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Original researches

Zooplankton products on certain sections of the «Dnipro-Donbas» canal

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Abstract. In May 2020 the quantitative and qualitative composition of zooplankton as a food item of aquatic bioresources was determined in the water area of the «Dnipro-Donbas» hydrotechnical canal. As a result of complex hydrobiological researches it was revealed that there are significant changes in the number of all groups of aquatic organisms, including zooplankton. 14 species of zooplankton were found. Taxonomic diversity is represented by three groups of *Rotatoria*, *Cladocera*, *Copepoda*. It was proved that climate change, wide fluctuations of water temperature have led to a decrease in the number and species diversity of zooplankton. The quantitative and qualitative composition of zooplankton is also affected by periodic pumping of water along the canal route. It was noted that planktonic organisms affect the level of eutrophication of the canal and the amount of oxygen in the aquatic environment; they form secondary products in the reservoir. It was established that the amount of 108 000 item/m^3 and zooplankton biomass of 781 mg/m^3 in the water area of different sections of the «Dnipro-Donbas» hydrotechnical canal are insufficient. When determining the groups of zooplankton, it was found that the roe of rotifers (*Rotatoria*) was the most numerous in the sampling sections, and in the area № 2 (Shulhivka Bridge area) in the spring it was completely absent. The maximum indicators of zooplankton number and biomass were observed in the section of the canal upper Shulhivka Bridge (59 000 item/m^3, 506.87 mg/m^3). The area of the canal near Shulhivka Bridge was characterized by the smallest quantitative development of zooplankton species (8 000 items/m^3, 53.7 mg/m^3). There were no rotifers in that area. Seasonal features of the frost-free and snowless winter of 2019–2020, warm spring of 2020 caused disbalance in the functioning of the aquatic ecosystem; it affected the formation of biological products of the canal and its consumption by the final link of trophic chains (fish).

Keywords: productivity; zooplankton; rotifers; copepods; water fleas; *Copepoda*; *Cladocera*; *Rotatoria*; the «Dnipro-Donbas» canal.

Продукція зоопланктону на окремих ділянках каналу «Дніпро-Донбас»

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Анотація. У травні 2020 року на акваторії гідротехнічного каналу «Дніпро-Донбас» визначали кількісний та якісний склад зоопланктону як кормового об'єкту водних біоресурсів. У результаті комплексних гідробіологічних досліджень виявлено, що відбуваються значні зміни чисельності всіх груп гідробіонтів, у тому числі зоопланктону. Знайдено 14 видів-зоопланктерів. Таксономічне різноманіття представлено трьома групами – *Rotatoria, Cladocera, Copepoda*. Доведено, що зміни клімату, різкі коливання температури води привели до зменшення чисельності та видового різноманіття зоопланктону. На кількісний та якісний склад зоопланктону впливає також періодичне прокачування води по трасі каналу. Зазначено, що планктонні організми впливають на рівень евтрофікації каналу, кількість кисню у водному середовищі та формують вторинну продукцію у водоймі. Встановлено, що кількість 108 000 екз/м^3 та біомаса зоопланктону 781 мг/м^3 на акваторії різних ділянок гідротехнічного каналу «Дніпро-Донбас» недостатні. При визначенні угруповань зоопланктерів встановлено, що найчисельнішими в місцях відбору проб були яйця коловерток (*Rotatoria*), а на ділянці № 2 (район Шульгівського мосту) навесні вони взагалі відсутні. Максимальні показники кількості та біомаси зоопланктону відзначені на ділянці каналу вище Шульгівського мосту (59 000 екз/м^3, 506,87 мг/м^3). Найменшим кількісним розвитком видів-зоопланктерів характеризується ділянка каналу поблизу Шульгівського мосту (8 000 екз/м^3, біомаса – 53,7 мг/м^3. Коловертки відсутні). Сезонні особливості безморозної та безсніжної зими 2019–2020 рр., теплої весни 2020 року обумовили дисбаланс у функціонуванні водної екосистеми, який вплинув на утворення біологічної продукції каналу та споживання її кінцевою ланкою трофічних ланцюгів (рибою).

