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New Data on Morphology, Taxonomy and Palaeoecology of Bony Fishes from the Middle-Late Miocene of Mykhailivka locality (Southern Ukraine)

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New Data on Morphology, Taxonomy and Palaeoecology of Bony Fishes from the Middle-Late Miocene of Mykhailivka Locality (Southern Ukraine). — **Kovalchuk, O. M.** — The article deals with results of studying of the bony fish osteological material from the Mykhailivka locality of fossil vertebrates, dated by the middle to late Samatian (middle-late Miocene), from the territory of Ukraine. A total of 16 species, belonging to 15 genera, 7 families and 4 orders were identified. The faunal composition of the Mykhailivka 1 indicates slightly brackish environment, while the fauna of Mykhailivka 2 existed in freshwater conditions. A new data on palaeoecology and palaeogeography of this locality in relation to other Sarmatian palaeocommunities within the Eastern Paratethys area based on isolated fish bones are presented in the paper.

Key words: bony fishes, Cyprinidae, Siluridae, Esocidae, Percidae, middle-late Miocene, Eastern Europe.

Introduction

Numerous localities of the late Miocene vertebrates have been reported from the Eastern Paratethys area [1, 3, 4]. Some of them revealed a rich bony fish fauna [21, 25]. These assemblages are quite variegated in taxonomic composition and ecological structure. Remains of more than 40 species belonging to 30 genera and 13 families (Acipenseridae, Cyprinidae, Cobitidae, Siluridae, Clariidae, Esocidae, Percidae, Moronidae, Sciaenidae, Gobiidae, Sparidae, Atherinidae, and Cyprinodontidae) were previously identified. Most of them are represented by isolated bones, otoliths and scales. Previous studies have shown that reconstruction of fossil fish faunas from this area can provide important information on their evolution, palaeoecology and palaeobiogeography during the late Miocene. This time was an important period of climatic transition in Europe [3]. During the late Miocene, the collision between the Afro-Arabian and Eurasian plates let to closure of the Tethys Sea and changes to oceanic circulation [7].

The fish faunas at this time were also changing, as the marine waters of the Paratethys receded and freshwater faunas invaded the area [14]. The Paratethys became separated from the Mediterranean during the Serravallian (late middle Miocene), leading to isolation of the marine waters which then resulted in a gradual change through brackish to fresh waters [22]. These developing areas of fresh water would have provided new habitats for freshwater fishes to invade. The climate in the late Miocene globally, and specifically in Europe, underwent a cooling and drying phase as the Earth transitioned from greenhouse to icehouse climate [7, 27].

The objective of this study is to provide new data on the middle-late Miocene fish fauna from the Mykhailivka locality with implications for palaeoenvironments and palaeogeography.

Material and methods

The studied fish fauna was collected in the northern Mykhailivka quarry (47°39'06.75"N, 31°57'10.09"E) at the left bank of the Pivdennyi Buh River near the Mykhailivka village (Mykolaiv region, Southern Ukraine). This quarry is well known for its fossils since the end of 1970s [6, 16, 19].

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Prisyazhniuk et al. [20] provided a detailed description of the profile including taxonomic, ecological and stratigraphic information based on bivalves, gastropods, nannoplankton and spore-pollen assemblages. The lower part of the section has been dated to the upper Bessarabian (upper middle Sarmatian s. l.), while the upper part has been assigned to the lower Khersonian (lower upper Sarmatian s. l.) [17].

The here studied fish fossils have been collected from the lower part (Mykhailivka 1), as well as from the upper part of the section (Mykhailivka 2). The investigated screen-washed material was sampled by V. O. Topachevsky, L. I. Rekovets and V. A. Nesin (National Museum of Natural History, NAS of Ukraine) during the field works in 1980s. About 1400 kg of sediments were sieved using 1 mm mesh. 574 isolated pharyngeal teeth of carp fishes, near 290 fish bones (e.g., jaw teeth, dentaries, praemaxillar bones, cleithra, fin rays, centra) and 30 otoliths were obtained. The collection is housed in the Department of Paleontology, National Museum of Natural History, NAS of Ukraine, Kyiv; acronym NMNHU-P.

Determination of the fossil bones and teeth is based on comparative material from the osteological collections of NMNHU-P. Ichthyologic systematics in this paper follows Nelson [15]. Measurements were taken with digital caliper, with accuracy to 0.1 mm. Selected teeth and other bones were photographed using a Leica M168C in the Schmalhausen Institute of Zoology, National Academy of Sciences of Ukraine. Terminology for teeth follows Rutte [24] and Sytchevskaya [29]. Palaeoecological analysis was conducted using the actualistic approach.

