Acta zoologica cracoviensia, **56**(1): 41-51, Kraków, 30 October, 2013

doi:10.3409/azc.56_1.41

History of the fossil carp fishes (Teleostei, Cyprinidae) in Ukraine

Olexandr M. KOVALCHUK

Received: 20 December 2012. Accepted: 10 September 2013. Available online 14 October 2013.

KOVALCHUK O. M. 2013. History of the fossil carp fishes (Teleostei, Cyprinidae) in Ukraine. *Acta zool. cracov*., **56**(1): 41-51.

Abstract. This paper presents the checklist of fossil cyprinids discovered on the territory of Ukraine. The purpose of the study was to summarize all literature and field palaeoichthyological data from 36 heterochronous Ukrainian localities. The investigated material originated from the Late Miocene, Pliocene, Pleistocene and Holocene sediments. Nearly 34 carp fish species in 18 genera are listed here. The list shows the main palaeohydrological changes in Ukraine of the last 9 Ma.

Key words: cyprinids, osteological material, Miocene, Pliocene, Pleistocene, Holocene, archaeological excavations.

✉ Olexandr M. KOVALCHUK, National Museum of Natural History of the National Academy of Sciences of Ukraine, Department of Paleozoology and Paleontological Museum, B. Khmelnitskogo str. 15, 01-601 Kyiv, Ukraine
E-mail: Biologiest@ukr.net

I. INTRODUCTION

Understanding of the history and trends of wildlife is extremely important in terms of the anthropogenic transformation of ecosystems. It is not possible without studying fossil organisms. The historical aspect of the description of the animal world is basic for understanding the real ties that bind the living world into a single functioning system. Information about finds of fossil vertebrates (e.g., teleost fishes), with their careful studying and interpretation, is important in this perspective.

Cyprinidae FLEMING, 1822, the largest and most successful family of freshwater fish in Europe, Asia, Africa and Northern America, is a good model for comprehending the evolutionary mechanisms driving the diversification and distribution of species (ZARDOYA & DOADRIO 1999; NELSON 2006). Their distribution closely reflects their biogeographical history.

According to the current molecular and phylogenetic data, cyprinids may have originated in the Eocene (ZARDOYA & DOADRIO 1999). The earliest undoubted fossil European cyprinid cited in the literature is derived from the mid-Oligocene (Stampian) of Germany and France (GAUDANT 1977, 1979; GAUDANT & ROUSSET 1979; CAVENDER 1991). The two main subfamilies, i.e., Cyprininae and Leuciscinae, may have originated in the mid-Oligocene and radiated during the late Oligocene and Miocene. Major speciation

events resulting in the current European cyprinid fauna occurred largely during the Pliocene (ZARDOYA & DOADRIO 1999).

Numerous finds of fossil and sub-fossil bony fish remains, including cyprinids, in the Neogenic and Anthropogenic sediments of Ukraine need to be synthesized and interpreted. It can be done on the basis of analysis of paleozoological and archaeological literature, incorporating data on the current distribution of the family Cyprinidae in water bodies of Ukraine and with reference to their environmental preferences (STERBA 1971).

II. MATERIAL AND METHODS

The material for this paper was compiled using special literature (PIDOPLICHKO 1938, 1956; LEBEDEV 1960; TARASHCHUK 1962, 1965), and also the results of my field excavations in 2009-2012. Overview of the finds was carried out in the stratigraphical order of appropriate horizons (Miocene, Pliocene, Pleistocene, Holocene), which have cyprinid remnants. Information about the finds of palaeoichthyological material within each geological epoch is presented in chronological order (from earliest references till present). Archaeological dating and chronology of Holocene according to its climatic sub-division in the paper follows ZALIZNYAK (2005).

Direct determination of the fossil cyprinids has been processed on the basis of diagnostic cranial and postcranial elements using the comparative ichthyological collection, which is housed in the department of vertebrate paleozoology (National Museum of Natural History), National Academy of Sciences of Ukraine, Kyiv – NMNH NASU) and also with reference to LEPIKSAAR (1994) and RADU (2005). Fish systematics in this paper follows NELSON (2006) and MOVCHAN (2011).

