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Asoriculus and *Neomys* (Mammalia, Soricidae) remains from the late Early Pleistocene Somssich Hill 2 locality (Villány Hills, Southern Hungary)

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Abstract – The present paper is the last part of the series describing the shrew genera identified from the late Early Pleistocene Somssich Hill 2 locality. Two species – *Asoriculus gibberodon* (Petényi, 1864) and *Neomys newtoni* Hinton, 1911 – are reported here with taxonomic descriptions and with summaries of their European records. The number of the shrew species of the locality increased to nine with these new ones. Mainly the water shrew (*Neomys*), but very likely *Asoriculus* (its probable ancestor) as well indicates the presence of open water body in the surroundings of the site. With 8 figures and 5 tables.

Key words – *Asoriculus gibberodon*, Early Pleistocene, *Neomys newtoni*, Somssich Hill, Soricidae

INTRODUCTION

The present article is the fourth part of the series published in this journal on the late Early Pleistocene Soricidae fauna of the Somssich Hill 2 locality, Villány Hills, Southern Hungary. Description of the locality and the history of the investigation of its fossil material are given by Botka & Mészáros (2014*b*; 2015*a*).

The fossil site was excavated by Dénes Jánossy (Jánossy 1983), and his material was elaborated by the cooperative research group of the Hungarian Academy of Sciences, the Hungarian Natural History Museum, and the Eötvös Loránd University (OTKA K104506, project leader: Piroska Pazonyi) in the Department of Palaeontology and Geology of the Hungarian Natural History Museum. Seven shrew species were mentioned by Botka & Mészáros (2014*a*) in a preliminary report on this material. These shrew specimens were described also in detail in the following articles: *Beremendia* (Botka & Mészáros 2014*b*, 2015*a*), *Crocidura* (Botka & Mészáros 2015*b*), and *Sorex* (Botka & Mészáros 2016). Ever since, two further species were identified from the shrew assemblage, which ones were mentioned only in preliminary faunal lists so far (Mészáros & Botka 2017, Pazonyi *et al.* 2017).

These two forms, *Asoriculus gibberodon* (Petényi, 1864) and *Neomys newtoni* Hinton, 1911, are present in this paper in detail, with their taxonomic, biostratigraphical, and palaeoecological implications. The European occurrences of the two species were summarized in two tables just like in the earlier published papers of this series.

MATERIAL AND METHODS

The 50 layers yielded only 7 *Asoriculus* and 42 *Neomys* remains. The studied material is stored in the Department of Palaeontology and Geology of the Hungarian Natural History Museum, Budapest. Abbreviations used in the descriptions and in the tables: I = incisor, A = antemolar, P = premolar, M = molar, M^x = upper tooth, M_x = lower tooth, L = length, W = width, H = height, BL = buccal length, LL = lingual length, AW = anterior width, PW = posterior width, n = number, min. = minimum, max. = maximum, SD = standard deviation, inv. n. = inventory number, spec. n. = number of specimens, teeth n. = number of teeth, MNI = minimum number of individuals. Morphological terms are used after Reumer (1984). Measurements are given in mm.

