1 sin. and (M) m1 dext. Note that the upper lateral scale is for the skull and mandibles A–E and H–I, and lower lateral scale for K–L, vertical scale is for the teeth. For context information see Table 1.

Material

A well-preserved skull with missing teeth except I sin. (TP09-16I-27-001); right mandible bearing incisor, m1 and m3, possibly belonging to the same individual as skull (TP09-16I-27-002); right fragmentary mandible with m1 (TP13-15K-39-001); left mandible with incisor and m1 (TP14-19K-158C-001).

Trenches and units

16I-27; 19K-158; 15K-39.

Context

Table 1.

Description

The skull from Tepecik-Çiftlik belongs to a typical mole rat as described for the family in Topachevskii (1969) with a wedge-like shaped skull in the lateral view and braincase shorter than the rostrum in length. A major character is the occipital region which is highly developed, wide and inclined almost 45° in the antero-dorsal and postero-ventral directions. The sagittal and lamdoidal crests are strong and the latter is in continuum with the squamosal process of the zygomatic arch and nearly as wide as it is. The mandible is mainly characterized by its well-developed alveolar process, elongated articular process bending laterally and finally a long, broad coronoid process slightly oriented in the posterior direction. The molars have a rounded occlusal outline, "S-shaped" occlusal pattern or some closed enamel islands depending on the wear stage; they bear significant characters to recognize those subfossils as belonging to the Spalacidae.

On the other hand, some variations are observed in our sample. For instance, one of the two mandibles (except 15K-790-39-001, Figure 6K–L) bears an incisor with a strong longitudinal groove on the mesial side of the tooth (Figure 6D). Likewise, the same mandible (16I-27-002) has a much robust corpus mandibulae and ascending ramus, greater size of the apex of the articular process and more pronounced and long coronoid processes in comparison with 19K-158C-001 (Figure 6H–I). These observations are also supported by the mandibular measurements which would indicate that those two specimens might belong to a different species (Table 3). Although fragmentary, a third specimen (Figure 6K–L) appears to be smaller than the two mandibles mentioned above. In addition, the size of the only available molar on this fragmentary mandible (Figure 6M) is smaller than the m1 of the other specimens (Figure 6F, J; see Table 2). Note that the length of m1s increases parallel to the wear stage. The youngest specimen (15K-790-39-1) has a clear conid and lophid pattern with still open sinusid and mesosinusid (Figure 6M). The hypoconid is less directed mesially and thus, the sinusid is less oblique compared to *Spalax leucodon*. The mesosinusid is bended mesially. At the advanced wear stage, those lingual and labial entrant folds are transformed into enamel islands as can be observed as enamel islands on the specimens 16I-27-002 and 19K-158C-001 (Figure 6F and J).

The taxonomical studies on the Spalacidae (or more precisely Spalacinae) did not resolve the number of the genera, subgenera as well as species or subspecies to be referred to this subfamily. For instance, some researchers consider only one extant genus, *Spalax* while some others prefer to distinguish *Nannospalax* (*Mesospalax* sensu Topachevskii 1969) and *Spalax* (see Musser and Carleton 2005, Krystufek and Vohralik 2009, Krystufek et al. 2012, Arslan et al. 2014 and references therein).

Similarly, mole rats from Anatolia has been reported under different species names, either *Spalax leucodon* (Kıvanç 1988, Nadachowski et al. 1990, Yiğit et al. 2003) or *Spalax nehringi* (Topachevskii 1969, Coşkun 2003), in addition to *Spalax ehrenbergi* which is generally considered as a distinct taxon (Ellerman and Morrison-Scott 1951, von Lehmann 1969, Coşkun and Bilgin 1988, Kıvanç 1988, Yiğit et al. 2003, Shehab et al. 2004, Coşkun et al. 2006).

