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A short account on the Middle Miocene fish fauna from the Fohnsdorf Basin (Styria, Austria)

By Jean Gaudant[1]

(With 12 figures)

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Abstract

The revision of the Middle Miocene fish fauna from the Fohnsdorf Basin has shown that cyprinids are abundant in the sapropelic shales overlying the coal seam. They are mainly represented by *Palaeoleuciscus* cf. *oeningensis* (Agassiz) and demonstrate the occurrence at that time of freshwater lacustrine waters in the Fohnsdorf Basin. Scarce gobiids were also found in this facies. On the contrary, the specimens of *Dicentrarchus latus* (Gorjanovic-Kramberger) are preserved in a more massive facies which indicates different environmental conditions. According to the behaviour of the recent species *Dicentrarchus labrax* (Linnaeus), which is primarily a marine fish that can live durably in brackish lagoons and even penetrate into freshwaters, *Dicentrarchus latus* (Gorjanovic-Kramberger) may be interpreted as suggesting the occurrence of at least one brackish episode in the history of the Fohnsdorf Basin, as already indicated by the occurrence of *Congeria* shells.

Keywords: Cyprinidae, Moronidae, Gobiidae, Miocene, Karpatian, Austria, lacustrine environment, brackish influences.

Introduction

The Fohnsdorf Basin is an intramontane basin which, like the Leoben Basin, depends on the Mürz-Mur fault system (Hölzel et al. 2006). It is filled with Miocene sediments which have been divided into three geological formations (Strauss et al. 2001; Gruber & Sachsenhofer 2001). The filling of the Fohnsdorf Basin began with the deposition of the fluvio-deltaic Fohnsdorf Formation which mainly consists of conglomerates and coarse sands that are overlain by the coal seam which was formerly worked. Above the coal seam, the Ingering Formation begins with *Congeria* limestone beds, grading into

[1] 17 rue du Docteur Magnan, F-75013 Paris, France (USM 203 du Muséum national d'Histoire naturelle et UMR 7207 du CNRS); e-mail: jean.gaudant@orange.fr

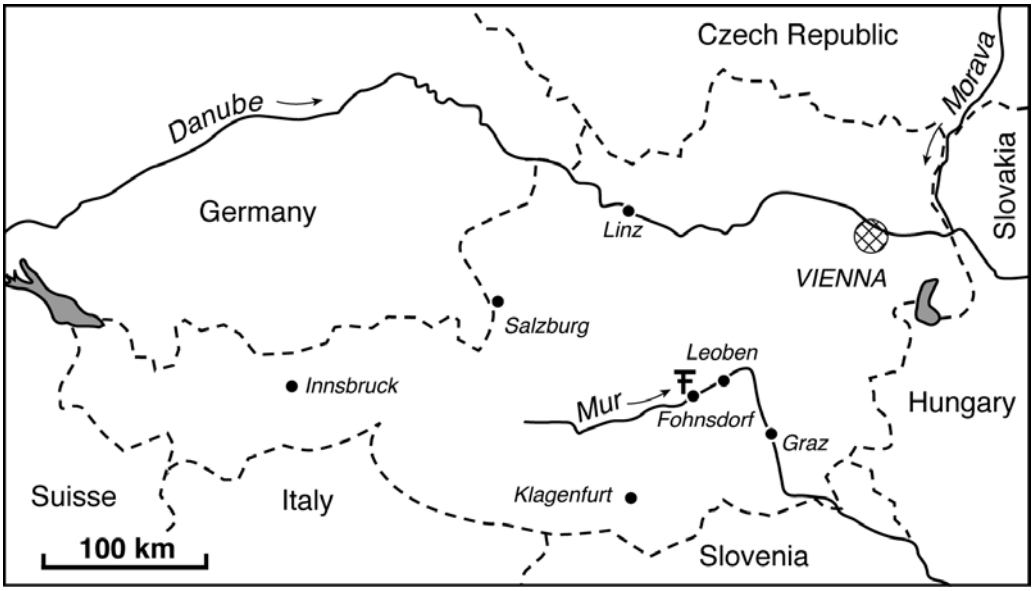

Fig. 1. Map of Austria showing the location of the Fohnsdorf Basin.

lacustrine sapropelic shales alternating with *Congeria* lumachelles and tuff layers, whereas its upper part corresponds to conglomerates and coarse sands. Finally, the Ingering Formation is overlain by the alluvial Apfelberg Formation in which conglomerates alternate with silt and coarse sands.

The age of the Ingering Formation was determined using fission tracks on zircon from a tuff layer occurring approximately 350 m above the coal seam, which was dated at 14.9±0.6 Ma (Sachsenhofer et al. 2000). The whole Ingering Formation is presently considered as being Lower to Middle Badenian (Middle Miocene) in age (Strauss et al. 2003). Consequently, the fossiliferous shales overlying the coal seam probably belong to the Lower Badenian. This age fully agrees with Mottl's opinion (1970), who, having identified three mammal species in the sandstone underlying the coal seam: a rhinocerotid belonging to the *Dicerorhinus sansaniensis-germanicus* group, a suid: *Hyotherium soemmeringi soemmeringi* von Meyer, and the proboscidian *Dinotherium bavaricum* von Meyer, considered that this association characterizes the Late to Latest Karpatian, which corresponds to the MN5 mammal zone.

