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## Ichthyofauna of the Bilotserkivskiy lower reservoir on the Ros river

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**Abstract.** The composition of ichthyofauna of Ukraine is changing due to natural processes and the influence of anthropogenic factors in the internal water bodies. Systematic analysis of changes allows controlling these processes and maintaining the diversity of species at a constant level. The purpose of the study was to investigate changes in the composition of the ichthyofauna of the Bilotserkivskiy lower reservoir (Ros River) after the discharge of industrial waste of the Bilotserkivvoda enterprise in 2017 and 2020, which led to the mass death of fish and crayfish. The studies were conducted by catching fish with species identification and a survey of fishermen from November 2016 to October 2020. Additionally, the species composition of fish in this section of the Ros River was considered before the reservoir was created. According to the results of the conducted studies, 24 fish species were identified in 2016, 21 in 2017, and 19 in 2020. Analysing the number of ichthyofauna since the 1960s, it can be concluded that every 10 years the species composition of the ichthyofauna of the Bilotserkivskiy lower reservoir lost about 2-3 species of fish, which is conditioned by the influence of riverbed overlap, industrial activities, uncontrolled and unidentified discharges into the reservoir, etc. After a detailed analysis of the number of ichthyofauna, it was established that by 2016, the following species had disappeared: common dace *Leuciscus leuciscus*, Dnieper chub *P. borysthenicus*, ide *I. idus*, sunbleak *Leucaspius delineatus*, vimba bream *Vimba vimba*, crucian carp *Carassius carassius*, weatherfish *Misgurnus fossilis*, spined loach *Cobitis taenia*; in 2017 – species such as gudgeon *Gobio gobio*, round goby *Neogobius melanostomus*, tubenose goby *Proterorhinus marmoratus*; in 2020 – char, ruffe. Quantitative and qualitative restoration of ichthyofauna is possible at the expense of fish from the Protoka River (Rotok). To continue fishing use, it is necessary to settle fish in the reservoir. The practical significance of this study is to determine the species composition of the ichthyofauna for further use of the reservoir for environmental and fishery purposes

**Keywords:** inland water bodies, freshwater fish, catch, industrial discharges, ecological fish groups

### Introduction

Almost a third of the entire river system of the European steppe zone is located on the territory of Ukraine. The Dniester, Southern Buh, and Dnipro rivers are among the five largest rivers in Europe [1]. Having such a potential of the natural environment, it is relevant to investigate the impact of anthropogenic stress on the environment and maintain ecological balance for the safety of water bodies.

Pollution of internal reservoirs of Ukraine has become threatening. Due to excessive pollution of wastewater, the ability to self-clean aquatic ecosystems also decreases,

as a result of which the quantitative and qualitative component of the food supply and fish spawning grounds decreases.

A significant transformation of water bodies (rivers and lakes), which affects the conditions of existence of various representatives of ichthyocenoses that are not able to fully adapt [2] to newly created ecosystems, is reflected in their number [3] and the nature of distribution, which leads to a decrease in the diversity of ichthyofauna with the replacement of long-cyclical species with short-cyclical and

