

New Early Miocene Shrews (Soricidae, Mammalia) from Kazakhstan

A. V. Lopatin

Paleontological Institute, Russian Academy of Sciences, Profsoyuznaya ul. 123, Moscow, 117997 Russia

e-mail: alop@paleo.ru

Received November 5, 2002

Abstract—Two new Early Miocene shrews, *Aralosorex kalini* gen. et sp. nov. (Altynshokysu, western Kazakhstan) and *Miocrocidosorex zzhigini* gen. et sp. nov. (Ayaguz, eastern Kazakhstan) of the subfamily Crocidosoricinae are described. In *Aralosorex*, the structure of M_1 and M_2 is typical of *Carposorex*, i.e., the posterolabial crest of the protoconid is connected to the ectocingulid; however, this genus is distinguished by the smooth enamel and the structure of P_4 , which has long arms of the posterocristid. *Miocrocidosorex* has two lower antemolars and lacks ectocingulids on M_1 and M_2 ; the latter character displays its similarity to *Crocidosorex*. It is proposed to divide the Crocidosoricinae into two tribes, Crocidosoricini Reumer, 1987 (*Crocidosorex* and, presumably, *Miocrocidosorex*) and Oligosoricini Gureev, 1971 (all other genera, including *Aralosorex*).

Key words: Shrews, Crocidosoricinae, new taxa, Early Miocene, Kazakhstan.

INTRODUCTION

Little is known about Early Miocene shrews of Asia (Storch *et al.*, 1998). Bendukidze (1993) described the heterosoricines *Gobisorex kingae* Sulimski, 1970 and *Gobisorex* aff. *kingae* from the Aral Formation (MN1) of the North Aral Region of western Kazakhstan; subsequently, they were determined as *Gobisorex* sp. (Lopatin, 1999). In the Aral Formation of the Altynshokysu locality, Lopatin (1996, 1999) discovered *Gobisorex* sp., Heterosoricinae gen. and Crocidosoricinae gen. Kordikova (2000) determined Soricidae indet. in the Aktau locality (MN4–MN5) of southeastern Kazakhstan.

In China, ?*Crocidosorex* sp. was registered in the Sihong Fauna (MN4) (Li *et al.*, 1983; Qiu and Qiu, 1995; Storch *et al.*, 1998). In addition, Soricidae indet. were identified in the Gashunyinadege Fauna, which is similar in geological age to the Sihong Fauna (Qiu and Wang, 1999).

From a number of Early Miocene (MN1–MN3) localities of Anatolia (Turkey), the heterosoricine *Dinosorex anatolicus* Hoek Ostende, 1995, the crocidosoricines *Oligosorex reumeri* Hoek Ostende, 2001 and *Oligosorex* cf. *reumeri*, and several forms of Soricidae indet. were described (Bruijn *et al.*, 1992; Hoek Ostende, 1995, 2001).

In essence, this is a complete list of the Early Miocene Soricidae from Asia. At the same time, in the Early Miocene of Europe, the Soricidae were rather diverse and abundant (Ziegler, 1989, 1997; Rzebik-Kowalska, 1997, 1998; Hoek Ostende, 2001). They were represented by two genera of the subfamily Heterosoricinae (*Dinosorex* and *Heterosorex*), at least nine genera of the Crocidosoricinae (*Ulmensia*, *Oligosorex*, *Crocidosorex*, *Clapasorex*, *Carposorex*, *Miosorex*,

Soricella, *Florinia*, and *Lartetium*), and the earliest Allosoricinae (*Paenelimnoecus* and *Allosorex*) and Soricinae (*Hemisorex*, beginning with MN4).

The present paper describes new Early Miocene Soricidae from Kazakhstan. The material comes from two localities, Altynshokysu (North Aral Region, collected by A.V. Lopatin in 1992 and 1993 and by H. de Bruijn, G. Daxner-Höck, T. Bolliger, and D. Kälin in 1994) and Ayaguz (Semipalatinsk Region, eastern Kazakhstan, collected by N.S. Shevyreva and V.M. Chkhikvadze in 1980). The first locality is dated as the beginning of the Aquitanian, MN1 (Lopatin, 1996, 1998, 2000) or MN0–MN1 (Lopatin, 2002a), while the second is dated as the boundary between the Aquitanian and Burdigalian, MN3/MN4 (Zzhigin and Lopatin, 2000; Lopatin and Zzhigin, 2003) or MN3b (Lopatin, 2002a).

When describing the structural elements of dentition, I used the terminology proposed by van den Hoek Ostende (2001) with slight modifications.

The following abbreviations are used in this study: (DK) private collection by D. Kälin, Balsthal, Switzerland; (IAUU) Institute of Earth Sciences, Utrecht University; (NMV) Natural Historical Museum of Vienna, Austria; (PIN) Paleontological Institute of the Russian Academy of Sciences, Moscow; and (PIUZ) Paleontological Institute of Zurich University, Switzerland.

SYSTEMATIC PALEONTOLOGY

Family Soricidae Fischer, 1817

Subfamily Crocidosoricinae Reumer, 1987

Crocidosoricinae: Reumer, 1987, p. 190.

Type genus. *Crocidosorex* Kretzoi, 1959, Lower Miocene of Europe.

Diagnosis (after Reumer, 1987, 1994, 1998, modified). I¹ nonfissident and lacking medial cuspule. I₁ bicuspluate, relatively small, and short; posterolabial extension small or absent; longitudinal axes of crown and root nonparallel, positioned at angle to each other. Three to five (occasionally, two) nondifferentiated lower antemolars present; dental formula 1.2–5.1.3. P₄ shaped into tetrahedron, posterocristid V- or Y-shaped, lingual arm occasionally reduced, posterior groove or sulcus present. Postcristid of M₃ connected to entoconid. Articular condyle of lower jaw small, its articular surface only slightly divided into two facets, masseteric fossa absent, and internal temporal fossa pocketed.

Composition. Two tribes, Oligosoricini Gureev, 1971 and Crocidosoricini Reumer, 1987.