Taxonomic part

Family **Cyprinidae**

***Leuciscus* sp.**

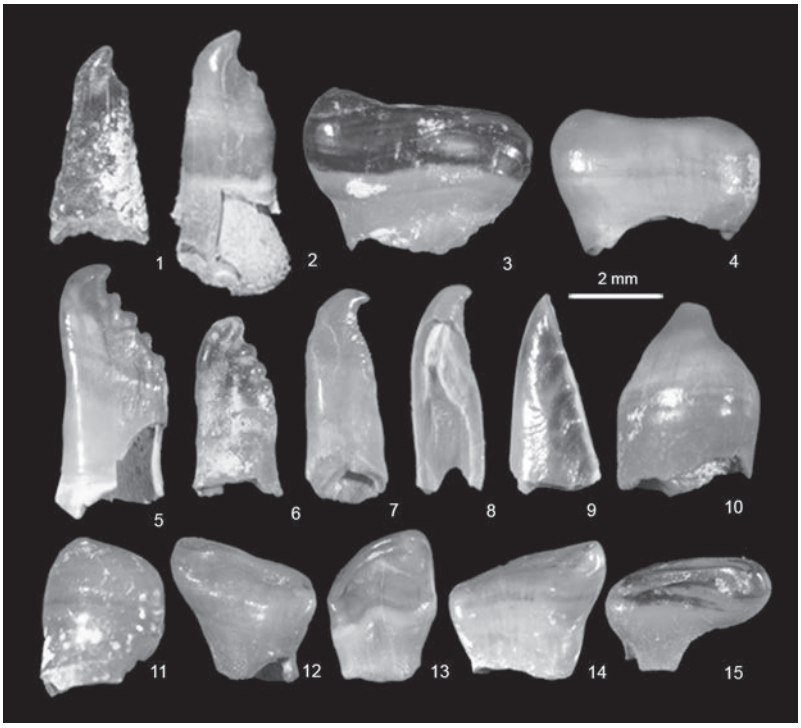
Material: 7 isolated pharyngeal teeth (NMNHU–P 33/1197-1203).

Description and comparison. Slender teeth have high crowns, with cylindrical pedicle and convex keeled tooth belly (Fig. 1.1 and 1.2). Tooth back is straight, with large hook at the tip (its base is about half of the crown width, the point is directed upwards). Grinding surface is narrow, with obliquely cut edge and small jags. A distinct contraction is at the neck. Height of the teeth is up to 8.0 mm, width of crowns — from 1.7 to 2.8 mm. The teeth are similar to *Leuciscus* sp. 2 from the Golubye Peski locality in Kazakhstan [29] in size of the crown and equally developed hook. At the same time they differ in the absence of the keel on the grinding surface, less flattened tooth belly and indistinct constriction in the neck. Pharyngeal teeth differ from those of Pokshesht site in the Republic of Moldova [9] in large size, the larger hook and the higher pedicle. Teeth of *Leuciscus* sp. from the Late Miocene–Early Pliocene Yalakdere Formation near Yalova (Turkey) have much smaller crowns [23].

***Rutilus* cf. *frisii* (Nordmann, 1840)**

Material: 40 pharyngeal teeth (NMNHU–P 33/859-876, 33/1204-1225).

Description and comparison. Pharyngeal teeth are quite large, with fungiform, laterally compressed crown and a distinct convex arcuate tooth back (Fig. 1.3 and 1.4). There is no hook at the tip. Grinding surface is narrow, slightly convex, with weak longitudinal wrinkle. Grinding plate in some specimens has traces of intravital obliteration. Tooth belly is convex and hangs over the neck. Pedicle is often broken, oval in the cross-section. Crown tapers to the neck and slightly higher than its width. Width of the crown is from 4.0 to 9.6 mm (Mykhailivka 1) and from 5.0 to 11.5 mm (Mykhailivka 2). Teeth are not different in size and morphology from those in extant *Rutilus frisii*. They are similar to *Rutilus* cf. *frisii* from the late Miocene of Pokshesht site by the equal width of the crown [9], but differ from them by more convex belly, less bevelled grinding edge and less high crown. Pharyngeal teeth of *Rutilus* cf. *frisii* from the Mykhailivka locality as compared with those in the early and late Miocene of Kazakhstan [29] have larger in size and less concave grinding surface.



Legend. **1–2** — *Leuciscus* sp., Mykhailivka 2: NMNHU–P 33/1197 (**1**), NMNHU–P 33/1198 (**2**).

