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USING OF THERAPEUTIC AND PREVENTIVE FEEDS OF STURGEON FARMING IN CLOSED WATER SUPPLY SYSTEMS

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The monograph presents biological peculiarities and characteristics of sturgeon fish, the influence of biotic and abiotic factors on the development and productive growth of sturgeon fish, including in the case of cultivation and breeding under conditions of closed water supply sytems.

The possibilities of control and management of sturgeon fish pathologies under conditions of closed water supply through the use of therapeutic and prophylactic feeds to compensate for the impact of aggressive factors of the aquatic environment are shown.

The recipes of therapeutic and preventive feeds for sturgeon fish under conditions of industrial aquaculture are developed.

The materials of the monograph will be of interest to scientists, teachers of higher educational institutions, students, undergraduates, doctoral students of fishery and biological specialties, specialists of fish-breeding organizations.

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THE CONTENT

INTRODUCTION

The development of commercial sturgeon farming will help to solve a number of environmental and socio-economic problems and issues related to the reduction of sturgeon stocks in the Caspian Sea. These include: reduction of poaching pressure and fishing pressure on sturgeons by obtaining alternative sturgeon products without using natural fish populations, creation and preservation of breeding stock of endemic sturgeons in aquaculture conditions and later in commercial sturgeon farms, partial restoration and increase in the number of sturgeons with preservation of their gene pool, increase in the number of environmentally friendly production facilities in Kazakhstan for growing commercial sturgeons and food products from them. Knowledge of basic biological features of fish farming objects, optimal conditions of their development, biological bases of nutrition and ability to rationally use various feed mixtures and their separate components in a form acceptable for fish and to ensure their correct application is the basis of success of each fish farm.

One of the most profitable and fastest growing sectors of fish farming is industrial aquaculture. Various fish diseases are one of the main problems facing this industry. Moreover, in recent years, industrial fish farms have been taking planting material from different farms to form breeding herds, which in turn contributes to the spread of diseases.

Closed water supply facilities allow organizing a stable production of commercial sturgeon farming regardless of environmental conditions. The realization of this task requires specialists, modern fish breeding equipment and dry full-grade pelleted feed, as well as therapeutic and prophylactic feed for the prevention and treatment of fish pathologies [1, 2].

Unfavorable environmental conditions (handling, poor feed and water quality) have a negative impact on the fish organism, weaken and increase its susceptibility to opportunistic bacteria that can cause infectious process in latent and acute form.

During sturgeon farming, there is an increase in the level of organic pollution and the number of opportunistic bacteria in the aquatic environment. At a certain concentration of microorganisms in the water of fish breeding tanks, their sharp increase in fish organs and tissues occurs. At the same time there are cases of weakening of general condition of fish and occurrence of various diseases, in this regard, research aimed at the development of therapeutic and prophylactic feeds for the prevention and treatment of fish pathologies, are a necessary task when growing fish in closed water supply conditions.

In this respect, the development of such an innovative product is an important task of industrial fish breeding as an applied scientific research area. Therefore, the development of recipes for therapeutic and prophylactic feeds to increase the resistance of sturgeon fish to various alimentary and bacterial diseases is relevant.

The materials presented in the monograph are devoted to research on the development of formulation of therapeutic and prophylactic feeds for sturgeon fish in the conditions of industrial aquaculture, summarizing the results of our research over the past few years during the implementation of the project of the Ministry of Education and Science of the Republic of Kazakhstan: «Development of a prescription of therapeutic and preventive feeds for sturgeon fish under conditions of industrial aquaculture».

According to the results of scientific and (or) scientific-technical activity (hereinafter - RSSTA) of this project was registered project № 24RK0163 «Innovative technology of production of mixed fodder for fish, birds and farm animals».

Today, within the grant for commercialization of scientific and (or) scientific-technical activity results with JSC «Science Fund» the project «Innovative technology of mixed fodder production for fish, birds and farm animals» for 2024-2026 on the basis of «Zhamalbek» LLP of Mangistau region is being implemented.

CHAPTER 1. THE FEEDING AND CULTIVATION PROBLEMS OF VALUABLE FISH SPECIES IN CLOSED WATER SUPPLY SYSTEMS

In Kazakhstan, it is perspective to develop technologies of cultivation of species of regional importance, having high adaptive abilities in relation to the conditions of cultivation in artificially created environment, where the condition of sturgeons under conditions of biological purification from organic and microbial contaminants when using combined feeds is of great importance. [3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14]. The most important and most abundant sturgeon species inhabiting the Ural River and the Caspian Sea is the Russian sturgeon. This object relates to both artificial reproduction and commercial farming.

1.1 The farming sturgeon fish under closed water supply conditions, types and structure of closed water supply systems

The attempts of artificial reproduction of Russian sturgeon as an object of aquaculture began in the early 19th century, but work on commercial cultivation became known only in the postwar years. Hybrids of sturgeon and sterlet have performed worse than the Russian sturgeon. The Russian sturgeon is suitable for commercial farming under industrial conditions, but it has a low yield of marketable products per unit weight and is inferior to the bester hybrid in terms of growth rate. Hybrids of Russian sturgeon with sterlet, Siberian sturgeon, and hybrids of Siberian sturgeon with sterlet have found application in commercial sturgeon farming, but their growth rate has not been sufficiently studied [15, 16, 17].

The body of the Russian sturgeon is elongated, spindle-shaped. The snout (rostrum) is short and blunt. The antennae without fringes are located closer to the end of the snout than to the mouth. The lower lip is interrupted. Body between rows of bugs may be covered with star-shaped plastids placed in several rows. There are 15-31 gill rakers. The sturgeon of the Azov population has a shorter head and a shorter snout than the Black Sea-Caucasian sturgeon. Coloration is extremely variable. The latest ichthyologic summaries do not list subspecies of the Russian sturgeon; nevertheless, the Russian sturgeon is morphologically and biologically heterogeneous throughout its extensive areal range [18]. It is a large fish inhabiting the Caspian Sea and other seas, reaching a length of 215 cm and a mass of 65 kg. In the Azov Sea, the average market weight of male sturgeon was 10-11 kg, female was 23-25 kg, and the maximum weight was up to 100 kg [19]. The Azov sturgeon has the fastest growth rate, and then follows the Volga-Caspian sturgeon. Sturgeon from the northwestern part of the Black Sea had the slowest growth rate [20].

In natural conditions, sturgeon can form hybrids with beluga, spike, sterlet, and stellate sturgeon [21].

The fertility varies from 70 to 800 thousand calves. The incubation period is about 9 hours. Sturgeon larvae are 10.5 to 12 mm long and, although they have a negative reaction to light already at the earliest stages of their growth, they begin to be partially carried down the river, making characteristic “candles” in the water column. After reaching a length of slightly more than 20 mm, sturgeon fry start actively feeding first with zoo-plankton and later with small benthos. After eclosion, some of the larvae “hide” under the gravel and remain in the river for a longer period of time. The population is maintained mainly by artificial reproduction at fish breeding plants [22, 23].

In the basin of the Azov Sea, sturgeon migrated to Don and Kuban rivers to reproduce. In Kuban it rose above the mouth of the Laba River. The main spawning river was the Don, where sturgeon migrated to spawn up to the area of the Tsimlyanskaya dam [19]. The duration of caviar development depends on water temperature and lasts no more than 3-4 days. The period of yolk feeding is 8-10 days, mixed feeding - up to 5 days. Young sturgeon feed on crustaceans (mysids, amphipods, cumaceans, chironomid larvae). Due to the growing shortage of producers and the impossibility of implementing spring fishery passes, even in the presence of adequate water reserves in the Tsimlyansk reservoir, the restoration of natural reproduction of sturgeon in the near future is not realistic, and the existence of the population will be maintained only by artificial reproduction. [24].