Comparison. The subfamily Crocidosoricinae differs from the Soricolestinae Lopatin, 2002 in the nondifferentiated lower antemolars and the structure of P₄, M₃, and ascending ramus of the lower jaw. It differs from the Heterosoricinae Viret et Zapfe, 1951 in the absence of masseteric fossa and the presence of pocketed internal temporal fossa, and in the structure of I¹. It differs from the Soricinae Fischer, 1817, Crocidurinae Milne-Edwards, 1868, Limnoecinae Repenning, 1967, and Allosoricinae Fejfar, 1966 in the structure of incisors and, as a rule, the larger number of lower antemolars; in addition, it differs from the Soricinae and Limnoecinae in the structure of P₄ and from the Soricinae in the less pronounced division of the articular facets of the mandibular condyle.

Remarks. In a recent review of mammalian taxa above the species level (McKenna and Bell, 1997), the majority of genera that are usually assigned to the Crocidosoricinae are transferred to the Soricinae and placed in the tribe Soricini, while *Soricella* and *Miosorex* are included in the Crocidurinae, according to Repenning (1967). In actual fact, among the extinct Soricidae, clear morphological distinctions are observed in the archaic Eocene Soricolestinae (Lopatin, 2002b); the Heterosoricinae, which combine primitive and advanced characters (Viret and Zapfe, 1951); and the Allosoricinae and Limnoecinae, which display special ways of evolution (Reumer, 1998). Among Holocene, Pleistocene, and Late Neogene taxa, well-pronounced distinctions are observed in the Soricinae (and tribes included in this subfamily) and Crocidurinae. Judging from the combination of plesiomorphic characters, Oligocene and Miocene shrews assigned to the Crocidosoricinae may be ancestors of all post-Paleogene Soricidae (Reumer, 1987), excluding the Heterosoricinae. Some researchers believe that the Pleistocene–Recent African genus *Myosorex* belongs to this subfamily (see, e.g., Reumer, 1994; Hoek Ostende, 2001).

Tribe Oligosoricini Gureev, 1971

Oligosoricini: Gureev, 1971, p. 66; 1979, p. 318.

Type genus. *Oligosorex* Kretzoi, 1959, Upper Oligocene–Lower Miocene of Europe and western Asia.

Diagnosis. Both arms of posterocristid of P₄ well-developed. Ectocingulid of M₁ and M₂ present.

Generic composition. *Oligosorex* Kretzoi, 1959, Upper Oligocene–Lower Miocene of Europe and Lower Miocene of Turkey; *Srinitium* Huguency, 1976, Lower Oligocene; *Ulmensia* Ziegler, 1989, Upper Oligocene–Lower Miocene of Europe; *Clapasorex* Crochet, 1975, *Soricella* Doben-Florin, 1964, and *Carposorex* Crochet, 1975, Lower Miocene of Europe; *Lartetium* Ziegler, 1989, Lower–Middle Miocene of Europe; and *Miosorex* Kretzoi, 1959 and *Florinia* Ziegler, 1989, Lower Miocene–bottom of the Upper Miocene of Europe.

Comparison. The tribe is distinguished from Crocidosoricini by the presence of the lingual arm of the posterocristid of P₄ and the ectocingulid of M₁ and M₂.

Genus *Aralosorex* Lopatin, gen. nov.

Etymology. From the Aral Sea.

Type species. *A. kalini* sp. nov.

Diagnosis. P⁴ with strongly projecting parastyle. Entocingulum of M¹ and M² weakly developed. P₄ with two long arms of posterocristid, labial arm reaching postcingulid; posterolingual basin present. On M₁ and M₂, posterolabial edge of protoconid forming clear crest in lower part (posterolabial crest of protoconid), which connected to posterior portion of ectocingulid on level with bottom of hypoflexid; ectocingulid broken on level with anterior edge of hypoflexid or continuous. Talonid of M₃ relatively long and having two reduced cusps and closed basin. Enamel smooth. Mental foramen located under P₄.

Composition. Type species.

Comparison. The new genus differs from all known genera of the tribe Oligosoricini in the structure of P₄, i.e., the presence of connection between the labial arm of the posterocristid and the postcingulid, which forms the posterolingual basin. In addition, it differs from all Oligosoricini, except for *Carposorex*, in the structure of M₁ and M₂ where the posterolabial crest of the protoconid is connected to the ectocingulid. In addition, it differs from *Clapasorex* in the absence of clear entocingulum on M¹ and M² and a more strongly projecting parastyle of P⁴. It differs from *Soricella* and *Florinia* in the more anterior position of the mental foramen and from *Florinia* and *Miosorex* in the less reduced talonid of M₃. It differs from *Carposorex* in the more strongly developed parastyle of P⁴ and the better developed arms of the posterocristid of P₄. In addition, the enamel on the lower teeth of *Aralosorex* is smooth, i.e., lacking fine wrinkles, which are characteristic of *Carposorex*.

Aralosorex kalini Lopatin, sp. nov.

Etymology. Named in honor of the Swiss paleontologist D. Kälin.

H o l o t y p e. PIN, no. 4516/600, right dentary fragment with M_2 and M_3 ; western Kazakhstan, North Aral Region, Altynshokysu locality; Lower Miocene, Aral Formation, bone-bearing level 2.

Description (Figs. 1–3). A small-sized shrew. I^1 is slightly elongated. The anterior edge of the crown is convex, the apex strongly curves posteriorly; therefore, the apex of the incisor is positioned at an acute angle to the talon. The posterior cuspule is small and weakly forked. A clear labial cingulum is present.

The material examined includes an isolated upper intermediate antemolar designated as A^x . It is very small, circular in occlusal view, and has a low conical central cuspule and a stout and broad cingulum on the lateral sides of the crown base. The longitudinal crest is well-pronounced. The entocingulum is connected to the base of the posterior side of the central cuspule.

P^4 has strongly projecting styles, a weakly concave anterior side, and a strongly concave posterior side. The angle between the labial and lingual sides is approximately 50° . The paracone is slightly displaced anteriorly from the crown center. The parastyle is small and looks like an elongated anterior process. The protocone is low and small and connected to the parastyle by a clear crest of the preprotocrista. The metastyle is large, strongly projects posteriorly, and is connected to the paracone by a wide crest of the posterocrista. The hypoconal flange is flattened and strongly juts out posteriorly. Its lingual side is bordered by a narrow crest extending from the protocone base. The hypoconal flange lacks a cusp. The postcingulum is stout at the level of the metastyle and paracone and becomes substantially narrower at the level of the hypoconal flange.