3–4 — *Rutilus* cf. *frisii*, Mykhailivka 1: NMNHU–P 33/859 (**3**), Mykhailivka 2: NMNHU–P 33/877 (**4**).

5–6 — *Scardinius haueri* (Münster, 1842), Mykhailivka 1: NMNHU–P 33/918 (**5**), Mykhailivka 2: NMNHU–P 33/1285 (**6**).

7–8 — *Aspius* sp., Mykhailivka 1: NMNHU–P 33/910 (**7**), 33/911 (**8**).

9 — *Chondrostoma* sp., Mykhailivka 2: NMNHU–P 33/1287.

10–11 — *Luciobarbus* sp., Mykhailivka 1, 2: NMNHU–P 33/1070 (**10**), 33/1397 (**11**).

12–13 — *Palaeocarassius* sp., Mykhailivka 1: NMNHU–P 33/966 (**12**), Mykhailivka 2: NMNHU–P 33/1349 (**13**).

14–15 — *Tinca* sp., Mykhailivka 1: NMNHU–P 33/1146 (**14**), Mykhailivka 2: NMNHU–P 33/1404 (**15**).

Fig. 1. Isolated pharyngeal teeth of carp fishes from the Mykhailivka locality.
Рис. 1. Ізольовані глоткові зуби коропових риб із місцезнаходження Михайлівка.

Scardinius haueri (Münster, 1842)

Material: 82 pharyngeal teeth (NMNHU–P 33/918-965, 33/1253-1286).

Description and comparison. Pharyngeal teeth are presented by several types. Some of them are slender, have high crown, cylindrical pedicle and a distinct neck (Fig. 1.5 and 1.6). Tooth back is arcuate, with elongated blunt hook at the tip. Grinding surface is narrow; its outer edge is sculptured by several jags, internal is wrinkled. Grinding edge slightly hangs over the convex belly. Width of the crown is near 1.7 mm. Other teeth of this species are small and slender, with rounded or oval pedicle. Crown is elongated and laterally compressed, narrowed to the top, which has long blunt hook. Tooth back is straight. There are 4–7 deep wrinkles at the belly. Grinding surface is narrow; belly is convex and laterally compressed. Width of the crown is 1.2 to 2.8 mm (Mykhailivka 1) and 1.7 to 3.4 mm (Mykhailivka 2). Teeth are completely similar to those in *Scardinius haueri* from the late Miocene locality Sandberg near Götzendorf in Austria [1] except more robust hook and narrow crown. Teeth are also similar to those from the late Miocene to early Pliocene Yalakdere Formation near Yalova (Turkey), but have broader crown, robust hook and more bevelled grinding surface. Presented specimens are comparable in size with *Scardinius* sp. from the Pokshesht site [9] and differ from them in more numerous jags on the grinding surface, arcuate tooth back and less broad pedicle. Pharyngeal teeth from the Mykhailivka locality are also very similar to those in *Scardinius erythrophthalmus* Linnaeus, 1758 from the late Miocene and Pliocene strata in Europe, but differ from them in less robust hook. They differ from *Scardinius tchuensis* Sytchevskaya, 1989 [29] from the middle Miocene — early Pliocene of Gornyi Altai in fewer jags on the grinding surface, more arcuate tooth back, as well as robust hook and smaller crown.

Aspius sp.

Material: 8 pharyngeal teeth (NMNHU–P 33/910-917).

Description and comparison. Pharyngeal teeth have high crown, extended into a hook at the tip. Tooth belly is convex, with straight back (Fig. 1.7 and 1.8). The hook is oriented towards the posterior edge of the crown. Grinding surface is comb-shaped and has small oblique wrinkles. Tooth neck is poorly expressed, with rounded pedicle. Height of the pharyngeal teeth is up to 5.8 mm, width of the crown —1.1–2.1 mm. Pharyngeal teeth are morphologically similar to those in *Aspius* sp. from the early Miocene locality Golubye Peski in Kazakhstan [29], but have robust hook, less wrinkled grinding edge, as well as flattened pedicle.

Chondrostoma sp.

Material: 2 pharyngeal teeth (NMNHU–P 33/1287-1288).

