

FISH OTOLITHS AND FORAMINIFERA FROM THE BORSKÝ MIKULÁŠ SECTION (SLOVAKIA, MIDDLE MIOCENE, UPPER BADENIAN, VIENNA BASIN) AND THEIR PALEOENVIRONMENTAL SIGNIFICANCE

ROSTISLAV BRZOBOHATÝ^{1*}, BARBARA ZAHRADNÍKOVÁ² & NATÁLIA HUDÁČKOVÁ³

¹*Corresponding author. Department of Geology, Masaryk University, 61137 Brno, Kotlářská 2, Czech Republic. E-mail: rosta@sci.muni.cz

²Slovak National Museum, Natural History Museum, Vajanského nábr. 2, P.O.BOX 13, 810 06 Bratislava, Slovakia.

E-mail: barbara.zahradnikova@snm.sk

³Department of Geology and Paleontology, Comenius University, 842 15 Bratislava, Mlynská dolina, Ilkovičova 6, Slovakia.

E-mail: natalia.hudackova@uniba.sk

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Abstract. Thirty-eight otolith-based species of fishes and 41 foraminifera species have been recorded in the Borský Mikuláš-Vinohrádky section in the upper Badenian deposits in the eastern part of the Vienna Basin, in West Slovakia. Two new species of otoliths are introduced here: *Tborogobius antirostratus* n. sp. and *Gerres mlynskýi* n. sp. Among the foraminifera *Biasterigerina planorbis* and *Elphidium crispum* associated with other elphidiids, *Lobatula lobatula* and *Cibicides crassiseptatum* prevail. Overall, the family of Gobiidae dominate in the assemblage of otoliths (>90 % of specimens). Meso- and epipelagial fishes or diversified gadids and sciaenids are missing. From the molluscs, the first record of *Aturia* sp. in the Borský Mikuláš section is observed.

Otoliths and foraminifera document a normal marine environment of well-aerated shallow water with a depth of 30-50 metres, with muddy to sandy bottoms of marine meadows and plenty of light in the subtropical climatic conditions. Several fish genera (for example *Gerres*) give evidence for the nearness of reef structures. There are no species (excepting *Lesueurigobius vicinalis*) in common with the known Lower Serravallian otolith fauna from the Eastern Paratethys. Some species from the Borský Mikuláš-Vinohrádky section can also be found in the Mediterranean Langhian-Serravallian interval and are interpreted as a relic of the lower Badenian (Langhian) fish assemblages.

INTRODUCTION

Badenian otoliths have been discovered in the Slovakian, Austrian and Czech parts of the Vienna Basin to differing degrees. Younger deposits mostly overlay basal lower and upper Badenian deposits, and our knowledge of otoliths originates mainly from boreholes, e.g. Brzobohatý & Stráník (2012). Some upper Badenian deposits are uncovered at

the periphery of the basin and contain larger otolith associations. Early studies of Badenian otoliths from the Vienna Basin were published by Prochazka (1892a, b), Toulá (1900), and Schubert (1902, 1905, 1906a,b, 1912). They mainly dealt with otoliths from the whole of the Badenian ('II. mediterranean', 'Tortonian'). Subsequent studies dealing with otoliths from the upper Badenian, were published much later (Slovak part of the basin: Holec 1973, 1975, 1978a,b, 2001; Chalupová 2001, 2003; Zahradníková 2012; Austrian part of the basin: Bachmayer & Weinfurter 1965; Weinfurter 1967; Brzobohatý 1978, 1994, 1995;

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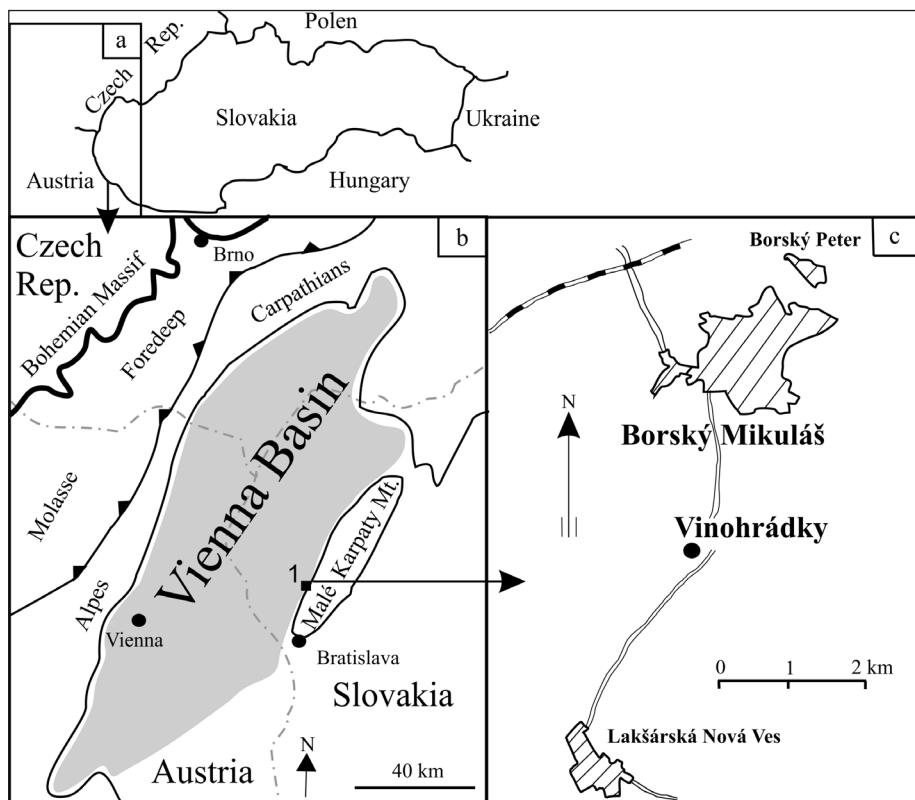


Fig. 1 - Geographical (a, c) and geological (b) position of Borský Mikuláš-Vinohrádky locality (1).

Czech part of the basin: Brzobohatý et al. 2007). Badenian otoliths from the Vienna Basin are also discussed or mentioned in Brzobohatý & Schultz (1978), Nolf (1981), Schultz (2013) and (as gobiids) in Schwarzhans et al. (2020b).

In the present paper, we provide data recorded from the upper Badenian locality of Borský Mikuláš-Vinohrádky, which lies in the eastern border region of the Slovak part of the basin at the foot of the Malé Karpaty Mountains (Fig. 1). The otoliths from this locality have been described or mentioned in several studies. The first is the work of Holec (1978a), where the author deals with this location among other sites of the Vienna Basin and determines the otoliths here belong to the following genera and species: ‘*Mugil* sp., *Pristipoma arcuata* (Bassoli & Schubert, 1906), *Sparus doderleini* (Bassoli & Schubert, 1906), *Dentex speronatus* (Bassoli, 1906) and *Otolithus (Sparidarum) vöslauensis* (Schubert, 1906)’. In an unpublished study, Holec (1978b) also reports from this site, in addition to the species mentioned above, otoliths belonging to ‘*Dentex latior* (Schubert, 1906) and *Gobius vicinalis* Koken, 1891’. Holec determines the environment as a neritic zone, close to the coast. He states that there is a massive occurrence of otoliths of the genus *Gobius*.

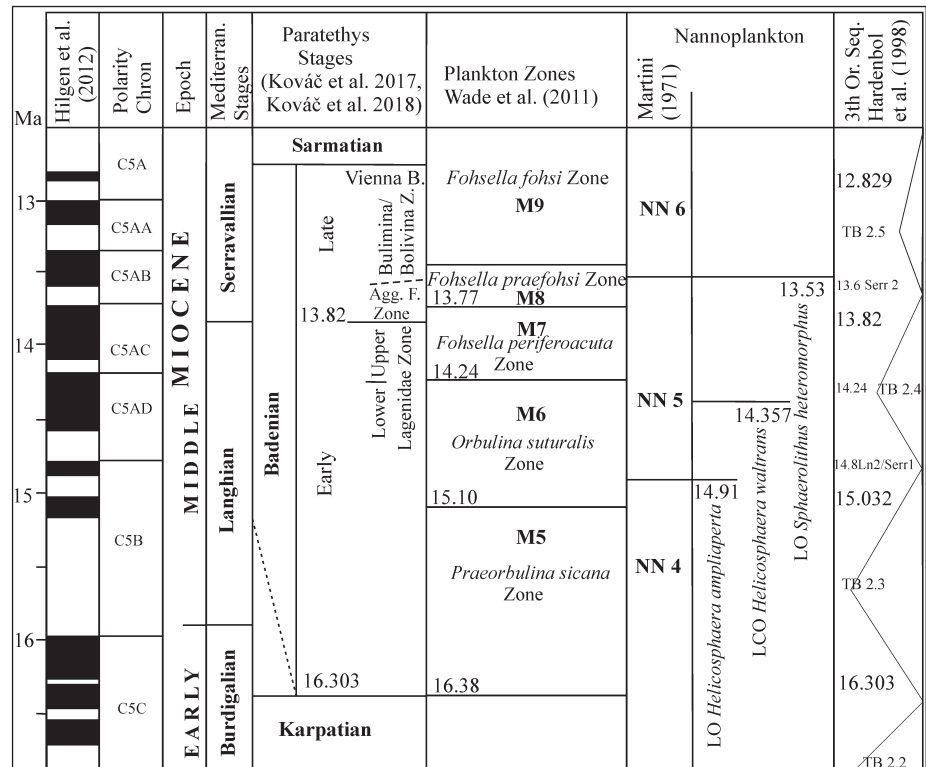
A second relevant article is by Zahradníková (2012), where the author compiles old informa-

tion and describes otoliths belonging to *Mugil* sp., *Brachydeuterus latior* (Schubert, 1906), *Sparus doderleini* (Bassoli & Schubert, 1906), *Boops insignis* (Prochazka, 1893), *Gobius vicinalis* Koken, 1891, *Gobius multipinnatus* (H. v. Meyer, 1852), *Gobius brevis* (Agassiz, 1839), *Acentrogobius* sp. and *Buglossidium frequens* Steurbaut, 1981.’ One specimen by the name of ‘*Gobius multipinnatus* (H. v. Meyer 1852)’ is from the same locality as that pictured by Schwarzhans (2014, pl. 9, fig. 1). It is necessary to mention here that *G. multipinnatus* is an invalid name - for more on this, see Gierl & Reichenbacher (2015).

An abundant marine mollusc community has also been reported here. Švagrovský describes some 93 gastropod and 38 bivalve species or subspecies identified from thin layers of fine-grained brown sands. However, because of their occurrence over a long range, these could not be used for a detailed stratigraphic assessment. From a paleoecological point of view, a lowering of salinity is assumed based on dwarf forms of about 20 marine molluscs species and shallow water sublittoral conditions.

It is the objective of this work to study the newly obtained rich material of otoliths (~6000 specimens) collected by Tomáš Mlýnský, the curator of the Balneological Museum Imricha Wintera in Piešťany, Slovakia).

Fig. 2 - Stratigraphic chart of the Badenian and the Vienna Basin regional stratigraphy.



GEOLOGICAL SETTING

The area of study near the village of Borský Mikuláš, is situated in the Slovak part of the pull-apart Vienna Basin which paleogeographically, is the northern part of the Central Paratethys. It lies within the Alpine-Carpathian mountain belt between the Eastern Alps and Western Carpathians (Fig. 1).

We follow here the division of the Badenian into two substages, the lower and upper Badenian, as presented for example by Kováč et al. (2017). The lower Badenian correlates with the Langhian age and the upper Badenian with the lower Serravallian age the Global geological time scale (Fig. 2).

The locality of Borský Mikuláš-Vinohrádky is a small outcrop located in the area of the lowland Záhorská nížina, southwest of the town of Senica. It is situated at a spring within vineyards, about 200 m from Kote 257 Vinohrádky (Fordinál et al. 2014), coordinates: 48° 36' 22.64'' N, 17° 11' 59.66'' E, on the right side of the road from Borský Mikuláš to Lakšárska Nová Ves (Fig. 1c). The upper Badenian stratum forms the highest elevations of the Miocene since it is located on the tectonic unit known as the Lakšár Elevation. The Badenian sediments appear in an outcrop (Fig. 3) at a height of 2-3 metres. Sand and clay alternate

with sporadic layers of small to coarse-grained gravel. The gravel layers are 2-10 cm thick with a frequent normal grading of the clastic material. Noticeable too is an oblique layering of sand and gravel. The predominantly rounded pebble material of the fine-grain gravel is relatively well-sorted with a predominance of quartz, quartzite, and chert. Coarser grains of different varieties

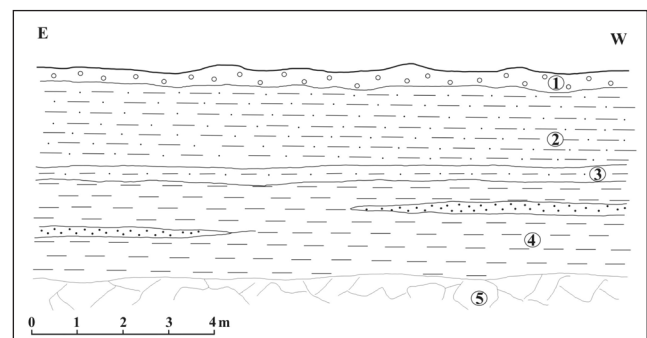


Fig. 3 - The lithofacial development of sediments in a schematic profile of the locality Borský Mikuláš-Vinohrádky. 1) The arable land with pebbles of pebbly and calcareous rocks. Thickness about 0.5 m. 2) Grey-brown fine-sandy clay to claystone with mollusc fauna, approx. 1.5 m thick. 3) Grey-brown clayey sands with rich mollusc fauna, approx. 0.3 m thick. 4) Grey, fine-sandy, strongly calcareous clays with layers and lenses of big fine-grained sands. Macrofauna was not found in them. Approx. 2.0 m thick. 5) Debris cone of weathered and decayed rocks of the outcrop (after Švagrovský 1981).

contain well-rounded pebble material, mainly limestones and dolomites, mostly of Triassic age. There are also Jurassic and Lower Cretaceous limestones, quartzites, cherts, quartz, sandstones, and unique pebbles of granitoids and basic volcanites (Baráth et al. 1994).

