



THE LATE MIOCENE, TUROLIAN (MN 11) *NEOCRICETODON* POPULATION FROM CSODABOGYÓS CAVE (KESZTHELY HILLS, WESTERN HUNGARY)

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Abstract: This publication aims to give a detailed taxonomic description of the rich *Neocricetodon* material collected from Csodabogyós Cave (Keszthely Hills, close to the village Balatonederics) in 2023. The sample is homogenous and close to *Neocricetodon skoffeki*.

Key words: Carpathian Basin, Miocene, Pannonian, Turolian, Rodentia, Cricetidae

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Introduction

Csodabogyós Cave is located north of Lake Balaton, on the eastern edge of the Keszthely Hills, near the village of Balatonederics at 393 m a.s.l. In 2023, during two excavations, about 200 kg of sediment was collected from the cave, from which a rich fossil assemblage of mainly small mammals was recovered. The complete faunal list of the site can be found in this volume (Pazonyi et al. 2025).

The faunal composition suggests that the fossils are of Late Miocene (MN 11) age. In the present work, we provide a detailed taxonomic description of the remains belonging to the genus *Neocricetodon*.

The fossil hamster material of the fauna has a special importance because the genus *Neocricetodon* was a very successful group. Its chronological range extended from the Late Miocene MN 10 Zone through the Pliocene MN 15 Zone (Kálin 1999). The geographical range covered the temperate climate part of Eurasia from Spain to China (Wu 1991, Daxner-Höck et al. 1996).

Material and methods

The length (L) and width (W) of the 788 of *Neocricetodon* molars recovered during the excavations were measured

under an MBS-10 stereomicroscope. The obtained data were sorted into separate databases for each tooth, and statistical analyses were performed within the R software environment (v. 4.3.1; R Core Team 2023).

The size distributions of the length and width, as well as the L/W ratio of each molar were examined separately, for each of the different upper and lower tooth positions. The descriptive statistical parameters are summarized in Table 2. The assumed normality of the distributions was checked by a Shapiro-Wilks test (Shapiro and Wilk 1965) using the ‘shapiro test ()’ function of the R. Normality was rejected if the resulting p-value was less than an a priori selected significance level, alpha = 0.05, thus the consequent decisions have a 95 % confidence. Then, the size of the *Neocricetodon* population from Csodabogyós Cave was compared with the *Neocricetodon* material from three other sites (Kohfidisch, Eichkogel and Tardosbánya) with a similar age. For this comparison, we used JH’s earlier unpublished measurements for Kohfidisch and Eichkogel, whereas in the case of Tardosbánya, the data from Kordos (1987) were used. The mean L, W and L/W values were compared with each other using their 95% confidence bounds. For the same reason, Welch’s t-tests (Welch 1947) were also used and performed by the ‘T test’ function of R, with the same 0.05 significance level as above. Since *Neocricetodon fahlbuschi* has been described from Kohfidisch and *N. skoffeki* from Tardosbánya

and Eichkogel, we also had the opportunity to perform a hierarchical cluster analysis using the 'hclust()' function of R, with a complete linkage method to decide whether the intermediate *Neocricetodon* population of Csodabogyós Cave can be referred to as one or two species, or rather can be ascribed to the previously described species. We cut the dendrogram at a height that generated two clusters, so we can define for each specimen from Csodabogyós Cave, which already established morphology they plot closer to.

Morphological nomenclature/terminology is after Mein and Freudenthal (1971). The micrographs were taken with a CMEX-5 digital microscope. Retouching was done by JH.

Systematic palaeontology

Order Rodentia BOWDICH, 1821
Family Cricetidae FISCHER, 1817
Subfamily Cricetinae FISCHER, 1817

Genus *Neocricetodon* SCHAUB, 1934

Type species. *Cricetulus grangeri* YOUNG, 1927.

Other species. *N. schaubi* KRETZOI, 1951, *N. polonicus* (FAHLBUSCH, 1969), *N. magnus* (FAHLBUSCH, 1969), *N. intermedius* (FEJFAR, 1970), *N. fahlbuschi* (BACHMAYER et WILSON, 1970), *N. moldavicus* (LUNGU, 1981), *N. occidentalis* (AGUILAR, 1982), *N. yinanensis* (ZHENG, 1984), *N. skofleki* (KORDOS, 1987), *N. polgardiensis* (FREUDENTHAL et KORDOS, 1989), *N. nestori* (ENGESSER, 1989), *N. browni* (DAXNER-HÖCK, 1992), *N. progressus* (TOPACHEVSKY et SKORIK, 1992), *N. similis* (WU, 1991), *N. hanae* (QIU, 1995), *N. seseae* AGUILAR, CALVET et MICHAUX, 1995, *N. ambarrensis* FREUDENTHAL, MEIN et MARTIN-SUÁREZ, 1998, *N. zhengi* (QIU et STORCH, 2000).

Remarks. The question of synonymy of the generic names *Neocricetodon* SCHAUB, 1934 and *Kowalskia* FAHLBUSCH, 1969 has a long history. A detailed discussion of this problem is given by Daxner-Höck et al. (1996), Freudenthal et al. (1998), Kretzoi and Fejfar (2005), Sinitsa and Delinisch (2016), and Wu and Flynn (2017), but a detailed reinterpretation of the history of this issue is

beyond the scope of the present paper. In the literature of the last 50 years, there were two different trends.

A. Scholars, who accepted the name *Neocricetodon* SCHAUB, 1934: Kordos (1987), Freudenthal and Kordos (1989), Freudenthal et al. (1991, 1998), Sesé (2006), Prieto and Rummel (2009), Maridet et. al. (2014), Sinitsa and Delinisch (2016).

B. Scholars, who accepted the name *Kowalskia* FAHLBUSCH, 1969: Fejfar (1970), Bachmayer and Wilson (1970), Engesser (1989), Daxner-Höck (1992, 1995), Daxner-Höck et al. (1996), Kälin (1999), Kretzoi and Fejfar (2005), Daxner-Höck and Höck (2015).