Description and comparison. Cultriform teeth have elongated, compressed and oblique crown (Fig. 1.9). There is no hook at the tip. Grinding surface is narrow and smooth, with a longitudinal groove. Tooth pedicle is quite short. Tooth back is arcuate, with distinct neck and convex belly. Height of the pharyngeal teeth is up to 5.0 mm, width of the crown — 2.2 mm and 2.4 mm. The teeth are similar to those in *Chondrostoma* sp. from the middle to late Miocene of Mount Zhaman, Zaezd in Kazakhstan and Shargain Gobi in Mongolia [29], but they are smaller, have wider crown, straight grinding plate and relatively narrower grinding surface.

Luciobarbus sp.

Material: 40 molariform teeth (NMNHU–P 33/833-858, 33/1226-1239), 136 mammilliform teeth (NMNHU-P 33/1070-1145, 33/1289-1348), 7 cylindrical teeth (NMNHU-P 33/1397-1403).

Description and comparison. Pharyngeal teeth of the genus *Luciobarbus*, as well as close *Barbus*, are highly heterodontous [1, 11, 12]. Therefore presented morphotypes of this species are described here separately (Fig. 1.10 and 1.11). Small teeth are molar-shaped, with low short crown. Some of them are rounded in the cross-section; others are elongated to the width. Pedicle is broken, tooth neck is clearly expressed (there is a distinct interception below the crown). Tooth back is convex, rising almost vertically to the top, which is slightly extended in the low blunt hook. Narrow and smooth grinding surface is slightly tapered to the tooth axis. Rounded tooth belly is convex, steeply descends to the neck. Width of the crown is 1.9–5.7 mm (Mykhailivka 1) and 2.8–6.1 mm (Mykhailivka 2). Mammilliform teeth have medium-sized crown, which is cylindrical or rounded in the cross-section. Pedicle is broad; smooth back is arcuate, with pointy hook. Grinding surface is narrow and smooth, slightly utricular, with weak tooth neck. There is a fuzzy interception at the base of the crown. Width of the crown is from 1.6 to 4.3 mm (Mykhailivka 1) and from 2.4 to 5.2 mm (Mykhailivka 2). Laterally compressed and flattened cylindrical teeth have low molar-shaped crowns. There is a shallow longitudinal groove on the narrow curved grinding surface. Width of the crown is from 2.6 to 5.1 mm. Presented pharyngeal teeth are similar to those in fossil and recent representatives of the genus *Luciobarbus*. They can be approximated with *Luciobarbus vindobonensis* Böhme, 2002 except smaller size. *Luciobarbus* sp. are comparable in size and shape with *Barbus* sp. from the Pliocene of Turkey, but duffer by the wider grinding surface and enhanced crown. It is shown that pharyngeal teeth are similar to those of *Squaliobarbus manracus* Sytchevskaya, 1989 from the late Miocene of Kazakhstan, but have less developed hooks and more flattened crowns.

Palaeocarassius sp.

Material: 152 pharyngeal teeth (NMNHU–P 33/966-1069, 33/1349-1396).

Description and comparison. Spatulate pharyngeal teeth have flattened chisel crown (Fig. 1.12 and 1.13). Pedicle is broad and cylindrical in the cross-section. Tooth back is straight or slightly convex, with rounded belly and clearly expressed neck. Anterior part of the crown is convex; posterior is flattened and medially impressed. There is a weak, posteriorly directed hook at the tip. Grinding edge

is bevelled towards the tooth belly and slightly hangs. Grinding surface is narrow, with quite deep arcuate wrinkle originating under the hook. Its bottom edge has narrow keel. There are several annular wrinkles at the neck. Height of the pharyngeal tooth is up to 5 mm. Width of the crown is from 2.0 to 5.3 mm (Mykhailivka 1) and from 2.2 to 5.1 mm (Mykhailivka 2). Pharyngeal teeth are similar to those of *Palaeocarassius mydlovarensis* Obrhelová, 1970 from the Sarmatian strata of the Czech Republic, but differ from them by a shorter grinding surface and medial compression on the posterior crown surface. They also can be approximated with *Palaeocarassius* sp. from the Miocene localities of Kazakhstan and Mongolia [29] except larger and longer hook at the top of the crown.

Tinca sp.

Material: 100 pharyngeal teeth (NMNHU–P 33/1146-1196, 33/1404-1452).