III. RESULTS AND DISCUSSION

There are about 2420 species of the 220 cyprinid genera in the modern fish fauna worldwide (NELSON 2006). It is the largest family of vertebrates. The modern fauna of Ukrainian teleost fishes includes near 58 cyprinid species in 31 genera (MOVCHAN 2011). Currently fossil carp fish remains are known from Ukraine in the Late Miocene – Late Holocene (Table I).

Miocene

For a long time fossil remnants of bony fishes were not known from the Miocene of Ukraine. TARASHCHUK (1962) reported only on finding calcined catfish (*Silurus* sp.) vertebra in the Sarmatian limestone of Zaporizhia region, as well as the presence of sturgeon (*Acipenser* sp.) bony plates (Late Sarmatian, Odesa region) in the NMNH NASU.

New localities with vertebrate fossil faunas, dated to Miocene and Pliocene age (Pidgirne, Popove, Verkhnya Krynitsya, Lobkove, Lysa Gora), were found near Vasilyevka (Zaporizhia region, southern Ukraine) during the field palaeontological studies in 2008-2011 (Fig. 1) (REKOVETS & PASHKOV 2009). Numerous remnants of large (Carnivora, Perissodactyla) and small (Insectivora, Lagomorpha, Rodentia) mammals, birds (Struthionifor-

Table I

Representation of the fossil carp fishes in Ukraine (by epochs)

Species	Miocene	Pliocene	Pleistocene	Holocene
Leuciscus leuciscus (L., 1758)	–	+	+	–
Leuciscus sp.	+	+	+	+
Squalius cephalus (L., 1758)	–	–	+	+
Idus idus (L., 1758)	–	+	+	+
Rutilus rutilus (L., 1758)	+	+	+	+
Rutilus frisii (NORDM., 1840)	–	+	+	+
Rutilus cf. *frisii* (NORDM., 1840)	+	–	+	–
Rutilus sp.	+	+	+	+
Scardinius erythrophthalmus (L., 1758)	+	+	+	+
Scardinius nordmanni (WILDH., 1886)	–	+	–	–
Scardinius sp.	+	–	+	–
Chondrostoma nasus (L., 1758)	–	–	+	+
Chondrostoma cf. *nasus* (L., 1758)	–	–	+	–
Chondrostoma sp.	+	–	+	–
Alburnus alburnus (L., 1758)	–	–	+	+
Alburnus sp.	–	–	+	–
Chalcalburnus mento (HECK., 1836)	–	–	+	+
Vimba vimba (L., 1758)	–	–	+	–
Blicca bjoerkna (L., 1758)	–	–	+	–
Abramis brama (L., 1758)	–	–	+	+
Abramis sp.	–	+	–	–
Ballerus ballerus (L., 1758)	–	–	+	–
Aspius aspius (L., 1758)	–	–	+	+
Pelecus cultratus (L., 1758)	–	–	+	–
Pelecus sp.	–	+	–	–
Barbus barbus (L., 1758)	–	–	+	+
Cyprinus carpio L., 1758	–	+	+	+
Cyprinus cf. *carpio* L., 1758	+	–	+	–
Cyprinus sp.	–	–	+	–
Carassius carassius (L., 1758)	+	+	+	+
Carassius auratus (L., 1758)	–	–	–	+
Carassius sp.	+	–	+	+
Tinca tinca (L., 1758)	–	+	+	+
Tinca sp.	+	+	+	–
Σ	**11**	**14**	**30**	**18**