In M^1 , the metastyle and the posterior part of the hypocone strongly project. The posterior side is strongly concave. The parastyle and mesostyle are clearly differentiated, the mesostyle does not bifurcate. The metacone is substantially larger than the paracone and is somewhat displaced lingually with reference to the latter. The crests of the paracrista, centrocrista, and metacrista are well-developed. The protocone is located substantially more labially than the hypocone, the well-developed crests of the preprotocrista and postprotocrista are present. The preprotocrista (the anterior arm of the protocone) terminates at the base of the anterolingual projection of the paracone, while the postprotocrista (metaloph) turns toward the hypocone at a large distance from the lingual wall of the metacone. The hypocone is very small and isolated from the protocone by a narrow and deep valley, which is occasionally bounded posterolingually by a very weak entocingulum. A long crest deviates from the posterior region of the hypocone, forms the posterolingual projection of the crown, and, labially, becomes a wide postcingulum.

M^2 is similar in structure to M^1 ; however, it is smaller, more symmetrical (the metastyle and the hypo-

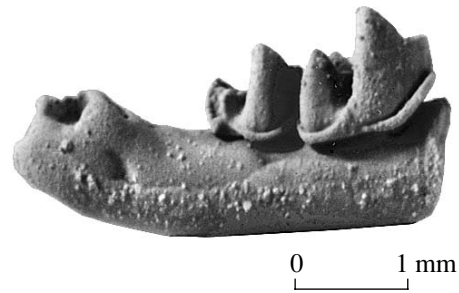


Fig. 1. *Aralosorex kalini* sp. nov., holotype PIN, no. 4516/600, fragment of the right dentary with M_2 and M_3 .

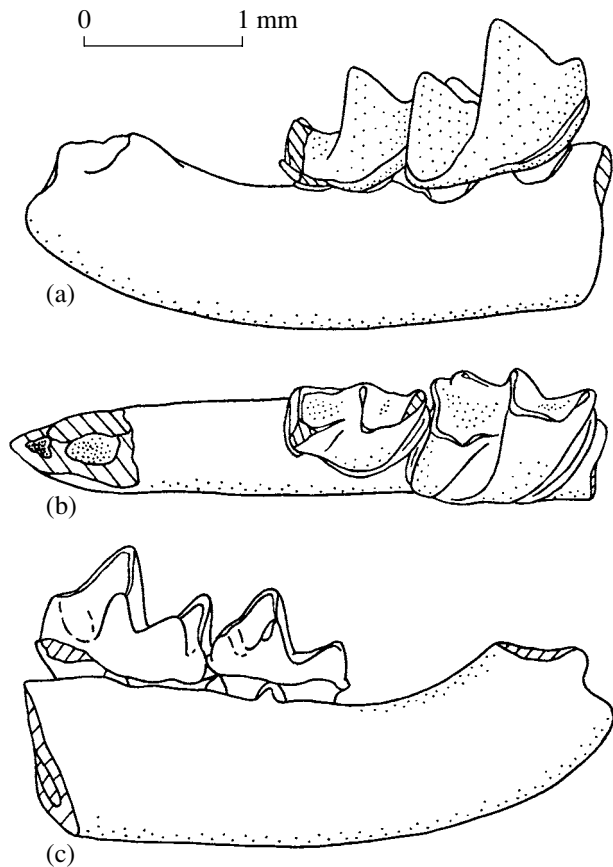


Fig. 2. *Aralosorex kalini* sp. nov., holotype PIN, no. 4516/600, fragment of the right dentary with M_2 and M_3 : (a) labial view, (b) occlusal view, and (c) lingual view.

cone are elongated to a lesser extent), and its hypocone is relatively weakly developed. M^3 is absent among the specimens under study.

The horizontal mandibular ramus is low (Fig. 2). Its lower edge is straight. The mental foramen is located under P_4 . The pocket of the external temporal fossa extends to the level of the molar bases. The mandibular foramen is somewhat above the alveolar edge.

I_1 is relatively narrow and slightly curved. Its apex is weakly elevated. Its denticles are weakly developed,