Description and comparison. Crown of the tooth is low and flattened (Fig. 1.14 and 1.15). Tooth neck is clearly expressed, with arched back and weak hook at the tip. Tooth belly is slightly convex, with narrow, laterally compressed grinding surface. Grinding edge is obliquely bevelled towards the tooth belly. Groove on the anterior edge of the grinding surface is indented by transverse wrinkles and forms a keel-form curl on the posterior back of the crown surface. Width of the crown is from 2.2 to 9.5 mm (Mykhailivka 1) and from 2.6 to 5.1 mm (Mykhailivka 2). Pharyngeal teeth closely resemble that of the extant *Tinca tinca*, but differ from them in morphology of the inner edge of grinding surface. Low crowns, the presence of the hook and raised crown edges bring them closer to *Tinca sayanica* Sytchevskaya, 1989, but the latter is characterized by swollen crowns, which are armed by developed stronger hook, the shallow incision on the grinding surface and the absence of a keel. Species from the Mykhailivka differs from *Tinca* sp. sensu Rückert-Ülkümen and Yiğitbaş [23] by less broad grinding surface and weaker hook. Teeth are comparable with those from the late Miocene of Pokshesht site in the Republic of Moldova [9] in size, but have wider crown. Clearly expressed broad incision on the crown surface and general details of the tooth structure are comparable with *Tinca* sp. from the locality Sandberg near Götzendorf, Austria [1].

Cyprinidae gen. indet.

Material: 4 fragments of fin rays (NMNHU–P 33/1453-1456).

Description and comparison. Distal fragments of the fin rays have distinct sawtooth external edge and are comparable with those in the small representatives of the family Cyprinidae (Fig. 2.1 and 2.2). Fin rays are laterally flattened; their width is 2.0 mm in average. Presented fin rays are morphologically similar to those in the subfamily Barbinae. They can belong to representatives of the genus *Luciobarbus*. However, given a small amount of the osteological material, these bones previously described here as Cyprinidae gen. indet.

Family **Siluridae**

Silurus sp.

Material: 2 fragments of pectoral spines, 4 centra (NMNHU–P 33/537-542), 75 proximal and 9 distal parts of pectoral spines, 2 cleithra, 1 dentary, 66 centra (NMNHU–P 33/570-722).

Description and comparison. Pectoral spine (Fig. 2.3 and 2.5) is distally thickened and dorsoventrally flattened with articular head at the proximal part. There are small outgrowths on the anterior and posterior bone surfaces. They are different-sized tooth-like jags, smaller and more regular in shape compared with those in *Silurus glanis*. Cleithrum (Fig. 2.6) is massive, slightly concave, with rounded posterior angle and distinctive wrinkle on external plate. There is a small protrusion on fossa muscularis interna. Dentaries are represented by fragments of laminar part of the grinding surface with rounded shallow tooth cavities. Pectoral spines, dentaries and cleithra are morphologically similar to those in the *Silurus* L., 1758. At the same time, jags on the posterior surface of pectoral spines are smaller and have more regular shape.

Fig. 2. Remains of carp fishes, catfishes, pikes and pikeperches from the Mykhailivka locality.

Рис. 2. Рештки коропових риб, сомів, щук і судаків із місцезнаходження Михайлівка.

Legend. **1–2** — Cyprinidae gen. indet., Mykhailivka 2: fin ray NMNHU–P 33/1453 (**1**), 33/1454 (**2**). Scale bars equal 1 mm.

3–7 — *Silurus* sp., Mykhailivka 1: pectoral spine NMNHU–P 33/537 (**3**), 33/540 (**4**), Mykhailivka 2: pectoral spine NMNHU–P 33/570 (**5**), cleithrum NMNHU–P 33/596 (**6**), centrum NMNHU–P 33/597 (**7**). Scale bars equal 5 mm.

8–9 — *Esox* sp., Mykhailivka 2: isolated jaw tooth NMNHU–P 33/554 (**8**), 33/555 (**9**). Scale bars equal 1 mm.

10–11 — *Leobergia zaissanica*, Mykhailivka 2: dentary NMNHU-P 33/565 (**10**), premaxilla NMNHU-P 33/567 (**11**). Scale bars equal 1 mm.

Family **Esocidae**

***Esox* sp.**

Material: 11 isolated jaw teeth (NMNHU–P 33/554-564).

Description and comparison. The long, slender teeth (Fig. 2.8 and 2.9) with two sharp edges; conical crown with slightly worn apex is broken. Cross-section is interiorly smooth and exteriorly convex. Presented teeth are similar to *Esox*, detailed determination is impossible.

Family **Percidae**

***Leobergia zaissanica* (Lebedev, 1959)**

Material: 2 dentaries, 3 premaxillar bones (NMNHU–P 33/565-569).

Description and comparison. Low dentary (Fig. 2.10) has medially tucked ventral edge. Symphoidal part is thickened, elevated and has a canine tooth, surrounded by incomplete rim of small teeth. The lower edge of the anterior part of praemaxillar bone (Fig. 2.11) is thickened and extends posteriorly in the narrow horizontal smoothly curved branch, which has small teeth. Presented bones are similar in morphology to those in *Leobergia zaissanica* [13].

