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ORIGINAL ARTICLE

The influence of environmental factors on fish productivity in small reservoirs and transformed waters

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The relevance of the article lies in the need to study artificial aquatic ecosystems, as uncontrolled anthropogenic impact is increasingly multifactorial and complex, characterized by a high degree of pollution, leads to irreversible changes in the structure of reservoirs, reducing the quality of the environment. This complicates the lives of all living organisms and has a particularly negative effect on human health and life expectancy. The problem of rational development of transformed water areas is complicated by circumstances of different origin of man-made nature. The load on reservoirs has led to the emergence of specific conditions for the formation of taxonomic composition, production and destruction processes and their quality. Optimizing the potential of artificial aquatic ecosystem systems will improve the quality of water resources and their conservation. Solving this problem requires in-depth research into the adaptive capacity and relationship of fish populations in the reservoir ecosystem. The research was conducted in the research laboratories of the Department of Aquatic Bioresources and Aquaculture of Kherson State Agrarian and Economic University and the Department of Ecology of the Stepan Gzhytskyi National University of Veterinary Medicine and Biotechnologies Lviv. Environmental conditions and influencing factors play an extremely important role in the life of fish. The main factors influencing the formation of parameters of artificial aquatic ecosystems are water volumes and discharge regimes, as well as the degree of pollution from industrial and domestic effluents. The dynamics of physico-chemical indicators of the quality of the aquatic environment during the experiment generally takes place within the normative for traditional breeding of pond fish, which did not significantly affect the course of the experiment. Biological indicators have become a priority in the modern period in the comprehensive ecological assessment of the aquatic ecosystem. The selected models were taken from two groups of yearling and annual carp (*Cyprinus carpio*), 20 individuals in each group. For the general assessment of the content of fish in the system of the pool type with recirculating water circulation, morphological indicators of blood were determined. When rearing young carp in polyculture, the spectrum of nutrition was taken into account, partially using the water from fish pools, which is enriched with nutrients, in particular various forms of nitrogen. When analyzing the functional status of the body of fish in the experimental group, there was an increase in the quality of indicators that reflect the homeostatic balance in the body, metabolic processes exceeded the values in the control. To ensure high-quality conservation of biodiversity and sustainable use, the proposed methods and technological recommendations can become an effective tool for the development of traditional knowledge of fisheries in our country.
Key words: artificial aquatic ecosystems, ecotransformation, anthropogenic impact, carp (*Cyprinus carpio*), rational use, biodiversity conservation.

Introduction

Rational use of water resources and conservation of their biological diversity is an urgent task today. It is necessary to take into account the need to preserve each type of resource in its range and in each place of its residence (Zhigin, 2015). Anthropogenic impact on aquatic ecosystems is becoming increasingly multifaceted and complex. As a result of destructive human activity, there are irreversible changes in the structure of ichthyofauna under anthropogenic pressure on natural and artificial aquatic ecosystems. The process of formation of anthropogenic factors on the state of fish populations in the conditions of aquatic ecosystems, in particular ontogenesis, is important. Due to the man-made origin of artificial ecosystems, the protection of such aquatic ecosystems acquires a peculiar character. This problem is especially acute in ecosystems where the balance between the production and destruction of primary organic matter is lost (Grynevych et al., 2018; Prysiazhniuk et al., 2019; Rudenko et al., 2019; Vodianitskyi et al., 2020; Piven et al., 2020; Borshch et al., 2020; Kofonov et al., 2020; Kalyn et al., 2020).

We should be aware of the direct anthropogenic pressure on ichthyofauna in terms of irrational fishing, uncontrolled recreational and sport fishing and illegal fishing, which, along with other factors of anthropogenic nature, has a powerful impact on the biota of ecosystems, although local in nature. In the early stages of ontogenesis, an important factor is to ensure proper feeding of young people for the intensive formation of internal organs and immunity (Hrynzhevskyi & Pekarskyi, 2004).

The use of metabolites, growth stimulants of artificial and natural origin, which affects the quality and biological value of fish products, is widely practiced in technological processes in fish farming. Given the neurohumoral regulation of anabolic and catabolic processes in fish, there is a likelihood (after the use of synthetic and hormonal drugs) of accumulation of metabolic products in muscle tissue, gonads, scales, and excretion of undigested residues in the aquatic ecosystem. The development of the fisheries industry of Ukraine in modern conditions requires deep knowledge of the peculiarities of technological processes, which is associated with mastering the theoretical foundations of the pond ecosystem, the relationship of cultivated objects with the environment and the impact of its components on fish (Andriushchenko & Vovk, 2014). The level of water pollution, irrational use of the potential of aquatic bioresources leads to a reduction in fish stocks. The issue of stocking reservoirs of various shapes and targets with high-quality stock with a high level of viability needs an urgent solution (Sherman et al., 2001).

