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LATE NEOGENE AND PLEISTOCENE PORGY FISHES (TELEOSTEI, SPARIDAE) OF THE EASTERN PARATETHYS, WITH COMMENTS ON THEIR PALAEOECOLOGY

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Late Neogene and Pleistocene porgy fishes (Teleostei, Sparidae) of the Eastern Paratethys, with comments on their palaeoecology. Šoster, A., Kovalchuk, O. M. — The present paper deals with results of the study of porgy fish (Sparidae) remains from the upper Miocene, lower and upper Pliocene, and the lower Pleistocene of Ukraine. Isolated molariform teeth were assigned to *Pagrus cinctus*, *Pagrus* sp., as well as to Sparidae? gen. et sp. indet. These findings expand our knowledge of the species composition of the Late Cenozoic fish assemblages of Southeastern Europe and force partially reconsider conclusions formulated earlier about their environment.
Key words: porgies, Sparidae, Miocene, Pliocene, Pleistocene, Ukraine, palaeoecology.

Introduction

Numerous localities yielding Miocene, Pliocene and Pleistocene fish remains have been reported from the Eastern Paratethys area (particularly, from the territory of Southern Ukraine). These assemblages are quite diverse in taxonomic composition and ecological structure. Most of the fish fossils are represented by isolated bones, otoliths and scales. Previous studies have shown that reconstruction of Late Cenozoic fossil fish faunas from this area can provide important information on the evolution, palaeoecology and palaeobiogeography of their representatives. It was clearly shown by the revision of carp fishes (Kovalchuk, 2015), catfishes (Kovalchuk & Ferraris, 2016), pikeperches (Kovalchuk & Murray, 2016), perches (Kovalchuk, 2014), and some other groups of bony fishes.

The main purpose of this paper is to present a description of remains belonging to porgy fishes (Sparidae), which were somewhat unusual elements in freshwater or slightly brackish environment of water bodies, closely connected with the basin of the Eastern Paratethys during the Neogene.

Geological setting

Numerous deep ravines cut through the high slopes of the Kuchurgan river valley in Odessa region (Ukraine) exposing the so-called "Kuchurganian" bone-bearing alluvial deposits (Korotkevich, 1988). Vertebrate fossils were buried in the lower Pliocene gravel sands, gritstone, diverse-grained sands and sandstones (Dubrovo & Kapelist, 1979; Korotkevich, 1988). In general, more than one hundred vertebrate species were described from these localities (Nesin, 2013), such as Novopetrovka (47°02′ N, 29°53′ E) and Trudomirovka (46°58′ N, 29°52′ E) (fig. 1). The multilayered Shirokino locality (47°05′ N, 37°48′ E; upper Pliocene, MN 16) was found between the villages Bezymiannoe and Shirokino, Volnovakha District, Donetsk Region. Bone remains of fishes, small and large mammals were obtained in gravels laying on the eroded surface of Neogene limestones (Nesin, Rekovets, 1993; Nesin, 2013). Bezymiannoe locality (47°05′ N,

Fig. 1. Localities with fossil remains of sparid fishes from Ukraine and their stratigraphic sequence.

37°50′ E; lower Pleistocene, MQR 3 after Vangengeim et al., 2001) is located near the eponymous village, also in Volnovakha District, Donetsk Region, Ukraine. The Plio-Pleistocene terrace section is bordered by a thick loess loam layer. Fish remains were buried in the dilluvial loam with inclusions of gravels (Krochmal' & Rekovets, 2010). More or less detailed information about the geological setting of the upper Miocene locality near Mariupol' is unavailable.

Material and methods

The investigated material is represented by isolated molariform teeth and their fragments. Almost all of them are waterworn and bear traces of post-mortem transportation. The collection of remains was obtained by screen-washing. These items are deposited in the Department of Palaeontology, National Museum of Natural History (NMNHU-P), National Academy of Sciences of Ukraine (collection No 53), as well as in N. Orlov's private collection (Mariupol', Ukraine). Determination of the fish remains is provided by the authors using diagnostic features and based on special literature. The ichthyological systematics in the paper follows Nelson (2006), while correlation of the Eastern Paratethys stages with the European Mammal Neogene Zones is after Nesin & Nadachowski (2001), Nesin (2013).