Palaeoecological analysis

Species diversity and taxonomic structure of cenoses are closely related to the structure of ecological communities [30]. Fossil remains of the Mykhailivka 1 locality obtained from the marl-clayey deposits with pebbles (from the underlying limestone) and abundant prints of freshwater (*Anisus*, *Valvata*, *Hydrobia*), rare marine (*Mactra*) and terraneous molluscs (*Carychium*, *Vertigo*, *Gastrocopta*) [20]. Ichthyocompelex of Mykhailivka 1 yielded 12 species. The remains of *Scardinius*, *Palaeocarassius*, *Luciobarbus* and *Tinca* are the most abundant. Their presence indicates that the former basin (likely

river) had an extensive system of small tributaries with warm slowly-flowing water, muddy bottom and thickets of underwater vegetation [8]. Fish fauna from the Mykhailivka 1 locality is mixed — freshwater, brackish and anadromous species are presented together. It suggests that the burial of remains took place in close proximity to large marine basin probably in river avandelta with moderate flow; this river flowed into the Sarmatian Sea. It allows us to explain the faunistic heterogeneity, and the presence of semi-anadromous fish tolerant to water salinity.

Fossils of the Mykhailivka 2 locality originated from the layer with interbedded sands and clays. The basal level contains shells of marine (*Mactra*), freshwater (*Lymnaea*, *Anisus*, *Planorbarius*, *Valvata*) as well as terraneous (*Carychium*, *Vertigo*, *Gastrocopta*) molluscs according to Prisyazhniuk et al. [20]. Ostracod fauna, which is known from the Mykhailivka 2, comprises generally freshwater taxa [10]. Fish assemblage of the Mykhailivka 2 can be considered as the next step in the development of faunistic complex that existed in the lower Pivdennyi Buh River at some distance from the sea basin. Its composition suggests the presence of several ecotypes acceptable to the different ecological groups. There were rapids with cold water (*Chondrostoma*, *Luciobarbus*), slowly flowing waters (*Esox*), overgrown well warmed plots (*Palaeocarassius*, *Tinca*) and backwaters (*Silurus*) in lower reaches of the river.

Palaeoecosystems are complex interacting systems of palaeocommunities and abiotic environmental parameters [2, 5, 26]. Consolidated faunal list of fishes from the Mykhailivka locality includes 16 species belonging to 15 genera, 7 families (Cyprinidae, Siluridae, Esocidae, Percidae, Moronidae, Sciaenidae, and Gobiidae) and 4 orders (Cypriniformes, Siluriformes, Esociformes, Perciformes). Basing on the distribution by families, carp fishes are predominate in the composition of fosilliferous strata (Table 1). The family Cyprinidae is represented by numerous taxa, while only one species is determined to Siluridae (*Silurus* sp.), Esocidae (*Esox* sp.), Moronidae (*Morone* cf. *nobilis*), and Sciaenidae (*Genyonemus*? sp.). Family Gobiidae is represented by three species and two genera (*Gobius*, *Neogobius*) (Table 1).

Table 1. **Qualitative and quantitative composition of bony fish remains from the Mykhailivka locality**
Таблиця 1. Кількісний і якісний склад решток кістистих риб із місцезнаходження Михайлівка

Species	Number of fish remains	
	Mykhailivka 1	Mykhailivka 2
Leuciscus sp.	–	7
Rutilus cf. *frisii*	18	22
Scardinius haueri	48	34
Chondrostoma sp.	–	2
Aspius sp.	8	–
Luciobarbus sp.	98	81
Palaeocarassius sp.	104	48
Tinca sp.	51	49
Cyprinidae gen. indet.	–	4
Silurus sp.	6	153
Esox sp.	–	11
Leobergia zaissanica	–	5
Morone cf. *nobilis*[1]	3	–
Genyonemus? sp.[1]	1	–
Gobius dorsorostralis[1]	10	–
Gobius n. sp.[1]	8	–
Neogobius rhachis[1]	8	–

[1] Determined by Dr. A.V. Batishko (Luhansk Taras Shevchenko National University) under the study of otoliths.