Such a taxonomic discussion is well beyond the scope of this study and therefore, we simply followed Musser and Carleton (2005) and Krystufek and Vohralik (2009) in order to consider Tepecik specimens under the generic name *Spalax* and compared cranio-mandibular and some lower dental characters with three extant species from Anatolia, *Spalax leucodon*, *Spalax xanthodon* (=*nehringi*) and *Spalax ehrenbergi*, based on combined definitions from Topachevskii (1969) and Krystufek and Vohralik (2009).

First of all, the Tepecik spalacid differs from the *Spalax* spp. (*sensu* Topachevskii 1969) in having a pair of suprocondyloid foramens. On the mandible, a well-marked but less deep depression is situated in the labial view, between the ridges of coronoid-alveolar processes and coronoid-articular processes, and that depression is somewhat anteriorly open. The angular process is distinct and inclined from the labial flank of the alveolar process and the sella externa is situated below the sella interna.

The following cranial characters are shared by the Tepecik spalacid and *Spalax leucodon* and distinguish them from *Spalax ehrenbergi*: parietal width smaller compared to its length on the dorsal view, upper incisor broader (2.8 mm in the Tepecik specimen contra average of 2.1 mm in *S. ehrenbergi*), greater width of zygomatic arch, the maxillary tooth row much greater, bigger proportion of the braincase height, wider interpterygoid fossa, well and equally developed sagittal and lambdoidal crests, width of parietals in dorsal view less than its length. Also, the alveolar process on the mandible exceeds dramatically the length of the articular (the length of those processes is more or less equal in *S. ehrenbergi*, Topachevskii 1969: 69).

The Tepecik spalacid differs from *Spalax leucodon* and *Spalax ehrenbergi* in having nasals with slit-like depression, presence of two roots on M1 based on the alveolar pattern although it is considered a variable character (Krystufek and Vohralik 2009; fig. 221B–C), slender rostrum (rostral width is 34.5% of the rostrum length which fits the mean of *Spalax xanthodon*; Krystufek and Vohralik 2009: 256) broader zygomatic arch, somewhat more sloping occipitals with pronounced ridges, infraorbital foramen much elongated dorsally, naso-frontal suture situated more anteriorly along the level of infraorbital foramen, more constricted interorbital area, sagittal crest nearly reaching naso-frontal suture line and lacking foramina on its anterior end, more compressed interparietals, diastema twice longer than the maxillary tooth row (diastema length: 19.8 mm), rostrum edges (premaxillary part) parallel without converging anteriorly, incisive foramina somewhat more elongated and the high medial ridge of the palate forming a lamellar broadening posterior to the palate.

However, some relatively minor morphological similarities occur between the Tepecik spalacid and *Spalax ehrenbergi* such as the presence of one longitudinal groove on the enamel (anterior face) of upper and lower incisors whereas it has been reported that *S. ehrenbergi* might have more than two. Note also that the presence of a groove is considered as a primitive character by Topachevskii (1969). On the other hand, the basisphenoid and the basioccipital seem to be fused as in *S. ehrenbergi* (without a fissure *sensu* Topachevskii 1969: 165).

Finally, some variations, thus possibly not informative characters at least at the generic level, concern the shape of nasals tip (e.g. pointed or blunt), posterior edge shape of the palatal bone (e.g. straight or dentate), position of the palatal foramina relative to M2 line and the color of the upper and lower incisors enamel ranging from orange-yellow-cream to white (see Sözen et al. 2006). Note that the Tepecik skull has nasals tip rather the being blunt, palatal foramina are at the posterior roots level line of M2 and the upper incisor enamel color is close to orange while lower ones are more or less cream-white.

As a conclusion, the majority of cranio-mandibular traits as well as the molar occlusal patterns shared with *Spalax xanthodon*, despite some minor possible variations, would permit identifying Tepecik specimen as *S. xanthodon*.