The fossil fishes were mainly yielded by the sapropelic shales outcropping near the northern part of the basin, although some are preserved in a different, more calcareous facies.

The fish material from Fohnsdorf is mainly kept in the palaeontological collections of the Geologische Bundesanstalt (Vienna), in the Joanneum (Graz) and in the Naturhistorisches Museum in Wien.

Fig. 2. *Palaeoleuciscus* cf. *oeningensis* (AGASSIZ, 1839). General view of specimen GBA 1982/13/29 (left side).

Family Cyprinidae CUVIER, 1817

Genus *Palaeoleuciscus* OBRHELOVÁ, 1969

***Palaeoleuciscus cf. oeningensis* AGASSIZ, 1839**
(Figs 2-4)

Material: GBA 1982/13/27, 1982/13/28, 1982/13/29 l+r, 1982/13/32, 207/66/5, 2007/66/27; Joanneum Graz 56 675, 56 716, 56 723, 56 725, 56 726.

The most abundant fishes found in the sapropelic shales from Fohnsdorf belong to the genus *Palaeoleuciscus* OBRHELOVÁ. Unfortunately, they are mainly represented by fragmentary remains, although several specimens are more or less complete in the studied material. The following description relies mainly on the specimen GBA 1982/13/29 l+r which is one of the best preserved (Fig. 2).

The standard length of this fish equals 92.5 mm. Its body is elongate, the maximum height of body being included six times in standard length.

The head (Fig. 3), which is large, constitutes almost one third of standard length. It is rather long as its height equals about 60% of its length. The skull roof is composed of a large frontal which is followed by a short, square shaped parietal. The orbit is large: the horizontal diameter is included about three times in head length. The lachrymal (Iorb. 1) is rather wide: it is almost as wide as long. The infraorbital canal makes a 120° angle on its surface. Behind the orbit, the fourth infraorbital (Iorb. 4) seems to have been rather wide. The oblique mouth is short so that the mandible articulates with the quadratum (Q) under the anterior part of the orbit. The preoperculum (Pop) exhibits a long lower arm, the length of which almost equals that of the vertical one. The operculum (Op) is wide, its width being almost one third of head length. As shown by several isolated bones, especially specimen GBA 1982/13/32 (Fig. 4), the operculum is characterized by the possession of a rather well developed antero-dorsal angle which is separated from the prominent

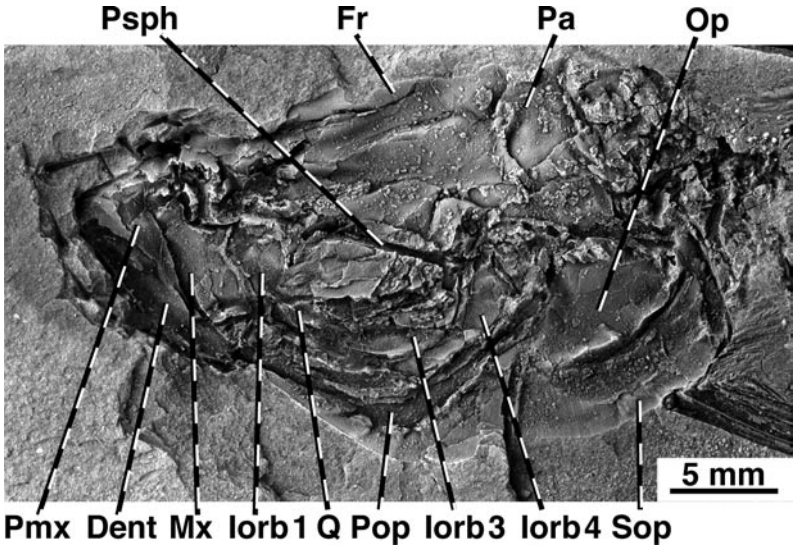

Fig. 3. *Palaeoleuciscus* cf. *oeningensis* (Agassiz, 1839). Head of specimen GBA 1982/13/29 (right side). Dent.: dentary; Fr: frontal; Iorb. 1: lachrymal; Iorb. 3, Iorb. 4: posterior infraorbitals; Mx: maxillary, Op: operculum; Pa: parietal; Pmx: premaxillary; Pop: preoperculum; Psph: parasphenoid; Q: quadratum; Sop: suboperculum.

postero-dorsal angle by a slightly concave dorsal outline. The posterior outline which is slightly depressed and the lower slightly convex outline joint in a postero-ventral angle which is projected backwards. The suboperculum (Sop) is rather large: its height equals 40% of that of the operculum.

Although the vertebral column is partly disjointed, it seems to have been composed of 39 or 40 vertebrae; 18 of them are included in the postabdominal region. Another specimen kept in the palaeontological collections of the Geologische Bundesanstalt (GBA 1982/13/27) had 40 vertebrae; 18 of them are postabdominal. Epineuralia and epipleuralia are present.