The debate has still not been closed, although the authors of the latest publications (Sesé 2006, Prieto and Rummel 2009, Maridet et al. 2014, Sinitsa and Delinisch 2016) accept the congeneric status of *Neocricetodon grangeri* and *Kowalskia polonica* and thus see *Kowalskia* FAHLBUSCH, 1969 as a later subjective synonym to *Neocricetodon* SCHAUB, 1934. We follow this latest conception.

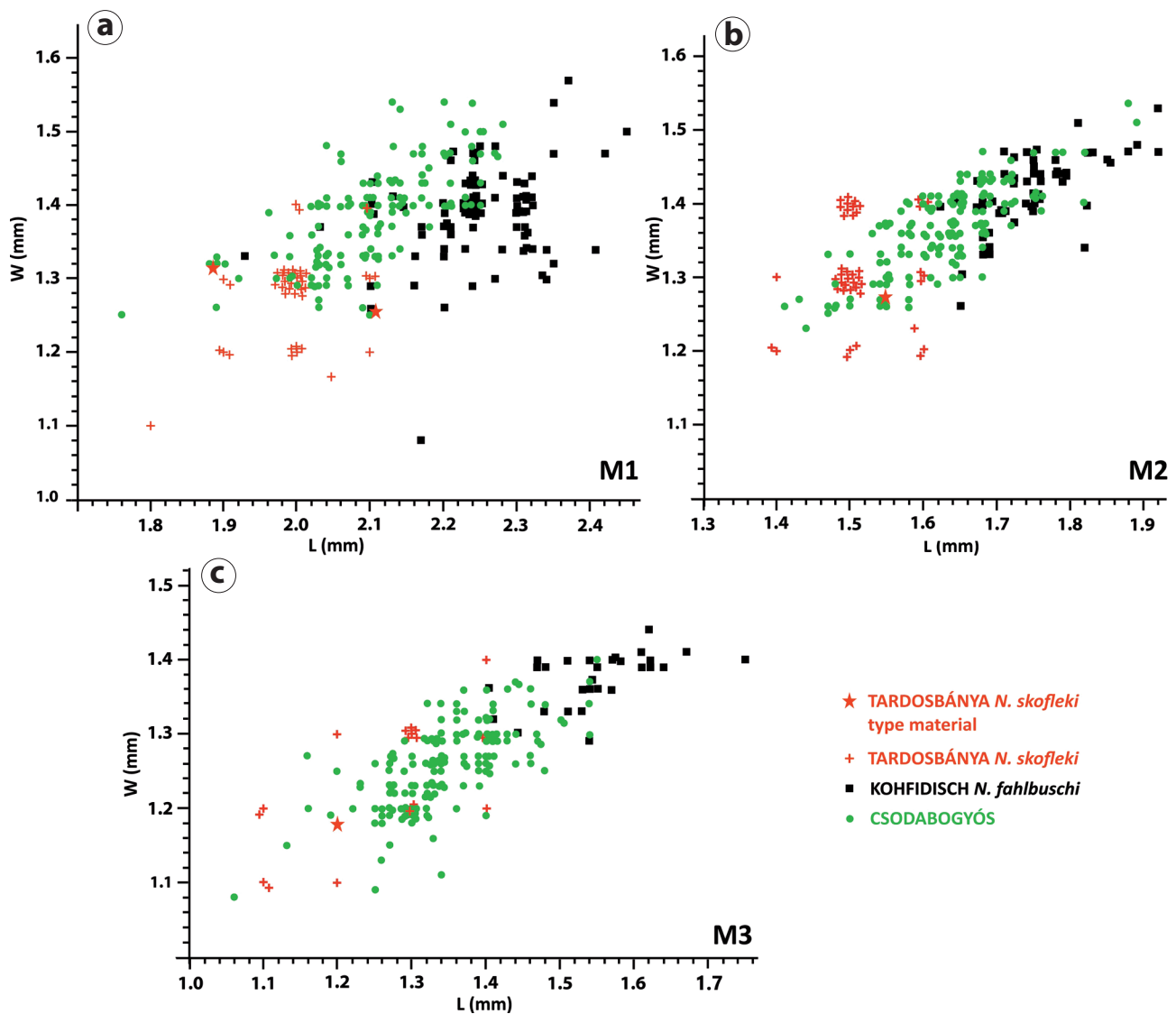
***Neocricetodon* cf. *N. skofleki* (KORDOS, 1987)**

Studied material. Csodabogyós Cave: 776 intact molars, 9 molar fragments.

Description. **M1** (Text-fig. 1a, Pl. 1, Figs 1–4). The occlusal outline is rectangular or bean-shaped (labial and lingual margins are slightly curved). Anterocone: unicuspid, unsplit variation is rare (A type after Freudenthal and Kordos 1989: fig.16/A). Material: 7 specimens, 5 %. The most frequent is a bicuspid variation. It is split on its posterior side, but the anterior surface is convex and smooth, without a groove or cleft. The labial cusp does not have a posterior connection (B type after Freudenthal and Kordos 1989: fig. 16/B). Material: 67 specimens, 49 %. Another bicuspid type is posteriorly split, the two cusps of the anterocone are anteriorly connected (no groove or cleft in the anterior surface), and both the lingual and labial cusps of the anterocone have posterior connections because the two branched antrolophule (Pl. 1, Fig. 2). It refers to the combination of the B and C types of Freudenthal and Kordos 1989: fig. 16/B, 16/C). Material: 49 specimens, 36 %. The fourth variation is the completely divided anterocone, where the two cusps are without anterior connection and the antrolophule is two-branched. It refers

Table 1. Measurements of studied *Neocricetodon* material from Csodabogyós Cave. SD – standard deviation, CV – coefficient of variation, p – p-value of the Shapiro-Wilks normality test. The test rejects the hypothesis of normality when the p-value is less than or equal to 0.05 (grey).