Artificial reproduction of the Russian sturgeon and methods of its domestication, up to full-cycle breeding at fish farms, are not only becoming increasingly important, but are in fact the only way to conserve this species in the modern period. Nevertheless, the Russian sturgeon is becoming more and more popular as an object of marketable fish farming.

Recently, industrial aquaculture has become widespread in the world, using intensive methods with high planting densities and high yields per unit volume or area. One of the forms of industrial aquaculture development is the fish farming and other hydrobionts in closed-cycle water-use facilities [25].

The development of systems with controlled environmental parameters is relatively recent. In Germany, work in this area began in 1960. French fish breeders carried out works on housing seafish (gobies, etc.) with partial water change. Such installations are increasingly being used in developed, originally fishing countries, for example, such as Norway. In Russia, the cultivation of hydrobionts in closed systems dates back to 1966, when V.K. Mozgov developed the method of year-round cultivation of fishes [26].

Since the 1960s, many different plants have been developed. The most famous of them is “Stellermatic”, developed in Germany by Theo Steller for continuous fish farming all year round. The installation consisted of 6-8 fish-breeding pools, sump pool, pump, compressor, control panel with water consumption of 0.2 ml/sec per 1 kg of fish. It was possible to keep up to 225 kg of fish in the pool. The oxygen level in the water coming into the fish-breeding pool was up to 15 mg/l. The monthly production was about 1.5 tons. Carp, canal catfish, trout and eel can be reared in this syste [17].

In 1978, Estonian specialists created a water recycling plant "Biorek" for trout farming. According to Asi A.A., 1980 [27], the plant consists of 6 pools of 2 $м^3$ each, two pumps, water heating unit, plate submerged biofilter (surface area 470 $м^2$), vertical sedimentation tank, technical oxygen enrichment system. The volume of the system is 40 $м^3$. Full water exchange is realized in 4 hours. Feed distribution is automated, in contrast to the installation "Stellermatic". The system holds up to 900 kg of trout at a time, which is 75 kg/$м^3$. The total energy consumption is 15 kW/h.

When operating such plants, the production process is fully independent of climatic conditions and its continuity despite the season [28]. Creation and successful operation of closed water-use plants opens new horizons for the conservation of rare and endangered species of various hydrobionts and their reproduction.

Due to the fact that a necessary condition for the maintenance of producers in the pre-spawning period is the creation of an optimal hydrological regime, work is being actively carried out to create optimal conditions for the maintenance and cultivation of sturgeon fish and their hydrobionts in the pre-spawning period.

Cultivation of hydrobionts in closed water supply facilities is associated with solving a number of very important problems related to water treatment, since in the system of closed water supply the planting density is many times higher than in the natural habitat. As a consequence, there is a huge increase in the concentration of substances of various degrees of toxicity (ammonia, NH_4^+, etc.).

Significant input of fodder and feed organisms also contributes to the pollution of the fish farming system. In this connection, various water filtration systems have been developed to prevent the death of farming objects [29, 30].

In closed circulation plants, the water flowing out of the fish tanks is treated, conditioned, oxygenated and returned to the fish tanks. An additional water supply is required to cover evaporation costs - 2-5 % per day of the total water volume in the plant. The plants can be located in industrial centers of any climatic zone. The only limiting factor for increasing fish production is feed of appropriate quality [25].

Closed systems for fish farming are conditionally divided into open and closed.

Closed systems are facilities for industrial fish farming, which have at their disposal a system of water regeneration and operate on a constant amount of heated water released into the external environment (installations of the type «Stellermatic»).

Closed circulation systems when using water have advantages and disadvantages. The main advantage compared to other methods is insignificant water consumption for the production of 1 ton of fish. This system is autonomous, does not depend on the surrounding conditions and does not have a harmful effect on them. The ingress of poisonous substances into the plant can be reduced to a minimum. The risk of introducing parasites and pathogens is reduced. This system is relatively independent of the energy base, transportation routes and occupies a small land area. But at the same time, more qualified personnel is required to service these systems.

There are 4 main blocks in the structure of closed water supply systems:

1. Fish tank block
2. Mechanical filtration block
3. Biological purification block
4. Water preparation unit, which includes ozonization of water, its disinfection, etc.

Mechanical water purification is used to reduce the concentration of suspended substances. After fish-breeding basins it is recommended to install a collecting basin, where water from fish-breeding basins enters, here there is a partial sedimentation of suspended solids, which undoubtedly facilitates the operation of the mechanical filter and increases the interval between washing the filter. As a rule, the mechanical filter is located immediately after such a collecting basin. However, according to S. Spoth (1983) [31], the physical sedimentation block should be included in the system after the biological reactor. It is difficult to agree with this statement for a number of reasons. In water about 70 % of ammonia is formed from suspended substances in water, and even their partial removal allows to get rid of 20 % of this substance [25].

In fish-breeding installations, from a regular settling tank to complex multistage filter systems with various fillers such as, for example, diatomaceous, gravel, sand, expanded clay, etc. are used. Using only a settling tank as a mechanical unit is not effective enough. The water purification effect reaches 40% when settling for 1.5 hours. A large number of suspended substances contributes to the development of heterotrophic bacteria, and also leads to inhibition of nitrification, in addition, additional time and oxygen are required for their oxidation and, as a result, an increase in the size of the biological treatment unit. The sediment that accumulates at the bottom of the settling tank, decomposing, causes secondary water pollution with decay products, so these accumulations must be regularly removed from the system. [31].

In some cases the use of flotators is known, which capture suspended particles and remove them in the form of foam into mud collectors. In this case, sand-gravel and other pressure filters are much more effective than sedimentation tanks, but at high loads there is siltation of the filter material, which is corrected by backwashing the filter with sufficient water.

The role of biological water treatment is the utilization of contaminants by microorganisms in the processes of mineralization, nitrification and denitrification. Biological water purification is the most important condition for the operation of closed aquaculture systems. If the recycled water is used more than three times, biological purification is mandatory. It allows to provide satisfactory conditions of fish habitat at high planting density. Taking into account the special importance of bio-logical water purification in closed water supply systems, there is a need to dwell on it in more detail. This method is based on the ability of microorganisms to use as a nutrient substrate many organic and some inorganic compounds contained in the treated water. Biological water purification is carried out in special facilities: biofilters, aerotanks, biological ponds and directly in the soil on the filtration fields, where there is a specific microflora or activated sludge. The biofiltration process can also be carried out to varying degrees in a mechanical treatment unit.

The conversion of ammonia (ammonium) into nitrate (nitrification), both in soil and water, is carried out by nitrifying bacteria, but there is no bacterium that can immediately convert ammonia into nitrate. The process consists of several stages, each stage being the responsibility of a different group of microorganisms.

The species of nitrifying bacteria are represented below:

- by bacteria that oxidize ammonia (Nitroso-): $NH_4^+ + 1^1/_2O_2 \rightarrow NO_2^- + 2H^+ + H_2O$, *Nitrosomonas europaea*, *Nitrosomonas multiformis*, *Nitrosomonas briensis*, *Nitrosomonas oceanus*;
- by bacteria that oxidize nitrite (Nitro-): $NO_2^- + {}^1/_2O_2 \rightarrow NO_3^-$, *Nitrobacter winogradskyi*, *Nitrobacter mobilis*, *Nitrobacter gracilis*, *Nitrobacter agilis*.

