FOSSIL FISH REMAINS FROM THE ROMANIAN OF PODARI, SW OF ROMANIA. THE FIRST REPORT.

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Abstract. The present work presents the first report of fossil fish fauna from the Pliocene of the Dacic Basin. So far, the fish remains from the sediments of the Dacic Basin were scarcely studied. Recently, during a field campaign, fossil material from the locality Podari, Craiova region of the Dacic Basin has been collected. In this work, we present the fish remains from the vertebrate assemblage. The fish fauna includes *Esox* sp., *Tinca* sp., *Scardinius* sp. and *Silurus* sp. Ecological interpretations and taphonomic observations on fishes suggest presence of standing or slow flowing well-vegetated water body and was buried in a near-shore environment or an alluvial plain close to the water in the Poldari site.

Keywords: Podari, Pliocene, Romanian, Dacic Basin, fish fossils.

Rezumat. Pești fosili din Romanianul localității Podari, SV României. Prima semnalare. Acest articol constituie prima semnalare a faunei fosile de pești din Pliocenul Bazinului Dacic. Până acum fosilele de pești din Bazinul Dacic au fost studiate foarte rar. Recent, în timpul unei campanii de teren s-a colectat material fosil din localitatea Podari, regiunea Craiovei. În prezentul articol prezentăm pești din asamblul faunei de vertebrate fosile. Fauna de pești include taxoni aparținând la *Esox* sp., *Tinca* sp., *Scardinius* sp. and *Silurus* sp. Interpretarea ecologică și observațiile tafonomice sugerează că fauna de pești a populat o apă stătătoare sau încet curgătoare, cu vegetație acvatică bogată și că fosilizarea s-a produs în apropierea unei zone de țărm sau pe o câmpie aluvială apropiată de această apă.

Cuvinte cheie: Podari, Pliocen, Romanian, Bazinul Dacic, pești fosili.

INTRODUCTION

Numerous localities with fossil vertebrates are known from the territory of Romania and especially from the Dacic Basin, Southern Romania. Many of them yielded microvertebrate faunas of Pliocene age, especially micromammals. Until now, fish faunas were not reported among this Pliocene remains. The only earlier report mentioned fish fossils from the Lower Pleistocene formations of this basin (VASILE et al., 2013). Fish remains of *Carassius*, *Tinca*, *Rutilus*, *Squalius*, *Scardinius*, *Esox* and *Silurus* were listed, but not described or illustrated.

The recent field work at the well-known vertebrate locality, Podari (Pliocene) yielded fossil fish material. In the present article, we describe and illustrate the collected taxa and make assessments on the paleoenvironment and taphonomic situation of this locality.

The Podari fossil site is located about 7 km south from the city of Craiova, on the right bank of the Jiu River and northwest from the village with the same name, on the eastern slope of Solomon Hill, about 1 km south-west of the Jiu River (Fig. 1).

