# CHAPTER «AGRICULTURAL SCIENCES»

## EFFICIENCY OF COMPLEX TECHNOLOGICAL SOLUTIONS FOR GROWING FISH TO INCREASE RESISTANCE TO THE INFLUENCE OF ABIOTIC AND BIOTIC FACTORS UNDER THE INFLUENCE OF CLIMATE TRANSFORMATIONS

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**Abstract**. *The purpose.* To substantiate the effectiveness of using the method of rearing fish at the early stages of ontogenesis before stocking water bodies using a scientific-experimental method. *Methodology* of the study is based on the functional status of the fish organism. The experimental part of the work was performed on the basis of the Department of Aquatic Bioresources and Aquaculture of the Kherson State Agrarian and Economic University (Ukraine), laboratory of the "Kherson Production and Experimental Plant for Breeding of the Ordinary Fish" State Institution and "Aquaculture Perspectives" Scientific Research Laboratory, "Scientific Research Laboratory of Physiological and Biochemical Research of S. Pentelyuk", Scientific Research Laboratory on ecological and chemical analysis and water monitoring of Public higher education institution Kherson State Agrarian and Economic University (KSAEU, Ukraine). For studies of the main parameters that were studied, standard methods were used [1–4]. The blood from heart and tail vein was obtained using Pasteur needle and heparinized syringe. For biochemical studies, apart from blood plasma, the muscle part was also collected. They were also frozen in ThermoMix and stored for further research. Using a digital camera and Micromed microscope. Muscle protein content was determined by the Lowry method. Biochemical studies of biological material were performed using ULAB 102 spectrophotometer. Catalase activity was determined by

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the spectrophotometric method, based on the ability of hydrogen peroxide to form a stable color with the reagent. Biochemical analysis of samples to study the level of activity of alanine aminotransferase (ALT), aspartate aminotransferase (AST), total protein content, and glucose concentration was carried out in the laboratory of the Department of Aquatic Bioresources and Aquaculture of KSAEU on a Humalyzer 3000 analyzer using standardized Human GmbH kits. Against the background of the outlined parameters, observations of the ethology of hydrobionts were carried out during the day, with the recording of certain details as necessary. All manipulations of the object of scientific research were carried out in accordance with the rules of the "European Convention for the Protection of Vertebrate Animals Used for Experimental and Other Scientific Purposes" (Strasbourg, 1986). *Results*. The results of the research work on the comprehensive study of the leading parameters of the growth efficiency with the use of optimization elements are presented. Positive results were obtained on the speed of development of young carp in polyculture with carp against the background of activation of metabolic processes in the body. The implementation of technological elements for optimizing the growth of hydrobionts in the early stages of ontogenesis helps to increase the viability of young and ensures the efficiency of stocking reservoirs with such young carp. The proposed biologically active substances in the composition of the ration reasonably provide the functionality of a micro-additive against the background of elements of resource-saving technology in the scheme of a modular fish farming system. *Practical implications.* The method of growing carp presented in the article before stocking with fish helps to increase growth parameters, increase resistance to the influence of abiotic and biotic factors. *Value/originality.* The use of resource-saving elements in the technology of growing fish. The uniqueness provides innovative solutions for optimizing the technology of growing carp and silver carp.

## 1. Introduction

The sustainable development of fisheries in today's conditions has the vector of rebooting technological systems in the industry as a whole. At the same time, the transformation of a number of parameters in accordance with physico-chemical, hydrobiological, physiological-biochemical, ecological-biological processes in aquatic ecosystems takes place in accordance with

the adaptation capabilities of the organism of hydrobionts. Undoubtedly, water ecosystems form a certain number of parameters in accordance with climate transformations in today's conditions.

Hydrobionts of introduced or aboriginal ichthyofauna must adapt, in some cases at the global level, rebuild the link of adaptation – compensatory mechanisms in order to stabilize vital functions. Under conditions of stress, which can be caused by abiotic and biotic factors that have a negative impact on the functional status of the fish organism, complex systems have a corrective, modeling effect on the organism of hydrobionts. It should be noted that the level of metabolic processes directly or indirectly shapes the speed of development, survival parameters, and productivity of fish.