The best known species are *Nitrosomonas europaea* and *Nitrobacter winogradskyi*.

Due to suspension of sewage liquid, adsorption of colloids and multiplication of microorganisms on this substrate, the so-called activated sludge is formed - it is a biocenosis of mineralizer microorganisms capable of sorbing on its surface and oxidizing organic substances of the purified liquid in the presence of air oxygen. In appearance it is small flakes of light to dark brown color. The main part of activated sludge consists of bacteria. There are 10^7 bacteria per 1 g of activated sludge with a total surface area of 1200 m^2. Their species composition depends on what substances the water being treated is polluted with. The biocenosis of activated sludge takes place in conditions of pronounced oxidative aerobic processes, therefore, along with other microbes, it contains nitrifier bacteria in large numbers (up to $3*10^7$ on 1 g of active sludge).

In fish farms, the main pollutants limiting water quality and its reusability are nitrogen compounds. For the activity of ammonifying and nitrifying bacteria it is necessary to maintain a constant environment. Under normal operation of biological purification facilities, the equilibrium between all representatives of microflora and microfauna is established. Violation of this equilibrium (change in numerical composition) leads to a noticeable change in the physical and chemical properties of the purified liquid.

Causes that disrupt the operation of biological water purification devices are overloading them with organic substances, getting into the purified water toxic substances, including drugs during preventive and therapeutic treatment of fish. Bacteria are equally active in fresh and salt water, but quickly die when salinity changes [32, 33].

The most responsible in the work of biological water treatment facilities is the start-up period, when the formation of activated sludge biocenosis occurs, characterized by a number of changes in the hydro-chemical regime in the plant. At this time, the biological treatment units are given the highest load on the treated water for the formation of bacterial film or flakes on the surface of the loading material.

According to V.I. Filatov (1980) [34], biofilters populated with colonies of nitrifying bacteria reach the operation mode in average 10.7 days, and completely new biofilters - 22.2 days. However, this period can be significantly increased during the formation of micro-flora at lower temperatures. Thus, in the experimental installation “Biorec”, the processes of ammonification and accumulation of ammonium reached the maximum on the 35th day of the installation operation, nitrification processes - on 40-43. As a result, the biofilter formation took about two months [27]. The introduction of detritus from the operating filter significantly accelerates the process of entering the regime. Similar data on the duration of the start-up period were obtained by other researchers [35].

It should be remembered that its duration depends on water temperature. For example, reaching the operating mode of biofilters in plants for growing cold-loving fish is prolonged up to 1-2 months. Apparently, the speed of entering the mode of biofilters is due to how close to optimal conditions for the development of organic oxidizing and nitrifying bacteria. Optimal parameters for the development of bacteria are water temperature 25°C, pH 6.5-7.5 and dissolved oxygen concentration up to 7 mg/l[36].

At increasing the temperature of purified water from 4-5° to 20°C, the rate of nitrification processes in submerged biofilters increases from 200 to 1100 mg/m^2 of ammonia nitrogen in 1 day.

An important role is played by the residence time (contact time) of treated water in biological purification facilities. Thus, its prolongation from 30 to 38 min. leads to an increase in nitrifying capacity of the filter from 48 to 60% for ammonium oxidation [35].

In order to shorten the period of bacterial biocenosis formation, artificial nutrient media are used; there are some attempts to accelerate the nitrification process itself by introducing special gas pedals [37].

Biological water purification by soil method gives a very high effect. However, this method requires large areas, loose soils with good filtering capacity; it cannot be practiced year-round, as the purification processes in this case depend on climatic and weather conditions.

Water purification in biological ponds is successfully used in hatchery facilities of some trout farms, in particular, trout farm “Skhodnya”. Along with microorganisms in the ponds, various hydrobionts, higher and lower vegetation are included in the purification process.

There are some data that the introduction of plant fertilizers into such ponds has a positive effect on the intensity of nitrification and nitrogen fixation processes, causing an increase in the number of bacteria of the corresponding physiological groups by 100 times. Backflushing of the biofilter should be avoided. The optimal amount of gravel in such filters is 15-40 m^3 per 1 ton of farmed fish, which corresponds to 1.5-4.0 m^3 biofilter for every 1 m^3 of pool. A settling basin is also needed. All this leads to large losses of production volumes and areas [31].

According to Japanese researchers, the largest number of microorganisms is in the upper layers of the feed material, and at a depth of more than 10 cm their number decreases by 90%. Therefore, these and other scientists [30] believe that the surface area of biofilters should be equal to the area of the fish-breeding pool, and taking into account that the height of biofilters, as a rule, is 3-4 m, their volume is 3-4 times larger than the volume of fish pools. When creating such industrial plants and placing biofilters indoors, there is an inefficient use of the areas that can accommodate fish pools [25].

It is recommended to use tanks for secondary sedimentation of treated water after the biological treatment units in order to settle the dead biofilm removed from the unit. When using bio-filters, a large (3.0-3.5 m) difference in the level of water supplied for treatment and treated water is also required. Additional pumps are required to lift water to the lost level, which complicates the operation of the plant and increases its energy consumption [31]. Studies conducted at the Department of Sewerage of IISI have shown that the increase of biofilter productivity should be sought in increasing the diameter of fractions of the charge and its porosity, but at the same time there is a decrease in the specific surface area of fouling.

The conclusion is that in order to increase the biofilter performance, the porosity of the feed material should be increased. It is very tempting to use not only the possibilities of attached sludge, but also its suspended part, as in an aeration tank.

Thus, the idea of creating such a device for biological water purification, which would combine the advantages of bio-filter with porous loading and aerotank with floating activated sludge. This possibility appears if the porous feed material becomes floating together with the suspended activated sludge.

In 1981, in the subsidiary farm “Soyuz” for the first time for water purification in a fish farming plant with a closed cycle of water use, a special structure with floating loading material representing large-porous pieces of foamed polyethylene with a diameter of 40-50 mm was applied. The chamber, where the porous filler was located, was placed inside a conical cylindrical tank, which acted as a secondary settling tank, trapping and precipitating the excessive dying biofilm discharged from the structure. In other words, the developed apparatus combined a biofilter, an aerotank and a secondary settling tank, which was named aerotank-porous filler tank [25].

The horizontal design of the aerotank-sump, which retains the advantages and principle of operation of its prototype, is proposed. This apparatus design was used for purification of circulating water at the plants of auxiliary fish farm of HEC-22 of JSC “Mosenergy”. The device and principle of operation of the apparatuses are described in detail in fishery publications [26].

Later, various modifications of biological water purification apparatuses with finer floating filler in the form of polyethylene balls became more and more common in the composition of closed systems.

However, the use of such granules creates certain difficulties due to the fact that it is difficult to keep them in the volume of the biofilter. They are easily washed out and circulate through the entire water supply system, up to the fish tanks, and can clog pipelines, shut-off valves and be carried out into the sewerage system. The volume of removed pellets has to be periodically replenished, which entails considerable additional costs. This disadvantage has been noted in a number of farms, e.g., Kaluga Turbine Plant, Gomel Centrolit Plant, HEC-3, Chelyabenergo [38].