Systematic paleontology

Class ACTINOPTERYGII Klein, 1885
Subdivision TELEOSTEI Müller, 1846
Order PERCIFORMES Bleeker, 1859
Family Sparidae Bonaparte, 1851
Genus *Pagrus* Cuvier, 1817
Pagrus cinctus (Agassiz, 1839) (pl. 1, figs 7–11)

1849 *Sphaerodus cinctus* Ag. — Sismonda, p. 21, table 1, figs 2–4.
1850 *Sphaerodus cinctus* Ag. — Costa, p. 197, table 9, figs 20, 23, 27.
1960 *Chrysophrys* sp. (cf. *Sphaerodus cinctus* Münster, 1870) — Pawłowska, p. 426, table 3, figs 5–6.
1969 *Sparus cinctus* (Agassiz, 1843) — Menesini, p. 41, table 7, figs 7–11.
1973 *Sparus cinctus* (Agassiz) — Caretto, p. 77, table 14, fig. 5.
1974 *Sparus cinctus* (Agassiz, 1843) — Menesini, p. 156, table 8, figs 21–23.
2010 *Pagrus cinctus* (Agassiz, 1836) — Schultz, Brzobohatý & Kroupa, pl. 3, figs 8–9.
2013 *Pagrus cinctus* (Agassiz, 1836) — Mikuž, Šoster & Ulaga, p. 126–127, table 1, figs 5–8.
2013 *Pagrus cinctus* (Agassiz, 1836) — Šoster & Mikuž, p. 78–79, table 3, figs 21–25.
2013 *Pagrus* cf. *cinctus* (Agassiz, 1839) — Mikuž & Šoster, p. 206–207, table 4, figs 32–35.
2014 *Pagrus cinctus* (Agassiz, 1839) — Mikuž, Bartol & Šoster, p. 34–35, table 1, fig. 1.

Material and localities. Three molariform teeth (Mariupol', upper Miocene); one complete tooth NMNHU-P 53/5119 (Trudomirovka, lower Pliocene); one tooth NMNHU-P 29/229 (Bezymiannoe, lower Pleistocene).

Description. The processed material consists of both symmetrical and asymmetrical teeth. Symmetrical teeth (pl. 1, figs 7–9) are round to slightly elliptically elongated. Teeth are laterally convex, gradually curved and flat (pl. 1, fig. 7) or medium-height (pl. 1, figs 8, 9). The apical surface of the teeth is smooth or irregular by the form of holes (pl. 1, fig. 9). Basal parts of the teeth are not preserved. The pulpal cavity is clearly visible in all specimens. The enamel is greyish-brown, brown or black. Asymmetrical teeth (pl. 1, fig. 10–11) are rounded, elliptically elongated or kidney-like in shape. The teeth are laterally convex, gradually curved and flat or medium-height. The apical surface of the teeth is smooth or slightly damaged, probably due to transportation within the sediment. The enamel is dark to light brown.

Measurements, in mm. Length — 2–13 (μ = 6); width — 1.5–11 (μ = 5).

***Pagrus* sp.** (pl. 1, figs 1–6)

Material and localities. Two molariform teeth NMNHU-P 53/5117–5118 (Novopetrovka, lower Pliocene); four molariform teeth (Shirokino 2, upper Pliocene).

Description. The studied material consists of symmetrical and asymmetrical teeth. Symmetrical teeth (pl. 1, figs 1–4) are round and slightly elliptically elongated. Teeth are convex and slightly conical in lateral view (pl. 1, fig. 4). The teeth's apical surface is irregular by the form of holes, which could be attributed to wear and post-mortem bioerosion. Basal parts are not preserved. The pulpal cavity is clearly visible in all specimens, and the enamel is brown. Asymmetrical teeth (pl. 1, figs 5–6) are elongated elliptically and are kidney-like in shape. The teeth are convex in lateral section and uniformly curved. Their apical surface is damaged, most likely because of bioerosion (pl. 1, fig. 5). Basal parts are poorly preserved (pl. 1, fig. 6) or absent (pl. 1, fig. 5). The pulpal cavity is filled with sediment. The enamel is dark brown or black.