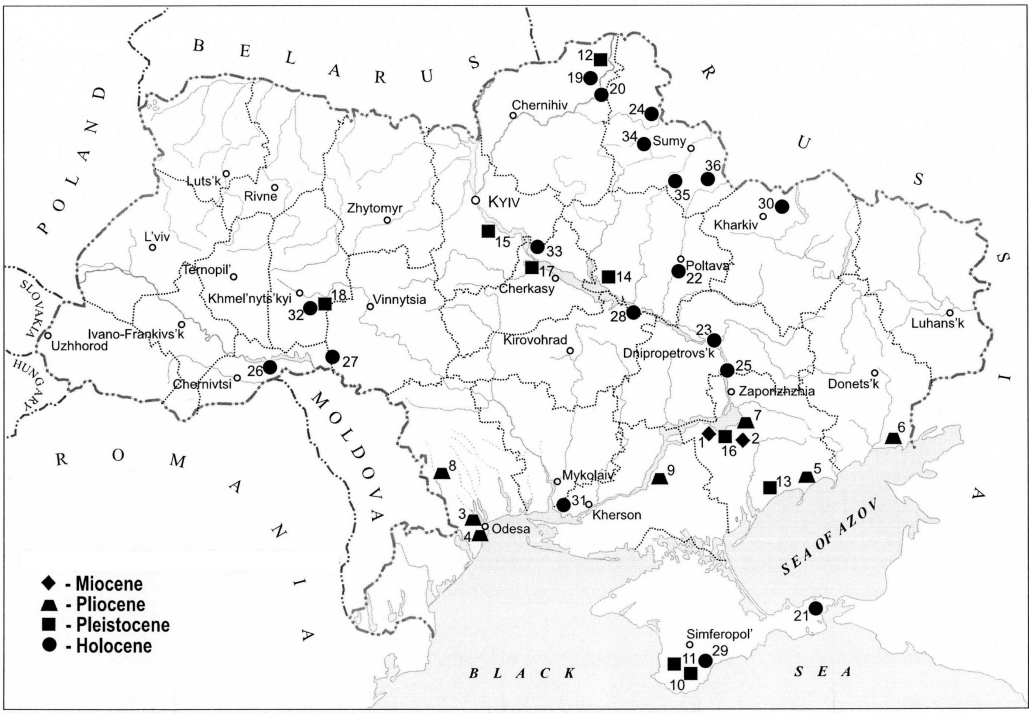

Fig. 1. Localities of the carp fish remnants on the territory of Ukraine: *Miocene:* 1 – Lysa Gora-2, 2 – Popove; *Pliocene:* 3 – Odesa, 4 – Odesa catacombs, 5 – Nogaisk, 6 – Bezimenne, 7 – Kamyanske, 8 – Kuchurgan, 9 – Kairy; *Pleistocene:* 10 – Murzak-Koba, 11 – Syuren, 12 – Novgorod-Siversky, 13 – Tichonovka, 14 – Middle Dnieper, 15 – Upper Dnieper, 16 – Lysa Gora-1, 17 – Kaniv, 18 – Medzhybizh; *Holocene:* 19 – Yukhnov A and B, 20 – Bystrinske settlement, 21 – Pantikapaion, 22 – Poltava, 23 – Igren', 24 – Volyntsevo, 25 – Solone, 26 – Lenkivtsi, 27 – Bernove, 28 – Dereivka, 29 – Zamil-Koba, 30 – Donets'ke settlement, 31 – Olbia, 32– Rakochi, 33 – Pekarska Kosa, 34 – Bilopillya, 35 – Novotroits'ke settlement; 36 – Nitsakha.

mes), bony fishes (Cypriniformes, Siluriformes, Salmoniformes, Esociformes, Perciformes), as well as individual bones of amphibians (Anura) and reptiles (Testudines) were found there. Palaeoichthyological material from Lysa Gora-2 (MN 11) recently has been processed by the author and comprises: *Leuciscus* sp., *Rutilus rutilus* (LINNAEUS, 1758), *Rutilus* cf. *frisii* (NORDMANN, 1840), *Rutilus* sp., *Scardinius erythrophthalmus* (LINNAEUS, 1758), *Scardinius* sp., *Chondrostoma* sp., *Cyprinus* cf. *carpio* LINNAEUS, 1758, *Carassius carassius* (LINNAEUS, 1758), *Carassius* sp., *Tinca* sp., and some other groups of Teleostei (KOVALCHUK 2011a, 2012; KOVALCHUK & REKOVETS 2012).