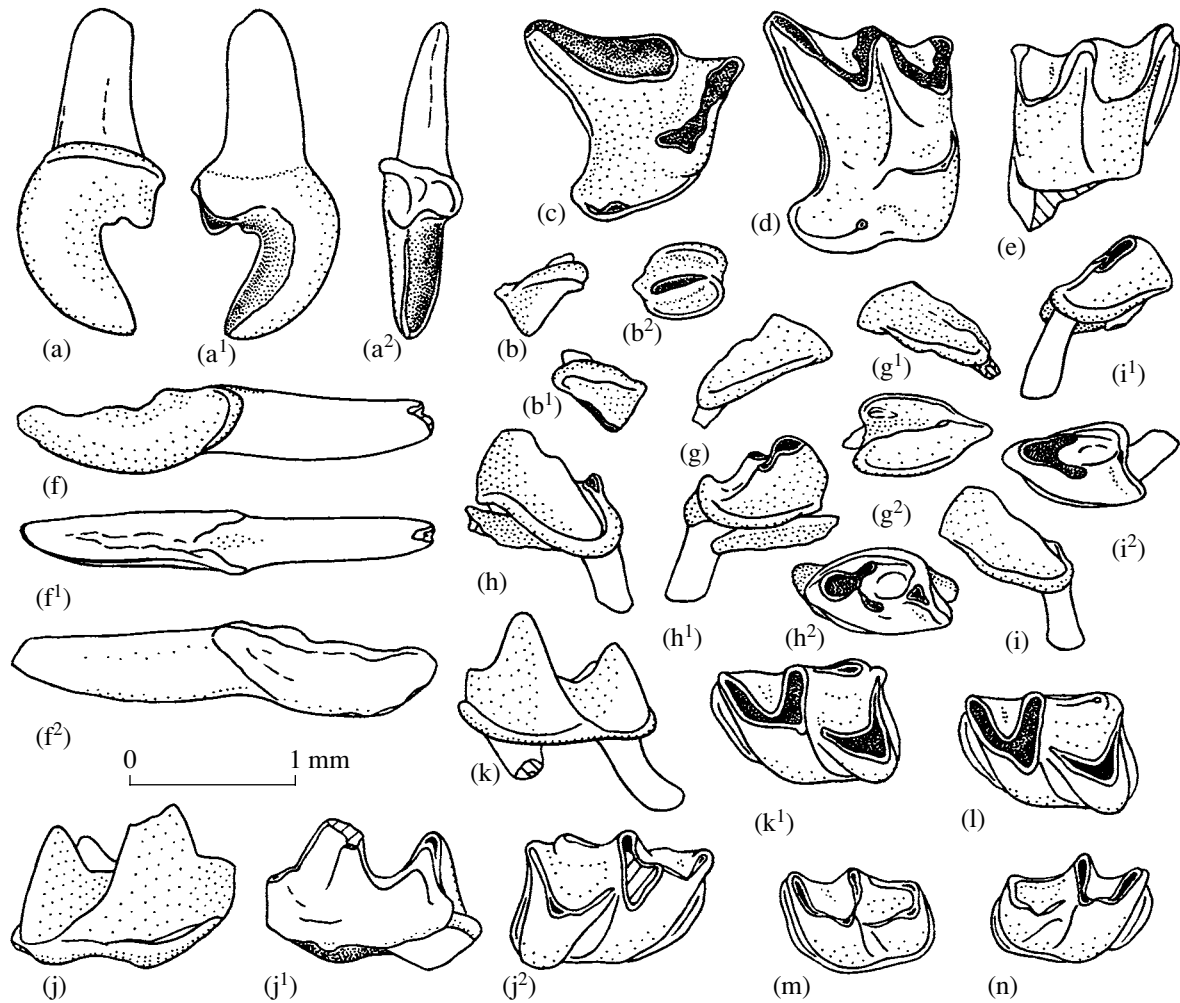


Fig. 3. *Aralosorex kalini* sp. nov.: (a–a²) specimen PIN, no. 4516/596, left I¹: (a) labial view, (a¹) lingual view, (a²) behind; (b–b²) specimen PIN, no. 4516/603, left A^x: (b) labial view, (b¹) lingual view, (b²) occlusal view; (c) specimen PIN, no. 4516/597, right P⁴; (d) specimen PIN, no. 4516/598, right M¹; (e) specimen PIN, no. 4516/599, left M²; (f–f²) specimen PIN, no. 4516/601, left I₁: (f) labial view, (f¹) occlusal view, (f²) lingual view; (g–g²) specimen PIN, no. 4516/602, right A₁: (g) labial view, (g¹) lingual view, (g²) occlusal view; (h–h²) specimen PIN, no. 4516/604, left P₄: (h) labial view, (h¹) lingual view, (h²) occlusal view; (i–i²) specimen PIN, no. 4516/606, left P₄: (i) labial view, (i¹) lingual view, (i²) occlusal view; (j–j²) specimen PIUZ, ALT no. 264, right M₁: (j) labial view, (j¹) lingual view, (j²) occlusal view; (k, k¹) specimen PIN, no. 4516/605, left M₂: (k) labial view, (k¹) occlusal view; (l) specimen PIUZ, ALT no. 265, left M₂; (m) specimen PIUZ, ALT no. 266, left M₃; (n) specimen PIUZ, ALT no. 267, right M₃.

the posterior denticle is more distinct than the anterior denticle. The crown base has a labial cingulid. The lingual edge of the crown is sharpened. The root weakly ventrally curves with reference to the longitudinal axis of the crown.

The number of lower intermediate antemolars is not known with certainty. The material under study includes only one isolated lower antemolar; this is presumably A₁ (Figs. 3g–3g²). This tooth is approximately equal in length to P₄; however, it is much lower. The crown of A₁ is elongated cordate and has a deep posterior fold. The central cusp is low and strongly transversely compressed. It gives rise to a longitudinal crest

that has a small posterior cuspsule (Fig. 3g). The stout lateral cingulids are well-developed. The ectocingulid is connected to the longitudinal crest in the posterolabial corner of the crown. A small supplementary cuspsule occupies an isolated position on the posterolingual projection (Figs. 3g¹, 3g²). One P₄ is preserved in articulation with a small bone fragment, which closely joins the tooth base in the region of the anterior root (Figs. 3h, 3h¹). This suggests that the posterior single-rooted antemolar located anterior to P₄ was not reduced to a diminutive tooth positioned under the anterior region of the crown base of P₄; on the contrary, it was relatively large and well-differentiated.

The crown of P_4 is relatively high and rounded triangular in occlusal view, its anterior end is pointed. The posterior edge of the crown has a superficial depression. The lateral sides are slightly convex, the labial part is longer than the lingual part and projects posteriorly to a substantially greater extent. The cingulid is well-developed on the lateral and posterior sides of the crown base. The protoconid is located in the anterior region of the crown. Two arms of the posterocristid extend posteriorly from the protoconid and form a Y-shaped border of the posterolingual basin. Each arm is connected to a small supplementary cusplule. The lingual arm terminates at the protoconid base, while the labial arm adjoins the central area of the postcingulid. Thus, the posterolingual basin is labially closed and posterolingually open.

M_1 is somewhat larger than M_2 . The precingulid and the postcingulid are well-developed and wide. The ectocingulid is narrow and well-pronounced throughout its extent (Figs. 3j, 3k) or broken in line with the anterior region of the hypoflexid (Fig. 2a). The entocingulid is only developed along the trigonid basin. A distinct posterolabial crest of the protoconid is connected to the ectocingulid on a level with the hypoflexid or the anterior region of the hypoconid. The hypoflexid is very deep and extends to the level of the ectocingulid. The trigonid is slightly longer than the talonid, while the talonid is somewhat wider than the trigonid. The paracristid is relatively low. The paracristid is anterolingually curved and has a clear notch. The trigonid basin is relatively deep. The protoconid and the metaconid are positioned close to one another, the metaconid is substantially smaller than the protoconid. The talonid basin is deep and closed. The hypoconid is substantially larger than the entoconid. The cristid oblique rests against the posterior wall of the protoconid. The clearly pronounced entocristid is higher than the cristid oblique. The postcristid (hypolophid) is free. The entostylid is small. M_2 is similar in structure to M_1 and differs in the smaller length, shorter trigonid, and more widely spaced protoconid and metaconid.