In the lower layers, the grey and grey-brown calcareous, moderately fine-sandy, stratified clays to slatey, disintegrating clay stones with layers and lenses of fine-grained brown sands occur. The psammites occur more frequently in the upper layers of the pelites, which then reach a thickness of about 2 m (Fig. 3, layer 4). The pelites gradually turn into yellow-brown and grey-brown clayey sands with a thickness of approximately 0.30 m (Fig. 3, layer 3) and, higher up, into sandy clays with a thickness of approximately 1.50 m (Fig. 3, layer 2). In the slope of this layer, there is sandy loam, locally with pebbles of early Miocene (Karpatian) age (Fig. 3, layer 1). The entire sequence is approximately horizontal (Švagrovský 1981). These deposits belong to the Studienka Formation, changing to the sand facies with algae bioherms of the Sandberg Member (Baráth et al. 1994). Both corresponds to the *Bolivina-Bulimina* Ecozone level of the Central Paratethys regional biostratigraphy, changing at the margin of the basin into shallower or brackish/freshwater deposits with *Ammonia* (Fig. 2). Strontium isotopic data obtained from the gastropod *Diloma* sp. (Fordinál et al. 2014) demonstrate a normal marine salinity and an age of 12.63-12.90 Ma (uppermost Badenian = top of lower Serravalian; the middle part of zone NN6). Otoliths have been found in layers 2 and 3 of the study strata. *Glycymeris pilosus* L., *Cardita jouaneti* Bast., *Ostrea digitalina* Eichw. and other molluscs and foraminifera, have been found together with fish remains. The abundant macrofauna remnants have been compiled by Švagrovský (1981, 1982a, b, 1984). Most of the mollusc fauna obtained from the locality are euryhaline taxa, which have persisted to this day. Based on the association of purely stenohaline species, we can assume a lower limit of normal marine salinity (30‰). In our assessment, the environment most likely was a flat sublittoral, specifically a euphotic zone. The seawater was mixed, well aerated, suitable for both stenooxybiontes as well as for euryoxybionts, which lived in the substrate. The inner parts of the nautiloid *Aturia* were recorded for the first time from this locality.

MATERIAL AND METHODS

The otoliths were obtained by screen-washing 300 kg of the sediment using a 0.4 mm mesh. They were then examined using a Wild Heerbrugg microscope. The systematic and quantitative distribution of taxa is given in the next chapter and in Fig. 4. The association has been analysed using the paleobathymetric method for otoliths proposed by Nolf & Brzobohatý (1994) (Fig. 6). All otolith-based species from the studied locality are listed and figured, and the two new species are described in full and a complete documentation of their ontogeny is included. The classification used is that of Nelson et al. (2016).

Foraminifers were obtained from five samples using standard separation methods (Kováčová & Hudáčková 2009) from 200 g of dried material. The washed residua were microsplit down to an amount containing c. 250 benthic specimens. All benthic foraminifera (>71 µm) were picked from the split, mounted on faunal slides, identified, and counted. Planktic ones were extremely rare in the samples (Fig. 8). A combination of a binocular stereoscopic microscope, a biological polarizing microscope and a scanning electron microscope were used for determination and imaging of foraminifers.

The taxonomical approach followed that of Loeblich & Tappan (1992) and Cicha et al. (1998). Paleoecological parameters of the obtained foraminiferal assemblages were evaluated based on the presence and dominance of those taxa exhibiting special environmental significance (Boltovskoy & Wright 1976; Langer 1993; Murray 2006). The paleoenvironmental interpretation of the benthic foraminiferal assemblages is based on the dominance of ecological indices and morphological groups (Langer 1993) and based on diversity (Simpson diversity and Shannon_H diversity) study (Murray 1973, 2006). A Bray Curtis similarity index with a paired group algorithm was used for clustering of samples using the PAST program (Hammer et al. 2001). The two-step method developed by Hohenegger (2005) was used to estimate the paleowater depth of the sedimentary basin. Depth ranges of the foraminifers were adapted from Murray (2006) and Sgarrella & Montcharmont-Zei (1993).

SYSTEMATIC PALEONTOLOGY (OTOLITHS)

Abbreviations: OL = otolith length; OH = otolith high; OT = otolith thickness; x = inner face curvature; y = outer face curvature.

Remarks: all otoliths and foraminifera pictured in plates 1-5 come from the upper Badenian section at Borský Mikuláš-Vinohrádky, Vienna Basin, Slovakia. Plates 1-4 (otoliths): Figures with only one letter show inner views. In the captions, Le stands for left otolith and Ri for the right otolith. All figured specimens (Pl. 1-4) are deposited in the collections of the Natural History Museum (NHM), Bratislava, Slovakia (Inv. Nr. Z 28227 - Z 28281). Pl. 5 (foraminifera): white measure bar represents 100 µm. SEM – QUANTA FEG 250, operated by I. Kostič.

Selected comments on specific taxa

Panturichthys subglaber (Schubert, 1906). A single slightly corroded left otolith (Pl. 1, Figs. A, B). The species occurs relatively rarely in shallow deposits of the lower and upper Badenian (Upper Lagenidae Zone to Bolivina-Bulimina Zone) of the Central Paratethys (Styrian and Vienna basins,

Carpathian Foredeep in Poland) (Schubert 1906a,b; Radwańska 1992; Brzobohatý 1994; Brzobohatý et al. 2007; Nolf & Brzobohatý 2009) and in the Middle Miocene of Portugal, Aquitaine, and the Mediterranean Miocene and Pliocene (Steurbaut 1984).

Encheliophis sp. (Pl. 1, Figs. I, J). A single corroded and thin left otolith with a narrow sulcus. It seems to be closely related to *E. woltrupensis* Schwarzhans, 2010 from the Middle Miocene of the Nord Sea Basin.

Gobius aff. *niger* Linnaeus, 1758 (Pl. 1, Figs. V, W, X; Pl. 1, Figs. V, W - OL = 2.7 mm, OH = 2.35 mm, OT = 0.65 mm; OL:OH = 1.15). Most of the 125 specimens of these otoliths are not perfectly preserved. Perspicuous praeventral tip, protruding postdorsal part and straight and smooth ventral margin of otolith and elongated elliptic subcaudal iugum lying in the forepart of cauda correspond with the morphology of the recent species *G. niger* (e.g. Nolf et al. 2009, pl. 125; Nolf 2018, pl. 75; Lombarte et al. 2018, fig. 3i; Gut et al. 2020, figs. 5g-i). But the predorsal part of the otoliths of the recent species is mostly more convex. Fossil otoliths described as *G. aff. niger* are mentioned from the Badenian of Poland (Radwańska 1992, p. 286, pl. 35, figs. 12-15; now synonymised with *G. reichenbacheri* Schw., Schwarzhans et al. 2020b) and from the lower Badenian of Romania (Bosnakoff 2011, fig. 6i - see below *Thorogobius iucundus*). Otoliths pictured as *G. multipinnatus* (H.v.M.) by Reichenbacher & Cappetta (1999, Lower Miocene, South France, pl. 3, figs. 6 and 7, non 8, 9, 10) and by Brzobohatý et al. (2007, pl. 8, figs. 6-8) seem to be also very close to our otolith set. Otoliths of recent *Gobius gasteveni* Miller, 1974 (e.g. Nolf 2018, pl. 74; Gut et al. 2020, fig. 3i, j) have a more convex dorsal part and a longer and outstanding postcaudal iugum running under nearly the whole cauda.

Gobius supraspectabilis Schw., Brz., Radw. & Proch., 2020 (Pl. 4, Figs. W, X, Y, Z). These 25 specimens represent the variability of the species very well. But the largest (Pl. 4, Figs. W, X) conspicuously exceeds (OL = 4.1 mm) the dimensions given in the description of the species (OL = 2.8 mm). One specimen (Pl. 4, Fig. Z) has a relatively outstanding subcaudal iugum. *G. supraspectabilis* has until now been relatively rarely documented in the four upper Badenian localities of the Vienna Basin.

Lesueurigobius magniungis Schwarzhans, 2017 (Pl. 1, Figs. K, L). The 25 specimens, which measure be-

tween 2.6 and 1.5 mm in length, represent the variability described by Schwarzhans et al. (2020b). Typical features such as the dorsally shifted predorsal angle, the wide sulcus in the ostial part, and the wide subcaudal iugum are expressed mainly by adult otoliths. Several juvenile specimens have an intimated praeventral tip. The species is known from the lower and upper Badenian of Poland (Carpathian Foredeep - Niskowa, Rybnica), Moravia and Slovakia (Vienna Basin), and Romania (Transylvanian Basin).

Lesueurigobius suerii (Risso, 1810) (Pl. 1, Figs. E-H; OL = 2.7 mm, OH = 2.7 mm, OT = 0.8 mm; OL:OH = 1.0). A total of 103 specimens, mostly well-preserved otoliths. Their morphology and the profile of the outer face fully correspond with the recent species *L. suerii*. This agreement is emphasized by the egg-shaped, broad subcaudal iugum (see e.g. Nolf & Girone 2000, pl. 2, figs. 7-12; Schwarzhans 2014, pl. 11). Fossil otoliths of the species have been depicted from the upper Badenian of the Vienna Basin by Brzobohatý (1983) - as *Pomatoschistus vicinalis*, and Holec (2001) - as *Gobius vicinalis*, and described from the Mediterranean Pliocene (Nolf & Girone 2000, pl. 2, figs. 7-12) and Pleistocene (Agiadi et al. 2019, fig. 4M; Agiadi et al. 2020, ?fig. 3p), Serravallian of the Karaman Basin (S-Turkey, Schwarzhans 2014, pl. 11, figs. 4-13) and the pre-upper Tortonian, pre-evaporitic Messinian and Zanclean of the Mediterranean (Schwarzhans et al. 2020a).

Lesueurigobius vicinalis (Koken, 1891) (Pl. 1, Figs. N-P). ~2,900 specimens. A rich collection of juvenile and adult otoliths (see also Zahradníková 2012, p. 42, text-fig. 5 and *Acentrogobius* sp., p. 44, text-fig. 8) conforms to the association of *L. aff. vicinalis* otoliths from the Badenian of the Vienna (Brzobohatý et al. 2007) and Styrian (Nolf & Brzobohatý 2009) basins very well. The species is common and widespread in shallow-water deposits of the uppermost Lower Miocene (Karpatian) and the lowermost Middle Miocene (Badenian) of the Paratethys. Further confirmed records are in the Lower Miocene of Portugal, Lower to Middle Miocene of the Aquitaine Basin, and the Hemmerian of the North Sea Basin (more see in Schwarzhans et al. 2020b).