The caudal fin rays have lost their distal part, but it is clear that the caudal fin was deeply forked. It was probably composed of 19 principal rays; 4 (?) and 7 marginal rays are present dorsally and ventrally, so that the caudal fin formula can be written: 4 ?+I+9/8+I+7.

The dorsal fin begins slightly behind the middle of body, as shown by the antedorsal distance which reaches 53% of standard length. As shown by specimen 56 673, kept in the Joanneum (Graz), it is composed of three short anterior rays, one long articulated ray and 7-8 rays which are both articulated and furcated. The dorsal fin is supported by 9 pterygiophores.

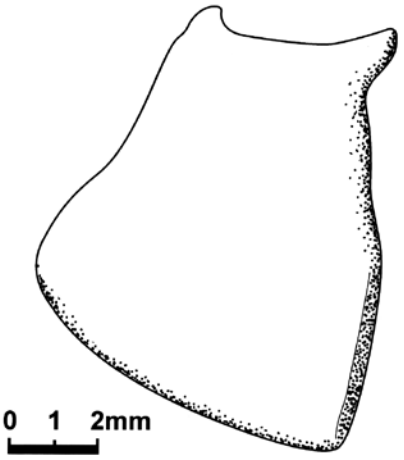

Fig. 4. *Palaeoleuciscus* cf. *oeningensis* (AGASSIZ, 1839). Isolated operculum. Specimen GBA 1982/13/32.

The anal fin is situated posteriorly: the anteanal distance equals 69% of standard length. It is too much distorted for determining its composition and that of its endoskeleton. However, as shown by the specimens catalogued 56675 and 56723, which are kept in the Joanneum (Graz), it is possible to know that the anal fin was composed of two anterior short rays, one articulated ray and 11 rays both articulated and furcated. It was supported by 13 pterygiophores.

The pectoral fins are rather well preserved. They are composed of 15 rays, including the upper articulated ray which is not furcated. Their distal part is not preserved.

The pelvic fins of specimen GBA 1982/13/29 are displaced forwards, so that they seem to be situated nearer the base of the pectorals than the origin of the anal fin. They consist of nine rays which are incompletely preserved.

The scales have only left indistinct traces in the anterior part of the abdominal region.

Taxonomical interpretation of the *Palaeoleuciscus* from Fohnsdorf:

From the preceding description it is possible to characterize these fishes as belonging to a rather large cyprinid species (standard length reaching up to 240 mm) having an elongate body, the maximum height of which is less than 25% of standard length (16.2% in specimen GBA 1982/13/29). Vertebral column: 39-40 vertebrae including the Weberian apparatus; 18 postabdominal vertebrae. Dorsal fin: iii+I+7-8 rays; 9 pterygiophores. Anal fin: ii+I+11 rays; 13 pterygiophores. Pectoral fins: I+14 rays. Pelvic fins: 9 rays.

These fishes differ from the *Palaeoleuciscus* from Leoben which have a smaller anal fin with only ii+I+8-9 rays and generally 9-11 pterygiophores (GAUDANT 1993). On the contrary, the composition of the anal fin of the *Palaeoleuciscus* from Fohnsdorf is similar to that of *Palaeoleuciscus* cf. *oeningensis* (AGASSIZ) from Eibiswald but these fishes have a vertebral column which is slightly shorter (16-17 postabdominal vertebrae against 18 in

Fig. 5. *"Barbus"* sp. General view of body. Specimen GBA 1982/13/30 (left side).

the material from Fohnsdorf). Additionally, the fishes from Fohnsdorf differ from those from Eibiswald by their body which is more elongate as their height of body is generally less than 25% of standard length, against 30% in the material from Eibiswald. Finally, a comparison should be made with the Badenian species *Palaeoleuciscus oeningensis* (Agassiz) from Öhningen (Germany). Like in the material from Eibiswald, these fishes have a rather large anal fin (ii+I+9-13 rays and 11-13 pterygiophores), but their vertebral column is slightly shorter than in the fishes from Fohnsdorf (16-17 postabdominal vertebrae against 18) and the body is more thick-set as the maximum height of body generally equals 30-34% of standard length, instead of less than 25% (and more generally less than 20%) in the fishes from Fohnsdorf. For this reason, the population Fohnsdorf may be eventually considered as a subspecies of *Palaeoleuciscus oeningensis* (Agassiz), although the more elongate shape of the body may also be related to a shortage of the food which was available during the deposition of the sapropelic shales.

Genus *"Barbus"* Cuvier, 1817[2]

***"Barbus"* sp.**

(Figs 5-9)

Material: The fish specimen GBA 1982/13/30 from Fohnsdorf, which is preserved in part and counterpart, is kept in the palaeontological collections of the Geologische Bundesanstalt (Fig. 5).