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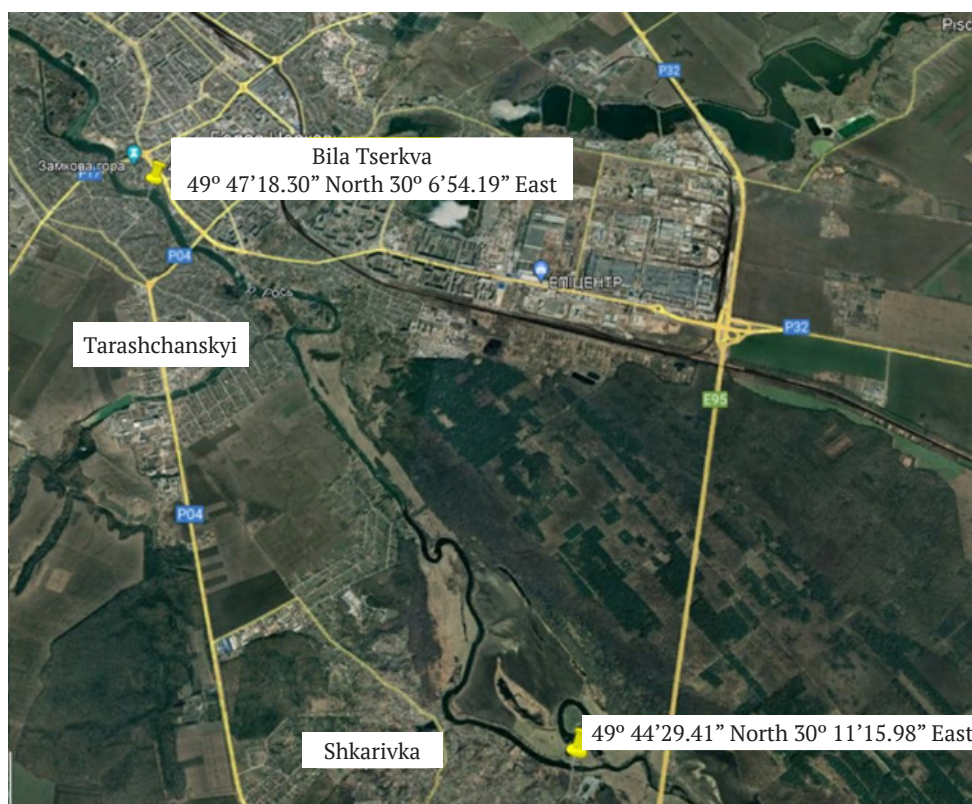
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more plastic ones. In turn, small rivers also play the role of ecological corridors for invading species. The preservation of the natural environment and its species diversity requires constant scientific research and systematic monitoring, especially in small rivers [4].

Ros River basin – is an intensively developed economic complex. Various industries (food, light, and petrochemical) take part in the river catchment area, which have an impact on various components of the aquatic ecosystem. Pollution with heavy metals, petroleum products, and organic substances, disruption of vegetation cover, physical contamination with water erosion products, ingress of pesticides and fertilisers into the water network – all these are the

results of harmful industrial activity [5]. The largest wastewater discharges belong to LLC Bilotserkivvoda, which fall on the Bilotserkivskyi lower reservoir; discharges of other subjects have a much smaller impact on the state of the reservoir's biota [6].

The Bilotserkivskyi lower reservoir is the third and last in a series of Bilotserkivskyi reservoirs on the Ros River, located in the city of Bila Tserkva (Figure 1). The dam was built near the village of Shkarivka, designed by the Ukrvodokanalproekt institute and was put into operation in 1971. The main task of the reservoir is to provide water to the private JSC Rosava (formerly the Bilotserkivskyi Tire Factory) [7].



**Figure 1.** Location of the Bilotserkivskyi lower reservoir on the Ros River

In 2017 and 2020, discharges from the Bilotserkivvoda enterprise occurred, which led to the mass death of fish and crayfish, as a result – reduction of the food base for fish. In the literature on this reservoir, the problem of changes in the composition and abundance of ichthyofauna before and after man-made consequences was quite little mentioned, so it became necessary to analyse the state of the ichthyofauna of the Bilotserkivskyi lower reservoir.

The purpose of the study was to investigate changes in the ichthyofauna of the middle part of the Ros River and after the creation of the Bilotserkivskyi lower reservoir in retrospect and analyse the impact of uncontrolled industrial discharges.

### Literature Review

The ichthyofauna of fresh water bodies is affected by a number of factors. The construction of dams during the creation of ponds and reservoirs often has a negative impact on fish

biocenoses [8]. Natural features of the riverbed partition are the change of dominant species, in particular, pelagic, herbivorous, and large species with long-distance reproductive migrations are replaced by omnivorous, benthopelagic, and insectivorous species that characterise fish living in a stable environment [9]. In Ukraine, ponds and reservoirs are usually dominated by invasive fish species, most of which are caught during stocking for biological reclamation [10]. Due to the spread of invasive species, changes in hydraulic and temperature conditions reduce or completely displace local fish.