Tooth	Length (mm)						Width (mm)					
	n	min–max	mean	SD	CV	p	n	min–max	mean	SD	CV	p
M1	137	1.76–2.28	2.1	0.092	4.37	0.010	139	1.25–1.54	1.38	0.068	4.92	0.021
M2	142	1.41–1.89	1.63	0.083	5.1	0.110	145	1.23–1.54	1.37	0.059	4.3	0.050
M3	152	1.06–1.55	1.34	0.08	5.96	0.067	152	1.08–1.40	1.26	0.058	4.62	0.126
m1	82	1.72–2.30	1.95	0.108	5.55	0.275	86	1.06–1.36	1.2	0.062	5.16	0.228
m2	123	1.39–1.79	1.62	0.094	5.81	0.009	123	1.15–1.47	1.32	0.072	5.44	0.195
m3	140	1.37–1.88	1.61	0.093	5.75	0.646	140	1.11–1.43	1.26	0.064	5.14	0.339



Text-fig. 1. Scatter plot of *Neocricetodon* upper molars L/W values from Kohfidisch, Tardosbánya and Csodabogyós Cave. a: M1, b: M2, c: M3.

to the C type of Freudenthal and Kordos 1989: fig. 16/C). Material: 11 specimens, 8 %.

The anterolophule can be a single enamel crest between the lingual cusp of the anterocone and the anterior angle of the protocone, or it can be forked (V-shaped) connected both the lingual and labial cusps of the anterocone with the anterior angle of the protocone. The anteromesoloph, after the sense of Daxner-Höck (1992) (= anterolophule labial spur in the earlier literature) is mainly long and reaches the labial margin (118 specimens, 93 %), or medium-sized (8 specimens, 6 %), and in one case it is short (1 %).

Protolophule I is well-developed (95 specimens, 71 %), or absent (39 specimens, 29 %). Protolophule II is regular (100 %).

Mesoloph: long, reaches the labial margin (121 specimens, 85 %), medium-sized (13 specimens, 9 %), cannot be examined (8 specimens, 6 %). Both anterior and posterior metalophule is developed: 17 specimens, 12 %. Only the posterior metalophule is found: 121 specimens, 85 %. Cannot be examined: 4 specimens, 3 %. The posterosinus is narrow.

The roots are possible to investigate in 129 specimens. There are 3 roots in 95 specimens, 74 %. The lingual root is grooved in 19 specimens, 15 %; and there are 4 roots in 15 specimens, 11 %.

The most frequent combinations are the following:

- B+C1A1 + protolophule 1. Anterocone lingual and labial cusp have anterior connection, anterolophule doubled, anteromesoloph long, anterior protolophule developed, mesoloph long, anterior metalophule absent: 31 specimens, 23 %.

- B1A1. Anterocone lingual and labial cusp have anterior connection, anterolophule simple (labial anterocone without anterolophule branch), anteromesoloph long, mesoloph long, anterior metalophule absent: 23 specimens, 17 %.

- B1A1 + protolophule 1. Anterocone lingual and labial cusp have anterior connection, anterolophule simple (labial anterocone without anterolophule branch), anteromesoloph long, anterior protolophule developed, mesoloph long, anterior metalophule absent: 28 specimens, 20 %.

M2 (Text-fig. 1b, Pl. 1, Figs 9, 10). The occlusal outline is rectangular. The lingual and the labial anteroloph are developed, but the labial one is stronger, and the anterosinus is slightly deeper and wider than the protosinus. Protolophule I and II are equally developed (137 specimens, 100 %). The mesoloph is long and reaches the labial margin (136 specimens, 99 %), or medium-sized (1 specimen, 1 %). Anterior and posterior metalophule are equally developed

in 99 specimens (72 %). Only the posterior metalophule is found in 38 specimens (28 %). The M2s have four roots, there is only one specimen having three roots.

Most frequent morphological combinations:

- 2A2. Protolophule I and II equally developed, mesoloph long, posterior metalophule developed: 97 specimens, 71 %.

- 2A3. Protolophule I and II equally developed, mesoloph long, anterior metalophule not developed: 39 specimens, 28 %.

M3 (Text-fig 1c, Pl. 1, Figs 13–15). The occlusal outline is subtriangular, with rounded angles. The lingual and labial anteroloph are developed like those in M2. The lingual anteroloph is absent in only one specimen. The protolophule is double. The mesoloph is mainly medium-sized (83 specimens, 65 %), or it can be long, reaching the labial margin (33 specimens, 26 %), or short (4 specimens, 4 %). In 7 specimens it is absent (5 %) (9 specimens cannot be examined). The metacone is developed as a prominent cusp in 47 specimens (34 %). It is part of the posteroloph in 82 specimens (60 %), and there are 7 specimens (5 %) which are intermediate in morphology.