[2] The heterogeneity of the genus *Barbus* Cuvier being evident, a new analysis of the relationships of the species belonging to this genus is needed. For example, it is quite unsatisfactory that, for example, the species *Barbus meridionalis* Risso which has no ossified dorsal ray coexists with the type species *Barbus barbus* (Linnaeus) which is characterized by its spiny ossified ray and which has 12 more vertebrae.

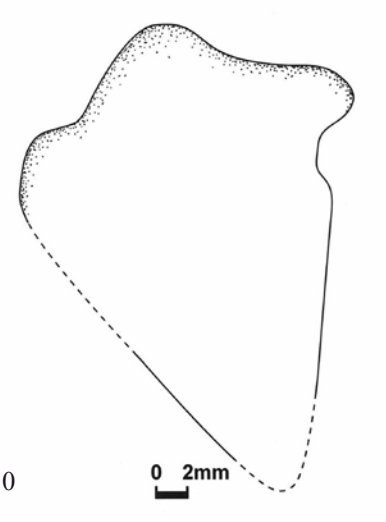

Fig. 6. *"Barbus"* sp. Operculum of specimen GBA 1982/13/30 (left side).

This specimen which is rather poorly preserved has a standard length of 245 mm. Its maximum height is included slightly more than six times in standard length, whereas the head length equals about one quarter of standard length.

Head: a large frontal is visible above the orbit. The preoperculum has a lower arm which is slightly shorter than the vertical arm. The dentary which shows a well developed coronoid process seems to articulate with the skull approximately under the posterior part of the orbit.

The isolated right operculum of this fish is also preserved on the same slab (Fig. 6). It is higher than wide, its maximum width being only 2/3 of its height. Its antero-dorsal process is damaged. This operculum is characterized by its prominent dorsal angle which is situated above the middle of the bone. The posterior angle is situated unusually high, above the upper third of the bone. The posterior outline is straight between the posterior angle and the antero-ventral angle.

The two pharyngeal bones are rather well preserved on the left part of the specimen; they are regularly arched. The main teeth row is composed of five hook-shaped ("Hakenzahn", RUTTE 1962) teeth (Fig. 7-8). Among them, the anterior tooth (noted 5 by RUTTE 1962) is rather small, more or less conical in shape. On the contrary, the second tooth (noted 4) is very strong and quite larger. The next two strong teeth (noted 3 and 2) are distally broken or worn out on the right pharyngeal bone. As shown by the opposite pharyngeal bone, both were conical; like the preceding ones no chewing surface ("Kaufläche") seems to have been present. The posterior tooth (noted 1), which is smaller, is typically hook-shaped and bears posteriorly a small chewing area.

A more or less similar isolated pharyngeal bone (GBA-1982/13/33) is also kept in the palaeontological collections of the Geologische Bundesanstalt (Fig. 9). It is a robust bone

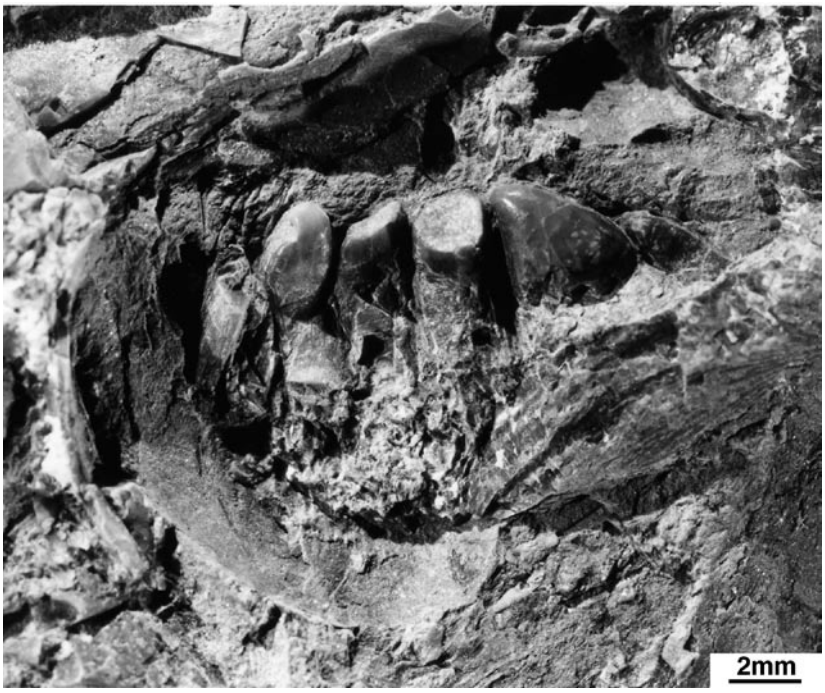

Fig. 7. *"Barbus"* sp. Pharyngeal bone of specimen GBA 1982/13/30 (right side).

measuring 27 mm in length. Gently arched, its tapering forepart is bent downwards. It bears a series of five pharyngeal teeth and the negative cast of another one. Its anterior tooth is a strong conical one which looks similar to the second tooth of specimen GBA 1982/13/30. The second one is hook shaped. Behind it one can observe the negative cast of another large tooth; then two smaller teeth are preserved. The former one, which is hook-shaped, seems to have borne a small chewing area under its hook. The posterior tooth (noted 1) is quite smaller; its distal part is conical.