Industrial wastewater pollution plays a key role in the problems of river system biodiversity. Through them, radionuclides, toxic organic and inorganic substances enter the water, in particular, sulphur, asbestos, solvents, polychlorinated biphenyl, lead, mercury, nitrates, phosphates, acids, alkalis, dyes, pesticides, etc. [11]. This leads to a number of changes that affect the flora and fauna of

water bodies. A change in the chemical state of water leads to changes in the ichthyofauna. In particular, it was found that an increase in oxygenation, temperature and number of macrophytes, and the concentration of potassium and a decrease in the concentration of phosphates, Mg and Cl ions creates favourable conditions for such species as crucian carp and tench [12].

In addition to these factors, the number of fish correlates with the area of the basin and the maximum depth of the reservoir and the area of the buffer zone [13]. Due to over-regulation of wastewater flow, water “blooming” is often observed in reservoirs, which causes significant damage to hydrobionts. The qualitative and quantitative composition of the ichthyofauna of natural waters – lakes, rivers, ponds, and reservoirs – is an extremely sensitive indicator of the state and level of anthropogenic load of the studied hydroecosystems. The river network of the Ros River basin is marked by diversity, which is a research perspective, however, the issues of species diversity of ichthyofauna, its qualitative and quantitative composition in various ecological groups have so far been considered only fragmentary, mainly as a result of episodic studies in individual tributaries and specifically on the Ros River, in particular [14-16].

O.I. Surmyi and Z.N. Mavryshcheva [17] investigated the species composition and linear dimensions of fish even before the construction of a reservoir in the Bila Tserkva district (Shkarivske or Bilotserkivskiy lower reservoir). They found 32 species of fish (pike *Esox lucius*, common roach *Rutilus rutilus*, common dace *Leuciscus leuciscus*, chub *Leuciscus cephalus*, Dnieper chub *P. borysthenicus*, ide *I. idus*, rudd *Scardinius erythrophthalmus*, asp *Aspius aspius*, tench *Tinca tinca*, gudgeon *Gobio gobio*, common bleak *Alburnus alburnus*, white bream *Blicca bjoerkna*, common bream *Abramis brama*, vimba bream *Vimba vimba*, Amur bitterling *Rhodeus sericeus*, crucian carp *Carassius carassius*, Prussian carp *Carassius auratus gibelio*, common carp *Cyprinus carpio*, grass carp *Ctenopharyngodon idella*, stone loach *Nemachilus barbatulus*, weatherfish *Misgurnus fossilis*, spined loach *Cobitis taenia*), and also provided information on the distribution and abundance of these species in the area under study from Bila Tserkva to Shkarivka village. One of the species is the grass carp (*Ctenopharyngodon idella*) – is noted by the authors as acclimatised for breeding in the ponds of the Alexandria arboretum, from where its spawn got into the Ros channel.

As of 2020, the species composition of fish has changed significantly. The study of the fish population of the rivers of the middle Dnipro region, including Ros, indicates the absence of vyrezub, Danube bleak, and lepomis in the catches [18; 19], which were previously mentioned

in the studies. During the study on the Protoka River, which is a right tributary of the Bilotserkivskiy lower reservoir, the species composition of fish is characterised by a fairly wide variety. In particular, in 2013 the presence of such species as European bitterling (*Rhodeus amarus*), spined loach (*Cobitis taenia*) and weatherfish (*Misgurnus fossilis*) was noted [20; 21]. In general, the species composition of fish in the Ros River and in some parts of it varies. This is influenced by a number of factors, including anthropogenic loads.

## Materials and Methods

The study was conducted from November 2016 to November 2020 at sites within the village of Shkarivka, Bilotserkivskiy district, at the discharge sites of the Rosava tire plant and the upper part of the reservoir near the dam of the Bilotserkivskiy lower reservoir, located on the Ros River between the city of Bila Tserkva and Shkarivka village.

In November 2016, an expedition visit to the reservoir was carried out to collect samples, which was later used for statistical analysis. In May 2017 and 2020, repeated visits were conducted to take ichthyological and hydrobiological samples in connection with the discharges of Bilotserkivvoda [22]. For additional analysis, the species composition of the only tributary of the Bilotserkivskiy lower reservoir, the Rotok River (Protoka), was studied. The study of ichthyofauna was based on the species composition, fish productivity, and other necessary components.

Ichthyological studies were conducted according to generally accepted methods: fish belonging to a certain species by characteristic, specific, individual, external features inherent only in a certain species, and their belonging to an ecological group.

