Insectivore faunas from the Lower Miocene of Anatolia — Part 6: Crocidosoricinae (Soricidae)

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The literature on the Crocidosoricinae is discussed, with emphasis on the genera *Crocidosorex* Lavocat, 1951 and *Oligosorex* Kretzoi, 1959. A new species of *Oligosorex*, *O. reumeri*, is described from the Lower Miocene locality Keseköy. The other localities in this study contain a closely related species, *Oligosorex* aff. *reumeri*. Three other shrews have been found, but the material is insufficient to allow a generic allocation. The shrews designated as Soricid I and Soricid II are considered to represent one evolutionary lineage. Soricid III is a small species, comparable to '*Crocidosorex* sp.' from the Lower Miocene locality Ulm-Westtangente (Germany).

Contents

Introduction

The Soricidae is by far the most diverse insectivore family today. Hutterer (1993) recognizes two subfamilies, containing 24 genera and 312 species. The shrews seem to have been less diverse during the Early Miocene. Almost all taxa from that period are placed in one subfamily, the Crocidosoricinae. The only other Eurasian subfamily found in the Lower Miocene of Eurasia, the Allosoricinae, is represented by one species from southern Germany only. The Heterosoricidae, classified as a subfamily of the Soricidae by some authors, is here considered to be a family (van den Hoek Ostende, 1995a). The first Soricinae possibly appear at the end of the Early Miocene (Ziegler, 1989; Reumer, 1994).

The Soricidae from the Anatolian localities Kilçak, Harami and Keseköy (see van den Hoek Ostende, 2001a, fig. 1) will be described below as part six of a series on the Insectivora from the Lower Miocene of Anatolia. Since the study of smaller mammals from the Lower Miocene of Anatolia was virgin territory until a couple of years ago,

most species found are new to science. Therefore, the taxonomy of the various species has to be elaborated before we can come to any stratigraphical or palaeoecological conclusions. This is the last paper in which the emphasis lies on taxonomy. Earlier papers (van den Hoek Ostende, 1992, 1995a, b, 1997, 2001a) dealt with other insectivore families from the same deposits.

The series presents part of the results of the co-operation between the Mineral Research and Exploration General Directorate of Turkey (M.T.A.) and Utrecht University in the project 'Reconstruction of the paleoenvironmental changes in the continental Neogene of Anatolia' supported by NATO grant CRG 910 750. The rodents collected in this project are described in the series 'Early Miocene faunas from the eastern Mediterranean area' (de Bruijn & Saraç, 1991, 1992; de Bruijn et al., 1993; de Bruijn & von Koenigswald, 1994; Ünay, 1994). The aim of the project is to come to a better understanding of the palaeoecology of the terrestrial environments of Anatolia, particularly focusing on the Early Miocene.

Material and methods

The material was collected by Engin Ünay and Gerçek Saraç of the M.T.A. and Hans de Bruijn of Utrecht University in the period 1987-1993. All material described in this paper was obtained by wet-screening. Since all localities are lignite mines the sediment is rich in plant remains, which tends to block the sieve. In order to solve this problem caustic soda was used in processing the material.

The measuring method and terminology for parts of the molars follow Reumer (1984), except for the oblique crest and the entoconid crest which, in analogy with the terminology used for other insectivores, are called the oblique cristid and the entocristid, respectively. All measurements are given in millimetres. The abbreviations used in the tables for the measurements of the lower molars are TRW for trigonid width and TAW for talonid width. P, used for the P^4, gives the measurement between the deepest point of the emargination and the front of the premolar. The abbreviations used for measurements of the upper molars are LL (lingual length), BL (buccal length), AW (anterior width), and PW (posterior width). The degree of emargination of the posterior flank of the M^1 and M^2 is expressed by the PE-ratio, as suggested by Reumer (1984). Other authors have not followed this method, although the PE-ratio is an objective way of determining the degree of emargination and thus preferable over subjective assessments as strong, moderate, slight etc.

The number of specimens available of a particular element is given between brackets in the description. If a measurement could only be taken in a number of specimens, this number is indicated between brackets behind that measurement in the table. In order to facilitate comparison, all elements have been illustrated as coming from the left jaw. The inversely printed elements are underlined in the plate captions.

The material will be stored in the M.T.A. (Ankara).

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Review of literature

Crocidosoricinae

This section is primarily intended to give some general information on the taxonomy of the Crocidosoricinae before the finds from Anatolia are discussed in detail. This review is basically a summary of a literature review recently written by Reumer (1994). Reumer considered in his review paper *Oligosorex* a junior synonym of *Crocidosorex*. As we will explain below, it is prefered to retain the two genera.

The subfamily Crocidosoricinae was established by Reumer (1987) with the following diagnosis:

'The lower incisor is cuspulate and relatively small; the posterior extension of its buccal face is not or only slightly developed. The P_4 is tetrahedron shaped; its wear surface is V-shaped; there is a (sometimes only weakly developed) posterior groove or sulcus. Sometimes 2, but usually 3-5 lower antemolars. Upper incisor not fissident. Condyle *Crocidura*-like, small, with articular facets that are only slightly separated.'

The typical morphology of the P_4 makes the Crocidosoricinae readily distinguishable from the Soricinae and the North American subfamily Limnoecinae. Most Crocidurinae P_4 have a triangular wear facet, but the extant crocidurine *Myosorex* has a P_4 that resembles that of the Crocidosoricinae. Whether this is a plesiomorphic character, or whether *Myosorex* is a remnant of the Crocidosoricinae is open for discussion (Reumer, 1994).

Reumer (1994) also discussed the morphology of the lower incisor of the Crocidosoricinae, which according to him is 'generally short. In the normal crocidosoricine situation, the I_{inf} is bicuspulate and the axes of the crown and root are not parallel, but placed under a weak angle.'

The oldest soricid reported is an indeterminate shrew from the Lower Oligocene of Ergilin-Dzo Svita, Mongolia (Yanovskaya et al., 1977). Reumer (1994) tentatively assigned *Gobisorex kingae* Sulimski, 1969 from the Middle Oligocene locality Shand-Gol Svita (Mongolia) to the Crocidosoricinae. Sulimski (1969) described *Gobisorex* as an early stage in soricine evolution, showing some resemblance to the heterosoricines. Re-examination of the material showed that it is not a crocidosoricine but a heterosoricid (Reumer, pers. comm.)

The Middle Oligocene crocidosoricine *Srinitium marteli* from Saint-Martin-de-Castillon (Hugueney, 1976), Aubanas-des-Alpes and Escoufle (Crochet, 1995) and *Srinitium* sp. from Pech du Fraysse (Remy et al., 1987) are the oldest shrews in Europe. Two genera appear in the Late Oligocene, *Oligosorex* found in Cournon-les-Souméroux, France and Herrlingen 8 and 9, Germany, and *Ulmensia*, which has thus far been found in Germany only (Ziegler, 1989; 1998). Outside of Europe only one indeterminate soricid find from the Upper Oligocene has been reported from Yindirte in China (Russel & Zhai, 1987).

The diversity of Crocidosoricinae increased during the Early Miocene. *Ulmensia* disappeared, but *Oligosorex* continued at least until MN 2. New genera are *Carposorex*, *Crocidosorex*, *Clapasorex*, *Soricella*, *Florinia*, *Miosorex*, and *Lartetium*. Most findings are from France and Germany, but as Reumer (1994) pointed out, this may very well reflect the distribution of collecting efforts. French and German Lower Miocene insec-

tivores have been subject to extensive studies (Crochet, 1975; Dobin-Florin, 1964; Ziegler & Fahlbush, 1986; Ziegler, 1989). So far, the only papers on Spanish Lower Miocene insectivores are by Gibert (1975a,b). His taxa *Limnoecus truyolsi* and *Oligosorex bruijni* were listed by Reumer (1994) as being of 'uncertain taxonomic affiliation' (*Limnoecus* is an American genus, and it is not clear whether or not the species *bruijni* is referable to *Oligosorex*). Italy and Greece each have one single record of Lower Miocene Soricidae. Rümke described *Crocidosorex* (= *Oligosorex*) *antiquus* from Oschiri (Sardinia), a locality that yielded a Lower Miocene island fauna (de Bruijn & Rümke, 1974). Doukas (1986) described a shrew from Aliveri, Greece, as Crocidurinae gen. et sp. indet., which was listed by Reumer (1994) as Crocidosoricinae indet.

The Anatolian Crocidosoricinae described thus far came mainly from the Middle Miocene. Engesser (1980) described a mandible fragment and an isolated M_2 from Sariçay, which he found morphologically similar to *Miosorex grivensis*. Apart from these finds, he also described an M^1 from the same locality, which he placed in a different species. An isolated M_1 and M_2 from Çandir are, according to Engesser, similar to '*Sorex' dehmi* (= *Lartetium dehmi*). Çandir also yielded a very worn M_1, which probably belongs to another species. Since the material is so limited, Engesser classified these soricids as gen. et sp. indet. Sen et al. (1998) described a single M^1 from the MN 4 locality Semsettin (Çankiri-Çorum Basin, Anatolia) as *Miosorex* sp. The relative width of the molar in combination with a clear hypocone suggests that an identification as *Lartetium* is more plausible, although any generic classification on the basis of a single molar is little more than an educated guess.

De Jong (1988) described Middle Miocene and lower Upper Miocene Crocidosoricinae from the Daroca-Calatayud area in Spain. Since de Jong's publication Lower Miocene deposits in the same area have yielded additional insectivore faunas containing Crocidosoricinae. These are currently under study by the author. Reumer (1994) indicated that the centre of distribution seemed to shift from Central Europe to Spain between the Early and Middle Miocene. This shift is partly an artefact because the insectivores from Central Europe were studied more intensively than those from other areas. Nevertheless, the Early Miocene shrew diversity in Central Europe seems to be higher than in Spain or Anatolia (this paper). It is also clear that the diversity of the Crocidosoricinae diminished after the Early Miocene, when a number of Lower Miocene genera became extinct. *Crocidosorex* is mentioned in a preliminary study of the Middle Miocene locality Xiacaowan (China) (Li et al., 1983). This identification is, however, uncertain, because it is based on limited material and because the authors found this shrew also similar to the American genus *Antesorex*. *Miosorex* and *Lartetium* survived into the Middle Miocene. *Miosorex grivensis*, which has been described from France, Spain and Germany, is the most successful crocidosoricine.

After the Middle Miocene the Crocidosoricinae disappear almost entirely. There are some records from the lowermost Upper Miocene (de Jong, 1988). When Reumer (1994) wrote his literature review no Crocidosoricinae had been described from MN 10-13. Meanwhile, some MN 10 localities in the Teruel Basin (Spain) have yielded *Miosorex* (van Dam, 1997). There are some questionable records from the Pliocene, amongst which is an island form from the Gargano peninsula (Italy). It is not inconceivable that the extant African genus *Myosorex* is a Crocidosoricinae, but until the status of this genus is re-evaluated, this can not be decided.

Crocidosorex and *Oligosorex*

The genus *Oligosorex* is of special interest to our study, since part of the soricid material from Anatolia is attributed to this genus. *Oligosorex* is generally considered a junior synonym of *Crocidosorex*. In this section the literature on these two genera is discussed, in order to explain why we believe that *Oligosorex* should be retained as a separate genus.