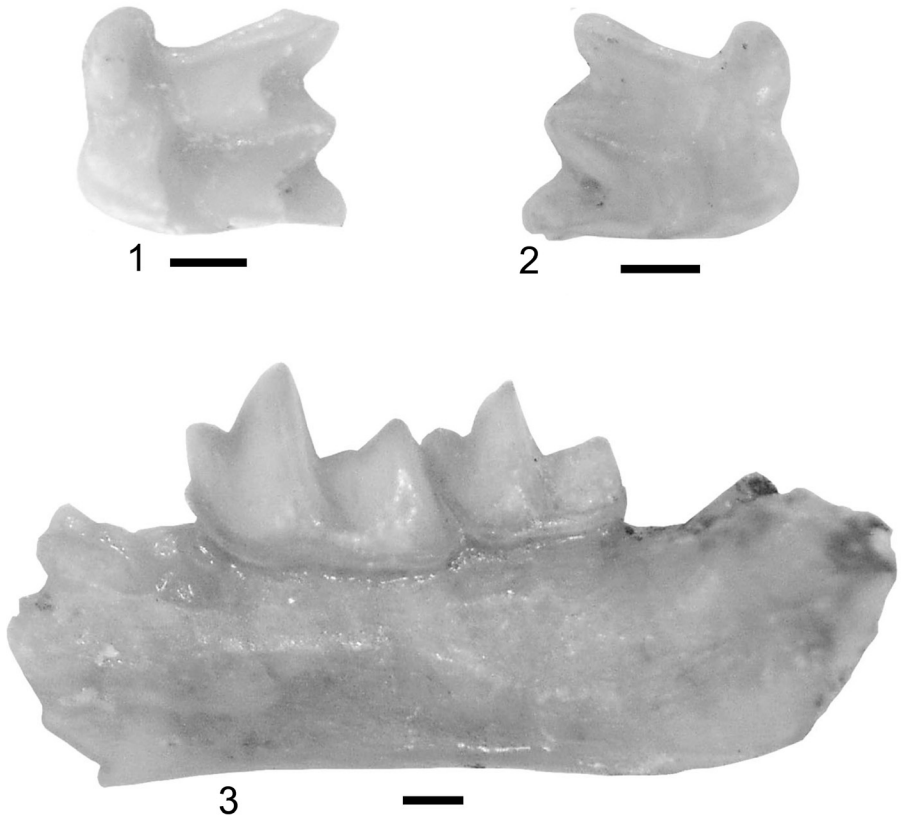
SYSTEMATIC DESCRIPTION

Phylum Vertebrata Linnaeus, 1758
Classis Mammalia Linnaeus, 1758
Order Eulipotyphla Waddell *et al.*, 1999
Family Soricidae Fischer von Waldheim, 1817
Subfamily Soricinae Fischer von Waldheim, 1817
Tribe Neomyini Matschie, 1909
Genus *Asoriculus* Kretzoi, 1959

Asoriculus gibberodon (Petényi, 1864) (Figs 1–3)

1864 *Crocidura gibberodon* n. sp. – Petényi, pp. 73–76, pl. I, fig. 7a-c.
1911 *Crocidura gibberodon* (?) Petényi – Kormos, pp. 158–159.
1934 *Soriculus Kubinyii* n. sp. – Kormos, pp. 303–304, fig. 36.
1948 *Neomys Castellarini* n. sp. – Pasa, pp. 11–14, fig. I: 12–15.
1959 *Soriculus* (*Asoriculus* n. sg.) *gibberodon* (Petényi) – Kretzoi, p. 238.
1962 *Soriculus gibberodon* (Petényi) – Sulimski, fig. 2a-b.
1962 *Asoriculus gibberodon* (Petényi) – Kretzoi, pp. 306, 353, pl. II, fig. 1.
1967 *Episoriculus gibberodon* (Petényi) – Repenning, p. 48.
1973 *Episoriculus tornensis* n. sp. – Jánossy, pp. 50–52, pl. I, figs 1, 10–12.

1973 *Episoriculus borsodensis* n. sp. – Jánossy, pp. 53–54, pl. I, figs 5–6, 9, 13.
1973 *Soriculus kubinyii* Kormos – Jánossy, pl. I, figs 2, 8.
1973 *Episoriculus gibberodon* (Petényi) – Jánossy, pl. I, figs 3–4, 7, 14.
1981 *Episoriculus borsodensis* Jánossy – Rzebik-Kowalska, pp. 236–238, tabs III–VI, figs 3–5.
1981 *Episoriculus gibberodon* (Petényi) – Rzebik-Kowalska, pp. 245–247, tabs VI–VII, fig. 6.
1982 *Episoriculus gibberodon* (Petényi) – van de Weerd *et al.*, pp. 93–95, pl. 1, figs 2–4.
1983 *Episoriculus* cf. *gibberodon* (Petényi) – Fejfar & Horáček, pp. 136–138, tab. 3, pl. VII, fig. 4a-c.
1983 *Episoriculus* cf. *castellarini* (Pasa) – Fejfar & Horáček, pp. 136–138, tab. 3, pl. VII, figs 1a-3b, 5c-6b.
1984 *Episoriculus gibberodon* (Petényi) – Reumer, pp. 92–100, tabs 36–42, figs 12–15, pl. 27, figs 3–11, pls 28–30, pl. 31, figs 1–2.
1985 *Episoriculus gibberodon* (Petényi) – Reumer & Doukas, pp. 117–118, pl. 2, figs 3–4.
1996 *Asoriculus gibberodon* (Petényi) – Dahlmann & Storch, pp. 184–185, pl. 1, fig. 15.
1998 *Episoriculus gibberodon* (Petényi) – Mészáros, pp. 108–109, tab. 5, pl. 3, figs 1–11.



Figs 1–3. *Asoriculus gibberodon* (Petényi, 1864). – **1.** Right M^1, occlusal view, layer 2. – **2.** Left M^2, occlusal view, layer 28. – **3.** Left mandible fragment with M_2 and M_3, buccal view, layer 8. Scale bars = 1 mm

2000 *Asoriculus gibberodon* (Petényi) – Rzebik-Kowalska, p. 31, tabs XXIX–XXX, figs 10D-F, 11C-F.
2001 *Asoriculus gibberodon* (Petényi) – Koufos *et al*., pp. 59–60, tabs 9–10, pl. 2, figs 7–12.
2003 *Asoriculus gibberodon* (Petényi) – Popov, pp. 64–68, tab. VI, figs 9–10.
2003 *Asoriculus gibberodon* (Petényi) – Furió, p. 152, fig. 5a-b.
2003 *Asoriculus gibberodon* (Petényi) – Vasileiadou *et al*., p. 553, fig. 4e-f.
2004 *Asoriculus gibberodon* (Petényi) – Popov, p. 408, fig. 2C-D.
2006 *Asoriculus gibberodon* (Petényi) – Rofes & Cuenca-Bescós, pp. 306–310, tabs 3–4, fig. 5A-H.
2010 *Asoriculus gibberodon* (Petényi) – Furió & Angelone, pp. 234–235, tab. 1, fig. 3: 1–5.
2010 *Asoriculus gibberodon* (Petényi) – Minwer-Barakat *et al*., pp. 536–538, tabs 1–2, fig. 1A-K.
2011 *Asoriculus gibberodon* (Petényi) – Angelone *et al*., p. 97, fig. 6: 5–7.
2012 *Asoriculus gibberodon* (Petényi) – Minwer-Barakat *et al*., fig. 4AS.
2012 *Asoriculus gibberodon* (Petényi) – Vasileiadou *et al*., pp. 213–214, fig. 2a-e.
2013 *Asoriculus gibberodon* (Petényi) – Cuenca-Bescós *et al*., fig. 4H.
2013 *Asoriculus gibberodon* (Petényi) – Rzebik-Kowalska, p. 22, tab. 25, fig. 5: 1–3.
2014 *Asoriculus gibberodon* (Petényi) – Siori *et al*., pp. 408–409, tab. 4, fig. 3D-E, G-H.
2016*b* *Asoriculus gibberodon* (Petényi) – Pazonyi *et al*., pp. 109–110, figs 8–9.
2017 *Asoriculus gibberodon* (Petényi) – Joniak *et al*., p. 16, fig. 3C-D.