The collection of ichthyological material was carried out by analysing catches from nets, interviewing amateur fishermen, the local population, and materials seized by the inspection from poachers. A 25 m long fry drag net was used to catch young fish. After the analysis, the test material was released back into the reservoir. The description of the species composition of fish and the processing of the material were performed according to the methods described in the determinants of freshwater fish [23; 24]. The findings were compared with the species composition of fish in this part of the Ros River before the creation of the reservoir [17] and after its development [25].

## Results and Discussion

In the Ros River, before the creation of the Bilotserkivskiy lower reservoir, 32 species of fish belonging to 8 families were recorded. In the future, there was a significant reduction in the number of species. In particular, there were 20 species from the family Cyprinidae (Table 1) in the 1960s.

**Table 1.** Analysis of the composition of the ichthyofauna of the Ros River and the Bilotserkivskiy lower reservoir before and after discharges (family Cyprinidae)

Types of fish	Ros River, middle part		Bilotserkivskiy lower reservoir (Ros River)		
	1960s [17]	1970s [25]	2016	2017	2020
European carp ( <i>Cyprinus sagrao</i> )	detected	detected	detected	detected	detected
Prussian carp <i>Sagassius auratus gibelio</i>	detected	detected	detected	detected	detected
Silver carp <i>Hypophthalmichthys molitrix</i>	not detected	not detected	detected	detected	detected

Table 1, Continued

Types of fish	Ros River, middle part		Bilotserkivskiy lower reservoir (Ros River)		
	1960s [17]	1970s [25]	2016	2017	2020
Common roach <i>Rutilus rutilus</i>	detected	detected	detected	detected	detected
Grass carp <i>Ctenopharyngodon idella</i>	detected	detected	detected	detected	detected
White bream <i>Blicca bjoerkna</i>	detected	detected	detected	detected	detected
Common bream <i>Abramis brama</i>	detected	detected	detected	detected	detected
Common rudd <i>Scardinius erythrophthalmus</i>	detected	detected	detected	detected	detected
Common bleak <i>Leucaspis de lineatus</i>	detected	detected	detected	detected	detected
Asp <i>Aspius aspius</i>	detected	detected	detected	detected	detected
Gudgeon <i>Gobio gobio</i>	detected	detected	detected	not detected	not detected
Bitterling <i>Rhodeus sericeus</i>	detected	detected	detected	detected	detected
Tench <i>Tinca tinca</i>	detected	detected	detected	detected	detected
Topmouth gudgeon <i>Pseudorasbora parva</i>	detected	detected	detected	detected	detected
Common dace <i>Leuciscus leuciscus</i>	detected	detected	not detected	not detected	not detected
Dnieper chub <i>P. borysthenicus</i>	detected	detected	not detected	not detected	not detected
Ide <i>I. idus</i>	detected	detected	not detected	not detected	not detected
Sunbleak <i>Leucaspis delineatus</i>	detected	detected	not detected	not detected	not detected
Spirlin <i>Alburnoides bipunctatus</i>	detected	detected	not detected	not detected	not detected
Vimba bream <i>Vimba vimba</i>	detected	detected	not detected	not detected	not detected
Crucian carp <i>Carassius carassius</i>	detected	detected	not detected	not detected	not detected
Total	20	20	14	13	13

The creation of the reservoir did not quickly affect the species composition of fish of this family, and in the 1970s, the species composition of the family Carpinidae remained unchanged. Over a longer period of time, until 2016, the species composition of fish of the family Carpinidae changed significantly. 7 species of fish have disappeared, in particular: common dace, Dnieper chub, ide, sunbleak, spirlin, vimba bream, and crucian carp. However, as a result

of artificial fish settlement, the silver carp appeared, which is used to regulate the number of microscopic algae. After uncontrolled industrial discharges into the reservoir's water area, gudgeon disappeared in 2017, which indicates the vulnerability of this species to water pollution.

Predatory fish species belonging to the families *Esocidae*, *Siluridae*, and *Percidae* were represented in the Ros River and reservoir by only 5 species (Table 2).