Remains of 12 species of 11 genera were identified in materials from the Mykhailivka 1, while the Mykhailivka 2 assemblage comprises only 10 species belonging to 10 genera. Six species (i.e., *Rutilus* cf. *frisii*, *Scardinius haueri*, *Luciobarbus* sp., *Palaeocarassius* sp., *Tinca* sp., and *Silurus* sp.) are common for both described palaeocommunities. Whereas fauna of the Mykhailivka 2 is somewhat younger than those of Mykhailivka 1, these two assemblages can be considered as successive stages of development of the same environment during the middle to late Sarmatian. It should be noted the appearance of a new taxa (e. g., *Leuciscus* sp., *Chondrostoma* sp., *Esox* sp., *Leobergia zaissanica*) in the Mykhailivka 2, as well as disappearance of some species described here on isolated pharyngeal teeth (*Aspius* sp.) and otoliths. It could be attributed to a gradual change in the hydrological regime of water bodies on the territory of Southern Ukraine, caused by the Sarmatian Sea regression. Fish faunas from the Mykhailivka 1 and 2 are comparable in taxonomic richness.

Described fish assemblages show affinity to some other Sarmatian localities within the Eastern Paratethys area in faunistic composition[2]. We used Jaccard coefficient (Kj) for quantification the degree of similarity between taxonomic lists (Table 2).

Table 2. **Values of the Jaccard coefficient for the Sarmatian freshwater fish assemblages**
Таблиця 2. Значення коефіцієнта Жаккара для угруповань прісноводних риб сарматського віку

Localities	Mykhailivka 1	Mykhailivka 2	Localities	Mykhailivka 1	Mykhailivka 2
Mykhailivka 1	–	–	München-Aufmeister	0.071	0.083
Mykhailivka 2	0.375	–	Fröttmannig	0.077	0.091
Popovo 3	0.250	0.474	Schernham b. Haag	0.143	0.167
Lysa Gora 2	0.222	0.333	Richardhof-Golfplatz	0.083	0.100
Frunzovka 2	0.143	0.294	Sandberg	0.111	0.125
Palievo	0.150	0.400	Borský Svätý Jur	0.267	0.308
Otradovo	0.333	0.636	Csákvár	0.067	0.167
Kubanka 2	0.222	0.429	Ambarelliköy	0.063	0.154
Novoelizavetovka 2	0.235	0.267	Kocgasi ASK	0	0.091
Pocşeşti	0.059	0.231	Sofca	0	0.071
Höwenegg	0.143	0.167	Baghmisheh-Marzdaran	0	0.083
Hammerschmiede	0.056	0.214			

It is shown that Mykhailivka 1 and Mykhailivka 2 are taxonomically similar (Kj=0.375). At the same time the similarity between the Mykhailivka 2 and Otradovo assemblages is significantly higher (Kj=0.636). The high values of Jaccard coefficient were also obtained for the Mykhailivka 2 versus Popovo 3, Kubanka 2, Palievo, Lysa Gora 2 and Borský Svätý Jur. All these assemblages (except the latter) are located in Southern Ukraine. There is a vanishingly small similarity between the Mykhailivka and Sarmatian localities which are known from the territory of Turkey (e.g., Kocgasi ASK, Sofca) and Iran (Baghmisheh-Marzdaran).

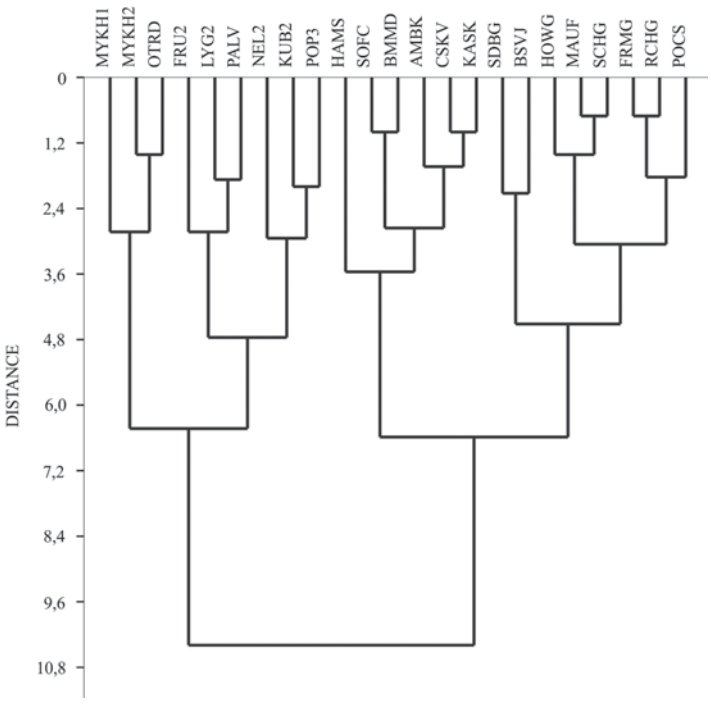


Fig. 3. Dendrogram of the Ward's hierarchical cluster analysis of Sarmatian localities with remains of freshwater fishes in the Eastern Paratethys area.