Thorogobius iucundus Schwarzhans, 2014 (Pl. 1, Figs. R-U). The variability of these 100 otoliths corresponds to the variability of the type assemblage from the Serravallian of the Karaman Basin (Schwarzhans 2014, pl. 13, figs. 3-13) including the shape of the anterior margin of otoliths and characters of the sulcus

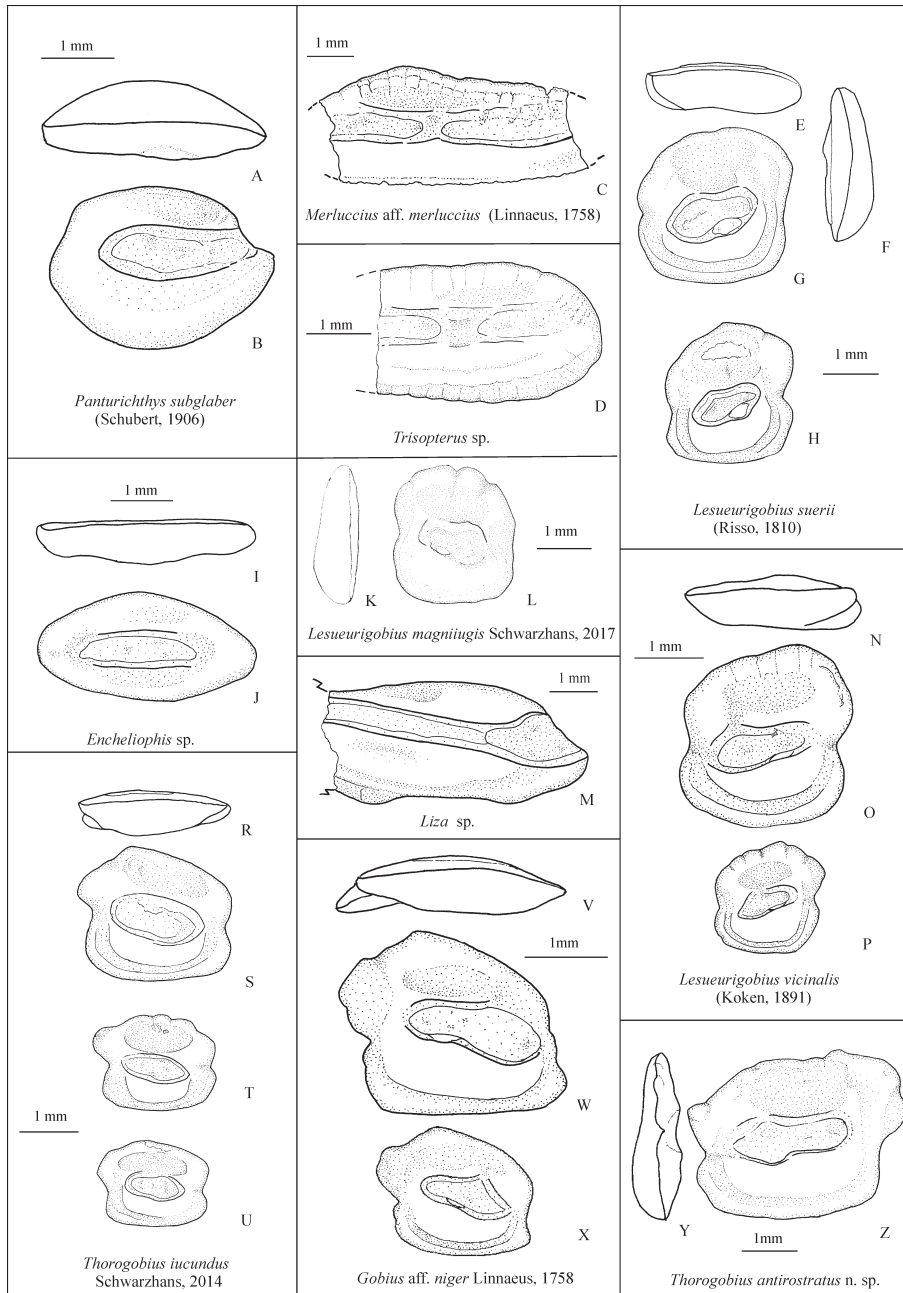


PLATE 1

- Figs. A, B - *Panturichthys subglaber* (Schubert, 1906), Le, A = ventral view, B = inner view, NHM Inv. Nr. Z 28227;
- Fig. C - *Merluccius* aff. *merluccius* (Linnaeus, 1758), Ri, NHM Inv. Nr. Z 28228;
- Fig. D - *Trisopterus* sp., Le, NHM Inv. Nr. Z 28231;
- Figs. E-H - *Lesueurigobius suerii* (Risso, 1810), Ri, E = ventral view, F = posterior view, G and H = inner view, NHM Inv. Nr. Z 28229-30;
- Figs. I, J - *Encheliophis* sp., Ri, I = ventral view, J = inner view, NHM Inv. Nr. Z 28233;
- Figs. K, L - *Lesueurigobius magniugis* Schwarzhans 2017, Le, K = posterior view, L = inner view, NHM Inv. Nr. Z 28232;
- Fig. M - *Liza* sp., Le, NHM Inv. Nr. Z 28234;
- Figs. N-P - *Lesueurigobius vicinalis* (Koken, 1891), Ri, N = ventral view, O, P = inner view, NHM Inv. Nr. Z 28240-41;
- Figs. R-U - *Thorogobius incundus* Schwarzhans, 2014, Le, R = ventral view, S-U = inner view, NHM Inv. Nr. Z 28235-37;
- Figs. V-X - *Gobius* aff. *niger* Linnaeus, 1758, Le, V = ventral view, W, X = inner view, NHM Inv. Nr. Z 28238-39;
- Figs. Y, Z - *Thorogobius antiostratus* n. sp., Le (reversed), Y = anterior view, Z = inner view, NHM Inv. Nr. Z 28242.

with the absence of a subcaudal iugum. Some of our adult specimens seem to be slightly thicker (OH:OT = 3.0) than the otoliths of the type assemblage.

A higher and well-rounded dorsal rim and a lower position of the postdorsal projection seem to differentiate otoliths of *T. incundus* from the '*Gobius*' *holcovae* Reich., Fil. & Miclea, 2019 described from the lower Sarmatian of the eastern Pannonian Basin. The absence of a subcaudal iugum and a wide and protruding postdorsal part differentiate *T. incundus* from the *Klincigobius serbiensis* (Gaudant 1998) described and revised with otoliths in situ from the lower Miocene of Serbia (Bradić-Milinović et al. 2019).

Thorogobius incundus is abundant in the uppermost lower Badenian of the Carpathian Foredeep in Poland - for example, in the Korytnica locality, described by Radwańska (1992) as *Gobius* sp. -, as well as in the uppermost lower and upper Badenian of the Vienna Basin (Brzobohatý et al. 2007 as *Priolepis* sp.), in the Serravallian of the Karaman Basin and possibly in the lower Badenian of Romania (Bosnakoff 2011, fig. 6i, as *Gobius* aff. *niger*).

Liza sp. There are eight small and corroded fragments of the 'mugilid' type. The best is a juvenile left otolith lacking the posterior part (Pl. 1, Fig. M). Its upper boundary of the ostium with stooping anterior part and a preserved section of cauda

resemble *L. steurbauti* Radwańska, 1984 from the Badenian of Poland. But the back part of its ventral rim is intensively protruding and differentiates our specimen not only from the above mentioned species but also from the corroded specimens from the Borský Mikuláš section described as '*Mugil* sp.' by Holec (1978a, p. 163, pl. 28, fig. 1) and by Zahradníková (2012, p. 39, text-fig. 1). This morphology could also be partly seen in *L. voesendorfensis* (Weinfurter, 1954) from the Austrian Pannonian or in the recent species *L. ramada* (Risso, 1826) (see Steurbaut 1984, pl. 29, fig. 23). The '*Mugil* sp.' specimen mentioned (Holec 1978a) differs from *L. steurbauti* otoliths by the slender bent of the caudal end and more concave ventral rim, including the rostral part. Mugilids are evidently represented by several species in the Paratethys during the Badenian.

Lepidorhombus sp. A left, thin, moderately elliptic otolith (Pl. 2, Figs. C, D; OL = 1.65 mm, OH = 1.25 mm, OT = 0.5 mm; OL:OH = 1.32). Anterior rim with small excisura and short rostrum, dorsal part of posterior rim oblique. Sulcus straight with shorter, narrower cauda and moderately wider and open ostium. Distinct circumsulcal depression close to the sulcus. Deep and wider ventral furrow in the middle part of the ventral field. Deep and sharply marked dorsal depression. Inner face regularly convex, outer face moderately convex in the posterior part, this specimen closely resembles *Lepidorhombus* otoliths - see, for example, the recent species *L. whiffagonis* (Walbaum, 1792) in Nolf (2013, pl. 342). There is the species *L. subtriangularis* Heinrich, 1970, known from the Badenian of the Central Paratethys (Schubert 1906a; Śmigielska 1974; Radwańska 1992; Schwarzhans 2010, pl. 114, figs. 1-11 - with synonymy). Our specimen seems to be close in appearance to the juvenile otolith pictured by Schwarzhans (2010, pl. 114, fig. 11). More adult specimens are required for an adequate taxonomic determination.

Pomadasys aff. *incisus* (Bowdich, 1825). There are 47 predominantly juvenile and corroded specimens. Only one adult otolith (Pl. 4, Figs. A, B) is well preserved (OL = 7.0 mm, OH = 5.2 mm, OT = 1.2 mm; OL:OH = 1.34). Its long and sharply bent posterior caudal part resembles also the extant otoliths of *P. argenteus* (Forsskal, 1775) or *P. stridens* (Forsskal, 1775) (see Nolf 2013, pl. 251 and Smale et al. 1995, pl. 83, figs. D1, 2 respectively). On the other hand, its ostium is more open, with an oblique downwards-tending lower boundary. This latter trait

can vary compared to, for example, *P. commersonnii* (Lacepède, 1801) (Smale et al. 1995, pl. 82, figs. F1 and F2). Despite this characteristic, our specimen is similar to those otoliths originally described as '*Pristipoma arcuata* (Bass. and Schub.)' by Weinfurter (1952, pl. 3, figs. 1, 2) from the youngest Badenian of the Styrian Basin and later by Holec (1978a, pl. 27, figs. 3, 4) from the Vienna Basin (Borský Mikuláš). Two adult Styrian otoliths are well preserved and have practically the same caudal morphology as our specimen but are relatively longer (OL:OH ~ 1.5) with a markedly protruding postdorsal point. Holec's exemplars are more corroded, with unclear ostial parts. The same could be stated for smaller otoliths described as '*Ot. (Sparidarum) voeslauensis* Schub.' (Holec 1978a, pl. 29, figs. 2, 3). Weinfurter's (1952) determination was later synonymised with *Pomadasys* aff. *incisus* as described by Steurbaut (1984). The same was accepted for the corroded otoliths of *Ot. (Sparidarum) voeslauensis* Schubert, 1906 from the Badenian of the Vienna Basin (see Nolf 1981) and the juvenile specimen of *Orthopristsis voeslauensis* (Schub.) pictured by Śmigielska (1973, pl. 2, fig. 3) from the Badenian of Poland (Steurbaut 1984). Schwarzhans (2010, p. 204) discusses the possibility that the otoliths mentioned by Weinfurter represent some different species as *P. incisus*. New material from Borský Mikuláš seems to support this idea, but insufficient adult and well-preserved otoliths do not allow for any more precise systematic conclusions.

Dicentrarchus sp. A single subadult otolith (Pl. 2, Figs. X, Y) and one fragment of the anterior part. The subadult specimen has a typical moronid sulcus and its whole morphology seems to be extremely close to the youngest otolith pictured as *Morone (Morone)* sp. from the Mediterranean Zanclean (Nolf 2013, pl. 204). Otoliths of both living European and Mediterranean species *D. labrax* (Linnaeus, 1758) and *D. punctatus* (Bloch, 1792) are more elongated with not so deeply convex a ventral rim (Tuset et al. 2008, figs. 46 A1-3 and B1-3). Moronid otoliths are very rare in the Badenian of the Central Paratethys. Two species are described in the Badenian of Poland. *Morone* aff. *labrax* from Rybnica is much longer and has a more horizontal dorsal rim (Radwańska 1992, pl. 18, figs. 6-7). *Morone* sp. from Korytnica (Radwańska 1992, pl. 18, figs. 8-11) differs clearly by its upper ostial rim. More adult specimens are needed to decide a systematic status of moronid otoliths from the studied locality.