In the process of operation of intensive fish farming plants, nitrates accumulate in the recycled water, which leads to the need to consume 10% or more of make-up water per day from the total volume of the plant. To reduce make-up water consumption to 1-2 % it is advisable to include in the structure of the closed water supply unit for denitrification to oxidize nitrites and nitrate reduction to free nitrogen and its removal from the treated water. Nitrate reduction to free nitrogen occurs under anaerobic conditions in the complete absence of oxygen. Bacteria take hydrogen ions necessary for the reaction from dissolved organic substances in the water, which are oxidized to carbon dioxide and water. In addition to the conversion of nitrates into free nitrogen, the denitrifier also reduces nitrites to free nitrogen, bypassing the phase of nitrate formation by denitrifying bacteria [39].

The water preparation block may include units and assemblies where water is prepared before it is directly delivered to the fish tanks. This block includes ultraviolet water sterilizers, ozonators, oxygenators, ion exchangers, physical adsorption.

Ultraviolet water disinfection is necessary to remove excessive amounts of microorganisms. After the water is treated in a biological filter, it takes out a significant number of microorganisms, the excessive amount of which in fish tanks is also undesirable. Efficiency and the possibility of using ultraviolet irradiators depends on a number of parameters of incoming water in the lamp, such as turbidity, color, the content of some metal ions (Fe^{2+}). These parameters must be known and monitored constantly, because they are the determining values when selecting models of ultraviolet irradiatorsй [40].

The use of ozonizers and oxygenators is increasingly being applied in industrial fish farming. Ozone is one of the strongest oxidizing agents. The use of ozonators allows solving a number of problems with oxygen deficiency, water color and is a good means of controlling microorganisms [31].

There are a number of additional nodes, but they are not widely used in the industrial cultivation of hydrobionts. Their application is mainly limited to exhibition aquarium complexes.

When growing fish in a closed water supply system it is possible to use polycyclic technology based on repeated receipt during the year of planting material and marketable products, this technology excludes peak loads on the system of closed water supply system by the amount of incoming pollution [36].

In the 80s of the last century, technological methods of growing various species of fish in closed water supply system were developed. According to the technological-logical scheme of commercial sturgeon cultivation, developed by All-Russian Research Institute of Freshwater Fishery in 1995, for cultivation of 100 tons of commercial sturgeon in two cycles, it was proposed to use six modules, including 5 blocks of biofilters BO-136, with the working surface area of 23000 m^2 each, in addition, one biofilter BO-1, with the working surface area of 700 m^2, for cultivation of young fish. Each of the 6 modules had a purification unit, two sedimentation filters, one water purification unit, one adaptation pool, and fish-breeding tanks. [35].

During operation of the fish farming complex, juvenile fish rearing was carried out in separate independent modules with an autonomous water treatment system with a regulated temperature regime.

The fish-farming equipment of the module for rearing young fish up to 3 g includes 10 pools (0.3 m^3 volume and 1 m area) with a total volume of 3 m^3. For sturgeon rearing it is suggested to use flat fish-breeding tanks with the volume from 5 to 10 m^3 and water layer of 1.2 m. These tanks ensure normal growth of sturgeon up to a planting density of 70-80 kg/m^3. Up to 18 flat tanks with a volume of 10 m^3 each and a depth of 1.2 m can be installed as part of the unit with the BO-136 biofilter [28].

Thus, the ratio of treatment and fish tanks is 1:2. Each of the five modules for growing marketable fish is equipped with two types of fish tanks: 6 pcs. “growing” pools (volume of 10 m^3) and 12 pcs. “fattening” pools (volume 10 m3). The total volume of fish tanks in each module is 180 m^3. In the “growing” pools, juvenile sturgeon increase their average piece weight from 3 g to 500 g, and in the “feeding” pools - from 500 g to 1.5 kg. Such 1.5 kilogram fish grown in the installations have high nutritional qualities due to their fat content [40].

The transition period (the time when production reaches full capacity) takes 395 days and begins with the stocking of all 10 basins of the fry module with aged sturgeon larvae (average unit weight 0.035 g) with an initial planting density of 5,000 pieces/m^2 (15,000 pieces/m^3). This moment of larvae planting marks the beginning of the first fish-water cycle. The total number of larvae planted in the installation is 50 thousand pcs. After 30 days, when the average weight of young fish reaches 3 g, and the total number of young fish, with the planned yield of 80%, is 40 thousand pieces, the young sturgeon is transferred into "growing-out" tanks of five modules. The total number of pools is 30 pcs.

Initially, at this stage, it is rational to densify the density of fish planting by using part of the fish breeding basins. After 180 days from the beginning of the first cycle, mature sturgeon larvae are again planted into the fish tanks of the fry module at the same density and quantity as in the first cycle - this will be the starting point of the second cycle.

After 210 days from the beginning of the first cycle (or 30 days from the second cycle), fish that have grown to 500 grams are transferred to "fattening" pools, and the vacated "nursery" pools are stocked again with three grams of planting material. The cycle ends with the removal of 1.5 kg sturgeon in the amount of 33,300 sturgeon (50 tons), with a final density of 83 kg/m^3 (56 sturgeon/m^2). The vacated tanks are stocked with 500 gr. sturgeon in the amount of 35 thousand pieces from the "growing-out" pools, which, in their turn, are stocked with three-gram young fish in the amount of 40 thousand pieces grown in module 1. In the future, every 180 days operations on transplanting and removal of products will be similar. The number of marketable products during this period is 50 tons, and the finished capacity of the line is 100 tons of marketable sturgeon [28].

In addition, according to the technological scheme, the maximum consumption of oxygen is 24.7 kg O_2/hour, and the total cost of technical oxygen is 137.1 tons per year. Planned total feed (LK-5) consumption is 272 tons. The minimum specific consumption of circulating water should be: for 3 g of young fish - 0.0075 l/s kg, for 100 g of young fish - 0.0040 l/s kg, for 500 g of fish - 0.0030 l/s kg and for 1.5 kg of fish - 0.0025 l/s kg. Sturgeon rearing is supposed to be carried out at an optimum temperature of 24°C. The area occupied by one module is 400 m^2. The output from 1 m^2 of the total area is 41 kg/m^2, from the fish breeding area - 82 kg/m^2 [28].

For the development and industrial production of plants with a closed water supply system it is necessary to pay special attention to the solution of the following issues: to create effective and low-energy means of water purification, to develop a system of control and management of environmental parameters, primarily O^2 and pH, to develop feed of appropriate quality for all ages and species of farmed fish, to develop biotechniques of cultivation and obtaining offspring from producers throughout the year, to develop biotechniques of fish cultivation, primarily planting fish, to develop a biotechnique of fish breeding.

It should be noted that in the previously developed technologies there is a significant scatter of normative data on the cultivation of sturgeon fish and their hybrid forms, which are currently the most perspective objects of industrial aquaculture.

At the present stage of aquaculture development, it is necessary to refine and optimize existing technologies on the basis of the development of cultivation methods at the contemporary level.

1.2 The forages and sturgeon fish feeding in industrial fish farming

Modern industrial fish farming is based on keeping fish under fully controlled aquatic conditions.

In modern conditions, natural feeds are no longer of fundamental importance when keeping fish in cages and basins. This has led to the large-scale use of artificial combined feeds, which should be balanced in terms of the main nutritional elements and meet the needs of aquaculture facilities in them [17].

When creating intensive technologies for growing valuable aquaculture objects with the use of compound feeds, the modern ecological and morphological method is used, which considers the development of an organism as consecutive, qualitatively different stages characterized by certain relations with the environment.