The genus *Crocidosorex* was described by Lavocat (1951). The genus and its type species, *C. piveteaui*, were based on a single mandible from the Late Oligocene/Early Miocene French locality Marcoin près Volvic, carrying P_4-M_3. Lavocat diagnosed the genus: 'Soricide possédant une dentition depurvue de pigment et une P_4 simplifiée comme *Crocidura*, une M_3 a talon biradiculée comme *Sorex*.' Thus, according to the diagnosis, the P_4 does not have the typical Y-shaped wear surface of Crocidosoricinae. Unfortunately, Lavocat's illustration of the specimen is very poor. In his description Lavocat mentions a peculiar characteristic of this soricid. The labial cingulum of the lower molars is missing, a condition that is not found in any other shrew.

Kretzoi (1959) introduced the genus *Oligosorex*, with the type species *O. antiquus* (Pomel, 1853). He included in this genus *O. meyeri*, a nomen novum for *Sorex pussilus* (von Meyer, 1846), a name pre-occupied by *S. pussilus* (Gmelin, 1774), an extant shrew from Iran. Storch (1988) considered *Sorex pussilus* (von Meyer, 1846) a nomen dubium, since the original description and illustration is insufficient and the type material is lost. Kretzoi gave the following diagnosis for *Oligosorex*: 'late Oligocene and Miocene Soricids of small dimensions, retaining three unicuspids between P_4 and the relatively small and primitive front incisor in the lower jaw.'

Repenning (1967) considered *Oligosorex* a junior synonym of *Crocidosorex* solely on the similarity of the diagnoses of the two genera. He explicitely states that he has not seen material of either genus and suggests that 'Study of the specimens, however, could well lead to the conclusion that the two genera are distinct'. Nevertheless, many authors since have followed Repenning in considering the two genera synonymous.

Hugueney (1974) gave a clear illustration of the holotype of *Crocidosorex piveteaui*. Her drawing and description clearly indicate that the P_4 has a crest on the labial side only. Lavocat (1951) compared this morphology with the P_4 of *Crocidura*. In fact, the P_4 of *C. piveteaui* is reminiscant of that of the Soricinae as was already noted by Ziegler (1989). It certainly does not have the Y-shaped wear surface typical for Crocidosoricinae. The drawing also clearly shows the other remarkable feature of *C. piveteaui*, viz. the absence of labial cingulums. In contrast to Repenning, Hugueney (1974) preferred to retain *Crocidosorex* and *Oligosorex* as separate genera, although she too indicated that further study of populations was necessary. Gibert (1975a) also considered *Oligosorex* a valid genus. However, his *O. bruijni* was considered a soricid of uncertain affiliation by Reumer (1994).

Crochet (1975), on the other hand, considered *Oligosorex* too poorly defined, and followed Repenning in considering it a junior synonym of *Crocidosorex*. Crochet described a new species in the genus, *C. thauensis* from the French Lower Miocene locality Bouziges. He proposed the following diagnosis for the genus: 'Soricinae primitif possédant une P_3 très réduite située sous la couronne de la P_4. P_4 est

biradiculée et montre parfois un semblant de crête postéro-lingual près du sommet de la cuspide principale. Préfosside des M_1 relativement large, plus ètroite et profonde sur M_2: entocristide des molaires longue, cuspides élancées, crête oblique basse; cingulum antérieur élargi sous le paraconide. Le talonide de M_3 se réduit linguaux. Foramen mentonnier sous P_4. Cuspide antérieur de P^4 séparée de la pointe principale par une fore dépression. Hypocône des molaires bien cuspidé, non relié au protocône par une crête (vallée importante).' Looking at Crochet's diagnosis, it is clear that it is largely based on the species *antiquus* and *thauensis*, and not on the type species of *Crocidosorex*, *C. piveteaui*. For instance, the tiny P_3 below the anterior part of the P_4 is a character shared by *antiquus* and *thauensis*, but we do not know the antemolars in front of the P_4 of *piveteaui*. Characters of the upper dentition are based on *thauensis* only (Crochet makes no reference to Rümke's description of the upper molars of *antiquus* published a year earlier (de Bruijn & Rümke, 1974)). The only character used implicitely is the peculiar P_4 of *piveteaui*, since Crochet refers *Crocidosorex* to the Soricinae, adding that the P_4 sometimes also has a lingual arm. We now know that this is the normal condition in early soricids and that *pivetaui* is aberrant in this respect. Indeed, Crochet comments on the P_4 in his discussion and already suggests that this element might be used to define a new subfamily of soricids, as was done later when Reumer (1987) defined the Crocidosoricinae.

Crochet is right in stating that the original diagnosis of *Oligosorex* is insufficient to discriminate the genus from other soricids. This is, however, no reason to reject the name and to consider it a junior synonym of *Crocidosorex*. In order to do so, we have to demonstrate that the type species of *Oligosorex* and *Crocidosorex* (*antiquus* and *piveteaui* respectively) are referable to one and the same genus. The two species are comparable in size, but there are no reasons to assume that they belong to the same genus. The peculiar P_4 of *C. piveteaui*, not found in any other Crocidosoricine, is enough reason to place this species in a genus of its own. The total absence of labial cingulums supports this.

Recognizing *Crocidosorex* as a genus that is characterized by its aberrant P_4 and the absence of labial cingulums provides another taxonomical problem. The subfamily Crocidosoricinae is mainly characterized by the morphology of the P_4. However, the P_4 of the type genus does not have the Y-shaped wear surface considered typical for the subfamily. Unfortunately, the other characters used to diagnose the Crocidosoricinae cannot be observed in the only available mandible of *Crocidosorex piveteaui*. If *Crocidosorex* is not referable to the same subfamily as the other genera currently included in the Crocidosoricinae, a new subfamily name should be proposed for these genera. Although the P_4 of *Crocidosorex* is not typically crocidosoricine, it is not typically soricine either. The labial crest does not connect to the posterior crest, as is usual in Soricinae. Furthermore, the first occurrence of Soricinae is in the Middle Miocene, whereas *Crocidosorex* is of Late Oligocene/Early Miocene age. Therefore *Crocidosorex* can for the moment best be considered to belong to the same subfamily as the other Early Miocene shrews in spite of its aberrant P_4. However, the choice of the genus as type genus of the Crocidosoricinae is in retrospect unfortunate.

Rümke (in de Bruijn and Rümke, 1974) described *Oligosorex antiquus* from the Lower Miocene locality Oschiri (Sardinia, Italy). She placed the species in *Crocidosorex* in which she included *Oligosorex*. She identified the Oschiri material using

comparative material from Montaigu-le-Blin, the type locality of *Oligosorex antiquus*. This comparative material was also described and illustrated by her. Among the material described from Oschiri are the upper molars and last upper premolar of the species. Rümke's descriptions are the first to include the upper dentition of *Oligosorex antiquus*.

Brunet et al. (1981) classified some soricid remains from Cournon-les-Soumeroux (France, MP 28) as *Oligosorex* sp. The material was considered to be similar to *Oligosorex antiquus*, but too scarce for a certain identification. The finds from Cournon-les-Soumeroux are the oldest record of *Oligosorex*.

Storch (1988) placed various finds from the Upper Oligocene/Lower Miocene of the Mainz Basin in *Crocidosorex*. A single M_2 from Hochheim-Flörsheim was classified as *Crocidosorex* sp. Since the generic classification of soricids is impossible on the basis of a single M_2, this element should be classified as soricid gen. et sp. indet. Storch also classified the soricid material from Weisenau as *Crocidosorex* sp. This material was originally described as *Sorex pussilus* Von Meyer, 1846. Kretzoi (1959) included this material in *Oligosorex* under the name *O. meyeri*, since the name *Sorex pussilus* was pre-occupied. Storch considered *Sorex pussilus* von Meyer a nomen dubium. The Weisenau material is best classified as *Oligosorex* sp.

Ziegler (1989) described a small soricid from Ulm-Westtangente as *Crocidosorex* (= *Oligosorex*) sp. Ziegler lacked any mandibles from which the dental formula could be determined and, despite having a large number of isolated elements, did not have the P_4. Since the P_4 is crucial for identifying the subfamily, strictly speaking we can not even say whether or not this small soricid is a Crocidosoricinae. Ziegler based his identification by comparing it to the three known small soricid genera from the Lower Miocene, *Carposorex*, *Claposorex* and *Crocidosorex*. *Carposorex* is characterized by wrinkled enamal and *Claposorex* is characterized by the presence of a lingual cingulum on the upper molars. Since the Ulm-Westtangente material did not show these features, *Crocidosorex* (*Oligosorex*) was the only possibility. Indeed, Ziegler noticed a number of similarities between his species and *Oligosorex*, such as a very open trigonid basin, very pointed cusps and a well-developed anterior cingulum of the lower molars. The species differs from other species of *Oligosorex* in its smaller dimensions and the presence of a continuous lingual cingulum on the lower molars. A third difference noted by Ziegler was the weaker development of the hypocone of the M^1 and M^2, but if we compare his illustrations with those of *O. antiquus* in de Bruijn and Rümke (1974), the development of this cusp is similar. It is possible, that the Ulm-Westtangente species is referable to *Oligosorex*, but without any data on the antemolars this cannot be decided. By trying to classify his species in one of the known genera, Ziegler excluded the possiblity that the Ulm-Westtangente species belongs to a new genus. The species is better classified as soricid gen. et sp. indet.

Oligosorex bruijni from the Spanish localities Ateca I and Villafeliche 2A was described by Gibert (1975a). This species resembles in many respects the small soricid of Ulm-Westtangente discussed above. The most apparent difference is the larger width of the upper molars. As in the German species, allocation to *Oligosorex* is open to doubt (see also Reumer, 1994), since we have no data on the antemolars of the species. In contrast to the German species, we do know the P_4 so it is certain that *O. bruijni* is referable to the Crocidosoricinae.

Systematic part

Soricidae Gray, 1821
Crocidosoricinae Reumer, 1987
Oligosorex Kretzoi, 1959
Oligosorex reumeri sp. nov.
Pl. 1, figs. 1-3; Pl. 2, figs. 1-3.

Derivatio nominis — This species is named after Dr J.W.F. Reumer, whose work contributed considerably to our knowledge of fossil Soricidae.

Diagnosis — The lower incisor is bicuspulate and relatively slender. The root and crown are in line. The lower molars have well-developed entocristids. The hypolophid is continuous with the lingual cingulum. M_1 and M_2 are subequal in length. The labial cingulum of the M_1 and most of the M_2 is interrupted at the base of the protoconid. The posterior emargination of the M^1 and M^2 is moderate. The hypocone of these molars is ridge-shaped.

Differential diagnosis — *Oligosorex reumeri* is smaller than *O. antiquus* and comparable in size to *O. thauensis*. It differs from these species in having an interrupted labial cingulum of the lower molars. It differs from *O. thauensis* in having an M_1 and M_2 of subequal size and a weaker development of the hypocone.

Type locality — Keseköy (MN 3).

Geographical and stratigraphical distribution — The type locality only.

Holotype — Maxillary dext. with P^4-M^2 (Ke 6621) (Pl. 2, fig. 2).