**Table 2.** Analysis of the composition of the ichthyofauna of the Ros River and the Bilotserkivskiy lower reservoir before and after discharges (families *Percidae*, *Esocidae*, and *Siluridae*)

Types of fish	Ros River, middle part		Bilotserkivskiy lower reservoir (Ros River)		
	1960s [17]	1970s [25]	2016	2017	2020
Perch <i>Perca fluviatilis</i>	detected	detected	detected	detected	detected
Pikerperch <i>Sander lucioperca</i>	detected	detected	detected	detected	detected
Ruffe <i>Acerina cernua</i>	detected	detected	detected	detected	not detected

Table 2, Continued

Types of fish	Ros River, middle part		Bilotserkivskiy lower reservoir (Ros River)		
	1960s [17]	1970s [25]	2016	2017	2020
Pike <i>Esox lucius</i> .	detected	detected	detected	detected	detected
Catfish <i>Silurus glanis</i> .	detected	detected	detected	detected	detected
Total	5	5	5	5	4

All these species are well adapted, both in the conditions of a river with a relatively strong current, and in a reservoir. From the 1960s to 2017, the presence of these species did not decrease. Even anthropogenic pollution of the reservoir did not lead to their complete disappearance. However, a repeated case of untreated discharges in 2020

led to the disappearance of ruffes (*Acerina cernua*), which indicates their greater vulnerability compared to other species.

In the Ros River in the 1960s, there were 8 more species of fish that belonged to the families *Odontobutidae*, *Nemacheilidae*, *Cobitidae*, *Gobiidae* (Table 3).

**Table 3.** Analysis of the composition of the ichthyofauna of the Ros River and the Bilotserkivskiy lower reservoir before and after discharges (families *Odontobutidae*, *Nemacheilidae*, *Cobitidae*, *Gobiidae*)

Types of fish	Ros River, middle part		Bilotserkivskiy lower reservoir (Ros River)		
	1960s [17]	1970s [25]	2016	2017	2020
Amur sleeper <i>Percottus glenii</i>	detected	detected	detected	detected	detected
Monkey goby <i>Neogobius fluviatilis</i>	detected	detected	detected	detected	detected
Round goby <i>Neogobius melanostomus</i>	detected	detected	detected	not detected	not detected
Tubenose goby <i>Proterorhinus marmoratus</i>	detected	detected	detected	not detected	not detected
Stone loach <i>Nemachilus barbatulus</i>	detected	detected	detected	detected	not detected
Weatherfish <i>Misgurnus fossilis</i>	detected	detected	not detected	not detected	not detected
Spined loach <i>Cobitis taenia</i>	detected	not detected	not detected	not detected	not detected
Total	7	6	5	3	2

As of 2020, there are only 2 species left, Amur sleeper (*Percottus glenii*) and the monkey goby (*Neogobius fluviatilis*) from the families *Odontobutidae* and *Gobiidae*, respectively. Immediately after the creation of the reservoir, spined loach (*Cobitis taenia*) and later weatherfish (*Misgurnus fossilis*) have disappeared. Pollution of the reservoir in 2017 led to the disappearance of two species of the family *Gobiidae*, and in 2020 – the stone loach (*Nemachilus barbatulus*) from the family *Nemacheilidae* disappeared.

According to the results of the latest research on the composition and condition of the ichthyofauna of the Bilotserkivskiy lower reservoir before discharges, it can be argued that the most represented is the family *Carpinidae*, which includes 13 species: carp, Prussian carp, silver carp, roach, grass carp, rudd, common bleak, gudgeon, bitterling, tench, and topmouth gudgeon. Less numerous are the families *Percidae* (perch, pikeperch), *Odontobutidae* (Amur sleeper), *Esocidae* (pike), *Siluridae* (wels catfish).

Studies of the actual commercial fish species of the Bilotserkivskiy lower reservoir indicate the presence of carp, Prussian carp, silver carp, perch, rudd, and pikeperch in the reservoir. The quantitative and qualitative composition of the ichthyofauna of the reservoir under study is

confirmed by the results of fry netting, in which the same species were found.

The results of the conducted studies of the Bilotserkivskiy lower reservoir in November 2016 allowed calculating the reserves of commercial fish species, which were (tonnes): 22.7: carp – 3.0, herbivores – 5.0, other species – 14.7, including: Prussian carp – 3.7, roach – 1.5, rudd – 0.5, tench – 0.5, pike – 4.0, pikeperch – 1.5, catfish – 1.0, perch – 2.0. The broad-fingered crayfish is also found in the reservoir. The latter's reserves were 2.1 tonnes.