Studied material and measurements – For the overview of the measurements see Table 1. Specimen numbers and MNI data by layers are given in Table 3.

Layer 8

– Left mandible fragment with M_2 (L: 1.33, W: 0.80) and M_3 (L: 1.00, W: 0.63).

Layer 21

– Left I^1 fragment.

Layer 25

– Right M^1 (LL: 1.43, BL: 1.40, AW: 1.75, PW: 1.68).

Layer 27

– Left I^1 fragment.

Layer 28

– Left M^2 (LL: 1.33, BL: 1.33, AW: 1.75, PW: 1.33).

Layer 45

– Right mandible fragment with M_3 (L: 1.00, W: 0.53);
– Left M_2 (L: 1.18, W: 0.65).

Description – The tip of some teeth is pigmented with light orange colour.

***I*¹** – The upper incisor is fissident. The dorsal margin and the buccal posterior margin make a sharp angle; the posterior margin has a slight undulation and a weak cingulum.

***M*¹ *and M*²** – Metaloph is present. The protocone and the hypocone are separated by a not too wide valley, which has a little cingulum at its lingual end. The metastyle of M^1 protrudes, but it protrudes less in M^2. Therefore, PW relatively to AW is more significantly less at M^2 than at M^1. The anterior margin bends obliquely beside the protocone. The hypocone is placed further towards the lingual side than the protocone (Figs 1–2).

***M*₂** – The buccal edge of the hypoconid is slightly convex. The talonid is wider than the trigonid. Cingula are week, but well visible on both lingual and buccal sides. The lingual one is slightly undulate. The entoconid is high. The entoconid crest is present, but it is much lower. The buccal re-entrant valley opens directly above the cingulum (Fig. 3).

***M*₃** – The buccal cingulum is week and slightly undulate, while the lingual one is less developed. The talonid is basined, and possessing both entoconid and hypoconid. The talonid is narrower than the trigonid (Fig. 3).

Genus *Neomys* Kaup, 1829

Neomys newtoni Hinton, 1911
(Figs 4–6)

1911 *Neomys newtoni* n. sp. – Hinton, p. 535, text-fig. 1a, tab. II, pl. XXV, fig. 1.
1949 *Neomys newtoni* Hinton – Friant, fig. 15: 1.
1991 *Neomys newtoni* Hinton – Rzebik-Kowalska, pp. 405–407, tabs XXXIV–XXXV, text-fig. 19.
2000 *Neomys* cf. *newtoni* Hinton – Rzebik-Kowalska, p. 35, fig. 10C.
2002 *Neomys newtoni* Hinton – Zaitsev & Baryshnikov, pp. 301–302, tab. II, fig. 10C-D.
2006 *Neomys newtoni* Hinton – Harrison *et al*., fig. 3b.
2010 *Neomys newtoni* Hinton – Maul & Parfitt, p. 96, tab. 4, fig. 2H-I.
2013 *Neomys newtoni* Hinton – Rzebik-Kowalska, p. 22, tab. 26, fig. 5: 4–5.
2016 *Neomys newtoni* Hinton – Rzebik-Kowalska & Rekovets, p. 21, tab. 9, fig. 9: 4–6.

Studied material and measurements – For the overview of the measurements see Table 2. Specimen numbers and MNI data by layers are given in Table 3.

Layer 4 – inv. n.: V.82.85.

– Right mandible fragment without dentition.

Layer 5 – inv. n.: V.82.54.