Rational fishery exploitation of both aquatic bioresources and the potential of fishery enterprises is due to urgency, and programs of annual replenishment of the ichthyofauna of water areas with viable fish stocking material are of practical importance. In today's conditions, the development of a strategy for the development of fisheries, the harmonization of the production of fish products in natural and artificial reservoirs with the maximum use of the potential of water resources is becoming a priority solution. That is why scientific and research works of a complex nature on the optimization of technological elements, rational use of industry resources come to the fore. Increasing the fish stocking material, increasing the resistance of body systems to the influence of various factors, improving the parameters of the development of young fish provides significant prospects for the sustainable development of the fishing industry as a whole.

## 2. The problem's prerequisites emergence and the problem's formulation

In most scientific works, the authors emphasize the need for rational use of water area resources, harmonization of trophic relations, as well as qualitative and quantitative parameters of fish against the background of ecological conditions of a certain water ecosystem [5–8]. Climatic transformations, the burden on ecosystems, the rapid development of technologies and their introduction into the technological scheme most often contribute to the "inconsistency" of physiological and biochemical mechanisms, adaptation possibilities of hydrobionts. As a result, there is a chain of successive changes: stress reactions in the organism of

hydrobionts, a decrease in the indicators of effective management of the industry, irrationality in the exploitation of resources, etc.

In the outlined conditions, one of the solution cases is the need to reconstruct ichthyofauna in aquatic ecosystems, to develop certain comprehensive recommendations. High results can be achieved and many problems in this field can be solved under the conditions of growing and introducing sustainable fish planting material of commercial fish species [9]. Research by scientists presents informative, objective data on the significant reduction of fish stocking material for stocking in the lower reaches of the Dnipro [10; 11].

In scientific works, the authors note and justify the importance of increasing the production of fish stocking material in modern ecological and technological conditions with the aim of further stocking of water areas, renewal of ichthyofauna and fishery exploitation of reservoirs [12]. Taking into account the practical value of the outlined range of problems, it is possible to note the determining role and use of optimization of technological and biological aspects of fish farming, in particular, carp in polyculture in the context of the farming cycle. In the research works, the authors emphasize the revision of the main parameters, technological aspects in the conditions of modern climatic transformations of fish wintering [13–15].

It is proposed to introduce different cases of solving problems at the stages when the development potential of hydrobionts is formed. In particular, the introduction of components in feeding of natural origin, as close as possible to ecologically safe ones [16–19]. Of course, the effectiveness of optimization measures in the context of technological aspects is ensured by comprehensive in-depth studies of the environment for hydrobionts [20–22]. Among the outlined issues that require an urgent solution, it should be noted the analysis of the ecological and biological features of the ichthyofauna of the Dnieper-Bug estuary system against the background of climatic transformations and the prospects of fishery exploitation [23–25].

Recommendation aspects are presented in the works of the authors, who focus attention on the developed strategic solutions for the development of fish farming and fishing in the transformed river systems of southern Ukraine, taking into account that the bio-production potential of water areas is not used rationally [26].

Based on the above, there was a need to develop and implement innovative ecological technology for the production of fishery products, rational exploitation of the reservoir.

Complex optimization measures of the technology of growing fish planting material, depending on modern ecological and technological factors, will contribute to the addition of the general idea and the successful search for the optimal model of growing young fish. The stocking of reservoirs with young carp in polyculture in the reservoirs of the Dnieper-Bug estuary system has been carried out for a relatively long time. However, obtaining high-quality, viable fish planting material is still relevant today.

## 3. Research results and discussion

A fragment of the technological scheme for the preparation of feed mixture for feeding hydrobionts is presented in the following Figure 1.

In compliance with generally accepted recommendations, the fish diet was optimized, the formation of all components was carried out in the laboratory of aquatic bioresources and aquaculture. In addition, a solar micropanel was used as an additional source of energy for the industrial needs of operating the system of pool installations, and the system included the installation of additional water filtration of fish ponds using plant crops and materials capable of filtering the water coming from the fish tanks at a certain level.

The sequence of technological processes is presented in Figure 1. Each of the stages provided for a preparatory period, the main and the period of approbation. It should be emphasized that some methods have already been tested and used without the preparatory part of the experiment. The advantage of the method, which is considered for additional feeding of fish in the early stages of ontogenesis, is the symbiosis of the farm with the laboratory for a joint optimization process.

