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MODERN TECHNOLOGIES OF REPRODUCTION NATIVE FISH SPECIES

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Institute of Fisheries of the National Academy of Agrarian Sciences of Ukraine

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CONTENTS

CONSERVATION AND ENHANCEMENT OF THE ENDEMIC TROUTS SPECIES IN THE RIVER NERETVA CATCHMENT (BOSNIA AND HERZEGOVINA) AFTER ALTERATION OF THE RIVER FLOW

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The paper presents diversity of the endemic trout species in the River Neretva catchment (Adriatic Sea watershed) with emphasis on ecology and recent genetics results and projects for the conservation and enhancement of their populations and status in the conditions of alteration of the river flow. The recent research clarifies taxonomical status of important species and provide clear conservation targets for their revitalization. The present valid list of the species endemic for River Neretva include: soft mouth trout, *Salmo obtusirostris* (Heckel, 1851), marble trout, *Salmo marmoratus* Cuvier, 1829 and native *Salmo trutta* with specific Adriatic haplotype. The previous enigmatic species *Salmo dentex* from Lower Neretva showed genetic similarity with marble trout from Upper Neretva waters, and is included in its complex as a variety typical for slow water flow conditions [1,2]. This high native trout diversity is endangered due to building of 4 dams in the major flow and several others along the tributaries. These dams formed large water reservoirs changing native ecosystems, prevent trout migrations to several spawning grounds and favor propagation of non-native species [3, 4]. This also led to fragmentation of all native trout populations and create critical situation for the genetic structure and species survival. The soft-mouth trout is presently extinct from 85% of historical distribution area and endangered status in remnant parts of River Neretva catchment supported with age structure change put in question future of soft-mouth trout in River Neretva [5]. The similar situation was observed for the other native trout species.

In order to improve this situation and promote better conservation actions and enhancement of the endemic trouts several revitalization and enhancement projects were initiated in the last ten years. The projected were oriented towards better conservation and protection activities of the natural populations, as well as development of artificial production of the juveniles for these species [6].

The present status of different endemic trout species from the River Neretva catchment, their biology, ecology and genetics will be discussed in the light of their survival and preservation of the population, using different methodologies from conservation biology and aquaculture.

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ECOLOGICAL AND BIOCHEMICAL CHARACTERISTICS OF COMMERCIAL FISH JUVENILE IN THE ZAPORIZHZHIA RESERVOIR

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The number, species diversity and physiological-functional status of fish juveniles always attracts great interest and is important for assessing and predicting the fish productivity of natural and artificial water bodies, developing and biological justification of measures for the rational use, conservation and propagation of fish resources [1]. Significant differences in species composition and morphometric parameters of fish juveniles in different biotopes of the Zaporizhzhia reservoir were detected [2]. Currently, the features of the biochemical status and metabolic processes in the tissues of fish juveniles are not well understood, but they can provide valuable information for integrated environmental monitoring under the conditions of human impact and transformation of aquatic ecosystems.

The aim of our work was the study and ecological assessment of the quality of aquatic environment and biochemical characteristics of the tissue components in commercial fish juveniles from different area of the Zaporizhzhia reservoir. For our study, following spawning and feeding areas were selected: the Samarskii bay near the Oleksandrivka village (48°32'19.0"N; 35°12'34.5"E), the central area of the reservoir near the Monastyrskoho island (48°27'12.2"N; 35°05'17.9"E) and Stari Kodaky village (48°21'48.2"N; 35°08'54.8"E), the lower area of the reservoir near the Viiskove village (48°09'59.3"N; 35°10'49.4"E).

Water for hydrochemical analysis was sampled every month to study the parameters characterizing the processes of water body self-purification – pH, concentrations (mg/dm^3) of dissolved oxygen O_2, ammonium nitrogen NH_4^+, nitrogen nitrite NO^{2-}, nitrogen nitrate NO^{3-}, phosphorus phosphate PO_4^{3-}, permanganate oxygen consumed (POC mgO_2/dm^3) according to generally accepted methods [3]. Using the mean annual values of the hydrochemical regime in the studied areas of the Zaporizhzhia reservoir, we carried out an ecological assessment according to the environmental and sanitary criteria for the quality of surface water in accordance with the methodology developed by V. D. Romanenko [4].

The juveniles (0+) of the perch *Perca fluviatilis*, common bream *Abramis brama*, roach *Rutilus rutilus* and white bream *Blicca bjoerkna* were caught in September using a ten-meter seine with a mesh-size 4 mm. The content of total protein in biological samples was determined by Lowry's method, the lipid content – by Folch's method. The obtained numerical data were subjected to statistical processing.

According to the results of the study, the average annual hydrochemical parameters corresponded to the fishery standards of Ukraine (SOU-05.01.-37-385:2006). According to the trophic-saprobiological (ecological and sanitary) criteria, water of the Zaporizhzhia reservoir belongs to the II−III quality classes ("good" and "medium") as a result of eutrophication and anthropogenic pressure. The ranking of the studied areas of the Zaporizhzhia reservoir showed that the water quality in the Samarskii gulf was characterized as "poor" (class IV, category 6) for PO_4^{3-} and "satisfactory" (class III, category 4) for NH_4^+ and POC; in other areas, the concentration of PO_4^{3-} was the worst parameter, which caused the class III, category 5 of water quality "mediocre". The most favorable environmental conditions were in the lower section of the Zaporizhzhia reservoir, near the Viiskove village − its water belonged to the class I category 1 ("excellent") according to the content of O_2 and class II categories 2 − ("very good" and "good") according to others parameters. In the middle area of the reservoir, water was characterized mainly as "good" (class II, category 3), and in terms of the content of NH_4^+ and POC characterized as "satisfactory" (class III, category 4).

The differences in hydrochemical parameters largely affected the biochemical characteristics of commercial fish juveniles. The highest values of total protein content were in juveniles from the lower part of the Zaporizhzhia reservoir, the values in juveniles from the middle part of the reservoir slightly differed, and the lowest values were obtained from fish in the Samarskii bay. The results of the study showed that in the Samarskii bay compared to the lower parts of the reservoir, the concentration of total protein in perch juveniles was lower by 8.12%, common bream − by 8.53%, roach − 21.65% and white bream − by 10.74%. It is obvious that fish protein metabolism is affected due to the negative human impact on water. It can be assumed that such a metabolic disorder in the organism of fish juvenilea is a consequence of a decrease in the quality of the reproductive body and eggs, which leads to a decrease on hatching and survival % of larvae, and may further negatively affect the population size and yield of fish per unit area in a body water. In the tissues of juvenile fish from the middle area of the reservoir, the total protein content was reduced by 5.64% for perch, by 2.47% for common bream, by 10.09% for roach, and by 3.31% for white bream. Analyzing the data obtained in the study of the tissue of fish juveniles from the areas of the reservoir near the Monastyrskoho island and near the Stari Kodaky village, it can be noted that they tended to decrease, but did not differ in statistical confidence.

Also, the most optimal values of the total lipids content were found in fish from the lower area of the Zaporizhzhia reservoir. The lipid concentrations in the tissues of fish juveniles, which were caught from the Monastyrskoho island, exceeded those of fish juveniles, which were caught in the lower part of the reservoir: for perch − by 17.54%, for common bream − 19.26%, for roach − 8.45%. The total lipids content in the tissues of fish juveniles, which were caught from the area near the Stari Kodaky village, exceeded this value of fish juveniles, which were caught from the lower part of the reservoir: for common bream − by 11.88%, for roach − by 12.5%, for white bream − by 2,94%. A significant predominance of total lipids was registered in fish juveniles, which were caught from the Samarskii bay compared to the fish juveniles, which were caught in the lower part of the reservoir − by 38.98% from perch, by 38.52% from common bream, 27.20% from roach. The obtained results showed significant shifts in the protein-lipid ratio, when the shortage of plastic substances is compensated by energy substances.

An analysis of data related to changes in protein and lipid metabolism in the tissues of commercial fish juveniles in different area of the Zaporizhzhia reservoir suggests that human pollution of water bodies with household and municipal sewage, changes in the chemical composition of water, temperature and oxygen regime have negative effects on the physiological-functional state and reproductive capability of commercial ichthyofauna.

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MICROSATELLITE DNA ANALYSIS OF RAINBOW TROUT (*ONCORHYNCHUS MYKISS*) FROM CARPATHIAN REGION OF UKRAINE

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Rainbow trout *Oncorhynchus mykiss* (Walbaum, 1792) belongs to Pacific salmon species and is characterized by a high nutritional value, has attractive technological-biological properties (high growth rate, adaptive plasticity, reproductive characteristics) [1, 2]. Rainbow trout is the major species of cold-water industrial aquaculture of Ukraine. The study of the structural and functional organization of the genome of fish is necessary for effective selective breeding. The use of molecular genetic methods with classical selection techniques allows the creation of stocks of brood fish with desirable economic and valuable parameters [3, 4].

The aim of the present study was to investigate the features of the genetic structure, the level of intrapopulation genetic variability of the local stock of rainbow trout using microsatellite DNA markers. The rainbow trout of the Chernivtsi local stock (town Beregomet, Chernivtsi region) was selected as an object for the study. The study of polymorphism was performed on six microsatellite markers: OMM1032, OMM1077, OMM1088, STR15, STR60, STR73 [5, 6].

Optimal conditions for SSR-PCR analysis were selected during the work. The conducted studies allowed determining the factors that have the greatest effect on the efficiency of amplification of rainbow trout SSR alleles, namely: DNA concentration, primer concentration in the reaction mixture and the number of amplification cycles. Optimal conditions for the PCR to produce clear and reproducible alleles for each locus were selected.

According to the results of microsatellite DNA analysis in the studied population, 28 allelic variants with a molecular weight of 113 p.n. - 296 bp were detected in all analyzed loci. The number of alleles per locus varied from 4 to 6. The highest polymorphous was in the locus OMM1077 (6 allelic variants were identified), among which the 294 bp allele was most commonly encountered with a frequency of 28.57%. Less polymorphic were the OMM 1032, STR 15 and STR 73 loci. Four allelic variants were identified for these three loci.

Calculations of heterozygosity for selected loci have been carried out. The lowest value of the actual heterozygosity (Ho) is observed at the locus of OMM 1088 (0.88829), and the highest heterozygosity (0.7951) is recorded at the locus of OMM 1077. The average value of the actual heterozygosity was 0.835. The mean value of the expected heterozygosity for the six loci was 0.7332. The high mean of heterozygosity indicates a high level of genetic variability. The actual increase in the level of heterozygosity for the studied loci may be due to the selection of individuals for specific productive qualities, but this assumption requires more extensive research. Expected heterozygosity was greater than actual for all loci, except OMM 1077, hence, there is no inbreeding phenomenon in this local stock.

Thus, the obtained results indicate that all used marker groups are suitable for genetic certification of rainbow trout populations. Investigated primers have the same annealing temperature, which allows for simultaneous amplification, which greatly reduces the time of the analysis of samples for flow identification of individuals in the population.

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PRODUCTIVE AND HEMATOLOGICAL PARAMETERS OF RAINBOW TROUT WHEN FEEDING THEM WITH ALLET AQUA AND AQUAFEED FISCHFUTTER FEEDS

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Adequate normalized feeding has a direct impact on the economic efficiency of rearing of fishes and, in particular, trout. Feeds should be dosed depending on its formulation, pellet size, the physiological state of the fish, water temperature and dissolved oxygen content [2, 12]. Due to the fact that the cost of trout feeds is more than 60% of all costs for its cultivation, the problem of rational use and saving is in the first place [1, 3]. It is also important to emphasize the quality of feeds when choosing them for fish feeding taking into account regional features of the enterprise location, etc. [7, 8].

The main step of the scientific and economic experiment was conducted in the conditions of Private enterprise "Western Fish Company" of Pustomyty district, Lviv region. For the experiment, the juvenile rainbow trout *Oncorhynchus mykiss* were selected on the principle of groups-analogues weighing 55.5 g and two groups of 300 specimens in each were formed [6]. The research was conducted in the spring-summer and autumn-winter periods. First experimental group in the separate tank was fed with Aller Aqua feed, while rainbow trout in the second tank was fed with Aquafeed Fischfutter feed.

During the experiment, growth and development of rainbow trout were studied. For this, we monthly randomly weighed 10 specimens from each tank: in the beginning, in the middle and at the end of the experiment, and determined their relative and absolute growth rates. Blood tests were also conducted to control the functional state of trout development depending on the effect of the feeding factor.

As is known, fish erythrocytes perform the same functions as those in warm-blooded animals: respiratory, support the ionic composition of blood, participate in water and salt metabolism, and take part in the transport of oxygen, carbon dioxide, and other nutrients [10, 11]. A comparative analysis between hematological parameters in the conditions of feeding with feeds of different manufacturers showed a slight increase in erythrocyte content as well as in hemoglobin by 10.7−9.7% in one of the experimental fish groups. As for leukocytes, their content was at the same level and did not depend on the type of feed. However, the phagocytic activity of neutrophils in blood of experimental fish insignificantly (by 4.0-0.9%) increased in the experimental groups, which indicates on best nutritional value of Aller Aqua feed for rainbow trout.

Blood proteins are a building material for both cells and tissues of the rainbow trout organism. Therefore, the level of major blood proteins, namely, albumins and globulins, characterizes supply of fish with protein from the feed. Analyzing these parameters, we found that the amount of total protein and its fractions in the blood of rainbow trout were within normal physiological limits. However, relatively higher levels of total protein and its fractions consistently increased in the first experimental group of fish fed with Aller Aqua feed.

It is known that blood enzymes are biological catalysts, that take part in all vital processes in the organism and when studying the level of their activity, we can determine the course of these processes. In addition, the most important in the synthesis of proteins are enzymes, which catalyze these transformations in particular those containing glutamic acid ($C_5H_9NO_4$), namely, the so-called transaminases [4, 5, 9]. In this regard, we analyzed the activity of aspartate (AsAT) and alanine aminotransferase (ALAT) under the effects of the investigated factor.

For a more complete evaluation of the effect of the investigated feed factor on the functional state of the rainbow trout growth, we conducted blood tests for total lipids. The level of lipids in the blood plasma of both fish groups, at the initial phase of the experiment, was on average 3.65 mmol/l. In the middle phase of the experiment, the growth of lipid content in the blood plasma, especially in the first experimental group of trout, was recorded. In the final phase of the experiment, this trend was somewhat leveled.

According to the results of the study, we found that the proposed types of feeds show different effects on the abovementioned parameters. Thus, much better results were obtained in assessing the morphological and biochemical components of blood trout fed with granulated Aller Aqua feed. It should also be emphasized that, regardless of some higher value of this feed, the economic efficiency compared to feeding with the Aquafeed Fischfutter feed is higher.

The obtained results reflect the direct relationship between blood parameters and the functional state of the rainbow trout growth intensity due to the effect of such an important factor as feeding. It is also important to emphasize that the fish feeding with granulated Aquafeed Fischfutter feed has had a different effect on the productive and economic parameters of trout grown.

Consequently, the experimental studies carried out allow us to state the much better nutritional value of granulated feeds manufactured by Aller Aqua and recommend it for use in rainbow trout feeding.

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HIGH QUALITY SPECIALIZED MIXED FODDERS FOR CARP CULTURE IN THE CONDITIONS OF POND FARMS AND AQUACULTURE

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An increase in the production of fish products is possible due to the intensification of fish farming through the introduction of industrial methods for fish rearing. Intensification of fish farming is an inevitable process, which is caused by the growing needs of the human population in live and chilled fish, at the same time with a decrease in catches of oceanic and marine fish. An important point in this process is to find the main ways and solutions of the tasks.

One of the main principles of the ecological concept of intensification in fish farming and the decisive step of increasing fish productivity of ponds is feeding of fish with artificial feeds. Artificial feeds make it possible to increase significantly the stocking density compared to normative values and to eliminate the danger of metabolic disorders and the emergence of alimentary diseases closely linked to the balance of feeds, rations, etc.

Therefore, when producing of artificial feeds, it is necessary to solve two mutually opposite tasks – it should be as nutritious as possible amd should have a minimum price.

In the intensification of fish farming, and especially with significant stocking densities, the main place is given to the full value of fish feeds and their good quality. Unbalanced feeds, very often at the initial stages of feeding, cause common symptoms, and further pathological processes accompanied by a decrease in appetite and growth rate of fish, significant mortality, pigmentation disorders, nervous disorders, hemorrhages, ulcers of the integument, cirrhosis, increased susceptibility to infectious and invasive diseases.