Ключові слова: продуктивність; зоопланктон; коловертки; веслоногі ракоподібні; гіллястовусі ракоподібні; *Copepoda*; *Cladocera; Rotatoria*; канал «Дніпро-Донбас».

Introduction

The level of productivity of aquatic ecosystems depends on a number of factors that significantly affect the state of the water bodies and the number of fish products in it; it is one of the main issues in the functioning of aquatic ecosystems (Cushing, 1990; Ficke t al., 2007). Constant process of formation of primary and secondary biological products indicates the proper state of water bodies, especially during global climate change (Chu et al., 2005; Farmer & Cook, 2013) and it prevents the accumulation of toxicants of various origins (Hubanova et al., 2019). It is known that due to climate change there are transformations both in terrestrial (Zhukov & Gubanova, 2015) and aquatic ecosystems (Magnuson, 2010; Zhukov et al., 2019).

In the steppe zone of Ukraine in the 1970s the principal canal «Dnipro-Donbas» was created for irrigation of lands which provides the needs of the population, the industry and the agriculture of Poltava, Dnipropetrovsk, Kharkiv regions with Dnipro water, carries out important function of implementation of sanitary-compensational flow augmentation in the Siverskyi Donets river (Gidrobiologiya kanalov …, 1990; Vischnevskiy, 2003; Novitskyi et al., 2015; Hubanova et al., 2019). Since the construction of the canal and the launch of its first stage (1982), there have been negative changes in the hydroecosystem: deterioration of the hydrological regime, quality and sanitary characteristics of water, siltation, overgrowing with aquatic vegetation etc. In some years, in summer and winter there were signs of fish die-off, periodically there is algal bloom of water (Koval et al., 1987; Gidrobiologiya kanalov …, 1990; Novitskyi et al., 2015). Longstanding research of Ukrainian canals shows that the processes of excess biomass production create serious biological obstacles to the operation of canals. This problem intersects with the general processes of eutrophication of both artificial and small and medium-sized water bodies of steppe zones of Ukraine (Vischnevskiy, 2003).

The main criterion for determining the hydroecological condition of the canal is the species diversity of hydrobionts, their quantitative ratio, the level of biological productivity, the influence of abiotic factors and mechanical means that contribute to the additional airing of the reservoir (Vasylieva et al., 2019). The principal canal, like any artificial system, requires constant human supervision in the form of measures of pumping water masses, biological reclamation for improving water quality, etc.

In connection with the above mentioned, it is important to carry out monitoring studies of zooplankton as one of the main components of the hydroecosystem and a source of secondary products in the water body (Yakovenko & Zaychenko, 2018). Zooplankter species are food item for many aquatic bioresources, including fish (both juveniles and adults). The presence of planktonic organisms and their numerical development in the «Dnipro-Donbas» canal is an important factor in the biological productivity of the water body, and significant volumes of zooplankton products can affect the quality of canal waters.

The aim of the work is to study the quantitative and qualitative composition of zooplankton as a food item of aquatic bioresources in the «Dnipro-Donbas» canal in the spring of 2020.

Materials and methods

At the end of May 2020 multiple hydrobiological research was conducted on the section 1 of the «Dnipro-Donbas» canal. Zooplankton samples were taken at five points of the canal and in the intake chamber: 1 – intake chamber, 2 – near the sluices, 3 – upper the Shulgivka bridge, 4 – near the Shulgivka bridge, 5 – pumping station № 1 (near Tsarychanka fish farm) (Fig. 1).

In studying of the qualitative composition of zooplankton conventional techniques (Metodika izucheniya…, 1975) and indexes were used. Species identification was performed with МБС-10 microscope. According to these methods, zooplankton samples were taken with Apstein plankton net № 67. The concentrate from the net was fixed at the location with 40 % neutral formalin. During laboratory investigation, high-quality zooplankton was studied under the МБС-10 microscope. Species identification of zooplankton was performed by determinants (Romanenko, 2006).

Qualitative samples of zoobenthos were taken with a dip net among the thickets of higher aquatic vegetation. Samples were immediately fixed with 40 % formalin. Further qualitative and quantitative processing of materials was performed in the laboratory. Determination of species belonging performed by the determinant. Biomass was determined by multiplying the individual mass by the number.

