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Fish Communities in Three Rivers of the South Podolia, Black Sea Basin, Ukraine

Yuliia Kutsokon[1]*, Anatolii Roman[2], Yurii Kvach[3] & Mykola Shcherbatiuk[4]

[1] Schmalhausen Institute of Zoology, National Academy of Sciences of Ukraine, Ukrainian Nature Conservation Group, 15 B. Khmelnytsky Street, 01030 Kyiv, Ukraine; E-mail: carassius1@ukr.net; ORCID: https://orcid.org/0000-0001-9721-5638
[2] Institute of Hydrobiology, National Academy of Sciences of Ukraine, 12 Heroiv Stalingradu Street, 04210 Kyiv, Ukraine; ORCID: https://orcid.org/0000-0001-6270-8141
[3] Institute of Marine Biology, National Academy of Sciences of Ukraine, 37 Pushkinska Street, 65048 Odesa, Ukraine; ORCID: https://orcid.org/0000-0002-6122-4150
[4] Kholodny Institute of Botany, National Academy of Sciences of Ukraine, 2 Tereshchenkivska Street, 01601 Kyiv, Ukraine; ORCID: https://orcid.org/0000-0002-6453-228X

Abstract: Qualitative and quantitative characteristics of the fish communities in three rivers of the South Podolia are studied: Savranka (97 km long), Kodyma (149 km) and Tyligul (173 km). Savranka and Kodyma are right tributaries of the South Bug River. The Tyligul River flows into the Black Sea via the brackish Tyligul Estuary. The study has been carried out in June 2019 at 10 localities. Totally, 1278 fish specimens belonging to 18 species were captured. In total, 17 fish species in Savranka, 20 species in Kodyma and 13 species in Tyligul have been registered, summarising data from the present study and published data. The invasive alien species (IAS), i.e. stone morocco *Pseudorasbora parva*, Prussian carp *Carassius gibelio* s.l. and pumpkinseed *Lepomis gibbosus* have been registered in the studied rivers. Both Sørensen and Czekanowski similarity indices indicate the intermediate status of Kodyma. According to the Sørensen index, the fish composition of this river is more similar to that in Savranka (0.86); however, using the quantitative Czekanowski index, it is also similar to Tyligul (similarity of 0.48 to Savranka and 0.45 to Tyligul). Several sites have been proposed for inclusion into the Emerald Network of Ukraine due to the presence of protected fish species such as *Cobitis taenia* s.l., *Rhodeus amarus* and *Misgurnus fossilis*.

Key words: Kodyma, Savranka, Tyligul, ichthyofauna, invasive alien species (IAS), Emerald Network

Introduction

Small rivers are often targets for the biodiversity conservation. According to the hierarchical classification of freshwaters from point of view of the biodiversity conservation planning, they belong to the category of habitats within one Aquatic Ecological System, i.e. situated within one ecological drainage unit (Higgins et al. 2005). Some rivulets are characterised by higher biodiversity compared to the mainstreams in their basins (Hohausová & Jurajda 1997). For many Ukrainian rivers, faunistic studies (including ichthyological) were carried out 50 years ago; for many of them, complete contemporary data are lacking. However, even well-studied water bodies need regular monitoring, as

*Corresponding author: carassius1@ukr.net

changes in the species composition may occur due to alien species introduction or extinction of native fish species (Movchan 2006). Currently, data on fish communities in small rivers in southern Ukraine are poor and regular ichthyological monitoring is lacking.

The Savranka, Kodyma and Tyligul rivers are main streams in South Podolia Region. Savranka and Kodyma are right tributaries of the South Bug middle stretch, with 97 km and 149 km length as well as 1,770 km^2 and 2,480 km^2 drainage basins, respectively. The Tyligul River flows into the brackish Tyligul Estuary connected to the Black Sea via an artificial canal. The length of the river is 173 km and its drainage basin is 5,420 km^2 (Shvets et al. 1957, Palamarchuk & Zakorchevna 2001). Similarly to other Ukrainian steppe flows, the Savranka, Kodyma and Tyligul rivers are characterised by low depths and water quantities, since they are fed mainly by snow and rainwater, with a minimum role of ground waters. The river level regime is characterised by spring flooding, low summer limit, which is disturbed by rain floods, an insignificant rise of water in autumn due to rains and relatively high and unstable in winter. The Savranka and Kodyma Rivers are also characterised by extreme hydrological and hydrochemical conditions, e.g. regular freezing, drying, lack of oxygen, high level of riverbed regulation, etc. Recently, these unfavourable natural conditions were complemented by chemical pollutions with mineral nutrients, herbicides and other agricultural contaminants (Vorona et al. 2009, Movchan 2015).