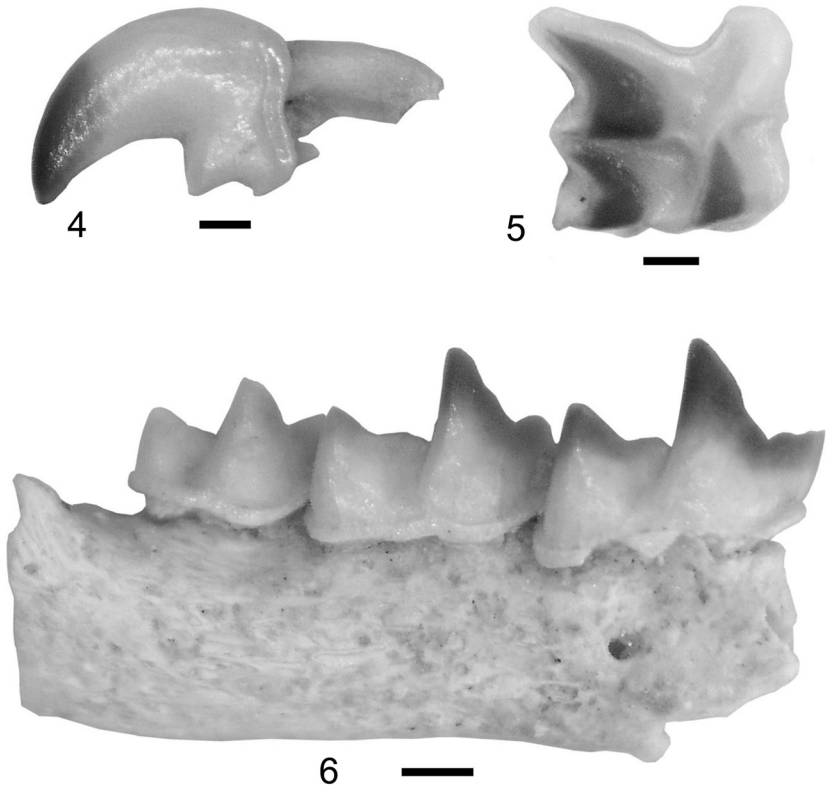
– Left mandible fragment with M_1 (L: 1.75, W: 1.10) and M_2 (L: 1.60, W: 1.05);
– Left I^1 (L: 2.15, H: 1.45);
– Left M_1 (L: 1.73, W: 1.00).

Layer 15 – inv. n.: V. 89.51.

– Right I^1 fragment;
– Left M^1 fragment.

Layer 22

– Left I^1 (L: 1.78, H: 1.30);
– 2 right I^1 fragments;
– Right I_1 (L: 4.60, H: 0.80);
– Right I_1 (L: 4.95, H: 1.03).



Figs 4–6. *Neomys newtoni* Hinton, 1911. – **4.** Left I^1, buccal view, layer 22. – **5.** Left M^1, occlusal view, layer 29. – **6.** Right mandible fragment with M_1, M_2, and M_3, buccal view, layer 40. Scale bars = 1 mm

Table 1. Measurements of *Asoriculus gibberodon* teeth from the Somssich Hill 2 locality (for the abbreviations see "Material and methods")

		n	min.	mean	max.	SD
M^1	LL	1	–	1.43	–	–
	BL	1	–	1.40	–	–
	AW	1	–	1.75	–	–
	PW	1	–	1.68	–	–
M^2	LL	1	–	1.33		–
	BL	1	–	1.33	–	–
	AW	1	–	1.75	–	–
	PW	1	–	1.33	–	–
M_2	L	2	1.18	1.25	1.33	0.1061
	W	2	0.65	0.73	0.80	0.1061
M_3	L	2	1.00	1.00	1.00	0.0000
	W	2	0.53	0.58	0.63	0.0707

Table 2. Measurements of *Neomys newtoni* teeth from the Somssich Hill 2 locality (for the abbreviations see "Material and methods")

		n	min.	mean	max.	SD
I^1	L	5	1.78	1.96	2.15	0.1408
	H	5	1.28	1.34	1.45	0.0762
M^1	LL	4	1.68	1.71	1.75	0.0315
	BL	4	1.65	1.66	1.68	0.0102
	AW	4	1.70	1.73	1.76	0.0298
	PW	4	1.85	1.92	1.98	0.0515
M^2	LL	4	1.39	1.53	1.68	0.1280
	BL	4	1.43	1.50	1.68	0.1156
	AW	4	1.58	1.80	1.94	0.1552
	PW	4	1.60	1.73	1.89	0.1203
P^4	BL	2	1.75	1.81	1.88	0.0884
	LL	2	1.33	1.39	1.46	0.0972
	W	2	1.75	1.78	1.80	0.0354
I_1	L	5	4.45	4.67	4.95	0.1867
	H	5	0.80	0.93	1.03	0.1081
M_1	L	6	1.58	1.68	1.78	0.0838
	W	6	0.88	0.99	1.10	0.0737
M_2	L	8	1.29	1.15	1.60	0.0970
	W	8	0.80	0.88	1.05	0.0791
M_3	L	2	1.08	1.19	1.30	0.0591
	W	2	0.68	0.71	0.75	0.0530

Layer 24

– Left I^1 fragment;
– Right I^1 (L: 2.00, H: 1.28);
– Right P^4 (BL: 1.75, LL: 1.46, W: 1.80);
– Left M^1 (LL: 1.75, BL: 1.66, AW: 1.70, PW: 1.85);
– Right M^1 (LL: 1.70, BL: 1.66, AW: 1.75, PW: 1.93);
– Left M^2 (LL: 1.60, BL: 1.68, AW: 1.84, PW: 1.89);
– Left M^2 fragment;
– Left I_1 (L: 4.73, H: 1.00).

Layer 25

– Left M^1 fragment;
– Right I_1 (L: 4.45, H: 0.83).