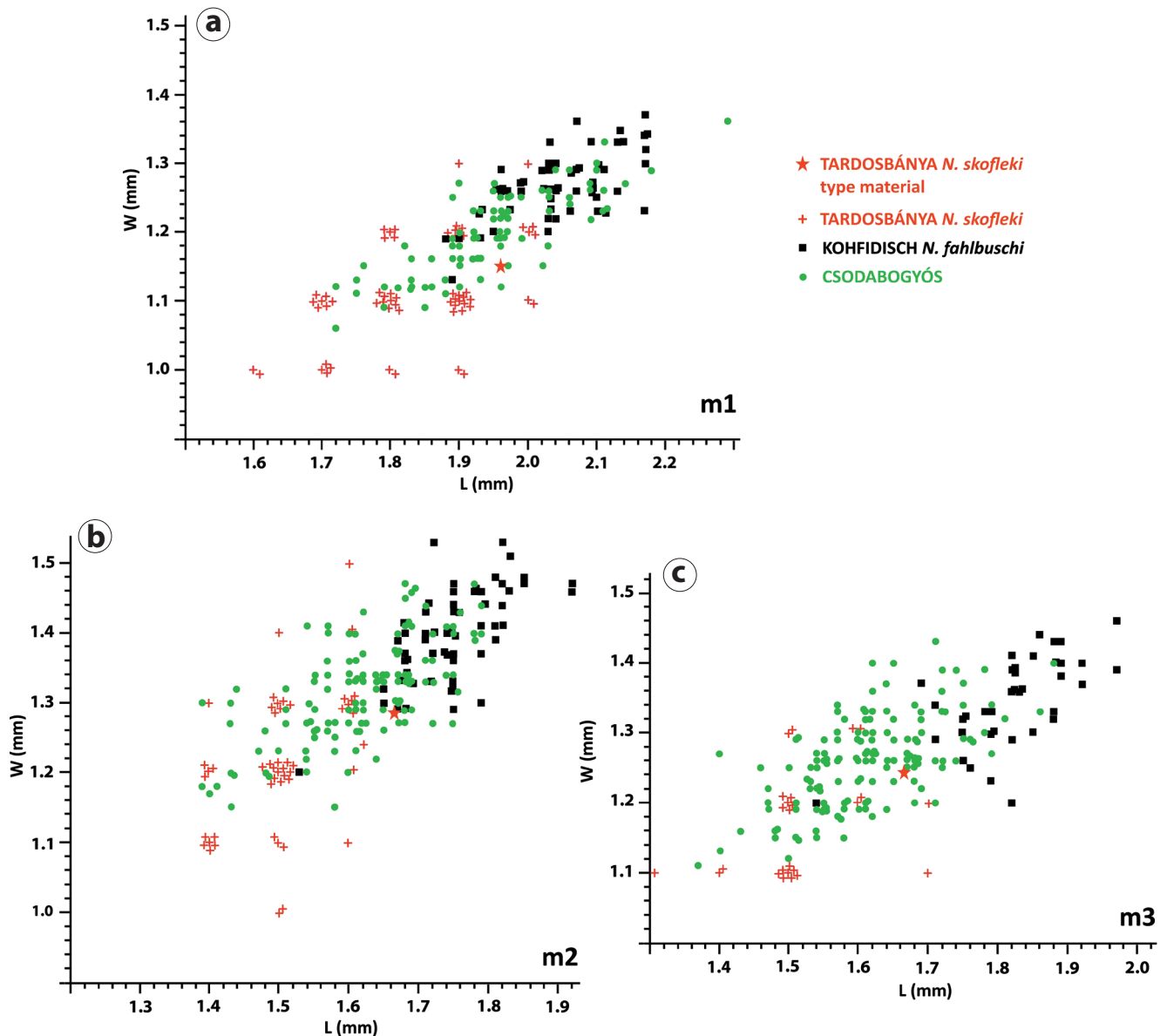
Most frequent morphological combinations:

- B2B. Mesoloph medium-sized, labial posteroloph long, no incision in the posteroloph: 70 specimens, 50 %.

- B2A. Mesoloph medium-sized, labial posteroloph long, incision developed in the posteroloph: 22 specimens, 16 %.

- A2B. Mesoloph long, labial posteroloph long, no incision in the posteroloph: 16 specimens, 11 %.

m1 (Text-fig. 2a, Pl. 1, Figs 5–8). The occlusal outline is rectangular with a smooth and rounded anterior surface. The unicuspid anteroconid (A type in Freudenthal and Kordos 1989: fig. 19/A) is rare (1 specimen, 1 %). The most frequent morphotype is the two-part, but slightly divided anteroconid (B type in Freudenthal and Kordos 1989: fig. 19/B). The division is weak in the posterior side, and the anterior side is either without a groove or with only a very shallow groove (69 specimens, 81 %). The bicuspid and divided anteroconid (C type in Freudenthal and Kordos 1989: fig. 19/C) is rare: 2 specimens, 2 %. The three-part anteroconid (D type in Freudenthal and Kordos 1989: fig. 19/D) is more frequent:



Text-fig. 2. Scatter plot of *Neocricetodon* lower molars L/W values from Kohfidisch, Tardosbánya and Csodabogyós Cave. a: m1, b: m2, c: m3.

13 specimens, 15 %. The three units of the anteroconid are not divided.

The anterolophulid can be a single enamel crest between the labial cusp of the anteroconid and the anterior angle of the protocone (type 1 in Freudenthal and Kordos 1989: fig. 19/1), 10 specimens, 12 %, or it can be forked (V-shaped) and connects both anteroconid cusps with the anterior angle of the protoconid (type 2 in Freudenthal and Kordos 1989: fig. 19/2) 72 specimens, 88 %. The mesolophid is always long (100 %), and reaches the lingual margin. Ectomesolophid (short or long) is developed in 14 specimens (17 %).

Most frequent morphological combinations:

- B2A2. The two anteroconid cusps are slightly divided, anterolophulid V-shaped, mesolophid long, ectomesolophid absent. Material: 47 specimens, 57 %.

- B2A1. The two anteroconid cusps are slightly divided, anterolophulid V-shaped, mesolophid long, ectomesolophid developed. Material: 13 specimens, 15 %

- D2A2. 3 anteroconid cusps, anterolophulid V-shaped, mesolophid long, ectomesolophid absent. Material: 11 specimens, 13 %.

m2 (Text-fig. 2b, Pl. 1, Figs 11, 12). The occlusal outline is rectangular. The labial anterolophid reaches the labial basis of the protoconid and closes the protosinusid. The lingual anterolophid is short, the anterosinusid is small and lingually open. The mesolophid is always long (100 %), and reaches the lingual margin. The ectomesolophid is developed in 36 specimens, 30 %.

Most frequent morphological combinations:

- A1B. Mesolophid long, posterosinusid open, ectomesolophid absent. Material: 85 specimens, 69 %.

- A1A. Mesolophid long, posterosinusid open, ectomesolophid developed. Material: 34 specimens, 28 %.

m3 (Text-fig. 2c, Pl. 1, Fig 16). The occlusal outline is triangular with rounded angles. The labial anterolophid reaches the labial basis of the protoconid and closes the protosinusid. The lingual anterolophid is better developed than the same one in m2, reaches the anterior surface of the metaconid, and closes the protosinusid. The mesolophid is long (63 specimens, 57 %), or medium-sized (48 specimens, 43 %). The ectomesolophid is developed in 11 specimens, 10 %.

Most frequent morphological combinations:

- 2A2B. anterolophulid-metalophulid connected, mesolophid long, cingulum is developed in the lingual margin, ectomesolophid absent. Material: 67 specimens, 49 %.