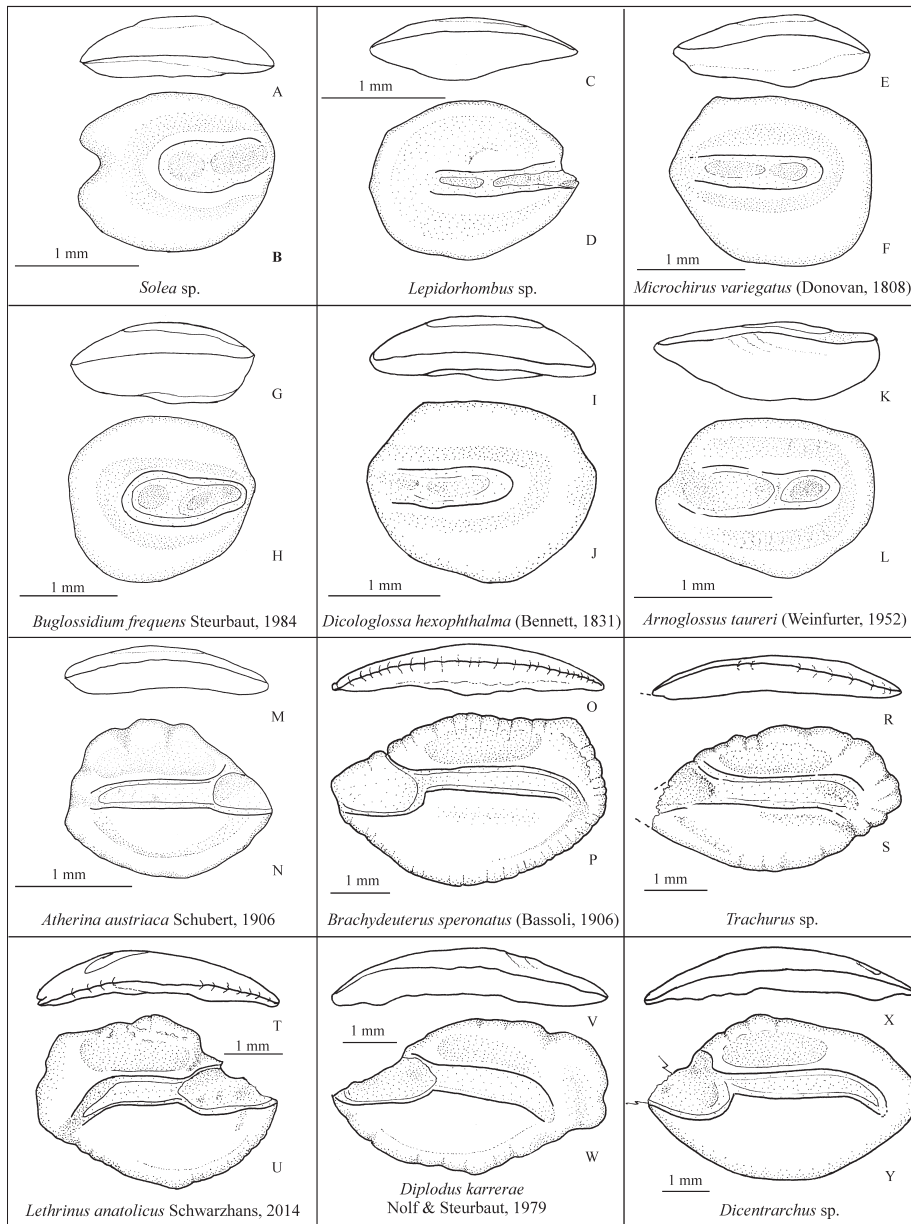


PLATE 2

Figs. A, B - *Solea* sp., Le, A = ventral view, B = inner view, NHM Inv. Nr. Z 28248;

Figs. C, D - *Lepidorhombus* sp., Le, C = ventral view, D = inner view, NHM Inv. Nr. Z 28249;

Figs. E, F - *Microchirus variegatus* (Donovan, 1808), Ri, E = ventral view, F = inner view, NHM Inv. Nr. Z 28250;

Figs. G, H - *Buglossidium frequens* Steurbaut, 1984, Le, G = ventral view, H = inner view, NHM Inv. Nr. Z 28251;

Figs. I, J - *Dicologlossa hexophthalma* (Bennett, 1831), Ri, I = ventral view, J = inner view, NHM Inv. Nr. Z 28252;

Figs. K, L - *Arnoglossus taureri* (Weinfurter, 1952), Ri, K = ventral view, L = inner view, NHM Inv. Nr. Z 28253;

Figs. M, N - *Atherina austriaca* Schubert, 1906, Ri (reversed), M = ventral view, N = inner view, NHM Inv. Nr. Z 28254;

Figs. O, P - *Brachydeuterus speronatus* (Bassoli, 1906), Ri, O = ventral view, P = inner view, NHM Inv. Nr. Z 28255;

Figs. R, S - *Trachurus* sp., Ri, R = ventral view, S = inner view, NHM Inv. Nr. Z 28256;

Figs. T, U - *Lethrinus anatolicus* Schwarzahans, 2014, Le, T = ventral view, U = inner view, NHM Inv. Nr. Z 28257;

Figs. V, W - *Diplodus karrerae* Nolf & Steurbaut, 1979, Ri, V = ventral view, W = inner view, NHM Inv. Nr. Z 28258;

Figs. X, Y - *Dicentrarchus* sp., Ri, X = ventral view, Y = inner view, NHM Inv. Nr. Z 28259.

Chelidonichthys sp. Of two left otoliths, the smaller is well preserved (Pl. 3, Figs. K, L). Its morphology (OL = 2.55 mm, OH = 1.9 mm, OT = 0.5 mm), including the sulcus, ventral furrow, and excisura ostii, is very close to that of *Chelidonichthys lucerna* (Linnaeus, 1756) (see Nolf 2013, pl. 183). More adult specimens are needed to decide a systematic status of the triglids from the Borský Mikuláš-Vinohrádky locality.

Platycephalus sp. A single, slightly corroded right otolith (Pl. 3, Fig. O) without a posterior part. It differs from *P. fusiculus* Radwańska, 1984 (syn. = *P. poyartinensis* Steurbaut, 1984 - see Schwarzahans 2010, p. 170) from the Badenian of Poland in wider ostium and the maximal otolith height lying over a

ostium-cauda boundary. The shape of otolith seems to be very close to otoliths described as *Genyonemus* ? sp. from the Ukrainian Tortonian (Bratishko et al. 2017, pl. 3, figs. 5-8) and synonymised with *Pontosciaena acuterostrata* (Rückert-Ülkümen, 1996). But the ostium of our specimen corresponds to those of platycephalids.

'*Polynemis*' *hygbebaertae* Steurbaut & Jonet, 1982. Fourteen mostly corroded otoliths, only one subadult showing a relatively well preserved polynemid sulcus (Pl. 3, Figs. E-H). Caudal colliculum present only in the anterior part of the cauda and reduced in the wide caudal end. Caudal tip deep and strongly curved towards the ventral rim. Ventral rim is concave and weakly corrugated; the dorsal rim has

a prominent predorsal angle. These features correspond with characteristics of the left otolith of '*P. huyghebaertae*' from the Styrian Badenian (Nolf & Brzobohatý 2009, pl. 5, fig. 4). One exemplar from the Badenian at Korytnica, Poland (Radwańska, 1992, pl. 31, fig. 4a,b) has a more prominent praeventral part. The species is rare in the Middle Miocene of Portugal, Aquitaine Basin, North Sea Basin, and Central Paratethys.

Argyrosomus aff. *regius* (Asso, 1801). Eight juvenile otoliths, mostly poorly preserved. Only one (Pl. 4, Figs. E, F; OL = 10.0 mm, OH = 6.0 mm, OT = 5.1 mm; OL:OH = 1.67, OL:OT = 1.96, Ol:Oh = 1.45) is similar to *A. regius* from Kienberg (Badenian of the Vienna Basin; Brzobohatý et al. 2007, pl. 7, figs. 1, 2). It differs first of all by a nearly symmetric concave ventral margin but corresponds very well in terms of the morphology of the sulcus (the end of the cauda is strongly curved ahead) and outer face. Bannikov et al. (2018) place Kienberg's otoliths in the range of *A. similis* (Weiler, 1966). The last-named otoliths are evidently more elongated (OL:OH = 2.1 by the holotype, Weiler 1966, text-fig. 43; Schwarzhans 1993, text-figs. 262-264), with the shorter caudal tip bent downward at about 90° and are synonymised with *Miracorvina bolsatica* (Koken, 1891) by Nolf (2013). The insufficient material does not allow for any more precise systematic conclusions.

Dentex aff. *maroccanus* Valenciennes, 1830 (Pl. 3, Figs. I, J). Thirty mostly juvenile otoliths. Juvenile specimens of closely related species (such as *D. gregarius*, *D. maroccanus*, *D. angolensis*, *D. macrophthalmus*) are difficult to differentiate morphologically (see also Schwarzhans 2010). We follow Nolf's (2013, p. 182, see *D. gregarius*) interpretation and respect the systematic determination used in the Badenian of the Vienna Basin by Brzobohatý et al. (2007).

Dentex aff. *gibbosus* (Rafinesque, 1810) (Pl. 4, Figs. C, D; OL = 7.2 mm, OH = 5.0 mm, OT = 1.3 mm; OL:OH = 1.44). Three left well-preserved adult otoliths. Their elongated shape, with picked dorsal part lying symmetrically about the deepest part of the ventral rim, and other morphology including sulcus acusticus, could be fully compared to recent subadult otoliths of *D. gibbosus* (Steurbaut 1984, pl. 26, figs. 18-24; Veen & Hoedemakers 2005, pl. 9, figs. 1-3; Nolf et al. 2009, pl. 87). But the curvature of inner and outer faces seems to be very low and does not allow the precise systematic conclusions. *D. gibbosus* is relatively abundant in the northwest part of the Vienna

Basin at the Kienberg locality (Badenian, Brzobohatý et al. 2007, pl. 5, figs. 17, 18), as well as in the Middle Miocene of the Aquitaine Basin, Portugal, and the Italian Tortonian.

Diplodus karrerae Nolf & Steurbaut, 1979. Thirty well-preserved juvenile otoliths (Pl. 2, Fig. V, W). Their morphology is without an expressive variability and the sulcus shape with a narrowing caudal bent is easily comparable to young otoliths of *D. karrerae* cited from the Serravallian of Aquitaine (Nolf 2013, pl. 261). The species is distributed in the Middle Miocene of Portugal, Aquitaine, and the North Sea Basin. In the Central Paratethys, *D. karrerae* occurs very rarely in the Korytnica Clay (the Badenian of Poland; Radwańska 1992, p. 247, text-fig. 100, pl. 23, figs. 5-7).

Diplodus sp. A single adult, perfectly preserved specimen (Pl. 3, Figs. C, D). An extremely straight middle part of the ventral margin and an outstanding postdorsal part differ from the morphologically closest otoliths of *D. karrerae*. A possible indication of the ventral margin could only be seen in an adult specimen of the species from the Hemmorian of the North Sea Basin (Schwarzhans 2010, pl. 90, fig. 3).

?*Diplodus* sp. A single subadult otolith with an extremely sharp spike in the middle part of the dorsal margin (Pl. 3, Figs. P, R). This mark seems to be present also in juvenile specimens of *Pagrus pagrus* but their sulcus acusticus is different (compare Nolf 2018, pl. 57).

Description of new species

Order **Perciformes** Bleeker, 1863

Family **Gerreidae** Bleeker, 1859

Genus *Gerres* Quoy & Gaimard, 1824

Gerres mlynskyi n. sp.

Pl. 4, Figs. N-T; Pl. 3, Figs. V, W, X

1973 *Pagrus* sp. - Śmigielska, p. 18, pl. 3, figs. 1, 2.

? 1980 *Gerres* sp. - Nolf & Cappetta, pl. 2, figs. 11-14.

partim 1984 *Gerres* sp. - Steurbaut, pl. 24, figs. 2, 3, non figs. 1,4.

partim 1992 *Gerres* sp. - Radwańska, text-fig. 96, pl. 21, figs. 3-5, 7, 8, non fig. 6.

? 1998 *Gerres* sp. - Reichenbacher, pl. 2, fig. 1, pl. 3, figs. 12-13.

? 2003 *Gerres* sp. - Brzobohatý, Reichenbacher & Gregorová, pl. 3, fig. 5.

2009 *Gerres* sp. 1. - Nolf & Brzobohatý, pl. 5, fig. 5 a, b.

Derivatio nominis: Refers to Tomáš Mlynský, the curator of the I. Winter Balneological Museum, Piešťany, Slovakia, and the collector of the otoliths from the Borský Mikuláš-Vinohrádky locality studied here.

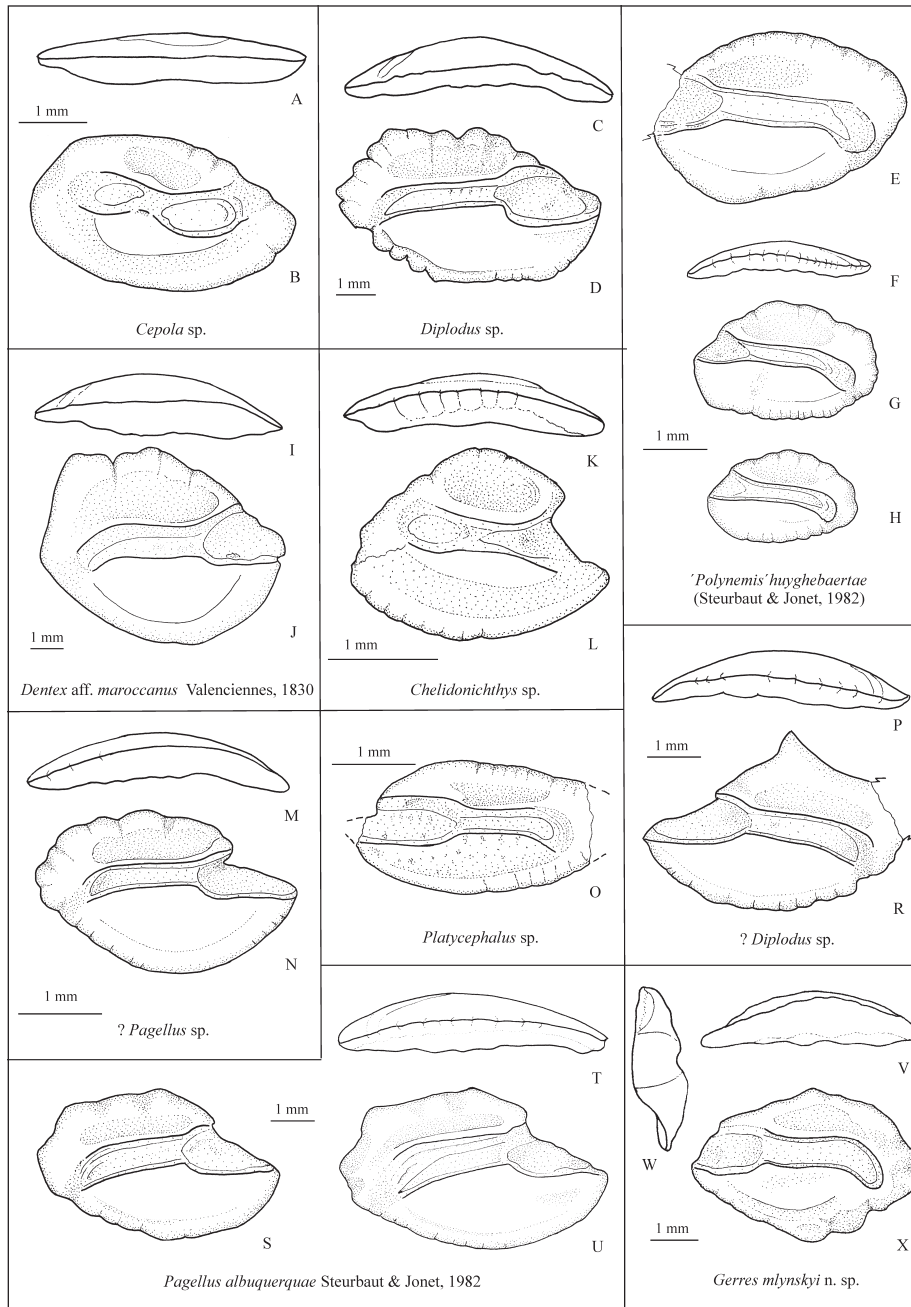


PLATE 3

Figs. A, B - *Cepola* sp., Le, A = ventral view, B = inner view, NHM Inv. Nr. Z 28260;