Pliocene

Remains of freshwater fishes, dated to Middle and Late Pliocene (Fig. 1), were first discovered in the vicinity of Odesa and identified as *Leuciscus* sp., *Scardinius nordmanni* (WILDHALM, 1886), *Pelecus* sp., *Tinca* sp. in the 19th century (WILDHALM 1886). Apart from cyprinids, bones of *Acipenser*, *Cobitis* and *Perca* were found in the Pontian Limestone near Odesa (TARASHCHUK 1962). At the beginning of the 20th century paleontologi-

cal research in southern Ukraine was continued by T. G. GRITSAY and others. M. O. SOKOLOV discovered a new great locality of fossil vertebrates – Nogaisk (modern Prymorsk, Zaporizhia region) in 1904. There are carp fish bones in the osteological material from this site: *Idus idus* (LINNAEUS, 1758) – 28 pharyngeal bones and 40 isolated teeth, *Rutilus rutilus* – 9 pharyngeal bones, *R. frisii* – 1 bone, *Scardinius erythrophthalmus* – 2 bones, *Tinca tinca* (LINNAEUS, 1758) – 107 pharyngeal bones, 95 teeth, 35 hyomandibulare, 18 articulare, 35 dentale, 7 quadratum, 31 ceratohyale, 11 epihyale, 8 urohyale, 71 operculum (TARASHCHUK 1962).

Late Pliocene (Khaprovian) fauna was found during excavations near Bezimenne (Donetsk region) in 1959: 1 pharyngeal tooth of *Rutilus* sp. and 2 bones of the big malacophagous fish. TARASHCHUK (1962) suggested that the latter could be *Mylopharyngodon piceus* (RICHARDSON, 1846), but I think that it is doubtful, given the sparse bone material and the absence of this species and its close relatives in the Pliocene of Ukraine. *Mylopharyngodon piceus* was introduced in the reservoirs of the country only in the 1950s (MOVCHAN 2011).

A rich fauna of Pliocenian freshwater fishes was found near Kamyanske (Zaporizhia region) in the 1960s (DUBROVO & KAPELIST 1979). Remains of the following species were identified: *Leuciscus leuciscus* (LINNAEUS, 1758) – 1 pharyngeal bone; *Rutilus frisii* (NORDMANN, 1840) – 189 isolated teeth and 3 bones; *Rutilus* sp. – 77 teeth; *Scardinius erythrophthalmus* – 456 teeth and 3 pharyngeal bones; *Abramis* sp. – 1 dentale; *Carassius carassius* – 8 fin fragments; Cyprinidae gen. et sp. indet. – 6 dentale, 18 pharyngeal teeth, 6 bone parts, 6 opercular bones (TARASHCHUK 1965).

The Pliocenian sediments of Kuchurgan (Odesa region) are distinguished by the presence of significant amounts of small mammal bones and a rather poor fish fauna (1 pharyngeal tooth of *Rutilus* sp.). From the Late Pliocene near Kairy (Kherson region) we have remnants of *Rutilus* sp. and *Cyprinus carpio* (TARASHCHUK 1962).

Pleistocene

The finds of fossil carp fishes, dated to Pleistocene age, are numerous in the territory of Ukraine (Table I, Fig. 1). Most of them are confined to archaeological sites from early to late Paleolithic. Excavations on the Late Paleolithic camp Murzak-Koba (A.R. Crimea) were conducted by expeditions under the guidance of S. M. BIBIKOV. 156 fish bone fragments, including cyprinids, were found there: *Rutilus frisii* – 82 isolated pharyngeal teeth, 28 fragments of pharyngeal bones, 9 caudal fins; *Vimba vimba* (LINNAEUS, 1758) – pharyngeal bone with a tooth; Cyprinidae gen. et sp. indet. – ribs, vertebrae etc. (LEBEDEV 1952a, 1960). Bones of *Squalius cephalus* (LINNAEUS, 1758) were found in the 1930s on the late Paleolithic camp Syuren in Crimea (TICHIJ 1928, 1929).

Archaeological excavations under the guidance of M. V. VOJEVODSKY on the Novgorod-Siverskyi Palaeolithic camp on the Desna river (Chernihiv region) have been conducted in 1939-1947 (LEBEDEV 1944, 1952b, 1960). NIKOLSKY (1945, 1952) described 146 fish bones from this locality, some of them are *Leuciscus* sp., *Rutilus rutilus* and *Abramis brama* (LINNAEUS, 1758).