Measurements, in mm. Length — 10–18 (μ = 15); width — 6–14 (μ = 11).

Sparidae gen. et sp. indet. (pl. 1, figs 12, 13)

Material and localities. One tooth fragment (Mariupol', upper Miocene); one tooth NMNHU-P 29/228 (Bezymiannoe, lower Pleistocene).

Description. The investigated material consists of two fragments of molariform teeth, which due to their fragmentation could not be determined to species or at least to generic level. However, they most likely belong to family Sparidae. The teeth are laterally convex, gradually curved and flat or medium-height. The apical surface is smooth (pl. 1, fig. 12) or damaged in the form of several mining textures visible on the surface (pl. 1, fig. 13). Basal parts are not preserved, and the pulpal cavity is visible. The enamel is white/brown.

Measurements, in mm. Length — 5; 13?; width — 3; 11.

Discussion and conclusions

Porgy fish *Pagrus cinctus* is very common in Miocene to Pliocene fish associations in paleogeographical provinces of the Paratethys and Mediterranean, since their remains are found in almost every fossil fish site. One of the first documented findings of remains belonging to Sparidae, originating from the Mediterranean island of Malta, are presented by Scilla dating back to 1670. Sismonda (1846) mentioned *Pagrus cinctus* from Miocene to Pliocene beds of Italy. *Pagrus cinctus* is also known from the lower Miocene of Malta (Menesini, 1974), Italy, France, Libia, Spain, Algeria (Menesini, 1969), Slovenia (Šoster &

Plate 1. Molariform teeth and their fragments assigned to *Pagrus* sp. (figs 1–6), *Pagrus cinctus* (figs 7–11) and Sparidae gen. et sp. indet. (figs 12–13): 1 — unnumbered, Shirokino 2; 2 — unnumbered, Shirokino 2; 3 — unnumbered, Shirokino 2; 4 — unnumbered, Shirokino 2; 5 — NMNHU-P 53/5117, Novopetrovka; 6 — NMNHU-P 53/5118, Novopetrovka; 7 — NMNHU-P 29/229, Bezymiannoe; 8 — unnumbered, apical view, Mariupol'; 9 — NMNHU-P 53/5119, Trudomirovka; 10 — unnumbered, apical view, Mariupol'; 11 — unnumbered, apical view, Mariupol'; 12 — unnumbered, apical view, Mariupol'; 13 — NMNHU-P 29/228, Bezymiannoe. Apical view in a, basal in b, lateral in c.

Table 1. Fish species composition from investigated localities

Species	Localities				
	Mariupol'*	Novopetrovka	Trudomirovka	Shirokino 2	Bezymiannoe
Acipenser gueldenstaedtii	–	+	+	–	–
Acipenser cf. *A. sturio*	–	+	–	–	–
Acipenser sp.	–	+	+	–	–
†*Rutilus robustus*	–	+	–	–	–
Rutilus sp.	–	+	+	+	+
†*Scardinius ponticus*	–	+	+	–	–
Abramis brama	–	–	–	–	+
Barbus sp.	–	–	–	+	+
Tinca tinca	–	–	+	+	+
Cyprinidae gen. et sp. indet.	–	–	–	–	+
Silurus soldatovi	–	–	–	+	–
Silurus glanis	–	–	–	–	+
Silurus cf. *S. glanis*	–	–	+	+	–
Silurus sp.	–	–	+	+	–
†*Esox sibiricus*	–	+	–	–	–
Esox lucius	–	–	–	–	+
Esox sp.	–	+	+	+	–
Sander lucioperca	–	–	–	+	+
Percidae gen. et sp. indet.	–	+	+	+	+
Pagrus cinctus	+	–	+	–	+
Pagrus sp.	–	+	–	+	–
Sparidae gen. et sp. indet.	+	–	–	–	+

* Only remains of sparid fishes from the Mariupol' were available for our study. We have not any information about additional fossils from this locality.