Table 3. Number of the specimens (n) and minimum number of individuals (MNI) of the Somssich Hill 2 *Asoriculus* and *Neomys* material, layer by layer

Layer	*A. gibberodon*		*N. newtoni*		Layer	*A. gibberodon*		*N. newtoni*	
	n	MNI	n	MNI		n	MNI	n	MNI
1	–	–	–	–	26	–	–	–	–
2	–	–	–	–	27	1	1	4	1
3	–	–	–	–	28	1	1	–	–
4	–	–	1	1	29	–	–	3	1
5	–	–	3	2	30	–	–	–	–
6	–	–	–	–	31	–	–	1	1
7	–	–	–	–	32	–	–	1	1
8	1	1	–	–	33	–	–	2	2
9	–	–	–	–	34	–	–	–	–
10	–	–	–	–	35	–	–	–	–
11	–	–	–	–	36	–	–	2	1
12	–	–	–	–	37	–	–	–	–
13	–	–	–	–	38	–	–	–	–
14	–	–	–	–	39	–	–	2	1
15	–	–	2	1	40	–	–	2	1
16	–	–	–	–	41	–	–	1	1
17	–	–	–	–	42	–	–	–	–
18	–	–	–	–	43	–	–	–	–
19	–	–	–	–	44	–	–	2	1
20	–	–	–	–	45	2	1	1	1
21	1	1	–	–	46	–	–	–	–
22	–	–	5	2	47	–	–	–	–
23	–	–	–	–	48	–	–	–	–
24	–	–	8	1	49	–	–	–	–
25	1	1	2	1	50	–	–	–	–

Layer 27

– Left A_1;
– Left M_1 (L: 1.58, W: 1.00);
– Left M_2 (L: 1.43, W: 0.85);
– Right M_2 (L: 1.29, W: 0.83).

Layer 29

– Right mandible fragment without dentition;
– Left M^1 (LL: 1.70, BL: 1.65, AW: 1.76, PW: 1.98);
– Right M^2 (LL: 1.39, BL: 1.46, AW: 1.58, PW: 1.60).

Layer 31

– Left I^1 (L: 1.88, H: 1.28).

Layer 32

– Right M^2 (LL: 1.68, BL: 1.45, AW: 1.94, PW: 1.73).

Layer 33

– Right I_1 (L: 4.60, H: 1.00);
– Right I_1 fragment.

Layer 36

– Right mandible fragment with M_1 (L: 1.60, W: 0.88), M_2 (L: 1.38, W: 0.80), and M_3 (L: 1.08, W: 0.68);
– Right I^1 (L: 1.98, H: 1.38).

Layer 39

– Left mandible fragment with M_1 fragment and M_2 (L: 1.50, W: 0.85);
– Right M^1 fragment.

Layer 40

– Left maxillary fragment with P^4 (BL: 1.88, LL: 1.33, W: 1.75), M^1 (LL: 1.68, BL: 1.68, AW: 1.71, PW: 1.93), and M^2 (LL: 1.48, BL: 1.43, AW: 1.84, PW: 1.69);
– Right mandible fragment with M_1 (L: 1.78, W: 1.00), M_2 (L: 1.53, W: 0.90), and M_3 (L: 1.30, W: 0.75).

Layer 41

– Right M^1 fragment.

Layer 44

– Right I^1 fragment;
– Left M_2 (L: 1.40, W: 0.83).

Layer 45

– Right mandible fragment with A_1, M_1 (L: 1.64, W: 0.95), and M_2 (L: 1.46, W: 0.90).

Description – *Neomys* remains differ from the ones of *Asoriculus* not only in their morphology, but also in their somewhat bigger size (Fig. 7). Pigmentation on the *Neomys* teeth is red to orange.

Mandible – Structure of the condyloid process is typical for genus *Neomys*. The upper and lower condyloid facets are separated by a narrow interarticular area (Fig. 6). The morphology of the condyloid and coronoid processes agrees with the description given by Rzebik-Kowalska (2013): "The coronoid process is narrow and its tip is rounded. The coronoid spicule is distinct, situated in 2/3 of the height of the coronoid process. The upper facet of the condyloid process is small, the lower is wide on the buccal side and narrow on the lingual side. The interarticular area is very narrow in the middle and it widens towards the upper and lower facets."