Order **Rodentia** Bowditch 1821
Suborder **Sciuromorpha** Brandt 1855
Family **Sciuridae** Fischer 1817
Subfamily **Sciurinae** Fischer 1817
Spermophilus xanthoprymnus Bennet 1835
(Figure 7; Tables 2–4)

Material

Three nearly complete skulls of which TP14-19K-101-001 with two incisors and P4–M3 on both sides of the maxilla; TP15-15I-54-001 with two incisors, P4–M3 dext. and M1–M3 sin.; TP15-15L-13C-001 with an incisor sin., M2 dext. and M2–M3 sin; a left mandible bearing incisor, p4 and m3 (TP15-15L-13C-002).

Trenches and unit

19K-101; 15I-54; 15L-13.

Context

Table 1.

Description

The medium size of these specimens together with typical occlusal morphology of molars and some key features of the cranium lead to identifying the genus *Spermophilus*, one of two extant Anatolian sciurid genera. In comparison to the skull of *Sciurus vulgaris* (Krystufek and Vohralik 2005), the Tepecik sciurid possesses a constricted interorbital region, zygomatic arches laterally narrower. Likewise in the lateral view, the cranial roof is uniformly convex on the anterior and posterior sides of the orbits (the maximum height of the cranial roof is shifted posterior to the orbits in *Sciurus* (*vulgaris*), post-orbital processes are shorter and weaker.

The upper molars have similar occlusal patterns as *Sciurus* but in the Tepecik specimens, the length tends to increase posteriorly, the M3 is somewhat greater in size, the crown height is greater but more or less brachyodont, cusps are more individualized, antero-posterior depression of molars is more pronounced lingually than labially, thus a triangular shape occurs where the protocone is a more flagrant valley between protoloph and metaloph is narrower.

At present, three extant species of *Spermophilus* are recognized as valid: *S. citellus* Linnaeus 1766, *S. xanthoprymnus* Bennet 1835 and a recently described one *S. taurensis* Gündüz et al. 2007 (see Hoffmann and Thorington, Jr. 2005, Krystufek and Vohralik 2005, Gündüz et al. 2007, Özkurt et al. 2007, Gür and Gür 2010). Their identification as separate species involves generally many specimens with their “complete” external characters (e.g. pelage color, baculum morphology, cranio-dental features) as well as morphometric, molecular phylogenetic and karyotype analyses (see Özkurt et al. 2007). On the other hand, fossil or subfossil samples restrict the information that can be gathered compared to the studies conducted on captive animals. Therefore, only some cranio-mandibular features of four specimens from Tepecik could be examined and compared with the extant representatives of this genus. Although the skull morphology is regarded as insufficient for taxonomic study in Sciuridae, it bears more informative characters in ground squirrels by means of phyletic analysis or morphometry, contrary to tree squirrels (Patterson 1983, Krystufek and Vohralik 2005, Gündüz et al. 2007).

The following four characters embodied in the skull have not been discussed up to now, possibly because they are part of variations in a given population but might still be diagnostic. For instance, one specimen (Figure 7A) displays (1) the frontal which is somehow more flat and antero-ventrally less curved in the lateral view compared to the others (Figure 7B, C) which would render the shape of the skull less convex as seen in *Spermophilus taurensis*. Likewise, (2) the orbital region in lateral view is less rounded, (3) the zygomatic process of the squamosal is positioned more anteriorly and more flared laterally and finally (4) the postero-dorsal edge of premaxilla between nasal bones and zygomatic process of the maxilla is narrower.

On the other hand, all three specimens possess a faint sagittal crest compared to the well-pronounced temporal crests (=supratemporal ridge). The latter arises posterior