The fish feed "Vita fish" is a high-quality feed for cyprinids, which is manufactured in Ukraine at a factory with high quality indicators – modern production lines that meet the standards of scientific and technological progress.

The basis of the production of the feeds "Vita fish" fish were the generalized results of scientific studies, which were tested and implemented into fish farming and showed high performance when using them. This was facilitated by close joint cooperation with Ukrainian and foreign research institutions.

Today the specialized feed "Vita fish" is used in many fish farms. Raw material for the production of this feed has very high quality, and the company is able to produce it in small batches with the optimized formulation according to the requirements of specific customers.

The feed "Vita fish" balanced in nutrient content, digestibility, energy value. The content of nutrients in the mixed fodders "Vita fish" and their digestibility, according to the physiology of nutrition, depends on the protein content, fat, carbohydrates and biologically active substances. Also, the manufacturer try to reduce the amount of fiber and ash when proeucing this feed

The energy content in this feed is indicated as total energy and as digestible energy, as well as the metabolic energy per 1 kg of feed.

Another important indicator of the quality of the feed "Vita fish" is the presence of phosphorus, which affects the hydrochemical state of water bodies. Thus, when rearing fish especially whith intensification, it is important to monitor the environmental conditions. In particular, the parameter of nutrient penetration through the feed into fish organism, and from it into the water body, is very important. They provide indicative information about the maximum possible risks of environmental pollution. First of all, these parameters depend on the specific feed conversion efficiency ratio (weight of feed spent per kg of fish weight gain), the content of phosphorus, nitrogen, as well as on their content in the fish itself.

Before starting feeding, it is advisable to perform a test feeding of fish to adapt to the specifics of the farms, taking into account abiotic and biotic factors of the water body at a certain growing period.

In general, according to the specification, the company also produces feed for salmonids and cyprinids to growing them in farms of different types of aquaculture.

For growing fry and juvenile carp, the company produces the extruded starter feed with protein contents of 45 to 33%. Productional feeds have the protein contents from 40 to 26%, and fat from 18 to 6%.

The company also produces specialized feed for replacement and brood stock of cyprinids and other fish species.

The composition of animal feed includes low-temperature fish meal, hydrothermally treated wheat, fish oil, pea protein, hemoglobin powder, yeast, vitamin premix, minerals, trace elements, lecithin.

This mixed feed is mnufactured by twin-screw extruders, which makes it suitable for intensive carp growing. Optimal distribution of energy leads to maximum growth with sufficiently good absorption of nutrients of the feed, good physiological condition and ability to sustain stress, low environmental pollution. Food can be used during the entire feeding period − from fry to commercial fish, ensuring their high quality.

The above-mentioned feed provides the fish organism with the necessary amount of nutrients, certain vitamins and minerals, contributes to normal life, helps to have a bright color, and increases the resilience of juveniles.

STATE AND PECULARITIES OF COLD-WATER FISH FARMING AND AQUACULTURE IN THE SUBCARPATHIAN AND CARPATHIAN REGIONS

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Trout breeding is one of the promising areas of cold-water fish farming and aquaculture, which allows producing delicious products with high nutritional and dietary qualities. In this regard, trout are bred in many countries across the world.

Breeding and growing of trout in the Subcarpathian and Carpathian regions has a long history. For this, there are remarkable opportunities in the region. A number of state, private and household fish farms are engaged in this activity. There is enough water for growing cold-water fish in the Subcarpathian and the Carpathian regions, it is supplied by gravity, artificial drops are built on mountain rivers and streams for its additional aeration.

For trout breeding − cultivation *Salmo trutta morfa fario* and *Salmo trutta morfa lacustris*, *Thymallus thymallus* and *Salvelinus fontinalis* needs water of mountain streams, reservoirs and lakes. The cultivation of *Hucho hucho* needs water in mountain area of Tysa, Rika, Teresva, Tereblya, Prut and Cheremosh rivers.

Consequently, a significant part of trout-breeding farms are located in Western Ukraine, and the main objects of cultivation in them are following species: brown trout, rainbow trout, steelhead salmon, Donaldson trout, brook trout, Adler gold and amber trout, etc.

The main objects of intensive trout-breeding farms in Western Ukraine are kamloops and rainbow trout. With favorable conditions, some fish farmers produce 1000 centers of commercial fish per hectare.

About 20% of the Subcarpathian and Carpathian water bodies are replenished with spring and stream water, which does not require special treatment and it is not source of infectious and invasive diseases. After aeration, it is immediately supplied to the hatchery, fry and rearing pools, fattening ponds. The favorable water temperature (4−5°C) makes it possible to use productive winter months, which positively affects the cost of production. Even in the coldest winters with frosts up to 25−30°C, water from some sources with a temperature of 7−10°C can be supplied to the hatchery, wintering ponds, rearing system of trays, cages, pools and fattening ponds without special preparation and heating. Water of mountain streams, rivers and other water bodies usually has a neutral pH, water hardness about 9−10°, rarer 8°, dissolved oxygen content − 10−15 mg/l, iron content does not exceed 1 mg/l. The water temperature does not exceed 20°C, even in the warmest days of the year. In winter, water temperature in most mountain water bodies does not fall below 3°C.

The oxygen regime of water in the farms, as a whole, is optimal and favorable for intensive trout breeding. However, it is often disturbed due to human activities in the catchment basin, in particular, streams that provide water for fish farms. The rapid deterioration of the oxygen regime is primarily caused by a decrease in the forest cover of the catchment basin, which reduces the shading of water bodies in the summer, thereby causing their rapid warming. Due to a decrease in the forest cover, runoff is accelerated and strengthened, flushing organic residues (leaves, wood) into water bodies, mineralization increases. Woodcutting accelerates soil erosion, increases the amount of solid runoff in water. Excessive anthropogenization of certain sections of streams and rivers and their catchment basin due to the construction of buildings or recreation centers also cause significant damage to trout-breeding farms.

Trout breeding farms in the Subcarpathian and Carpathian regions mainly produce fish seeds and commercial fish. The brood stock is replenished at the expense of age-2-

3 replacement groups and from fattening stock. The brood stock consists of age-4-7 females aged, weighing 1000−4000 g and age-3-5 males weighing 700−2000 g. Periodically, some breeders are rejected and replaced by age-2-3 replacement fish weighing 600−900 g. During selective breeding, attention is drawn primarily to body weight and external features: body shape, muscle development, color.

For the full use of hatcheries during the autumn-winter period, brown trout eggs are used, and during the spring-summer – rainbow trout eggs are used. Some hatcheries incubates Kamloops and brook trout as well as steelhead salmon and rarer grayling.

Reproductive products − eggs and sperm from trout are produced by stripping. Incubation is carried out in the apparatus of the horizontal and vertical types. In trout breeding farms, the most common are Shuster or Ropsha tray apparatuses, which can fit 45−60 thousand eggs per 1 m^2 of the incubator. Up to 600 thousand eggs per 1 m^2 can be placed in vertical-type hatcheries apparatuses on trout breeding farms.

Pure water, without impurities, with a temperature of 6−10°C and with an oxygen content of 7−9 mg/l, is supplied to incubation apparatuses. In order to prevent egg damage by *Saprolegniales*, its prophylactic treatment is carried out at the beginning of incubation and then at the eye pigmentation stage a solution of formaldehyde (CH_2O), chloramine (NH_2Cl), etc.

The overall development of rainbow trout eggs, from laying of eggs to hatching of yolk sac larva at a temperature of 6°C lasts 61 days on average (366 degree-days), for 12°C − 26 days (312 degree-days). With good quality of eggs and sperm, the death rate during incubation is 10−15%. In the future, yolk sac larvae are kept in apparatus at a density of 100 thousand specimen/m^3 until the resorption of the yolk sac. As larvae grow, the density is reduced to 25−30 thousand specimen/m^3. The amount of feed is determined based on the feed table, the larvae and fry are fed every 50 to 60 minutes for 12 hours.

The next stages of trout breeding are: growing of fingerlings, young-of-the-year and table fish. Fish are grown in rectangular, square or oval trays, pools, ponds. At the same time, considerable attention is paid to the hydrochemical regime, intensity of water exchange, temperature of the water (not higher than 14−16°C) and oxygen content (not lower than 7 mg/l).

RARE FISH SPECIES IN THE REPUBLIC OF MOLDOVA

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The Red List of Threatened Animals and Plants of any country should objectively reflect the rarity status of species and be relatively independent of the regulations of other countries [1]. The law protecting various species of plants and animals and providing for the periodic publication of this roster is the Law on the Red List of Threatened Animals and Plants of the Republic of Moldova No. 325 of December 15, 2005 [2].

The first edition of the Red List of Threatened Animals and Plants of the Moldavian Soviet Socialist Republic was published in 1978, where only 29 species were assigned to the animal kingdom, among which there was not a single species of fish [3]. In the second edition of the Red List of Threatened Animals and Plants of the Republic of Moldova (2001), 13 species of fish (*Pisces*) and cyclostomes (*Cyclostomata*) were included (in some of the controversial statuses), of which: one species was critically endangered (CR) − *Umbra krameri* (Walbaum,1792); five endangered species (EN) − *Huso huso* (Linnaeus, 1758), *Acipenser gueldenstaedtii* (Brandt et Ratzeburg, 1833), *Acipenser stellatus* (Pallas, 1771), *Rutilus frisii* (Nordmann,1840), *Barbus borysthenicus* (Dybowski, 1862) and seven vulnerable species (VU) − *Eudontomyzon mariae* (Berg, 1931), *Hucho hucho* (Linnaeus,1758), *Leuciscus idus* (Linnaeus, 1758), *Barbus petenyi* (Heckel, 1852), *Lota lota* (Linnaeus,1758), *Zingel zingel* (Linnaeus, 1766), *Zingel streber* (Siebold, 1863) [4].

The list of protected fish species was almost doubled in the third edition of the Red List of Threatened Animals and Plants of the Republic of Moldova (2014), to 24 species, of which: six species are critically endangered (CR) − *Eudontomyzon mariae* (Berg, 1931), *Huso huso* (Linnaeus, 1758), *Acipenser gueldenstaedtii* (Brandt et Ratzeburg, 1833), *Hucho hucho* (Linnaeus,1758), *Anguilla anguilla* (Linnaeus, 1758), *Carassius carassius* (Linnaeus, 1758); five endangered species (EN) − *Acipenser stellatus* (Pallas, 1771), *Umbra krameri* (Walbaum,1792), *Alburnoides bipunctatus* (Bloch, 1782), *Sander volgensis* (Gmelin, 1789), *Caspiosoma caspium* (Kessler,1877) and thirteen species are vulnerable − *Acipenser ruthenus* (Linnaeus,1758), *Rutilus frisii* (Nordmann,1840), *Leuciscus idus* (Linnaeus, 1758), *Petroleuciscus borysthenicus* (Kessler,1859), *Pelecus cultratus* (Linnaeus, 1758), *Barbus petenyi* (Heckel, 1852), *Tinca tinca* (Linnaeus, 1758), *Lota lota* (Linnaeus,1758), *Gymnocephalus schraetser* (Linnaeus, 1758), *Zingel zingel* (Linnaeus, 1766), *Zingel streber* (Siebold, 1863), *Cottus poecilopus* Heckel, 1837, *Knipowitschia longecaudata* (Kessler, 1877) [5].

At present, under conditions of increasing anthropogenic pressure, long-cycle fish species with a pronounced anadromous character suffer the most. First of all *Acipenseridae* must be attributed to this group. In the Dniester and Prut rivers, only sterlet *Acipenser ruthenus* and *Acipenser stellatus* are sporadically found. The remaining species (*Huso huso*, *Acipenser gueldenstaedtii* and *Acipenser nudiventris*) are critically endangered (CR) due to poacher fishing during migrations and worsening spawing conditions. Also, this group of critically endangered (CR) fish species includes *Hucho hucho* and *Anguilla anguilla*.

At the moment, in our opinion, there is a gradual revival of populations of *Leuciscus idus*, *Pelecus cultratus*, *Lota lota*, *Zingel zingel* and *Zingel streber* in the Prut river, which indicates a more favorable ecological condition of this river compared to the Dniester river, where these species have almost completely disappeared.

Of particular interest to us is the *Rutilus frisii*, living in the Dniester river, which recently has rapidly increased its numbers, despite the high illegal fishing pressure. Until the end of the 19th century, this species of fish was widely distributed in most rivers of the Black Sea-Azov basin (except for the Danube River, where the taxon is rare) [6]. A few decades ago, it was believed that it would completely disappear in the

Dniester river, but for some reason the population began to revive. Currently, two populations of *Rutilus frisii* have emerged within the Republic of Moldova: one is semi-anadromous of the lower reaches in the Dniester river, and the other is more numerous in the Dubossary reservoir. For example, the share of this species in the last four years, in the control catches by nets that were carried out in the Dubossary reservoir, reached 2.65%. This local population has been adapted in this way: fish migrates upstream for spawning and uses the biotope of the reservoir as a place of active feeding and growth. The rapid growth of *Rutilus frisii* is mainly due to the malacophagous type of feed − fish easily crushes the shells of mollusks due to the developed pharyngeal tooth. For the Dniester river ecosystem, *Rutilus frisii* becomes a very important biological meliorator. Among the reasons that, in our opinion, played a decisive role in the partial restoration of *Rutilus frisii* populations in the Dniester river, we can mention the following: clearing the spawning grounds of lithophilic fish species after amplitudinous floods in 2008 and 2010 and *Dreissenida*e expansion, the main trophic resource in this species feeding.

For small-sized fish species, most of which belong to the “Endangered” (EN) and “Vulnerable” (VU) groups, restrictions or bans on fishing will not have the desired effect, because they do not represent economic value and are not readily available when using illegal fishing methods. The populations of these fish species are usually distributed in limited areas, and the success of their protection in these places is directly dependent on the ecological well-being of water bodies. Thus, the ban on catching these species often creates the illusion of the competent executive authorities that by accepting it, the species are protected, but in fact, it distracts attention from the real danger that threatens them.

Considering that the Dniester and Prut rivers are transboundary ecosystems, measures to preserve the species diversity of the ichthyofauna should be taken in a coordinated way by all stakeholders. As a rule, a symbolic price is paid for their natural resources − a situation described as the “tragedy of the common good”. In this regard, it is necessary to expand the protected wet zones of the Dniester river lower area and the Prut river lower area, on both sides. Creating sites with a special protection status in the lower currents of the Dubossary dam (to the town of Criuleni) and the Costesti-Stynka dam (to Branishte village) for five kilometers will provide a “sparing zone” in which the species diversity of the ichthyofauna will be preserved. To ensure more effective protection of fish species, which are made to Red List of Threatened Animals and Plants, the parties also, need to cooperate more closely in such areas as regulating commercial and amateur fishing, conducting dredging works with associated sand mining, construction of hydraulic structures, etc.

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ASSESSMENT OF THE SIMILARITY DEGREE OF *GOBIIDAE* FOOD COMPOSITION FOR FORMING POLYCULTURE IN THE SHABOLATSKY ESTUARY

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Shabolatsky estuary is located in the northwestern area of Black Sea and was formed as Dnistro river estuaries, which were separated by a sand bar from the sea. The estuary belongs to the type of semi-open, brackish-water estuaries-lagoons. For centuries, the Shabolatsky estuary served as a place for marine and freshwater fish and was traditionally used for ranching mariculture [1].

One of the most important components of the ichthyocomplex of the Shabolatsky estuary are gobiids represented by the two most widespread fish species − round goby *Neogobius melanostomus* and grass goby *Zosterisessor ophiocephalus* [1].

An analysis of the food relationships for gobies, one of the main objects of ranching mariculture in the Shabolat estuary, showed that the maximum similarity degree in the diet compositions of the grass goby and round goby was observed in autumn (SD − 33.2), the minimum − in spring (SD − 20.8) (Table 1) [2].