Figs. C, D - *Diplodus* sp., Le, C = ventral view, D = inner view, NHM Inv. Nr. Z 28261;

Figs. E-H - '*Polynemis*' *huyghebaertae* (Steurbaut & Jonet, 1982), Ri, E, G, H = inner views, F = ventral view, Inv. Nr. Z 28262-64;

Figs. I, J - *Dentex* aff. *maroccanus* Valenciennes, 1830, Le, I = ventral view, J = inner view, NHM Inv. Nr. Z 28265;

Figs. K, L - *Chelidonichthys* sp., Le, K = ventral view, L = inner view, NHM Inv. Nr. Z 28266;

Figs. M, N - ?*Pagellus* sp., Le, M = ventral view, N = inner view, NHM Inv. Nr. Z 28267;

Fig. O - *Platycephalus* sp., Ri, inner view, NHM Inv. Nr. Z 28268;

Figs. P, R - ?*Diplodus* sp., Ri, P = ventral view, R = inner view, NHM Inv. Nr. Z 28269;

Figs. S-U - *Pagellus albuquerquae* Steurbaut & Jonet, 1982, Le, T = ventral view, S-U = inner views, NHM Inv. Nr. Z 28270-71;

Figs. V-X - *Gerres mlynskyi* n. sp., Ri, V = ventral view, W = anterior view, X = inner view, NHM Inv. Nr. Z 28272.

Holotype: Left otolith (Pl. 4, Figs. N, O - photo; Pl. 3, Figs. V, W, X - drawing) deposited in the Slovak National Museum, Natural History Museum in Bratislava, Slovakia. Inv. Nr. Z 28272.

Paratypes: Pl. 4, Figs. P-T (Inv. Nr. Z 28273-77) and 31 other specimens (partly fragments) from the same locality.

Stratum typicum: Calcareous clay of the upper Badenian (= Lower Serravallian, Middle Miocene), Borský Mikuláš-Vinohrádky, Vienna Basin, Slovakia.

Dimensions: OL = 4.95 mm, OH = 3.35 mm, OT = 0.8 mm; OL:OH = 1.48 (Holotype).

Diagnosis: Elongated rhomboidal outline with \pm median dorsal tip and \pm central ventral tip (deepest point), gerreid-like and horizontally lying sulcus acusticus, very high crista superior bordering the whole cauda, deep and sharply demarcated ventral line, broader and deeper in the back half, and smooth and clearly marked ventral field.

Description. Rhomboidal otoliths up to at least 6 mm length with an OL:OH index of 1.35-1.55. The rostrum is blunt, the antirostrum short with a small excisura. The dorsal rim is high and crenulated in the second half, usually with the highest point in the middle part. The postdorsal angle is indistinct. The ventral rim is deep, strongly crenulated in the middle and posterior part, and finely crenulated in the anterior part. The inner face is markedly convex; the sulcus is suprmedian with shorter and deeper ostium. The cauda is two times longer than the ostium and slightly concave in the middle part. The dorsal area is deep and bordering the whole caudal part.

PLATE 4

Figs. A, B - *Pomadasys* aff. *incisus* (Bowdich, 1825), Le, A = ventral view, B = inner view, NHM Inv. Nr. 28278;

Figs. C, D - *Dentex* aff. *gibbosus* (Rafinesque, 1810), Le, C = ventral view, D = inner view, NHM Inv. Nr. 28279;

Figs. E, F - *Argyrosomus* aff. *regius* (Asso, 1801), Le, E = ventral view, F = inner view, NHM Inv. Nr. 28280;

Figs. G-M - *Thorogobius antirostratus* n. sp., Le, G = ventral view, H-M = inner views, NHM Inv. Nr. 28242-47;

Figs. N-T - *Gerres mlynskyi* n. sp., Ri, N = ventral view, O-T = inner views, NHM Inv. Nr. 28272-77;

Figs. U, V - *Dentex doderleini* (Schubert, 1906), Ri, U = ventral view, V = inner view, NHM Inv. Nr. 28281;

Figs. W-Z - *Gobius supraspectabilis* Schwarzahans, Brzobohaty, Radwanska & Prochazka, 2020, Ri, X = ventral view, W, Y, Z = inner views, W, X = reversed, NHM Inv. Nr. 28282-84.



The outer face is markedly concave with many radial furrows in smaller specimens and folds in larger ones. Inner face curvature: $x > y$.

Remarks. Gerreids are very rare in the Paratethys (Poland, Radwańska 1992; Austria, Reichenbacher 1998, Brzobohatý et al. 2003; Styria, Nolf & Brzobohatý 2009). There is a well-preserved ontogenetic series in the Borský Mikuláš material. It fully corresponds to specimens described and pictured in Radwańska (1992, pl. 21, figs. 3-5, and 8). Juvenile otoliths seem to be highly similar to *Gerres* sp. from the Mediterranean Miocene (Nolf & Cappetta 1980, pl. 2, figs. 11-14) and the Karpatian (latest Lower Miocene) of the Korneuburg Basin (Northern Austria, Reichenbacher 1998, pl.

3, figs. 12, 13; Brzobohatý et al. 2003, pl. 3, fig. 5). The same could be stated for *Gerres* sp. 1 from the Styrian Basin (Nolf & Brzobohatý 2009, pl. 5, fig. 1) and partly for *Gerres* sp. from the Aquitaine (Sturbaut 1984, pl. 24, figs. 2, 3, 5, non 1, 4), which could be synonymous. Two juvenile specimens of *Gerres* sp. from the Lower Miocene of South France (Reichenbacher & Cappetta 1999, p. 18, pl. 1, figs. 17, 18) differ from the Badenian ones through the regularly and moderately concave ventral part. The deep and strongly crenulated middle and posterior part of the ventral rim and the clearly hooked caudal end differentiate the new species from *Gerres* ? *lacunosum* Grenfell, 1984 from the Australian Upper Oligocene-Lower Miocene.

Otoliths of three recent species are morphologically close to the new one. Otoliths of *G. infasciatus* Iwatsuki & Kimura, 1998 differ with respect to the deepest point of the ventral margin lying more anteriorly. They also display a less roughly undulated posterior part of the ventral rim, and caudal termination at a right angle. Otoliths of *G. filamentosus* Cuvier, 1829 (Cyrus & Blaber 1982, figs. 5b, 6b, 7a, b; Smale et al. 1995, pl. 80, figs. D1, 2) are relatively shorter, with a more rounded outline and more ventrally expanded lower ostial boundary. The species prefers euryhaline to marine areas of 25–35‰ (Cyrus & Blaber 1982). Otoliths of *G. macracanthus* Bleeker, 1854 (Lin & Chang 2012, pl. 37) are more rounded and with a clearly oblique caudal part of the sulcus.

Many more dissimilarities are obvious in comparison with other peri-mediterranean species of the genera such as *G. longirostris* (Lacepède, 1801) (Smale et al. 1995, pl. 80, figs. C1-3), *G. nigri* Günther, 1859 (see Nolf 2013, pl. 249; there is a misprint: *G. nigri* is erroneously pictured as *Euctinostomus melanopterus*), *G. rappi* Regan, 1820 (Smale et al. 1995, pl. 81, figs. B1, 2), *G. oblongus* Cuvier, 1830 (Smale et al. 1995, pl. 80, figs. E1-3) and *G. oyena* (Forsskal, 1775) (Smale et al. 1995, pl. 81, figs. A1-4; Nolf et al. 2009, pl. 80).

The genus *Gerres* includes the coastal (infralittoral) fishes of the Indo-Pacific area. All mentioned recent species also live in the Red Sea except *G. nigri* which occurs in the East Atlantic waters from Guinea to Congo. Otoliths of *G. mlynskyi* also occur in the Badenian strata of Poland and Styria and in the Middle Miocene ('Sallomacian') strata of Aquitaine (see synonymy).

Family Gobiidae Cuvier, 1816

Genus *Thorogobius* Miller, 1969

***Thorogobius antirostratus* n. sp.**

Pl. 4, Figs. G-M; Pl. 1, Figs. Y, Z

1973 *Gobius praetiosus* Prochazka - Śmigieliska, pl. 4, fig. 6, (non 3, 4, 5, 7).

2012 *Gobius multipinnatus* - Zahradníková, text-fig. 6.

2020 *Thorogobius* sp. - Schwarzhans et al. 2020b (pl. 5, fig. 14).

Derivatio nominis: Refers to the protruding predorsal part of otoliths.

Holotype: Left otolith (Pl. 4, Figs. G, H - photo; Pl. 1, Figs. Y, Z - drawing, reversed) deposited in the Slovak National Museum, Natural History Museum in Bratislava, Slovakia. (Inv. Nr. Z 28242).

Paratypes: Pl. 4, Figs. I-M (Inv. Nr. Z 28243-47) and 193 specimens from the same locality.

Stratum typicum: Calcareous clay of the upper Badenian (= Lower Serravallian, Middle Miocene), Borský Mikuláš-Vinohrádky (Vienna Basin, Slovakia).

Dimensions: OL = 3.65 mm, OH = 2.8 mm, OT = 0.9 mm; OL:OH = 1.3 (Holotype).

Diagnosis: OL:OH = 1.25-1.39. The dorsal rim is anteriorly depressed, highest above the end of the cauda, predorsal angle is protruding sharply forward, postdorsal projection is broad, not bend outwards.