The proposed scheme for raising fish stock of young *Cyprinus carpio* in polyculture with *Hypophthalmichthys hybrid* was used in the experimental group compared to the control group. The fish ponds of the recirculation system with a volume of 250 $m^3$ each had the appropriate equipment, levels of filtration sections, a built-in natural feed cultivation section with a timer and the possibility of autonomous operation. *Cyprinus carpio* larvae in polyculture with *Hypophthalmichthys hybrid* were grown in each tank


**Figure 1. Fragment of the preparation of a fodder mixture in the laboratoryand in farm conditions (growing section)**

with an average initial mass of 0.325 mg when planted. To analyze the parameters of the physiological and biochemical state of the fish organism, 15 specimens from each group were selected from the total number of 500 specimens. During the growing period, an experimental study was carried out with fixed parameters. At the end of the experimental study, the functional state of the body of carp and crucian carp before their stocking of aquatic ecosystems was comprehensively investigated.

At the beginning of the preparatory stage of the experimental work, the model plant was assembled and tested in the conditions of laboratory research, after which it was transported to the production conditions of a full-system farm. Feeding at different stages of the ontogenesis of fish was carried out in accordance with the current standards in fish farming. At the same time, the size and dispersion of particles and granules were gradually changed in order to increase bioavailability. At the time of transition of fish larvae to mixed nutrition, these components were introduced. The culture obtained from the mother solution of own cultivation in an environment based on water treatment was filtered and processed, after which it was formed for introduction into the diet. Based on a ratio of 1:2 working solution of S. Platensis: humic substances of the commercial preparation 15 mg per kg of feed), feed parts were treated with a sprayer. The hydrochemical state was monitored according to the schedule, in addition, automatic measurements of the main parameters were active.

This work presents a fragment of the main research results of one of the stages of scientific and experimental research. Let's consider the obtained results and substantiated conclusions presented for discussion regarding each of the parameters.

The aquatic environment is an ecosystem for hydrobionts, which has a direct impact on the formation of processes and functionality of the fish organism. At this stage, monitoring studies were carried out systematically in accordance with the planned schedule. Therefore, the temperature regime and the level of free hydrogen ions (pH) show average values of 24.3 °C and 7.3. Gradually, with the development and stabilization of the parameters of the organism's homeostasis, *Cyprinus carpio* and *Hypophthalmichthys hybrid* carried out a decrease in the actual temperature value for the purpose of gradual adaptation in the future when stocking reservoirs with grown juveniles.

It should be noted that the actual values of the hydrochemical state were within the limits of all parameters. At the time of introduction of the feed mixture, the pH of the water environment in the pools fluctuated slightly, which is a well-founded phenomenon. In general, the hydrochemical regime during the growth of juvenile fish in the reservoirs created an ecosystem of the aquatic environment optimal for the vital activity of juvenile fish according to the main parameters (Figure 2).

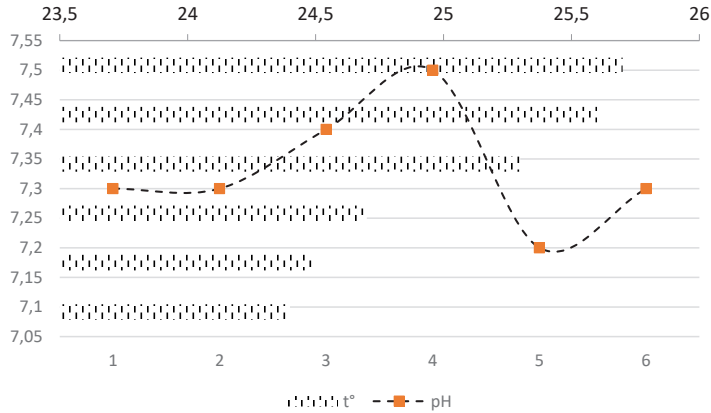


**Figure 2. Analysis of systematic measurements of hydrochemistry parameters in fish ponds when larvae are fed with feed mixture of *Cyprinus carpio, Hypophthalmichthys hybrid***

In addition, in parallel to the laboratory studies, systematic sampling and control of the hydrochemical parameters of the water area, where stocking with juvenile fish was planned, was carried out. During the growing season, the average temperature of the water environment ranged from 21.8 to 32.4 °C. Since the necessity of an adaptation period with a decrease, if necessary, of the temperature factor of the water environment before stocking (introduction) of hydrobionts is physiologically justified. The content of oxygen dissolved in water ranged from 4.9 to 6.2 mg/dm$^3$, at the same time, the level of hydrogen ions, the pH ranged from 7.6 to 7.9 units, the permanganate oxidizability index was 40.5-43.6 mg$O_2$/dm$^3$. Ammonium nitrogen – 0.46 to

0.76 mg/dm$^3$. All parameters were recorded in the work log with further processing and analysis.