The aim of our work was to increase the fish productivity of small reservoirs and transformed waters by stocking carp-resistant fish stock material resistant to the negative impact of environmental factors, against the background of using the latest technologies of energy supply of the technological cycle. Achieving this goal is possible by raising young fish in recirculating aquaculture systems.

Materials and Methods

The research was conducted in research laboratories of the Department of Aquatic Bioresources and Aquaculture of Kherson State Agrarian and Economic University and the Department of Ecology of Stepan Gzhytskyi National University of Veterinary Medicine and Biotechnologies Lviv. Two groups of fingerlings and one-year-old fish, 20 individuals in each group, were taken for research. Young fish were housed in a basin-type system with recirculating water circulation. The system provides sectional units of the tank for the cultivation of phytoplankton and zooplankton microalgae. Feeding was carried out from the main fish pools, the rest of the water came from the settling tank. The treated water in the bioreactor was manually introduced into the tanks once a week in a ratio of 1:2 (for phytoplankton microalgae) and 1: 3 (for zooplankton). When growing young carp in multiculture took into account the spectrum of nutrition. Feed production was carried out in an extruder designed for relatively small volumes. Feeding of young carp was additionally carried out on the background of the general diet with a mixture of pre-treated duckweed, spirulina, zooplankton in the ratio (10:70:20). After cultivation, the natural feed was filtered, processed and weighed for subsequent introduction into the total feed mass.

Water from fish pools, which is enriched with nutrients, in particular various forms of nitrogen, was partially used as a nutrient medium. The bioreactor for the cultivation of microalgae and zooplankton consisted of an aeration mechanism, heaters with a timer of a given temperature, and a storage tank with a medium for zooplankton. Water was added to the plant, which was pre-treated by changing the principle of electrophoresis of structural elements and subjected to treatment. Pools with carp juveniles had autonomous output and interconnection with the bioreactor. As an additional source of energy - the solar plateau provided the opportunity to use alternative energy sources for additional aeration and lighting for aquaponics - plants in the system of fish pools. The planting density of carp fry in pools at the beginning of cultivation was 1 thousand specimens/m^2.

The study of chemical parameters of water was carried out according to generally accepted methods. For the general assessment of the content of fish in the system of the pool type with recirculating water circulation, morphological indicators of blood were determined. Blood was taken in vivo from the tail vein (*Vena caudalis*), heparin was used as a coagulant at a rate of 20 IU per 1 ml of blood. In heparin-stabilized blood, the hematocrit, hemoglobin concentration and erythrocyte count were determined according to the guidelines. The concentration of total protein in the serum was determined spectrophotometrically by the Lowry method (Vlizlo, 2012).

Results and discussion

Table 1. Physicochemical indicators of the quality of the aquatic environment of the studied water bodies (Andriushchenko & Vovk, 2014)

Indexes	Pool 1 Fingerlings	Pool 2 One-year-old fish	Boundary permissible concentration
Water temperature, °C	24.9	25.2	23-25
pH	7.1	7.2	6.5-7.5
The content of dissolved oxygen in the water at the outlet of fish ponds, mg/l	5.8	6.4	< 5.0
The content of dissolved oxygen in the water at the outlet of the biofilter, mg/l	2.7	3.3	< 2,0
Total ammonia nitrogen (NH_3-N + NH_4-N), mg N/l	2.9	3.1	2.0-4.0
Nitrates NO_3^-, mg/l	16.3	18.0	up to 60
Nitrites NO_2^-, mg/l	0.2	0.3	up to 1
Oxidation, mg O/l	13.5	13.9	up to 16.8
Salinity,%	0	0	0

Abiotic environmental factors play an important role in fish life. The water temperature significantly affects the intensity of metabolism - determines the beginning of spawning migrations of fish. Other physical and chemical properties of water are also important for fish (Zhuravlev, 2005; Andriushchenko & Vovk, 2014).

Analyzing the dynamics of the content of dissolved oxygen in water, in the course of research it was found that the content of dissolved oxygen in water in pools 1 and 2 was within normal limits (Table 1). In general, the physicochemical regime of water during the experimental studies was at a level close to the optimal values and did not significantly affect the course of the experiment.