Processing and analysis of the results were performed using statistical methods (Plohinskiy, 1970; Zar, 2010) and Microsoft Excel for Windows and Statistica 6.0 application packages.

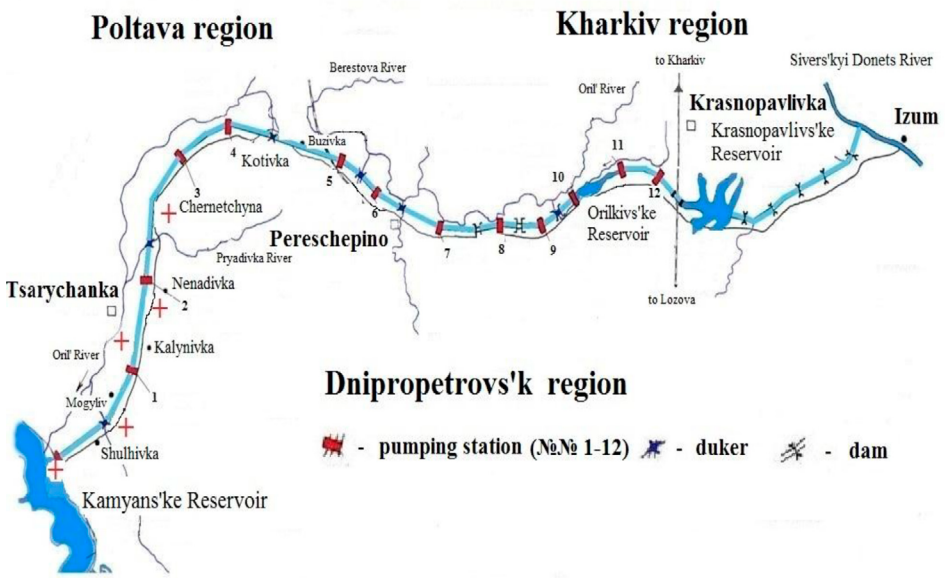

Fig. 1. Places for zooplancton sampling selection in the «Dnipro-Donbas» canal

Results

Compared to previous years, the spring season of 2020 was characterized by wide temperature fluctuations, excessive drought, which significantly affected the amount of organic matter in the water, the level of aquatic organisms and the energy disbalance in the water system in general.

When processing the selected materials, the species composition and the main indicators of the quantitative development of zooplankton as the number and biomass were determined.

As a result of sample processing, 14 species of zooplankton were identified. They are *Rotatoria* (*Asphanchna priodonta, Brachionus angularis, Brachionus calyciflorus, Brachionus foroicula, Keratella cochlearis, Keratella quadrata, Trichocera capucina, Poliarthra trigla, Filinia longiseta*), *Copepoda* (*Acanthocyclops vernalis, Mesocyclops oithotoides, Cyclops vicinus, Nauplii copepod*), *Cladocera* (*Bosmina longirostris*).

Data on the quantitative development of zooplankton are presented in Table.

The structure of zooplankton in different parts of the researched area of the «Dnipro-Donbas» canal has no significant differences. All identified species of animal organisms belong to three systematic groups: *Rotatoria, Cladocera* and *Copepoda*.

The species development of zooplankton is very low during the spring. Especially it is subject to rotifers, which are represented by 5–6 species that occur singly. However, a lot of very large-sized roe number of this systematic group was found. Roe of this size, as a rule, is registered after wintering during the genesial cycle of reproduction of rotifers, so they must soon develop in significant number.

The level of species diversity of copepods and water fleas is insignificant. Crustaceans are represented by 1–2 species throughout the researched area of the canal. However, if cyclops and their larvae occur as single specimens, the water fleas like *Bosmina longirostris* developed in groups of large number. Bosmins, like daphnia, are active filterers, consumers of primary products, they help to reduce phytoplankton biomass and form the basis of secondary products.