M_3 is characterized by small dimensions and a narrow talonid. Its talonid is slightly inferior in length to the trigonid. The hypoconid and entoconid are strongly reduced. The talonid basin is bordered posteriorly, labially, and lingually by low crests, i.e., the complete postcristid, cristid oblique, and entocristid, respectively (Figs. 2b, 3m, 3n). The cristid oblique terminates at the base of the posterior wall of the trigonid on a level with the notch of the postcristid. The entostylid is absent. The crown base is bordered anteriorly, labially, and posteriorly by cingulids; lingually, it is also bordered opposite the trigonid basin.

Measurements, mm. Holotype: M_2 (length \times width), 1.15×0.75 ; M_3 (length \times trigonid width–talonid width), $0.95 \times 0.6–0.45$; lingual depth of the horizontal mandibular ramus under M_2 , 1.05; under M_3 , 1.05.

Incisors (height \times length, n —sample size, Δ —mean value): I^1 ($n = 7$), $1.0–1.1 \times 0.75–0.9$ ($\Delta = 1.05 \times 0.84$); I_1 (specimen PIN, no. 4516/601), 1.35×0.6 .

Antemolars (length \times width): A^x (specimen PIN, no. 4516/603), 0.55×0.45 ; A_1 (specimen PIN, no. 4516/602), 0.9×0.6 .

Cheek teeth (length \times width): P^4 (specimen PIN, no. 4516/597), 1.3×1.15 ; M^1 ($n = 4$), $1.15–1.2 \times 1.4–1.5$ ($\Delta = 1.175 \times 1.45$); M^2 (specimen PIN, no. 4516/599), $1.1 \times ?$; P_4 ($n = 2$), $0.9–0.95 \times 0.5$; M_1 ($n = 6$), $1.15–1.23 \times 0.7–0.8$ ($\Delta = 1.19 \times 0.72$); M_2 ($n = 5$), $1.05–1.15 \times 0.65–0.75$ ($\Delta = 1.12 \times 0.7$); M_3 ($n = 5$), $0.95–1.0 \times 0.55–0.6$ ($\Delta = 0.97 \times 0.58$).

Material. In addition to the holotype, six lower jaw fragments and 45 isolated teeth and tooth fragments from bone-bearing level 2 of the Altynshokysu locality: isolated I^1 , A^x , P^4 , M^1 , M^2 , I_1 , A_1 , two P_4 , and M_2 stored at the PIN; three dentary fragments (two with M_2 and one with M_3), I^1 , three P^4 , five M^1 , two M^2 , M_1 , M_2 , and two M_3 stored at the PIUZ; two lower jaw fragments without teeth, two upper incisors, two M_1 , two M_2 , and M_3 stored at the IAUU; a dentary fragment without teeth, four I^1 , M^1 , three M_1 , and M_2 stored at the NMW; and M^1 , two M^2 , and three M_2 stored at the DK.

Tribe Crocidosoricini Reumer, 1987

Crocidosoricinae: Reumer, 1987, p. 190.

Type genus. *Crocidosorex* Lavocat, 1951, Lower Miocene of Europe.

Diagnosis. Lingual arm of posterocristid of P_4 absent. M_1 and M_2 lacking ectocingulid.

Composition. *Crocidosorex* Lavocat, 1951 and, presumably, *Miocrocidosorex* gen. nov.

Comparison. The tribe in question differs from the tribe Oligosoricini in the absence of the lingual arm of the posterocristid of P_4 and the ectocingulid of M_1 and M_2 .

Genus *Miocrocidosorex* Lopatin, gen. nov.

Etymology. From the generic names *Miosorex* and *Crocidosorex*.

Type species. *M. zzhigini* sp. nov.

Diagnosis. Formula of lower dentition 1.2.1.3. Talonid of M_3 reduced, with very small and narrow basin. Mental foramen located under trigonid of M_1 .

Composition. Type species.

Comparison. The new genus differs from *Crocidosorex* in the strongly reduced talonid of M_3 and the more posterior position of the mental foramen.

Remarks. The structure of P_4 in *Miocrocidosorex* is not known; therefore, this genus is only tentatively assigned to the tribe Crocidosoricini. In addition, the number of antemolars in *Crocidosorex* is also unknown. The assignment of *Miocrocidosorex* to the tribe Crocidosoricini is supported by the absence of



Fig. 4. *Miocrocidosorex zashigini* sp. nov., holotype PIN, no. 4051/151, fragment of the left dentary with M_1 – M_3 and alveoli I_1 , A_1 , A_2 , and P_4 .

ectocingulids on M_1 and M_2 ; this character is extremely rarely observed in the Crocidosoricinae; previously, it was only registered in *Crocidosorex piveteaui* (Lavocat, 1951). In any event, the set of specific characters (the absence of the ectocingulid on M_1 and M_2 , the extent to which the talonid of M_3 is reduced, and the position of the mental foramen) allows one to assign this shrew to a separate genus of the subfamily Crocidosoricinae. *Miocrocidosorex* is characterized by a reduced dental formula, only two antemolars are retained between I_1 and P_4 , as is observed in some other

Miocene Crocidosoricinae, such as *Miosorex*, *Soricella*, and *Florinia*. M_3 of *Miocrocidosorex* is reduced more strongly than that of other genera of the subfamily Crocidosoricinae, except for *Florinia*; a distinction from M_3 of *Florinia* is the closed talonid basin.

Miocrocidosorex zashigini Lopatin, sp. nov.

Etymology. Named in honor of the Russian paleotheriologist V.S. Zashigin.

Holotype. PIN, no. 4051/151, dentary fragment with M_1 and M_3 and alveoli of I_1 , A_1 , A_2 , and P_4 ; eastern Kazakhstan, Semipalatinsk Region, Ayaguz locality; Lower Miocene, strata of greenish sandy clays.