- 2B2B. anterolophulid-metalophulid connected, mesolophid medium-sized, cingulum is developed in the lingual margin, ectomesolophid absent. Material: 47 specimens, 34 %.

- 2A2A. anterolophulid-metalophulid connected, mesolophid long, cingulum is developed in the lingual margin, ectomesolophid is developed. Material: 11 specimens, 8 %.

Remarks to the *N. skofleki* type material. There are 3 M1s. The two cusps of the anterocone are anteriorly connected (C type after Freudenthal and Kordos 1989). Two of them are narrower than the M1s from Csodabogyós Cave. There is one m1. The two cusps of the anteroconid are more deeply divided than the anterocoid cusps in the Csodabogyós material. In the case of the m2, an ectomesolophid is present.

Discussion and remarks

Many authors studied the evolutionary relations of the *Neocricetodon* species and gave comparisons: Daxner-Höck (1992, 1995), Daxner-Höck and Höck (2015), Freudenthal and Kordos (1989), Sinitza and Delinisch (2016), Wu (1991). After the investigation of the *Neocricetodon* population from Csodabogyós Cave, we believe that this material has only regional, Central European importance. Because of this, we focus on the comparison to the Central European Turolian *Neocricetodon* assemblages (Tabs 2, 3).

The comparison is based on the direct study of the material of Kohfidisch and Eichkogel in the collection of the Naturhistorisches Museum Vienna in 1997 by JH, and the direct study of the type material of *Neocricetodon skofleki* in the collection of the SZTFH = Szabályozott Tevékenységek Felügyeleti Hatósága (earlier Hungarian Geological Institute; V14063, V14064 and V14065) in 2024.

The length and width of the molars are almost exclusively normally distributed (Tab. 1). Small deviations were found only for M1 (L and W), M2 (W) and m2 (L). The normality of a measured variable is quite common in nature if it is a result of independent additive effects, whereas multiplicative effects lead to right-skewed log-normal distributions (see, e.g., Gaddum 1945, Grönholm and Annala 2007). This suggests that there was only one species of *Neocricetodon* in Csodabogyós Cave. The results of Welch's t-test show that at a 95 % confidence level ($p < 0.05$ for all pairs), the mean size of all four sites differs from each other. The size parameters (L, W) of the *Neocricetodon* population of Csodabogyós Cave fall between those of the Kohfidisch and Eichkogel/Tardosbánya material for all teeth. The result of the cluster analysis (based on the the size parameters, L and W) is ambiguous; it varies depending on which molars are being studied. From the *Neocricetodon* material of Csodabogyós Cave, the cluster analysis places M1, M2 and m2 in a cluster with the Kohfidisch *N. fahlbuschi* material, whereas M3 and m1 are placed together in a cluster with the Eichkogel and Tardosbánya *N. skofleki* material (Text-fig. 3).

In Tables 2, 3 we give a comparison of the morphological characters of the *Neocricetodon* populations from Kohfidisch, Eichkogel, Tardosbánya and Csodabogyós Cave. Among the studied 30 characters, 12 are common or close among Eichkogel, Tardosbánya and Csodabogyós Cave. 14 characters are unsuitable for any distinction. There is no character that is clearly common among Kohfidisch and Csodabogyós Cave. On this basis, we classified the population of Csodabogyós Cave as *Neocricetodon cf. skofleki*.

Some European *Neocricetodon* species are not involved in the detailed comparison; we only briefly mention those important characters in the distinction from *N. skofleki*.

Neocricetodon moldavicus from the MN 10 faunas of Calfa and Bujor, Moldova. In the M1, the mesoloph is moderately developed, the anteromesoloph (labial spur of the anterolophule) is weak, protolophule I is absent or short. In the m1, the mesolophid is short or medium length, and the ectomesolophid is indistinct.

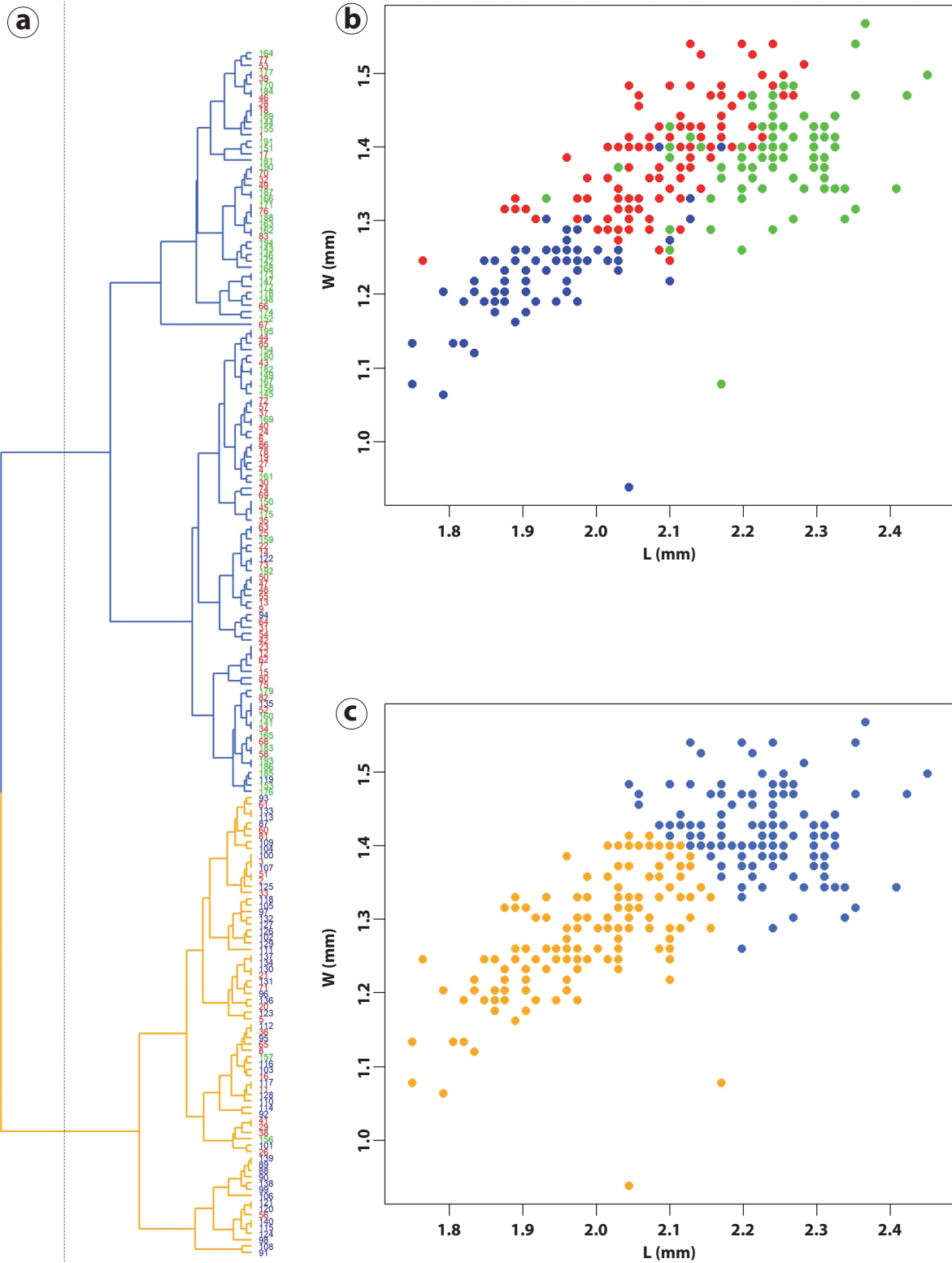
Neocricetodon ambarrensis from the MN 10 fauna of Ambérieu 2C, Ain, France. It has smaller mean dental measurements, moderately developed mesolophs in M1 and moderately developed mesolophids in m1.