Mikuž, 2013 a; Mikuž & Šoster, 2013 b). It is recorded from Middle Miocene (Badenian) beds of the Czech Republic (Schultz et al., 2010), Poland (Pawłowska, 1960; Schultz, 1979), Slovenia (Mikuž et al., 2013), Austria (Daxner-Höck et al., 2004) and Slovakia (Gregorová, 2009). *Pargus cinctus* is documented in Pliocene beds of Spain (Ruiz et al., 2008), Malta (Menesini, 1974), Italy (Menesini, 1969) and in area of the Mediterranean Sea (Landini & Menesini, 1984).

V. I. Tarashchuk (1962) identified the remains of porgy fishes from Bezymiannoe as belonging to *Mylopharyngodon* (Cyprinidae). Such unusual determination can be explained by the presence of some similarities between molariform teeth of Sparidae and pharyngeal teeth of *Mylopharyngodon*. However, the latter are more conical in lateral section, or round to elliptically elongated, the enamel on their apical surface looks inflated, giving the crown a balloon-like shape. Enamel at the base of pharyngeal teeth is narrow and it protrudes inward of the pulpal cavity and widens upward towards the apical part of the tooth. Furthermore, teeth belonging to *Mylopharyngodon* have a semicircular indentation at their apical part, which is oriented parallel to the pharynx. This feature is absent in the processed material.

Extant sparids, commonly called porgies or sea breams, geographically are widely distributed, as they are very common in the Pacific, Atlantic and Indian Oceans (Nelson, 2006). According to Nelson (2006), there are six sparid subfamilies (Boopsinae, Denticinae, Diplodinae, Pagellinae, Pagrinae, and Sparinae) including 33 genera (e. g., *Archosargus*, *Boops*, *Calamus*, *Chrysophrys*, *Dentex*, *Diplodus*, *Lagodon*, *Pagellus*, *Pagrus*, *Pimelepterus*, *Rhabdosargus*, *Sparus*, *Stenotomus*, etc.). Regarding the extinct sparid fishes, their fossil record in the Eastern Paratethys is rather poor. Bannikov (2010) noted the presence of a handful number of species belonging to *Sparus* Linnaeus, 1758 (e. g., *S. brusinai* (Kramberger, 1882) — middle Miocene of Croatia, Serbia, Turkey, Romania, Moldova and Ukraine[1]; *S.* (?) *brevis* (Lednev, 1914) — middle Miocene beds of Azerbaijan; *S. diatomaceus* (Bogatshov, 1942) — upper Miocene (Maeotian) of the Tamanian peninsula), and some problematic Sparidae described on otoliths. *Pshekharus yesinorum* Bannikov et Kotlyar, 2015 was described from the Lower Sarmatian (Middle Miocene) of northern Caucasus (Bannikov & Kotlyar, 2015).

Sparids are present in marine environments such as reef, demersal and benthopelagic (Santini et al., 2014). Although porgy fishes are mainly marine organisms, they are known to occasionally enter freshwater and brackish habitats (Nelson, 2006). Most of them are durophagous, meaning that they feed on hard-shelled organisms such as corals, molluscs and crabs. Despite being predators, sparids can also be omnivores and herbivores,

The processed material originates from dilluvial sedimentary sequences of lagoon or river firth, where conditions were brackish or freshwater. Such environment of the studied localities is assumed based on the predominance of freshwater fishes, and a relatively small percentage of brackish (primarily anadromous) species (table 1). The authors interpret the presence of sparid remains by the fact that these fishes in some instances may enter brackish or even freshwater environment. Fishes of the family Sparidae can thrive and spawn in brackish waters in Australia (Nelson, 2006) and in some places in the Adriatic Sea (Medaković et al., 2015). Furthermore, processed remains are relatively big in size; it is assumed that adult individuals of porgy fishes entered lagoons in order to spawn in brackish waters, where they perished due to predation. It means that the connection between the Eastern Paratethys and the nearest water bodies (earlier considered as completely freshwater) was actually much closer, thus, the studied localities were slightly brackish.

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