The fish populations of the rivers Savranka, Kodyma and Tyligul are almost unstudied. There are only two previous publications. The fish fauna of Kodyma and Savranka has been studied based on one site in each river, resulting into reporting ten species in each of them (Dykyy et al. 2013). For the lower Tyligul flow, 12 fish species have been recorded (Kutsokon & Kvach 2015). There were also previous taxonomic studies on samples from Kodyma and Savranka. Vasil'ev et al. (2005) registered two triploid populations of representatives of the genus *Cobitis*: *C. taenia* L., 1758 in the Savranka River and *C. rossomeridionalis* Vasil'eva & Vasil'ev, 1998 in the Kodyma River. Later, *C. rossomeridionalis* was recognised as the junior synonym of *Cobitis tanaitica* Bacescu & Mayer, 1969 (Kottelat & Freyhof 2007). Janko et al. (2005) considered

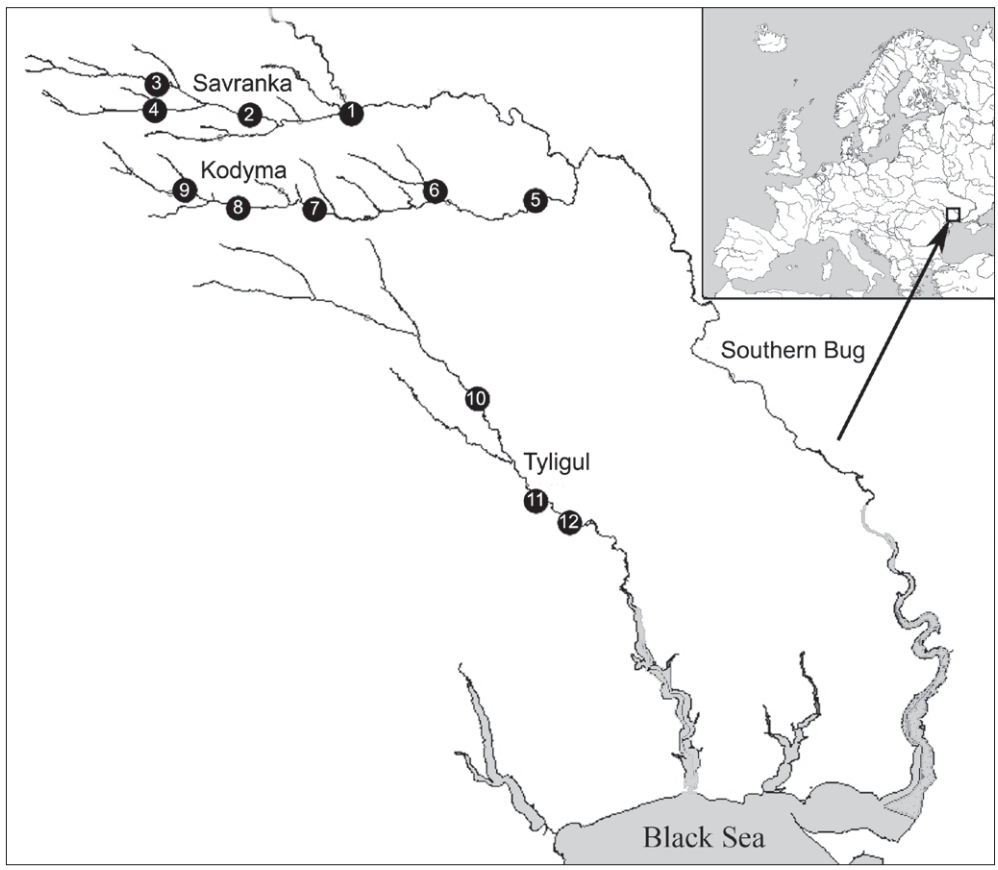

Fig. 1. Studied localities in the rivers Savranka, Kodyma and Tyligul. For localities 1–10, see Table 1; 11, Demydove Village; 12, Zavodivka Village (Kutsokon & Kvach 2015).