The actual productivity for commercial fish species of the Bilotserkivskiy lower reservoir in November 2016 in general was 319.7 kg/ha, including by species: carp – 42.3 kg/ha, herbivores – 70.4, other species – 207.1 kg/ha, including: Prussian carp – 52.1 kg/ha, roach – 21.1 kg/ha, rudd – 7.0 kg/ha, tench – 7.0, catfish – 14.1 kg/ha, pike – 56.3 kg/ha, pikeperch – 21.1 kg/ha, perch – 28.2 kg/ha. The crayfish productivity was 29.6 kg/ha.

Species composition of the ichthyofauna of the Bilotserkivskiy lower reservoir (Ros River) in May 2017 showed a sharp decrease in the species composition of the ichthyofauna in the reservoir. Fish belonging to 7 families were found. As usual, the most numerous family was

*Carpinidae* – 7 species (Prussian carp, roach, white bream, bream, common bleak, bitterling, topmouth gudgeon); *Percidae* – 3 species (perch, pikeperch, ruffe), *Gobiidae* – 1 species (monkey goby); *Odontobutidae* – 1 species (Amur sleeper).

In terms of relative abundance, the reservoir was dominated by valuable commercial fish species, namely: bream (14.6%) and pikeperch (27.9%). Among other fish species, European perch, Eurasian ruffe, and monkey goby predominated in number.

The species composition of fish in November 2016 was 19 species, and in May 2017 – only 18 species. The species composition decreased by 1 species.

Analysis of the age composition of fish showed a small number of age groups in the reservoir. Prussian carp had 7 age groups (this order was the largest), bream – 5, and perch – 3 age groups. In all other fish species, namely roach, pikeperch, and white bream, only 2 age groups of non-sexually mature fish are established.

Fish productivity of the Bilotserkivskiy lower reservoir (Ros River) in May 2017 (71 ha) was – 319.7 kg/ha. After the chlorine discharge in May 2017, the fish productivity was only 240–250 kg/ha. That is, it decreased by 70 kg/ha, primarily due to carp and herbivorous fish.

The species composition in 2020 compared to 2016 decreased by 2 species. The study found not only a decrease in the number of species composition of ichthyofauna, but also fish productivity in the reservoir as a whole.

For more than 50 years (1960s–70s – 2020s) as part of the ichthyofauna of the middle part of the Ros River in the Bila Tserkva district has undergone significant qualitative and quantitative changes. This was caused by the results of intensive hydraulic engineering construction at the end of the 20<sup>th</sup> century, when the transition from a river to a lake (reservoir) type of reservoir took place. This is also the commercial use of the reservoir, which has led to a sharp decrease in the species diversity of the ichthyofauna. The use of the reservoir for water supply has led to an emergency discharge of technological water by the Bilotserkivvoda enterprise, which, in turn, sharply reduced the qualitative and quantitative composition of the fish population of the Bilotserkivskiy lower reservoir (Ros River).

It can be concluded that in 2016 the following species disappeared since the 1960s: common dace *Leuciscus leuciscus*, Dnieper chub *Leuciscus borysthenticus*, ide *I. idus*, sunbleak *Leucaspius delineatus*, vimba bream *Vimba vimba*, crucian carp *Carassius carassius*, weatherfish *Misgurnus fossilis*, spined loach *Cobitis taenia*, in 2017 – gudgeon *Gobio gobio*, round goby *Neogobius melanostomus*, tubenose goby *Proterorhinus marmoratus*, in 2020 – char, ruffe. Every 10 years the species composition of the ichthyofauna of the lower Bilotserkivskiy reservoir lost at least 2–3 species of fish, which is conditioned by the influence of anthropogenic factors, industrial activity, uncontrolled and unidentified discharges into reservoirs.