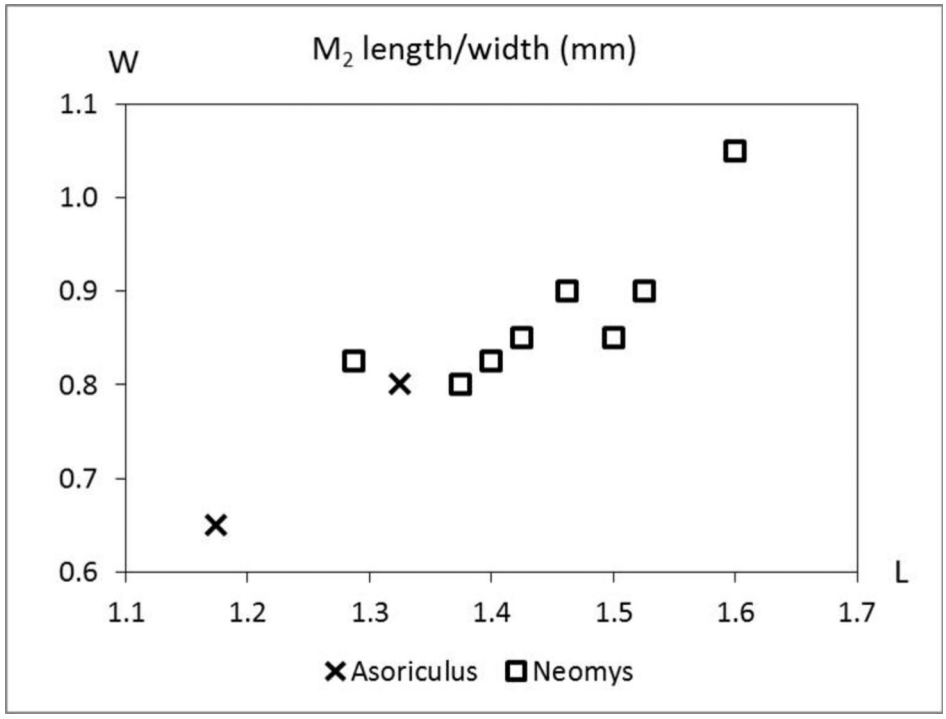


Fig. 7. Scatter plot of the measurements (M_2 L/W ratio) of the *Asoriculus* and *Neomys* remains from the Somssich Hill 2 locality

***I*^{1}** – The buccal cingulum is week and undulate. The lower margin of the talon is concave. The apex even as the talon are pointed. The upper margin of the apex is rounded (Fig. 4).

***P*^{4}** – The parastyle is big with a low parastylar crest. The protocone is separated from the hypocone by a broad valley. The hypoconal flange is surrounded by a well-developed cingulum.

***M*^{1} *and M*^{2}** – The protocone is high, but its metaloph is low. It is separated from the hypocone by a broad valley. The hypocone is placed further towards the lingual side than the protocone. A wide cingulum runs along the flat hypoconal flange. AW<PW at M^1, but AW>PW at M^2 (Fig. 5).

***I*$_1$** – The lower incisor is monocuspulate with up-turned apex. There is a weak cingulum on the posterior margin of its buccal side.

***M*$_1$ *and M*$_2$** – The first two molars are very similar to each other in morphology. M_2 is slightly smaller than M_1. Low entoconid crests are present. The lingual cingulum is wider than the buccal one; the latter is slightly undulate (Fig. 6).

***M*$_3$** – It is typically smaller than M_2, but it is not reduced in morphology. Its talonid is basined (Fig. 6).

CONCLUSIONS

Asoriculus gibberodon is a long-lived species. Its FAD is mentioned by Mészáros (1998) from Tardosbánya, Hungary (Late Miocene, MN 12 zone). The species was present in Europe to the middle Early Pleistocene. Its youngest record is from the Żabia Cave, Poland (Early Biharian; Rzebik-Kowalska 2013) (Table 4). *Neomys newtoni* is a typical element in the Early and Middle Pleistocene vertebrate faunas. Its oldest occurrence data originate from the Żabia Cave (Rzebik-Kowalska 2013) and the LAD of the species is mentioned from Schöningen, Germany (ca. 330 ka) by van Kolfschoten (2014) (Table 5). The present record is the first report on its appearance in Hungary (Fig. 8).

Co-occurrence of the two species is known from some localities (Żabia Cave, Poland and Monte Peglia and Soave Cava Sud, Italy) (Rzebik-Kowalska 2013; Kotsakis *et al.* 2003), although the latter two Italian records are uncertain. Therefore, it is likely that *Asoriculus* is the ancestor of *Neomys* (Maul & Rzebik-Kowalska 1998), nevertheless, the phylogenetic approach made by Rofes & Cuenca-Bescós (2009) does not confirm this hypothesis. Thus, the rare common occurrence of the two species supports the theory of Pazonyi *et al.* (2016*a*, 2017) that a few specimens of the site were re-deposited. Preservation and number of the specimens suggest that *Neomys* was autochthonous, while *Asoriculus* was re-transported (Table 3).