Measurements of the holotype

P^4	M^1	M^2
P =0.79	PE-ratio=0.13	PE-ratio=0.18
LL=0.94	LL=1.15	LL=1.12
BL=1.16	BL=1.04	BL=1.26
W =1.20	AW=1.19	AW=1.27
	PW=1.01	PW=1.25

Description of the holotype — The holotype is a fragmentary maxillary carrying P^4, M^1 and M^2. In front the maxillary is broken at the anterior alveole of the P^4. At the back the jaw is broken below the posterior margin of the M^2.

The anterior side of the P^4 is only slightly concave, the posterior side is emarginated. The lingual side makes an angle of about 40° with the labial side. The hypoconal flange reaches far to the posterior side. The tip of the paracone lies just in front of the middle of the P^4. A relatively short, sharp posterocrista runs from the tip of the paracone backwards. The slightly protruding parastyle lies in front of the paracone. There is no parastylar crest. The protocone is small. Its anterior arm is very short and is connected to the parastyle. A low ridge, starting at the base of the protocone, borders the hypoconal flange on the lingual side. The hypocone is absent. The posterior ridge continues along the posterior side of the hypoconal flange, where it is indistinct, and over the well-developed cingulum along the lingual side of the paracone. Near its end the ridge becomes more pronounced.

The M^1 is somewhat wider than long. The posterior side is moderately emarginat-

ed. The anterior arm of the protocone ends against the anterior flank of the paracone near the base of that cusp. The metaloph is divided in a strong arm that ends freely halfway between the base of the metacone and the hypocone and a weak arm connecting the metaloph to the base of the metacone. Hypocone and protocone are separated by a narrow valley that is bordered by a lingual cingulum. The hypocone is ridge-shaped. The posterior ridge is well defined along the hypoconal flange and on the wide cingulum along the posterior flank of the metacone, but somewhat weaker near the posterior emargination. The posterior arm of the paracone is somewhat longer than the anterior arm. The posterior arm of the metacone is about 50 % longer than the anterior arm. The mesostyle is undivided.

The metaloph of the M^2 is divided in a similar fashion as in the M^1. The molar resembles the M^1, but the arms of the labial cusps are all of similar length. The hypocone is less developed than in the M^1.

Measurements — The measurements are listed in Table 1.

Description

Mandible. Many mandible fragments have been found, often bearing some of the molars and/or the last antemolar (P_4). Unfortunately, none of the jaw fragments contains any of the other antemolars. A very small alveole lies anterolingually of the anterior alveole of the P_4. Between these alveoles and the alveole of the lower incisor lie two alveoles of equal size. The foramen mentale is small and lies below the P_4. The only condyle preserved is damaged. It shows a large, elliptical lower facet and a wide interarticular field. The upper condyle is broken off.

I_1 (5). The lower incisor is relatively slender. It is bicuspulate. The cuspules are rather indistinct and lie on the buccal side of a flattening, which forms a sharp edge with the lingual side. The tip is only slightly curved. On the lingual side there is a

Table 1. Measurements of *Oligosorex reumeri* sp. nov. from Keseköy.

tooth	N		range	mean	tooth	N		range	mean
P_4	7	Length	0.75-0.81	0.77	P^4	13	P	0.62-0.92	0.75
		Width	0.50-0.56	0.52			LL (11)	0.77-1.08	0.87
							BL	1.19-1.29	1.25
							Width (11)	1.06-1.20	1.15
M_1	41	TrW	0.59-0.73	0.67	M^1	21	LL (20)	1.00-1.16	1.08
		TaW	0.62-0.81	0.73			BL	1.06-1.18	1.13
		Length	1.07-1.28	1.18			AW	1.03-1.30	1.19
							PW	1.31-1.51	1.39
							PE-ratio (20)	0.13-0.26	0.21
M_2	42	TrW	0.66-0.75	0.69	M^2	22	LL	0.87-1.12	1.00
		TaW	0.65-0.77	0.71			BL	0.96-1.08	1.02
		Length	1.05-1.21	1.14			AW	1.20-1.35	1.29
							PW	1.15-1.40	1.23
							PE-ratio	0.14-0.25	0.20
M_3	22	Length	0.85-0.95	0.91	M^3	1	Length		0.52
		Width	0.49-0.62	0.55			Width		0.82

thick ridge at the enamel-dentine boundary. This ridge curves inwards halfway down, forming a narrow ledge that runs all the way to the tip of the incisor. The buccal extension is short and bordered by a faint ridge. The crown and the root lie in line.

P_4 (7). The last antemolar has not been found isolated. In occlusal view the anterior side is pointed; the posterior side is rather straight or slightly undulating. The antemolar is two-rooted. The lingual and labial sides are convex, the lingual side more so than the labial side. The labial side of the P_4 is somewhat longer than the lingual side. Seen from the labial or lingual side the antemolar is lowest at its posterior end. The enamel boundary slopes up in a gentle curve, but rises abruptly directly below the tip of the protoconid and continues parallel to the mandible. The protoconid lies in the anterior part of the P_4. The posterocristid is divided into two arms of equal length, giving the protoconid the Y-shaped wear surface that is typical for the Crocidosoricinae. The two arms border an indistinct posterior sulcus. The P_4 is bordered posteriorly by a broad cingulum. The lingual and labial cingulums are well developed. These cingulums end abruptly at the point where the enamel boundary slopes up.

M_1, M_2 (45, 42). The M_1 and M_2 of soricids are often difficult to distinguish from one another. However, in this species the differences are fairly clear as can be seen in the many mandible fragments carrying the M_1 and/or M_2. The trigonid of both elements is narrower than the talonid, but in the M_1 the difference in width is larger than in the M_2. The paraconid of the M_1 is placed far to the front of the molar. Thus the trigonid basin is more open than in the M_2. The trigonid of the M_1 is longer than the talonid. Trigonid and talonid of the M_2 are of the same length. The oblique cristid ends in the M_1 near the base of the protoconid, whereas it ends at the middle of the protoconid-metaconid crest in the M_2. The talonid basin in both elements is bordered by a well-developed entocristid, which is completely fused with the entoconid. The hypolophid runs behind the entoconid and continues as the lingual cingulum, which ends against the paraconid. The anterior cingulum is well developed. It continues along the labial side and ends against the base of the protoconid. In the M_1 the labial cingulum reappears below the re-entrant valley and continues along the base of the hypoconid as the posterior cingulum, which is somewhat less developed than the anterior cingulum. The posterior cingulum ends against the flank of the hypolophid. In the M_2 the interruption of the labial cingulum is shorter than in the M_1. In some specimens it is even continuous, becoming very narrow at the base of the protoconid. The re-entrant valley lies well above the level of the cingulum.

M_3 (22). The trigonid of the M_3 resembles that of the M_2, but is somewhat smaller. The talonid is much narrower than the trigonid. The talonid basin is bordered by a ridge, which is formed by the oblique cristid, hypoconid, hypolophid, entoconid and entocristid. Only the hypoconid is more or less discernible as a cusp. The molar is surrounded by a cingulum, which is only interrupted at the base of the paraconid and in the postero-lingual corner. The anterior and labial cingulums are well developed. Lingually and on the posterior side the cingulum is — very — narrow.

Maxillary. Many maxillary fragments have been found with the last antemolar (P^4) and/or M^1 and M^2 in place. The only M^3 found is also preserved in a piece of maxillary. Unfortunately, no fragments have been found with the anterior dentition in place. Two pieces of maxillary show at least two alveoles in front of the P^4, suggesting that *Oligosorex reumeri* had at least three upper antemolars.

I^1 (10). The angle between the apex and the talon is just lower than 90°. In very fresh specimens the apex reaches a bit further down than the talon. The buccal posterior margin is straight to slightly convex and is bordered by a broad cingulum that tapers out along the median side. The incisor is not fissident.

P^4 (13). The other P^4 show only minor differences with the one preserved in the holotype.

M^1 (21). The metaloph is divided in 9 of the 21 specimens. In worn specimens the hypocone becomes more or less incorporated in the posterior ridge. In the other features the M^1 resemble the holotype.

M^2 (22). A division of the metaloph is found in 6 of the 22 specimens.

M^3 (1). The only M^3 found is preserved in a piece of jaw together with the M^1 and M^2. No isolated M^3 have been found, probably because these small elements were lost while sieving the sediment. The protocone is a low and small cusp. Its anterior arm is short and ends against the base of the paracone. The posterior arm of the protocone runs along the lingual side of the molar and is connected to the metacone. The paracone is the largest and highest cusp. Its anterior arm was probably long. A large part of this arm is preserved, but since the labial part of the M^3 is damaged, its original length cannot be determined. The mesostyle is undivided. The metacone extends along the posterior side of the M^3. Its wear surface, however, is very small and ends halfway the molar. Possibly the extended lingual part of the metacone originates from a hypocone which is incorporated into the metacone and is no longer discernible as a separate cusp.

Oligosorex aff. *reumeri* sp. nov.
Pl. 2, figs. 4-7; Pl. 3, figs. 1-2.

Localities — Kilçak 0, Kilçak 0″, Kilçak 3A, Kilçak 3B, Harami 1, Harami 3 (all MN 1).

Measurements — The measurements are listed in Tables 2 and 3.

Description — The material of this species from Kilçak 0″, the largest assemblage, has been described extensively. For the other localities only the differences with the material from Kilçak 0″ have been indicated. The P_4 has not been found in Kilçak 0″. This element is described in full with the material from Kilçak 3A.

Kilçak 0″

M_1, M_2 (14, 12). The difference between the M_1 and M_2 is far less clear than in *Oligosorex reumeri* from Keseköy. The paraconid of the M_1 is not placed as far to the front of the molar as it is in the species from Keseköy. Thus, the M_1 and M_2 are mainly distinguishable on the basis of the somewhat narrower trigonid of the M_1. The trigonid of both elements is narrower than the talonid. Trigonid and talonid are of the same length. The oblique cristid ends at about two-third of the protoconid-metaconid crest. The entocristid, which is completely fused with the entoconid, is well developed. The hypolophid runs behind the entoconid. The anterior cingulum is well developed. It continues along the labial side and becomes very narrow at the base of the protoconid and may even be interrupted at that point. The posterior cingulum is

Table 2. Measurements of *Oligosorex* aff. *reumeri* sp. nov. from the Kilçak localities.