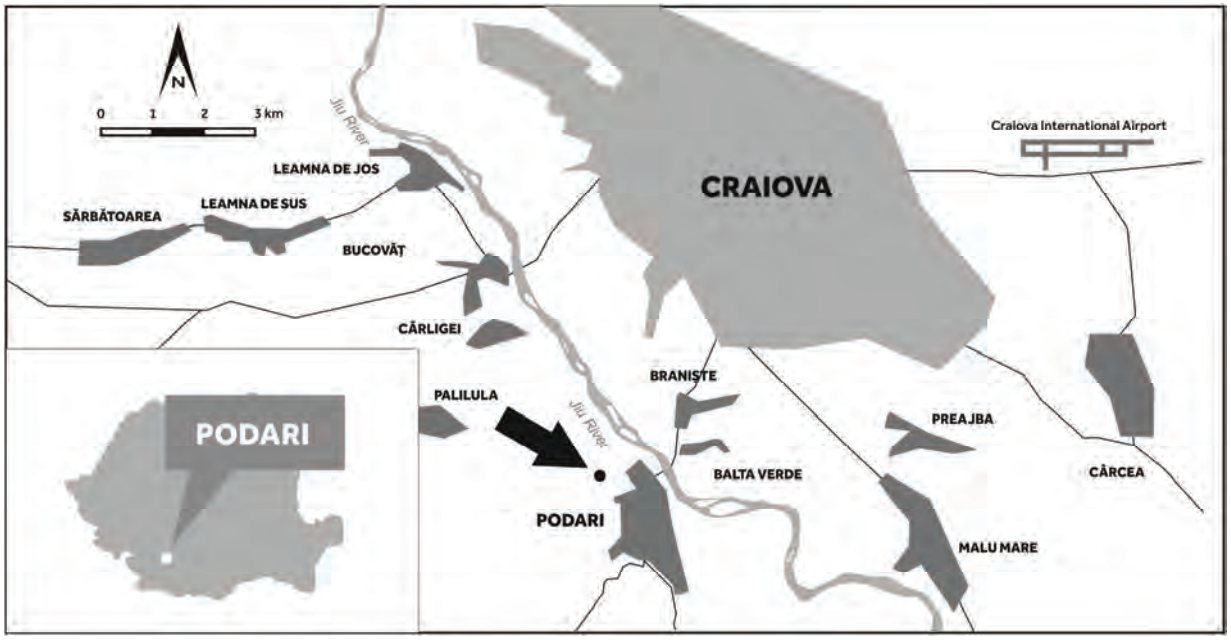

Figure 1. The location of the Podari outcrop (indicated with an arrow) near Craiova, SW of Romania.

GEOLOGICAL SETTINGS

The Podari fossil site was first mentioned by BANDRABUR (1971), which notified the presence of Pliocene age mollusks. These mollusks were described in a later article by ANDREESCU et al. (1981). The micromammals were reported by FERU et al. (1979) and studied by a team from ISER (Institute of Speleology Emil Racoviță), IGR (Romanian Institute of Geology) and Oltenia Museum, team led by Costin Rădulescu and Petre Samson (RĂDULESCU et al., 1993, 1993a, 1999). As a result of the research, PANĂ et al. (2004) published a study on the small gastropods, and ȘTIUCĂ et al. (2003) described a new species of the water-mole family Talpidae.

The studied section has a thickness of ca. 20 m. The basal part of the sediments is represented by grayish-blue clays with scarce fossils. The deposits above, of approximately 14 m height, are made up of fine to coarse sands, gravel lenses, followed by sands with oblique lamination and sands with parallel lamination. All layers contain ferruginous and calcareous concretions. The fossil fauna of the sands, overlying the greyish-blue clays, contains mainly gastropod shells, where Viviparidae is the dominant family. The following upper part (5-6 m thick) of the described section is represented by a sequence of clays and clayey sands, with layers rich in fossil remains of unionid bivalve mollusks with sculptured shells. In this upper section, Viviparidae are present as a secondary group. The uppermost layer of the profile is represented by a 10 cm thick black clay with remains of coal and contains pellicles of iron oxides and gypsum crystals. This thin level provides the vertebrate fauna, including fishes, which are described in the present works. The section is covered by recent soil.

The described sediments are part of the western side of the Dacic Basin (PANĂ et al. 2004) and represent the Romanian stage based on palaeomagnetic measurements, micromammal biochronology and mollusk zonation. The palaeomagnetic age corresponds to the middle Gauss epoch (ANDREESCU et al., 1981), recently calibrated to the C2An Chron, subchrones C2An2n and C2An-1r. ANDREESCU et al. (2011, 2013) indicated an absolute age of 3.2 to 3.0 Ma. The age of the uppermost layer with fish remains can be correlated to the Mammal Zone MN16 (RZEBIK-KOWALSKA, 2002) or MN16a (ȘTIUCĂ et al., 2003) based on the occurrences of *Micromys praeminutus (*KRETZOI, 1959) and *Propliomys hungaricus* (KORMOS, 1934). ENCIU (2007) showed that this association of micromammals from Podari is similar with the one from Arondelli-Villafranca d'Asti in Italy of middle Piacenzian age, and partially with the Hungarian locality Csarnóta 2 dated to the Early Pliocene. In the Dacic Basin, the Podari locality is considered as an equivalent of the Cernătești and Tulucești micromammals sites (ANDREESCU et al., 2013). The fossil mollusk fauna of the underlying horizon of the level with the vertebrate fauna is very rich at the Podari. About 45 species of gastropods and 40 species of bivalves were found (ENCIU, 2007). Among them the sculptured unionids are the most important for age estimation, *Pristinunio pristinus* (Bielz), *Rytia brandzai* (Sabba), and *R. lenticularis*, being characteristic for the middle part of the Romanian (OLTEANU, 2006).