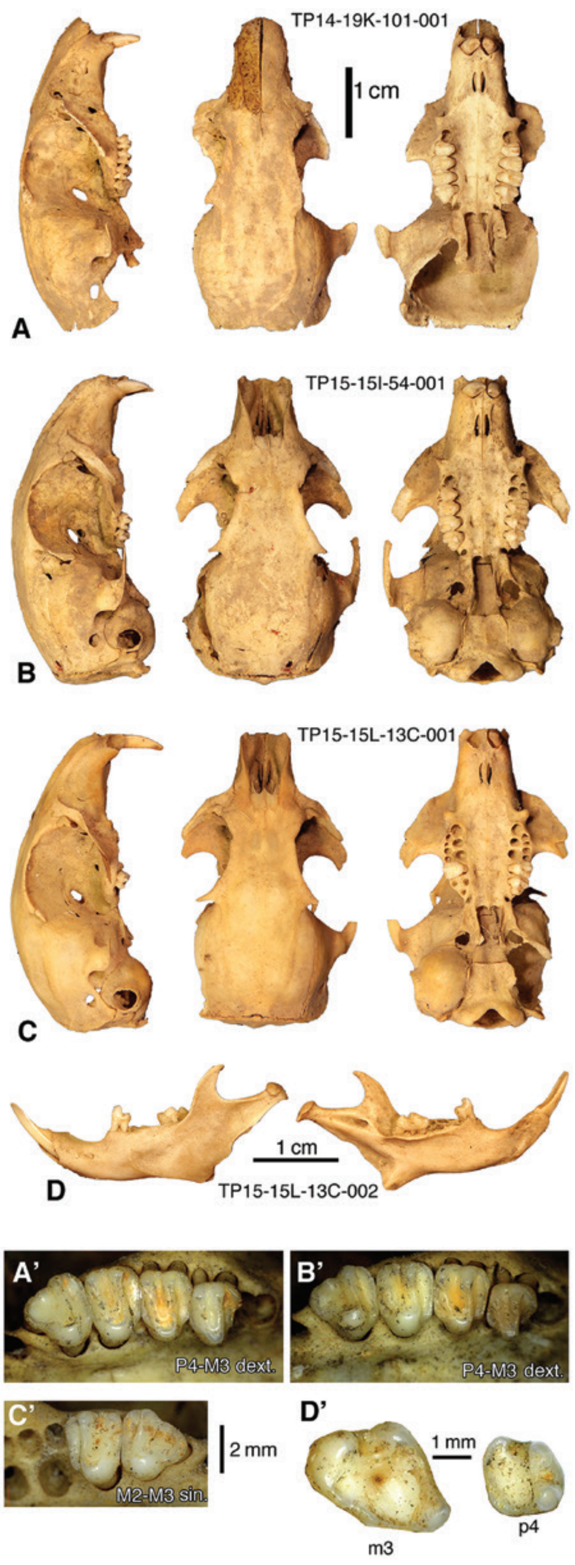

Figure 7: Skulls and left mandible of *Spermophilus xanthoprymnus* with *in situ* tooth series gathered from trenches 15I, 15L and 19K. (A–C) Skull in lateral, dorsal and ventral views; (A′–C′) upper molars of the relevant maxillae; (D) mandible in labial and lingual views with (D′) occlusal view of *in situ* m3 and p4. Vertical scale of 1 cm is for skulls, 2 mm for upper and 1 mm for lower molars.

to the post-orbital process and is posteriorly convergent in all specimens but one differs from the others (Figure 7C) by having a gradual convergence (i.e. V-shaped). In other words, those crests lack an abrupt angle on the level of the tympanic bullae, afterwards crests converge and join the sagittal crests (i.e. U-shaped; Figure 7A, B). Finally, Krystufek and Vohralik (2005) underlined the connection of the zygomatic process of the maxilla with rostrum based on figures in Mursaloğlu (1964; fig. 2), Gromov et al. (1965; figs. 52–53) and Ognev (1963; figs. 58–61, 63–66) where *Spermophilus citellus* has a less angular shape (i.e. smooth curve) compared to that of *Spermophilus xanthoprymnus*. However, they concluded that they had no observation for such a feature on their *S. xanthoprymnus* specimen. Such a character can also be used as a landmark in the morphometrical analysis as was used by Gündüz et al. (2007), although some morphological variation is observed on the shape of this curve (Figure 7B).