Although this pharyngeal bone is rather well preserved, the interpretation of its pharyngeal dentition is rather problematical because it differs from that of specimen GBA 1982/13/30 by the lack of the small anterior tooth. Whereas the three largest teeth clearly belong to the main row, the interpretation of the last two teeth remains uncertain. The first one probably belongs to a lateral row as it is hiding the base of the posterior outline of the negative cast of the third tooth. Because of its small size, we suspect that the small posterior tooth also belongs to a lateral row.

Body: the vertebral column seems to have included 37 or 38 vertebrae: there are 19 or 20 free abdominal centra and 14 postabdominal centra. The abdominal vertebrae support the long pleural ribs, the distal extremity of which reaches the ventral edge of the abdominal cavity.

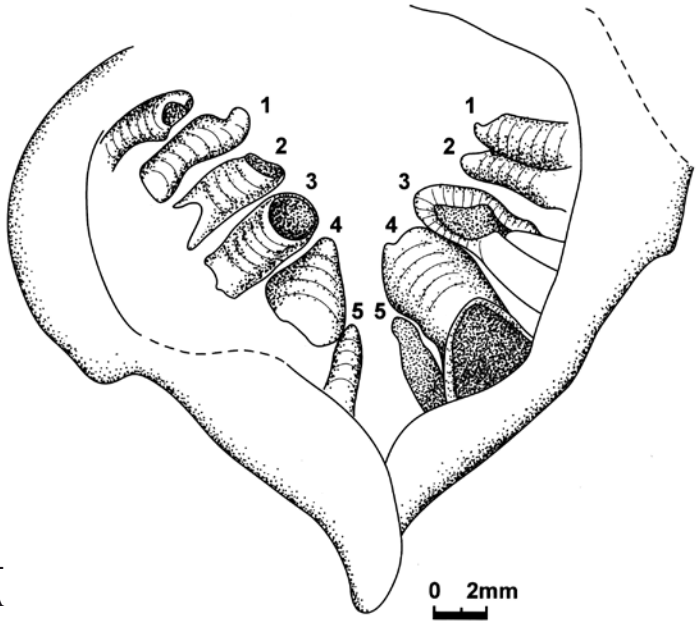

Fig. 8. *"Barbus"* sp. Pharyngeal bones of specimen GBA 1982/13/30.

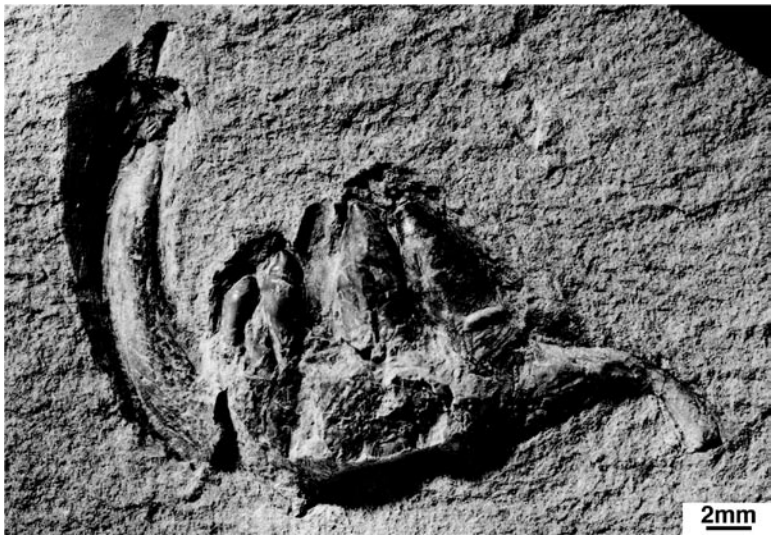

Fig. 9. *"Barbus"* sp. Isolated pharyngeal bone: specimen GBA 1982/13/33.

The caudal fin, which was furcated, is incompletely preserved. The caudal axial skeleton is composed of the posterior uro-terminal centrum and two free preural vertebrae.

The dorsal fin begins near the middle of the body, measured from the tip of the snout to the posterior part of the hypurals. Two rather strong short rays are situated in front of a

long articulated ray and seven bifurcated rays. The distal part of the long rays is not preserved. The dorsal endosketon includes eight pterygiophores.

The anal fin is situated posteriorly: it begins far behind the posterior part of the dorsal fin base. It is small and consists of two rather strong short rays and probably six rays, including the long unforked ray. The anal endoskeleton consists of five pterygiophores.

Neither the pectoral nor the pelvic fins are preserved.