Table 1

Similarity degree of the diet composition of gobies from the Shabolatsky estuary in different seasons 2009–2012

Nutrition objects, in percentages by weight	*Zosterisessor ophiocephalus*	*Neogobius melanostomus*	*Zosterisessor ophiocephalus*	*Neogobius melanostomus*	*Zosterisessor ophiocephalus*	*Neogobius melanostomus*	*Zosterisessor ophiocephalus*	*Neogobius melanostomus*
	Spring		Summer		Autumn		Average for the year	
Nereis diversicolor	8,4	–	7,3	6,6	1,3	1,5	7,2	1,7
N. sp.	4,6	–	4,1	–	–	–	4,2	–
Abra ovata	3,6	1,8	–	0,2	–	0,02	2,4	0,7
Mytilaster lineatus	1,0	1,1	–	0,5	–	0,03	0,4	0,3
Hydrobia sp.	1,3	–	–	0,2	–	0,1	0,8	0,3
Mysidae gen sp.	–	–	1,4	0,1	–	0,1	0,1	0,4
Idothea baltica	22,2	8,0	47,5	4,5	79,8	23,4	36,8	12,7

Continuation of the table 1

Nutrition objects, in percentages by weight	*Zosterisessor ophiocephalus*	*Neogobius melanostomus*	*Zosterisessor ophiocephalus*	*Neogobius melanostomus*	*Zosterisessor ophiocephalus*	*Neogobius melanostomus*	*Zosterisessor ophiocephalus*	*Neogobius melanostomus*
	Spring		Summer		Autumn		Average for the year	
Sphaeroma serratum	7,0	53,4	2,0	15,3	–	26,3	5,3	37,1
Gammarus lacusta	35,5	0,2	18,2	11,1	8,4	6,6	27,8	4,8
Gammarus sp.	5,1	–	1,5	0,9	1,9	4,5	3,8	1,8
Palaemon adspersus	2,8	11,0	1,6	12,0	–	10,3	1,1	9,0
Pomatoschistus marmoratus	–	20,6	1,5	11,7	–	17,5	0,5	16,1
Zosterisessor ophiocephalus	1,0	–	9,5	–	–	–	2,7	–
Neogobius melanostomus	6,7	–	0,5	4,7	–	2,2	4,1	0,7
N. fluviatilis	0,6	–	0,5	21	–	9,5	0,3	8,3
SD	**20,8**		**29,3**		**33.2**		**31,2**	

In general, the similarity of the diets of these goby species from the Shabolatsky estuary is not great. They occupy close, but different food niches. Therefore, both species are quite suitable for forming polyculture for fish ranching [2].

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ASSESSMENT OF THE DIET OVERLAP OF MULLETS (*MUGILIDAE*) FOR POLYCULTURE IN THE SHABOLATSKYI LAGOON

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Shabolatskyi (Budakskyi) lagoon is one of the water bodies of the north-western Black Sea region, which is characterized by high biological diversity and fish productivity.

The native ichthyofauna of the lagoon includes *Mugil cephalus* (Linnaeus, 1758), *Liza saliens* (Risso, 1810), and *Liza aurata* (Risso, 1810). In the 80s-90s of the 20th century, a *L. haematocheilus* population (Temminck & Schlegel, 1845) was formed in the Shabolatskyi estuary and is capable of self-reproducing [1].

An analysis of the trophic relationships of the main objects of fish ranching in the

Shabolatskyi estuary showed that the highest diet overlap was observed among mullets (*Mugilidae*) (Table 1) [2].

Table 1. **Average annual diet overlap indices for all length-age groups of mullets (*Mugilidae*) during the feeding period in 2012-2014**

Species		*Mugilidae*			
		L. saliens	*M. auratus / L. aurata*	*L. haematocheilus*	*M. cephalus*
Mugilidae	*L. saliens*	–	**72.3**	56.2	55.6
	M. auratus / L. aurata	**72.2**	–	58.7	58.5
	L. haematocheilus	56.2	58.7	–	**78.7**
	M. cephalus	55.6	58.5	**78.7**	–

The average annual diet overlap values of *L. haematocheilus* and *M. auratus* / *L. aurata* were 78.7, *L. saliens* and *M. cephalus* — 72.2. For mullets, the highest similarity was the qualitative composition of the diets for all species in the spring period [3]. In summer, the composition of food changed significantly that reduced the tension of trophic relationships. In autumn, the greatest similarity was observed for age-1+ *L. saliens* and *M. auratus / L.aurata* (diet overlap index – 74.5), age-1+ and age-2+ of *L. haematocheilus* and *M. cephalus* (diet overlap indexes – 84.2 and 85.0, respectively). At the same time, the diets of *L. haematocheilus* and *M. auratus / L. aurata* differed significantly from *L. haematocheilus* and *M. cephalus*. If the majority of the diets of the first fishes were animal prey, detritus and plant components prevailed in the latter. Trophic relationships among all mullets foraging in the Shabolatskyi lagoon were quite tense in recent years, which largely affected their growth rates and the weight of table fish. This fact must be taken into account in the directed formation of fish ichthyocenosis in the lagoon, in order to organize fish ranching.

In the Shabolatskyi lagoon, it is advisable to introduce fish ranching practices of the controlled cultivation of mullets in cages and specially fenced areas of the lagoon. Also, it is necessary to pay serious attention to the development of active methods of harvesting commercial fish during free fattening [4].

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AQUACULTURE OF BROWN TROUT (*SALMO TRUTTA* MORFA FARIO LINNAEUS) IN UKRAINE

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The brown trout (*Salmo trutta morfa* fario Linnae) has been and remains one of the most valuable native fish species in the ichthyofauna of Ukraine, whose population and biomass in the rivers of the Carpathian region are steadily decreasing. At present, this species of *Salmonidae* in the Carpathian rivers-drainage system is represented mainly by single specimens of underyearlings and two-year-olds, three-year-olds specimens are extremely rare [2]. Such a critical state is caused by the action of factors of human origin, in particular industrial and household pollution of rivers, hydraulic engineering [3], as well as a result of brood stock poaching [4] in the absence of artificial re-stocking of natural water bodies.

So, an urgent task is to carry out a complex of fish-breeding works to restore the population of the brown trout population, primarily through its artificial reproduction using the technological potential of industrial aquaculture.

For the successful reproduction and development of the brown trout in artificially created conditions, it is necessary to pay a considerable attention to one of the most important links − the hatcheries process.

In the early ontogenesis of the brown trout, which is quite long − from freshly fertilized eggs to the stage, when the larvae begin to move and eat actively, there are three main stages, each of which requires special control and attention. The first stage is from egg fertilization to the stage of eye pigmentation, the second is from the eye stage to hatching and the third stage is from the hatching of yolk sac larvae to the beginning of active movement and feeding.

The period of hatching of brown trout eggs depends on the temperature. In natural conditions, it occurs at a temperature of 0−6ºC. From the moment of egg fertilization to the moment of the free embryo hatching, at best, it takes from 150 to 200 days. However, with a decrease in temperature in mountain rivers to 0–2 ° C, development stops and this diapause in most cases leads to the death of embryos.

Hatching of brown trout eggs in industrial conditions at a higher water temperature than in natural conditions: 8°C − in 2015−2016, 9.1ºC − in 2016−2017, against 0−6 ºC, makes it possible to speed up the process of embryogenesis, and the stability of the temperature regime in the hatcheries and the absence of sharp changes in environmental parameters make it possible to avoid significant losses at the sensitive stages of early ontogenesis (the beginning of separation of the blastodisc, the beginning of gastrulation and before proceeding to the eye pigmentation stage).

The onset of the main stages of embryonic development of brown trout hatching in 2015−2017, practically did not differ in the number of degree-days, but the difference in temperature, even by 1.1°C between the two hatching periods, contributed to a more rapid resorption of the yolk sac.

The term of brown trout embryogenesis from the moment of fertilization to the stage of vascularization of the yolk sac, on which eye pigmentation becomes noticeable, lasted 25 days in 2015-2016. It was this period that corresponded to 232 degree-days; at the same time in 2016-2017 the onset of this stage took place on the 22nd day of hatching, which corresponded to 228 degree-days.

The period from egg fertilization to hatching lasted 53 days in 2015-2016, which corresponded to 446 degree days and 45 days (438 degrees-days) in 2016-2017.

Before hatching, active movement of the embryos inside the egg was observed. This dynamic movement quite often leads to thinning of the ovum membrane under the action of enzymes.

The stage of hatching from eggs lasted 4 days, the most actively hatching was observed on the second or third day after hatching of the first individuals.

Analyzing the conditions of free embryos exposure during 2015−2017, it can be noted that the water temperature during the whole period differed by 1.1°C, that is, there was a slight tendency to temperature fluctuations between hatching events. However, this difference for hatching of brown trout eggs is insignificant.

The duration of the resting stage from hatching in 2015−2016 was 20 days, in 2016−2017 − 17 days.

So, changes in the temperature of water influenced the period of larva raise in the water column after the hatching, which took place in 2015−2016 for 21 days, whereas a higher temperature of water in 2016−2017 reduced this time to 18 days.

The final resorption of the yolk sac and the complete transition to the exogenous feeding of brown trout larvae in 2015−2016 occurred in 38 days after hatching, and as the water temperature rose from 2016−2017, this process accelerated and occurred on the 33rd day after hatching.

The larva yield determined based on the mortality rate for the eye pigmentation stage was 11%. At the next stage, it decreased slightly and amounted to 7.4%. In our studies, the loss to the stage of eye pigmentation and after hatching was almost the same − 11.0 and 10.5%, respectively.

The overall mortality of the brown trout embryos during hatching, before the larvae raised into the water column, was 29%. The percentage of mortality was within the limits allowed for the artificial reproduction of brown trout in industrial cold-water farms.

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PHYSIOLOGICAL AND BIOCHEMICAL JUSTIFICATION OF THE METHOD OF THE TREATMENT OF CYANOBACTERIA *SPIRULINA* (ARTHROSPIRA) PLATENSIS WHEN FEEDING YOUNG-OF-THE-YEAR CARP

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At early stages of the development of aquatic organisms, one of the decisive factors that have a direct effect on the dynamics of metabolic processes and the development rate of an organism is feeding. When implementing programs for stocking the water areas, the body weight of grown-up fish fry defines the final result. Therefore, the technological aspects of feeding hydrobionts, "ecological" methods of their breeding and the level of water pollution are important components of aquaculture [3, 4]. Water plays an important physiological role and is the main activator of microbiological, physicochemical processes in production technologies. Changing the water structure by special treatment allows affecting the interaction with individual molecules, enzyme complexes, and micro capillary permeability at the nanostructure level. The use of physicochemical methods of water treatment is very promising, and the use of contact non-equilibrium low-temperature plasma for its treatment belongs to modern methods of preparation, which have potential advantages for use in various industries [5].

When feeding carp fingerlings with the purpose of stocking with more resistant fry it is important to take into account the biological needs of their organisms. The use of a special method for the treatment of spirulina (*Arthrospira*) cultivated on a special medium according to the scheme established earlier [2,5] provides such an opportunity. It should be noted that when introducing methods of feeding carp fingerlings, it is necessary to take into account that the use of the feed factor is decisive in the formation of biopotentials and the quality characteristics of future products. Today, during the European integration, the aquaculture sector is not an exception, so dietary supplements, growth stimulants, adaptogens should not be synthetic neither hormonal, since preference is given as close as possible to organic products [1].

The experimental part of the work was conducted at the Scientific and Experimental Student Center "Water Bioresources and Aquaculture of the Dnipro" in the Dnipro State Agrarian and Economic University. The study of the rate of development of carp fingerlings was carried out by weighing and morphometric evaluation. The nutritional value of the feed (general ration) and the stock culture of *Spirulina (Arthrospira) platensis* was determined, and a comparative analysis of feed absorption was carried out. The selection and processing of biological samples was carried out in accordance with valid methods. The results are processed statistically. The main results were used when making a patent for a utility model.

The erythrocyte picture of the blood is quite an informative study, since it reflects the course of adaptation-compensatory reactions, regenerative and degenerative processes in the blood and blood-forming organs. The results of the study of the hematological composition of blood of carp fingerlings showed that the total number of erythrocytes and hemoglobin content in the experimental group exceeded the value in the control group of fish by 9 and 12%, respectively. In the study of the basic morphofunctional parameters of the fingerlings blood, a relationship between the body weight and red blood cell composition was found, that is, the greater the weight (in the experimental group), the greater the total number of red blood cells, and, conversely, a decrease in body weight leads to a decrease in oxidative blood properties. The hematocrit index reflects the general state of homeostasis of the body of carp fingerlings, a greater level of hematocrit in the experimental group is associated with a large number of red blood cells in their blood. Hemoglobin is the main protein fraction in the blood, the leading function of which is to supply the tissues with oxygen and remove carbon dioxide. Therefore, the determination of hemoglobin in the blood is one of the important indicators of the overall functional state of the body. As is known, the erythrocytes degree saturation with hemoglobin characterizes the average hemoglobin content in the erythrocyte. The microcorpuscular indices in the blood of carps of the research group were higher in the control group: the hemoglobin content in the erythrocyte (MCH) was 5.3%, the average red blood cell volume was 4%, the average concentration of hemoglobin in the erythrocyte 3.8 %. Probably, the indicated values of erythrocyte indexes have a correlation with the total number of red blood cells and hemoglobin concentration.

One of the important indicators of the state of metabolism in the body is protein composition of the blood. Depending on the intensity of protein metabolism, the content of total protein and its fractions in blood serum may vary. The results of our research on the main indicators of protein metabolism showed that the total protein content was higher in the blood of carp, which was treated with spirulina in addition to the general ration. The difference was 12.1%. The protein ratio reflects the ratio of the albumin and globulin fractions of blood, in the experimental group it was 1.38, which was 23% higher compared to the control group. A higher albumin level may be a sign that protein-synthesizing processes are more active in the organism. In addition, in the study of the feed coefficient, it was found that in the experimental group it was less than the control value, which makes it possible to discuss about the more active dynamics of metabolic processes, therefore, and the nutrient absorption by carp in the experimental group.

Thus, the cultivation of *Spirulina (Arthrospira) platensis* on a special medium – plasma-chemically activated plasma, contributed to the enrichment of the chemical composition of cyanobacteria. The use of such spirulina in feeding carp fingerlings contributed to the activation of metabolic processes in his body. The daily consumption of carp fingerlings spirulina by the year has affected the general functional status of their organism, the processes of oxidation and the oxygen capacity of the blood. Repeated experimental studies and a comparative analysis are planned regarding the chemical composition of the carp muscles of the experimental and control groups. That will allow a more comprehensive assessment of the effect of the studied feed factor on the qualitative and quantitative indicators.

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BACTERIAL CORRECTION OF ALGOCENOSIS IN THE WATER BODIES OF KYIV CITY AND KYIV REGION

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The degradation of water resources of the industrialized regions of the country is currently one of the most pressing environmental problems. Along with the toxication and eutrophication of the aquatic environment, the “blooming” of blue-green algae − cyanobacteria (cyanoprokaryotes) in the summer period has become a new, eco-expression phenomenon. As such, the process of intensive development of cyanobacteria contributes to a fundamental change in the parameters of aquatic ecosystems, including chemical and organoleptic properties, leads to a sensitive decrease in the oxygen content, emit toxic compounds (cyanotoxins) in dangerous doses, which ultimately leads to the death of hydrobionts, including fish.

Currently, one of the effective biological ways to prevent the mass reproduction of cyanobacteria is to take the so-called "correction of algocenosis" or "algolization" [1]. Among the means of such biological restoration is the bacterial preparation "Komplezim", which is recommended [2] to use for cleaning and renewing the sanitary regime, the biological balance of natural and man-made water bodies exposed to artificial or natural pollution [3, 4].

In the summer period of 2018, we carried out a series of investigations aimed at identifying chemical factors for the correction of algocenosis of small natural reservoirs within the Kyiv city and Kyiv region, for which regular “blooming” was previously observed, accompanied by the formation of cyanotoxins.

The aim of these works was to improve the method of ecological rehabilitation of various water bodies polluted by cyanotoxins due to the algolization of non-pathogenic strains of the bacteria *Bacillus subtilis* and *Bacillus licheniformis* contained in the bacterial preparation "Komplezim", and an assessment of the ecological state of aquatic environment based on the obtained experimental hydrochemical and hydrobiological data.

The results of the research showed that under the effect of the bacterial preparation "Komplezim", pH values and water oxidation level of in these water bodies were within the acceptable limits. The result of the use of the bacterial preparation "Komplezim" was a prolonged and uniform reduction of permanganate and bichromate oxidation in the studied water bodies. Calcium, magnesium and sulfate levels in the salt composition of water were below the control values. The study has convincingly shown that bacteria from the composition of the above mentioned preparation in the aquatic environment favor the active processing of organic decay products, which are also enriched with calcium, magnesium, sulfates and other biologically important inorganic salts. The consequence of the use of the bacterial preparation "Komplezim" is also an increase in the concentration of chlorides of organic origin, simultaneously with nitrites in water that has a positive effect on the state of aquatic biotopes.

The results suggest that the bacterial strains that are part of the "Komplezim" are able to effectively suppress the reproduction processes of blue-green algae (cyanobacteria) by correcting algocenosis and help to optimize the hydrochemical conditions for growing pond fish.