On the mandible, the body depth (vertical length between the mesial alveolus of m1 and the ventral edge of the mandible) is closer to that of *Spermophilus taurensis*, which is smaller than in *Spermophilus xantroprymnus* and *Spermophilus citellus*. That feature is dependent on the dorsal line of diastema and the anterior flank of the m1 alveolus in the lateral view (see Gündüz et al. 2007; fig. 10, Özkurt et al. 2007; fig. 3, Gür and Gür 2010; fig. 2).

One of the most debated issues concerns the roots of the p4. The only p4 we have so far on one mandible has two roots (Figure 7D). Previous studies mentioned that *Spermophilus xanthoprymnus* tends to retain three roots on p4 as an ancestral character (Storch 1975) deducted from the fossil form up to late Pleistocene, *Spermophilus citelloides*, while the extant *Spermophilus citellus* has only two (Krystufek and Vohralik 2005). On the other hand, *Spermophilus torosensis*, synonym of *Spermophilus taurensis*, holds two roots on p4, with only the exception of some specimens, which is also the case for *S. xanthoprymnus* (Özkurt et al. 2007). Finally, a recent study involving with the late Pleistocene rodent fauna from Serbia underlined that the posterior root of p4 in *S. citelloides* is divided into two parts, in other words, not fused in the majority of cases (50–80% after Kowalski and Nadachowski 1982) as seen in *S. citellus*. Yet, 80% of specimens ascribed as *S. citelloides* from Burgtonna (Germany; Heinrich 1978) have fused posterior roots which results in total of two roots and thus, the number of roots is not a reliable character for species identification (von Koenigswald 1985, Bogicevic et al. 2017). This observation is also consistent with that of Dikmenli (1996) who suggests that the number of roots on p4 displays intraspecific variation in *S. xanthoprymnus*. Overall, the number and the form of the roots of p4 should be considered as an interspecific variation, involving the entire species of *Spermophilus*, rather than being only intraspecific for *S. xanthoprymnus*.

In conclusion, cranial, mandibular and dental comparisons would allow securely ascribing Tepecik sciurids to *Spermophilus xanthoprymnus*.

Discussion and conclusion

Systematics

The primary aim was to describe the rodents from the site for the first time and to enhance the knowledge on micromammal fossils from the Holocene of Anatolia. The first results on the micromammalian fauna from Tepecik-Çiftlik settlement provided six species of rodents: two species of arvicolines *Microtus* cf. *arvalis* and *Arvicola* cf. *amphibius*, one house mouse *Mus* cf. *musculus*, one souslik *Spermophilus xanthoprymnus*, one hamster *Mesocricetus brandti* and one mole-rat *Spalax xanthodon*, which are all part of the extant fauna of Anatolia. This list is certainly far from providing the spectrum of rodents that may have inhabited this region during the mid Holocene times. Excavations at the Tepecik-Çiftlik settlement will be pursued over

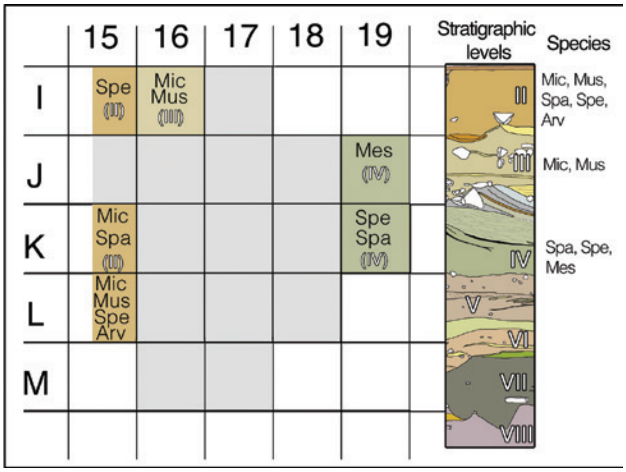

Figure 8: A closer view of the matrix displaying the studied trenches, stratigraphic levels and spatial and stratigraphic distribution of the species found so far from Tepecik-Çiftlik.
Note that the color codes on the matrix indicate the level; grids in gray color indicate trenches that have been opened but which have not been studied for rodents. Mic, *Microtus* cf. *arvalis*; Mus, *Mus* cf. *musculus*; Spa, *Spalax xanthodon*; Spe, *Spermophilus xanthoprymnus*; Arv, *Arvicola* cf. *amphibius*; Mes, *Mesocricetus brandti*.

the coming years, and we intended to enlarge the sampling to collect more data on small mammals from all the levels excavated.