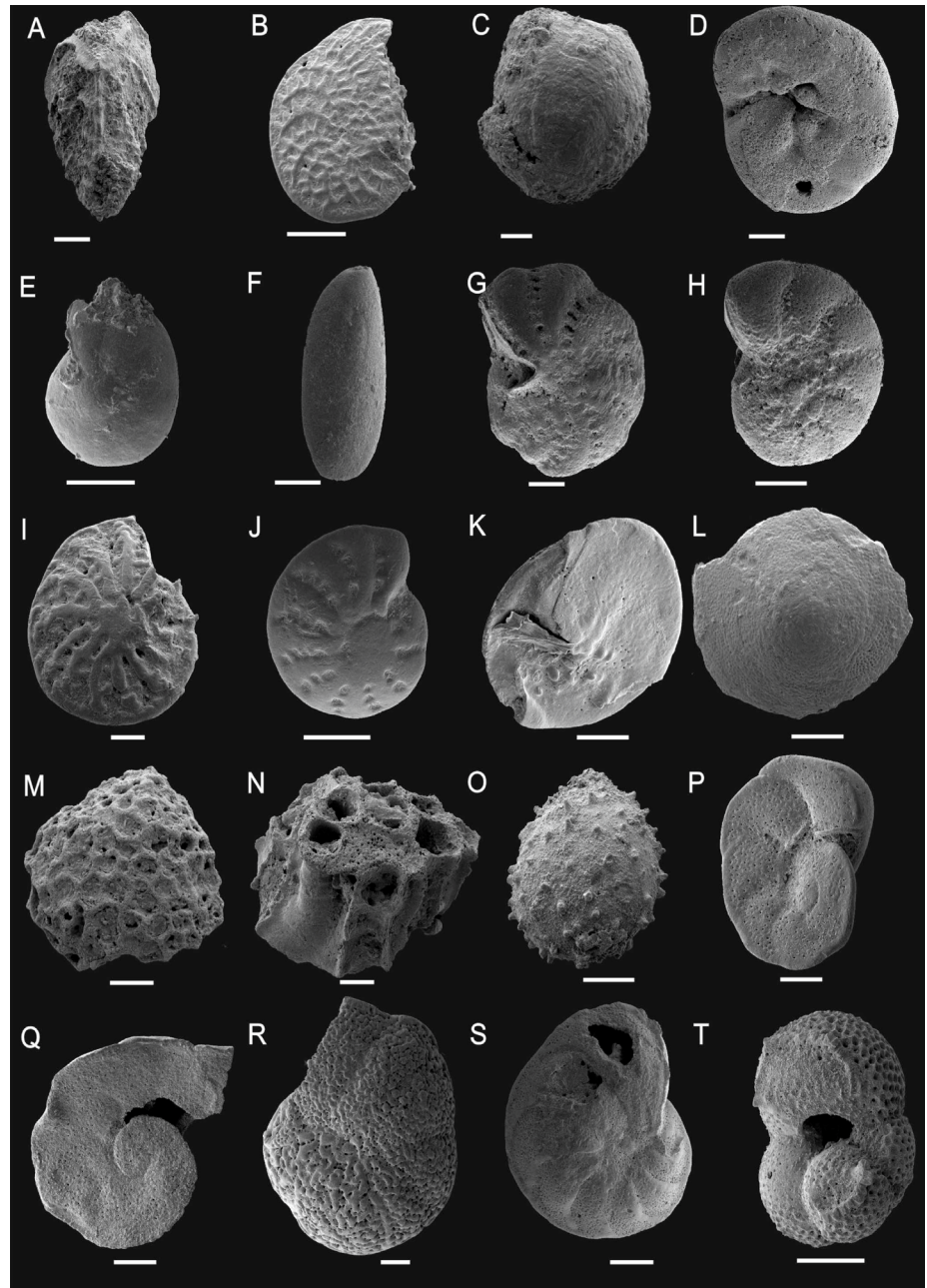
Description. Elongated gobiid otoliths with a protruding predorsal part. The inclination angle of the ostium is 13-19°. The ostial lobe is very weak, the forepart of the collum is clearly depressed; no caudal iugum. The dorsal depression is prominent, the ventral furrow is distinct, very close to the ventral rim. The outer face is convex, smooth or with an indistinct short radial furrow on the dorsal part. Inner face curvature: $x < y$.

Remarks. Totally missing subcaudal iugum and slightly convex inner face argue for an assignment to the genus *Thorogobius*. Morphologically they are closely related to *T. incundus* Schwarzhans, 2014, pl. 13, figs. 3-13 from the Serravallian of the Karaman Basin, but their predorsal angle protrudes more forward, mostly creating a sharp tip (see Pl. 4, Fig. I).

One specimen described as *Gobius praetiosus* Proch. by Śmigieliska (1973, pl. 4, fig. 6) from the Badenian of Poland (Niskowa near Nowy Sacz, upper Langhian and/or Serravallian; Studencka 2019) seems to be very close to the new species – especially with respect to the protruding predorsal part and lack of subcaudal iugum. The same could be stated for *G. multipinnatus* otolith (Zahradníková 2012, text-fig. 6) from the Borský Mikuláš section. Both could be included in the variability of *T. antirostratus*. Some specimens of 'genus *Gobiidarum*' sp. 2 from the Catalanian Miocene (Hoedemakers & Batllori 2005, pl. 12, figs. 3, 4, 5, non pl. 12, figs. 6, 7) also seem to be very close and represent the same genus. But their predorsal part is shorter and situated more ventrally. An outline of *T. antirostratus* otoliths is also very similar to those of '*Gobius*' sp. 4 (Brzobohatý 1994, pl. 6, figs. 4-6; Gainfarn, Badenian, Vienna Basin). The postcaudal iugum and the more horizontal-lying sulcus differ the last-named from the new species. Compared with *Thorogobius truncatus* (Schwarzhans 1979, p. 38, pl. 10, figs. 119-120, pl. 13, fig. 146) the new species has an outstanding predorsal tip, a relatively shorter and higher sulcus, and a concave margin of the outer face. In comparison with *T. petilus* Schwarzhans, Agiadi & Carnevale, 2020 (p. 690, figs. 11D-

PLATE 5

- Fig. A - *Reussella spinulosa* (Reuss, 1850), sample BM4;
 Fig. B - *Elphidium fichtelianum* (d'Orbigny, 1846), sample BM5;
 Fig. C - *Borelis melo* (Fichtel & Moll, 1798), sample BM1;
 Fig. D - *Discorbis* sp., sample BM4;
 Fig. E - *Cibicidoides pachyderma* (Rzehak, 1886), sample BM5;
 Fig. F - *Pseudotriloculina consobrina* (d'Orbigny, 1846), sample BM4;
 Fig. G - *Elphidium advenum* (Cushman, 1922), sample BM1;
 Fig. H - *Porosonion granosum* (d'Orbigny, 1846), sample BM4;
 Fig. I - *Elphidium rugosum* (d'Orbigny, 1846), sample BM1;
 Fig. J - *Elphidium* sp., sample BM 4;
 Fig. K, L - *Biasterigerina planorbis* (d'Orbigny, 1846), sample BM4;
 Fig. M - *Cymbaloporetta* sp., sample BM4;
 Fig. N - *Miniacina miniacea* (Pallas, 1766), sample BM4;
 Fig. O - *Globulina punctata* d'Orbigny, 1846, sample BM1;
 Figs. P, R - *Cibicidoides lobatulus* (Walker & Jacob, 1798), sample BM4;
 Fig. Q - *Cibicidoides lobatulus* (Walker & Jacob, 1798), sample BM5;
 Fig. S - *Cibicides crassiseptatus* Łuczowska, 1960, sample BM1;
 Fig. T - *Globigerina bulloides* d'Orbigny, 1826, sample BM1.



H), the new species has, first of all, an outstanding predorsal tip and a more vaulted inner and outer face. *Thorogobius* sp. from the Agia Triada Section (Zanclean, eastern Mediterranean; Agiadi et al. 2020, fig. 3t) seems to be highly corroded and different from our species.

A deep incision in the middle of the anterior part and a higher position of the predorsal tip distinguish our otoliths from the recent *T. angolensis* (Norman, 1935) (see, e.g., Radwańska 1992, text-fig. 145; Schwarzhans 2013, pl. 13, figs. 5-7) and *T. laureatus* Sauberer, Iwamoto & Ahnelt, 2018. Otoliths of both cited species are longer OL:OH > 1.4. An anterior

part of other recent species from the Mediterranean Sea, *T. macrolepis* (Kolombatovic, 1871), or deep-water Atlantic species *T. rofeni* P. J. Miller, 1988 is ± vertical (Lombarte et al. 2018, fig. 4a). The predorsal part of *T. ephippiatus* (Lowe, 1839) is short and more round (Nolf 2013, pl. 319; Nolf 2018, pl. 80). Otoliths of *T. alvheimi* Sauberer, Iwamoto & Ahnelt, 2018 differ from the new species by a non protruding predorsal tip and an anterior excisura very near to the ventral rim of the otolith. The sulcus of the fossil otoliths is more clearly divided into the ostial and caudal parts. Otoliths of all mentioned recent *Thorogobius* species are compiled in Schwarzhans et al. (2020b, pl. 5).

Families	Taxa bold = extant species	Iconography	Number of otoliths	Previous works
HETERENCHELYIDAE	<i>Panturichthys subglaber</i> (Schubert, 1906)	Pl. 1, Fig. A, B	1	
MERLUCCIIDAE	<i>Merluccius aff. merluccius</i> (Linnaeus, 1758)	Pl. 1, Fig. C	1	
GADIDAE	<i>Trisopterus</i> sp.	Pl. 1, Fig. D	1	
CARAPIDAE	<i>Encheliophis</i> sp.	Pl. 1, Fig. I, J	1	
GOBIIDAE	<i>Gobius supraspectabilis</i> Sch., Brz., Rad. & Pr. 2020	Pl. 4, Fig. W-Z	25	
	<i>Gobius aff. niger</i> Linnaeus, 1758	Pl. 1, Fig. V-X	125	
	<i>Lesueurigobius magniiugis</i> Schwarzahns, 2017	Pl. 1, Fig. K, L	25	
	<i>Lesueurigobius suerii</i> (Risso, 1810)	Pl. 1, Fig. E-H	103	
	<i>Lesueurigobius vicinalis</i> (Koken, 1891)	Pl. 1, Fig. N-P	~2900	Za
	<i>Thorogobius antirostratus</i> n. sp. (Pl. 1, Fig. Y-Z, Htp)	Pl. 4, Fig. G-M	199	Za
	<i>Thorogobius iucundus</i> Schwarzahns, 2014	Pl. 1, Fig. R-U	100	
MUGILIDAE	<i>Liza</i> sp.	Pl. 1, Fig. M	8	?Ho, Za
ATHERINIDAE	<i>Atherina austriaca</i> Schubert, 1906	Pl. 2, Fig. M, N	1	
CARANGIDAE	<i>Trachurus</i> sp.	Pl. 2, Fig. R, S	1	
SCOPHTHALMIDAE	<i>Lepidorhombus</i> sp.	Pl. 2, Fig. C, D	1	
BOTHIDAE	<i>Arnoglossus taureri</i> (Weinfurter, 1952)	Pl. 2, Fig. K, L	3	
SOLEIDAE	<i>Buglossidium frequens</i> Steurbaut, 1984	Pl. 2, Fig. G, H	11	Za
	<i>Dicologlossa hexophtalma</i> (Bennett, 1831)	Pl. 2, Fig. I, J	12	
	<i>Microchirus variegatus</i> (Donovan, 1808)	Pl. 2, Fig. E, F	15	
	<i>Solea</i> sp.	Pl. 2, Fig. A, B	1	Ho
GERREIDAE	<i>Gerres mlynskyi</i> n. sp. (Pl. 3, Fig. V-X, Htp)	Pl. 4, Fig. N-T	37	
HAEMULIDAE	<i>Brachydeuterus speronatus</i> (Bassoli, 1906)	Pl. 2, Fig. O, P	14	Ho, Za
	<i>Pomadasy aff. incisus</i> (Bowdich, 1825)	Pl. 4, Fig. A, B	47	Ho
MORONIDAE	<i>Dicentrarchus</i> sp.	Pl. 2, Fig. X, Y	1	
LETHRINIDAE	<i>Lethrinus anatolicus</i> Schwarzahns, 2014	Pl. 2, Fig. T, U	4	
CEPOLIDAE	<i>Cepola</i> sp.	Pl. 3, Fig. A, B	12	
TRIGLIDAE	<i>Chelidichthys</i> sp.	Pl. 3, Fig. K, L	2	
PLATYCEPHALIDAE	<i>Platycephalus</i> sp.	Pl. 3, Fig. O	1	
POLYNEMIDAE	<i>'Polynemis' huyghebaertae</i> Steurbaut & Jonet, 1982	Pl. 3, Fig. E-H	14	
SCIAENIDAE	<i>Argyrosomus aff. regius</i> (Asso, 1801)	Pl. 4, Fig. E, F	8	
SPARIDAE	<i>Dentex dodderleini</i> (Schubert, 1906)	Pl. 4, Fig. U, V	1	Ho, Za
	<i>Dentex aff. gibbosus</i> (Rafinesque, 1810)	Pl. 4, Fig. C, D	3	
	<i>Dentex aff. maroccanus</i> Valenciennes, 1830	Pl. 3, Fig. I, J	30	
	<i>Diplodus karreræ</i> Nolf & Steurbaut, 1979	Pl. 2, Fig. V, W	30	
	<i>Diplodus</i> sp.	Pl. 3, Fig. C, D	1	
	? <i>Diplodus</i> sp.	Pl. 3, Fig. P, R	1	

Fig. 4 - List of otoliths-based fish taxa from the upper Badenian of the Borský Mikuláš-Vinohrádky section (Za = Zahradníková 2012; Ho = Holec 1973, 1975, 1978a,b, 2001).

DISCUSSION

Environmental evaluation

Otoliths. In the Borský Mikuláš section, 38 otolith-based taxa of Teleostei were identified, among which *Gerres mlynskyi* and *Thorogobius antirostratus* are new. Twenty-five taxa are assigned to the species level, and 13 (mostly single fragments or juvenile specimens) are mentioned in open nomenclature (Fig. 4). Three species (*Lesueurigobius suerii*, *Dicologlossa hexophtalma*, and *Microchirus variegatus*) are still present in the extant fauna. All genera are presented by marine species; fourteen of them can also live in brackish water and six in freshwater (Fig. 5). Demersal and benthopelagic fishes strongly dominate both in the

number of species and of otoliths. Nine taxa are oceanodromous; no taxa present here were purely brackish or freshwater. From a climatic point of view, subtropical fishes clearly dominate, with tropical genera (*Encheliophis*, *Lethrinus*) represented by single otoliths. The genus *Brachydeuterus* is more commonly today restricted to tropical waters. But a slightly broader climatic tolerance for fossil species *B. speronatus* is discussed by Brzobohatý et al. (2007). Genera restricted mostly to temperate waters (*Trisopterus*, *Merluccius*) are represented by only single fragments as well. Fishes from muddy and sandy bottoms markedly prevail (21 taxa), a relatively high portion of which (8 taxa) are tolerant to or also preferring rocky bottoms. Five genera (*Encheliophis*, *Liza*, *Gerres*, *Lethrinus*, and *Diplodus*)

Fig. 5 - Ecological data (Froese & Pauly 2020) of the extant fish genera and species from the Borský Mikuláš-Vinohrádky section.