One of the most important bases of intensification of production at cultivation of any kinds of animals is rational feeding, based on application of highly effective compound feeds.

Thanks to successes of fish nutrition science, biologically grounded mixed fodders have been developed, the composition of which, on the basis of available modern scientific data, mainly corresponds to the nutritional needs of fish and the tasks of cultivation.

Successful farming of valuable aquaculture objects depends on the quality of initial and production feeds.

The concept of the nutrient content of feed mixtures has a major place in fish farming. Protein sources in fish diets are one of the important points in maintaining the level of protein and essential amino acids, as well as their availability. Raw sources of pro-protein are represented by products of animal, plant and microbial origin.

To the present day, the following directions have been noted in the research related to the search for quality and efficient feeds for sturgeons:

-Development of initial compound feed recipes;

-Mass cultivation of microorganisms, algae and invertebrates as feed additives;

-development of the optimal ratio of artificial and alive fodders in the diet when growing young fish;

- development of recipes of dry granulated production mixed fodders, composition of wet paste and granules fodder mixtures.

The attention of many researchers in the field of fish feeding is directed to the mechanisms of biochemical adaptation of the organism to food, the influence of its composition on the enzyme systems of digestive glands and tissues.

In order for growing to be effective, artificial feed must meet a number of requirements, including its physiological, biochemical and sensory effects.

The main objectives of the development of new formulations of mixed fodders are their improvement by increasing production properties, cheapening, replacement of scarce components with non-traditional raw materials [41,42].

The assortment of mixed fodders is constantly expanding due to the development of new formulas, more appropriate to the needs of fish, the introduction of new components and improvement of manufacturing methods, allowing on the basis of resource-saving technologies to produce products of higher quality.

Fish farming in closed water supply systems is done with artificial feed. The use of live feeds and feed components in their natural state is unrealistic due to their high feed coefficients and input of large amounts of contaminants. In this regard, the quality of feeds, which depends on their producers, is one of the most important conditions for successful operation of closed water supply systems. The criteria of feed quality are their compliance with the nutritional needs of farmed fish, the amount of contaminants entering the system during their use in the form of excreta and water-soluble nitrogen compounds during fish respiration, as well as their price level.

For sturgeon fish, based on the study of their nutritional requirements in basic nutrients, amino acids, fatty acids, and vitamins, starter and production feeds have been developed [41].

Sturgeon larvae begin to ingest feed before the intestine is free of melanin (pigment) plugs. During this period, fish begin to be accustomed to dry mixed fodders, which are given in the form of dust to develop a positive nutritional reaction. Larvae that have passed to mixed feeding are fed with starter mixed fodder and small forms of zooplankton (daphnia, Artemia nauplii, etc.) [41, 42].

After ejection of melanin plug, the fry are started to be given coarse fodder of 50-100 microns in size. The period of adaptation to mixed fodder lasts 2-3 days. Feeding of young sturgeon fish up to the weight of 3 g should be carried out with coarse fodder of starter mixed fodderIn the composition of sturgeon starter feeds, the protein content should be 45-55 %, fat - 8-11 %, carbohydrates - 6-12 % [31, 43].

There are several starter feed recipes [31] for sturgeon fish: СТ-4Аз, ОБ-1Аз (developer – AzRIFI), ОСТ-4, ОСТ-6 (developer ASTU), БМ-1 and etc.

At present, it is recommended to use starter feed OCT-6, which contains fish hydrolysate, when feeding early juvenile sturgeon fish. The use of this mixed feed makes it possible to refuse to add excessive live feed to the larvae's diet [18].

Daily norms of feeding sturgeons with dry mixed fodder for young sturgeon fish up to the weight of 3 g have been developed. The ration for larvae and fry is calculated every three days [31, 44, 45].

During the period of water temperature increase in summer up to 30°C it is recommended to reduce the feed rate by 50% and stop adding fats to mixed fodder. The feed distribution rate is reduced by 2-3 times. It is desirable to use automatic feed dispensers for feeding young sturgeons.

When feeding young fish, it is important that the size of mixed fodder coincides with the weight of the growing fish. The transfer of fish from one size of coarse fodder to another should take place gradually, over several days, by mixing one size of coarse fodder to another [46, 47].

For farms with carp breeding stock it is possible to recommend feeding young caluga with fish larvae. Feeding in the first days of exogenous feeding is done 1-2 times with carp larvae. Survival rate of caluga when feeding with larvae increases, search reaction increases many times. The daily feeding rate of this type of food should not exceed 15-20 % of the larvae weight [31, 48].

When the fish reach a weight of 2 g, the addition of live feed to the diet is stopped [18].

Good results of growing young Amur sturgeon, especially Kaluga sturgeon, are achieved if feeding of dry starter feed is alternated with feeding of wet pellets.

The composition of wet pellets: 70% of sifted starter feed and 30% of minced fish from low-value fish or pollock. In the absence of fish in the composition of pellets can include 30-35% of beef spleen. Feeding with pellets can be started when the weight of young Amur sturgeons is about 0.5 g. Due to the moisture content of pellets, their daily rate should be increased by 20-25% of the recommended rate of feeding with dry starter food [31, 48].

The most optimal feeding regimen for Amur sturgeon during the initial period of rearing is the following: alternation of 6 feedings of live feed and 6 feedings of dry feed. It is possible to use oligochaetes or Californian worm as live feed (instead of trumpet worm) [31, 49].

For feeding sturgeon fish weighing more than 3 g it is recommended to use product feeds. At present, the industry produces several types of product feeds for sturgeon fish: OT-6, OT-7 (developed by ASTU). These fodders contain fish meal, soybean meal, wheat and other sources of vegetable protein, yeast, fish oil, premixes (Chart 1).

Chart 1 – The recipes of product feeds for sturgeon fish

The components	**OT-6**	**OT-7**
1	2	3
Fish flour	40	39,0
Vitasar	25	20,0
Wheat flour	10	3,0
Soybean meal	10	10,0
Fodder yeast	7	5,0
Gluten corn	-	15,0
Fish oil	7	7,0

Premix ВМП ПО-5	1,0	1,0
1	2	3
The nutrients		
Protein	44-45	45-46
Fat	11-12	10-11
Carbohydrates	26-28	24-25

Daily feeding rates for sturgeon fish with production feeds are presented in the chart 2 [17, 18, 31].

Chart 2 - Daily feeding rates for sturgeon fish with complete feeds

Body weight, g	**Daily rate, % depending on water temperature**			
	12-17°C	**17-20°C**	**20-24°C**	**24-27°C**
1	2	3	4	5
3-50	8-6	10-5	10-8	8-6
50-100	4	5-4	5	3-4
150-200	3	5-4	5	3-4
200-250	3	4-3	4	3-2
250-300	3	4-3	4	3-2
350-400	2	4-3	4	3-2
450-500	2	3	4	3-2
500-800	1,5	2,0	3,0	1,0
800-1500	1,5	2,0	3,0	1,0

All-Russian Research Institute of Freshwater Fisheries has developed a new effective compound feed for sturgeon producers RGM-9PO, which includes fish meal, blood meal, Vitazar, soybean meal, milk powder, corn gluten, dicalcium phosphate, fish oil, premix. It contains 52% protein, 12% fat, no more than 1.5% fiber and at least 3840 kcal of metabolizable energy.