tooth	loc.	N		range	mean	tooth	loc.	N		range	mean
P_4	Ki3A	1	Length		0.82	P^4	Ki0″	1	P		0.72
			Width		0.53				LL		0.75
									BL		1.39
									Width		1.11
M_1	Ki0″	11	TrW	0.70-0.79	0.74	M^1	Ki0″	8	LL (5)	1.15-1.22	1.17
			TaW	0.79-0.88	0.83				BL	1.22-1.33	1.27
			Length	1.18-1.31	1.25				AW	1.29-1.34	1.31
	Ki3A	5	TrW	0.72-0.78	0.74				PW (6)	1.55-1.59	1.57
			TaW	0.81-0.87	0.83				PE-ratio (5)	0.21-0.29	0.25
			Length	1.11-1.23	1.18		Ki3A	5	LL (4)	1.06-1.16	1.12
	Ki3B	9	TrW	0.66-0.76	0.73				BL	1.09-1.25	1.20
			TaW	0.74-0.86	0.81				AW	1.18-1.40	1.30
			Length	1.14-1.26	1.21				PW (4)	1.41-1.51	1.46
									PE-ratio (4)	0.23-0.28	0.25
M_2	Ki0	2	TrW	0.75-0.77	0.76	M^2	Ki0	1	LL		—
			TaW	0.76-0.78	0.77				BL		1.11
			Length	1.20-1.22	1.21				AW		1.46
	Ki0″	15	TrW	0.71-0.82	0.77				PW		—
			TaW	0.75-0.84	0.80				PE-ratio		—
			Length	1.15-1.32	1.23		Ki0″	5	LL (2)	1.06-1.12	1.09
	Ki3A	5	TrW	0.62-0.83	0.74				BL	1.12-1.14	1.13
			TaW	0.65-0.83	0.75				AW	1.38-1.55	1.46
			Length	1.22-1.28	1.25				PW (2)	1.41-1.46	1.44
	Ki3B	4	TrW	0.72-0.82	0.75				PE-ratio (2)	0.18-0.25	0.22
			TaW	0.74-0.82	0.78		Ki3A	4	LL	1.03-1.14	1.09
			Length	1.14-1.34	1.25				BL	1.04-1.08	1.07
									AW (2)	1.40-1.41	1.41
M_3	Ki0″	2	Length	1.05-1.06	1.06				AW (2)	1.40-1.41	1.41
			Width	0.59-0.64	0.62				PW	1.45-1.50	1.47
	Ki3A	1	Length		1.05				PE-ratio	0.18-0.23	0.20
			Width		0.60		Ki 3B	3	LL	0.97-1.10	1.03
	Ki3B	1	Length		1.05				BL	1.01-1.10	1.00
			Width		0.58				AW	1.33-1.49	1.40
									PW	1.31-1.40	1.38
									PE-ratio	0.22-0.23	0.22

narrow and ends against the flank of the hypolophid. The lingual cingulum is weak and often absent. The re-entrant valley lies well above the level of the cingulum.

M_3 (2). The trigonid of the M_3 resembles that of the M_2, but is clearly smaller. The talonid is strongly reduced. Only the hypoconid can be discerned as an individual cusplet in a ridge consisting of the oblique cristid, hypoconid, hypolophid, entoconid, and entocristid. This ridge starts at the middle of the protoconid-metaconid crest and ends against the base of the metaconid, surrounding the talonid basin. The anterior cingulum is well developed. The labial cingulum is interrupted at the base of the protoconid in one of the two specimens. In the other one it is continuous, though very narrow near the base of the protoconid. The lingual cingulum is absent.

Table 3. Measurements of *Oligosorex* aff. *reumeri* sp. nov. from the Harami localities.

tooth	loc.	N		range	mean	tooth	loc.	N		range	mean
I_1	Ha3	2	Length	1.78-1.82	1.80	I^1	Ha1	4	Length	0.98-1.11	1.04
									LT	0.43-0.47	0.45
									Heigth	0.74-0.92	0.84
M_1	Ha1	2	TrW	0.70-0.77	0.74	M^1	Ha1	2	LL	1.12-1.25	1.19
			TaW	0.74-0.85	0.79				BL	1.17-1.23	1.20
			Length	1.26-1.26	1.26				AW	1.29-1.33	1.31
									PW	1.50-1.51	1.51
									PE-ratio	0.21-0.23	0.22
							Ha3	1	LL		—
									BL		1.32
									AW		1.32
									PW		—
									PE-ratio		—
M_2	Ha1	4	TrW	0.71-0.77	0.74	M^2	Ha1	3	LL	1.06-1.09	1.08
			TaW	0.74-0.78	0.76				BL	1.03-1.17	1.09
			Length	1.13-1.20	1.18				AW	1.37-1.42	1.39
	Ha3	1	TrW		0.65				PW	1.37-1.43	1.40
			TaW		0.70				PE-ratio	0.21-0.23	0.20
			Length		1.21		Ha3	3	LL	1.07-1.12	1.10
									BL	1.16-1.18	1.17
M_3	Ha1	1	Length		1.06				AW	1.37-1.40	1.39
			Width		0.58				PW	1.36-1.45	1.41
									PE-ratio	0.17-0.19	0.18

I^1 (4). The angle between the apex and the talon is sharp. The talon is well developed. The apex and talon are pointed, and reach down to about the same level. The buccal posterior margin is straight or slightly undulating and is bordered by a broad cingulum. The incisor is not fissident.

P^4 (1) The angle between the labial and lingual sides is small. The posterior side is concave. The hypoconal flange reaches just beyond the middle of the P^4. The paracone is a high and narrow cusp. Its posterocrista is sharp. The parastyle lies in front of the tip of the paracone. The parastylar crest is absent. The well-developed protocone lies antero-lingually of the paracone. Its anterior arm continues as the ridge connecting protocone and parastyle. The posterior arm of the protocone is short and runs along the paracone, with a constant distance between the arm and the base of that cusp. The hypocone is absent. A low ridge borders the hypoconal flange on the lingual side. The only cingulum is the postero-lingual cingulum along the base of the posterocrista of the paracone. This well-developed cingulum bears a low ridge.

M^1 (8). The molar is somewhat wider than long. The posterior side is moderately emarginated (average PE-ratio = 0.25). The anterior arm of the protocone ends against the base of the paracone. In six of the eight specimens the metaloph is divided in a weak arm connecting to the base of the metacone and a strong arm ending freely between the metacone and the hypocone. In the other two the latter arm is present only. The hypocone is a low, ridge-shaped cusp, which is separated from the proto-

cone by a valley. This valley is bordered by a short lingual cingulum, which continues along the base of the protocone in one of the eight specimens. The posterior ridge runs from the hypocone along the posterior side of the molar and is most pronounced on the wide cingulum along the posterior flank of the metacone. The posterior arms of the paracone and metacone are only somewhat longer than their anterior arms. The mesostyle is undivided.

M^2 (5). The M^2 is wider than it is long. The posterior side is moderately emarginated (PE-ratio of the two specimens for which it could be calculated is 0.18 and 0.25). The anterior arm of the protocone ends against the anterior flank of the paracone near the base of that cusp. The metaloph ends freely between the base of the metacone and the hypocone. The hypocone is a low, ridge-shaped cusp, which is separated from the protocone by a valley. This valley is bordered by a short lingual cingulum. The posterior ridge is pronounced and runs from the hypocone along the posterior margin of the molar. The two arms of the paracone are of the same length; the posterior arm of the metacone is somewhat longer than the anterior arm. The mesostyle is undivided, though the two individual cusplets are discernible in one unworn specimen.

Kilçak 0

M_2 (2). The two specimens from Kilçak 0 closely correspond to with those from Kilçak 0″. One of the two specimens has a weak lingual cingulum. The labial cingulum is continuous in both M_2.

M_3 (2). Neither M_3 has a lingual cingulum. The labial cingulum is continuous, though it is very thin at the base of the protoconid in one M_3.

M^2 (1). The only M^2 is damaged, lacking the larger part of the hypoconal flange. The metaloph is forked.

Kilçak 3A

P_4 (1). One of the three soricid P_4 from Kilçak 3A is somewhat smaller than the other two. In occlusal view the anterior side is pointed; the posterior side is slightly undulating. The lingual side is slightly convex. The labial side, which is somewhat longer than the lingual side, is convex. Seen from the labial side the antemolar is deepest at its back. In lingual view the enamel boundary slopes up in a gentle curve. Labially it has a similar curve, but rises abruptly directly below the tip of the protoconid and continues parallel to the mandible. The protoconid lies in the front part of the P_4. Its wear surface has the typical Y-shape of Crocidosoricinae. The two arms of the posterocristid border a rather deep posterior sulcus. The P_4 is bordered posteriorly by a broad cingulum, which has a small cusplet in the middle. The lingual cingulum is well developed; the labial cingulum is narrow.

M_1, M_2 (5, 4). A weak lingual cingulum is found in four of the five M_1 and one of the four M_2. The labial cingulum is continuous, though particularly in the M_1 it may become very thin near the base of the protoconid.

M_3 (1). The only M_3 has a continuous labial cingulum. The lingual cingulum is absent.

I^1 (3). The incisors from Kilçak 3A agree well with those from Kilçak 0″.

M^1 (5). The metaloph is connected to the base of the metacone in three of the five

specimens. None has a lingual cingulum along the base of the protocone.

M^2 (4). The metaloph is connected to the base of the metacone in one of the four M^2. The lingual cingulum along the base of the protocone is absent.

Kilçak 3B

M_1, M_2 (2, 2). One of the two M_1 has a weak lingual cingulum. The labial cingulum is continuous in both M_2. This character cannot be observed in the M_1, since it is too worn in one specimen, whereas the other specimen is damaged labially.

I^1 (2). Both I^1 are very worn and provide no extra information.

M^1 (4). One of the four M^1 has a lingual cingulum along the base of the protocone, which ends against the anterior flank. A connection between the metaloph and the metacone is absent in all specimens.

M^2 (3). The M^2 from Kilçak 3B agree well with those from Kilçak 0''. A weak ridge connecting the metaloph to the base of the metacone is present in one of the three specimens.

Harami 1

M_1, M_2 (2, 4). The labial cingulum is interrupted in one of the M_1, continuous in the other specimens. All specimens possess a weak lingual cingulum.

M_3 (3). The labial cingulum is continuous; the lingual cingulum is absent.

M^1 (3). The metaloph is divided in all three specimens. There is a lingual cingulum along the base of the protocone, which ends against the anterior flank of that cusp. In two specimens this cingulum is narrow near the base of the protocone, in the third one it is the same width throughout.

M^2 (3). All three specimens have a divided metaloph. The lingual arm bends in the direction of the hypocone in two of the three specimens, but ends before reaching this cusp. It is short in the third one and ends freely between the hypocone and the base of the metacone.

Harami 3

I_1 (2). The lower incisor is relatively slender. It is bicuspulate. The tip is only slightly curved. On the lingual side there is a ridge at the enamel-dentine boundary. This ridge curves inwards halfway down the incisor, forming a narrow ledge that runs to the tip of the tooth. The buccal extension is short; it is bordered by a well-defined cingulum. The crown and root lie in line.

M_2 (1). The specimen is very worn and shows few features.

M^1 (1). The specimen resembles the M^1 from Harami 1. The hypoconal flange is broken. The lingual cingulum is narrow at the base of the protocone.

M^2 (3). The metaloph of one of the M^2 from Harami 3 ends freely. In a second specimen it is divided in an arm connecting to the base of the metacone and a short free-ending arm. In the third specimen it connects to the metacone. The lingual cingulum continues along the base of the protocone in one specimen. In the others it is interrupted at this point. All three M^2 have a cingulum against the anterior flank of the protocone.

Remarks — Soricid taxonomy is largely based on the number of antemolars.

Unfortunately, we do not have any mandibles with the antemolars in front of the P_4. We do have endentulous mandibles, which show three alveoles between the P_4 and the lower incisor. The two alveoles directly behind the lower incisor are large and of about the same size. The third alveole is very small and lies antero-lingually of the P_4. The element to which this alveole belonged must have been tiny. Such a small third antemolar is typical for *Oligosorex*. In *Oligosorex antiquus* this small alveole lies under the anterior part of the P_4, in line with the other alveoles (Crochet, 1975). In *O. thauensis* the alveole is partly fused with the anterior alveole of the P_4 and lies lingually of this alveole. The alveole of the third unicuspid in *O. reumeri* takes an intermediate position: it does not lie in line with the other alveoles as in *O. antiquus*, but unlike in *O. thauensis* the alveole is completely separated from the anterior alveole of the P_4. The function of a vestigial P_3 in three different species is not clear. Looking at Rümke's illustration of a mandible of *Oligosorex antiquus* (de Bruijn & Rümke, 1974, fig. 5) it is unlikely that it played a major role in the occlusion. Possibly this unicuspid functioned as a kind of wedge, stabilizing the anterior part of the P_4 which has a relatively small root. This would explain why in *O. thauensis* and *O. reumeri* the element is not placed in line with the other antemolars, but lies anterolingually of the P_4.