fishes from the Kodyma River as triploid hybrids *C.* 1 *elongatoides*/1 sp./1 *taenia* but fishes from the Savranka River as *C.* 1 *elongatoides*/2 *taenia* and *C.* 1 *elongatoides* /1 *tanaitica*/1 *taenia*. Another taxon, the genus *Gobio*, is presented in the Savranka River by *G. sarmaticus* Berg, 1949 (Vasil'eva et al. 2005). Movchan (2011) registered *C. taenia* and *Gobio gobio* in the Southern Bug basin; however, according to his data, *Cobitis tanaitica* occurred only in the lower reach of this basin.

Many riverine valleys are valuable for the native biodiversity conservation. Ukraine, as associated member of the European Union, has committed itself to develop the Emerald Network, which is analogous to the Natura 2000 network for the conservation of vulnerable species and habitats. For example, there were many river-valley sites approved by the Berne Convention Secretariat for the Emerald Network of Ukraine. The process of the establishment of the Emerald Network has also demonstrated the insufficient knowledge of certain areas such as the north part of the Odesa Region (Vasyliuk et al. 2019).

Our study aims to characterise the fish communities in three small rivers in the South Podolia as well as to identify sites with species of conservational importance.

Materials and Methods

The study was carried out in June 2019. Fishes were sampled at 10 localities: four in the Savranka River drainage, five in Kodyma River and one in Tyligul River (Table 1, Fig. 1). Our preliminary data on the fish community of the Tyligul River (Kutsokon & Kvach 2015) were also used in the analysis. Ichthyological collections of the National Museum of Natural History of the National Academy of Sciences of Ukraine (Kyiv) were also examined.

In field studies, the biotope characteristics at each sampling site were registered: depth, soil, water stream characteristic and aquatic vegetation. The main peculiarity of the studied rivers was their shallow waters overgrown by reed (more than 70% of the riverbed area); often, such areas were completely dried. At the open waters with a depth of 0.5 m, the reed thickets were only near the banks. The bottom of the Savranka, Kodyma and Tyligul Rivers was flat, muddy-clay and viscous on the slopes, or solid, sandy, sometimes rocky on the rifts. In general, three main types of biotopes were identified:

1. Flowing, well-aerated sites with solid sandy, sandy-clay or rocky bottoms (localities Nos. 1 and 4 in Table 1, totally 13 species).

2. Slow-flowing areas with silt-sandy or silt-bottom, with little aquatic vegetation (localities Nos. 7 and 8 in Table 1, totally 10 species).

3. Non-flowing isolated ponds with silt-bottom, intensively overgrown with aquatic plants (localities Nos. 5, 6 and 10 in Table 1, total 14 species).

The above-mentioned classification is rather conditional and often the sampling sites combined two or three types of biotopes (i.e., localities No. 2 and 3 in Table 1 contain one or two types and were inhabited in total by 16 species).

Fishes were sampled at the 1 m depth by the round dipnets with 0.5 m diameter and 0.5 cm mesh size (Roman 2016). The same sampling method was used at the all localities. When possible, the content of the local anglers' catches were identified and included to qualitative analysis only. After the catch, all fishes were placed in a water tank, identified at the species level and, after calculating the quantitative ratio of the recorded taxa, fishes were released back to the river.

The fish species identification was based on the keys by Kottelat & Freyhof (2007) and Movchan (2011). The fish nomenclature followed the FishBase (Froese & Pauly 2019).