Description (Figs. 4, 5). A medium-sized shrew. The horizontal mandibular ramus is relatively deep. Its lower edge is straight and becomes weakly concave only under the anterior region of M_2 . The mental foramen is located under the trigonid of M_1 . The pocket of the external temporal fossa is well-developed and extends to the level of the alveolar edge. The mandibular foramen is also located at the alveolar level. The posterior edge of the alveolus of I_1 reaches the paraconid of M_1 .

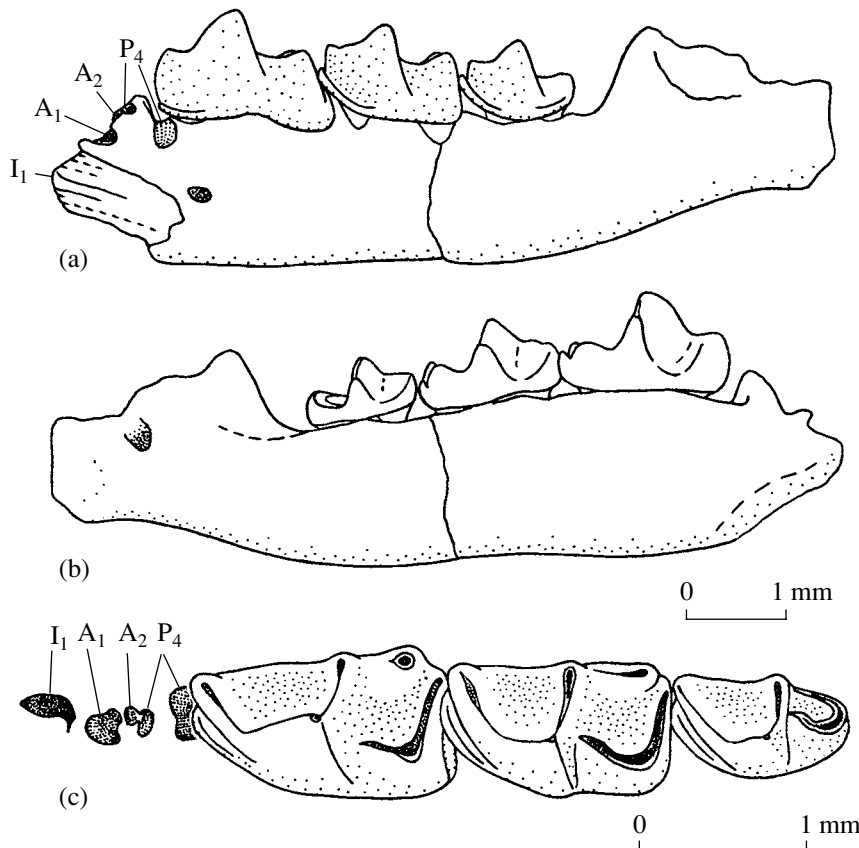


Fig. 5. *Miocrocidosorex zashigini* sp. nov., holotype PIN, no. 4051/151, fragment of the left dentary with M_1 – M_3 and alveoli I_1 , A_1 , A_2 , and P_4 : (a) labial view, (b) lingual view, (c) M_1 – M_3 , and alveoli of I_1 – P_4 , occlusal view.

Judging from the alveoli (Fig. 5), the jaw contained two small single-rooted antemolars and a small double-rooted P_4 ; A_2 was extremely strongly reduced and located under the base of the anterior region of P_4 .

M_1 is substantially larger than M_2 . The precingulid is weak, the entocingulid is developed only opposite to the trigonid basin. The hypoflexid is small, a hardly visible enamel eminence (probably, a rudimentary ectocingulid) is present under it. The trigonid is substantially longer than the talonid, while the talonid is slightly wider than the trigonid. The paraconid is relatively small; the paracristid is short, longitudinally extended, and has a distinct notch. The trigonid basin is shallow. The protoconid and metaconid are positioned close to one another, the protocristid is short. The talonid basin is relatively small and closed. The entoconid is stout and the entocristid is short. The cristid oblique is connected to the base of the posterior wall of the protoconid. The postcristid is free and the entostylid is small. The postcingulid is narrow and clearly pronounced.

M_2 is similar in structure to M_1 ; however, it differs in the smaller dimensions; more widely spaced protoconid and metaconid; and the longer paracristid, protocristid, and entocristid. The precingulid is well-developed, while the postcingulid is poorly pronounced or absent.

M_3 is small and narrow and has a reduced talonid, which is almost half as long as the trigonid. The structure of the trigonid is similar to that of M_2 . The talonid basin is shallow and narrow, the hypoconid and entoconid are strongly reduced. The entostylid and postcingulid are absent. A weak ectocingulid is located under the hypoflexid. In a strongly worn tooth, the lingual cusps and the trigonid and talonid basins disappear.

Measurements, mm. Holotype: length of M_1 – M_3 , 4.0; length of M_1 – M_2 , 2.95; tooth dimensions (length \times width): M_1 , 1.65 \times 1.0; M_2 , 1.45 \times 0.9; M_3 (length \times trigonid width–talonid width), 1.1 \times 0.6–0.5; lingual depth of the horizontal mandibular ramus under M_1 , 1.6; under M_2 , 1.55; and under M_3 , 1.5.

Specimen PIN, no. 4051/152: length of M_1 – M_2 , 2.8; dimensions: M_1 , 1.65 \times 0.95; M_2 , 1.3 \times 0.8; and the lingual depth of the horizontal mandibular ramus under M_2 , 1.3. Specimen PIN, no. 4051/153: length of M_3 , 0.95; and the lingual depth of the horizontal mandibular ramus under M_3 , 1.15.

Material. In addition to the holotype, two dentary fragments (one with M_1 and M_2 and one with a strongly worn M_3) from the type locality.

DISCUSSION

The subfamily Crocidosoricinae appeared in Europe at the beginning of the Oligocene (*Srinitium*) and became abundant at the end of the Oligocene (*Oligosorex* and *Ulmensia*) and, especially, in the Early Miocene (*Ulmensia*, *Oligosorex*, *Carposorex*, *Croci-*

dosorex, *Clapasorex*, *Soricella*, *Florinia*, *Miosorex*, and *Lartetium*). *Miosorex* and *Lartetium* persisted to the Middle Miocene (Rzebik-Kowalska, 1998). *Miosorex* and *Florinia* were found at the bottom of the Upper Miocene (Rzebik-Kowalska, 1998; Mészáros, 1999). By the end of the Late Miocene, the Crocidosoricinae had become extinct almost everywhere. Questionable finds of later crocidosoricines were reported from the Pliocene of Italy and included *Lartetium dehmi* (Viret et Zapfe, 1951) from Gargano (Giuli et al., 1987; Rzebik-Kowalska, 1997).