With further monitoring of the state of the ichthyofauna of the reservoir, the hydrological location of the river is upstream and less subject to anthropogenic pollution, tributaries of the reservoir can serve as a mechanism for restoring the ichthyofauna. According to M.B. Prychepa [20], the species composition of the ichthyofauna consisted of 20 species of fish, which are grouped into 7 orders and 8 families. The following species were found in the catches:

*Perca fluviatilis* – perch, *Gymnocephalus cernua* – Eurasian ruffe, *Esox lucius* – pike, *Silurus glanis* – wels catfish, *Rutilus rutilus* – common roach, *Scardinius erythrophthalmus* – common rudd, *Abramis brama* – common bream, *Carassius auratus* – goldfish, *Blicca bjoerkna* – white bream, *Tinca tinca* – tench, *Alburnus alburnus* – common bleak, *Cyprinus carpio* – European carp, *Pseudorasbora parva* – topmouth gudgeon, *Hypophthalmichthys molitrix* – silver carp, *Ctenopharyngodon idella* – grass carp, *Gobio gobio* – gudgeon, *Misgurnus fossilis* – weatherfish, *Gasterosteus aculeatus* – three-spined stickleback, *Perccottus glenii* – Amur sleeper, *Neogobius fluviatilis* – monkey goby.

The species composition of the ichthyofauna of the Protoka (Rotok) River exceeded bottom (44.4%) and bottom-swimming fish species (22.4%). A small proportion of natural species in the river's ichthyofauna (16.6%) indicates insufficiently favourable living conditions for these species. It can be noted that the species distribution of ichthyofauna in the Protoka River is strongly influenced by the large number of hydraulic structures in the reservoir. This has a negative effect on fish migration and is unfavourable for fish that react to oxygen dissolved in water [20].

In some sections of the Protoka River, there is no common bleak *Alburnus alburnus*, tench *Blicca bjoerkna*, common roach *Rutilus rutilus* as a result of stopping migration routes by spillway structures, small short-cyclical fish species were observed [24]. It was these species that were characterised by the greatest ecological plasticity and resistance to living conditions [20].

Under conditions of restriction of river sections by hydraulic structures, invasive fish species dominated. At the same time, among the native fish species, a small amount fell on perch *Perca fluviatilis*, weatherfish *Misgurnus fossilis*, and carp *Cyprinus carpio* (the latter came from ponds adjacent to the river). In the Protoka River, phytophilic and psammolithophilic groups of fish were dominant and accounted for 65 and 20%, respectively; zoobenthophages accounted for 50%, predators – 20% [20].

The analysis showed that in the changed areas, namely in areas located within the city limits, the species composition of ichthyofauna on the Protoka River is significantly depleted. However, this has led to an increase in the number of limnophilic and briefly cyclical fish species, in particular goldfish *Carassius auratus*, topmouth gudgeon *Pseudorasbora parva*, and Amur sleeper *Perccottus glenii* [20].

More species diversity of ichthyofauna was recorded in areas above the city of Bila Tserkva, where the following species were found: common roach *Rutilus rutilus*, alburnus, white bream *Blicca bjoerkna*, pike *Esox lucius*, tench *Tinca tinca*, common rudd *Scardinius erythrophthalmus*, gudgeon *Gobio gobio*, Eurasian ruffe *Gymnocephalus cernua* [20].

In the mouth of the Protoka River, two more species are added to the ichthyofauna, such as well catfish *Silurus glanis* and monkey goby *Neogobius fluviatilis*. This can be explained by changes in the banks, the preservation of the riverbed, the presence of plants that are adapted to large currents and specific ecological conditions that affect the species composition of the reservoir [20].

During the study in 2018, among the 20 fish species recorded in the Protoka (Rotok) river, only 3 species belong to the undesirable invading species from the Far East. These species were introduced into the water bodies of Ukraine in

the 19<sup>th</sup>-20<sup>th</sup> centuries (topmouth gudgeon, goldfish, and Amur sleeper), and to the group of self-settlers who fell into the Dnipro River basin in the second half of the 20<sup>th</sup> century, this is such a species as the three-spined stickleback [20].

Comparing the species composition of the ichthyofauna of the Bilotserkivskiy lower reservoir and the Protoka River, it can be concluded that no significant species difference was observed, but there are some native species that have not been observed in the reservoir in recent years, such as Loach *Misgurnus fossilis*, Eurasian ruffe *Gymnocephalus cernua* but the value of tributaries, namely estuary sections, lies in their ability to create so-called ecological corridors for the healthy functioning of the hydroecosystem.