Unconditionally, the water environment creates optimal or, on the contrary, unfavorable conditions for viability, maintenance of parameters of homeostatic balance in the organism of hydrobionts. However, attention should also be paid to the physiological and biochemical parameters of the fish organism. Since the whole system functions in symbiosis, with a certain corresponding reflection on the influence of abiotic and abiotic factors. Therefore, the morphometric analysis of blood under the conditions of studying the level of effectiveness of the influence of certain factors is an informative and important study. The results of the study of the leading morpho-functional parameters of blood in fish during ontogenesis made it possible to more fully reveal the adaptive capabilities of their organism under the conditions of using technological factors (Table 1).

Thus, the general picture of the leading parameters demonstrates compliance with the physiologically acceptable actual values. However, the course of metabolic processes under the conditions of using the technological factor of fish growth in the experimental group was more active. This is actually evidenced by the higher rates of homeopoiesis processes and synthetic processes in the body of the fish of the experimental group. An increase in the content of erythrocytes and hemoglobin in the blood of fish confirms the activation of erythropoiesis systems in their body, and in turn, there is an increase in the total respiratory surface of erythrocytes.

Each of the parameters adjusts a certain functional system in the body, therefore, the study of concentrations, the analysis of the difference between experimental and control values provides an opportunity to more comprehensively analyze the influence of the factors being studied and to evaluate their effectiveness of introduction into the technological scheme of raising young carp.

A high level of blood oxygenation can be achieved due to a greater number of erythrocytes and an increase in their hemoglobin content. Therefore, the analysis of microcorpuscular indicators of blood is informative, it provides an opportunity to consider the parameters of hemoglobin concentration in cells, which will be discussed further in the work. Analyzing the data in Table 1, it should be noted that, in general, the indicators of the morphological and biochemical composition of blood are within physiological norms.

Table 1

**Analysis of the physiological and biochemical state of blood under the conditions of the introduction of technological factors (M±m, n=15)**

| Parameters | *Cyprinus carpio* | | *Hypophthalmichthys hybrid* | |
|---|---|---|---|---|
| | **Control C** | **Experiment C** | **Control H** | **Experiment H** |
| Red blood cell, RBC, T/l | 2,25 ± 0,031 | 2,36 ± 0,092 | 2,29 ± 0,039* | 2,46 ± 0,055 |
| Hemoglobin, Hb, | 83,20 ± 0,512 | 85,82 ± 1,201 | 82,23 ± 1,291 | 86,08 ± 1,380* |
| Mean corpuscular volume, MCV, mkm$^3$ | 142,38 ± 2,308 | 161,9 ± 3,355 | 140,65 ± 1,953 | 158,50 ± 3,279*** |
| Mean corpuscular hemoglobin, MCH, pg | 37,07 ± 0,414 | 36,64 ± 1,481 | 35,91 ± 0,675 | 35,15 ± 1,030 |
| Mean corpuscular hemoglobin concentration, MCHC, % | 24,56 ± 2,078 | 22,62 ± 0,119 | 23,39 ± 0,823 | 22,17 ± 0,334 |
| Total protein, g/l | 17,97 ± 0,547 | 22,26 ± 1,016** | 18,88 ± 0,704 | 21,88 ± 0,746* |

Note: Control C, Experiment C – control, experimental group Cyprinus carpio; Control H, Experiment H – control, experimental group Hypophthalmichthys hybrid

* Correlationis Significant at the 0.05 level (P<0.05); **Correlationis Significant at the 0.01 level (P<0.01); ***Correlationis Significant at the 0.01 level (P<0.001)

It is noted that there is an increase in red blood cells in the experimental groups. Thus, the total number of erythrocytes in the blood of fish in the experimental group for flounder probably (p<0.05) exceeded the similar data in the control group by 7.2%; the hemoglobin content was 4.7%, respectively, the hematocrit was also higher, the difference was 9.9%.