In a previous study (Lopatin, 1999), I informed about a new crocidosoricine (Crocidosoricinae gen.) from the Early Miocene Aral Faunal Assemblage (Kazakhstan) that is similar to both *Crocidosorex* (*Oligosorex* sensu Hoek Ostende, 2001) and *Carposorex* and probably belongs to a new genus. This is *Aralosorex kalini* gen. et sp. nov. described above. It is similar to *Oligosorex* in the structure of the posterocristid arms of P_4 , which are better developed than those of *Carposorex*. On the other hand, the new genus has such a characteristic feature of *Carposorex* as the presence of contact between the posterolabial crest of the protoconid and the ectocingulid of M_1 and M_2 on a level with the bottom of the hypoflexid. Apparently, *Aralosorex* is closely related phylogenetically to *Carposorex*.

The genus *Carposorex* established by Crochet (1975) is known as the type species *C. sylviae* Crochet, 1975 (= *Crocidosorex* sp. sensu Baudelot, 1972) from the Late Aquitanian Laugnac locality (MN2b) in France and several Early Miocene forms from France (Paulhiac, MN1, and La Brète, MN2) and Germany (Stubersheim 3, MN3–MN4), which were identified as *Carposorex* sp. (Crochet, 1975; Ziegler, 1989; Rzebik-Kowalska, 1998). *Carposorex* sp. from Stubersheim differs from *C. sylviae* in the structure of M_1 , i.e., the smooth enamel, continuous ectocingulid, and less pronounced labial arm of the posterocristid (Ziegler, 1989). In the first two characters, it is similar to *Aralosorex kalini*.

Crochet indicated that *Carposorex* and *Crocidosorex* (including *Oligosorex*) display a special structure of P_4 ; this allows one to combine these genera in a separate subfamily of the family Soricidae, which also includes the Heterosoricinae, Crocidurinae, Soricinae, and Limnoecinae (Crochet, 1975, p. 650). However, Crochet believed that structural features of P_4 in the above listed genera possibly display their primitive state in the Soricinae; therefore, he did not establish this new group. Reumer (1987) formally established the subfamily Crocidosoricinae and included the genera *Crocidosorex*, *Oligosorex*, *Miosorex*, *Soricella*, *Clapasorex*, *Carposorex*, and *Srinitium* in its composition.

In addition to the type species *C. piveteaui* Lavocat, 1951, Crochet included two closely related species, *C. antiquus* (Pomel, 1853) (type species of *Oligosorex*) and *C. thauensis* Crochet, 1975, in the genus *Crocidosorex*. *Oligosorex* is commonly considered to be a

junior synonym of *Crocidosorex* (Crochet, 1975; Ziegler, 1989; Reumer, 1998; Rzebik-Kowalska, 1998; etc.). The majority of supporters of this point of view follow the opinion of Repenning (1967), which was only based on the similarity of the original diagnoses of these genera (Lavocat, 1951; Kretzoi, 1959). Other researchers considered *Oligosorex* to be a separate genus (Baudelot, 1972; Huguenev, 1974; Gibert, 1975; Gureev, 1971, 1979). Recently, Hoek Ostende (2001) has convincingly demonstrated the presence of substantial differences between these genera and restricted the composition of *Crocidosorex* to the type species. In this species, the lower molars lack ectocingulids and the structure of P₄ is aberrant to crocidosoricines. Hoek Ostende indicates that proper *Crocidosorex* (in contrast to *Oligosorex*) differs from the other genera of the subfamily Crocidosoricinae in the structure of the posterocristid of P₄; consequently, it may belong to a separate group; this would result in a certain taxonomic problem. However, it is impossible to examine other distinctive features of the Crocidosoricinae on the basis of available material on *C. piveteaui*; therefore, Hoek Ostende recommends retaining *Crocidosorex* in the composition of this subfamily.

At the same time, the name Crocidosoricinae Reumer, 1987 is a family-group taxon that has a senior synonym, Oligosoricini Gureev, 1971 (Gureev, 1971, 1979). Gureev established the tribe Oligosoricini to combine the genera *Oligosorex*, *Crocidosorex*, *Miosorex*, *Soricella*, *Gobisorex*, *Domnina*, *Paradomnina*, *Quercysorex* (= *Amphisorex*: Gureev, 1979), *Alluvisorex*, and *Angustidens*. Currently, the first four genera are assigned to the subfamily Crocidosoricinae; the subsequent four are assigned to the Heterosoricinae, *Alluvisorex* is placed in the Soricinae, and *Angustidens* is placed in the Limnoecinae (Reumer, 1998). Therefore, the name Oligosoricini has not received wide acceptance, since this is obviously an artificial group. It is worth noting that, although Oligosoricini is the senior name, there is no need to replace the term Crocidosoricinae by Oligosoricinae if the subfamily is considered to include two tribes, Oligosoricini and Crocidosoricini (this statement is substantiated above). This case falls under Article 35.5 of the *International Code of Zoological Nomenclature* (1999, p. 44), which reads as follows: "If, after 1999, a name in use for a family-group taxon (e.g., for a subfamily) is found to be older than a name in prevailing usage for a taxon of higher rank in the same family group (e.g., for the family within which the older name is the name of a subfamily), the older name is not to displace the younger name."

The new soricid taxa described above from two beds of different ages of the Lower Miocene of Kazakhstan give only preliminary data on the morphological and taxonomic diversity of the Early Miocene Asian Crocidosoricinae. However, these data allow one to make certain conclusions concerning the Oligocene–Miocene stage of Soricidae evolution. In particular, *Aralosorex* is similar in the structure of P₄ to both *Oli-*

gosorex and the Soricinae; this is evidence for the presence of the so-called soricine morphotype of P₄ (Repenning, 1967; Reumer, 1987), at least, a primitive state of this morphotype, in the Oligocene–Miocene Crocidosoricinae from Asia. This suggests that the subfamily Soricinae appeared in Asia in the Late Oligocene or at the Oligocene–Miocene boundary.