When analysing the qualitative composition of zooplankton in the sampling areas, we can conclude that zooplankton in the area above the Shulgovka Bridge was the most diverse (10 species) and near WSC too (8 species), rotifers of the genus *Brachionus* were dominant in these areas, among water fleas and copepods there were *Acanthocyclops vernalis* and *Bosmina longirostris*.

Data of the zooplankton quantitative development, presented in Fig. 2, indicate a direct dependence of its development on the intensity of vegetation of plant organisms.

This situation is usually typical for the spring period. The maximum indicators of zooplankton number and biomass were

Table. Indicators of zooplankton quality development in the section of the «Dnipro-Donbas» canal from the main water supply construction (WSC) to the pumping station № 1 (spring 2020)

Zooplankton groups	Sampling area				
	Intake chamber	WSC, 20 m from sluices	Shulhivka bridge		Pumping station № 1 (near Tsarychanka fish farm)
			Upper the bridge	Near the bridge	
Rotifers (*Rotatoria*)	2 50 %	5 62.5 %	6 60 %	–	1 20 %
Water fleas (*Cladocera*)	2 50 %	1 12.5 %	2 20 %	1 50 %	2 40 %
Copepods (*Copepoda*)	–	2 25 %	2 20 %	1 50 %	2 40 %
Total	4 100 %	8 100 %	10 100 %	2 100 %	5 100 %

Note. Above the line is the number of species, below the line is the percentage of the total number of species.

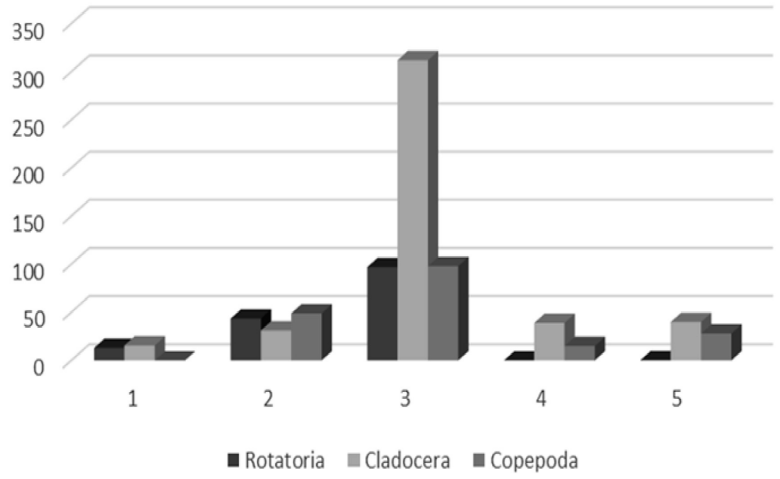

Fig. 2. Zooplankton biomass in the researched areas (mg/l): 1 – intake chamber, 2 – near sluices, 3 – upper Shulhivka bridge, 4 – near Shulhivka bridge, 5 – pumping station № 1 (near Tsarychanka fish farm)

observed in the section of the canal above Shulhivka Bridge (59 000 items/m^3, 506.87 mg/m^3). Compared with other areas of the canal zooplankton, which belongs to three systematic groups: rotifers (*Rotatoria*), copepods (*Copepoda*) and water fleas (*Sladocera*), developed more actively, water fleas number and biomass was 8–10 times higher than similar indexes in comparison with other researched areas. The area located near the WSC ranks the second place in the intensity of zooplankton development (28 000 items/m^3, 123.8 mg/m^3). The number of zooplankton (9 000 items/m^3) near the pumping station № 1 was almost three times lower. The area of the canal near Shulhivka Bridge is characterized by the lowest quantitative development of zooplankton species. No rotifers were found in this area, the residual amount of zooplankton is 8 000 items/m^3, biomass is 53.7 mg/m^3. Also, when inspecting the researched areas, it was noted that intake chamber is the most unfavourable for the existence of *Copepoda*.

Discussion

Analysing the material showed that climate and seasonal changes affect significantly the behaviour of ecosystems and change the species diversity of aquatic organisms in them (Pankhurst & Munday, 2011; Vasylieva et al., 2019). For example, among the variety of abiotic environmental factors, temperature is one of the key elements of direct and indirect impact on the life of aquatic organisms. Ambient temperature affects all stages and periods of life and seasonal cycles of invertebrates and fish, the speed and efficiency of metabolic processes, the behaviour and distribution of aquatic organisms in freshwater bodies (Jobling, 2003; Elliott & Elliott, 2010; Magnuson, 2010; Golovanov, 2013).