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BIOLOGICAL VALUE AND TOXIC EFFECT OF Fe, Zn, & Cu ON STURGEONS (*ACIPENSERIDAE*)

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Fe, Zn and Cu, depending on the form of release into the water body and concentration, are at the same time pollutants with a high accumulation capacity and vital elements for fish. The effect of Fe, Zn and Cu on sturgeons depends on many factors, the main of which are their concentration in the environment, the duration of exposure to fish, sex and age of fish (the juveniles are less tolerant), general physiological and biochemical state of fish. The above mentioned conditions determine the detrimental or positive effects of these elements on sturgeons [1, 2].

In sturgeon, these elements are accumulated primarily in the blood-forming organs, among which their greatest content is in the liver and spleen. The lowest content of Fe, Zn and Cu was recorded in gonads and muscles. Fe, Zn and Cu are characterized by inherent capacity for synergy. Their transformations in fish organism are interconnected and the content of one of them affects the manifestation of the properties of another [2, 3].

Iron (Fe). Sturgeon fish are able to actively accumulate iron from the environment due to its high biological activity. For example, hemoglobin is a complex iron-containing erythrocyte protein that can bind to oxygen, ensuring its transfer to tissues, and contains 0.34–0.48% of iron in the form of heme. The excess of this element is deposited in the liver and spleen, acting as a kind of reserve and in the form of complex complexes serving as starting material for further synthesis. In sturgeon, the organ responsible for the biochemical transformation of various forms of iron is the spleen, a blood-forming organ in which the conversion of inorganic iron into an integral part of hemoglobin takes place. In general, sturgeons are characterized by its accumulation in the most blood-filled organs, the spleen, which performs the functions of blood formation, and the liver, which contains the main iron-containing protein − ferritin. With prolonged intoxication of sturgeon with iron, their immunity is reduced, desquamation of the epithelium of the gills is noted. It can cause inhibition of the activity of digestive enzymes and disrupt the permeability of biological membranes [3−5].

Zinc (Zn). In sturgeon organism, zinc is inferior in content only to iron, sometimes even exceeding it in terms of accumulation in individual organs and tissues. Analyzing the literature data on the physiological role of zinc, it is necessary to note the multifunctionality of this element. In particular, it plays an important role in the supramolecular organization of intracellular complexes, affects the activity of the sex and gonadotropic hormones of the pituitary (activates the enzymes that bind CO_2), is part of the enzymes providing glycolysis and respiration, necessary for the formation and functioning of the intracellular membranes. In addition, Zn^{2+} ions increase the level of α-amylase enzyme activity (by 10% relative to the control group in Russian sturgeon) [4]. It is worth noting that the effect of this element on the digestive enzymes of mature specimens is less than on the same enzymes in juveniles. Most of Zn is accumulated in the mesonephros or primordial kidney, one of the most important organs of blood formation of sturgeon fish species. In general, Zn has a pronounced ability to accumulate in organs and tissues with age. Its accumulation in gills leads to a decrease in oxygen consumption and causes respiratory spasms, worsens respiration and provokes asphyxia. As a result of its toxic effects, the renal tissue and digestive enzymes are impaired, the growth rate decreases, and the reproductive and behavioral functions of fish are disturbed. The groups of greatest risk are fingerlings (characterized by a high ability to accumulate Zn in gills) and female breeders (accumulating in the kidneys, causing chronic toxicosis). During the acute poisoning of this element in sick fish marked darkening of the color of the body, swelling of gill lobes, hyperplasia and peeling of respiratory epithelium [1−3].

Copper (Cu). Copper is very important in phenolic, nitrogen and nucleic exchanges. The main role of copper in tissue respiration is participation in enzymatic catalysis, since it is a necessary component of oxidative enzymes. It is also necessary for the effective assimilation of carbohydrates and minerals. This element is of great importance in increasing the immunobiological resistance and resistance of the organism to the harmful effects of environmental factors in the processes of growth and development of the organism. In addition, it participates in the processes of pigmentation, affecting the formation of melanin and the color of fish. Also, copper is an antagonist of group A vitamins (retinoids), accelerating the processes of their oxidation. The exchange of copper in the sturgeon organism is closely linked to the exchange of iron, since Cu affects both absorption and the use of the latter. In particular, it acts as a catalyst in the process of converting organic Fe into an integral part of hemoglobin. It should also be noted that in sturgeon in the spawning period, the content of this element in the liver decreases, and in gonads − increases. For all sturgeons, the largest quantities of copper are concentrated in the spleen. In particular, it is accumulated 1.8 times more than the liver; in 3,6 times more than the kidneys; 4.8 times more than gills, and 6.9 times more than the intestine [3−5]. Moreover, with an increase in the age of fish, the difference between the accumulation of this element in females and males begins to be observed. In males, more copper accumulates in the muscles, gills and spleen, as opposed to females (all copper in the liver and spleen). This specificity is primarily due to more significant changes in the biochemical processes in females in the process of transition to the spawning state - the mobilization of internal resources of the body during this period affects the redistribution of chemical elements in all organs and tissues, and the dynamics of accumulation of elements constantly fluctuate under the influence of many factors. When acute poisoning of fish is excited, it increases motor activity resulting in dystrophy. Synergistic action of Zn and Cu provokes the appearance of pathologies of gills, their respiratory epithelium becomes loose, swollen, hyperplastic, and the epithelium of the filaments grows. In the liver and kidneys, processes of degeneration and destruction of erythrocytes begin. In chronic poisoning, there is a general exhaustion, bleaching of integument, violation of the integrity of the fins. Lack of copper leads to a deterioration of the heart, brain, liver, contributes to the development of cataracts and inhibition of fish growth [1, 2].

The basis of structural and functional changes in the organism of sturgeons when exposed to Fe, Zn and Cu are the processes of detoxification, energy resources mobilization in order to compensate for energy costs, to ensure the dynamics of the ratio of pro-oxidant and antioxidant substances. If the optimal concentrations are exceeded and the long-term effect of these elements on fish, a transition to metabolic depression is observed. In general, the response of the organism of sturgeon to the toxic effect of heavy metals is a complex of nonspecific adaptive reactions.

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APPLICATION OF STARTED FEED DEVELOPED IN THE REPUBLIC OF BELARUS IN GROWING-UP *ESOX LUCIUS* AND *SILURUS GLANIS* FRY

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Fish seeds of predatory fishes such as *Esox lucius*, *Sander lucioperca*, *Silurus glanis*, etc. are always in great demand among fish farms. These species are necessary both for stocking fish ponds and for stocking natural water bodies. However, the potential yield when stocking natural water bodies and ponds with non-grown-up fry is very small (0.1 %) [1]. The development of new approaches in the technology of producing growing-up fry of predatory fish species, using artificial feeds allows not only increasing the efficiency of works on reproduction, but also to reduce the use of live feeds at early stages of its cultivation.

The literature describes a number of techniques and methods for producing and growing-up *Esox lucius* and *Silurus glanis* seeds. Most authors from different countries of the world agree on the need to grow-up the fry to an increased weight condition. The use of growing-up fry significantly increases the yield of *Esox lucius* and *Silurus glanis* underyearling. Most of the methods described for growing-up fry are based on the use of different forms of feeds (nauplii of *Artemia salina*, pond zooplankton, etc.) as a starter feed. In recent years, a number of Belarusian and foreign scientists have proved the possibility of using artificial feeds for growing-up *Esox lucius* and *Silurus glanis* fry.

The most crucial moment in the life of fry is the transition from endogenous to mixed, then to exogenous type of food. During this period, there are complex histological changes in the digestive system due to a change in the objects of fish feeding. It is known that the period of onset of exogenous feeding is the most vulnerable in the life of fish. The lack of suitable feeds leads to the mass death of the larvae [2]. Scientists have shown that feeding should be started already when there are yolk sac stocks that make up at least 50% of the initial weight [3]. As a starter feed for growing-up fry of predatory fish species, artificial feeds are often used, mainly high-protein, for *Salmonidae* or *Acipenseridae*.

Starter feeds for fry of predatory fish species were developed at the laboratory of feeds and fish feeding laboratory of the Republican Unitary Enterprise «Fish Industry Institute». It includes fish meal, soybean meal, baker's yeast, egg powder, wheat germ flakes and premix. By the content of protein, fat, fiber, macro-, microelements and vitamins, this starter feed is fully consistent with needs of predatory fish fry. The content of crude protein in above mentioned feeds − 47%, crude fat − 7.0%, crude fiber − 1.5%.

The work on growing-up *Esox lucius* and *Silurus glanis* fry was carried out at the joint stock market entity Fish farm «Novinki», in the Postavskiy district, Vitebsk region. Larvae of *Esox lucius* and *Silurus glanis* were obtained from artificial spawning of brood stock in the conditions of the hatcheries. For the growth-up of the *Esox lucius* larvae, Amur apparatus with a volume of 0.2 m^3 were used, for *Silurus glanis* larvae − 2 ICA-type tanks, with an area of 4 m^2. The duration of rearing *Esox lucius* larvae was 7−10 days, *Silurus glanis* larvae − 12−15 days.

In the process of cultivation of any aquaculture object, the balance of the diet plays an important role. Survival, growth rate, specific feed conversion efficiency depends on it. To determine the optimal diet for growing these species, a different ratio between starter feeds and live food was used. Fish were fed once per day; starter feeds were given manually from 6.00 to 23.00 with an interval of 2 hours. *Esox lucius* larvae were fed with zooplankton, while *Silurus glanis* − *Artemia salina nauplii* for growing. In the control, fry received only starter feeds in the amount of 100% of the daily diet. The stocking density in all variants of the experiment was the same for 20 thousand specimen/m^3. Three experimental groups were formed for each species of fry, in which the starter feeds in the daily ration was 30%, 50% and 70%, respectively.

As the research results showed, the best for *Esox lucius* is a diet consisting of 30% of live feed and 70% of the starter feed. With such a ratio of feeds, the average yield of the grow-up *Esox lucius* fry was 65.0%, which is by 17.7 percentage points (hereinafter referred to as pp) significantly more than in the control, and by 2.0 and 1.7 pp more than in 1st and 2nd experimental groups. The maximum mass of the fry was observed in the 1st experimental group, which was 49.6 mg, which is 0.8 mg more than in the 2nd and 0.3 mg more than in the 3rd experimental group. In the control group, the minimum mean weight of larvae was 30.4 mg and the survival rate was 47.3%. Growing only on the starter feed can be considered as an alternative option in the absence of live feed or in the presence of adverse weather conditions. Specific feed conversion efficiency for *Esox lucius* fry was 4.3.

A series of experiments on growing-up *Silurus glanis* fry with using starter feeds, which was developed in the laboratory of feeds and fish feeding laboratory of the Republican Unitary Enterprise «Fish Industry Institute» also showed that it is capable of replacing expensive live feed. The smallest yield of the fry after growing-up, as in the experience with the *Esox lucius*, was observed in the control group, where the diet was only the starter feed. The average yield in this group was 55.0%, and the mean weight was 50.1 mg, which is 9.9 mg less than in the 1st experimental group, 10.8 mg less than in the second, and 13.9 mg less than the third. As in the experience with the *Esox lucius*, the best yield of the grown-up *Silurus glanis* fry was obtained in the third variant, which was 75.0%, while the mean weight reached 64.0 mg. Specific feed conversion efficiency for *Silurus glanis* fry was 2.3.

Thus, the obtained data on the growing-up *Esox lucius* and *Silurus glanis* seeds using starter feeds, which was developed at the Republican Unitary Enterprise «Fish Industry Institute» suggest that the ration consisting of 30% of live feed and 70% of starter feed is optimal. This ratio allows getting both the maximum yield of fry and high mean weight.

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PERSPECTIVES OF THE USE OF COMPLETE HIGH-QUALITY FISH FEEDS (*ARTEMIA* SP.) FROM THE HYPERSALINE LAKES OF THE NORTH-WESTERN BLACK SEA REGION FOR GROWING STURGEON FRY

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The current state of the sturgeon population is at a critical level as a result of the regulation of rivers by a cascade of reservoirs, the loss of natural spawning grounds and other consequences of human impact. To restore the populations and commercial stocks of sturgeons, as a compensatory measure, fish hatcheries have been created for artificial reproduction and subsequent stocking of sturgeon fry to the lower reaches of the Dnipro River. The technological process of reproduction and growing of viable fry mainly depends on their feeding with complete feeds with high protein content, nutritional and biologically active substances. Balanced feeding of fry with complete nutrition at the early stages of ontogenesis ensures an increase in growth rates and body weight, survival, accumulation of necessary mineral elements in the body, and normalization of metabolism.

In industrial conditions, high-quality feeds from forage mixtures of different granulometric compositions are used. At the same time, the necessary requirement for reaching sturgeon juvenile weight of more than 50 mg is to ensure the proportion of live feeds at a level of 20–30%. As live fish feeds, *Daphnia* reared in artificial trays are often used.

The best-selling analogue of *Daphnia* is the *Branchiopoda* crustacean *Artemia*, which is used as a complete high-quality live feed for the juvenile of valuable fish species. This was established in Norway and the United States in the early 30s of the

XX century, after which a massive collection of *Artemia* cysts for fish breeding plants and fish hatcheries started in the 1960s, but soon the shortage of *Artemia* began to restrain the development of aquaculture [1].

In 1977, at the FAO Technical Conference in Kyoto (Japan), Belgian scientists from the University of Ghent stated that the lack of *Artemia* cysts is an artificial problem that can be managed by searching for new sources of its existence in inoculation of *Artemia* into Brazilian water bodies [2].

The largest reserves of *Artemia* in the world are concentrated in the waters of the post-Soviet countries of various geographic zones, in the coastal zones of the Black, Azov and Caspian Seas. But to date, the locations of *Artemia* concentrations and their numbers have not been sufficiently studied, while these data are necessary to satisfy the needs of both fish rearing palnts, when feeding valuable fish species, and feed hatcheries. In particular, in Ukraine, the development of technologies for the production of granulated feeds with the addition of dry *Artemia*, as a source of protein, to meet the needs of aquaculture is extremely important.

Studies of Anufrieva E.V. and Shadrina M.V. dedicated to the biota of hyper-saline lakes in the South Ukraine indicate the presence in them in significant quantities that can be used for the effective and sustainable development of aquaculture [3-6].

The purpose of the research is to determine the state of *Artemia* stocks in coastal hypersaline lakes of the North-Western part of the Black Sea, namely in the reservoirs near the village of Geroyske, Goloprystanskyi district, Kherson region. To determine the required information, the sex structure of the population, linear and weight parameters, and fecundity at eleven sampling stations were investigated.

Among the main factors that define the living conditions and the biological state of the *Artemia* population is the hydrochemical regime of the water body. Among the variety of factors that define the quantitative development of *Artemia* populations, the main are: water mineralization, chlorides and sulfates concentration, chlorides to sulfates ratio during the growing season [7].

According to the chemical composition of water, the studied lakes belong to the chloride-sodium class, marked by high water hardness, low or medium alkaline reaction, high content of organic matter, low oxygen content. The general water hardness was on lakes from 88 to 425 mmol/dm^3. The low level of dissolved oxygen in water was noted in all investigated lakes, from 1.4–3.2 mg/dm^3. The pH was almost the same − 7.88 − 8.64. Salinity in lakes ranged from 7.72 to 141.8 g/dm^3. Significant quantitative indicators of the concentration of *Artemia* were noted in lakes with a salinity of 77.2 − 79.4 g/dm^3 and the highest indices of it with a salinity of 141 g/dm^3.

In the sexual structure, the females insignificantly dominated, the females to males ratio ranged from ♀: ♂ = 1: 0.74 to ♀: ♂ = 1: 0.93. The share of females was 51.8 to 57.4%.

The analysis of quantitative parameters for the group of hypersalinity lakes was practically the same (710–810 specimen/m^3), which probably depended on such a chemical composition of water and a size series in the population of *Artemia* of respective generations. But the largest quantitative indicators were in the lake with a salinity of 79.4 g/dm^3, amounting to 940 thousand ind./m^3. Such high abundances are typical for the summer period in July. In August, the number of adult crustaceans of *Artemia* increases by almost 30%. For example, in August the salinity of the lake increased from 79.4 to 141.8 g/dm^3, which is due to insolation, intense evaporation of fresh water, and the number of *Artemia* increased from 940 to 1380 thousand ind./m^3. The number of planktonic cysts of *Artemia* was 390 thousand ind./m^3.