Regarding the study of morpho-functional parameters of carp blood under experimental conditions, we note that the content of erythrocytes in the blood of fish that received additional biologically active components during feeding and were grown in conditions of additional energy-saving elements in the technological map was higher by 4.9% with a higher concentration of hemoglobin by 3.14% than in the control group.

Microcorpuscular indicators of blood, in particular, Mean corpuscular volume, (MCV) were corrected with the content of erythrocytes, the percentage of hematocrit and the buffer system – the content of hemoglobin.

The actual value exceeded the MCV parameters in the control samples of carp by 12.7% (P<0.001). The microcorpuscular indicator of MCV in the blood of the carp of the experimental group was higher than the value in the control group by 13.8%.

The study of protein metabolism in the body of experimental fish complements the picture of the state of physiological and biochemical systems, in addition, it provides an opportunity to analyze the course of synthetic processes, the reserve of amino acids for protein synthesis. Thus, in the experimental group, the content of total protein exceeded the value in relation to the control group in the blood sample of carp by 15.9% (P<0.05). The study of this parameter in the carp group also showed higher values in the experimental group by 23.9% (P<0.01) in relation to the control values. The activity of the enzymatic complex according to one of the marker parameters – catalase in the liver sample in the experimental group was higher than in the control group both when sampling *Cyprinus carpio* and when sampling *Hypophthalmichthys hybrid* (Figure 3).

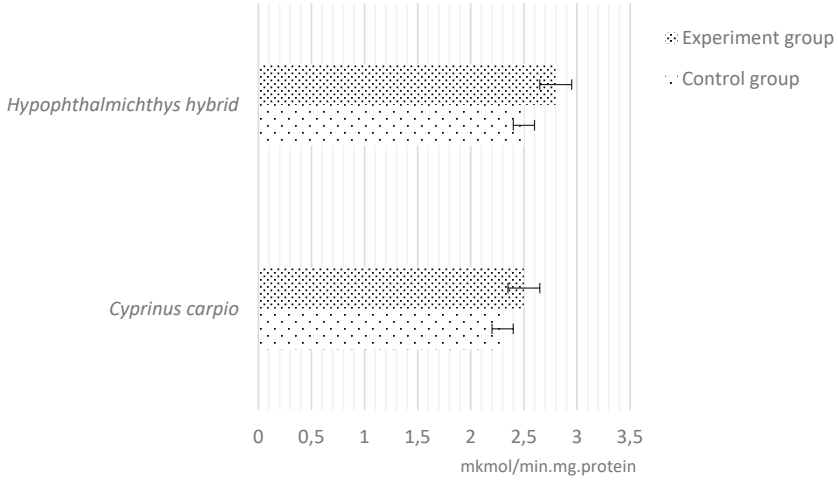


**Figure 3. Analysis of the activity of liver catalase of *Cyprinus carpio* and *Hypophthalmichthys hybrid* under the influence of technological factors, (M ± m, n = 15)**

In fisheries, one of the important links is the quality of products that reach the average consumer. In the context of scientific and research concepts, of course, the parameters of the functional status of the fish organism ensure the formation of the organism's resistance to the influence of abiotic and biotic factors, the formation of parameters of growth and development in ontogenesis, etc.

However, at the end of the growing season, the qualitative and quantitative parameters of the products are important for producers. In particular, the chemical composition of the muscle part of the product to be consumed. Therefore, in the context of practical value, under the conditions of studying the influence of the outlined factors, in the experimental study, the chemical composition of the muscle part of carp and carp from the control and experimental groups was analyzed (Figure 4).

Therefore, the analysis of the biochemical composition of the muscle part of the carp samples showed a higher protein content by 4.5% and fat by 6.4% in the experimental group.

While the samples of the muscle part of the *Hypophthalmichthys hybrid* also had higher actual values in the experimental group than in the control: protein content by 4.8%, fat by 7.8%.

The parameters of metabolic processes in the body of *Cyprinus carpio* and *Hypophthalmichthys hybrid,* were studied by one of the leading enzymatic complexes: alanine aminotransferase (ALT) and aspartate aminotransferase (AST). Since ALT and AST are marker parameters of the functioning of metabolic processes (protein, carbohydrate, lipid metabolism), organs, systems in the body of fish. The results are shown in the following Figure 6.