It is known that the increase of water temperature and increase of the period without ice affect the thermal stratification and hydrodynamics of water bodies (Le Treut et al., 2007). In water bodies without ice cover there is no mixing of water; it causes a different redistribution of energy in hydroecosystems and leads to a decrease in oxygen concentration. Global warming also causes intense evaporation of water from the surface of water bodies, which further reduces the level of lakes, rivers and seas. Of course, the above mentioned affects the hydrochemical state of water and the level of bioproductivity in the water bodies in general (Vinberg, 1962). It should be noted that the quantitative and qualitative composition of zooplankton as a food item of aquatic bioresources is directly and indirectly affected by non-periodic pumping of water along the route of the «Dnipro-Donbas» canal in the spring-summer season (Vasylieva et al., 2019). A distinctive tendency is the improvement of water quality after pumping along the route of the canal compared to the period of stagnation (several months of existence of the canal as a water body with standing water). The highly mineralized water of the canal is diluted with the water masses of the Kamianske Reservoir, as a result the total mineralization is halved and the chloride content is third less. Due to dilution, the dynamics of eutrophication processes decreases, airing of water masses during mixing takes place, which, undoubtedly, has a positive effect on the state of the hydroecosystem of the «Dnipro-Donbas» canal.

We should pay attention to the group *Copepoda*: in most of the researched areas its number is the same. Copepods are mainly predators; they also require animal products and can compete with other consumers of organic matter (Yakovenko & Dvoretskyi, 2012; Novitskiy & Gubanova, 2016).

During the inspection of the researched areas it was noted that the most unfavourable for the existence of *Copepoda* is the intake chamber; it is explained by the deterioration of water quality during prolonged stagnation of water masses, the development of blue-green algae and their mass death.

Data on the qualitative and quantitative development of zooplankton in the canal indicate the dominance of water fleas – bosmins (*Bosmina*). On the one hand, they are the main food item for some species of fish, on the other hand, being good filters, they absorb more phytoplankton and thus reduce the amount of oxygen in the water body due to the reduced number of oxygen producers (Yakovenko et al., 2017; Yakovenko & Zaychenko, 2018). Starvation causes not only metabolic disturbance associated with digestion, but also disturbance of the respiratory process of fish, which indirectly leads to their death, even with sufficient oxygen in the water body (Golovanov, 2013).

Based on the analysis of all obtained data, we believe that the lack of the required amount of products in the water body can cause starvation for all parts of the food chain, lead to disturbance of the functional properties of the «Dnipro-Donbas» canal and cause anthropogenic surface water pollution (Koval et al., 1987; Oksyiuk, 1990; Stepova & Roma, 2016; Novitskiy et al., 2019).

Conclusion

In May 2020, the quantitative and qualitative composition of zooplankton as a food item of aquatic bioresources was determined in the water area of the «Dnipro-Donbas» hydrotechnical canal. 14 species of zooplankton were found, the taxonomic diversity of which is represented by three groups of *Rotatoria*, *Cladocera*, *Copepoda*.

It is proved that climate change, wide temperature fluctuations of water have led to a decrease in the number and species diversity of zooplankton. The quantitative and qualitative composition of zooplankton is also affected by periodic pumping of water along the canal route.

The area of the «Dnipro-Donbas» canal near the Shulhivka Bridge is characterized by the smallest quantitative development of zooplankton species, and *Rotatoria* has not been detected in this area. The intake chamber of canal is the most unfavourable for the existence of *Copepoda*.

In general, the development of zooplankton in the researched area of the canal should be considered unsatisfying. The productivity of zooplankton in the spring is much lower than in other seasons; it can lead to starvation of certain groups of aquatic organisms, including fish. Therefore, it is effectually to conduct regular seasonal monitoring studies of the «Dnipro-Donbas» canal waters for further adjustments to the planned biomeliorative measures.

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