Feeding young carp in addition to the general diet with a mixture of pre-treated duckweed, spirulina, zooplankton in the ratio (10:70:20), which improved morphofunctional parameters of the blood and reflected on the physiological state of the body, growth rate. When growing young fish in recirculating waters, the mass of experimental yearlings and annuals was greater than the control by 1.03 and 1.05 times (Fig. 1).

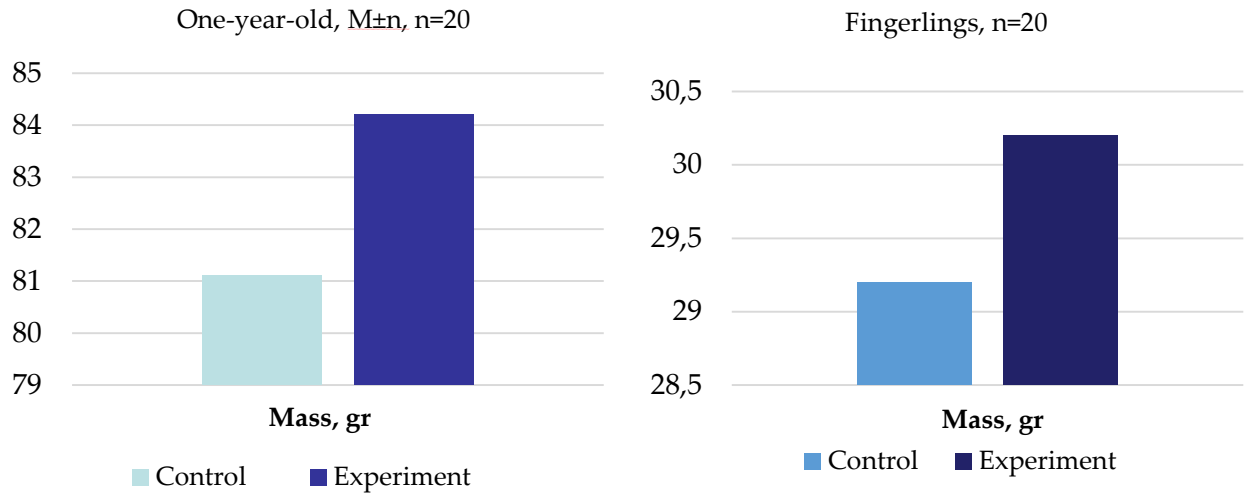

Fig. 1. The mass of carp fish when grown in recirculating waters

Studies have shown that the hematological profile of the studied carp fish depends on feeding and housing. From the data shown in Figure 2, the total number of erythrocytes increased in these yearlings and annuals by 1.02 and 1.2 times relative to the control group of fish ($p < 0.05$). The hemoglobin content is 1.23 and 1.25 times higher in all groups of carp fish. Hematocrit (HCT) reflects the proportion of erythrocytes in total blood volume, it is used to assess the severity of anemia. Its increase or decrease relative to the norm indicates the presence of disease or stress (Bahareva, 2016). The hematocrit value is 1.0 and 1.15 times higher in the experimental groups of yearlings and peers of carp fish, compared with the control.