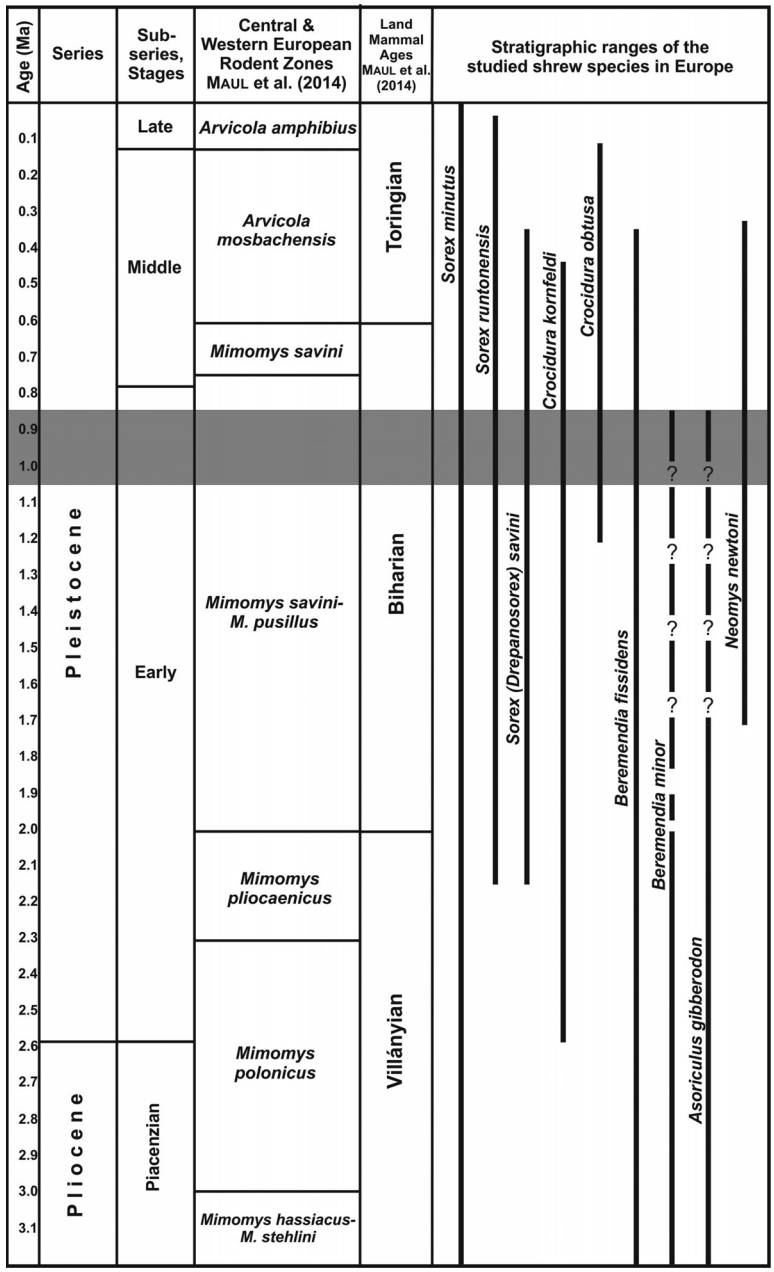


Fig. 8. Stratigraphical position of the Somssich Hill 2 locality (grey area, after PAZONYI *et al.* 2016*a*), and the stratigraphical range of the shrew species identified at the locality (BOTKA & MÉSZÁROS 2014*b*, 2015*b*, 2016, and this study). Rodent Zones and Land Mammal Ages are used according to MAUL *et al.* (2014)

Table 4. List of the European occurrences of *Asoriculus gibberodon*. Underlined localities indicate the co-occurrence of both species

Countries, localities	**Miocene**		**Pliocene**		**Pleistocene**			**References**
	MN 12	**MN 13**	**MN 14**	**MN 15**	**MN 16**	**MN 17**	**Early**	
Poland								
Podlesice			+					Stefaniak *et al.* (2009)
Zamkowa Dolna Cave B			+					Stefaniak *et al.* (2009)
Zalesiaki 1B			+	+				Rzebik-Kowalska (2005*a*)
Wże 1				+				Rzebik-Kowalska (2005*a*)
Rbielice Królewskie 1A, 2					+			Rzebik-Kowalska (2005*a*)
Kielniki 3B						+		Stefaniak *et al.* (2009)
Zamkowa Dolna Cave A						+		Stefaniak *et al.* (2009)
Żabia Cave							+	Rzebik-Kowalska (2013)
Hungary								
Tardosbánya	+							Mészáros (1998)
Vértesacsa	+	+						Joniak *et al.* (2017)
Osztramos 1, 9, 13			+					Reumer (1984)
Csarnóta 2				+				Reumer (1984)
Dunaalmás 4				+	+			Jánossy (1986)
Beremend 5					+			Jánossy (1986)
Osztramos 7					+			Jánossy (1986)
Villány 3						+		Reumer (1984)
Beremend 1–3, 17							+	Jánossy (1996)
Villány 5							+	Jánossy (1986)
Somssich Hill 1, 2							+	Jánossy (1986); Pazonyi *et al.* (2017); present article
Spain								
Fuente del Viso		+						van den Hoek Ostende & Furió (2005)
Purcal 4		+						van den Hoek Ostende & Furió (2005)
Alhaurín el Grande-1			+					Guerra-Merchán *et al.* (2013)
Cuzo 1			+					van den Hoek Ostende & Furió (2005)
La Gloria 4			+					van den Hoek Ostende & Furió (2005)
Peralejos E			+					van den Hoek Ostende & Furió (2005)
Villalta Alba Rio 1			+					van den Hoek Ostende & Furió (2005)

Table 4. (continued)