TARASHCHUK (1962) wrote about the finds of isolated pharyngeal teeth of *Cyprinus carpio* and Cyprinidae gen. et sp. indet., dated by early Anthropogene, at the end of the

1940s near Tichonovka village (Melitopol'skyi district, Zaporizhia region). Fossil remains of carp fishes are also known from the Pleistocene sediments of Middle Dnieper (Poltava region) – *Squalius cephalus*, *Idus idus*, *Rutilus rutilus*, *R. frisii*, *Scardinius erythrophthalmus*, *Chondrostoma nasus* (LINNAEUS, 1758), *Blicca bjoerkna* (LINNAEUS, 1758), *Abramis brama*, *Barbus barbus* (LINNAEUS, 1758), *Cyprinus carpio*, *Carassius carassius*, and also from Upper Dnieper (Kyiv region) (SHPET 1949; TARASHCHUK 1962) – *Leuciscus leuciscus*, *Alburnus alburnus* (LINNAEUS, 1758), *Alburnus* sp., *Chalcalburnus mento* (HECKEL, 1836), *Vimba vimba*, *Aspius aspius* (LINNAEUS, 1758), *Pelecus cultratus* (LINNAEUS, 1758).

Lysa Gora-1 is a locality of Neopleistocene vertebrate fauna (Likhvin age, Holstein, MQR 3, OIS 11), which was discovered in Zaporizhia region in 2009. Fish species listed from this site are as follows: *Leuciscus* sp., *Rutilus* cf. *frisii*, *Rutilus* sp., *Scardinius erythrophthalmus*, *Scardinius* sp., *Chondrostoma* cf. *nasus*, *Chondrostoma* sp., *Cyprinus* cf. *carpio*, *Cyprinus* sp., *Carassius carassius*, *Carassius* sp., *Tinca* sp. (KOVALCHUK 2012; KOVALCHUK & REKOVETS 2012).

There are indeterminate remains of Cyprinidae in the Kaniv Nature Reserve museum (KOVALCHUK et al. 2011). Beside this, I recently identified palaeoichthyological material from the Paleolithic camp Medzhybizh. It is a famous locality of fossil vertebrates and human artifacts on the right bank of the Southern Bug river (Letychivskyi district, Khmelnitskyi region) (REKOVETS 2001). In particular I determined the following carp species: *Leuciscus leuciscus*, *Rutilus rutilus*, *R. frisii*, *Scardinius erythrophthalmus*, *Chondrostoma nasus*, *Alburnus alburnus*, *Vimba vimba*, *Blicca bjoerkna*, *Abramis brama*, *Ballerus ballerus* (LINNAEUS, 1758), *Barbus barbus*, *Cyprinus carpio*, *Carassius carassius* and *Tinca tinca*.

Holocene

Cyprinid remains from the Holocene sediments of Ukraine are the most numerous as compared to other epochs (Fig. 1). Intensive archaeological excavations of the different-aged sites (since Neolithic till the Middle Ages) were conducted in Ukraine during the 1930s-1970s.