The Dacic Basin was the most western part of the Eastern Paratethian epicontinental sea. It existed from the Sarmatian s.l. until the Pleistocene, partially as a gulf and isolated basin. The basin was bordered by the Carpathians in the north and by the Balkan orogene in the south (ANDREESCU et al., 2013). With intermittent variations from marine to brackish and freshwater environments, it turned finally to a freshwater basin with pronounced endemism. The Romanian stage of the basin is characterized by habitats rich in carbonates and nutrients (JIPA & OLARIU, 2009).

MATERIAL AND METHODS

Bulk collecting of sediment was performed at Podari quarry. The screen washing of more than 300 kg of sediments revealed heterogenic fossil material composed mostly of fish skeletal remains, which includes vertebrae, pharyngeal teeth both isolated and associated with pharyngeal bone and elements of the postcranial skeleton. Apart from fishes, the fossil material contains other vertebrate remains e.g. snakes, turtles and mammals. Here, we present only the results of the fish material.

The material was compared with photographs published in the database of the Department of Archaeology at The University of Nottingham (DATUN), as well as with skeletons of *Esox lucius* (Figs. 2 B, D', and D") (Collection of the Natural History Museum, Sibiu) and available literature (e.g. BÖHME, 2002, 2010, 2010a; GAUDANT, 1977, 1994, 2015; RÜCKERT-ÜLKÜMEN & YIGITBAS, 2007).

The measurements of the fossil bones were done using the Unior calliper (model 271) with a measurement error of 0.02 mm. Some of the fossils were measured on digital images, using a standard scale reference of 1 cm. The images were taken with a Nikon D700 camera mounted on a tripod, using a Sigma lense of 105 mm and extension tubes. The close observation of bone morphology was done using an Optika stereomicroscope (model S-10-L). All material described herein is stored in the Oltenia Museum, Craiova, Romania.

Systematic paleontology

Class: Actinopterygii Cope, 1887
Order: Esociformes Nelson, 1994
Family: Esocidae Cuvier, 1817
Genus: *Esox* Linnaeus, 1758
Esox sp.