The spatial and stratigraphic distribution of the species from Tepecik-Çiftlik (Figure 8) outlines the initial preview state. However, it is noteworthy to mention that the preliminary results from the excavation site are interpreted solely at species level, rather than classifying by stratigraphic positions, trenches or units due to possible disturbances or secondary introduction of some species to a given unit. For instance, the presence of *Mesocricetus brandti* from only one trench at the level 4 should possibly not indicate the total absence of this species in younger (or older) levels or in other trenches. Similarly, the abundance of *Mus* and *Microtus* species in levels 2 and 3 would allow us to question the absence in the older levels. Also, well-preserved remains of *Spalax* and *Spermophilus* from levels 2 to 4 would reinforce the idea that their presence might be due to post-burial taphonomy, as they are well-known burrowers. Finally, the absence of some expected taxa such as *Apodemus*, *Lepus* or soricid insectivores would not definitely implicate that they are not present. Therefore, it would be unlikely to shed light on these problematics well before increasing as much as possible the amount of the remains, homogenously gathered from all trenches, units and levels.

The assumptions mentioned in this study and systematics of rodent fauna assembled from Tepecik-Çiftlik contribute to our knowledge about the Holocene subfossil micromammals, which is poorly known in Anatolia when compared to that of European localities (Erdal 2017) and their environmental context.

Taphonomy

Despite uncertainties on the origin of some fossil remains, the available record allows us to make some assumptions concerning the taphonomy of some species. For instance, predation marks (i.e. tooth or beak marks) are observed on some skulls and mandibles (e.g. Figure 4J′), while on some isolated molars, especially those of *Microtus* which are not illustrated, seem to have been somehow digested as the occlusal surface are not worn but mainly laterally eroded. The major predators of each species cited in the present study are provided within the intensive work of Krystufek and Vohralik (2005, 2009) although the list is constituted generally by birds, e.g. the barn owl (*Tyto alba*), eagle owl (*Bubo bubo*), some falcon species (*Falco tinnuculus*, *Falco naumanni*, *Falco vespertinus*), eagles (*Aguila* sp.). As to Tepecik-Çiftlik fauna, the only list is provided by Buitenhuis (unpublished) in an excavation report and it comprises at different percentages canids (dog, wolf and fox), suids (domestic pig and wild boar), ovicaprids (sheep and goats), cattle and aurochs, equids (wild horse, ass and onager), deer and hares. Note that all identifiable material is remarkably well preserved, according to that report. In addition, Bıçakçı et al. (2012) reported some unidentified bird remains throughout the Chalcolithic level at Tepecik-Çiftlik site in addition to other predators such as wolves, bears and foxes. More recently, animal bone remains which are mainly used for implement purposes were recovered during the 2013 and 2015 excavations from the Chalcolithic level (Figure 2) and identified by Campana and Crabtree (2017) as *Bos taurus*, *B. primigenius*, *Capreolus capreolus*, *Sus scrofa*, *Equus ferus*, *E. hemionus hydruntinus*, *Cervus elaphus*, *Lepus europaeus* and *Vulpes vulpes*. Note that the bone remains of *Lepus* for making tools is very important for the presence of this taxon, although not encountered yet in our assemblages. On the other hand, *Vulpes* could equally be a predator candidate of the rodents from Tepecik-Çiftlik as their wide feeding habit (i.e. omnivorous) also includes rodents and hares (e.g. Contesse et al. 2004, Bakaloudis et al. 2015).