Neocricetodon occidentalis from the MN 11 fauna of Crevillente 2, Spain. It has larger mean measurements.

Neocricetodon progressus from the MN 11 fauna of Palievo, Southern Ukraine. M2, M3 and m1 are narrower, m2 is shorter, mesoloph and mesolophids and anteromesoloph are reduced, three-part anterolophid is absent (Sinita 2012, Sinita and Delinisch 2016).

Neocricetodon browni from the MN 13 fauna of Maramena, Thrace, Greece. It has wider anterocones in M1 and wider anteroconids in m1.

Neocricetodon nestori, from the MN 13 fauna of Baccinello 1, Tuscany, Italy. The anterocones and anteroconids are divided, three-part anteroconid is absent, ectomesolophids are absent.



Text-fig. 3. Results of cluster analysis. a: Dendrogram based on size parameters (L and W) of m1 teeth. See figures (b) and (c) for explanation of colours. b: Size distribution of m1 teeth of Csodabogyós Cave (red), Eichkogel (blue) and Kohfidisch (green) sites. c: Size distribution of m1 teeth of two main clusters (orange and light blue).

Table 2. Comparison of morphological characters of upper molars of four Central European MN 11–12 *Neocricetodon* populations. Data after Kordos (1987), Daxner-Höck and Höck (2015) and personal observations of JH.

Character	<i>N. fahlbuschi</i> Kohfidisch	<i>N. skofleki</i> Tardosbánya	<i>N. skofleki</i> Eichkogel	Csodabogyós Cave
enamel	thick enamel, predominantly in the labial walls	thin enamel, weak low cingula	thin enamel, weak low cingula	thin enamel, weak low cingula
valleys	narrow	wide	wide	narrow and wide specimens equally occurred
M1 roots	furrowed ling. roots 46%, 4 roots 54%	3 roots, sometimes furrowed ling. roots	3 roots, sometimes furrowed ling. roots	3 roots 74 %, grooved ling. roots 15 %, 4 roots 11 %
M2 roots	4 roots	4 roots	4 roots	4 roots
M3 roots	3 roots	3 roots	3 roots	3 roots
M3/m3	comparatively large	comparatively small	comparatively small	comparatively small
M1 anteromesoloph	long 32 %, medium or short 24 %, absent 44 %	long 83 %, medium or short 0 %, absent 17 %	long 61 %, medium or short 23 %, absent 16 %	long 86 %, medium or short 14 %, absent 0 %
M1 labial anteroconule	69 % isolated cusp with anterolophule, 31 % without anterolophule but with anterior connection with the lingual anteroconule	100 % isolated cusp, having labial anterolophule	isolated or connected with the anteromesoloph, anterolophule or paracone	36 % with anterolophule and with anterior connection, 49 % without anterolophule but with anterior connection with the lingual anteroconule, 8 % with anterolophule and without anterior connection
M1 lingual anterolophule	69 % present	?	30 % present	46 % present
M1 mesoloph	long 38 %, short 49 %, absent 14 %	long 100 %, short or medium 0 %	long 86 %, short or medium 14 %	long 90 %, medium 10 %
M1 protolophule	double 71 %, only posterior 29 %	?	double 64 %, only posterior 36 %	double 67 %, only posterior 33 %
M1 metalophule	double 43 %, only posterior 57 %	double 13 %, only posterior 87 %	double 70 %, only posterior 30 %	double 12 %, only posterior 88 %
M2 mesoloph	long 53 %, short to almost absent 47 %	long 100 %	long 65 %, middle dev. 35 %	long 100 %
M2 protolophule	double	double 100%	double 98%, only anterior 2%	double 100%
M2 metalophule	double 84 %, anterior 16 %	only anterior 17 %, double 56 %, only posterior 27 %	double 62.5 %, only posterior 37.5 %	double 72 %, only posterior 28 %
M3 lingual anteroloph	present 64 %, absent 36 %	?	?	present 99.5 %
M3 mesoloph	long, reaches the lab. margin 9 %, middle dev. 20 %, short 4 %, absent 5 %	long, reaches the lab. margin 28 %, middle dev. 43 %, short 7 %, absent 14 %	long, reaches the lab. margin 18 %, middle dev. 51 %, short 8 %, absent 21 %	long, reaches the lab. margin 26 %, middle developed 66 %, short 3 %, absent 5 %
M3 metacone	prominent 36 %, part of the posteroloph 29 %, intermediate 36 %	prominent 69 %, part of posteroloph 31 %	prominent 8 %, part of posteroloph 92 %	prominent 34 %, part of the posteroloph 60 %, intermediate 5 %

Neocricetodon polonicus, from the MN 14 fauna of Podlesice, Poland. It has smaller dental measurements.