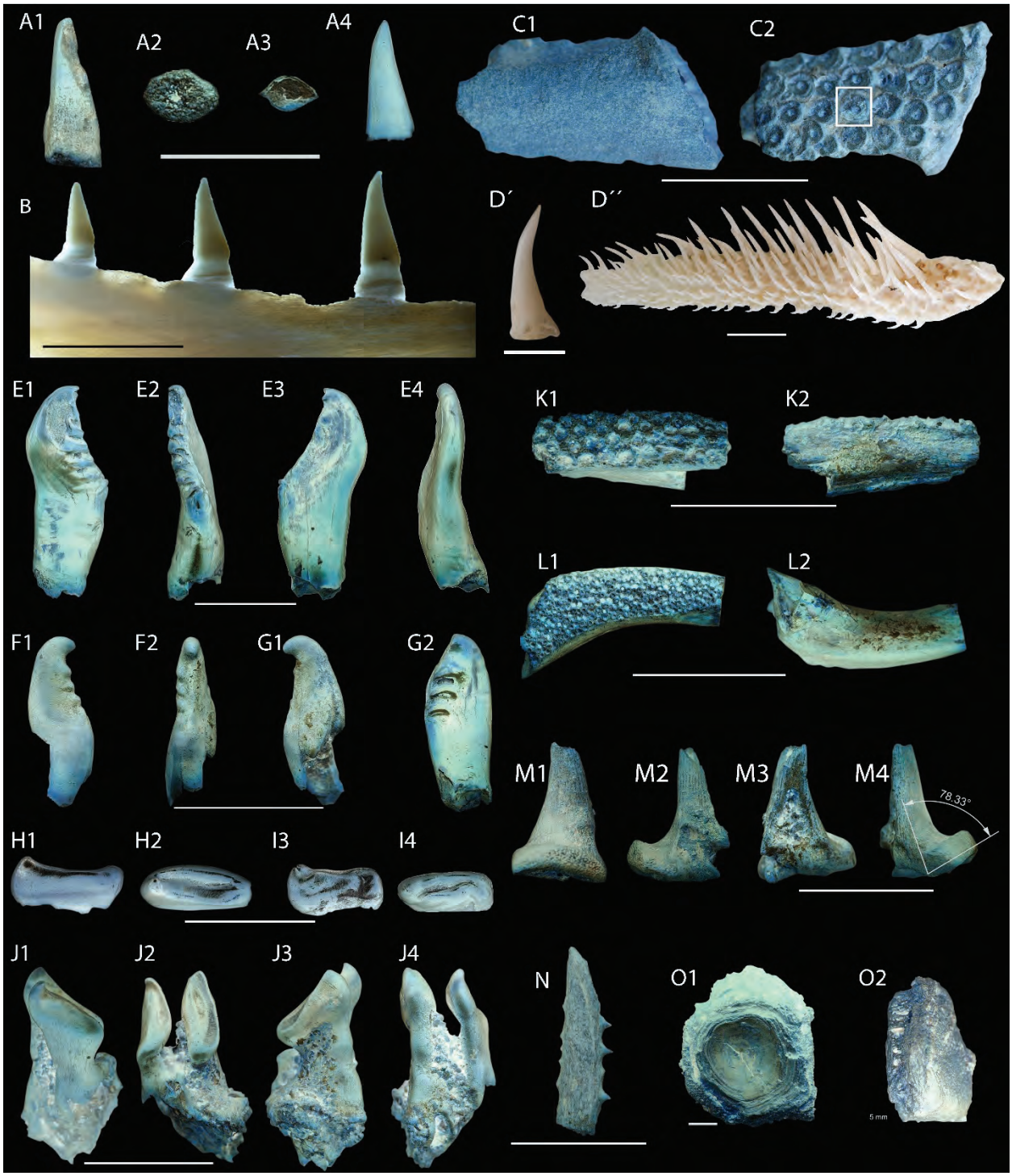

Figure 2. Fossil fishes from the locality Podari. *Esox* sp. (A, C) and recent *Esox lucius* (B, D): A - isolated teeth, B – dentary with teeth, C – fragments of palatine, D´ – vomerine tooth, D´´ – palatine bone. *Scardinius* sp. (E-G): pharyngeal teeth from different positions. *Tinca* sp. (H-J): H, I, – isolated pharyngeal teeth and J – pharyngeal teeth articulated with pharyngeal bone. *Silurus* sp. (K-O): K – dentary, L – praemaxillae, M – proximal and N – distal portions of the pectoral spine, O – vertebra. Scale bars 5mm. For D' scale bar is 2 mm.

Material: One anterior fragment of the left palatine (Figs. 2 C1 and C2) and two dentary teeth (Figs. 2 A1, A2, A3 and A4).

Description: The preserved fragment of palatine is small, 5.4 mm wide and 9.9 mm long. The palatine bone presents a very characteristic aspect for the pikes, the tooth bases are arranged in longitudinally parallel to each other rows; in the preserved bone, four of these rows are observable. The tooth bases are round with thick tooth wall and rather small dental cavity in the centre. The tooth base rows have a distinct side marked by collagen ruptures of the hinge-like building a "C"-shaped structure (Fig. 2 C2). The two *Esox* teeth come from the dentary and are few millimetres in length (the larger 3.9 mm long, 1.5 mm wide at the base; the smaller 2.8 mm long, 1.2 mm wide at the base). The dentary teeth differ completely from the vomerine or palatal ones. The dentary teeth are straight, laterally compressed with a cutting ridge present on the anterior and posterior edges, which are well pronounced in the lower half of the crown. The vomerine and palatal teeth are slender, curved, in the cross-section almost circular and lack any cutting ridge (e.g. Fig. 2 D'). The dorsal surface of the bone is smooth and convex.