The most distinctive feature of *Oligosorex reumeri* is the interrupted labial cingulum in all of the M_1 and most of the M_2. Such an interruption is rare among shrews. It is known from *Crocidosorex piveteaui*, which completely lacks the labial cingulum, and it is also found in *Lartetium petersbuchense* (Ziegler, 1989).

Initially undue emphasis was put on the presence of a divided metaloph in the M^1 and M^2 of *Oligosorex reumeri*. I found only one reference which described such a bifurcation, Doukas' (1986) description of Crocidurinae (= Crocidosoricinae) gen. et sp. indet. from Aliveri. Furthermore, Ziegler's (1989) illustration of *Soricella* cf. *discrepans* from Ulm-Westtangente (pl. 4, figs. 8-9) also shows a divided metaloph in both the M^1 and M^2. This led me to believe that such a bifurcation was a rarity among shrews. It is, however, quite common among recent shrews and of no taxonomical value (Reumer, pers. comm., June 1998)

The material from Harami and Kilçak is considered insufficient to define a new species and has been classified as *Oligosorex* aff. *reumeri*. The most apparent difference between the species from Keseköy and that from the Harami and Kilçak localities is the larger size of the latter. In *Oligosorex* aff. *reumeri* an interrupted labial cingulum in the lower molars is an exception. It is found in one of the M_1 from Harami 1 and in some specimens from Kilçak 0''. It is difficult to give percentages of specimens in which this character is present, because, particularly in the M_1, the labial cingulum becomes very thin near the base of the protoconid, making it hard to judge whether or not it is truely interrupted. Furthermore, the cingulum is easily damaged. Other differences in the lower molars are the stronger development of the lingual cingulum in *O. reumeri* (the lingual cingulum of *O.* aff. *reumeri* is better developed in Harami 1 than it is in the Kilçak localities), and the oblique cristid of the M_2, which ends more labially in *O.* aff. *reumeri*. The wear facet of the only available P_4 of the older species (Ki3A 2181) has longer arms than the P_4 of *O. reumeri*. Some of the upper molars of *Oligosorex* aff. *reumeri* have a lingual cingulum along the base of the protocone. Such a cingulum is absent in *O. reumeri*.

Despite the large differences between the two species, we suppose that *Oligosorex* aff. *reumeri* and *O. reumeri* are part of one evolutionary lineage. This hypothesis is mainly based on a trend in the development of the lingual cingulum of the lower molars, which is weak or absent in Kilçak, well developed in Harami 1 and well developed and connected to the hypolophid in Keseköy.

It is possible that some of the lower molars described above do not belong to *Oligosorex* but to one of the soricids described here after. These soricids are comparable in size to *Oligosorex*. This problem will be discussed in detail in the remarks on Soricid I and II. The incisors from Harami 3 are in size and morphology similar to the incisors of *O. reumeri* from Keseköy. Therefore the incisors from Harami 3 have been allocated to *Oligosorex* and not to Soricid III, which is the most common shrew in that locality.

Reumer (1994) described the lower incisor of the Crocidosoricinae as having — as a rule — a weak angle between the axes of crown and root. Though such an angle is found in several crocidosoricine genera, it is not found in our material of *Oligosorex*. In this respect the lower incisors rather resemble those of *Miosorex*.

Crocidosoricinae gen. et sp. indet.

Apart from *Oligosorex* another medium sized shrew is found in the various localities. Soricid I from Kilçak and Harami and Soricid II from Keseköy are two similar, and probably closely related, species. The main difference is the much smaller M^3 of the Keseköy species. Both are relatively rare elements in the faunas. The limited material does not allow assigning them to any known or new genus. Given the great similarity between the two species, we believe that they belong to one genus. A third species, found in all localities except Kilçak 0″ and Keseköy, is considerably smaller than the other Early Miocene Anatolian shrews.

Soricid I

Pl. 3, figs. 3-6.

Localities — Kilçak 0″, Kilçak 3A, Harami 3.
Measurements — The measurements are listed in Table 4.

Description

The material from Kilçak 0″ is described in full. For the other localities only the differences with the material from Kilçak 0″ are indicated, except for the P_4, which has only been found in Kilçak 3A.

Kilçak 0″

P^4 (2). The anterior and posterior sides of the P^4 are concave. The hypoconal flange reaches beyond the middle of the premolar. It is bordered by a faint posterior ridge. The paracone is a high and narrow cusp. Its tip lies just in front of the middle of the P^4. The parastyle lies in front of the paracone on a strongly protruding section of the premolar. It is connected to the protocone by a low ridge. The parastylar crest is absent. The well-developed protocone lies antero-lingually of the paracone. The

Table 4. Measurements of Soricid I from Kilçak and Harami.

tooth	loc.	N		range	mean
P_4	Ki3A	2	Length	0.91-0.94	0.93
			Width	0.59-0.60	0.60
P^4	Ki0″	2	P	0.78-0.82	0.82
			LL	0.89-0.96	0.93
			BL	1.44-1.50	1.47
			Width	1.19-1.25	1.22
M^1	Ki0″	2	LL	1.22-1.23	1.23
			BL	1.28-1.32	1.30
			AW	1.31-1.42	1.37
			PW	1.59-1.69	1.64
			PE-ratio	0.25-0.27	0.26
M^3	Ki0″	3	Length	0.68-0.73	0.70
			Width	1.23-1.32	1.28
	Ki3A	3	Length	0.63-0.68	0.66
			Width	1.18-1.24	1.22
	Ha3	1	Length		0.72
			Width		1.18

posterior arm of the protocone is very short. The hypocone lies postero-lingually of the protocone and lingually of the tip of the paracone. It is well developed and continues as a thick lingual ridge, which is connected to the faint posterior ridge bordering the hypoconal flange. This posterior ridge continues on the well-developed cingulum on the lingual side of the paracone. Near the posterior side of the P^4 the ridge becomes very pronounced.

M^1 (2) The molar is wider than long. The posterior side is moderately emarginated (PE-ratios are 0.25 and 0.27). The lingual side is slightly undulating. The anterior arm of the protocone ends against the base of the paracone. The metaloph is short and ends freely. The hypocone is a well-developed, cone-shaped cusp. It is separated from the protocone by a wide valley, which is bordered by a lingual cingulum. In one of the two specimens this cingulum continues along the base of the protocone and ends against the anterior flank of that cusp. The posterior ridge runs from the hypocone along the posterior side of the molar. The posterior arms of the paracone and metacone are only somewhat longer than their anterior arms. In an unworn specimen the mesostyle is incompletely divided, but in the other specimen it seems undivided.

M^3 (3) The M^3 is relatively long for a soricid M^3. The protocone is small. Its anterior arm continues as a ridge on the well-developed cingulum bordering the anterior flank of the paracone. The metaloph ends freely in the trigon basin. The paracone is the largest cusp of the M^3. Its anterior arm is much longer than the posterior arm. The metacone is very small. The hypocone lies posterolingually of the metacone. In one of the three specimens it is almost completely incorporated in the metacone. In a second specimen it is an individualised cusplet, which causes a bulge in the posterior outline

of the molar. The third specimen is damaged in the region of the hypocone. Probably this specimen also had an individualised hypocone.

Kilçak 3A

P_4 (2). The P_4 have the Y-shaped wear surface that is typical for the Crocidosoricinae. The two arms are rather long and border a shallow sulcus. The lingual and labial sides are concave. The posterior side is slightly undulating. The lingual cingulum is narrow and runs from near to the front to the posterior end of the premolar. The labial cingulum is wider than the lingual cingulum and runs all along the labial side. In one specimen the front part of the cingulum is broken off. In both P_4 only the posterior root has been preserved, but the point of attachment of the anterior root is clearly visible.

M^3 (3). The M^3 agree well with those from Kilçak 0''. In one of the specimens the anterior cingulum ends against the anterior flank of the paracone. The hypocone is individualised in one of the three M^3, partly fused with the metacone in the second specimen and absent in the third.

Harami 3

M^3 (1). The M^3 from this locality resembles those from Kilçak 0''. The hypocone is partly fused with the metacone.

Soricid II

Pl. 3, figs. 7-10.

Locality – Keseköy.

Measurements — The measurements are listed in Table 5.

Description

I_1 (3). Three lower incisors from Keseköy differ from the others in having better developed cuspules. Particularly the posterior cuspule is distinct; the median edge drops nearly at a right angle. The second cuspule is much lower, consisting of a gentle slope between the posterior cuspule and the strongly curved tip. In other respects the incisor resembles that of *Oligosorex reumeri*. It is bicuspulate, relatively slender and the root and the crown lie in line. The buccal extension is not very well developed.

I^1 (2). Among the upper incisors from Keseköy two specimens stand out by having a stronger curve on the back and showing traces of original pigmentation. The angle between the apex and the talon is sharp. Both the apex and the well-developed talon are pointed; the apex reaches somewhat further downwards than the talon. The buccal posterior margin is slightly convex and is bordered by a well-developed cingulum. The incisor is not fissident.

P^4 (1). The premolar has the typical outline of the soricid P^4. The anterior side is rather straight, the posterior side is slightly emarginated. The lingual side stands at an angle of c. 40° with respect to the labial side. The hypoconal flange reaches far to the posterior side and is bordered by a low ridge. The paracone is very large. The small parastyle lies just in front of the paracone. There is no parastylar crest. The pro-

Table 5. Measurements of Soricid II from Keseköy.

tooth	N		range	mean
I_1	3	Length	1.82-2.05	1.93
I^1	2	Length	1.10-1.10	1.10
		Lt	0.47-0.48	0.48
		Height	0.93-0.96	0.95
P^4	1	P		0.78
		LL		0.84
		BL		1.45
		Width		1.25
M^1	2	LL	1.12-1.18	1.15
		BL	1.15-1.22	1.19
		AW	1.36-1.41	1.39
		PW	1.68-1.69	1.69
		PE-ratio	0.17-0.26	0.22
M^2	1	LL		1.09
		BL		1.10
		AW		1.55
		PW		1.57
		PE-ratio		0.21
M^3	2	Length	0.54-0.57	0.56
		Width	1.07-1.13	1.10

tocone is well developed. Its anterior arm is connected to the parastyle. The posterior arm of the protocone is very short. The hypocone, which lies postero-lingually of the protocone, is poorly developed. It looks more like an elevated ridge than as a real cusp. The hypocone is the starting point for a ridge, that continues along the side of the hypoconal flange, over the cingulum lingually of the posterocrista to the back of the P^4. This ridge is very low near the emargination in the hypoconal flange, pronounced near its end.