Taxonomical interpretation: According to the shape of its operculum and the morphology of the pharyngeal teeth – especially the reduced size of the anterior tooth and the shape of the chewing area of the posterior tooth –, it is possible to suggest a closeness of this skeleton with the members of the subfamily (or tribe) Barbinae. Another character, which fully agrees with this interpretation, is the small size of the anal fin. However, the lack of ossified ray in the dorsal fin clearly distinguishes this fish from the recent species *Barbus barbus* (Linnaeus) and also from the Miocene species *Barbus steinheimensis* Quenstedt, from Steinheim am Albuch (Gaudant 1989). On the contrary, a similarity exists between the skeleton from Fohnsdorf and the recent European species *Barbus meridionalis* Risso which has no ossified ray in the dorsal fin and a reduced number of postabdominal vertebrae.

Order Perciformes Bleeker, 1859

Family Moronidae Fowler, 1907

Genre *Dicentrarchus* Gill, 1860

***Dicentrarchus latus* (Kramberger, 1891)**
(Fig. 10)

Material: NHMW 1898/0028/0001, 1898/0028/0002; GBA 2007/66/21, 2007/66/29; Joannum Graz 8 549, 56 714, 56 715, 208 721.

Several incomplete specimens belonging to this species are present in the studied material from Fohnsdorf. The two best preserved ones are kept in the Naturhistorisches Museum in Wien.

The first one (NHMW 1898/0028/0001; Fig. 10A) exhibits the anterior part of a fish, the estimated standard length of which was about 400 mm ; the maximum height of body equals 80 mm. Although its head is rather poorly preserved, the presence of a rather low supraoccipital crest is visible behind the frontal. The operculum is present, however its upper posterior spine is eroded. Nevertheless it is clear that it was ornamented by two spines, the larger one being situated at the extremity of the ridge originating near the articulation with the hyomandibular process. The upper one was separated from it by a rounded concavity.

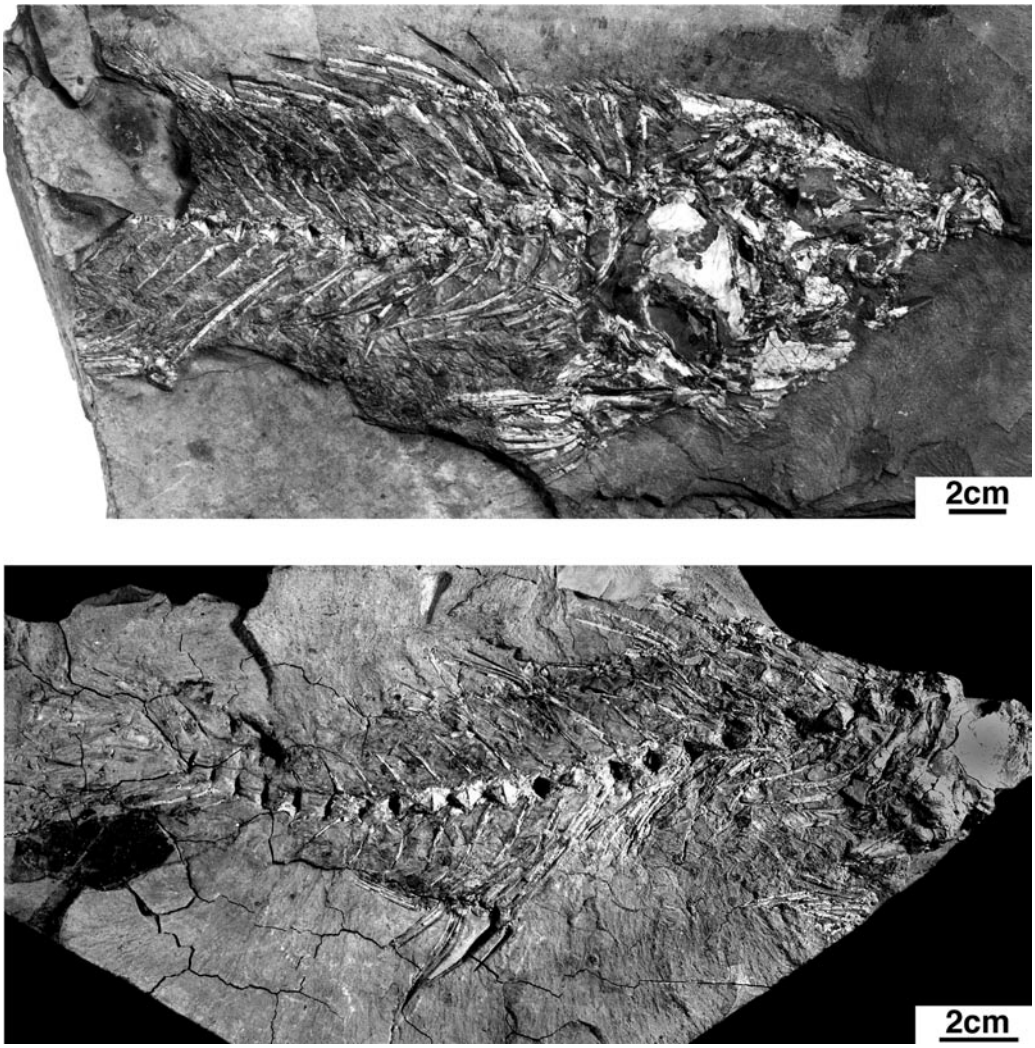

Fig. 10. *Dicentrarchus latus* (KRAMBERGER-GORJANOVIC, 1891).
A: Anterior part of body. Specimen NHMW 1898/0028/0001.
B: General view of specimen NHMW 1898/0028/0002.