Countries, localities	Miocene		Pliocene		Pleistocene			References
	MN 12	MN 13	MN 14	MN 15	MN 16	MN 17	Early	
Asta Regia				+				van den Hoek Ostende & Furió (2005)
El Arquillo 3				+				van den Hoek Ostende & Furió (2005)
La Calera				+				van den Hoek Ostende & Furió (2005)
Layna				+				van den Hoek Ostende & Furió (2005)
Lomas de Casares 1				+				van den Hoek Ostende & Furió (2005)
Orrios 7				+				van den Hoek Ostende & Furió (2005)
Tollo de Chiclana 1, 1B, 3, 13			+	+	+			Minwer-Barakat *et al.* (2012)
Moreda					+			van den Hoek Ostende & Furió (2005)
Orrios 3					+			van den Hoek Ostende & Furió (2005)
Barranco León 5/D							+	Agustí *et al.* (2010)
Venta Micena							+	Agustí *et al.* (2010)
Fuente Nueva 3							+	Rofes & Cuenca-Bescós (2006)
Sima del Elefante (TELRU)							+	Rofes & Cuenca-Bescós (2006)
Greece								
Maritsa		+						Doukas (2005)
Maramena		+	+					Doukas (2005)
Kessani		+	+					Vasileiadou *et al.* (2012)
Silata		+	+					Doukas (2005)
Apolakkia				+				Doukas (2005)
Tourkobounia 1					+			Doukas (2005)
Marathoussa							+	Koufos *et al.* (2001)
Slovakia								
Ivanovce				+				Fejfar & Sabol (2005)
Plesivec						+		Rofes & Cuenca-Bescós (2006)
Koliňany 1						cf.		Fejfar & Horáček (1983)
Včeláre 3, 4						cf.	cf.	Fejfar & Horáček (1983)
Bulgaria								
Dorkovo			+					Rzebik-Kowalska & Popov (2005)
Muselievo				+				Rzebik-Kowalska & Popov (2005)
Varshets						+	+	Rzebik-Kowalska & Popov (2005)

Table 4. (continued)

Countries, localities	Miocene		Pliocene		Pleistocene			References
	MN 12	MN 13	MN 14	MN 15	MN 16	MN 17	Early	
Romania								
Dranic-0, -2, -3				+				Rzebik-Kowalska (2005*b*)
Betfia VII/1, IX, X, XI, XIII							+	Rzebik-Kowalska (2002)
Germany								
Gundersheim-Findling				+				Ziegler *et al.* (2005)
Austria								
Deutsch-Altenburg 9, 20				+	+			Ziegler & Daxner-Höck (2005)
Italy								
Brisighella		+						Rofes & Cuenca-Bescós (2006)
Monticino		+						Rofes & Cuenca-Bescós (2006)
Moncucco Torinese		+						Angelone *et al.* (2011)
Cascina Arondelli					+			Kotsakis *et al.* (2003)
Rivoli Veronese						+		Kotsakis *et al.* (2003)
Capo Mannu D1 (Sardinia)							+	Furió & Angelone (2010)
Monte Peglia							cf.	Kotsakis *et al.* (2003)
Soave Cava Sud							+	Kotsakis *et al.* (2003)
Monte La Mesa							+	Kotsakis *et al.* (2003)
Monte Argentario							+	Siori *et al.* (2014)
France								
Mont Héléne			+					Rofes & Cuenca-Bescós (2006)
Balaruc 2					+			Rofes & Cuenca-Bescós (2006)
Seynes					+			Rofes & Cuenca-Bescós (2006)
Montoussé 5						+		Rofes & Cuenca-Bescós (2006)
Les Valerots							+	Rofes & Cuenca-Bescós (2006)
Mas Rambault							+	Rofes & Cuenca-Bescós (2006)
Ukraine								
Odessa		cf.						Rzebik-Kowalska & Rekovets (2016)

Genus *Neomys* is considered as an indicator of open water bodies based on recent analogues (extant water shrews). The remains occur only in certain layers with low number of specimens. This fact suggests that the open water surface was not within the nearest environment of the site. Only those individuals fell into the karstic cavity of the locality that moved away from the water for some reason.

Table 5. List of the European occurrences of *Neomys newtoni*. Underlined localities indicate the co-occurrence of both species

Countries, localities	Pleistocene		References
	Early	Middle	
Poland			
Żabia Cave	+		Rzebik-Kowalska (2013)
Zalesiaki 1A	+		Rzebik-Kowalska (1994)
Kozi Grzbiet	+	+	Rzebik-Kowalska (1994)
England			
West Runton		+	Maul & Parfitt (2010)
Westbury		cf.	Maul & Parfitt (2010)
Italy			
Monte Peglia	cf.		Kotsakis *et al.* (2003)
Soave Cava Sud	aff.		Kotsakis *et al.* (2003)
Hungary			
Somssich Hill 2	+		Pazonyi *et al.* (2017); present article
Ukraine			
Medzhybozh		+	Rzebik-Kowalska & Rekovets (2016)
Kuznetsovka		+	Agadjanian & Kondrashov (2007)
Germany			
Miesenheim I		cf.	van Kolfschoten & Turner (1996)
Schöningen		+	van Kolfschoten (2014)
Voigstedt		+	Maul & Parfitt (2010)
Czech Republic			
Přezletice		+	Maul & Parfitt (2010)
Romania			
Betfia VII/3	cf.		Rzebik-Kowalska (2000)
Russia			
Treugolnaya Cave		+	Zaitsev & Baryshnikov (2002)

*

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