### Conclusions

Based on the results of research conducted at the Bilotserkivskiy lower reservoir (Ros River) 24 species were identified in 2016, 21 – in 2017, and 19 species – in 2020. Analysing the number of ichthyofauna since the 1960s, it can be concluded that approximately every 10 years the species composition of the ichthyofauna of Bilotserkivskiy lower is reduced by 2.5 species of fish, which is conditioned by the influence of a number of anthropogenic factors, overregulation of the river current, and commercial use of water bodies.

After analysing the number of ichthyofauna since the 1960s, it can be concluded that in 2016 the following species are disappeared: common dace *Leuciscus leuciscus*, Dnieper chub *Leuciscus borysthenicus*, ide *I. idus*, sunbleak *Leucaspius delineatus*, vimba bream *Vimba vimba*, crucian carp *Carassius carassius*, weatherfish *Misgurnus fossilis*, spined loach *Cobitis taenia*, in 2017, such species as gudgeon *Gobio gobio*, round goby *Neogobius melanostomus*, tubenose goby *Proterorhinus marmoratus*, in 2020 – char, ruffe. Restoration of the natural composition of the ichthyofauna of the Bilotserkivskiy lower reservoir is possible due to a tributary – the Protok (Rotok) River. Discharges of pollutants and toxic substances (chlorinated water) by the Bilotserkivvoda enterprise led to the death of fish, crayfish and a decrease in the ichthyofauna and fish feed production.

For the purpose of directed control and restoration of ichthyofauna in conditions of industrial and anthropogenic load on reservoirs, it is necessary to periodically conduct research on the feed base of ichthyofauna and, if necessary, implement a set of measures to improve the development of the feed base and develop a water protection strategy, approaches to solving issues of the revitalisation of reservoirs for the restoration of ichthyofauna.

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## Іхтіофауна Білоцерківського нижнього водосховища на річці Рось

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**Анотація.** Внаслідок природних процесів і впливу антропогенних факторів у внутрішніх водоймах України змінюється склад іхтіофауни. Системний аналіз змін дозволяє контролювати ці процеси і підтримувати різноманіття видів на сталому рівні. Метою дослідження було вивчити зміни складу іхтіофауни Білоцерківського нижнього водосховища (р. Рось) після скиду промислових відходів підприємства «Білоцерківвода» у 2017 та 2020, що призвело до масової загибелі риби та раків. Дослідження проводились методом вилову риб з ідентифікацією видів та опитуванням рибалок з листопада 2016 по жовтень 2020 років. Додатково враховували видовий склад риб у цій ділянці річки Рось до створення водосховища. За результатами проведених досліджень було виявлено 24 види риб 2016 році, 21 – у 2017 році та 19 – у 2020 році. Аналізуючи чисельність іхтіофауни починаючи з 60-х років ХХ століття можна зробити висновки, що кожні 10 років видовий склад іхтіофауни Білоцерківського нижнього водосховища втрачав близько 2-3 видів риб, що зумовлено впливом перекриття русла, діяльністю промисловості, неконтрольованих та неідентифікованих скидів у водойму тощо. Після проведеного детального аналізу чисельності іхтіофауни встановили, що до 2016 року зникли такі види: ялець *Leuciscus leuciscus*, бобирець *P. borysthenticus*, в'язь *I. idus*, вівсянка *Leucaspius delineatus*, рибець *Vimba vimba*, карась золотий *Carassius carassius*, в'юн *Misgurnus fossilis*, щипавка *Cobitis taenia*, у 2017 році такі види як пічкур *Gobio gobio*, бичок-кругляк *Neogobius melanostomus*, бичок-рижик *Proterorhinus marmoratus*, у 2020 році – це голец, йорж. Кількісне та якісне відновлення іхтіофауни можливе за рахунок риби із річки Протоки (Роток). Для продовження рибогосподарського використання необхідне зариблення водосховища. Практична цінність цієї роботи полягає у визначенні видового складу іхтіофауни для подальшого використання водойми в природоохоронних і рибогосподарських цілях

**Ключові слова:** внутрішні водойми, прісноводна риба, вилов, промислові скиди, екологічні групи риб