Table 1. Studied localities in the rivers Savranka, Kodyma and Tyligul

No.	Locality	River	Latitude, °N	Longitude, °E
1	Savran	Savranka	48.132921	30.095922
2	Pishchana	Savranka	48.123203	29.729039
3	Olhopil	Savranka	48.185941	29.480507
4	Stratiivka	Mala Savranka	48.138309	29.425698
5	Kumari	Kodyma	47.926006	30.676451
6	Kryve Ozero	Kodyma	47.946247	30.342793
7	Bobryk Pershyi	Kodyma	47.911559	30.181048
8	Poznanka Persha	Kodyma	47.921406	29.937689
9	Olenivka	Kodyma	47.950206	29.507618
10	Nastasiivka	Tyligul	47.532138	30.424912

Table 2. Species composition of the fish communities in the studied rivers by localities. Localities 1–10, present data (see Table 1); 13, Pishchana (2002, museum collection); 14, Pishchana (Dykyy et al. 2013); 15, Kamianyy Mist (1990, museum collection); 16, Krymka (2002, museum collection); 17, Krymka (Dykyy et al. 2013); 11–12, Demydove, Zavodivka (Kutsokon & Kvach 2015). *The species or even the generic status of gudgeon from Tyligul needs further studies.

Species	Savranka							Kodyma									Tyligul	
	1	2	3	4	%	13	14	5	6	7	8	9	%	15	16	17	10	11-12
Rutilus rutilus (L.)	+	+		+	13.98	+	+		+			+	9.86	+	+	+		+
Petroleuciscus borysthenicus (Kessl.)	+	+			0.92			+					1.38	+				
Scardinius erythrophthalmus (L.)	+	+			0.77		+	+	+	+	+		18.86	+	+	+	+	+
Alburnus alburnus (L.)														+	+			+
Leucaspius delineatus (Heck.)				+	1.23			+		+	+		16.61					+
Blicca bjoerkna (L.)														+				+
Rhodeus amarus (Bloch)	+	+			42.70	+	+		+		+		3.11		+	+		+
Pseudorasbora parva (Temm. & Schl.)	+	+	+		7.68		+				+		0.35					+
Gobio gobio (L.), s.l.		+			1.08	+	+		+			+	1.21	+	+			+*
Carassius gibelio (Bloch), s.l.	+	+			7.07				+	+	+		19.55					+
Tinca tinca (L.)														+				
Cobitis taenia L., s.l.	+	+	+	+	7.37		+		+	+	+	+	7.61			+	+	
Misgurnus fossilis (L.)		+			0.15		+									+		+
Barbatula barbatula (L.)				+	0.31				+			+	0.87			+		
Silurus glanis L.		+			0.15													
Esox lucius L.	+			+	0.46		+		+		+	+	1.21	+	+	+		+
Pungitius platygaster (Kessl.)	+	+			13.82	+	+	+	+	+	+		14.88			+	+	+
Lepomis gibbosus (L.)	+	+			0.61				+				0.52					
Perca fluviatilis L.	+	+	+	+	1.54		+				+	+	3.11	+	+	+		
Gymnocephalus cernuus (L.)		+			0.15				+				0.17	+				
Proterorhinus semilunaris (Heck.)									+		+		1.38			+		
Total: 21 species	11	14	3	6	17	4	10	4	12	5	10	6	16	10	7	10	3	12
	17 species							20 species									13 species	

The qualitative species composition of the three rivers was compared using the Sørensen Index in the PAST program. Its quantitative counterpart, the Czekanowski Index (PS_{ij}), was calculated by the sum of minimum values of each species in the compared localities (Sørensen 1948):

$$PS_{ij} = 200 \Sigma_k \min (y_{ki}, y_{kj}) / (\Sigma_k y_{ki} + \Sigma_k y_{kj}),$$

where $\min (y_{ki}, y_{kj})$ is the minimum value of y_{ki} or y_{kj}.