Future research should also focus on the intensity of digestion marks, relevant percentage of digested elements and detailed examination of predation marks to match them with potential predators. However, such studies need abundant samples and detailed information on the related stratigraphic units, which is not yet available.

A second question mark concerns the post-burial taphonomy which might have occurred due to burrowing or nesting habit of some rodents. Such as, the three species represented by nearly complete skulls are by chance known as burrowers (e.g. *Mesocricetus brandti*, *Spalax xanthodon* and *Spermophilus xanthoprymnus*; Krystufek and Vohralik 2009, Gür and Gür 2010, Yağcı et al. 2010); some *Spalax* remains (Figure 6A–G) have been found within a sediment cover which is recently deposited between two excavation seasons. Therefore, a question arises concerning their presence in the fossil record, if it is related to any post-burial facts after sedimentation or not. On the other hand, another *Spalax* specimen (mandible, Figure 6K–M), which has a darker appearance, is found in sediment mixed with ash. That should point out that the *Spalax* in question was burnt *in situ*. Likewise, the left mandible of *Microtus* cf. *arvalis* has also dark brown "caramelized" appearance (Figures 3.26–28). Especially the occlusal surface of m3 and the antero-labial side of m1 are almost black in color, which would be explained according to filling context, i.e. ashes and carbonized plant remains (Table 1). Finally, it is noted that Anatolian ground squirrels are still abundant and observed in the area and it is also possible to encounter their tunnels or nest holes during the excavation at Tepecik-Çiftlik (e.g. Figure 2E).

On the other hand, it is noteworthy to mention the study of Morlan (1994) which questions the taphonomy of fossorial rodents in such archeological sites, whether they are buried long after sedimentation or not. According to the author, such fossorial species burrow to live but not to die and if it is the case, some examination methodologies are proposed in order to distinguish as much as possible their taphonomy (e.g. completeness or portion of skeletal element, fracture state, tooth marks, digestion, cut marks, etc.; see also Morlan 1994, table 1). Finally, note that the skull and jaw samples (Figure 6A–G) gathered from the spot which coincides with the trench and unit 16I-27 certainly represents an example of how recent an individual has undergone post-burial taphonomy, unlike other *Spalax* remains.

Such a discussion is beyond the scope of this study and those questions will be answered in future by inspecting in detail all the trenches and units providing the species of which the taphonomy is unclear and by combining this with the knowledge on other vertebrate remains from the site.

Environment

Some assumptions on the paleoenvironment can be asserted by comparing the geographical distribution of modern species and of subfossils. For instance, according to the presence of three fossorial species in our assemblage (*Spalax xanthodon*, *Spermophilus xanthoprymnus*, *Mesocricetus brandti*), the common habitat preference indicates rather a dry steppe environment with sparse plant cover or perennial short grasses with a precipitation less than 50 mm during the winter (Yiğit et al. 2003, Coşkun and Ulutürk 2004, Krystufek and Vohralik 2005, Gür and Gür 2010, Yağcı et al. 2010). In addition, *M. brandti* and *S. xanthodon* are mostly reported to avoid woody areas or forests, bushy or some rocky environment as well as swampy conditions (Lyman and O'Brien 1977, Krystufek and Vohralik 2005). Again, *S. xanthoprymnus* is observed in pasture on well-drained soils, likewise *M. brandti* on rocky steppe plains bordering cultivated fields. As to *Mus domesticus*, the situation is different; it represents primarily a commensal species, and it is thought that the cohabitation with humans evolved in the Fertile Crescent or the Levant region for the origin of the commensal niche of the house mouse (Slabova and Frynta 2007, Weissbrod et al. 2017). The oldest evidence from diverse sites dates *ca*. 12,000 BP, just before the Neolithic period but that would be much earlier (e.g. 15,000 BP) if the commensalism is not just related to the agricultural sedentism but also to the pre-agricultural hunter-gatherer incipient sedentism (see Weissbrod et al. 2017 and references therein). Therefore, the commensalism of house mice with Tepecik-Çiflik humans is in accordance with the settlement chronology (*ca*. 5900–6400 cal. BC).