In the second specimen (NHMW 1898/0028/0002; Fig. 10B), the head is destroyed, except for the opercular region which shows a poorly preserved operculum. The estimated standard length was about 300 mm, whereas the maximum height of body equals 70 mm. The vertebral column includes 14 postabdominal vertebrae.

An incomplete specimen lacking the caudal region, which is kept under the catalogue number 56714 in the Joanneum (Graz) shows that the lower edge of the preoperculum

bears several spines which are oriented forwards. At least seven small oblique spines are present in the postero-ventral region of this bone.

Body: The vertebral column consists of 10 abdominal vertebrae supporting rather short pleural ribs, the distal extremity of which does not reach the ventral edge of the abdominal cavity. Several epipleuralia are present under the first vertebral centra.

There are nine rather short spines in the anterior dorsal fin. The length of the fourth spine (which is the longest one) equals half the maximum height of body. The endoskeleton of the first dorsal fin consists of eight pterygiophores. Three predorsal bones having a transversally expanded dorsal extremity are present between the supraoccipital crest and the first pterygiophores.

The posterior dorsal fin is poorly preserved on another specimen (NHMW 1898/0028/0002; Fig. 10B) which exhibits the main part of a body without head (only remains of the operculum are preserved). However, 11 pterygiophores are present. The composition of the posterior dorsal fin was determined on specimen GBA 2007/66/29 which shows 9-10 rays supported by 10-11 pterygiophores. It should be noted that the number of pterygiophores is indicative of a larger number of fin rays, which was probably 11 or 12

As shown by specimens NHMW 1898/0028/0001 and …/0002, the anal fin, which is opposed to the posterior dorsal fin, begins slightly behind it. It has three spines, the second one being both the longest and the strongest. Behind them, there are eight rays, as shown by specimen number 8549 kept in Graz Joanneum.

Small remains of some pectoral rays are present. Below, one can see the basal part of the pelvic rays. The pelvic fins are supported by rather robust pelvic bones articulating with the lower arm of the cleithrum.

Taxonomical interpretation of the moronids from Fohnsdorf

In his description of the holotype of *Labrax latus*, Gorjanovic-Kramberger (1891) noted the occurrence of 24 vertebrae, 14 of which being postabdominal, like in the material described above (NHMW 1898/0028/0002; GBA 2007/66/29), and also like in "*Perca*" *lepidota* Agassiz, from the Middle Miocene of Öhningen (Gaudant 1980). The composition of the dorsal fins is also very similar: nine spines in the first dorsal, and one spine and, probably, 11 or 12 rays in the second dorsal fin, (12 is the number which is observed in "*Perca*" *lepidota* Agassiz), whereas Gorjanovic-Kramberger noted I+11-12 rays. In the anal fin, there are three spines and eight fin rays, as in "*Perca*" *lepidota* Agassiz, against I+9 in the holotype of *Labrax latus*, according to Gorjanovic-Kramberger.

The main difference between *Labrax latus* Gorjanovic-Kramberger and "*Perca*" *lepidota* Agassiz concerns the shape of the body as the height of body reaches 30-35% of standard length in the Middle Miocene species from Öhningen, whereas this ratio does not exceed 27% in the holotype of *Labrax latus* Gorjanovic-Kramberger and can be estimated around 20-23% in the two incomplete specimens kept in the palaeontological collections of the Naturhistorisches Museum in Wien. For this reason, it appears that

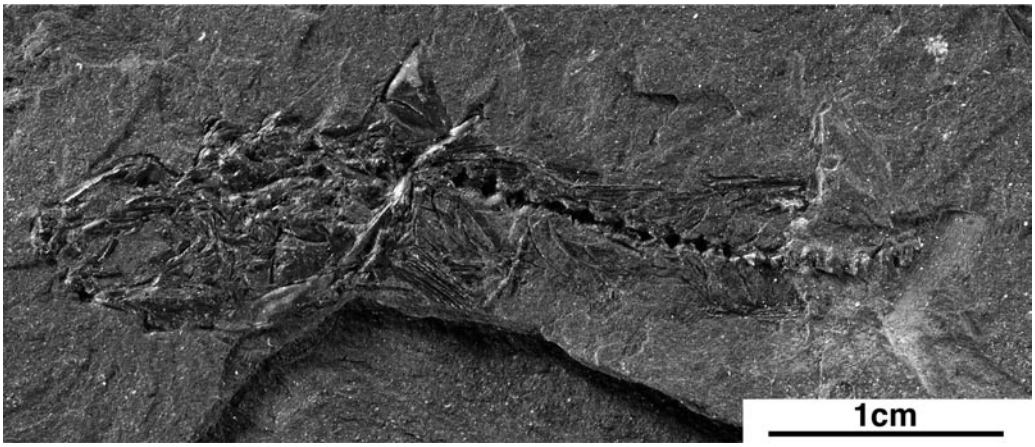

Fig. 11. *Gobius* sp. General view of specimen NHMW 2009z0101/0001.