Genera Species	Environment							Climate			Distribution				Biology					Notices		
	Demersal	Benthopelagic	Pelagic	Oceanodromous	Marine	Brackish	Fresh	Tropical	Subtropical	Moderate	Eastern Atlantic	Mediterranean	Red Sea, Persian Bay	Western Indian Ocean	Bottom							
															Mud	Sand	Rock	Reef-associated	Gregarious			
<i>Panturichthys</i>	D			M				T	S		A	M				M						
<i>Merluccius merluccius</i>	D			M				(S)	M		A	M						Ro				
<i>Trisopterus</i>		Bp	(P)	O	M	(B)		(S)	M		A	M				M	S					non-migratory commens. (holothur.) + seagrass beds
<i>Encheliophis</i>	D			M				T					RP	I							Ra	
<i>Gobius</i>	D			M	B	F		T	S	M	A	M		I		M	S					
<i>Lesueurigobius</i>	D			M				S			A	M				M	S					
<i>Thorogobius</i>	<D			M				<T	S	M	A	M				(M)	S					
<i>Liza</i>	D			M	B	(F)		T	S		(M)	RP	I								(Ra)	
<i>Atherina</i>	D		P	(O)	M	B	F	(T)	S		A	M									(G)	lagoons, estuaries
<i>Trachurus picturatus</i>		Bp		O	M			S			A	M									Ro	G
<i>Lepidorhombus</i>	D	Bp		M				S	M		A	M				M						
<i>Arnoglossus</i>	D			M				S			A	M				M	(S)					
<i>Buglossidium</i>	D			M				S			A	M					S					
<i>Dicologl. hexophthalma</i>	D			M				S			A	M				M	S					
<i>Microchirus variegatus</i>	D			M				S			A	M				M	S					
<i>Solea</i>	D			O	M	B	(F)	S			A	M				M	S					+ burrows
<i>Gerres</i>	D	Bp		M	B	F		T	S	M	A		RP	I							Ra	lagoons, estuaries
<i>Brachydeuterus auritus</i>	D	Bp	night	M	B			T			A					M	S					
<i>Pomadourus incisus</i>	D			M	B			S			A	(M)					S	Ro				
<i>Dicentrarchus</i>	D		P	O	M	B	F	S			A	M					S	Ro			(G)	
<i>Lethrinus</i>		(Bp)		M	(B)			T			(A)		RP	I							Ra	<sand, seagrass, reefs
<i>Cepola macrophthalma</i>	D			M				S			A	M				M	S					+ burrows
<i>Chelidonichthys</i>	D			M	(B)			T	S	M	A	M	R	I		M	S	Ro		(G)		variable bottom
<i>Platycephalus</i>	D	(Bp)		(O)	M	B		T	S				RP	I		M	S	Ro				
<i>Argyrosomus regius</i>		Bp	(P)	O	M	B		S			A	M				M	S	(Ro)				
<i>Dentex maroccanus</i>	D			M				S			A	M				(M)	S	(Ro)				
<i>Dentex gibbosus</i>		Bp		M				S			A	M					(S)	Ro				
<i>Pagellus</i>	D	Bp		O	M			T	S	M	A	M		I		(M)	S	(Ro)		(G)		+ seagrass beds
<i>Diplodus</i>	D	Bp		O	M	B		T	S		A	M	RP	I		(M)	S	Ro	Ra	(G)		< sublittoral

can be considered reef-associated fishes. Some extant species of the genera *Trachurus*, *Atherina*, *Dicentrarchus*, *Chelidonichthys*, and *Diplodus* live gregariously.

The paleobathymetric analysis (Fig. 6) indicates sedimentation depths in the Borský Mikuláš-Vinohrádky section of 30-50 metres. It is a distinctly shallower indication than that stated in the report of Zahradníková (2012; 50-100 metres) and corresponds to the 'shallow sublittoral' paleobathymetry of the locality based on molluscs (Fuchs 2018). Purely shallow-water fishes of the first 20 meters (*Liza*, *Atherina*) are documented by very sporadic otoliths. The same holds in the case of fishes usually living under the depth of 30 metres (*Merluccius*, *Panturichthys*). A portion of sublittoral and eurybathic taxa such as *Trisopterus*, *Lesueurigobius*, *Thorogobius*, *Lepidorhombus*, *Arnoglossus*, *Buglossidium*, *Chelidonichthys*, and *Platycephalus* is highly significant. From this group, gobiid otoliths are predominant in the whole otolith association (Fig. 7). Gobiids are mostly represented by *Lesueurigobius* and *Thorogobius* species common in the Central Paratethys basins and do not indicate any specific environments (Schwarzhan et al. 2020b).

Fishes representing the extant Eastern Atlantic-Mediterranean region clearly dominate (Fig. 5). The genus *Brachydeuterus* is a purely Eastern Atlantic taxon, it is absent from the present-day Mediterranean. Only three genera live in the Western Indian Ocean, including the Red Sea (*Encheliophis*, *Platycephalus*, and *Liza* ?). Gerreids live mostly in the Indo-Pacific and are relatively abundant in the Red Sea (~6 species). Two Atlantic species of the genus are restricted to the Western Atlantic (*G. cinereus* (Walbaum, 1792)) or the Eastern Central Atlantic (*G. nigri* Günther, 1859). The same could be stated for fishes of the typical Indo-Pacific genera *Lethrinus*, with only one species (*L. atlanticus* Valenciennes, 1830) living in waters of the Eastern Central Atlantic off the tropical African coast (Froese and Pauly 2020).

Foraminifera. In the studied samples, 41 taxa of benthic foraminifers were identified (Fig. 8). Nine of them remain in the open taxonomy because of poor preservation. *Globigerina bulloides* is the only identified planctonic species. The benthic assemblage is dominated by *Biasterigerina planorbis* and *Elphidium crispum* associated with other elphidiids,

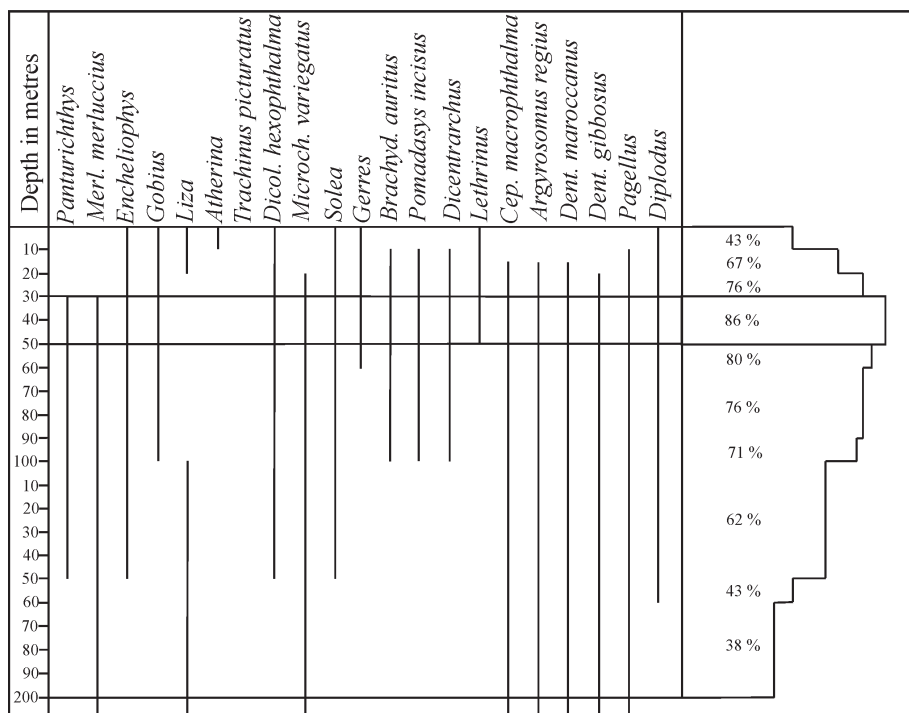


Fig. 6 - Present-day bathymetric range of fish taxa in the Borský Mikuláš-Vinohrádky section (without 0-200 m running taxa; data after Froese and Pauly 2020).

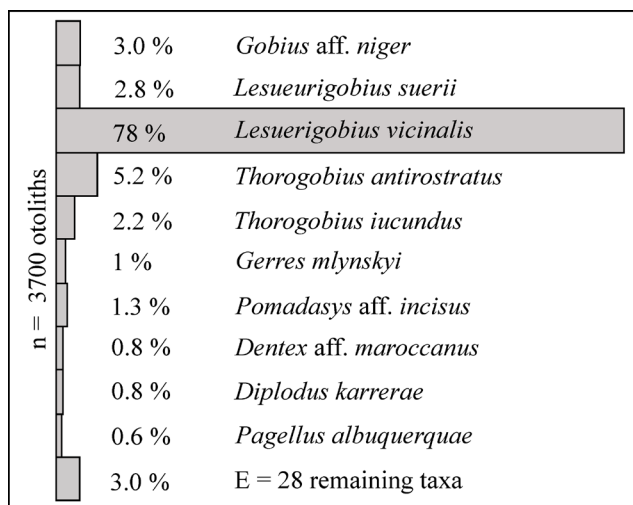


Fig. 7 - Histogram of the most abundant otolith species (> 0.5 %) in the Borský Mikuláš-Vinohrádky section.

Lobatula lobatula and *Cibicides crassiseptatum* (Pl. 5, Fig. 8). *Elphidium crispum* shows no specific preference for a particular type of sediment. In a study by Jorissen (1987), this species is found at sites where the organic matter content is slightly elevated, which is supported by the presence of *Cancris auriculus*, *Nonion* sp., and *Haynesina depressula*. All the benthic taxa mentioned are also considered as motile epiphytic suspension feeders (Langer 1993) (Fig. 9). The group of epiphytic species is sensitive to low oxygen conditions. The high percentages of the spe-

cies mentioned suggest the presence of seagrass or macroalgae meadows in the vicinity (Langer 1993; Murray 2006). All studied samples are very similar in species composition, but sample BM1 contains a high percentage of epiphyte herbivorous taxa, while sample BM4 contains a slightly shallower infaunal and passive suspension feeders.

Simpson diversity is higher in the BM4 sample, with a median value of 0.9, compared with 0.8 in the BM1 sample (Fig. 10). The Bray-Curtis similarity index (Hammer et al. 2001) shows close results for the BM1 and BM 4 samples. Depth estimation shows most of the species inhabited a 20-100 metre water depth range (Fig. 11). But judging by the presence of *Cancris auriculus*, we can narrow down the paleowater depth to between 30 to 50 metres (Murray 2006; Adegoke et al. 2017). Using the advanced method of Hohenegger (2005), we calculate an assumption of depths of 34.4 to 31.6 metres.

BIOGEOGRAPHIC AND STRATIGRAPHIC NOTICES

Otoliths. A relatively high correspondence (42-54% of common species) of the studied assemblage is observed with other otolith faunas such as those from the Kienberg section (upper Langhian-lower Serravallian, Vienna Basin, Brzobohatý et al.

Fig. 8 - List of foraminifers in the Borský Mikuláš-Vinohrádky section and number of specimens in the samples BM 1-5.