Remarks: The bone has small surface uplifts on one side and smooth surface of the other side. These uplifts are forming approximately four unevenly distributed rows, "C"-shaped structures that are the support bases for the palatine teeth of the pike. The opening that can be seen in the "C"-shape structures indicates the rupture of the attachments of the predentine or collagen formation that form the hinge-like teeth of the pike. FINK (1981) showed that the *Esox* genus has this flexible type of attachment. This flexible attachment type can be found in the palatine, vomer and pharyngeal bones of the genus *Esox*. A similar attachment was described for the Palaeocene species *Esox tiemani* (WILSON, 1984). The preserved fossil material (palatine fragment, teeth) of the pike from Podari can be identified only at the generic level.

Stratigraphic distribution: The order Esociformes that includes *Esox* genera - has its origin during the Mesozoic (NEWBREY et al., 2008). North American fossils demonstrate that the pikes first occurred in the early Campanian (WILSON et al., 1992). In Europe, this genus is known from the early Oligocene of Western and Eastern Europe (*Esox* sp.; GAUDANT, 1979a). So far in Romania, the genus is reported only from the late Oligocene – early Miocene of the Eastern Carpathians (loc. Gura Humorului, *Esox moldavicus*, SYCHEVSKAYA, 1974) (CONSTANTIN, 1999) and the Pleistocene of Southern Romania (VASILE et al., 2013, 2015), (loc. Copăceni, *Esox* sp.). During the Pliocene, they are known from the locality Priozernoe, Republic of Moldavia by *Esox moldavicus* (KOVALCHUK et al., 2014a), as well as from West Mongolia, *Esox sibiricus*, (SYTCHEVSKAYA, 1989) and late Pleistocene of Siberia, *Esox* sp. (SYTCHEVSKAYA et al., 2015; BÖHME & ILG, 2003).

Ecology: The distribution of the Recent pikes, with *Esox lucius* as model, shows their circumpolar distribution with a wide range of habitats. Pikes are found in rivers, lakes and even in weakly saline waters (CRAIG, 2008). In these environments, *Esox* has a key role in the structure of the entire freshwater communities. Here it can be responsible sometimes for the local influence or even disappearance of almost all other fish species (CRAIG, 2008). *Esox* is linked to a dense water plants environment since plants offer a spawning habitat (KOTTELAT & FREYHOF, 2007). The presence of dense water vegetation is a major environmental requirement for this fish (RAAT, 1988; BRY, 1996).

Order: Cypriniformes Bleeker, 1859
Family: Cyprinidae Bonaparte, 1832
Subfamily: Tincinae Jordan, 1878
Genus: *Tinca* Cuvier, 1816
Tinca sp.

Material: Six pharyngeal teeth, two isolated and four articulated with pharyngeal bones. Figs. 2 H1, H2, I1, I2, J1, J2, J3 and J4.

Description: The isolated teeth are similar in size, they measure 4.2 and 3.7 mm in height, about 1.5 and 1.4 mm wide and they are 2.2 and 1.9 mm long (Figs. 2 H1, H2 and I1, I2 respectively). The pedicle and neck of the tooth are not present in these loose teeth. The tooth root is short and compact. The tooth crown is compressed anterodorsally. An elongated and shallow depression spans the entire length of the grinding surface; it terminates laterally in a small hook. The other two teeth are complete and still articulate on a fragment of the pharyngeal bone (Figs. 2 J1, J2, J3 and J4). They are of similar size with the length of 3.2 and 3.2 mm, thickness of 1.3 and 1.1 mm and height of 4.7 and 5.18 mm. At the distal end, a small hook is present. Along the upper part of the grinding surface, they have an elongated, not very deep, depression. The masticatory surface makes with the tooth axis an angle of about 60-65°.

Remarks: The general shape of the pharyngeal teeth corresponds to descriptions and figures in e.g., BÖHME, 2002; GAUDANT 1979, 1994; RÜCKERT-ÜLKÜMEN & YIGITBAS, 2007, KOVALCHUK, 2015.