Wet mixed fodders ВОРЗ-2 (for the sturgeon repair group), ВОРЗ-3 (for sturgeon producers), ВОРЗ-Ст (for the sterlet repair group and producers) are also used for feeding sturgeon producers and breeding herds [50].

At present in Russia, ASTU and All-Russian Research Institute of Freshwater Fisheries have developed and are using the following recipes of dry mixed fodder for sturgeon fish, approved in accordance with the procedure established in the industry[51, 52].

OCT-6 - starter mixed feed for early juvenile sturgeon fish with fish hydrolysate, developed by ASTU, approved on 15.01.2001. Contains (%): crude protein - 51, crude fat - 11, crude carbohydrates - 18, crude fiber - 1,5, polyunsaturated fatty acids omega 3 - 1.5-2, polyunsaturated fatty acids omega 6 - 1.0-1.5, minerals - 11. The level of total energy is 13 MJ/kg;

OCT-7 - starter mixed fodder for early juvenile sturgeon fish (granulated, extruded) weighing up to 3-5 g with fish hydrolysate, crab meal, developed by ASTU, approved on 28.12.2006. Contains (%): crude protein - 51, crude fat - 9, crude fiber - up to 1.5, mineral substances - up to 12. Total energy is equal to 13 MJ/kg;

OCT-8 - sturgeon starter feed for sturgeon fish weighing up to 3-5 g (granulated, extruded) with fish hydrolysate, crab fat. Approved 28.12.2006. Contains (%): crude protein - 51, crude fat - 9, crude fiber - up to 1.5, mineral substances - 11. Developed in ASTU;

OT-7 - production feed for sturgeon fish (for marketable fish, RMS) weighing 3 g and more with corn gluten (granulated, extruded). It contains (%): crude protein - 44, crude fat - 12, crude carbohydrates - 21, crude fiber - up to 2, polyunsaturated fatty acids ω3 - 1,3-1,8, PUFA ω6 - 0,8-1,0, mineral substances - 10. Total energy is equal to 12 MJ/kg. Developed by ASTU, approved on 15.01.2001;

OT-9 - special production compound feed for prevention of sturgeon fish lordosis and scoliosis. Contains (%): crude protein - 44, crude fat - 12, crude fiber - up to 2.5, crude carbohydrates - up to 24. Total energy - 12 MJ/kg. Developed by ASTU, approved on 28.12 2006.

In addition to these compound feeds, feed recipes have been previously developed OCT-4 (ASTU), OCT-5, OT-5 (ASTU, БИОС), recipes that need to be redesigned [53].

For all sturgeon feeds (dry and wet) ASTU developed a vitamin-mineral (VMP PO-5) and vitamin premix (PO-5) containing 16 vitamins and vitamin-like substances, as well as an antioxidant and a supplement. Recipes were approved for implementation in the industry on 15.01.2001. [15].

Compound feeds OCT-4, OCT-7, OCT-8, OT-7, OT-9, premixes ПО-5 ВМП ПО-5 have patent protection, patent holder ASTU [17].

According to the literature evaluation, there are still no special feeds for the conditions of closed water supply systems for sturgeon farming. Insufficient research has been carried out on inclusion in feeds for closed water supply systems of binding (adhesive) substances and increasing resistance of the organism to possible microbial and organic pollution of the aquatic environment.

1.3 The diseases of fish farming in closed water supply system

The economic efficiency of fish farming in general and industrial sturgeon farming in particular is largely determined by the ability to control the most dangerous and widespread diseases of farming objects.

Aquatic objects are constantly surrounded by microorganisms that are able to penetrate into them, associate or reside in tissues and organs without causing harm. They are constantly present in the gastrointestinal tract, from where, under certain conditions, they can quickly penetrate into internal tissues and organs, actively multiply.

The constant presence of pathogenic and opportunistic microflora in the aquatic environment is a hidden focus of bacterial infections, which can be quickly realized in the form of outbreaks of mass disease among cultured objects.

Diseases in aquaculture occur at every stage of the biotechnical cycle, and their spectrum varies depending on rearing conditions, aquatic animal species, various biotic and abiotic environmental factors, and the area where the disease is spread.

Bacterial diseases of fish are one of the main factors constraining the development of fish farming. The most widespread among them are such diseases as aeromonosis (rubella) and pseudomonosis of carp fish, salmonid furunculosis, and myxobacterioses. The list of quarantine and especially dangerous fish diseases includes aeromonosis of carp and salmonids, myxobacterioses of salmonids and sturgeons.

The main objective of ichthyopathological monitoring is to determine the sources, mechanisms and factors of transmission of pathogens and ways to prevent and treat them.

Infection can spread through water, but the main source of infection is fish.

Older fish usually do not get sick, but are carriers of viruses. Favorable temperatures for the development of viral diseases are 17-19°C, but they can also occur at temperatures between 9 and 23°C. The most studied and widespread among viral diseases of sturgeon fish is the disease caused by white sturgeon iridovirus (WSIV). According to the classification of the International Epizootic Bureau (OIE), WSIV has been classified as a dangerous fish disease. In recent years, the causative agent has been observed in many fish species, including Russian sturgeon. Currently, no treatment methods for viral diseases of sturgeon fish have been developed.

Conditionally pathogenic microorganisms are a large group of microbes that can coexist with a macroorganism and not harm it.

When the host organism is weakened and under unfavorable environmental conditions, opportunistic bacteria are capable of causing infectious processes in latent and acute forms. The following bacterial diseases have been observed in sturgeon fish growing in industrial conditions under a closed water supply cycle: myxobacteriosis, flavobacteriosis, bacterial hemorrhagic septicemia (BHS). The highest aggressiveness and pathogenic invasiveness are possessed by complexes of mobile aeromonads of different species, aeromonads with different species of Enterobacteriaceae, flavobacteria; pseudomonads with *Enterobacteriaceae*; various representatives of the sem. Enterobacteriaceae in combination with Proteus and others.

Myxobacteriosis of sturgeon fish is included in the list of quarantine and especially dangerous fish diseases. The disease is caused by *Flexibacter*, *Cytophaga* and *Sporocytophaga* bacteria. Clinical signs of the disease are hemorrhages on the body surface and at the base of the bug, polymorphic lesions on the body surface, destruction of the epithelium of gill lobes, interradial membrane and supporting elements of fins. All age groups of sturgeon fish are susceptible to the disease, but young fish are most affected.

Bacterial hemorrhagic septicemia (BHS) is the most widespread bacterial disease causing significant damage to aquaculture enterprises. Bacterial hemorrhagic septicemia (BHS) affects all species of sturgeon fish at any age in case of breach of cultivation techniques.

The disease is caused by *Aeromonas* bacteria isolated from parenchymatous organ sowings in monoculture or in association with other microorganisms (*Bacilus, Micrococcus, Plesiomonas*, etc.). Fish mortality can be high (up to 70%). Clinical signs of the disease are spot hemorrhages on the body surface, pale, anemic gills, exophthalmia [6].

Despite the great variety of clinical manifestations of bacterial diseases, their diagnosis has been sufficiently developed. Their control is currently a rather serious problem.

Usually, chloramine B, potassium manganese, hydrogen peroxide, tetracycline, oxytetracycline, nitrofurazon, etc. are used for this purpose.

Stress factors can cause mycoses of sturgeon fish, the causative agents of which are fungi of the order Saprolegniales. *Saprolegniosis* usually develops against the background of another disease or a sharp decrease in the body's defenses. Clinical signs are white cotton wool-like plaque on the surface of the body. The pathogen of this disease is widespread in nature.