Foraminifera, Taxa	Iconography	Number of specimens			
		BM1	BM2	BM4	BM5
<i>Ammonia inflata</i> (Sequenza, 1862)		1	0	0	43
<i>Ammonia tepida</i> (Cushman, 1926)		0	0	1	9
<i>Ammonia viennensis</i> (d'Orbigny, 1846)		0	0	3	12
<i>Amphistegina lessonii</i> d'Orbigny in Guérin-Menéville, 1832		6	0	0	9
<i>Asterigerinata mamilla</i> (Williamson, 1858)		9	14	0	5
<i>Biasterigerina planorbis</i> (d'Orbigny, 1846)	Pl. 5, Fig. K,L	83	0	55	38
<i>Borelis melo</i> (Fichtel & Moll, 1798)	Pl. 5, Fig. C	2	0	2	2
<i>Cancris auricula</i> (Fichtel & Moll, 1798)		0	0	3	6
<i>Cibicides crassiseptatus</i> Luczkowska, 1960	Pl. 5, Fig. S	10	0	2	7
<i>Cibicidoides</i> ex gr. <i>ungerianus</i> (d'Orbigny, 1846)		1	0	0	0
<i>Cibicidoides lobatulus</i> (Walker & Jacob, 1798)	Pl. 5, Fig. P,Q,R	3	0	3	5
<i>Cibicidoides pachyderma</i> (Rzehak, 1886)	Pl. 5, Fig. E	0	0	3	1
<i>Cymbaloporetta</i> sp.	Pl. 5, Fig. M	0	0	1	0
<i>Discorbis</i> sp.	Pl. 5, Fig. D	0	0	2	1
<i>Elphidium advenum</i> (Cushman, 1922)	Pl. 5, Fig. G	12	0	21	5
<i>Elphidium crispum</i> (Linnaeus, 1758)		44	0	26	49
<i>Elphidium fichtelianum</i> (d'Orbigny, 1846)	Pl. 5, Fig. B	1	0	2	8
<i>Elphidium flexuosum</i> var. <i>reussi</i> Marks, 1951		5	0	0	1
<i>Elphidium josephinum</i> (d'Orbigny, 1846)		2	0	0	0
<i>Elphidium macellum</i> (Fichtel & Moll, 1798)		15	0	22	14
<i>Elphidium rugosum</i> (d'Orbigny, 1846)	Pl. 5, Fig. I	4	0	2	1
<i>Elphidium</i> sp.	Pl. 5, Fig. J	0	0	8	3
<i>Fursenkoina subacuta</i> (d'Orbigny, 1852)		1	0	0	0
<i>Globigerina bulloides</i> d'Orbigny, 1826	Pl. 5, Fig. T	5	0	0	1
<i>Globulina punctata</i> d'Orbigny, 1846	Pl. 5, Fig. O	1	0	0	0
<i>Guttulina austriaca</i> d'Orbigny, 1846		3	0	4	0
<i>Haynesina depressula</i> (Walker & Jacob, 1798)		0	0	3	2
<i>Miniacina miniacea</i> (Pallas, 1766)	Pl.5, Fig. N	0	0	2	0
<i>Neoeponides</i> sp.		1	0	0	1
<i>Nonion</i> cf. <i>tumidulus</i> Pishvanova, 1960		0	0	0	1
<i>Porosonion granosum</i> (d'Orbigny, 1846)	Pl. 5, Fig. H	3	0	8	4
<i>Pseudotriloculina consobrina</i> (d'Orbigny, 1846)	Pl. 5, Fig. F	4	0	5	6
<i>Quinqueloculina striolata</i> Reuss, 1850		0	0	3	0
<i>Quinqueloculina</i> sp.		0	0	2	1
<i>Reussella spinulosa</i> (Reuss, 1850)	Pl. 5, Fig. A	0	0	7	1
<i>Reussella</i> sp.		0	0	13	0
<i>Rosalina globularis</i> d'Orbigny, 1826		3	0	0	0
<i>Rotalia</i> sp.		0	0	2	0
<i>Saccamina</i> sp.		1	0	0	0
<i>Sahulia conica</i> (d'Orbigny, 1839)		1	0	6	0
<i>Triloculina</i> sp.		1	0	0	0

2007), the Florian Beds (Styrian Basin, Langhian-lower Serravallian, Nolf & Brzobohatý 2009) and the Korytnica Clay (Carpathian Foredeep of Poland, upper Langhian-lower Serravallian, Radwańska 1992). But in the localities mentioned, there are also otoliths of myctophids or other groups of meso- and epipelagic fishes, giving evidence of possible communication with the open sea.

The histogram of the most abundant otolith species in the Borský Mikuláš-Vinohrádky section (Fig. 7) is generally similar to the one from the

somewhat older Kienberg-vigneyard section. However, the dominance of gobiids is more outstanding, the part of sparids is smaller, and the meso- and epipelagic fishes (Myctophidae, Bregmacerotidae) and diversified gadids and sciaenids are missing.

On the other hand, the otolith assemblages of the lower Serravallian (Konkian) in the Eastern Paratethys are completely different from the Borský Mikuláš-Vinohrádky fish fauna. There are no shared species, except for the widely distributed *Lesueurigobius vicinalis*, proving a high level of isola-

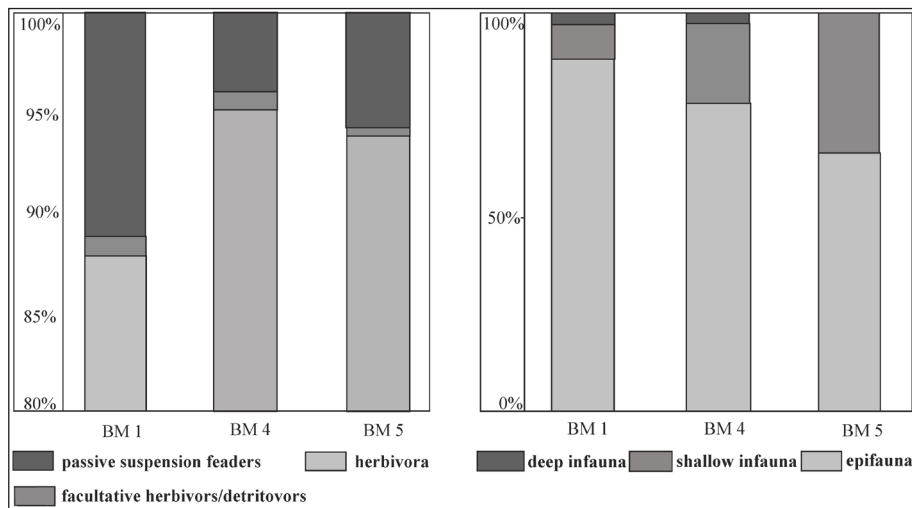


Fig 9 - Comparison of percentage content of important groups of foraminifers in the Borský Mikuláš-Vinohrádky section.

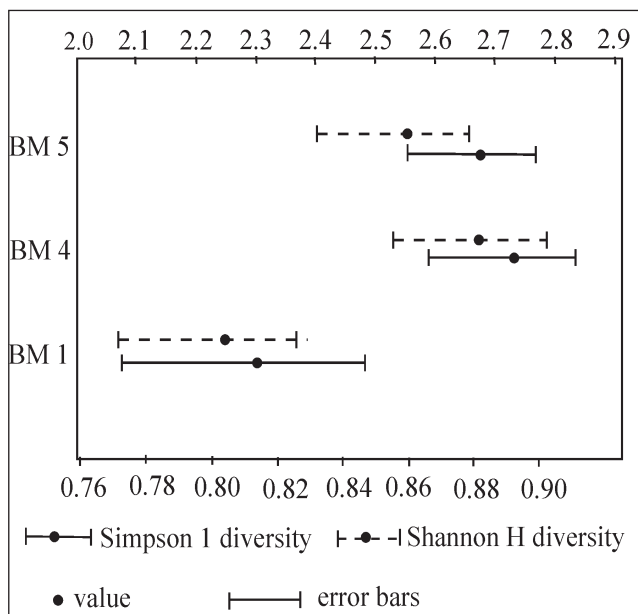


Fig. 10 - Diversities (Shannon H diversity and Simpson alpha) of benthic foraminiferal assemblages obtained from the Borský Mikuláš-Vinohrádky section.

tion from the Eastern Paratethys Basin during the early Serravallian (see Bratishko et al. 2015; Schwarzhans et al. 2020b). This observation seems to be in contrast with the sudden appearance of species with Eastern Paratethyan affinities in the Central Paratethyan mollusc fauna (Harzhauser et al. 2018).

A high degree of relationships on the species level (42%) is also found with the otolith-based fauna of the Serravallian from the Karaman Basin in the eastern part of the Mediterranean realm (Turkey; Schwarzhans 2014). *Atherina austriaca*, *Brachydeuterus speronatus*, *Lethrinus anatolicus*, *Diplodus karrerae*, *Leuseurigobius suerii*, *Thorogobius iucundus*, *Arnoglossus*

taureri, *Buglossidium frequens*, and *Dicologlossa hexophthalma* represent the shared species. These species, together with *Panturichthys subglaber*, *Merluccius merluccius*, *Lesueurigobius vicinalis*, and *Argyrosomus regius* also constitute the usual part of the lower Badenian (= Langhian) shallow-water assemblages (Radwańska 1992; Brzobohatý & Nolf 2018) and present rather a relic of shallow-water fish fauna surviving into the upper Badenian of the Central Paratethys until the closure of the transdinaride corridor (Bartol et al. 2014). The contemporaneous occurrence of *Lesueurigobius vicinalis* and *L. suerii* in the same locality and stratigraphic niveau (Borský Mikuláš-Vinohrádky) also question Schwarzhans's (2014) opinion considering a stratigraphic succession of both species in the upper Langhian to Serravallian.

Foraminifera. As regards foraminifera, similar observations were obtained from the 'medieval quarry' locality of the Devínska Kobyla Hill (Pivko et al. 2017), from the Sandberg locality (Hudáčková & Ruman 2017) and from Devínska Kobyla (Hyžný et al. 2012), where epiphytic foraminifera highly dominate in the uppermost Badenian sediments, which are understood as normal seawater to hypersaline lagoons. This interpretation is also fully consistent with the strontium isotopic studies of *Diloma* sp. from the Borský Mikuláš locality published by Fordinál et al. (2014).

CONCLUSIONS

- The uppermost Badenian (early Serravallian) section of the Borský Mikuláš-Vinohrádky locality provided 38 otolith-based taxa of Teleostei, among

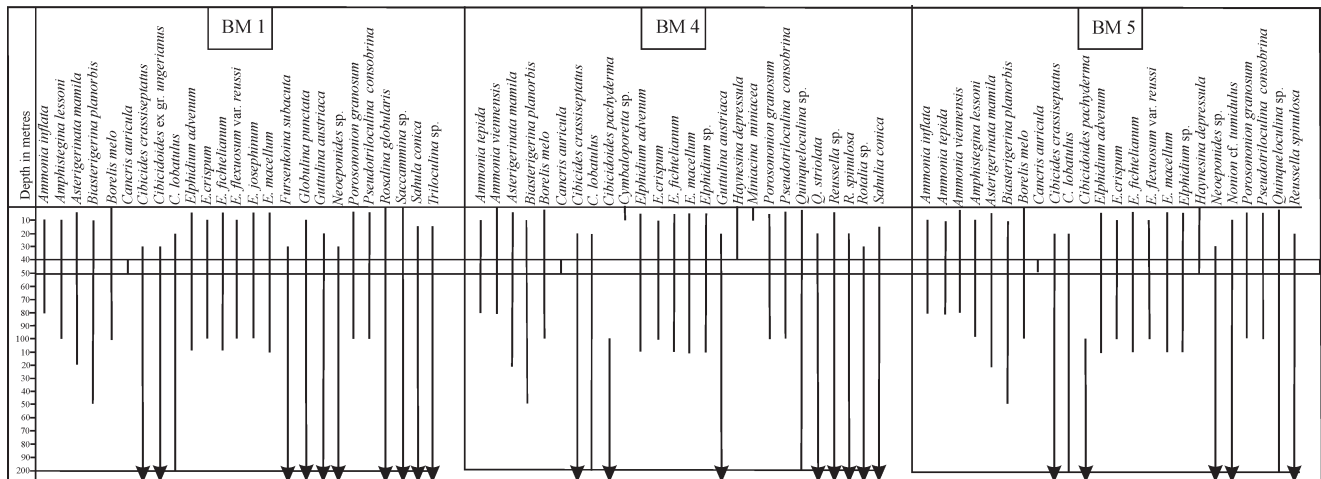


Fig. 11 - Bathymetry (Foraminifera) of Borský Mikuláš-Vinohrádky section (samples BM 1, 4 and 5) estimated using co-occurrence approach.

which *Gerres mlynskyi* and *Thorogobius antirostratus* are new, and 41 taxa of foraminifera.

- Both groups document a normal marine environment of well-aerated shallow water between 30-50 metres in depth, with plenty of light, muddy and sandy bottom, in subtropical climatic conditions.

- Histograms of the most abundant otolith species (Fig. 7) are generally close to the somewhat older Kienberg-vineyard section (upper Langhian-lowermost Serravallian) in the western part of the Vienna Basin. However, the dominance of gobiids is outstanding, and the number of sparids is smaller. Meso- and epipelagic fishes (Myctophidae, Bregmacerotidae) and diversified gadids and sciaenids are entirely missing in the Borský Mikuláš-Vinohrádky section. On the other side, otoliths of the reef-associated genera *Gerres* (together with *Encheliophis*, *Liza*, *Lethrinus*, and *Diplodus*) constitute >1% of specimens and document the possible proximity of reef environments.

- Three fish taxa today living in the Western Indian Ocean, including the Red Sea (*Encheliophis*, *Platycephalus*, and *Liza* ?) are represented by single otoliths. They could represent relics of the older Middle-Miocene fauna, rather than representing new invaders indicative of a late Badenian connection between the Central Paratethys and the West Indo-Pacific area. The more frequent otoliths of the genera *Gerres* and *Lethrinus*, living today in the Atlantic and Indian Ocean and missing in the recent Mediterranean, seem to support this interpretation.

- Among foraminifera epiphytic taxa such as *Biasterigerina planorbis* and *Elphidium crispum* associated with other elphidiids, *Lobatula lobatula* and *Cibicides crassiseptatum* prevail.

Similar assemblages occur in the coeval sediments in the southern part of the Malé Karpaty Mt. (Devínská Kobyla Hill and Sandberg locality, western part of Bratislava) and document uppermost Badenian normal seawater to hypersaline lagoons. High percentages of foraminifera species suggest the presence of seagrass or macroalgae meadows in the vicinity.

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