ACKNOWLEDGMENTS

I am grateful to V.S. Zazhigin (Geological Institute of the Russian Academy of Sciences) and A.K. Agadjanian (Paleontological Institute of the Russian Academy of Sciences) for useful discussions about the morphology and evolution of the Soricidae, and to H. de Bruijn (Utrecht, Netherlands), G. Daxner-Höck (Vienna, Austria), T. Bolliger (Zurich, Switzerland), and D. Kälin (Basel, Switzerland) for placing materials at my disposal.

This study was supported by the Russian Foundation for Basic Research, project nos. 00-15-97754, 01-05-65448, 02-04-48458, and 02-04-06299.

REFERENCES

1. S. Baudelot, These Univ. Toulouse, No. 496, 1 (1972).
2. O. G. Bendukidze, *Small Mammals from the Miocene of Southwestern Kazakhstan and Turgay* (Metsniereba, Tbilisi, 1993) [in Russian].
3. J.-Y. Crochet, Coll. Int. CNRS, No. 218, 631 (1975).
4. J. Gibert, Proc. Kon. Nederl. Akad. Wetensch. **78** (2), 108 (1975).
5. C. de Giuli, F. Masini, D. Torre, and V. Boddi, Boll. Soc. Paleontol. Ital. **25**, 267 (1987).
6. A. A. Gureev, *Shrews (Soricidae) of the World Fauna* (Nauka, Leningrad, 1971) [in Russian].
7. A. A. Gureev, *Fauna of the USSR: Mammals*, Vol. 4, No. 2: *Insectivores (Mammalia, Insectivora): Hedgehogs, Moles, and Shrews (Erinaceidae, Talpidae, and Soricidae)* (Nauka, Leningrad, 1979) [in Russian].
8. L. W. van den Hoek Ostende, Proc. Kon. Nederl. Akad. Wetensch. **98** (1), 1 (1995).
9. L. W. van den Hoek Ostende, Scripta Geol., No. 122, 47 (2001).
10. M. Huguenev, in *Rev. Sci. Bourbonn.*, pp. 52–68 (1974).
11. *International Code of Zoological Nomenclature* (London, 1999), ed. 4.
12. E. G. Kordikova, Senkenb. Lethaea **80** (1), 67 (2000).
13. M. Kretzoi, Vertebr. Hung. **1** (2), 247 (1959).
14. R. Lavocat, *Revision de la faune de mammifères oligocène d'Auvergne et du Velay* (Sci. Avenir, Paris, 1951).
15. Ch. Li, Y. Lin, Y. Gu, *et al.*, Vertebr. Palasiat. **23** (4), 313 (1983).
16. A. V. Lopatin, Stratigr. Geol. Korrelyatsiya **4** (2), 65 (1996).
17. A. V. Lopatin, Paleontol. Zh. **39** (3), 77 (1998) [Paleontol. J. **39**, 307 (1998)].
18. A. V. Lopatin, Paleontol. Zh. **40** (2), 66 (1999) [Paleontol. J. **40**, 281 (1999)].

19. A. V. Lopatin, *Paleontol. Zh.* **41** (2), 81 (2000) [*Paleontol. J.* **41**, 311 (2000)].
20. A. V. Lopatin, in *Geology, Geochemistry, Geophysics at the Boundary of the 20th and 21st Centuries: Mat. All-Russ. Sci. Conf.*, Vol. 1: *Tectonics, Stratigraphy, and Lithology* (Svyaz'-Print, Moscow, 2002a), pp. 160–162 [in Russian].
21. A. V. Lopatin, *Paleontol. Zh.* **43** (6), 78 (2002b) [*Paleontol. J.* **43**, 599 (2002)].
22. A. V. Lopatin and V. S. Zazhigin, *Paleontol. Zh.* **44** (1), 64 (2003) [*Paleontol. J.* **44**, 61 (2003)].
23. M. C. McKenna and S. K. Bell, *Classification of Mammals above the Species Level* (Columbia Univ. Press, New York, 1997).
24. L. G. Mészáros, *Ann. Univ. Sci. Budapest, Sec. Geol.* **32**, 35 (1999).
25. Zh. D. Qiu and X. M. Wang, *Vertebr. Palasiat.* **37** (2), 120 (1999).
26. Zh. X. Qiu and Zh. D. Qiu, *Palaeogeogr. Palaeoclimatol. Palaeoecol.* **116**, 41 (1995).
27. Ch. A. Repenning, *Prof. Pap. US Geol. Surv.*, No. 565, 1 (1967).
28. J. W. F. Reumer, *Rev. Paleobiol.* **6** (2), 189 (1987).
29. J. W. F. Reumer, *Carnegie Mus. Natur. Hist., Spec. Publ.*, No. 18, 345 (1994).
30. J. W. F. Reumer, in *Evolution of Shrews*, Ed. by J. M. Wójcik and M. Wolsan (Publ. Mammal. Res. Inst., Białowieża, 1998), pp. 5–22.
31. B. Rzebik-Kowalska, *Mém. Trav. EPHE, Inst. Montpellier*, No. 21, 249 (1997).
32. B. Rzebik-Kowalska, in *Evolution of Shrews*, Ed. by J. M. Wójcik and M. Wolsan (Publ. Mammal. Res. Inst., Białowieża, 1998), pp. 23–92.
33. G. Storch, Zh. Qiu, and V. S. Zazhigin, in *Evolution of Shrews*, Ed. by J. M. Wójcik and M. Wolsan (Publ. Mammal. Res. Inst., Białowieża, 1998), pp. 93–120.
34. J. Viret and H. Zapfe, *Ecl. Geol. Helv.* **44** (2), 411 (1951).
35. V. S. Zazhigin and A. V. Lopatin, *Paleontol. Zh.* **41** (3), 90 (2000) [*Paleontol. J.* **41**, 310 (2000)].
36. R. Ziegler, *Stuttgarter Beitr. Naturk., Ser. B*, No. 154, 1 (1989).
37. R. Ziegler, *Ann. Naturhist. Mus. Wien* **99A**, 43 (1997).