Stratigraphic distribution: Fossil forms of the genus *Tinca* are described from several localities in Europe. *Tinca* cf. *furcata*, Agassiz, 1843, is mentioned from the late Miocene of Germany (GAUDANT, 2015), *Tinca sp.* from the late Miocene of the Republic of Moldavia and Ukraine (KOVALCHUK, 2014, KOVALCHUK et al. 2014) and also in formations of the late Miocene to the early Pliocene of Turkey (RÜCKERT-ÜLKÜMEN et al. 2006, RÜCKERT-ÜLKÜMEN & YIGITBAS, 2007), Ukraine (KOVALCHUK, 2013) and the Pannonian Basin in Austria from Götzendorf (GAUDANT, 1994). *Tinca sayanica*, Sytcheskaya, 1989, is described for the first time in the late Miocene to the early Pliocene deposits from Mongolia (SYTCHEVSKAYA, 1989), while *Tinca tinca* is described from the late Pliocene of Netherlands (GAUDANT, 1979) and the

Pliocene of Croatia (KUREČIĆ & LENARDIĆ, 2015); *Tinca* sp. appears in the early Pleistocene of Romania (VASILE et al. 2013, 2015) and also in the middle Pleistocene of England (BÖHME, 2010).

Ecology: The typical habitat of the recent species of *Tinca* is densely vegetated shallow waters of lakes or still-water channels. The spawning areas are also closely linked to dense water vegetation (KOTTELAT & FREYHOF, 2007).

Subfamily: Leuciscinae Howes, 1991
Genus: *Scardinius* Bonaparte, 1837
Scardinius sp.

Material: five isolated pharyngeal teeth (Figs. 2 E1, E2, E3, E4, F1, F2, G1, and G2).

Description: Pharyngeal teeth of individuals of different sizes are present in the material. The most complete and largest one from Podari site is 10.2 mm high and 3.7 mm in its widest part. The tooth is strongly bent (nearly S-shaped) and with a high crown that makes about 50% of the total height of the tooth. The hook is rather small and sharp. The grinding surface is composed of seven protuberances located on its medial border and extremely reduced flat surface, running dorsoventrally and parallel to the medial border. In medial view, the protuberances have convex outline. The tooth belly is smooth and convex. The tooth pedicle is broken at its base.

Remarks: The teeth described here resemble the characteristics (grinding surface, the shape of the protuberances) of the recent genus *Scardinius* (RUTTE, 1962).

Stratigraphic distribution: The genus *Scardinius* is known in the fossil record since the late Miocene of Europe and Western Asia (BÖHME & ILG, 2003; KOVALCHUK, 2015). The Recent distribution of the genus is restricted mainly to Europe as well as partially to Western Asia (KOTTELAT & FREYHOF, 2007) with less than 10 species.

Ecology: The genus *Scardinius* prefers water bodies with low water energy, e.g. lakes, ponds, slowly flowing large rivers, usually associated with submerged vegetation (BÖHME & ILG, 2003, KOTTELAT & FREYHOF, 2007).

The cypriniform fishes are documented since the early Paleocene deposits of North America and early Eocene of Asia and Europe. They are the most diverse freshwater fish group in the world with more than 3.000 valid species (PASCO-VIEL et al., 2010; REICHENBACHER et al., 2011). This diversity leads to an amazing variety of the skeletal morphology. Within Cyprinidae, which are frequently presented in the fossil record by pharyngeal teeth, the identification is difficult due to heterodont dentition. The tooth morphology varies even within the same tooth raw. Due to this, the identification below the generic level is extremely difficult.

Order: Siluriformes Rafinesque, 1820
Family: Siluridae Cuvier, 1816
Genus: *Silurus* Linnaeus, 1758
Silurus sp.

Material: one dentary, one premaxilla, two fragments of the pectoral spine - the distal and proximal portions, one vertebra. (Figs. 2 K1, K2, L1, L2, M1, M2, M3, M4, N, O1, O2).