Parasitic diseases may also pose a threat in closed water supply facilities. Out of 92 species of parasites observed in sturgeon fish, the absolute majority are parasites found in a wide range of fish.

When sturgeon fish are farmed in closed water supply facilities, there is an impoverishment of the parasitofauna, which is represented by individual species of the following classes – *Parasitomonada (Mastigophora),Cyrtostomata, Hymenostomata (Ciliophora), Coelenterata, Amphilinida (Plathelminthes), Nematoda (Nemathelminthes), Acanthocephala (Acanthocephales), Hirudinea (Annelida).*

The most pathogenic, often causing fish mortality, are the following *Trichodina nigra, T. pediculus, T. acuta, Trichodinella epizootica*, as well as *Polypodium hydriforme, Diclybothrium armatum, Diplostomum spathaceum, D. paracaudum, Piscicola geometra, Ergasilus sieboldi, Argulus foliaceus.* Most of the above listed parasite species are found in many fish species, and only 2 species are specific to sturgeon species: *Polypodium hydriforme and Diclybothrium armatum*.

In closed water supply installations, protozoa also cause disease (pp. *Costia, Ichthyophthirius, Epistylis, Apiosoma, Trichodina, Trichodinella),* monogenies *(p. Diclybothrium),* crustaceans *(pp. Ergasilus, Argulus*). The development cycle of these parasites is direct (without intermediate hosts).

Special attention should be paid to the source of infestation in closed water supply installations. The spread of the infectious or invasive agent can occur from fish to fish, through the water and through fish farming equipment.

Water itself can also be a source of infection [1].

Under optimal environmental conditions and stable host condition, parasites are observed sporadically. In weakened individuals, infestation may increase in a matter of days. Diagnosis of the disease is made on the basis of clinical signs, epizootologic data and non-mediated detection of large numbers of parasites. Prevention of parasitic diseases is to optimize growing conditions, avoid contact with sick fish.

Feed can also be a source of pathogens. Viruses, bacteria, fungi or parasites can be transmitted through frozen or live feed. In addition, the use of dry feed stored in inadequate conditions can be a source of bacteria or mycotoxins, the products of various fungi.

A number of fish diseases are caused by insufficient or excessive intake of micronutrients with feed.

In industrial aquaculture with the transition to high-intensity norms of fish farming (in cages, pools, etc.), nutritional diseases cause damage. They are categorized into three groups.

The first group includes diseases associated with the use of unbalanced fat, protein, carbohydrate, mineral and vitamin composition of mixed fodders.

The second group includes diseases that occur in fish as a result of consumption of poor-quality feed contaminated with micro-organisms (bacteria or fungi), products of their vital activity or containing oxidized fats.

The third group includes diseases caused by metabolic disorders in fish in connection with the feeding of unrelated foods.

For the formation of tissues and the normal course of metabolic processes in fish, they need a number of mineral substances, the requirements for which vary from species to species. Many of the consumed minerals fish can adsorb from the water directly through the gills and skin. When kept in soft, mineral-poor water, fish should receive the necessary trace elements with food. Diseases caused by the lack or excess of trace elements in the body, are susceptible to fish of all ages. Lack of specific elements in fish feed increases their susceptibility to disease.

Feeding fish with poor-quality feeds, oxidized by fats, highly polluted with microflora (bacteria and fungi) and containing toxic substances of various origin, leads to the development of pathological processes and death.

Common alimentary diseases of fish are associated with the use of unbalanced and poor-quality feeds.

For example,

-deficiency of unsaturated fatty feeds in fish shows impotence, lethargy, spiral movements;

-with deficiency of vitamin D, vitamin C, vitamin E, vitamin K, magnesium, phosphorus develop scoliosis, lordosis;

-with a deficiency of unsaturated fatty acids, amino acids, low-molecular-weight peptides there is an increased water content in the muscles, etc.

In many cases, an individual fish may be resistant to a particular pathogen. However, in the aquatic environment there is always the possibility of transmission of the infectious agent and there are always fish that are more weakened and susceptible to disease. Weakened and dead fish are the most important source of infection. They should be isolated from the system.

Disinfection and disinfection of pools, inventory, fish farming equipment is of great importance in the complex of preventive measures. As disinfectants for this purpose use chlorine lime, calcium hypochlorite, quicklime, chloramine B and others (according to existing instructions).

To prevent various diseases, it is necessary to systematically clean pools, fish farming equipment, which serve as a source of accumulation of organic pollution and contribute to the development of pathogenic microorganisms.

Water used for closed water supply installations should undergo preventive disinfection. For this purpose, disinfection with ultraviolet rays (UV), ozonation (introduction of ozone OD) are used.

Fish-to-fish parasites, such as Argulus foliaceus, can also spread the disease. These organisms themselves are harmful to fish, but can also carry viruses and bacteria. The components of this vector can be inventory, fish farming equipment, filter parts that have not been thoroughly disinfected before being used in other containers, etc. The vector can be used to treat fish.

In aquaculture, the organization and implementation of therapeutic and prophylactic measures in many cases coincide. They are aimed at destroying pathogens with the help of special therapeutic drugs at all stages of fish farming.

At the stage of incubation of eggs, its therapeutic and prophylactic treatment is carried out. The complex of therapeutic measures also includes treatment of fish with medicines, introduction of medicines with feed, introduction of medicines by injection.

An important direction of prevention of microbiocenosis disturbance in conditions of fish farms is to create a high level of veterinary and sanitary culture and protection of veterinary facilities from the entry and exit of pathogens.

Prophylactic measures carried out in fish farms include a set of veterinary and sanitary rules aimed at preventing diseases that can cause fish death.

First of all, it is a thorough ichthyopathological examination and mandatory quarantine for fish before planting in closed water supply installations. Quarantine period is determined in each specific case, it should be not less than 30 days.

1.4 The bacterial preparations in the composition of compound feed for aquaculture objects

Development of fish breeding on an intensive basis requires solving technical problems, as well as the issues of feeding and the use of complete and balanced feed for all types of farmed objects.

One of the most important tasks is to create and apply in practice feed mixtures that would be maximally digested by the organism to ensure its vital functions and have preventive properties.

In the natural environment, the organism's own microflora appears in the intestine immediately after birth and coexists with it throughout life, and its composition changes in accordance with age, nutrition and living conditions [54].

In artificial conditions, the possibility of formation and maintenance of microflora peculiar to certain species of animals, including fish, is very limited, which is associated with the specifics of their keeping and feeding [4].

The microbiocenosis of the digestive tract plays a huge role in the vital activity of the macroorganism. In addition to direct participation in digestive processes, gastrointestinal microorganisms are also one of the most important elements of nonspecific immunity.

In conditions of intensive production, when a large number of fish are concentrated on limited areas, there is a threat of infection by microorganisms, which forces the use of therapeutic preparations, including feed antibiotics. This inevitably leads to selection and subsequent circulation in farms of opportunistic and pathogenic microorganisms with increased resistance to antibiotics [12]. In addition, being immunosuppressants, these drugs negatively affect the immunophysiological status of fish.

Increase in the number of various representatives of microflora, which are not peculiar to the normoflora of fish, can lead to the formation of non-specific for fish microbiocenosis, which can cause further digestive disorders, reduced growth rates, as well as the manifestation of various bacterial diseases.

To correct such conditions, the most interesting and biologically justified is the use of preparations that help to stabilize the activity of the gastrointestinal tract and increase the immune status.