The weights of *Artemia* are directly proportional to the percentage ratio in the age composition of population. Among the studied specimens there were three groups in size series for males and females. The first group of males with the smallest average length (L = 4 − 6 mm) had an average weight of 0.054 mg; II group (L = 6 − 8 mm) − 0.101 mg, group III (L = 8−10 mm) − 0.180 mg. The males had a significantly higher average individual weight, due to the morphological features and the presence of cyst in the brood pouch at different stages of development, respectively, in groups: I − 0.38 mg, II − 0.213 mg, II − 0.195 mg. It should be noted that in group III with a length of a body − 8−10 mm, males practically do not differ from females by weight, forming respectively 0.180 mg for males and 0.195 mg for females. Thus, the determination of the individual biomass of *Artemia*, taking into account the proportion of size groups in the population, allowed determining the production potential of hypersalinity lakes during peak concentrations of adult individuals in the population.

The determined biomass indicates the high development level of *Artemia* and the respective productive potential of high-quality feed stocks that can be potentially used for aquaculture. The biomass of *Artemia*, in lakes in July amounted to 140.5 to 166.4 g/m^3, while in August the highest value recorded was 243.4 g/m^3. From literary sources, the experts in artemia hypersalinity lakes have established categories by the level of productivity: <10 g / m^3 − low productivity, 10−30 g / m^3 − average productivity, 31−50 g/m^3 − high productivity, ≥ 50 g/m^3 − very high productivity [8].

Thus, the hypersaline lakes of the North-Western part of the Black Sea are classified as highly productive in terms of the development of *Artemia*, and its significant resource is not used extensively in the absence of efficient consumers. In this regard, we believe that further research is needed on the Black Sea lakes to identify the category of high-yielding *Artemia* development, to extract excessive quantities of high-quality feed for the needs of aquaculture with resource-saving technology.

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FORMATION THE BROOD STOCK OF EUROPEAN GRAYLING *THYMALLUS THYMALLUS* (LINNAEUS)

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In recent years, the problem of preserving the biological diversity of aquatic ecosystems has acquired particular importance. There is no doubt that the most vulnerable component of biodiversity and a sensitive integrated indicator of its adverse changes are rare species of animals and plants [1, 2]. Restoration of the abundance of each rare species means restoring their functions in the ecosystem, and should be regarded as an important step to conservation, and sometimes - to the restoration of biodiversity in general.

European grayling (*Thymallus thymallus* L.) in Ukraine is one of the most valuable species with unstable abundance and insufficiently studied fish. Therefore, there is an urgent need to develop methods for the formation of its brood stock and technological links of artificial propagation in order to maintain a constant population of this species. One of the ways of such propagation and preservation is the creation of special reserves (protected areas, natural parks, etc.). The above-mentioned measures can become the basis for increasing the efficiency of both natural and artificial propagation of European grayling. At the same time, the creation of genetic resources will be solved with the aim of preserving this species for subsequent reproduction of the population abundance [3, 4].

Brood stock is the basis of both the fish hatcheries and the full-system fish farm. The main purpose of the work was to create an initial stock of European grayling. In this regard, one of the main tasks among the problems in reproduction of this species was the development of technology for the formation of brood stock in artificial conditions and its adaptation to conditions of captivity, untypical for natural populations. Age-2+ fish were cultivated in a pond with an area of 135 m^2 with a depth of 0.8 m and full water exchange three times a day. In the winter, the water temperature fluctuated within 2−5ºC. Fish feeding in these conditions was carried out every other day using the high-protein feed "Inicio plus" (pellet size of 2 mm) and "Efico Alpha 717" (pellet size of 3 mm) of the Danish company "Biomar". The mean weight of the age-2+ fish in September was 69.1 g with the length of 23.6 cm. The condition factor was 1.2.

The cultivation of age-2+ fish was carried out in a pool of 4.5 m^2. The water temperature during the year ranged from 2 to 17ºC. According to foreign literary sources and from practical experience of Slovak and Polish fish hatcheries, it is known that growing grayling when fed with artificial feeds is carried out only up to age-1+. Specimens, who become mature, are advised to be fed exclusively with natural feeds. When feeding with artificial feeds, the formation of eggs occurs in females, but they are not suitable for fertilization. In this regard, 8 months before the spawning, the diet of the replacement stock of the European grayling was changed from artificial to natural. In our studies, frozen midge fly larvae − *Chironomidae* were used. The conversion of the natural feed for the period of the formation brood stock was 6 units. A long practice of work with European grayling during the reproduction process showed positive results of application for the anesthetic "Propiscin". However, in 2017, after the ban in the EU countries of this preparation, fish were anesthetized with clove oil. Ovulation of eggs in the first spawning females occurred without stimulation. In mature males, after light pressure on the abdomen, milking was observed, and ovulated eggs flowed freely out the female. The average weight of brood stock, which was cultivation in fish farms conditions, used for reproduction was 181.3 g, and the mean length was 25 cm. Weights of males ranged from 190 g to 260 g, females − from 134 to 200 g; length of females − from 24.5 to 29.0 cm, males − from 26 to 32 cm. The average fecundity of females was 2762 eggs. Fertilization rate was 60%. Fulton's condition factor for European grayling was 1.1 in females and 0.9 in males.

Reproductive parameters of age-2+ females grown under artificial conditions and first used in spawning were characterized by high fluctuations of their fecundity from 2193 to 3511 eggs. The relative fecundity ranged from 15.18 thousand to 17.55 thousand eggs. Compared to the age-2+-3+ females from natural water bodies, the average working fecundity of females grown under artificial conditions were higher by 35%. The ejaculate volume of males grown under artificial conditions was 0.4 ml^3 on average, which was similar to that of natural populations. Temperature of the water during spawning was 5−7ºC. The sexual products were obtained in two stages, due to the uneven maturation of eggs. Preventive treatment of the eggs was carried out at the eyed ovum stage with formalin solution at a concentration of 1: 2000 with an exposure of 15 minutes. The yield of eggs after fertilization was 40% on average.

According to the results of the work on the cultivation of European grayling in the conditions of industrial trout farms of the Carpathian region, a technology has been developed that provides the opportunity for the formation the brood stock of this fish species. The above-described technology ensures a scheme of an uninterrupted cycle of the production of young-of-the-year for stocking, as well as the use of a part of juvenile fish for the annual renewal of the European grayling brood stock.

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COMPARATIVE ANALYSIS OF THE GENETIC STRUCTURE OF UKRAINIAN CARP OF ANTONINSKY-ZOZULENETS BREEDS

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Selection and breeding work covers the issues of fixing the genetic potential of existing breeds of Ukrainian intrabreed types of carp and monitoring of the accumulation of changes and features of the genetic structure, preservation of the gene pool of rare and unpopulated carp arrays, the creation of new types of high-backed few-scaled carp with improved economic characteristics, including the use of genetic resources of foreign selection [1].

The creation of the broodstock of Antoninsky-Zozulenets carp was the initial moment for establishment of the Ukrainian scaled and framed carp breeds. These breeds have shown their great potential for achieving high production results in conditions of intensive production on fish farms.

The Antoninsky-Zozulenets array of carp is the hereditary foundation of many types of Ukrainian carp, so research of the gene pool and consolidation of genetic potential are important tasks. Research in this direction require a comprehensive analysis using molecular-genetic markers.

Quantitative evaluation of electrophoretic protein mobility has become a real possibility using the methods of biochemical genetics.The most important aspect of such approaches is the correspondence of the gene that encoding the protein and its product, which can be identified by electrophoretic methods, that is, the correspondence of the phenotype and genotype. The main genetic position of population dynamics are based on the principle of proximity of the gene and the feature. These genetic position allow us to solve numerous practical questions of domestic fish farming [2].

The purpose of this work was to carry out a comparative analysis of the genetic structure of the Ukrainian framed and scaled carp of the Antoninsky-Zozulenets intra-breed types based on the analysis of the frequency distribution of alleles and genotypes by polymorphic genetic-biochemical systems.

Blood samples were taken from the tail vein in the framed and scaled carp of the Antoninsky-Zozulenets type (n-35) from PJSC "Khmelnitsky rybhosp" (the Volohysk district) in 2018.

Analysis of polymorphism and distribution of allelic variants of proteins were performed by electrophoretic separation method in starch and polyacrylamide gels with histochemical staining [3]. The following genetic-biochemical systems were studied: the transport proteins group - transferrin (TF), albumin (ALB), ceruloplasmin (CP), purine nucleoside phosphorylase (PN) and hemoglobin (HB), group of enzymes metabolizing a variety of exogenous substrates - esterase (EST) and group of enzymes of glucose metabolism - amylase (AM).

The differences between scaled and framed carp of the Antoninsky-Zozulenets type were found out as a result of a comparative analysis of the genetic structure of certain genetic-biochemical systems of plasma and erythrocytes.

Five allelic variants were identified by transferrin loci in this study: Tf A,Tf B, Tf C_1, Tf C_2, Tf D. Analysis of the transferrin genotypes showed that only 12 of the 15 possible combinations were present, among which the C_1C_1 genotype was dominant. The allele Tf C_1 was dominated with the highest frequency (0.600 in scaled and 0.367 in framed carp), that was confirmed by previous studies of the genetic structure also in carp of Lublin intrabreed types which had a similar pattern of alleles distribution in the TF loci [4]. The alleles Tf A and Tf D had a significantly lower frequency, so the frequency of the allele Tf A was 0.200 in the scaled and 0.333 in the framed carp, and the frequency of the Tf D allele was 0.167 and 0.333 in the scaled in the framed carp respectively.

Albumin was represented by two allelic variants (A and B) in the studied groups of scaled and framed carp, as in many other species [5]. The distribution of slow and fast allelic variants (A, B) by the Alb loci was in equilibrium state, so frequencies of the allele A were 0.600 and 0.550 in scaled and framed carp, and frequencies of allele B were 0.400 and 0.450 (in scaled and in framed carp respectively).

Esterases include 4 groups of enzymes with different functions. Esterase forms are inherited codominantly as in the case with transferrin inheritance. Differences between populations can be demonstrated by comparing the concentration of the esterase alleles in the blood of control groups of individuals. For carp, this quantity is usually 3-4, but it can reach 7 alleles [6]. Two allele esterases were found: F-fast and S-slow forms. Frequency of Est F prevailed in both populations, so the frequency of the allele in the framed carp was 0.667, and in the scaled carp - 0.867. There was no SS genotype among the three expected genotypes of esterase in scaled carp. The unbalanced state of the esterase loci was observed in both populations, because there was a statistically significant excess of heterozygotes according to the Hardy–Weinberg principle.

TF, ALB and EST loci were polymorphic. Amylase, hemoglobin, purine nucleoside phosphorylase, and ceruloplasmin loci were monomorphic.

The allelic variant TF C_1 was observed with the highest frequency by TF loci. The predominance of this allelic variant is characteristic of Ukrainian carp breeds. The ratio of actually detected genotypes by TF loci is closer to the theoretically calculated in framed and scaled carp breeds.

The unbalanced state of the EST and ALB loci due to a significant excess of heterozygote was observed in both investigated carp groups. This may indicate certain processes of genetic consolidation of these populations.

Thus, these genetic and biochemical systems in combination with phenotypic traits will allow to further assess the level of genetic variability, genotype composition, degree of intra - and interpopulation differentiation which are important indicators in the process of selective breeding work.

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CURRENT STATE AND ENVIRONMENTAL ASPECTS OF THE FORMATION OF ECOSYSTEMS IN THE ESTUARIES OF THE NORTHERN BLACK SEA REGION

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Odesa region has is a significant number of Black Sea estuaries, namely: a group Tuzla estuaries, Sasyk, Shabolatskyi, Dnistrovskyi, Sukhyi, Khadzhybeiskyi, Kuialnytskyi, Dofinivskyi, Hryhorivskyi, Tylihulskyi and a number of smaller estuaries. They constitute an important part of the water fund of the region. In recent years, their ecosystems underwent significant changes [1].

For a long time, the estuaries were used by the inhabitants of the northern Black

Sea region for shipping, fishing, and salt mining. In the XX century, the intensity of estuaries used for commercial purposes sharply increased. New settlements, deep-water seaports, industrial enterprises, pumping stations, resorts have grown on their banks; shipping and connecting channels was built across barrier spits [2].

However, fish farming and fishing remain one of the main areas of commercial exploitation in the estuaries [3]. The estuaries characterized by high biological productivity and feed supply, respectively, can provide a significant yield of table fish and others aquaculture products.

Despite the fact that the Black Sea estuaries are well studied regarding fisheries (their feed supply, fish fauna, numerous recommendations for improving fish productivity have been developed), their fisheries have developed unevenly and are currently in a poor condition.

The general deterioration of the ecological state in the North-Western part of the Black Sea is caused by human impact, and, in turn, leads to a decrease in the fish productivity of all Black Sea estuaries [1].

Despite the difficult ecological condition of the Black Sea estuaries, they have largely retained their high biological productivity, and fish farming and fisheries in these estuaries has good prospects. Achieving satisfactory results is possible only with the implementation of a set of targeted actions to improve fish productivity, adapted to the individual conditions of each estuary.

At present, ecosystems of the estuaries, which develop in natural conditions, are degrading and almost completely lost their fisheries importance and only a small part of them remain safe and highly productive. In cases of decline, human intervention in the development of estuary ecosystems can significantly improve their condition. But fisheries are not interested in supporting large-scale intervention projects in estuary ecosystems, which may lead to the complete loss of water bodies for fisheries, or cause diverse negative environmental consequences in the region.

In current conditions, there is a risk of irrational use of financial and material and technical means for implementation of ill-conceived fish farming activities and projects - stocking reservoirs with unsuitable species composition and length-weight characteristics, building doubtful fish-breeding facilities, carrying out inefficient reclamation, research and development, etc.

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FISH-BIOLOGICAL CHARACTERISTICS OF DANUBE SALMON (*HUCHO HUCHO* L.) BREEDERS

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Danube salmon (*Hucho hucho*) according to the taxonomic status of the modern taxonomy of salmonids belongs to the genus *Hucho*. Its range of distribution are the rivers of the Danube basin. In Ukraine, the holovatytsia (the local name of the Danube salmon) within the Transcarpathian region inhabited the rivers Teresva, Tereblya and Rika, which are the tributaries of Tysa, as well as the Black and White Tysa, in Subcarpathian region – the tributaries of the Prut River. The Danube salmon has a special genetic value as a representative of the most ancient branch of salmonids [1]. In particular, it should be noted that this is exclusively valuable table fish, but is classified as non-commercial species due to the low population size. The current state of Danube salmon populations in Ukraine is on the brink of extinction.

The priority for the reproduction and cultivation of the Danube salmon belongs to Slovak Republic. Scientists Holcik J., Hensel K., Nieslanik J., Skacel L. in the monograph "Hlavatka. *Hucho hucho*" mention the artificial cultivation of this fish in the foothills of the Budyatin castle (Slovak Republic) in 1690. However, the authors note that fish grown in ponds were caught from natural water bodies [2].

A significant achievement for the preservation of the Slovak population of *Hucho hucho* was a government decree in 1924 that established the status of a fish farm near Zmiiev and obliged to catch breeders from the Orava River, collect eggs, to incubate them, grow-up fry and re-stoke them in the Orava River, as well as to form the initial brood stock.

The history of artificial reproduction of *Hucho hucho* in the Orava River has more than a century of tradition, and the peak was achieved thanks to the fish farmer S. Ivashko, who authored numerous publications on biology, technology of reproduction and breeding the Danube salmon from 1935 to 1959 [2].

The work of Polish specialists who in 1948 organized a research laboratory to carry out work on the artificial reproduction of *Hucho hucho* at the «Lopuszna amateur and sport fishing station» near Krakow, deserve attention and imitation. Impressive is the fact of documenting the provision of these scientific works, which was officially approved in 1941. For 71 years of existence, the laboratory has developed technologies for the artificial reproduction of *Hucho hucho* and *Thymallus thymallus*, and the breeding stock of these species were grown on the farm and allows re-stocking natural water bodies with viable fry every year [3].

We should note that attempts to recreate the Danube salmon in Transcarpathia were made in the 1930s, but the larvae died during the incubation. An unfortunate experience has shown a lack of awareness of the biology of the object. Currently, artificial reproduction has taken a worthy place in the strategy for the conservation of Danube salmon in Ukraine. For this purpose, the SE «Lopushno trout farm» was redeveloped, in which growing conditions most closely correspond to the biological characteristics of all life cycle stages of the Danube salmon.