Results

In total, 1,278 specimens of 18 species were caught during the study: 16 species in the Kodyma River, 17 in the Savranka River and 3 in the Tyligul River (Table 2). At each locality, the number of the recorded species ranged from 3 to 14. In total, of the 17 fish species found in the Savranka River, seven were registered in this water body for the first time: *Petroleuciscus borysthenicus* (Kessler, 1859), *Leucaspius delineatus* (Heckel, 1843), *Carassius gibelio* (Bloch, 1782) s.l., *Barbatula barbatula* (L., 1758), *Silurus glanis* L., 1758, *Lepomis gibbosus* (L., 1758) and *Gymnocephalus cernuus* (L., 1758). Similarly, four fish species (out of 16 species recorded) were registered for the first time in the Kodyma River: *L. delineatus*, *Pseudorasbora parva* (Temminck & Schlegel, 1846), *C. gibelio* and *L. gibbosus*. Three invasive alien species were found in the Savranka and Kodyma rivers: stone moroko *P. parva*, Prussian carp *C. gibelio* and pumpkinseed *L. gibbosus*. Their share in the total fish fauna comprised c. 15% in Savranka and c. 20% in Kodyma. The most numerous species in Savranka was European bitterling

Rhodeus amarus (Bloch, 1782) but, in Kodyma, it was Prussian carp *C. gibelio*. The Ukrainian stickleback *Pungitius platygaster* (Kessler, 1859) was quite numerous in both rivers; it prevailed in the Tyligul River, representing 81% of the fish community (Kutsokon & Kvach 2015).

The fish communities in Savranka and Kodyma were the most similar as revealed by the Sørensen Index (0.86). Both rivers were less similar to the Tyligul River: 0.79 similarity between Tyligul and Kodyma and 0.73 between Tyligul and Savranka. However, the Czekanowski Index showed high similarity of the Kodyma fish community to both Savranka (0.48) and Tyligul (0.45), while the two latter rivers were less similar between one another (0.29).

Discussion

In this study, we have examined the fish communities in three small rivers in SW Ukraine, e.g. Savranka, Kodyma and Tyligul. The riverbeds, especially of the Kodyma and Tyligul rivers, were intensely overgrown by reed, which often restricted us when finding places for sampling. During the study, the water levels in Savranka and Kodyma were relatively high due to the intense rainfalls at the time of sampling. Nevertheless, at the locality 7 in the Kodyma River (Table 1), we have observed mortality of rudd *Scardinius erythrophthalmus* (L., 1758), together with few specimens of the other species, possibly caused by hydrogen sulphide release from the bottom silt. The possible reason of the fish mortality, except for the toxic level of hydrogen sulphide, could be also the inflow of fertilizers and pesticides from the agricultural fields during rainfalls. In addition, this mortality might be caused by decay of flooded herbaceous plants during floods.

Currently, 54 fish species are known in the Southern Bug River basin and 44 species have been registered in its middle stream (Kostyushin et al. 2007, Movchan 2011). The riverine fish fauna studied by us is composed of only 18 species, which is c. 30% of total fish fauna of the main riverine basin. The native species comprised only 14, which is approximately 80%. In the first half of the 20th century, 74 fish species were known for the entire riverine basin, including the estuary (Slastenenko 1956). Some of the native fish species have gone extinct due to the dam regulation of the Southern Bug River. This is especially valid for reophilic and migratory fish species. On the other hand, several new alien species have been introduced. The pumpkinseed *Lepomis gibbosus* (erroneously identified as *Lepomis macrochirus*) has been first observed in the lower section of the Southern Bug River in 2002 (Movchan 2002). The author considers that this species has migrated into the Southern Bug River from the lower Dnipro River because these two rivers have a common estuary. Four further species have been found in the upper and middle parts of the Southern Bug River: *Gasterosteus aculeatus* L., 1758, *Neogobius fluviatilis* (Pallas, 1814), *Neogobius melanostomus* (Pallas, 1814) and *Neogobius gymnotrachelus* (Kessler, 1857); two additional alien species are known for the middle stream of the river, *Pseudorasbora parva* and *P. platygaster* (Movchan et al. 2002). The latter two species occur in both Savranka and Kodyma as well. According to Movchan et al. (2002), the Ponto-Caspian gobies migrate upstream from the lower stretch of the river. In contrast, *G. aculeatus* and *P. parva* may have been introduced with pond fish.