M^1 (2). The M^1 is much wider than long. The posterior side is moderatly emarginated (PE-ratios are 0.17 and 0.21). The lingual side is slightly undulating. One of the two M^1 is preserved in a piece of jaw together with the only M^2 of this species found in Keseköy. In labial view the base of the crown of this specimen is lightish brown, whereas the cusps are black. This may indicate an original pigmentation. However, the isolated M^1 has no difference in colour between the crownbase and the tips, and in lingual view the M^1 and M^2 in the piece of jaw are completely black. Thus the difference in colour may also be a result of the fossilisation process.

The protocone is large. Its anterior arm ends against the base of the paracone. The metaloph ends freely, halfway between the base of the metacone and the hypocone. The protocone and hypocone are separated by a valley, which is bordered by a lin-

gual cingulum. The lingual cingulum continues along the protocone, ending near its base. The hypocone is a well-developed, cone-shaped cusp. In one of the two specimens a faint ridge runs over the posterior flank of the hypocone. This ridge continues as a well-defined ridge, which borders the posterior side of the M^1. The posterior flank of the hypocone of the other specimen is rounded; in this M^1 the posterior ridge starts at the base of the hypocone.

The anterior arm of the paracone bends slightly at its end, forming a small parastyle. The posterior arm is connected to the mesostyle, which is undivided. The metacone is much larger and higher than the paracone. Paracone and metacone both have a posterior arm that is longer than the anterior arm.

M^2 (1). The molar is much wider than long. The posterior side is moderately emarginated (PE-ratio = 0.21). The lingual side is slightly undulatling. The protocone is large. Its anterior arm ends against the anterior flank of the paracone. The metaloph ends freely, halfway between the base of the metacone and the hypocone. The hypocone is well developed, but, in contrast to the M^1, not cone-shaped. It is separated from the protocone by a wide valley, which is bordered by a short lingual cingulum. A narrow ridge runs over the tip of the hypocone. This ridge ends near the base of the protocone on one side and continues as the posterior ridge on the other. The posterior ridge is well developed throughout, though somewhat narrower near the posterior emargination than at its lingual and labial end. The metacone is somewhat larger and clearly higher than the paracone. The posterior arm of the paracone and the metacone are somewhat longer than their anterior arms. Parastyle, mesostyle and metastyle lie in a direct line. The mesostyle is undivided.

M^3 (2). The outline of the occlusal surface is semi-ovoid. The protocone is a small, low cusp. Its anterior arm ends against the base of the paracone, the posterior arm ends freely in the trigon basin. The paracone is the highest and largest cusp. Its anterior arm is much longer than its posterior arm. The mesostyle is undivided. The metacone is small. A small hypocone lies posterolingually of the metacone in one of the two specimens. It is a very small, ridge-shaped cusp, which lies in line with the anterior arm of the metacone. The posterior side is slightly bulged at the position of the hypocone. In the other specimen the hypocone is completely incorporated in the metacone. There are no cingulums.

Remarks — Soricid I from Kilçak and Harami is somewhat larger than *Oligosorex* aff. *reumeri*. Soricid II from Keseköy is somewhat larger than *O. reumeri*. The upper molars of Soricid I and II are clearly wider than those of *Oligosorex*, giving them a rather elongated outline. The general morphology of the molars is reminiscent of that of *Lartetium*. Like the Anatolian species this genus has upper molars that are clearly wider than long and have a relatively well-developed hypocone.

Distinguishing Soricid II from *Oligosorex reumeri* in Keseköy is relatively easy, since the elements of Soricid II show, in contrast to those of *O. reumeri* a difference in colour between the tips and the crownbase, which is probably due to original pigmentation. This colour difference also helped in distinguishing the upper and lower incisors of Soricid II from those of *Oligosorex reumeri*. The teeth of Soricid I from Kilçak and Harami are uniform in colour, so that traces of pigmentation can not be used to separate Soricid I from *Oligosorex* aff. *reumeri*. The P_4 from Kilçak 3A and the

P^4 from Kilçak 0″ are attributed to Soricid I primarily on the basis of their size. There are two size categories in these elements, the smaller of which is assigned to *Oligosorex* aff. *reumeri*, the larger to Soricid I. The identification of the M^3 of Soricid II from Keseköy is certain. These M^3 differ considerably from those of *Oligosorex reumeri*, which have been found associated with the M^1 and M^2 in a piece of maxillary. The M^3 from Kilçak 0″, Kilçak 3A and Harami 3 are placed in Soricid I on the basis of their similarity to the M^3 of Soricid II.

It is remarkable that the lower molars of Soricid I and Soricid II have not been found. The absence of lower molars is considered real for Soricid II. It is unlikely that the lower molars of this form could be misidentified as those of *Oligosorex reumeri*, since this would imply that they also had an interrupted labial cingulum, a character that is very rare among shrews. Furthermore, the M_1 and M_2 of Keseköy both show a unimodal distribution for their lengths. It is conceivable that the lower molars of Soricid I were included in the molars described as *Oligosorex* aff. *reumeri*. Although the upper molars of Soricid I are considerably wider than those of *Oligosorex* aff. *reumeri*, they are of similar length. Thus the lower molars are expected to have a similar length also. Since in insectivores wider upper molars do not necessarily imply that the lower molars are also wider — transverse jaw movements give the same cutting action, regardless of the width of the lower molars —, the lower molars of *Oligosorex* aff. *reumeri* and Soricid I may be indistinguishable.

Like in *Oligosorex* the lower incisor of Soricid II does not have a weak angle between the length axes of root and crown.

Soricid III

Pl. 4, figs. 1-5.

Measurements — The measurements are listed in Table 6.

Geographical and stratigraphical distribution — This species has been found in the Anatolian localities Kilçak 0″, Kilçak 3A, Kilçak 3B, Harami 1, Harami 2 and Harami 3. All of these localities have been assigned to MN 1.

Kilçak 0″

M_1, M_2 (2, 1). No isolated lower molars of this species have been found in Kilçak 0″. There are two mandibles, one with the M_1 and M_2 and the other with the M_1 and a fragment of the M_2. One of the jaw fragments shows a foramen mentale below the alveoles of the P_4. The tips of the molars are darker than the base, suggesting an original pigmentation. The M_1 and M_2 are very similar. The main difference is the somewhat longer trigonid of the M_1. In both the M_1 and the M_2 the trigonid is longer than the talonid. In all three preserved molars the hypoconid is very worn. It must have been a large cusp. The oblique cristid ends at about two-thirds of the protoconid-metaconid crest. The entoconid is low. The talonid basin is bordered by a well-developed entocristid. The hypolophid runs behind the entoconid and is separated from this cusp by a very narrow valley. The anterior cingulum is well developed. It continues along the base of the protoconid as the continuous, narrow labial cingulum. The posterior cingulum is well developed and ends against the flank of the hypolophid. The lingual cingulum, which runs from the hypolophid to the paraconid, is narrow.

Table 6. Measurements of Soricid III from Kilçak and Harami.

tooth	loc.	N		range	mean	tooth	loc.	N		range	mean
M_1	Ki0″	2	TrW	0.58-0.61	0.60	M^1	Ki0	1	LL		—
			TaW	0.65-0.66	0.66				BL		1.03
			Length	1.00-1.00	1.00				AW		1.10
	Ha2	1	TrW		0.58				PW		—
			TaW		0.63				PE-ratio		—
			Length		1.07		Ki3A	1	LL		0.94
	Ha3	3	TrW	0.61-0.63	0.62				BL		1.06
			TaW	0.64-0.67	0.65				AW		1.16
			Length	1.10-1.16	1.14				PW		1.24
									PE-ratio		0.25
M_2	Ki0	1	TrW		0.62		Ha1	1	LL		—
			TaW		0.64				BL		1.04
			Length		1.05				AW		1.07
	Ki0″	1	TrW		0.66				PW		—
			TaW		0.66				PE-ratio		—
			Length		1.02		Ha3	1	LL		—
	Ha1	2	TrW	0.63-0.65	0.64				BL		1.01
			TaW	0.63-0.63	0.63				AW		1.06
			Length	1.06-1.11	1.09				PW		—
	Ha3	7	TrW	0.98-1.08	0.62				PE-ratio		—
			TaW	0.58-0.65	0.63						
			Length	0.61-0.65	1.03	M^2	Ki0″	1	LL		0.83
									BL		0.86
M_3	Ha3	1	TrW		0.58				AW		1.18
			TaW		0.46				PW		1.15
			Length		0.83				PE-ratio		0.18
							Ha3	2	LL		—
									BL	0.92-0.96	0.94
									AW	1.13-1.17	1.15
									PW		—
									PE-ratio		—

M^2 (1). The specimen is very worn. The posterior emargination is moderate (PE-ratio = 0.18). The protocone is relatively small. Its anterior arm ends against the anterior flank of the paracone, near the base of that cusp. The metaloph is short and ends freely. The hypocone is poorly developed and forms part of the ridge bordering the hypoconal flange. The posterior ridge is very thin near the posterior emargination, becoming more pronounced on the cingulum bordering the posterior flank of the metacone. The paracone and metacone are large. The two arms of the paracone are of the same length; the posterior arm of the metacone is somewhat longer than the anterior arm. The original division of the mesostyle cannot be judged from this worn specimen. There is a short and narrow cingulum against the anterior flank of the protocone.

Kilçak 3B

M_2 (1). The lingual cingulum in the specimen from Kilçak 3B is absent. The molar is somewhat larger than the one from Kilçak 0''. In other respects the two specimens are similar.

M^1 (2). Both M^1 from Kilçak 3B are damaged. One specimen is very worn and is damaged labially, the anterior arm of the paracone and posterior arm of the metacone are broken. The other specimen lacks the hypoconal flange. The protocone is large. Its anterior arm connects to the base of the paracone. The metaloph is long and ends freely. The hypocone is well developed. The valley between the hypocone and the base of the protocone is bordered by a short lingual cingulum. One of the two specimens also has a short cingulum against the anterior flank of the protocone. The posterior emargination is bordered by a distinct ridge, which starts at the hypocone and runs over the well-developed cingulum along the posterior flank of the metacone. The anterior arm of the paracone is straight. The posterior arm of this cusp is clearly longer than the anterior arm. The posterior arm of the metacone is only somewhat longer than the anterior arm. The mesostyle is undivided.

Kilçak 3A

M^1 (1). The specimen from Kilçak 3A is the only complete M^1 of this species, and thus the only one for which a PE-ratio can be calculated. The posterior emargination is moderate (PE-ratio = 0.25). The specimen agrees well with those from Kilçak 3B. There is no cingulum against the anterior flank of the protocone and the anterior arm of the paracone is slightly bent.

Harami 1

M_2 (2). The two specimens from Harami 1 are very similar to the M_2 from Kilçak 0''.

M^1 (1). The molar is damaged, missing a large part of the hypoconal flange and most of the posterior ridge. In morphology it agrees well with the M^1 from Kilçak 3B. There is no cingulum against the anterior flank of the protocone. The anterior arm of the paracone bends slightly to form a parastyle.

Harami 2

M_1 (1). The faunule of Harami 2 contains one soricid element only, an M_1 of Soricid III which agrees well with those from Kilçak 0''.

Harami 3

M_1, M_2 (3, 7). These specimens are very similar to the ones from Kilçak 0''.