Determination of the significant number of osteological material, including carp fishes, is a result of these studies (LEBEDEV 1960; BIBIKOVA 1963; ZHITENEVA 1967; SHPET 1972; SUCHOBOKOV 1975; PETRAUSKAS 2006; YANISH & KAMINSKAYA 2008; YANISH 2009; BYLKOVA & YANISH 2010; KOVALCHUK 2010; KOVALCHUK & RYZHOV 2011; KOVALCHUK 2011b). 1939-1947 – Chernihiv region, Novgorod-Siverskyi district, Yukhnov A and B settlements (III-II cent. BC): *Leuciscus* sp., *Idus idus*, *Rutilus frisii*, *Scardinius erythrophthalmus*, *Abramis brama*, *Cyprinus carpio*, *Tinca tinca*; Chernihiv region, Pishchanyi Rov (II-IV cent. AD): *Squalius cephalus*, *Idus idus*, *Rutilus rutilus*, *R. frisii*, *Abramis brama*, *Aspius aspius*, *Cyprinus carpio*, *Carassius carassius*, *Tinca tinca*; Chernihiv region, Maydan (VI-VIII cent. AD): *Leuciscus* sp., *Squalius cephalus*, *Rutilus frisii*, *Chondrostoma nasus*, *Cyprinus carpio*; Chernihiv region, Bystrinske settlement (VIII-IX cent. AD): *Rutilus rutilus*, *R. frisii*, *Carassius* sp. (LEBEDEV 1960). 1945-1946 – A.R. Crimea, Pantikapaion (II cent. BC), excavations under the guidance of V. D. BLAVATSKY: *Rutilus rutilus*, *Abramis brama*, *Cyprinus carpio* (LEBEDEV 1960). 1946 – Poltava region, Slavic settlement near Poltava (VIII-XIII cent. AD), expedition under the guidance of

I. I. LYAPUSHKIN: *Leuciscus* sp., *Idus idus*, *Rutilus rutilus*, *Chondrostoma nasus*, *Abramis brama*, *Cyprinus carpio*, *Carassius carassius*, *Tinca tinca*, Cyprinidae gen. et sp. indet. (LEBEDEV 1960). 1947 – Dnipropetrovsk region, Dnipropetrovskyi district, Igren' village, early Neolithic camp (excavation by A. V. BODYANSKY): *Cyprinus carpio* (BIBIKOVA 1963). 1948 – Sumy region, Putyvl'skyi district, Volyntsevo village, Slavic settlement (VII-VIII cent. AD), expedition under the guidance of V. I. DOVZHENKO: *Cyprinus carpio* (BIBIKOVA 1963). 1949, 1952 – Dnipropetrovsk region, Solonyansky district, Neolithic necropolis near Solone: *Rutilus frisii*, *Cyprinus carpio* (SHPET 1972). 1950-1954 – Chernivtsi region, Kel'menetskyi district, Lenkivtsi village, early Tripolian settlement (excavation by E. K. CHERNYSH): *Rutilus frisii* (BIBIKOVA 1963); Chernivtsi region, Bernove village, Chalcolithic pits (expedition under the guidance of T. S. PASSEK): *Rutilus frisii* (LEBEDEV 1960). 1960-1961 – Kirovohrad region, Onufriivskyi district, Dereivka village, Chalcolithic settlement (excavation by D. Ya. TELEGIN): *Rutilus rutilus*, *Scardinius erythrophthalmus*, *Aspius aspius*, *Cyprinus carpio* (BIBIKOVA 1963). 1960s – A.R. Crimea, early Neolithic camp Zamil-Koba: Cyprinidae gen. et sp. indet.; Khmelnitskyi region, Kamyanets-Podil'skyi district, early Tripolian settlement Luka-Vrublevets'ka (VI-III cent. BC): *Rutilus frisii*, *Barbus barbus*, *Cyprinus carpio* (SHPET 1972). 1970s – Kharkiv region, Kharkivskyi district, early Slavic settlement Donets'ke: *Abramis brama*, *Cyprinus carpio* (SUCHOBOKOV 1975). 1980-1990s – Poltava region, Middle Dnieper, IX-X cent. AD: *Rutilus rutilus*, *Scardinius erythrophthalmus*, *Chalcalburnus mento*, *Aspius aspius*, *Cyprinus carpio*, *Carassius carassius*, *Tinca tinca* (PETRAUSKAS 2006). 2000s – Mykolaiv region, Ochakivskyi district, Olbia (VI cent. BC – IV cent. AD), Bilozerka settlement (IV cent. BC – III cent. AD): *Squalius cephalus*, *Rutilus rutilus*, *R. frisii*, *Alburnus alburnus*, *Abramis brama*, *Aspius aspius*, *Cyprinus carpio*, *Carassius auratus* (LINNAEUS, 1758) (YANISH & KAMINSKAYA 2008; YANISH 2009; BYLKOVA & YANISH 2010). 2003-2006 – Khmelnitskyi region, Letychivsky district, late Medieval Rakochi castle (XVI cent. AD): *Rutilus frisii*, *Rutilus* sp., *Cyprinus carpio* (KOVALCHUK 2010). 2010 – Cherkasy region, Kanivskyi district, Pekarska Kosa (IV-II thousand BC): *Cyprinus carpio* (KOVALCHUK & RYZHOV 2011); Sumy region, Bilopillya (XVIII cent. AD): *Carassius carassius* (KOVALCHUK 2011b). Besides, data about finds of Holocene cyprinid bones also are known from Novotroits'ke and Nitsakha settlements (SUCHOBOKOV 1975).