Neocricetodon magnus, from the MN 14 fauna of Podlesice, Poland. It has larger mean dental measurements.

Neocricetodon intermedius from the MN 15 fauna of Ivanovce, Slovakia. The M1 anterocone is deeply split and the number of the roots is always four.

A short historical overview of the study on the Turolian *Neocricetodon* materials from Austria and Hungary

Bachmayer and Wilson (1970) described the “*Kowalskia*” *fahlbuschi* n. sp. from Kohfidisch.

Daxner-Höck (1972) published “*Kowalskia*” cf. *fahlbuschi* from Eichkogel.

Table 3. Comparison of morphological characters of lower molars of four Central European MN 11–12 *Neocricetodon* populations. Data after Kordos (1987), Daxner-Höck and Höck (2015) and personal observations of JH.

Character	<i>N. fahlbuschi</i> Kohfidisch	<i>N. skofleki</i> Tardosbánya	<i>N. skofleki</i> Eichkogel	Csodabogyós Cave
m1 anteroconid	double	2–4 anteroconulids	simple 17 %, double 79 %, 3 parted 4 %	simple 1 %, double 82 %, 3 parted 16 %
m1 anterolophulid	double 40 %, labial stronger 20 %, lingual stronger 40 %	double 60 %, labial 12 %, lingual 8 %, weak or absent 20 %	double 74 %, simple labial 26 %	double 88 %, simple 12 %
m1 mesolophid	weak but long 70 %, shorter 30 %, rarely absent	long 96%	long 90 %, middle dev. 10 %	long 100%
m1 ectomesolophid	present 8 %	present 12 %	present 19 %	present 17 %
m1 metalophulid, hypolophulid	anterior	anterior	anterior	anterior
m2 metalophulid, hypolophulid	anterior	anterior	anterior	anterior
m2 mesolophid	low but long 81 %	long 100 %	long 99 %, middle developed 1 %	long 100 %
m2 ectomesolophid	present 3 %	present 7 %	present 37 %	present 30 %
m3	frequently longer than m2, almost as long as m1	not longer than m2	not longer than m2	not longer than m2
m3 mesolophid	long 38 %, short and touching the metaconid or otherwise low 62 %	long 43 %	long 58 %, middle dev. 42 %	long 57 %, middle dev. 43 %
m3 ectomesolophid	present 9 %	present 5 %	present 7 %	present 11 %
m3 entoconid	large independent cusp 60 %, swelling at the end of the long hypolophid 10 %, intermediate 30 %	weak or absent		reduced, swelling at the end of the hypolophid

Kordos (1987) described “*Karstocricetus*” *skofleki* from Tardosbánya, Hungary. In this publication, he realized the identity of the cricetid materials from Eichkogel and Tardosbánya.

Freudenthal and Kordos (1989) described “*Cricetus*” *polgardiensis* from the Late Miocene (MN 13) karstic fissures of Polgárdi (Hungary), and emphasized the close relation of the cricetid populations from Tardosbánya and Polgárdi.

Daxner-Höck (1992) accepted the above-mentioned view of Kordos (1987); she classified the populations of Tardosbánya and Eichkogel as “*Kowalskia*” *skofleki* and defined the differences between “*Kowalskia*” *fahlbuschi* from “*Kowalskia*” *skofleki* as follows:

- larger mean measurements of *K. fahlbuschi*;
- the teeth are more robust, the enamel is stout, especially in the labial margin of the teeth, and in the labial margin of the sinuses. The sinuses are narrow;
- there is a tendency for shortening of the mesolophids (the length is variable from short to long);
- anterolophule labial spur (anteromesoloph) is relatively rare. Other secondary ridges in the anterosinus and the protosinus are not found;
- M3 and m3 are relatively long, the posterior width is less reduced;

– posterior metaloph in M1/M2 is mainly absent in “*K.*” *fahlbuschi*.

Daxner-Höck and Höck (2015) gave a synthesis of the Austrian Neogene rodent faunas and declared that there are two “*Kowalskia*” species in the fauna of Kohfidisch: “*K.*” *fahlbuschi* and “*K.*” *skofleki*. The ratio of the occurrences of the two species is 10 : 1. In the list of the Eichkogel fauna they indicated only “*K.*” *skofleki*.

Sinitza and Delinisch (2016) performed the cladistic analysis of 15 *Neocricetodon* species. They found that *N. skofleki* can be grouped with the advanced *Neocricetodon* species, together with *N. browni*, *N. polgardiensis*, and *N. similis*. At the same time, *N. fahlbuschi* is positioned in a sister clade with *N. hanae*.

Conclusions

An extremely rich microvertebrate fauna was collected by the authors in 2023 from Csodabogyós Cave, close to the village Balatonedics. Based on the composition of the assemblage, we classified the biochronological position as Late Miocene, Turolian, MN 11 Zone, 8.7–7.7 Ma.