Therefore, the obtained results of the study of the course of protein metabolism, liver function and resistance under the conditions of a stress factor according to one of the marker enzymes ALT, demonstrated that technological factors did not have an impact with probable changes in the actual values between the control and experimental groups of fish. The level of AST measured in the experimental groups was significantly different from the values in the control group ($P<0.05$). The activity of the studied enzymes is widely used in the analysis of the functional status of the organism as a whole, as a physiological-biochemical indicator of resistance to stress factors of various origins, and therefore the adaptation capabilities of the fish organism.

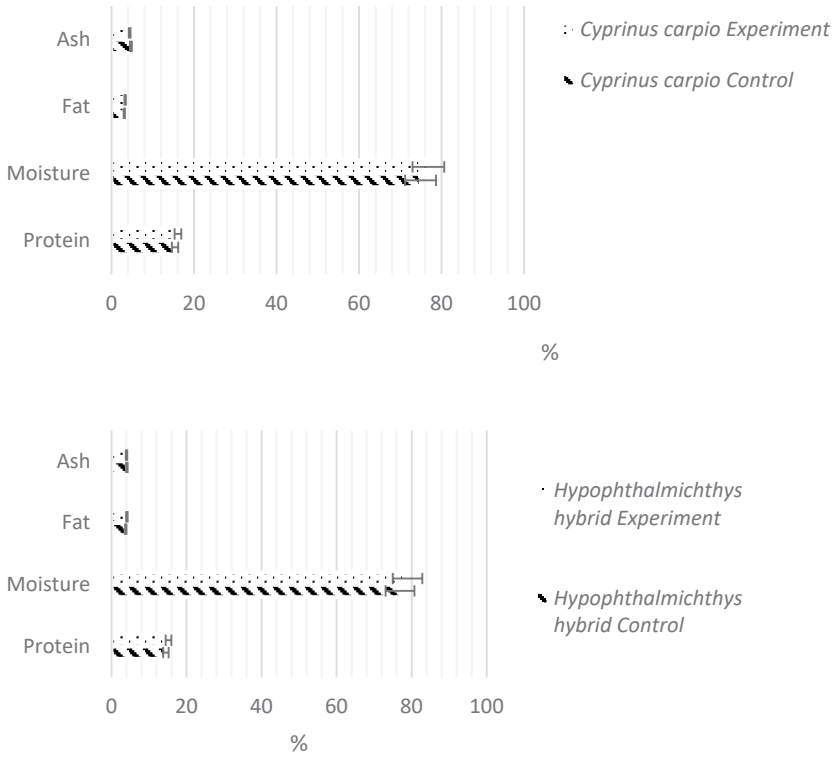


**Figure 4. Study of the muscle part of *Cyprinus carpio* and *Hypophthalmichthys hybrid* under experimental conditions (M ± m, n = 15)**

The analysis of glucose concentration in the blood of experimental and control fish complemented the study of metabolic processes under the influence of abiotic and biotic factors. Since carbohydrate metabolism provides the level of energy resources in the organism of hydrobionts, catabolic processes of carbohydrate metabolism. Glucose concentration depended on the level of fish activity against the background of metabolic processes. In the experimental group, this parameter had a tendency to lower values in relation to the control. The parameters did not exceed the maximum allowable physiological values, however, attention should be