Labrax latus GORJANOVIC-KRAMBERGER cannot be considered as a synonym of "*Perca*" *lepidota* AGASSIZ. Relying on the morphology of the scales of this species, MICKLICH & BÖHME (1997) suggested that "*Perca*" *lepidota* AGASSIZ may exhibit affinities with the moronids.

Family Gobiidae BONAPARTE, 1832

Genre *Gobius* LINNAEUS, 1758 (s. l.)

***Gobius* sp.**
(Figs 11-12)

M a t e r i a l : A rather poorly preserved skeleton of a small gobiid fish from Fohnsdorf is kept in the palaeontological collections of the Naturhistorisches Museum in Wien, where it received the catalogue number 2009z0101/0001 (Fig. 11). It exhibits a distorted head which was abnormally elongated and more or less dorso-ventrally crushed during the fossilization process. Consequently, both operculae are preserved on both sides of the head, the estimated length of which was about 11-12 mm. The caudal region is not preserved.

The isolated right operculum (Fig. 12) is exposed near the head; it exhibits a typical subtriangular shape, with a regularly rounded postero-ventral outline.

In the anterior part of body, eight abdominal vertebrae are visible behind the cleithrum. They bear slender, rather short, pleural ribs.

In the anterior dorsal fin, there are six slender spines. The base of the last one seems to have been rather distant from that of the preceding one. The posterior dorsal fin is in-

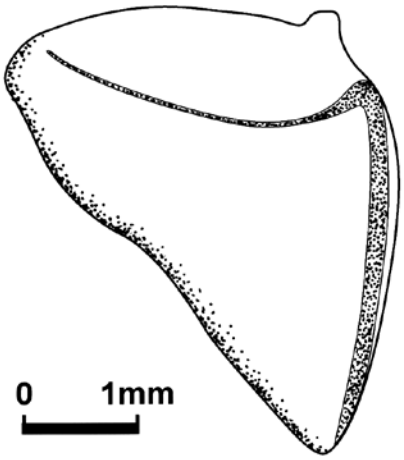

Fig. 12. *Gobius* sp. Isolated operculum of specimen NHMW 2009z0101/0001.

completely preserved: one can only observe one slender spine and the first four fin rays and the six anterior pterygiophores. The posterior dorsal fin is almost exactly opposed to the anal fin in which only the anterior slender spine, three fin rays and the anterior three pterygiophores are preserved.

The pectoral fins are poorly preserved; their composition remains unknown. The basal part of a pelvic fin is visible slightly behind the base of the pectoral rays.

Scales have left rather indistinct traces of radii in the sediment.

Additionally to this incomplete skeleton, some gobiid fragments were recently collected by Dr. Daxner-Höck at Dietersdorf, east. of Fohnsdorf. Among them, there is a typical gobiid skull roof and a fish fragment showing a head and a distorted vertebral column; they are kept in the palaeontological collections of the Naturhistorisches Museum Wien (NHMW 2010/0006/0003a+b).

Taxonomical interpretation: Because of the incompleteness of the gobiid skeleton described above, it is impossible to determine its relationship within the gobiid family and even within the Gobioidei, especially because the shape of the palatine is unknown, a character which can be used for distinguishing Eleotrids from Gobiids, as already shown by Regan (1911). However, in the first dorsal fin, the last spine is distant from the preceding ones, as in the Miocene species *Gobius brevis* (Agassiz) (Gaudant 2000; Reichenbacher et al. 2007; Brzobohaty & Gaudant 2009).

Conclusion

The revision of the Karpatian fish fauna from the Fohnsdorf basin has shown that the cyprinids are the more frequent in the studied material. These fishes demonstrate that this basin was filled by fresh water during the deposition of the sapropelic shales overlying the coal seam. However, the presence of a moronid, *Dicentrarchus latus* GORJANOVIC-KRAMBERGER, which belongs to a recent genus mainly living in the sea and in lagoonal environments, suggests at least the temporary occurrence of brackish waters in the Fohnsdorf basin. This confirms the information provided by the presence of *Congeria* beds, already noted by POLESNY (1970) above the sapropelic shales in the Sillweg profile. The presence of *Congeria* cf. *antecroatica*[3] and *Theodoxus crenulatus* in a calcareous facies is undoubtedly indicative of brackish conditions. Precisely, the specimens of *Dicentrarchus latus* GORJANOVIC-KRAMBERGER are generally preserved in a grey silty marl in which mica is rather abundant, a fact which indicates a difference in the sedimentation conditions between this facies and the sapropelic shales which yielded cyprinids.

It should be noted that STRAUSS et al. (2001) and SACHSENHOFER et al. (2003) consider the brackish influence observed in the Fohnsdorf Basin as the result of tectonics movements which established a connection between this basin and the marine Lavant Basin which was directly in communication with the Styrian Basin.

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