The systematic position of the *Neocricetodon* population from Csodabogyós Cave can be classified based on the following facts:

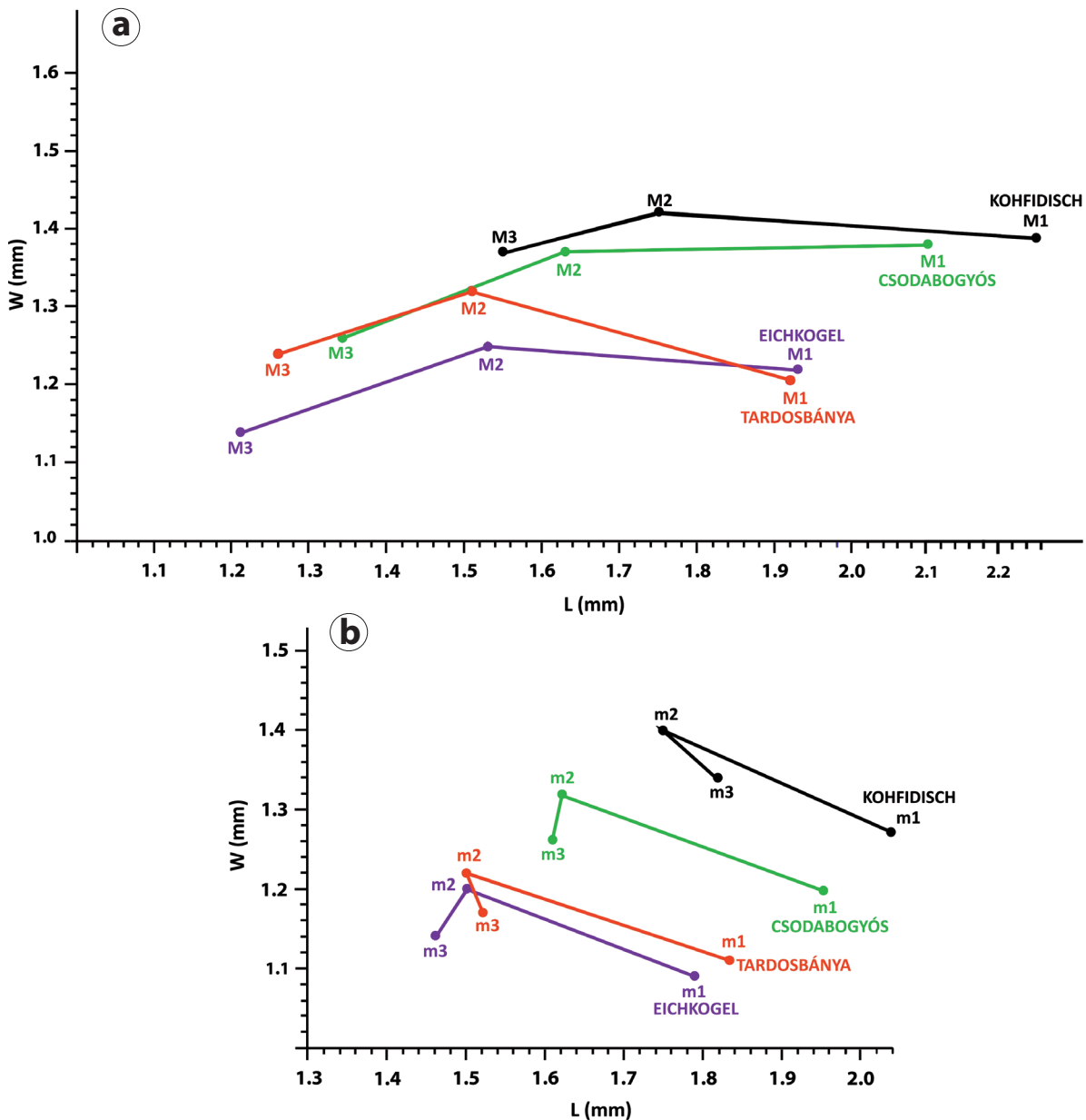
1. On scatter plots, the ranges of Csodabogyós Cave population overlap with those of other Central European populations (Text-figs 1, 2). On the plots of mean values (Text-fig. 3), the position of the specimens from Csodabogyós Cave is located between those from Kohfidisch and Tardosbánya.

2. Among the studied 29 morphological characters (Tabs 2, 3), 12 are closer to *N. skofleki*.

According to Daxner-Höck (1995) in Central Europe, there are at least two lineages of *Neocricetodon*. The first one starts with *N. fahlbuschi* (Kohfidisch, MN 10), leading to *N. polgardiensis* (Polgárdi 4, MN 13). The molar pattern of *N. fahlbuschi* is characterized by large and complex last molars and the tendency to split the lingual root of the M1. The mesoloph/mesolophid is of medium length, rarely long, and the posterosinus and the posterior metalophule

in M1–2 are frequently absent. This tendency continues in *N. polgardiensis*.

The second lineage is represented by *N. schaubi* (Csákvár, MN 11) and *N. skofleki* (Eichkogel, MN 11 and Tardosbánya, MN 11) in the Turolian, by the Pliocene modernized species *N. polonicus* and *N. magnus* (Podlesice, MN 14), *N. intermedius* (Ivanovce, MN 15), and by the late Turolian/Ruscinian *N. browni* (Maramena, MN 13/14), which is slightly larger but morphologically close to *N. skofleki*. This second lineage is characterized by long and strong mesoloph/mesolophids, by the tendency to build extra ridges in the sinuses and sinusids, rather three than four roots in the M1, and by a posterosinus. The population from Csodabogyós Cave may be an early representative of *N. skofleki* because of the less divided anterocones and anteroconids on M1/m1s.



Text-fig. 4. L/W mean values of *Neocricetodon* molars from Kohfidisch, Tardosbánya, Eichkogel and Csodabogyós Cave. a: upper teeth, b: lower teeth.

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Explanations of the plate

PLATE 1

Neocricetodon cf. *skofleki*, Csodabogyós Cave

1. M1, VER 2024.481.33.
2. M1, VER 2024.481.37.
3. M1, VER 2024.481.38.
4. M1, VER 2024.481.36.
5. m1, VER 2024.484.25.
6. m1, VER 2024.484.61.
7. m1, VER 2024.484.24.
8. m1, VER 2024.484.45 reversed.
9. M2, VER 2024.482.42.
10. M2, VER 2024.482.10.
11. m2, VER 2024.485.44 reversed.
12. m2, VER 2024.485.46.
13. M3, VER 2024.483.35.
14. M3, VER 2024.483.80.
15. M3, VER 2024.483.48 reversed.
16. m3, VER 2024.486.27.



1



2



3



4



5



6



7



8



9



10



11



12



13



14



15



16

1 mm