Formation of the Danube salmon broodstock was carried out in the Chernivtsi region at the above mentioned enterprise, however, the breeders was caught in the Teresva River [4]. For the study we used healthy age-6-7 breeders grown using certified European specialized artificial feed.

The average weight of the body of age-6 Danube salmon females was 2596 g and had a wide range of fluctuations from 1700 to 3700 g; the average length of their body was 69.9 cm, with a variation of 62 to 78 cm, respectively. The males, on average, had a weight of 2859 and an average length of 71.6 cm, with fluctuation margins ranging from 1850 to 3400 g, and 61-78 cm respectively.

The average weight of age-7 Danube salmon breeders used in spawning was 3331.3 g with an average length of 74.9. The weight of males fluctuated from 2080-4850 g, females - from 2350-3500 g; in length: 68-84 cm and 66-78 cm, respectively. Fish growth during the year reached 760 g.

The condition factor brood fish of both age groups was identical - 0.77.

The collection of sexual products from age-6-7 Danube salmon breeders was performed without hormonal stimulation. Analysis of the reproductive indices of age-6-7 females showed that the average working fecundity of age-6 females was 6,603 eggs with fluctuation from 5882 to 7794 eggs, and in the average working fecundity in age-7 fish was 7309 eggs (6958 - 8671 eggs).

Compared to obtained data on the productivity of artificially grown brood fish with retrospective data K. Vlasova (1959), there were somewhat higher rates in wild fish, since the age-6 females caught in Tysa River had a weight of 4200 g and its absolute fecundity was 8540 eggs [5]. At the same time it is necessary to keep in mind that the working fertility is naturally lower in comparison with absolute, and the growth of fish in the natural environment, in the presence of sufficient amounts of feed organisms, is usually higher than when cultivated under artificial conditions. That is, the conditions of aquaculture and feeding with specialized artificial feeds do not reduce the fishery and biological parameters of Danube salmon in comparison with native populations.

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MODERN ASPECTS OF STURGEON CULTURE IN REPUBLIC OF BULGARIA

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The aquaculture in Republic of Bulgaria belongs to relatively new areas of economic activity and does not belong to the structurally-defining sectors [1]. After a sharp decline of aquaculture in the 1990s, it is beginning to recover by the end of the first decade of the 21st century. Today in Republic of Bulgaria aquaculture is characterized by a desire to diversify farmed hydrobionts. In addition to fish farming, the cultivation of mollusks is developing. Also, great interest is directed to the development of the production of delicatessen, with a high market price, species whose products can be sold on foreign markets. Such species are representatives of the *Acipenseridae* family. Sturgeon culture in Bulgaria was started at the end of the last century. Despite a brief history, sturgeon culture plays an increasingly important role of the aquaculture in Republic of Bulgaria. The aim of the work is to characterize the modern aspects of sturgeon culture in Republic of Bulgaria.

Used generally accepted methods of scientific analysis of the information array, collected from specialized sources (scientific publications, statistical materials, regulatory documents, etc.).

The development of aquaculture is inextricably linked with the state and development of commercial fishing. It is the critical deterioration of natural fish stocks that has led to an increase in the production of aquaculture products [2]. Particular concern is the state of the natural populations of representatives of the *Acipenseridae* family, in which a significant number of species are critically endangered (CR). The conservation and sustainable management of aquatic biodiversity is a difficult task, due to the specific characteristics of aquatic ecosystems. In Republic of Bulgaria out of 104 endangered species (EN) of animals and plants, 22 are fish [3]. All representatives of the *Acipenseridae* family in Republic of Bulgaria are recorded in the listed in the International Red List of Threatened Animals and Plants. A century ago, *Huso huso* (Linnaeus, 1758), *Acipenser stellatus* (Pallas, 1771), *Acipenser gueldenstaedtii* (Brandt et Ratzeburg, 1833), *Acipenser ruthenus* (Linnaeus,1758), *Acipenser nudiventris* (Lovetsky, 1828) and *Acipenser oxyrinchus oxyrinchus* (Mitchill, 1815) were found in the Danube river. Today, the *Acipenser oxyrinchus oxyrinchus* is considered to have disappeared, a *Acipenser nudiventris* practically does not occur, and the rest are in critical condition. In the EU, natural *Acipenseridae* populations still exist only in Republic of Bulgaria and Romania, but they are rapidly disappearing from the Danube river [4; 5]. In addition, the genetic structure of their populations is changing [6].

In a number of countries, a ban on sturgeon fishing was adopted [5, 7, et al.]. For the protection of hydrobionts in the Danube river has developed a general plan [5]. In 2001, Republic of Bulgaria Bulgaria developed a “Action Plan for sturgeon fish in the Bulgarian area of Danube and Black Sea„ [8]. The paper provides data on sturgeon catches in the last century. In the period of 1920−1926, the total catch of sturgeon species ranged from 29.3 to 72.4 t; 1945−1949 − from 25.2 to 39.2 t. (according to Drensky); 1960−1974 − from 31.5 to 43.3 t (according to Marinov). Figure 1 demonstrates the dynamics of sturgeon catches in Republic of Bulgaria of the period 1987-2011.

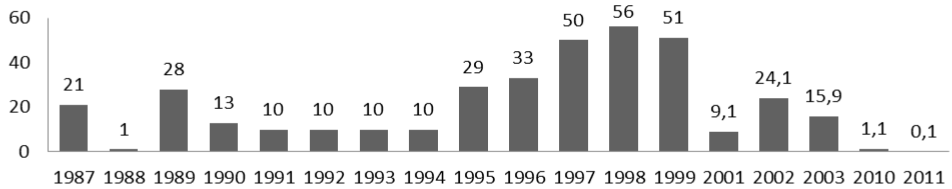


Figure 1. **Sturgeon catches in Republic of Bulgaria, t [9; 10]**

In addition to a sharp decrease in the number of catches sturgeon from the Danube river, there was a significant change in the species composition of catches [11]. Thus, in the middle of the last century, the *Acipenser gueldenstaedtii* occupied almost half of the total catch in the Danube river. The remaining part was occupied by *Acipenser stellatus* and only 5.7% was accounted by *Huso huso* [8]. In the period 1960-1974, more than half of the catch came from *Acipenser ruthenus*, the number of *Acipenser gueldenstaedtii* decreased by 22%, and *Huso huso* more than five times. At the end of the 20th century, the main part of the catch was *Huso huso* and in second place was *Acipenser ruthenus*. In the period 2010–2011 catches only included *Huso huso* and *Acipenser ruthenus*, with the number of *Huso huso* being three times higher than *Acipenser ruthenus* (Tab.1).

Table 1. **Sturgeon catch in the Bulgarian Danube River sector for the period 1945–2011 [8; 9]**

Species	Period, years				
	1945-1949	1960-1974	1995-2001	2001-2003	2010-2011
H. huso, %	5.7	4.6	79.1	58.6	75
A. gueldenstaedtii, %	50.8	28.7	10.5	9.8	–
A. stellatus, %	43.5	8.4	6.7	14.3	–
A. ruthenus, %	–	58.3	3.7	17.3	25
average per period, t	32.5	36.0	25.3	16.4	0.1-1.1

Despite the availability of strategic documents and the efforts of scientists to conserve natural populations of the *Acipenseridae* [6; 8; 11; 12], the situation has not changed for the better. The catastrophic state of sturgeon populations required urgent action not to limit, but to ban their catch. Thus, in Republic of Bulgaria, since 2012, the catch, any movement and sale of sturgeon fish and their products has been completely prohibited. In 2016, this ban was retained for another 5 years [9]. It does not apply to fish and products obtained in aquaculture conditions.

Aquaculture has an important role in saving natural sturgeon populations [7; 13 et al.]. The value of aquaculture is primarily determined by two aspects. First, when banning sturgeon fishing, it is the only legal source of sturgeon products for the consumer. Secondly, aquaculture is an effective tool for reducing the anthropogenic pressure on the remaining sturgeon populations in the wild nature. Despite the importance of sturgeon culture development, this branch of aquaculture is not well developed in Europe [14]. So, Europe is a large market, but a weak producer (it produces only 1.23% of world aquaculture production). Basically, *Mytilus* (about a quarter of the total), *Salmo salar* and *Oncorhynchus mykiss* (a total of about one-third of the total cost of production) are grown in Europe (*https://ec.europa.eu/fisheries)*.

For Republic of Bulgaria, the development of sturgeon culture is not only an important source of increasing the efficiency of aquaculture, but also one of the primary tasks in rescuing local populations of sturgeon fish species. Sturgeon culture in Republic of Bulgaria began to develop in 1995, when in Bolyartsi village, Plovdiv region, created the first sturgeon fish farm. Today, this farm is the ancestor of sturgeon fish cultivation and is a leading producer and exporter of black caviar.

Despite its successful development, the share of sturgeon culture in total production of aquaculture in Republic of Bulgaria is still insignificant, with negative trends in recent years (Fig. 2).

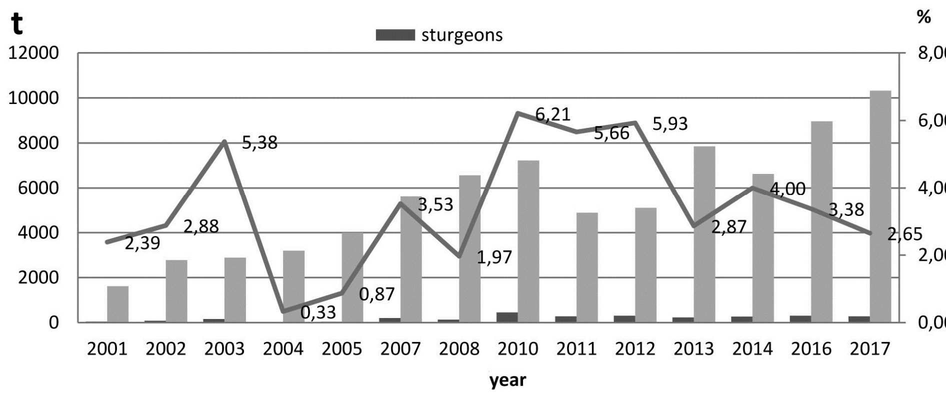
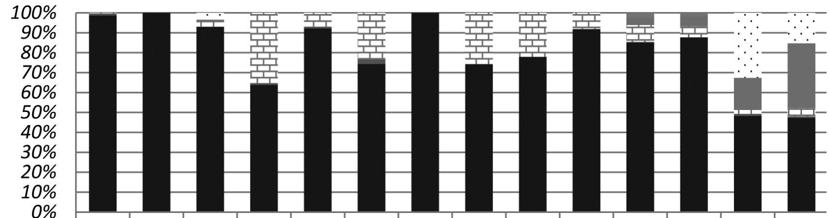


Figure 2. **Share of sturgeons in the total fish production in Republic of Bulgaria.**

By the beginning of 2019, 21 fish farms, who are engaged sturgeon culture appear in the official register [15]. 10 of them are registered only for produce sturgeon culture. In the Republic of Bulgaria was created full-system sturgeon farms, in which commercial fish grown in cages located in large reservoirs. Also, there is a diversification of farmed species in this sturgeon farms (Fig. 3).

Sustainable development of sturgeon farming is possible only on the basis of scientific research and insights. Vasilieva [7] notes that, for the successful development of sturgeon breeding, along with other factors, it is necessary to use modern biotechnologies for growing fish; availability of restock material; high-quality specialized feed. Such high-tech farming requires good cooperated operation between science and practice.

In the Republic of Bulgaria Bulgaria, scientific research on sturgeon fish species is extremely insufficient and they mainly concern natural populations [6; 12; 16; 17; 18 et al.]. The first scientific studies dedicated for representatives of the *Acipenseridae* family, cultivated under conditions whith intensive cage technology, began at the Department of Animal Science at the Plovdiv Agrarian University on the basis of a private sturgeon farm.



Year	2001	2002	2003	2004	2005	2007	2008	2010	2011	2012	2013	2014	2016	2017
Hybrids, t	0	0	5,3	0	0	0	0	0	0	0	0	0	98,6	41,8
A. stellatus, t	0	0	0	0	0	0	0	0	0	0	5,6	4,7	1	1
A. baerii, t	0	0	2	0	0	0	0	0	0	0	8,2	13,4	47,8	88
H. huso, t	0,1	0	3,4	3,7	21,5	46,2	0	115,1	61	24,4	19	14,3	5,9	11,4
A. ruthenus, t	0,4	0	0,3	0,1	2,2	4,6	0	0,4	0	0,6	0,7	0,4	3,1	2
A. gueldenstaedtii, t	38	80	144	6,7	281	147,1	129,1	333,2	215,4	277,6	191,6	232,3	146	129,6

Figure 3. **Structure of the sturgeon aquaculture in the Republic of Bulgaria [9]**

The work is carried out with both native and introduced species and hybrids. Investigate reproductive characteristics of sturgeon fish in the conditions of intensive technology cultivation. The Department of Animal Science at the Plovdiv Agrarian University collaborates with the Institute of Biology and Immunology of Reproduction at the Bulgarian Academy of Sciences. The first results of cooperation are presented at scientific conferences [19; 20]. At the department, together with scientists from the University of Food Technologies, they are developing a scientific project to improve the productive and functional qualities of sturgeon in aquaculture [21; 22; 23; 24]. The development of this project is a good example of successful cooperation not only of scientists from different directions, but also of science and practice.

Sturgeon culture in the Republic of Bulgaria belongs to relatively new areas of economic activity. Sturgeon culture began to develop at the end of the last century and has good development prospects, taking into account the state of the natural sturgeon populations and a total ban on their fishing. In our days started a comprehensive research in the field of sturgeon culture. They are mainly devoted to improving the quality of products and reproduction in the conditions of intensive aquaculture.

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DEVELOPMENT OF METHODS TO REDUCE THE EFFECT OF TRANSPORT STRESS IN JUVENILE FISH BY STEEPING THEM INTO *Β*-GLUCANS SOLUTION

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An important role in reducing losses during transportation of juvenile fish caused by a decrease in their viability due to the stress they suffer, plays both the transportation process itself (compliance with the requirements of water parameters, minimization of mechanical stimuli, etc.) and additional measures. In particular, use of drug therapy and prevention. Together with anesthetics used mainly in the transportation of broodstocks and some other chemotherapeutic agents, there are agents based on natural monosaccharides.

In modern aquaculture, *β*-glucan is used as a feed supplement [5], as a drug for intraperitoneal and rectal administration. These methods are not convenient for use in juvenile fish and do not always have the possibility to be implemented in the process of transporting live fish. Therefore, the development of a method that will allow the use of β-glucan for fish directly in the transportation process is of great practical interest both for industrial aquaculture and for environmental protection measures.

β-glucans are monomeric polysaccharides that are part of natural raw materials. Of particular interest is *β*-1,3/1,6-glucan contained in stacks of yeasts fungi, higher fungi as well as some bacteria. Glucose in these molecules is attached in positions 1 and 3 with a branch in positions 1 and 6 [1]. The studies of the action of this substance suggest its effect on reducing the stress on fish organism [2]. The positive effect of *β*-glucans in fish has been broadly studied [3], [4]. The effect of *β*-glucan on the fish organism has much in common with the processes occurring in the organism of all animal species. Thus, β-glucans activate and strengthen the innate immunity, thereby ensuring the protection of the body against invading antigens, and *β*-1,3/1,6-glucans activate both non-specific and specific immunity.

A special place in preserving the biodiversity of water bodies is played by measures related to the stocking of water bodies with juvenile fish produced at fish farms. An integral part of such measures is transportation of fry to the site of fish release. The technique of *β*-glucan application developed by us will significantly reduce the loss of juvenile fish both during transportation and during the adaptation period in the natural environment, by increasing the overall resistance and reducing the effect of stress factors.

To confirm the above mentioned an experiment was conducted. In this experiment, parameters of leukocyte formula were monitored during 30 days after imitation of transportation. A conclusion on significant positive effect of this monosaccharide on fish immunity was made based on the ratio of these parameters in the group with and without the use of *β*-glucan solution.

In the future, works will be carried out to improve the methods of the application of *β*-glucan solutions to reduce the effect of stress factors and increase the overall resistance of juvenile fish organism.

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EFFECT OF ANTHROPOGENIC FACTORS ON NATIVE ICHTHYOFAUNA

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In connection with the development of technogenic society, the anthropogenic pressure on water bodies is growing quite intensively. Neglect of environmental safety standards leads to deterioration of the sanitary state of water bodies, the death of hydrobionts and other systemic problems [6]. At the same time, changes in hydrological parameters of water bodies, increases in catches, improvement of fishing gears contributed to the fact that some aquatic species disappeared, the number of others significantly decreased, and ecological niches filled with third species, for which new living conditions became more acceptable [1].