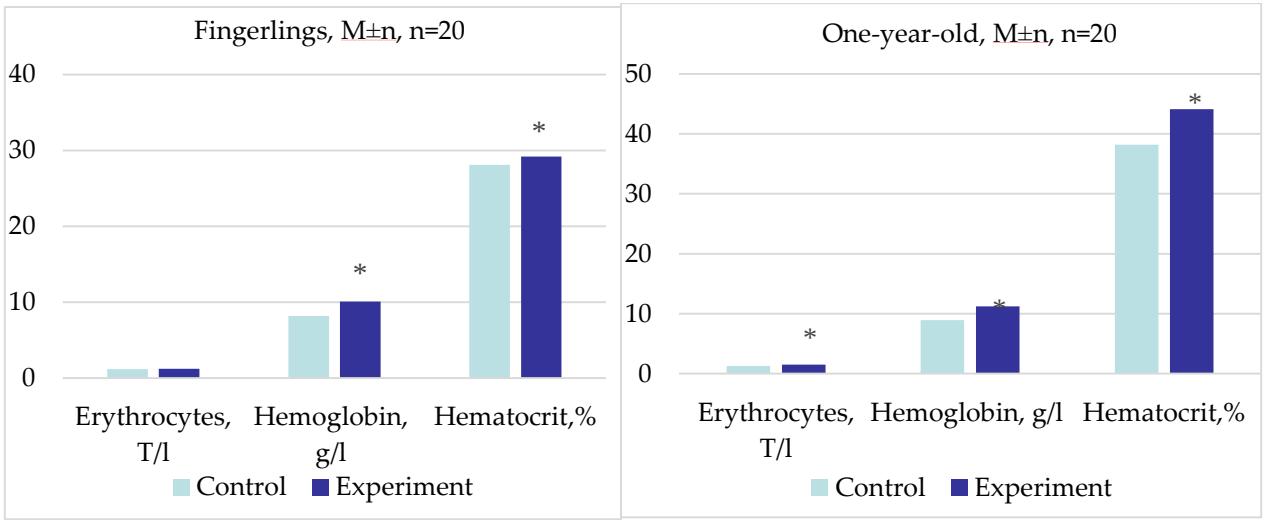

Fig. 2. Morphological parameters of carp fish blood

In the study of total protein of carp fish in recirculating aquaculture systems, an increase of 1.3 and 1.2% was observed. This indicates that the cultivation of fish in such a system increases the body's resistance and enhances antioxidant protection (Fig. 3).

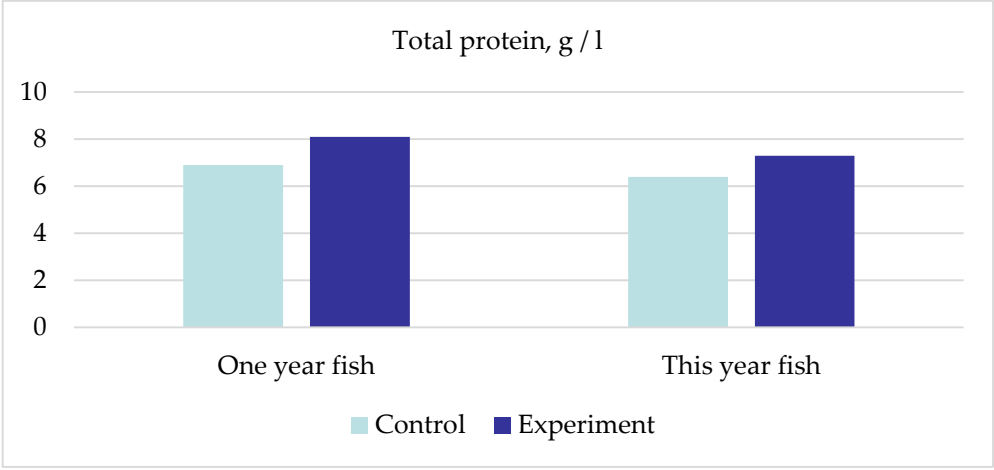

Fig. 3. Dynamics of total protein in the fish blood

Results and discussion

The available sources of the Food and Agriculture Organization of the United Nations (FAO) confirm the information that the aquaculture sector provides an average of 40 million tons of food worldwide (excluding the use of algae, aquatic plants). In the industrial aquaculture sector, the search for new technologies or the improvement of existing ones in the reproduction and rearing of fish is one of the opportunities to improve the quality of fish products that will be obtained at the end of the growing season (Morgalev et al., 2010). To meet the physiological needs of the fish, it is necessary that the diet contains an average of 30 to 50% natural feed. But each type of diet depends on aquatic organisms and its biological features. A number of authors who in their research recommend the use of skin and brain preparation, which is made in wet form from the remnants of the skin contains a large amount of protein, essential amino acids and fat. It is recommended to use as a part of starting compound feeds for rearing of larvae of fishes (Spolaore et al., 2006; Sherman & Heina, 2013; Petrjakov, 2015).

Today in Ukraine there is a harmonization of biotechnological methods, national legislation and standards with modern international requirements. The control over the production of products should take place consistently throughout the technological cycle. The newest existing methods are more informative, are carried out in a shorter time and allow to achieve a resource-saving effect against the background of obtaining high quality products. The literature contains information on the use of taxa Decapoda, *Paramecium caudatum*, where the toxicity of the studied object is determined by the level of change of certain parameters of the functional system of life of organisms by biophysical, physiological, microscopic methods or by visualization. The issue of development of own production of high-quality fish products in accordance with European standards with the rational use of technological methods, innovative energy-saving technologies and material and technical base remains relevant. The determining factor in obtaining quality food raw materials for fish farming is the state of physiological and biochemical processes in the body of fish. Therefore, the development and search for optimal technological measures are relevant. In the works of Kholodnyi I.M. as one of the options presented a method for pre-treatment of microalgae.