According to Dykyy et al. (2013), only 10 fish species have been observed in the Savranka River. A total of 16 fish species are known in the Kodyma River (Dykyy et al. 2013, museum collections). However, Dykyy et al. (2013) have studied only two localities: Krymka Village (Kodyma River) and Pishchana Village (Savranka River). Ten species have been observed at each of them (12 species in total), including *P. platygaster* (incorrectly identified as *Pungitius pungitius*). All the fish species recorded in these rivers (except of the weatherfish *Misgurnus fossilis* (L., 1758) in Kodyma) have been confirmed by the present study (Table 2). In addition, the museum collections contain specimens of *Alburnus alburnus* (L., 1758), *Blicca bjoerkna* (L., 1758) and *Tinca tinca* (L., 1758) caught in Kodyma at Krymka Village (near the river mouth). However, the latter two species have been found in 1990 only (Table 2).

The fish species listed in the last edition of the Red Data Book of Ukraine (2009) have not been found in Kodyma, Savranka and Tyligul. However, three species mentioned in the Resolution 6 of the Berne Convention Habitat Directive, e.g. *Cobitis taenia* (nine localities), *Rhodeus amarus* (four localities) and *Misgurnus fossilis* (one locality) have been registered. In the studied area, we have also identified animals from other taxonomic groups listed in the Resolution 6 as well as habitats from the Resolutions 4 (A. Kuzemko, unpublished data). These territories, with the help of the Ukrainian Nature Conservation Group, have been proposed to the Committee of the Berne Convention as Emerald Network sites in Ukraine.

Three invasive alien fish species are present in Kodyma and Savranka. The stone moroko *P. parva*

has been found at four localities, the Prussian carp *C. gibelio* at five localities and pumpkinseed *L. gibbosus* at three localities. In the Savranka River, the stone moroko has been registered in 2013 (Dykyy et al. 2013) but, for the Kodyma River, our finding of this species is a new record. New records are also those of the other two species in both rivers. In the Tyligul River, two invasive fish species have been found: stone moroko and Prussian carp. The percentage of these species in the Savranka fish community is c. 15% but, in the Kodyma River, it is c. 20% and, in the Tyligul River – 38% (Kutsokon & Kvach 2015). Thus, we confirm the range expansion and the successful naturalisation of these species in the small rivers in the South Podolia.

Both Sørensen and Czekanowski indices show the intermediate status of Kodyma. The species composition of this river is more similar to Savranka but also close (by the quantitative index) to Tyligul. Both Tyligul and Kodyma are typical steppe low-water rivers while Savranka is more flooded and located mostly in the forest-steppe zone. Although there is a large number of fish species in the Kodyma River, which quantitatively prevail and are hardy to steppe conditions. This group is also present in the southern Tyligul River.

There are at least three scenarios of formation of the fish fauna in the studied rivers. The first possible source might be the brackish Black Sea and the freshwater fauna has moved upstream and gradually colonised the rivers. Furtherly, the source might be the Sarmatian Sea that has contained the modern Volhynian-Podolian Upland as a part of its sea bottom. This water body is known as a biodiversity centre and some northern species such as *Gasterosteus aculeatus*, *Salmo labrax* Pallas, 1814 and others have penetrated the Black Sea basin via this route. However, the most possible is a third scenario when, due to periodically repeated events, the faunal complexes remained isolated for a while and then re-contacted each other. Finally, the fish fauna of each water body has been formed only by species, which have found optimal conditions for their reproduction and development (Afanasyev 2015). The Tyligul, Savranka and Kodyma rivers have diverse biotopes, which predetermines different composition of their fish species. However, the extreme hydrological conditions significantly affect the number of fish species, especially eliminating rheophilic ones.

Substantial parts of the Tyligul River stream are overgrown with reed or remain generally dry during a long period of the year. Therefore, it has extremely low fish diversity. Only a few species that normally tolerate complex hydrochemical conditions (oxygen deficiency, high concentration of nitrogen and other pollutants) are present in this river. The probable source of the Savranka and Kodyma biodiversity is the Southern Bug River; increased fish diversity has been observed in the mouth sections of these rivers (Table 2). In the case of Tyligul, this possibility is excluded, since it flows into the brackish Tyligul Estuary characterised by a relatively high salinity (up to 30‰).

The data about the fish fauna and communities in the rivers of the south-western region of Ukraine is extremely important as an indicator of the native and alien fish species distribution. This information is crucial for the rational use of resources and nature conservation.

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