The anthropogenic impact on the ichthyofauna leads to unpredictable consequences: water pollution negatively affects the genetic structure of populations, regulation of river flow leads to the formation of isolates and a significant change in the genotype reaction, irrational fishing and the introduction of new fish species causes a significant reorganization of biocenological links and leads to the displacement of one species with others. This disrupts the basic principle of environmental protection – the preservation of the natural biological diversity of environmental objects [4].

A significant amount of fish is mainly caught from the basins of large rivers. Among the rivers of Ukraine, the main fishery important water objects are the Dnipro (among its tributaries – the main ones are Pripyat and Desna), the lower Danube, somewhat less – Dnistro, Southern Bug and Siverskyi Donets [5].

Creation of the cascade of the Dnipro reservoirs led to a significant reduction in river flow, gradually led to a decrease in the area and useful volume of floodplain lakes and estuaries of the lower reaches of this river. Such actions caused the loss of the ability of reservoirs to self-repair, the appearance of marked processes of degradation of natural hydro-ecosystems (eutrophication, siltation, waterlogging, formation of hydrogen sulfide zones) and caused certain disruptions of the ecological conditions of existence of valuable aquatic species of high trophic levels.

The economic activity of communal, industrial and agricultural enterprises leads to the reduction and elimination of hydrobionts, including natural feed organisms. Destruction of biotopes contributes to the reduction in the absolute number of hydrobionts; in particular, certain species of plankton and benthos disappear. The noise factor, which occurs as a result of logging and gravel extraction from the river bed, leads to the scaring of fish from shallow waters, which are favorable places for spawning, creates obstacles to the free migration of breeders of valuable fish species to the spawning grounds and feeding areas located upstream, complicates the conditions for fry emigration. Erosion processes associated with log trailing cause significant contamination of water bodies with suspended substances, which, in turn, cover with eggs with mud, make it difficult for fry to breathe and in some cases lead to their death [2].

As a result of the increased human impact on biogenesis of continental waters, some representatives of native ichthyofauna were endangered and were included in the Red List of Threatened Animals and Plants of Ukraine. In connection with this, an actual problem that requires an urgent solution is the preservation of the gene pool and the formation of brood stocks of rare and endangered fish species.

Today, the problem of the restoration of flood waters and native ichthyofauna of the river-flood network in the rehabilitation environment is extremely important, as confirmed by the conclusions of the International Union for the Conservation of Nature (IUCN). Due to insufficient number of purposeful, scientifically substantiated and practical strategies for regulating habitats of invading species from the state in the near future, it is possible to predict the further increase in their quantities and new water bodies, which they have invaded. This will undoubtedly negatively affect the quantitative and qualitative composition of the native ichthyofauna of water bodies [1].

At present, Ukraine has not yet developed a basic system and methodology for the effective conservation of the gene pool of rare and endangered fish species and the genetic structure of these species of various populations has not been determined. The main purpose of the research should be to assess the current state of populations of individual rare and endangered species of sturgeons and salmonids listed in the Red List of Threatened Animals and Plants of Ukraine, and to develop a holistic mechanism of the scientific basis and methodology for preserving their gene pool with subsequent reproduction of the population sizes [3].

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DISEASES RISK ASSESSMENT OF NATIVE SPECIES FROM *SALMONIDAE* FAMILY IN UKRAINE

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The world aquaculture production has increased at an average annual rate of 6.2%. Aquaculture is one of the fastest growing food-producing sectors, supplying approximately 40% of the world's fish food [1]. However, while modern aquaculture systems provide high yields, many still have a negative impact on the native species and environmental safety in whole. There is no reliable official comprehensive data on the viral diseases in salmonid aquaculture of Ukraine, but available reports indicate the presence of dangerous viruses in aquaculture facilities [2, 3]. Taking into account that few fish viruses have been detected in aquaculture recently, they can imply a considerable risk for native species directly in the environment.

The cell culture assay and PCR were used for the virus detection and the infectious diseases risk assessment as described in OIE manual [4]. Three viruses from the

Birnaviridae and *Rhabdoviridae* families were identified for rainbow trout (*Oncorhynchus mykiss*) aquaculture systems connected with rivers. Thus originating in aquacultural facilities viral disease could be transmitted to the native salmonids (e.g. susceptible fish species such as brown trout, huchen, grayling, etc).

To decrease the risks associated with the viral diseases, various regulations should be developed in Ukraine. In addition, it is necessary to prevent viral diseases in farmed aquatic animals by vaccination, by prohibition of uncontrolled fish transportation, to improve culture systems, and to monitor the infectious agents and the diseases spread. As a multidisciplinary approach, the fish health inspection for both aquacultured and native fish should be promoted by scientists, veterinarians, fish producers and policy makers.

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REALIZATION OF THE SPAWNING OF THE MOZAMBIQUE TILAPIA *OREOCHROMIS MOSSAMBICUS* (PETERS, 1852) USING THE METHOD OF PITUITARY INJECTION

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Tilapia is a member of the Perciformes order, Percoidei suborder, Cichlidae family, Tilapiinae subfamily. It has a high, flattened laterally body, one long dorsal fin with a large number of rays, the front part of which there are needle-shaped rays, body color is matte greenish or yellowish [1].

According to FAO, by the growth rate of aquaculture production, in 2004 tilapia ranked first amounting to more than 1.82 million tons. Tilapia is cultured in more than 120 countries. The largest producers are China (897.3 thousand tons), Southeast Asia (Philippines, Indonesia, Thailand), Mexico, Egypt. In Europe tilapia is cultivated in Germany, France, Belgium, Czech Republic, Bulgaria, Ukraine and some other countries. The natural habitats of tilapia are reservoirs of Africa, Jordan and Israel [2, 3].

The Mozambique tilapia *Oreochromis mossambicus* (Peters, 1852) was the object of the study. The studied individuals were caught in the cooling reservoir of the Zaporizhzhya NPP at age-0+ and they were grown up to age-2 in the laboratory. Biological analysis of fish was carried out in accordance with generally accepted ichthyological methods. As the physiological method, pre-dried and prepared pituitary of cyprinid fish has been used.

During the experiment, 2 mature tilapia females and 2 males were selected. The total length of females was 112 mm and 134 mm with an individual weight of 22.1 g and 40.7 g, respectively. The total length of males was 163 mm and 156 mm, and their individual weight was 57.6 g and 51.8 g respectively. Pituitary injection was performed as follows: for preliminary injection – 0.5 mg of the pituitary gland per 100 g of fish weight; for provoking injection – 1 mg per 100 g of fish weight. Based on the individual weight of the fish, the preliminary injection dose to females was 0.11 mg and 0.2 mg, respectively; males – 0.29 mg and 0.26 mg. The provoking injection dose to females was 0.22 mg and 0.41 mg, respectively (table. 1).

Table 1. **Linear and weight parameters and calculation of pituitary injections for Mozambique tilapia**

Sex	♀	♀	♂	♂
Total length (L), mm	112	134	163	156
Standard length (l), mm	90	106	135	126
Weight, g	22.1	40.7	57.6	51.8
Preliminary pituitary injection, mg	0.11	0.2	0.29	0.26
Provoking pituitary injection, mg	0.22	0.41	–	–

According to the calculation, the preliminary pituitary injection was made for females and after 24 hours – the provoking injection for females and previous for males. Then, the breeders were placed in pairs in separate 200 L aquaria, where nests were already formed. The male had nuptial dress, the next day the spawning of fish occurred; 126 tilapia fries were obtained. Thus, the results showed a positive use of pituitary injections for physiological stimulation of tilapia spawning.

Tilapia is a promising species of freshwater aquaculture in Ukraine and one of the main species grown in industrial fish farming. The pituitary injections can significantly accelerate the development of sexual products, thereby making it possible to control the speed and time of spawning.

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GROWING JUVENILE RUSSIAN STURGEON (*ACIPENSER GULDENSTAEDTII BRANDT & RATZEBURG, 1833)* WITH ADDING INACTIVATED BAKER'S YEAST TO THEIR DIET

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Intensive development of sturgeon aquaculture in recirculating aquaculture systems (RAS) ensures maximum use of the growing potential of all members of this family of cartilaginous fishes – *Acipenseridae*. At the same time, it is well-known that one of the biggest problems during the development of life-sustaining sturgeon fingerlings is the harmonization of the features of their digestive system with starter feeds available on the market. Feeds for sturgeon, for the most part, in its prescribed composition, differ significantly from the natural food supply of this age group of fish. As a consequence, feed producers and farmers are confronted with doubtful situations of uneven growth of sturgeon juveniles, with its subsequent prolonged deceleration and the emergence of a number of nutritional disorders caused by the organism depletion due to inappropriate nutrition. Thus, the greatest losses of the number of Russian sturgeon under conditions of industrial cultivation are registered during the first month of their post-embryonic development. Accordingly, it is important to search for the optimal components of start feeds, which would satisfy not only the requirements for the somatic growth of juvenile, but also ensure the harmonious development of all systems of the body, including the formation of the immune system. Recently, inactivated baker's yeast began to be used in fish farming as a biologically active additive to the main feed. For example, it is known that their application in this way has a positive effect on the organism of both salt-water and freshwater fish. Studies of a broad range of scientists underline the immunomodulatory effect of inactivated baker's yeast and the possibility of their use as a transfer of nutrients, vitamins and minerals.

Using yeast as well as their products formed through biosynthesis in sturgeon aquaculture lasts several decades. The main advantage of this particular group of single-celled fungi in starter fodder is the presence in their composition of a large number of easily accessible oligopeptides, amino and nucleic acids, which are easily digestible by a rapidly growing organism. However, they also contain substances that are not digested or not absorbed, and in certain concentrations, they can even cause contamination with a negative result for the fish organism. Therefore, it is extremely important to carry out an analysis of the effects of various concentrations of inactivated baker's yeast on the growth potential of Russian sturgeon juveniles and related metabolic processes. This will allow them to find out their optimal doses in starter feeds for fish of this species, while growing under the conditions of RAS [1−3].

Studies have been carried out during the last few years (2016−2018), at the Experimental Fish Farm of Lviv Research and Experimental Station of the Institute of

Fisheries of the National Academy of Agrarian Sciences of Ukraine. The objects of study were yolk sac larvae of Russian sturgeon placed in a recirculating aquaculture system (RAS). The larvae were raised at a temperature of 16°C. The dissolved oxygen content in water was 7.00 − 8.12 mg/dm^3.

As a result of the research, it was found that the use of inactivated yeast in the feeding of Russian sturgeon fry immediately after its transition to feed starter fed increased survival rate by 16.5% and promoted intense growth. It was also found that in order to achieve optimal fishing effect on the growth of young Russian sturgeon it is advisable to use yeast in the amount of 15% during the first two weeks after switching to artificial feeding, and 5% of the weight of the main feed for the next 2 weeks. This combination allows increasing the body weight gain for 24 days by 20,24%, as well as reduce the mortality by 6.7% compared with the control group. The use of inactivated yeast as a supplement to feed of 5, 10 and 15% positively affects the exterior features of the Russian sturgeon fry. In particular, the average body width of fish is increased by 4.5 − 9.1% relative to the control group, which indirectly indicates optimal nutrition conditions.

Histological studies confirmed the positive effect of the additive to the starting feed of inactivated yeast on the morphological structure of the digestive organs of Russian sturgeon. In particular, the use of 10% yeast from the weight of the main feed in feeding contributes to an increase in the height of the microvilli and the layer of glycocalyx by 38.2% relative to the control group, which significantly improves digestion and transport of nutrients.

It has been proved that feeding 5% of the weight of the main feed of yeast in the sturgeon diet, during the 24 days from the beginning of the transition to feeding with artificial feed, has a positive effect on the fish system of antioxidant protection. This is manifested in reducing the intensity of the formation of the product of dysmutation in their liver − hydrogen peroxide, as well as in the absence of a difference in the content of malondialdehyde in the liver of the control and experimental groups. In addition, it was found that the use of 15% yeast during four weeks of n sturgeon feeding with artificial feed reduces the content of triacylglycerols (TAG) in the liver by 34.24% relative to the control group. The probable difference in TAG content in the liver of sturgeon from the control and experimental group, which fed 5% yeast, was not detected.

In our research, we confirmed the hypothesis about the positive effect of feeding with the use of inactivated yeasts on the activity of digestive enzymes in the intestines of Russian sturgeon fry. Thus, the growth of α-amylase activity was found to be 83.0% and 25.0%, relative to the control group, seven days after the start of experimental feeding with the addition of 10 and 5% of inactivated yeast, respectively.

Introduction to the diet of Russian sturgeon of inactivated baker's yeast in the amount of 15% of the weight of the main feed, during the first week of its transition to feeding artificial fodders, causes an increase in lipase activity by 51.8% relative to the control group. This confirms the expediency of using a higher concentration of baker's yeast during the first weeks, followed by a transition to a lower concentration, namely 5% [4].

The use of inactivated baker's yeast in feeding young Russian sturgeon has a positive effect on its protein metabolism. So, when baker's yeast is fed in an amount of 5% by weight of the main feed, for two weeks, the activity of the main amylolytic enzyme − trypsin − increases by 12.2% compared to the control group, and when fed 15% − by 14.8%.

The use of inactivated baker's yeast as an additive to starter feed for Russian sturgeon in conditions of RAS will be appropriate in an amount of 15% within two weeks after its transition to feeding on artificial feeds. The next − the third and fourth weeks − should be fed 5% to achieve the optimal effect. The above scheme of feeding allows to get higher by 25,18% in comparison with traditional, productivity of Russian sturgeon cultivation.

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PERSPECTIVE DIRECTIONS OF USING THE ONLY REPLACEMENT-BROOD STOCK OF BELUGA (*HUSO HUSO* L.) IN THE REPUBLIC OF BELARUS

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The public joint-stock company «Experimental Fish Farm «Selets»», situated in Berezovsky District, Brest Region (Republic of Belarus), formed the only in Belarus an aquaculture the replacement-brood stock of *Huso huso* (L.) of 877 specimens (303 specimens are contained in warm-water aquaculture and 574 specimens in cold-water aquaculture) of age-11 fish. The population affiliation and species purity of the *Huso huso* in the formed stock still remained unexplored.

According to the task of the State Program of Scientific Research (GPNI "Genomika", 2019-2020), scientists and managers were tasked to create an elite replacement-brood stock of *Huso huso* in the Republic of Belarus and determine the possibilities of its further use. To accomplish this goal, ichthyological, fish breeding and genetic studies of *Huso huso* in aquaculture were planned and started, promising areas were identified for using the results of research on individual genetic certification for specimens in order to conduct targeted breeding and commercial cultivation of *Huso huso* on fish farms in the country to increase the efficiency of sturgeon breeding, to obtain expensive Beluga black caviar, as well as to assess the possibilities of introducing fry into natural water bodies for the purpose and species conservation in natural watercourses. Also promising areas were identified for using the results of research on individual genetic certification of specimens in order to conduct targeted selection and commercial cultivation of *Huso huso* on fish farms in the country to increase the efficiency of sturgeon breeding, to obtain expensive Beluga caviar, and also to assess the possibility of introducing fry into natural waterbodies. To achieve this goal, ichthyological, fish breeding and genetic studies have been planned and initiated on beluga in aquaculture.

In the spring of 2019, 122 *Huso huso* specimens contained in pools in warm-water aquaculture were tested. With the aid of an individual ultrasound scan of the *Huso huso*, it was found that the replacement and brood stock is represented: 66.4% were females at stages 2−3 of gonad development; 29.5% were males at 2−3 stages of testes development; 4.1% of individuals whose sex could not be determined (non-selection). The average weight of females was 53.26±8.6 kg (minimum - 31 kg; maximum - 69.0 kg); males - 42.73±7.76 kg (minimum 32.0 kg; maximum - 63.0 kg); disassembly - 43±5.18 kg. For 7 *Huso huso* specimens, measurements of a number of morphometric parameters were carried out. Individual chipping of females and males by external labels from Hallprint (Australia) companies with the selection of biological samples for molecular genetic identification studies was also carried out. A qualitative sperm was obtained from one of *Huso huso* males, which were at 3 stages of testes maturity, by means of injections of Surphagon, which was successfully used for hybridization with other sturgeon species (*Acipenser ruthenus*, *Acipenser baerii*).