Description: The dentary and premaxilla are fragmentary preserved. The dental shelfs of both bones possess the bases of the teeth. They are round, have the same size and arranged irregularly close to each other. The dorsal process and body of the spine are preserved at the proximal portion of the pectoral spine. Our fossil is a fragment of the anterior part of these pectoral spines. The fragment preserves the articular head and a small part from the body of the spine. The well-preserved dorsal process is massive. Striae or ripples cannot be observed due to the bad preservation of the bone. The dorsal process makes with the body of the spine an angle close to 80°. The body of the spine at the base is almost cylindrical in cross-section and bears irregular striations along its surface, without dentition.

The distal part of the spine is anterodorsally compressed. The bone surface possesses hardly visible irregular striations. At both lateral sides of the bone, a serration is preserved. On one side, the spines are longer than in another one.

The vertebra centrum is encased partially in a sandstone concretion and only one side can be observed. The diameter of the vertebra centrum is 23 mm, the thickness - app. 7.4 mm. The exposed cotyle is large and shallow.

Remarks: The pattern on the dental shelf, the shape and structure of the pectoral spine, as well as the vertebra dimension, resemble the genus *Silurus* (BÖHME, 2002). Due to fragmentary preservation of the bone material, any further identification is impossible.

Stratigraphic distribution: The genus *Silurus* is known in the fossil record since the earliest Tortonian (late Miocene) of Europe (Hammerschmiede, BÖHME & ILG, 2003), the late Miocene of Ukraine (KOVALCHUK, 2011), and the Pliocene deposits of the Republic of Moldavia and Ukraine (KOVALCHUK et al. 2014, 2015). Most of the papers refer the material only to the genus level as *Silurus* sp.

Ecology: In present days, only two species of *Silurus* live in Europe: *Silurus glanis*, Linnaeus, 1758, and *Silurus aristotelis* Garman, 1890. They occupy rather similar habitats characterized by large and medium-sized rivers and nutrient-rich lakes with well-developed vegetation (KOTTELAT & FREYHOF, 2007) and can tolerate brackish waters (RÜCKERT-ÜLKÜMEN & YIGITBAS, 2007).

DISCUSSION AND CONCLUSIONS

The Podari locality yielded a fossil fish fauna consisting of four taxa, *Esox* sp., *Tinca* sp., *Scardinius* sp. and *Silurus* sp.. Unfortunately, the available material and its preservation does not allow identification at the species level. All four genera are found in the recent ichthyofauna of the water bodies of Romania. They are the frequent elements of the late Neogene ichthyofaunal assemblages from Central (Germany, Hungary) to Southeast and Eastern Europe (Greece, Turkey, Ukraine, Russia) (BÖHME & ILG, 2003). Following an actualistic approach to evaluate the palaeoenvironmental reconstruction we conclude that the presence of *Tinca*, *Scardinius*, *Silurus* and *Esox* suggests the presence of standing water body (lake, pond) or slow flowing large rivers, rich in nutrients and well-developed, dense vegetation.

We provide also some tentative taphonomic observations on a few preserved cyprinid pharyngeal teeth. None of the teeth shows resorption traces on their bases. The roots of the teeth are always broken. The cyprinids change their teeth during the entire lifetime. The teeth replace due to resorption of its foot and later removal of the remaining tooth crown. These remains can be accumulated in the sediments. In contrary to this, the teeth showing traces of breakage or fragments of the pharyngeal bone with teeth originate from fish as a result of post mortem breakage and of allochthonous origin (BÖHME, 2010a). Taking this into account, we suggest deposition in allochthonous environment for the fossil cyprinid (*Scardinius* sp., *Tinca* sp.) remains. In addition to this, all fossil bones are found in the organic rich clays containing coal and iron pellicles, interpreted to be a nearshore environment. The state of preservation of the fossil material does not allow us the identification beyond the generic level.

Further investigations might reveal additional and better-preserved material. We consider the present article to be just a first step in the research of the fossil fish fauna from the Pliocene of Dacic Basin. The recent industrial extension of the outcrop opens new possibilities for collecting. We also consider that close-by existing outcrops need to be investigated and the results synchronized.

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