As weak competitors against their congeners *Mus macedonicus* (Macholan 1999a), the dispersal of *Mus musculus* occurred thanks to and parallel to the increase of human settlements westward and to its commensalism ability with human populations which allowed it to avoid any competition with other species (Auffray et al. 1990, Cucchi et al. 2005). That would be enhanced by the charred plant remains or some wild plant seeds (e.g. wheat, barley, pea, bitter vetch, lentil) found in the site and which constitute partly the dietary of Tepecik-Çiftlik human population (Özdemir et al. 2017). In contrast, it is reported that *M. macedonicus* tends to avoid human settlements (Harrison and Bates 1991, Macholan 1999b, Krystufek and Vohralik 2005).

Among the two voles, the common vole *Microtus arvalis* seems to be more abundant so far, relative to the water vole *Arvicola amphibius* in the Tepecik fossil record. One of possibilities is that the larger body size of *Arvicola* compared to *Microtus* would cause it to be a somewhat demanding prey for a small predator. Hence, the accumulation of the remains of *Arvicola* is expected to be of a lesser degree than that of *Microtus*. On the other hand, however, the case of *M. arvalis* is not surprising because of its relatively large and geographically continuous range in Eurasia, i.e. from Spain throughout Europe, Anatolia and Middle East to central Russia (Shenbrot and Krasnov 2005, Yiğit et al. 2016a) and its habitat preferences such as meadows, grasslands and especially agricultural areas (Markov et al. 2012, van Kolfschoten 2014). Note that *A. amphibius* is represented only by one upper third molar despite that its modern geographic distribution seems to be greater than that of *M. arvalis* (Shenbrot and Krasnov 2005, Batsaikhan et al. 2016). However, it is a known issue that, contrary to other rodents from Tepecik, *A. amphibius* is mostly associated with streams, irrigation ditches and marsh-like vegetation cover with surrounding bodies of water, according to observations from Near and Middle East (Harrison and Bates 1991, Qumsiyeh 1996) and from Turkey (Krystufek and Vohralik 2005). Thus, the presence of *A. amphibius* should be related somehow to the presence of the Melendiz River around the settlement. Nowadays *Arvicola* species are widely scattered in Anatolia but the population density is low contrarily to *Microtus* populations (Krystufek and Vohralik 2005) which would also explain the relative abundance of *Microtus* in Tepecik-Çiftlik records.

The paleoenvironmental assumption based on rodent subfossils from Tepecik-Çiftlik is similar to that of Buitenhuis (unpublished) who drew attention to the abundance of hunted animals and denoted the presence of open meadow and grass lands with wood stands in which deers and equids could hide. On a larger scale, the results of the analyses of wood charcoal assemblages at the Pınarbaşı site (Figure 1) represent some congruity with our assumption. For instance, Asouti (2003) showed the presence of tree and shrub taxa which are associated overall with a wood-steppic environment including widely spaced drought-resistant trees and alternating grasslands. Likewise, multi-proxy analyses (i.e. mineralogy, sedimentology, stable isotopes, diatoms and pollens) on the core gathered from Eski Acıgöl, a crater-lake site situated north of Tepecik-Çiftlik, point out that moistures values were above the modern values, and water levels were higher in early Holocene compared to the late Holocene (Roberts et al. 2001). Around 6500 cal. BC, which coincides more or less with the levels Tepecik-Çiftlik and also mid-Holocene (see Walker et al. 2012), "humid" condition made this area have a much drier climate during the second half of the Holocene with declined mesic deciduous trees and lake regression (see Roberts et al. 2001, Asouti 2003 for further details). Nowadays, the Çiftlik basin is poorly drained and although there is high consumption of underground water, marshes are still observed at the center of the plain, fed from the snowmelt in late spring. All these data are in agreement with environmental assumptions based on rodent subfossils from Tepecik-Çiftlik.

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