Among the promising areas of study and use of the only one in the country repair-brood herd of *Huso huso* can be attributed to the following work:

1. Assessment of the species purity and determination of its population by using molecular - genetic methods;

2. Formation of an elite herd with chipped internal electronic tags individuals with registration of an individual genetic passport;

3. Use of genetic data for the development of intraspecific crossing patterns in order to exclude inbreeding;

4. The use of sperm for hybridization with other sturgeon species. Selling sperm to different fish farms;

5. Development of technologies of artificial reproduction in order to obtain fry for the needs of fish farms in the Republic of Belarus and neighboring countries. Commercial cultivation in fish farms up to 1.5-3 kg, getting balyk products;

6. Growing females to produce expensive black caviar with the aim of selling it in the Republic of Belarus and foreign markets. When organizing caviar sturgeon production, especially when exporting, it is necessary to take into account the requirements of CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora), according to which the sale of expensive and delicious sturgeon products is carried out only from aquaculture farms. For this purpose, it is necessary to organize genetic certification of broodstock;

7. Export part of broodstock and fry to the countries of near and far abroad in order to breed and preserve this species in natural habitats;

8. Consider the possibility of introducing chipped fry into the natural waterbodies in to the Dnipro River basin with the aim to creating local freshwater populations;

9. Develop efficient technologies for the cultivation of beluga for industrial, pond and pasture farms, various types and forms of ownership;

10. To develop a complex of sanitary and veterinary measures for the control, prevention and control of diseases and parasites;

11. Improve the methods of ultrasound scanning and other methods for the purpose of rejecting substandard females;

12. Develop technologies for sperm cryopreservation and use it's as a commercial product for use in aquaculture and preservation of endangered species in natural watercourses;

13. Utilize the capabilities of the RAS, the Belarusian State Regional Power Plant, the Belarusian Nuclear Power Plant under construction, the communal property energy complexes in order to increase the number of *Huso huso* in Republic of Belarus.

CONDITION ASSESSMENT OF THE ABORIGINAL FISH SPECIES FROM THE BAY IN KYIV RESERVOIR

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The study of ichthyological material was carried out in the commercial fish farm created in a lagoon in the Kyiv reservoir. In this lagoon, which is a separate area of the reservoir, 15 commercial fish species were recorded (in total, commercial fishery statistics records 24 commercial fish species in the Kyiv reservoir). The majority of the catches of small-meshed nets was white bream *Blicca bjoerkna* (45.5% by number) and Prussian carp *Carassius auratus gibelio* Bloch (24.6% by number). In large-mesh nets, silver carp *Hypophthalmichthys molitrix,* bighead carp *Hypophthalmichthys nobilis* (immigrant commercial fish species), and common carp *Cyprinus carpio* composed 65.8% of the catch by number and 86.1% by ichthyomass. The native ichthyofauna in the bay is characterized by a rather high proportion of commercial valuable fish species, which indicates the possibility for organizing an intensive fishing of the formed fish stock with a high level of selectivity. The total commercial stock of native ichthyofauna in this bay is 146 kg/ha, which is three times as much as that for the Kyiv reservoir.

Fish of juvenile and median age groups composed the majority of the native fish species population. Older age groups (exclusively small ordinary fish species) in the catches were presented by single specimens (Table 1).

Table 1. **Mean biological parameters of native fish species in the lagoon commercial fish farm of the Kyiv reservoir, M±m**

Species	Modal age groups, years	Length, cm	Weight, g	Fulton's condition factor
Abramis brama	5–7	29.5+1.1	603+56	2.33+0.05
Sander lucioperca	2–3	31.3+2.0	464+73	1.46+0.13
Blicca bjoerkna	4–5	18.3+0.9	171+20	2.38+0.11
Carassius auratus gibelio	5–6	21.4+1.3	405+67	3.58+0.17
Perca fluviatilis	4–6	21.3+1.8	233+31	2.26+0.12
Cyprinus carpio	3–4	32.8+3.3	1273+340	3.63+0.22

The structure of the modal and oldest age groups of the majority fish species of the ichthyofauna in this lagoon significant differed from those of the Kyiv reservoir. Thus, the weighted mean length of the common bream *Abramis brama* in the Kyiv reservoir was 32.1−36.8 cm, for pikeperch *Sander lucioperca* it was 36.0−38.0 cm, and for the white bream Blicca bjoerkna − 19.0–24.0 cm [1].

A mode shift to the right side of variation range on the background of its shortening observed for the studied fish in the lagoon indicates an increased elimination of medium and older age groups of major commercial fish species. At the same time, taking into account the quantitative parameters of their catches, we can conclude that the number of juvenile age groups is high, thereby, the dynamics of stock core recruitment of fish populations can be considered balanced.

In the conditions of this lagoon, we can see the most optimal harvest model for commercial fish farms − juvenile age groups are practically not harvested, while mass harvest of formed ichthyomass occurs when they reach certain commercial conditions. Thus, the share of nets with mesh sizes a-40-50 mm accounted for 22.6% of the total catch of common bream *Abramis brama* (as control efforts of the nets) in number and 22.2% in weight, and the share of nets with mesh sizes a-60 70 mm − 11.4 and 13.4%, nets with mesh sizes a-80-90 mm − 1.8 and 2.5%. For Prussian carp *Carassius auratus gibelio*, these values were, respectively, 39.5 and 40.1%, 5.6 and 10.6%, and 0.1 and 0.2%. In nets with mesh sizes a-100 mm, native species were noted in isolated cases.

It should be noted that in this case the reproductive core of the population would be formed mainly by first spawning specimens, while the number of age groups in the spawning stock will be limited (no more than two). The latter circumstance significantly increases the risk (in the case of the appearance of several adjacent low-yield generations) of undermining the reproductive capacity of the local stock. The calculated average weighted number of spawning events for small ordinary fish species according to the exploitation scheme will be 3.1, and for large ordinary fish species − 1.8 (compared to average for ordinary fish species from the Dnipro reservoirs − 3.2 [2]).

At the same time, as mentioned above, high quantitative values allow to a certain extent neutralizing the deterioration of the qualitative structure of the spawning stock, while the ability to regulate the distribution of the commercial fishing pressure across different age groups makes it possible to reduce the overall mortality rate to the natural level.

The integral indicator, which characterizes recruitment, mortality and feeding conditions is the size of the commercial stock (Table 2).

Table 2. **Estimated commercial stock of ihtiofauna in lagoon used for commercial fish farm**

Species	Number, thousand specimen	Fish stock, tons	Fish productivity, kg/ha
Hypophthalmichthys	11.8	22.9	50.9
Cyprinus carpio	23.7	22.0	48.9
Abramis brama	25.6	15.2	33.8
Sander lucioperca	6.3	2.9	6.4
Carassius auratus gibelio	113.0	33.5	74.5
Perca fluviatilis	10.9	2.7	5.9
Blicca bjoerkna	66.2	9.0	20.0
Others	12.3	2.4	5.4
All	269.8	110.6	245.8

The data of table 2 indicate that the total commercial stock of the ichthyofauna in the lagoon can be estimated as 250 kg/ha, more than 50% of which is accounted for native ichthyofauna. In accordance with the approved limits for the commercial catch of aquatic bioresources in the Kyiv reservoir, the total commercial stock of the native ichthyofauna is 3.4 thousand tons or 44.9 kg/ha if calculated for the total water area. Thus, due to the effective strategy for the protection and use of the ichthyofauna, the fish productivity of lagoon, which is used by commercial farming, increased by 3.3 times for native fish species.

The implementation of ranching aquaculture in the conditions of a separated area of a large reservoir allows maintaining stable characteristics of ichthyocenosis due to the almost complete absence of pressure on juvenile groups of native fish species with intensive harvest when they reach commercial size.

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SPATIAL BIOMARKER TO ASSESS THE CONDITIONS OF THE REPRODUCTION OF NATIVE FISH IN SURFACE WATERS OF UKRAINE

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Problems of the propagation of native fish in Ukraine's surface waters started appearing simultaneously with the inclusion of rivers and lakes in water management complexes (regulation, irrigation, sewage disposal, hydraulic engineering, hydropower), as well as with changes in the structure of the surface of land catchment area of dry valley hydrobiocenoses (plowing of river and lake basins, forest cutting, non-compliance with the status of coastal water protection zones and protective belts, drainage reclamation). Many researchers have pointed out problems of the reproduction of native fishes [1, 3, 4]. However, no changes occurred in management policy. As a result, in Ukraine, which has significant water resources, the issue of effective natural reproduction of native fishes has become urgent; fish productivity of the river-lake network has decreased several-fold, the need for the restoration and rehabilitation of transformed water bodies has arisen [1, 2, 3, 4, 5].

Objects and methods of the study. The objects of the study were right tributaries of Prypiat (Styr, Horyn, Sluch, Ikva, Stokhid, Vyzhivka rivers, small Khrinnytske and Mlynivske reservoirs, large reservoirs of the Dnipro river system of dams, lake system in the Shatskyi National Nature Reserve, estuarine system of the Dnipro, Dniester and Danube rivers).

Study results and discussion. Disruption of the natural propagation of fish in aquatic ecosystems was determined based on the state of the catchment surface state, aquatic environment quality, biological diversity and fish productivity of water bodies, which are related by a functional relationship:

$$I_{diversity} = f\left(\Delta K_{эк}, \frac{\sum I_n}{n}, \Delta n, N, St, \tau \right) \quad (1)$$

were: $\Delta K_{ек}$ – transformation of the catchment surface; $\sum In/n$ – average characteristics of the accounted indices of the hydrobiocenoses and aquatic environment state $\sum In/n = \frac{Ia + Ib + Ic + Iэ}{n}$; Δn – change in the abundance or species composition of fish due to the introduction, restoration (disappearance) of sensitive species; N – the number of border (intermediate) ecotones; St – presence of stressful situations; τ – floodplain flooding period.

With this approach, we can study correlations, determine the limiting factors influencing the diversity and productivity of water bodies in order to control the situation. The presence of environment-forming factors makes it possible to compare the level of disturbances in moderately transformed and very congested basins, flowing and non-flowing water bodies with natural (non-transformed) ecosystems or basins.

Indeed, the classification of the state of surface waters and the indexation of the state of aquatic environment can be carried out on the basis of the anthropogenic factor of influence − with respect to the maximum permissible concentration, sensitivity to the oxygen regime, food supply. However, a comparison of the results of field studies only in relation to undisturbed water bodies, without taking into account the ichthyo-ecological state of the water basin, entails the possibility of a methodological error.

The parameters of the river's ecosystem vary depending on the level and period of stay of water on the floodplain, where: river water is settled and cleaned to quality class I; live food (zooplankton) develops in it and the temperature rises to 10−12°C, which are necessary for spawning and embryogenesis of most native fishes; at the same time, the number of border zones — ecotones, which are migration routes for fish under unfavorable environmental conditions — disruption of the oxygen regime, lack of food supply and deterioration of water quality, increases. Such boundary ecotones tend to become tributaries of the rivers I and II class, sources, and topographic lows − phantom lakes-spawning grounds.

Based on the above, we proposed a spatial biomarker to assess the reproduction conditions of the native fish in waters, by finding the physiologically necessary characteristics of the black box − the state of the aquatic environment [fig. 1].

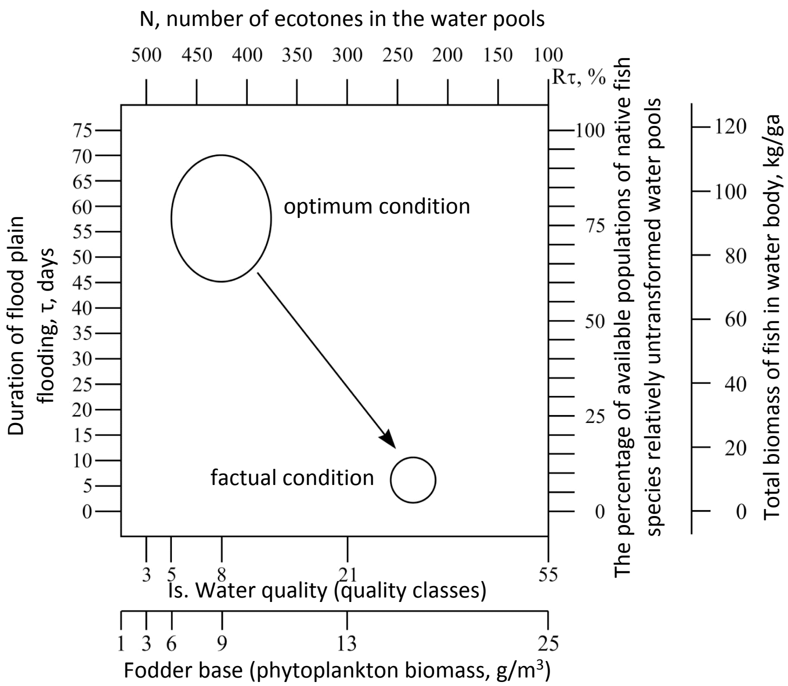

Fig. 1. **Spatial biomarker to asses the reproduction conditions of ichthyofauna in river basins**

The least costly and most realistic trend of fish stocks replenishment in Ukrainian water bodies is the restoration and rehabilitation of the natural process of native fish reproduction in the river-lake network in regions.

Among the priority measures, following should be done:

– identification of spawning and wintering grounds in river basins, their certification and protection;

– restoration and rehabilitation of wintering grounds in river mouths - tributaries (I & II class);

– cutting and removing phytomass of higher aquatic vegetation from natural spawning grounds, which, when decomposed in shallow waters, creates hydrogen sulfide zones − cause of fish egg and juvenile fish death;

– adherence to the protection of the coastal protective strips, the prohibition of fishing during spawning and spawning run periods;

– creation of the Verhniy Dnipro Reserve with the core in the Kyiv reservoir for biodiversity conservation on the basis of the reserve network (National Nature Reserve Shatskyi and Prypiat-Stokhid), biosphere reserves (Poliskyi, Rivnenskyi), including the adjoining territories of Poland and Belarus, whose water resources create a single hydroecological corridor.

The spatial biomarker of the conditions for reproduction of native fishes, the components of which is: the duration of floodplain flooding, the number of ecotones, the quality of the aquatic environment, the feed reserve (zooplankton), the state of populations and the number of fish products, is proposed. Behind such an approach, we can see the correcting links, determine the customer's responsibility to increase the productivity and efficiency of the situation.

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A VALUE CHAIN APPROACH AS A KEY ELEMENT IN PROFITABILITY IMPROVEMENT OF FISHERIES ENTERPRISES

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Profitability improvement is a key factor determining the further development of the fisheries and aquaculture industries. These resources are needed to improve the material and technical base and to establish new technologies [1] that will lead to harmonizing the work of the industry in Ukraine and the EU, as well as bringing the work of the fisheries industry in the line with European environmental and social standards. At the same time, the main source of funding for these events will be the enterprises' own funds or concessional loans from relevant European financial institutions, which must also be returned by final beneficiaries from their own funds. Therefore, today the question of the economic efficiency of fisheries and aquaculture enterprises is extremely urgent and relevant [2, 3, 4].

Unfortunately, the majority of fisheries companies put special attention only for fish harvesting efficiency. They have effective gillnets, nicely trained crews and good experience in commercial fish harvesting [3, 4]. However, storage of fish and its transportation is tremendously overlooked. Commercial fishing companies must sell fish immediately after harvesting for smaller prices to small local aggregators that dictate prices and keep them as low as possible. This economic issue do not meet the requirements of efficient business management. The loans for certain enterprises are high and their financial condition does not allow modernization and renovation of an outdated fleet, the mechanization of fishing and the introduction of new means and methods of fishing. Their profits are enough for the minimum wage of workers, the purchase of new gillnets and minor fleet maintenance [3,5].

Investigations showed that if the enterprise install the cold chain it will be able to store fish longer time and collect fish for a while. After that, this enterprise will be able to attract bigger customer, such as processor of wholesaler, who will give up to 50% better price for the same fish species. Generally speaking, the cold chain facilities are very useful to achieve food safety norms and usually pay off in 1-2 years. In addition, proper transport might help the producer to establish direct long turn contracts with fish processing company and double the income. Numerous leasing companies could provide proper vehicle for reasonable price.

It is necessary to mention that this approach might be relatively hard for small SMEs. In this occasion, some commercial fishing cooperatives look more reliable. Some small SMEs may gather, purchase facilities and share them later. They will be able to aggregate fish and attract wholesalers that give better prices, like it was implemented in some countries of South-East Asia [1].

Furthermore, formal agreements with a processor or a wholesaler can show the bank real money flow and make fishing enterprises "bankable" and give them an access to loans and other products of banking sector that might help small business to grow.

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