IV. CONCLUSIONS

On the basis of palaeontological and archaeozoological data from the territory of Ukraine we can argue about the presence of at least 34 species and 18 genera of fossil cyprinids. These species belong to Leuciscinae, Pelecinae, Barbinae, Cyprininae and Tincinae subfamilies. Most of them were identified to genus level using open nomenclature. The majority of the fish taxa (30) are derived from the Pleistocene sediments of Ukraine. A general increase in the number of species from the Late Miocene up to the Holocene is noted. It can be explained by good conditions of their preservation and reduction of relative geological age of these remnants.

Unevenness in the spatial distribution of the fossil cyprinids in Ukraine was observed in connection with better study of separate regions within major river basins (Table II). Fish

Table II

Representation of the fossil carp fishes in Ukraine (by regions and genera)

Region	*Leuciscus*	*Squalius*	*Idus*	*Rutilus*	*Scardinius*	*Chondrostoma*	*Alburnus*	*Chalcalburnus*	*Vimba*	*Blicca*	*Abramis*	*Ballerus*	*Aspius*	*Pelecus*	*Barbus*	*Cyprinus*	*Carassius*	*Tinca*	Σ
A.R. Crimea	–	+	–	+	–	–	–	–	+	–	+	–	–	–	–	+	–	–	**5**
Cherkasy	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	**1**
Chernihiv	+	+	+	+	+	+	–	–	–	–	+	–	+	–	–	+	+	+	**11**
Chernivtsi	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	**1**
Dnipropetrovsk	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	+	–	–	**2**
Donetsk	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	**1**
Kharkiv	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	+	–	–	**2**
Kherson	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	+	–	–	**2**
Khmelnitskyi	+	–	–	+	+	+	+	–	+	+	+	+	–	–	+	+	+	+	**13**
Kirovohrad	–	–	–	+	+	–	–	–	–	–	–	–	+	–	–	+	–	–	**4**
Kyiv	+	–	–	–	–	–	+	+	+	–	–	–	+	+	–	–	–	–	**6**
Mykolaiv	–	+	–	+	–	–	+	–	–	–	+	–	+	–	–	+	+	–	**7**
Odesa	+	–	–	+	+	–	–	–	–	–	–	–	–	+	–	–	–	+	**5**
Poltava	+	+	+	+	+	+	–	+	–	+	+	–	+	–	+	+	+	+	**14**
Sumy	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+	–	**2**
Zaporizhia	+	–	+	+	+	+	–	–	–	–	+	–	–	–	–	+	+	+	**9**

remains of the *Rutilus*, *Scardinius*, *Abramis*, *Cyprinus*, *Carassius* and *Tinca* genera are the most common in heterochronous sediments. Undoubtedly, further palaeoichthyofaunistic studies on materials of Neogenic and Anthropogenic localities in Ukraine are very promising in my opinion. They have the potential to complement the existing conception about ways and rates of formation of the regional freshwater fish faunistic complex (YAKOVLEV 1964), compare it with other European fish assemblages (LÕUGAS 1997, 1998; MAKOWIECKI 1998), help to solve some taxonomic questions, determine the stratigraphic role of cyprinid remnants, and also create detailed palaeoclimatic schemes for the Neogene and Anthropogene of the Eastern Europe.

A c k n o w l e d g e m e n t s. I extend my gratitude to Prof. Dr. L. I. REKOVETS for valuable comments and advices. My English was extensively reviewed by Dr. O. I. BUKREEVA, whose kindness is greatly acknowledged.

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