M_3 (1). The only available M_3 is preserved in a mandible. Its trigonid is a smaller version of the trigonid of the M_2. The talonid is strongly reduced. The oblique cristid, hypoconid, hypolophid, entoconid, and entocristid form a ridge that starts at the middle of the protoconid-metaconid crest and ends against the metaconid, encircling a shallow talonid basin. The hypoconid is the only discernible cusp in this ridge. The anterior and labial cingulums are well developed. There is a short, narrow lingual cingulum bordering the trigonid valley.

M^1 (1). The only specimen is damaged, lacking the hypoconal flange. The anterior

arm of the paracone is slightly bent. There is no cingulum at the anterior flank of the protocone. An indistinct transverse ridge connects the metaloph to the base of the metacone.

M^2 (2). Both M^2 from Harami 3 lack the hypoconal flange. They resemble the specimen from Kilçak 0''. The mesostyle is undivided.

Remarks — This small shrew is remarkably similar to the one from the German locality Ulm-Westtangente (MN 2) described by Ziegler (1989) as *Crocidosorex* sp. The trigonid basin is widely open, the cusps are very pointed, the anterior cingulum is well developed and the lingual cingulum is continuous. The M^1 is, however, somewhat wider than in the German species, which is primarily caused by the larger width of the labial cusps. The hypoconal flange is also wider. Soricid III also resembles '*Oligosorex*' *bruijni* from the Spanish localities Ateca I and III and Villafeliche 2A (MN 4), however, the M^1 is much narrower. Unfortunately, no mandibles with the anterior dentition or its alveoles have been found. Without information on the number of antemolars, the genus cannot be determined.

Soricid III is small, even smaller than the extant *Sorex minutus.* It is known by its upper molars and the lower molars only, most of the latter preserved in the jaw. In view of the size of this shrew, isolated antemolars must have been lost while sieving the sediment. Strictly, the subfamily cannot unambiguously be identified without the P_4. However, since most soricids of the same age are Crocidosoricinae, it is tentatively assumed that this species belongs to that subfamily. It certainly does not belong to the only other Eurasian subfamily known from the Lower Miocene, the Allosoricinae, since the entoconid of the lower molars is well developed.

It is remarkable that Soricid III is absent in Keseköy. This absence is probably not due to sampling, since Keseköy is by far the richest assemblage. Furthermore, Keseköy yielded rather complete material, which minimises the chance that these small teeth were lost during sieving. In Harami 3 Soricid III is the most common soricid.

Discussion and conclusions

Soricid taxonomy is largely based on characteristics of the mandible such as the morphology of the condyle and the number and position of the antemolars. Limited value is attributed to molar morphology. This provides a problem when only isolated teeth are available. Since authors normally concentrate on the characters of the mandible, little attention is given to the description of the molars.

A similar situation was found in the Heterosoricidae. Engesser (1975) based his classification of the Heterosoricidae largely on features of the mandible, but he also gave a large number of useful characters of the dental morphology to distinguish between the European genera *Heterosorex* and *Dinosorex*. Since complete mandibles are relatively rare, it is useful to examine the possibility of distinguishing soricid genera on the basis of dental morphology. For example, one of the characteristics used by Engesser to distinguish between the two heterosoricid genera was the posterior arm of the protocone of the M^3, which may either end freely in the trigon basin or continue along the posterior margin and connect with the metacone. These two configura-

tions are also found in the Soricidae. The posterior arm of the protocone of *Oligosorex* connects to the metacone. In our Soricid I, Soricid II and in *Miosorex* the posterior arm of the protocone ends freely in the trigon basin. For detecting useful dental characteristics extensive descriptions are needed. Therefore full descriptions are given in this paper in the same way we described the other Anatolian Lower Miocene insectivores.

Three groups of Soricidae are recognized in our material. The first one is the small Soricid III which is found in the older localities, but not in Keseköy. The absence of the genus in Keseköy is probably ecologically determined. Soricid III is most common in Harami III. This locality probably represent a somewhat different palaeoenvironment than the other localities, as is deduced from the absence of the heterosoricid *Dinosorex* (van den Hoek Ostende, 1995a) and the cricetid *Mirabella* (de Bruijn & Saraç, 1992). Apparently Soricid III had a specific ecological preference. Its absence in Keseköy possibly indicates a change in environment.

Apart from the small soricid, two types of middle-sized shrews were found. The most common soricid in most localities is *Oligosorex*, represented by *Oligosorex* aff. *reumeri* in Kilçak and Harami and *Oligosorex reumeri* in Keseköy. Soricid I (Kilçak and Harami) and Soricid II (Keseköy) are relatively rare elements in the fauna. These two unnamed shrews both have well-developed hypocones and relatively wide upper molars, and are considered to be closely related. It is remarkable that both Soricid II and *Oligosorex reumeri* are smaller than their presumed ancestores in Kilçak and Harami. The decrease in size was made possible by the extinction of the Soricid III lineage and possibly helped to avoid competition with *Theristikos*, a small shrew-mole which is the most common insectivore in Keseköy.

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References

For References see Part 8 in this volume.

Manuscript received 30 September 1998.

Plate 1

Figs. 1-3. *Oligosorex reumeri* sp. nov. from Keseköy.
1: I_1 sin. (Ke 6517).
2: Mandible dext. with P_4-M_2 (Ke 6524); a: occlusal view; b: labial view.
3: Mandible sin. with M_1-M_3 (Ke 6532); a: occlusal view; b: labial view.

All figures × 20, underlined numbers indicate specimens illustrated in inverse.

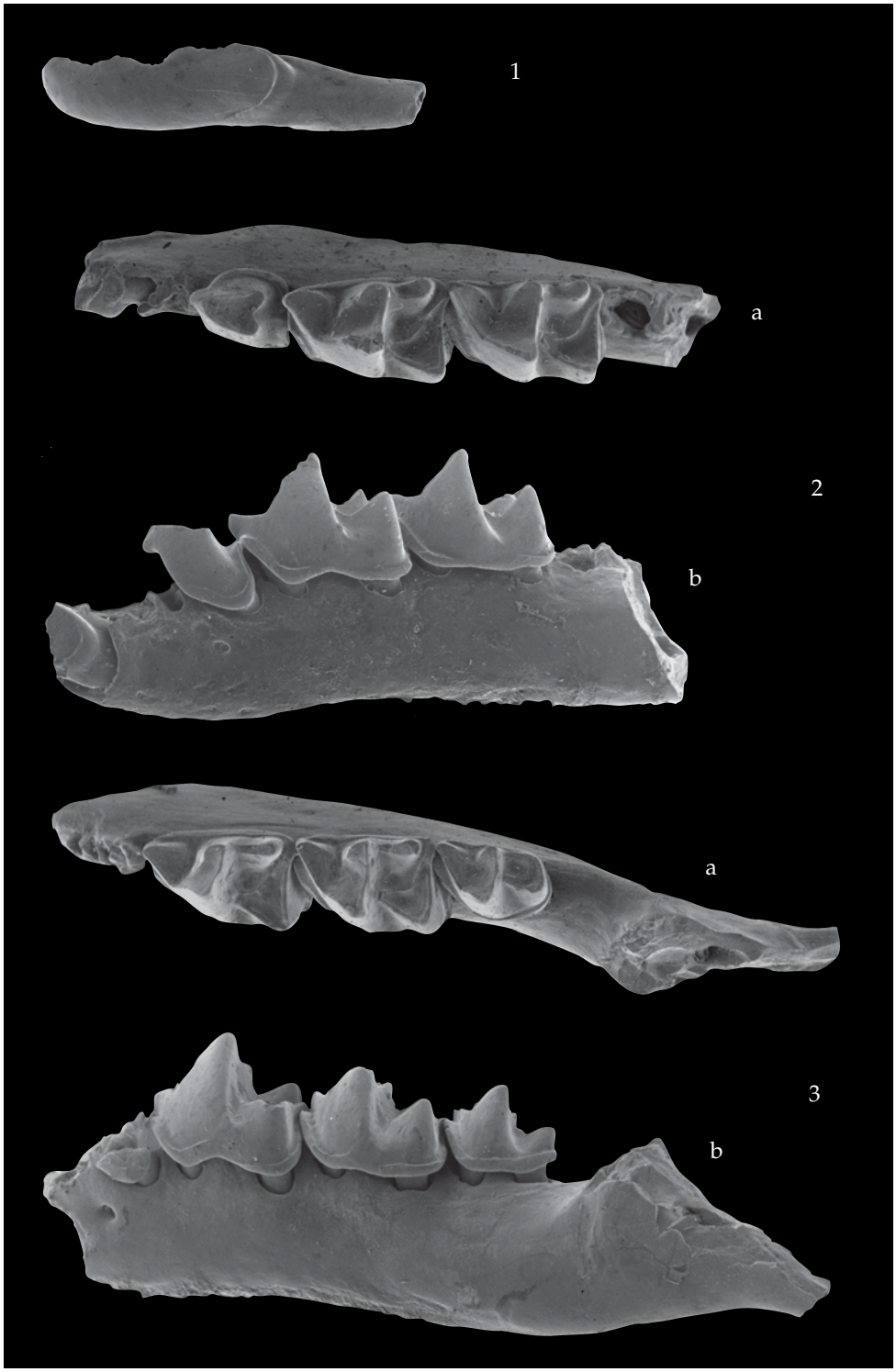
1
a
2
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Plate 2

Figs. 1-3. *Oligosorex reumeri* sp. nov. from Keseköy.
1: I^1 sin. (Ke 6604).
2: Maxillary with P^4-M^2 dext. (Ke 6621, holotype).
3: Maxillary with M^1-M^3 sin. (Ke 6622).

Figs. 4-7. *Oligosorex* aff. *reumeri* sp. nov.
4: P_4 sin. (Ki3A 2181).
5: Mandible with M_1 and M_2 dext.; a: occlusal view; b: labial view.
6: M_3 sin. (Ki0″ 2905).
7: P^4 dext. (Ki0″ 2916).

All figures × 20.