Рис. 3. Дендрограма подібності місцезнаходжень із рештками прісноводних риб сарматського віку в межах Східного Паратетису (за даними ієрархічного кластерного аналізу за методом Варда).

Abbreviations:

MYKH1 — Mykhailivka 1; **MYKH2** — Mykhailivka 2; **POP3** — Popovo 3; **LYG2** — Lysa Gora 2; **FRU2** — Frunzovka 2; **PALV** — Palievo; **OTRD** — Otradovo; **KUB2** — Kubanka 2; **NEL2** — Novoelizavetovka 2; **POCS** — Pocşeşti; **HOWG** — Höwenegg; **HAMS** — Hammerschmiede; **MAUF** — München-Aufmeister; **FRMG** — Fröttmannig; **SCHG** — Schernham b. Haag; **RCHG** — Richardhof-Golfplatz; **SDBG** — Sandberg; **BSVJ** — Borský Svätý Jur; **CSKV** — Csákvár; **AMBK** — Ambarelliköy; **KASK** — Kocgasi ASK; **SOFC** — Sofca; **BMMD** — Baghmisheh-Marzdaran.

[2] We used here own data [8] as well as results, previously published by other researchers [4, 21].

The fish fauna of twenty three Sarmatian localities within the Eastern Paratethys area (including Mykhailivka 1 and Mykhailivka 2) was analyzed statistically using the Ward's hierarchical cluster analysis (Fig. 3). It is shown that eight small clusters can be allocated. These clusters represent localities with a similar composition of the fish fauna. Mykhailivka 1 and Mykhailivka 2 assemblages together with those of Otradovo compiled a single cluster. It should be noted a significant affinity of the Mykhailivka 2 and Otradovo; at the same time Mykhailivka 1 occupies a separate position that was established earlier (see Table 2). A group of localities Frunzovka 2, Lysa Gora 2, Palievo as well as Novoelizavetovka 2, Kubanka 2 and Popovo 3 are closest clusters. Thus, given the geographical proximity of these palaeocommunities, we can talk about the common history of freshwater fish fauna in this part of the territory, directly adjacent to the Eastern Paratethys in the middle to late Sarmatian.

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Нові дані про морфологію, таксономію і палеоекологію костистих риб із середнього–пізнього міоцену місцезнаходження Михайлівка на півдні України. — Ковальчук, О. М. — Стаття присвячена результатам опрацювання палеоіхтіологічного матеріалу з місцезнаходження Михайлівка, датованого середнім–пізнім сарматом (середній–пізній міоцен), на території України. Загалом визначені рештки 16 видів, які належать до 15 родів, 7 родин і 4 рядів. Фауністичний склад угруповання Михайлівка 1 відображає солонуватоводне середовище, у той час як фауна Михайлівки 2 існувала в умовах прісної водойми. У статті представлені нові дані щодо палеоекології та палеогеографії цього місцезнаходження по відношенню до інших угруповань пізнього сармату в межах зони впливу Східного Паратетису, отримані у процесі вивчення ізольованих елементів скелету риб.

Ключові слова: костисті риби, Cyprinidae, Siluridae, Esocidae, Percidae, середній–пізній міоцен, Східна Європа.

Новые данные о морфологии, таксономии и палеоэкологии костистых рыб из среднего–позднего миоцена местонахождения Михайловка на юге Украины. — Ковальчук, А. Н. — Статья посвящена результатам обработки палеоихтиологического материала из местонахождения Михайловка, датированного средним–поздним сарматом (средний–поздний миоцен), на территории Украины. Определены остатки 16 видов, принадлежащих к 15 родам 7 семейств и 4 отрядов. Фаунистический состав сообщества Михайловка отражает солоноватоводную среду, в то время как фауна Михайловки 2 существовала в условиях пресного водоема. В статье представлены новые данные о палеоэкологии и палеогеографии этого местонахождения по отношению к другим сообществам позднего сармата в пределах зоны влияния Восточного Паратетиса, полученные при изучении изолированных элементов скелета рыб.

Ключевые слова: костистые рыбы, Cyprinidae, Siluridae, Esocidae, Percidae, средний–поздний миоцен, Восточная Европа.

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