The experimental results presented in the article have a number of advantages in the context of technological aspects and organization, the actual production of aquaculture products: the presence of all components of the recirculation system in a single technological map, environmental safety of cultivation and production of finished aquaculture products (Hrytsyniak & Tretiak, 2001; Hrynzhevskyi & Pekarskyi, 2004; Hrytsyniak & Tretiak, 2007; Ditriv, 2014). According to the authors' research, the hydrochemical regime of water bodies and the forage factor contribute to the formation of morphometric indicators of aquatic organisms. Phytoplankton are promising feed and food additives. In particular, Spirulina Platensis is a raw material rich in protein, has a balanced amino acid composition, contains vitamins and minerals. Spirulina biomass after entering the body has a bioprotective and biostimulating effect. This is due to the chemical composition of algae.

The establishment of the leading priority areas of scientific support of fisheries in Ukraine is evidenced by the functioning of the Scientific and Technical Program "Fisheries" within the thematic plan of the leading scientific institution of Ukraine, the Institute of Fisheries – "Scientific support of aquaculture and improving the use of aquatic inland waters of Ukraine". The determining factor in obtaining high-quality high-protein food raw materials is the state of physiological-adaptive compensatory mechanisms in the body of fish. Therefore, the development and search for optimal technological measures are relevant. Thanks to scientific research there is a constant improvement of growing conditions, compound feed recipes, introduction of nutrients into their composition with the necessary appropriate characteristics. This will solve the problem (Merzlova, 1997; Stetsenko, 2007).

In the available literature in the scientific and practical context, emphasis is placed on physiological and biochemical mechanisms and their correlation with the productive parameters of aquatic organisms. In particular, in the first days of fish life, practitioners note the importance of ensuring the feeding of young fish in order to intensively form its internal organs, immune status for rapid growth. Many ways have been developed to improve fish productivity indicators, using the optimization of the general diet, the use of non-traditional feed additives in fish farming. The production of components for feeding does not involve their preliminary cultivation and inclusion in the technological scheme. Practical experience of using fish feed with artificial feed, using another form of increasing fish productivity by using different forms of polyculture with different ratios, age group is effective in terms of biological and economic standards, taking into account the hydrobiological regime, the state of natural forage. However, the implementation of these measures involves a preliminary period for long periods of implementation to obtain results.

Research of Burkat et al. (2003) contains information on the effectiveness of the introduction of drugs based on Echinacea purpurea as immunomodulators in the technological map of cultivation of agricultural facilities. The results of research in scientific works on the use of phytopreparations in fish biotechnological map for feeding fish, provide an opportunity to note the characteristic softness of their action, low toxicity and high content of biologically active substances. The experience of using phytoplankton, in particular, microalgae in fish farming is reflected in scientific work. The author notes the positive effect of chlorella, spirulina, because they are a natural food for many species of fish and after entering the body have a corrective effect on metabolic processes. Recently, biotechnology has been developed using photo-autotrophs, in particular microalgae. However, the issue of complex improvement of the technological process of growing tilapia in the conditions of RAS by preliminary processing of the components of the diet and the conditions of keeping and feeding is insufficiently studied (Ditriv, 2014). T. Lebska presented interesting studies on the addition of squid in the formation of minced meat. In any case, research is aimed at providing aquatic organisms with high-protein components, which in turn enhance metabolic processes in the body (Ievtushenko, 2011; Zhigin, 2011; Zhigin, 2015). In addition, the relevance of feeding aquatic organisms with natural components increases with the integrated use of recirculation systems. Thus, scientific and practical results confirm the effectiveness of this method of growing up. The authors note that the use of recirculation systems (RAC) provides an opportunity to annually grow aquatic organisms with self-regulation of hydrochemical and other regimes and to control the entire cycle of production of organic aquaculture products. The advantages of this technology are the expansion of the choice of cultivation objects, in such a system it is possible to grow warm-water, cold-water, sea (mariculture), fresh-water objects.

Conclusion

When analyzing the functional status of fish in the experimental group, it was noted that the indicators that reflect the homeostatic balance in the body, metabolic processes were better and exceeded the values in the control. Thus, the proposed methods and technological recommendations can become an effective tool for the development of traditional knowledge of fisheries in our country.

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