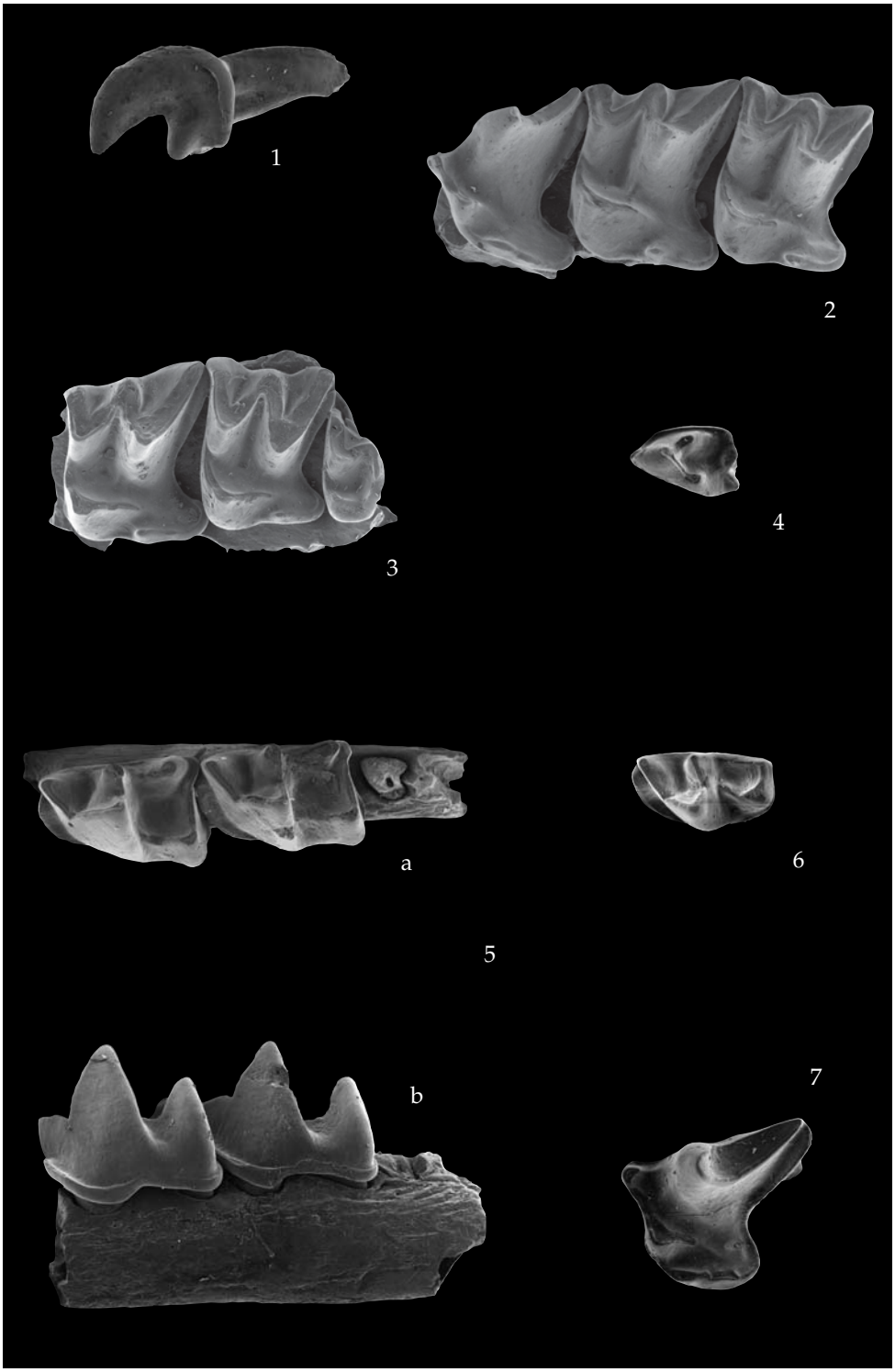
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Plate 3

Figs. 1-2. *Oligosorex* aff. *reumeri* sp. nov.
1: M^1 sin. (Ki0″ 2927).
2: M^2 sin. (Ki0″ 2934).

Figs. 3-6. Soricid I.
3: P_4 sin. (Ki3A 2183).
4: P^4 sin. (Ki0″ 2918).
5: M^1 dext. (Ki0″ 2924).
6: M^3 dext. (Ki0″ 2939).

Figs. 8-10. Soricid II from Keseköy.
8: I_1 sin. (Ke 6515).
9: Maxillary with M^1 and M^2 sin. (Ke 6624).
10: M^3 dext. (Ke 6669).

All figures × 20, underlined numbers indicate specimens illustrated in inverse.

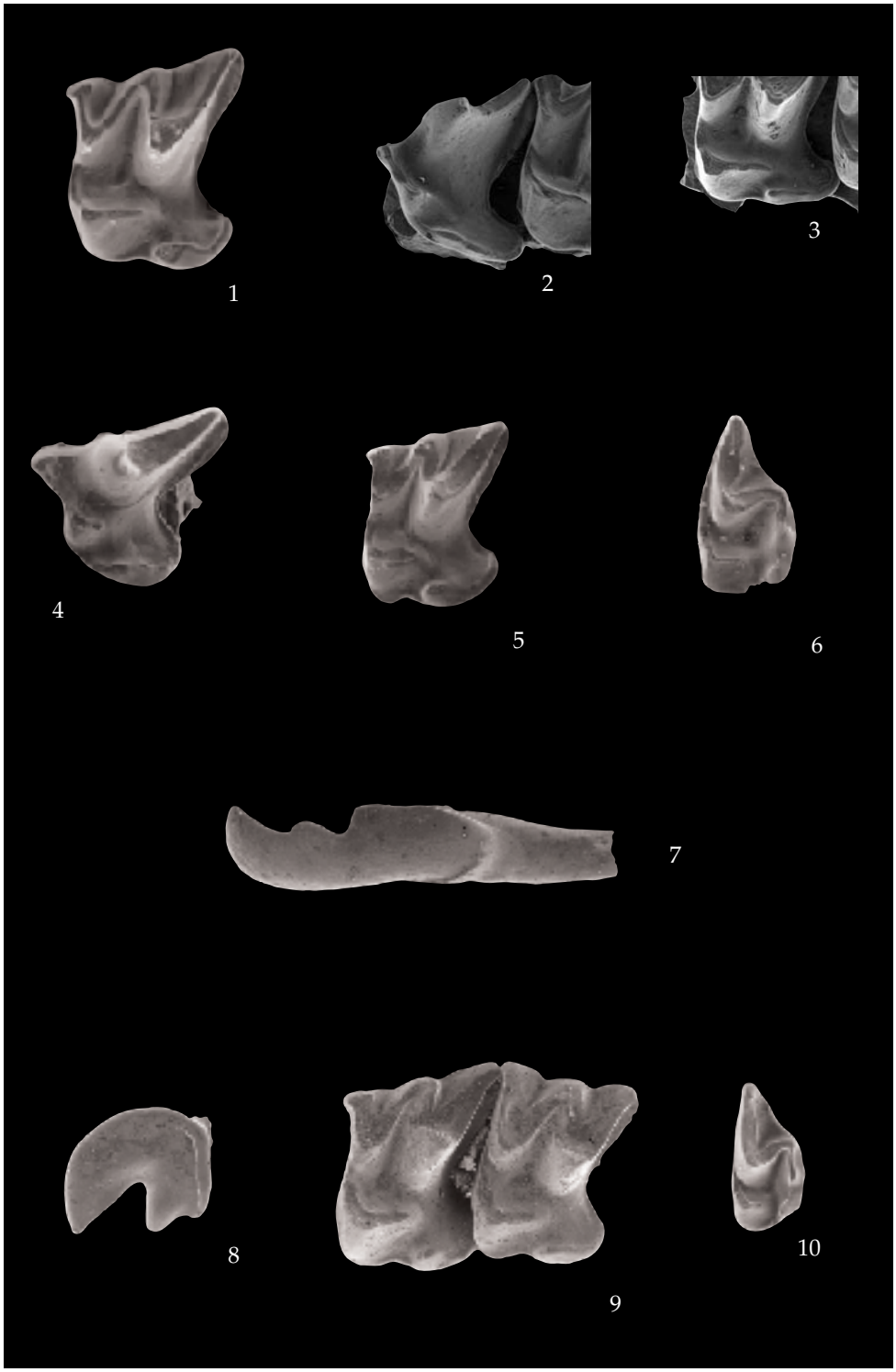
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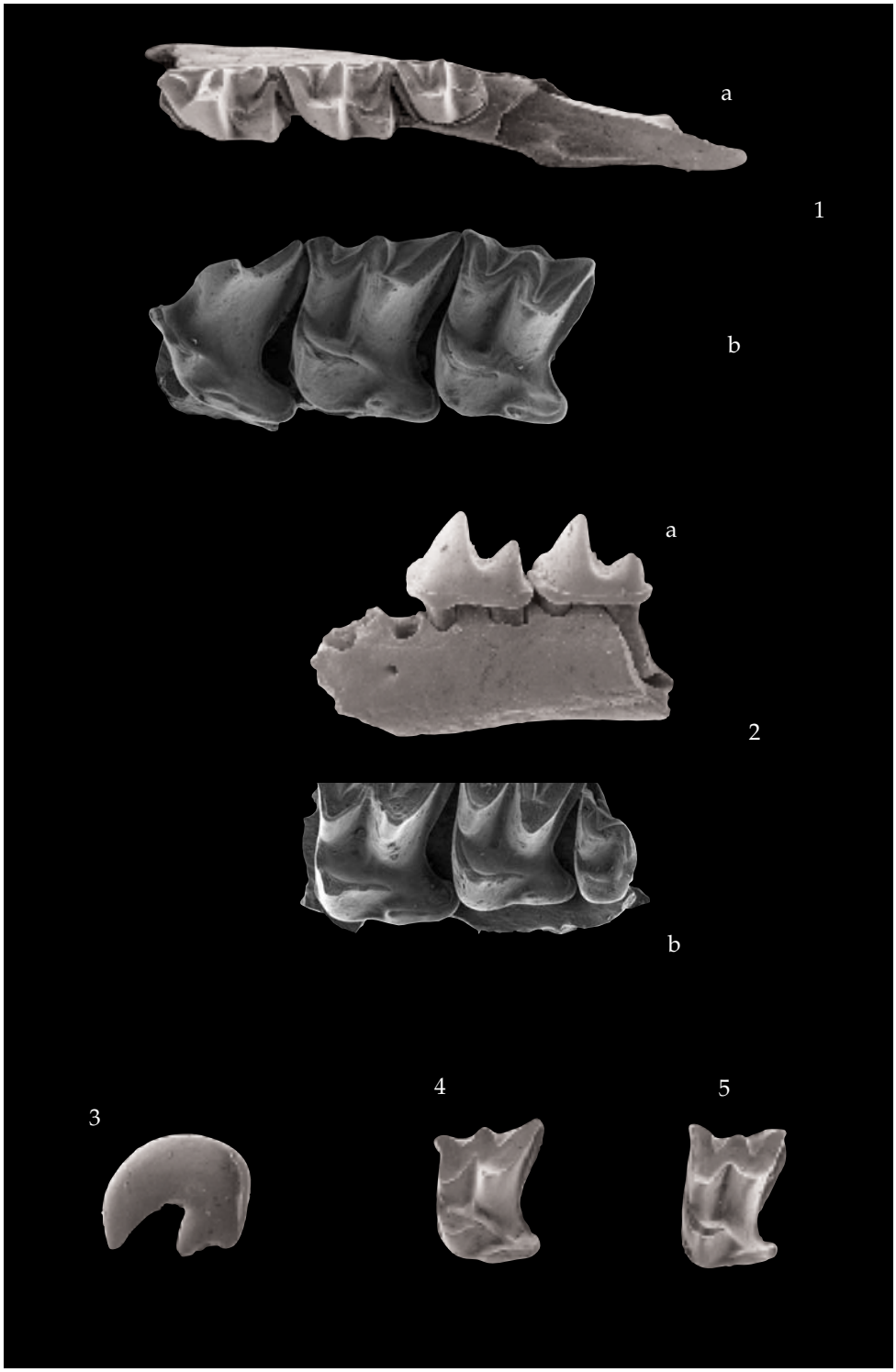
Plate 4

Figs. 1-5. Soricid III.
1: Mandible sin. with M_1–M_3 (Ha3 654); a: occlusal view; b: labial view.
2: Mandible sin. with M_1 and M_2 (Ki0″ 2944); a: occlusal view; b: labial view.
3: I sin. (Ha3 666).
4: M^1 dext. (Ki3A 2216).
5: M^2 sin. (Ki0″ 2944).

All figures × 20, underlined numbers indicate specimens illustrated in inverse.


a
1
b
a
2
b
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