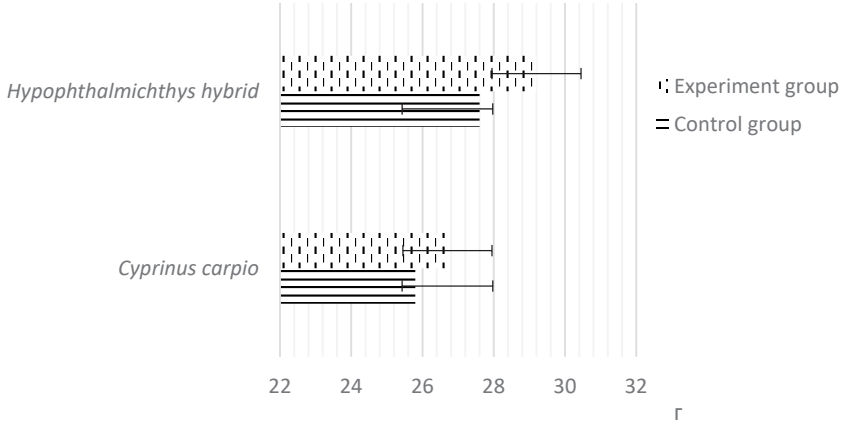


**Figure 5. Analysis of development parameters *Cyprinus carpio* and *Hypophthalmichthys hybrid,* (M ± m, n = 250)**

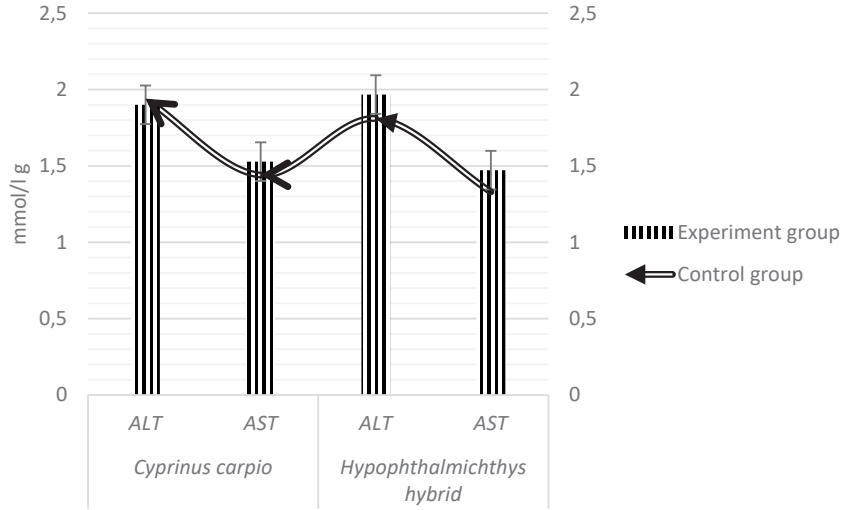


**Figure 6. Analysis of the enzymatic complex of marker enzymes of protein metabolism, the level of stress resistance under experimental conditions of *Cyprinus carpio* and *Hypophthalmichthys hybrid,* (M ± m, n = 15)**

paid to a sharp increase in the concentration of glucose in the control group, which in turn identifies as one of the options, the stressful state of the fish.

Summarizing the whole complex of the obtained results, we note that the organism of hydrobionts is a single functional system that, like a litmus test, shows a certain reaction to each factor. Of course, the parameters of the speed of fish development are adjusted with the main physiological and biochemical processes in their body. In addition, neurohumoral regulation of all vital functions reacts reactively to the arrival of biologically active substances of various nature.

## 4. Conclusions

Summarizing the results of the research work, we note that the urgent need for an in-depth review of the technological foundations of raising and growing young fish in order to improve resistance to the influence of abiotic and biotic factors can be solved under the conditions of the introduction of innovative technological solutions to the general scheme.

Annual stocking programs will be effective if viable juvenile carp are used in polyculture. On the basis of generally accepted, classic methods of growing hydrobionts, it is possible to improve individual links of the technological process. The introduction of such elements of the fodder factor and the element of technological exploitation of basin systems in the context of filtration and the additional element of alternative energy sources contribute to the achievement of the set goals. Young fish have a higher resistance to the negative impact of abiotic and biotic factors.

In particular, the erythrocyte pattern of blood reflects the course of positive functional processes in the body of experimental fish. As a result, the effective use of the potential capabilities of the body of the experimental young carp, better respiratory function, which positively affects the development processes, accumulation of body weight, resistance to the influence of various factors, was noted. Developmental potential positively correlates with physiological and biological status, speed of growth and development in ontogeny, etc. Summarizing the positive results of the use of several elements to optimize the technology of rearing fish in the early stages of ontogenesis, we will focus on the stimulating function of development, improve blood composition within physiological parameters, energy saving and optimization of resources. In turn, the addition to the

diet of fish as natural substances contributes to the restructuring of the body's adaptive mechanisms to the influence of abiotic and biotic factors. After stocking the aquatic ecosystem with such fish *Cyprinus carpio* and *Hypophthalmichthys hybrid*, the effect will be much higher than by the standard method. Studies that are not fully presented in this scientific work reflect a positive effect on the qualitative and quantitative parameters of fish after stocking the aquatic ecosystem. The main aspects will be presented in the following research papers.

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