Such preparations include bacterial preparations that have favorable effects on physiological functions and biochemical reactions of the host organism through optimization of its micro-ecological status when administered naturally.

The closed water supply installations are practically a closed space in which the most favorable conditions for fish keeping and breeding should be created taking into account gas, temperature regimes, planting density, accumulation of metabolites, products of organic decomposition, intensification of growing processes. Violation of any of the listed indicators becomes the cause of mass diseases and death of fish.

Diseases are the external manifestation of the consequences of impaired immunity and general resistance (adaptive potential) caused by the influence of adverse environmental factors on fish health, and a reflection of pathological processes at the molecular, cellular, tissue, organ and organismal levels, arising in response to the impact of pathogens, toxicants and deterioration of environmental conditions.

Sturgeon fish species are characterized by significant resistance to various pathologies, and if the technology of keeping them is observed and there is no introduction of the pathogen from outside, then the closed water supply installations is an ideal place for breeding healthy fish. However, with the development of aquaculture and the expansion of international relations, the situation with infectious and parasitic diseases of sturgeon fish is aggravating.

Pathological processes in fish follow the same patterns as in higher vertebrates. However, there are significant differences in their manifestation due to anatomo-physiological features and the level of evolutionary development of fish as lower aquatic vertebrates.

Fish farming under closed water supply conditions does not solve the disease problem, and therefore successful fish farming is impossible without ichthyopathological monitoring.

In recent years, new approaches to keeping fish in densely planted aquaculture have become widespread in aquaculture, associated with the restoration of the natural ecology of the organism and based on the use of active biological products.

One aspect of this approach is the normalization of the altered microbial landscape of the organism in closed water supply installations using bacterial and bioproducts [3].

It is known from the experience of scientific approbations that the greatest positive effect is produced by the introduction of 0.2 % lactobacillus into the feed for young sturgeons [5, 43].

The effect of introducing different doses of lactobacillus into the feed composition on the number of intestinal microflora was noted. Thus, in juvenile Russian sturgeon that consumed mixed fodder with 0.2% lactobactin at the first stage of rearing, the number of bacteria was 6 times lower compared to the control, and when 0.4% of this preparation was added, it was 130 times lower. There were no differences in the growth rate of young sturgeon consuming mixed fodders with different amounts of lactobacillus, but there was a 20% decrease in feed costs when 0.2% lactobacillus was added and a 10% decrease when 0.4% lactobacillus was added. [43].

The medical product "Aqualact" based on lactobacilli of the intestines of sturgeons from their natural habitat can be used as a therapeutic agent that increases the resistance of sturgeon fish to digestive disorders and damage to body surfaces caused by bacterial contamination of water and feed. [55, 4].

The basis of the M-30 preparation is *Lactobacillus acidophilus* bacteria, which multiply rapidly when they enter the intestines of fish, creating a biocenosis in it, suppressing the growth of pathogenic microflora. The effect of the preparation is confirmed by studies on the prevention of bacterial infections in pond fish using carp and herbivorous fish as an example. [56].

There is also experience in using other lactobacillus preparations in growing sturgeon species of fish: in the conditions of Mozhaisk production and experimental fish hatchery, Moscow region, acidophilus milk was used [12, 57] and in the conditions of the fish farm CJSC “Kazachka” in the Rostov region - the preparation bifilactrin [58], in the conditions of the experimental modular installation of the complex probiotic preparation Intestivit [4].

The drug of the colibacteria family - "Colibacterin" is the very first domestic bacterial drug. It contains an antagonistically active strain of non-pathogenic Escherichia [8, 10, 59].

Specific bacteriophages are successfully used for sanitizing mucous membranes, skin and wound surfaces from pathogenic and opportunistic bacteria. Bacteriophages are viruses that affect exclusively bacteria and are environmentally safe biological preparations. An important property of bacteriophages is their high specificity; they selectively lyse bacteria not only of a certain type, but even their individual serological groups. The emergence of antibiotic resistance in bacteria does not affect their sensitivity to bacteriophages, so the latter are often active even against multiresistant microflora. [8].

Another large class of biopreparations used to correct dysbacteriosis are probiotics. The term “probiotic” was first proposed in 1965 as an “antonym” to an antibiotic to denote microbial metabolites that have the ability to stimulate the growth of any microorganisms [60]. In 1971, A. Sperti used this term to denote various tissue extracts that have a stimulating effect on microorganisms. Subsequently, the original definition of probiotics underwent changes [11, 61].

R. Parker [62] used the term “probiotics” to denote microbial preparations that have the ability to regulate the microbial ecology of the intestine. According to his definition, probiotics are microorganisms or their components that are capable of maintaining the balance of intestinal microflora. Later, R. Fuller [63] called all preparations from living microorganisms probiotics that, when introduced into the host organism, have a beneficial effect due to intestinal correction.

Currently, the term "probiotics" is used to denote a wide class of microorganisms that have antagonistic activity against pathogenic microflora. [11].

Probiotics in the modern understanding are substances of microbial and non-microbial origin, which, when administered naturally, have a beneficial effect on the physiological and biochemical functions of the host organism by optimizing its microecological status [1, 9, 11, 13, 64, 65].

Probiotics are used to stabilize intestinal microflora in acute and chronic diseases and dysfunctions of the gastrointestinal tract, metabolic disorders, after taking antibacterial drugs, hormonal and radiation therapy, in preoperative and postoperative periods, in gynecological and dental patients, for prophylaxis and as adjuvant therapy for cancer patients [66, 67, 68, 69, 70].

The influence of probiotics is due, firstly, to their antagonistic activity against pathogens, realized due to the production of anti-bacterial substances, change in the pH of the medium, which provides a mediated effect on the enzymatic activity of pathogens; secondly, due to competition with pathogens for adhesion receptors; thirdly, due to the stimulation of immunity (stimulation of macrophage activity, increase in the level of antibodies); thirdly, due to the stimulation of immunity (stimulation of the activity of macrophages, increase in the level of antibodies). [1, 9, 11, 63, 71, 72, 73, 74].

It should be noted that probiotics may consist of several strains of microorganisms and may contain both live cultures and inactivated cultures, as well as microbial metabolites [74, 75, 76].

All existing probiotics are divided into two groups - liquid and dry. Microorganisms in dry probiotics are in a kind of “hibernation”. The shelf life of dry preparations is longer than that of liquid preparations, they do not require strict adherence to storage conditions, they are also stored longer and are convenient for transportation of metabolites [74, 75, 77].

The disadvantage of such probiotics is that when drying the bacteria in their composition loses part of their useful properties, and after entering the body they need at least 8-10 hours for the bacteria to move from “hibernation” to the active form and begin to act. This disadvantage should be taken into account when using dry probiotics [61, 78, 79].

In recent decades, probiotics and probiotic products have found wide application in livestock and fish farming [80, 81].

Among those used in medicine, the best known are probiotics, which contain pure spores of bacteria *Bacillus subtilis* strain IP 5832. These are the preparations Bactisubtil and Flonivin BS (ICN), Bactisporin. All preparations based on B*acillus subtilis* bacterial spores have a similar mechanism of action.

The preparation “Subalin”, developed on the basis of live bacteria *Bacillus subtilis* 2335/105, producing alpha-2 interferon, increases the immuno-physiological status of the organism by normalizing the microflora of the gastrointestinal tract. Subalin is characterized by a wide range of antagonistic activity against pathogenic and conditionally-pathogenic organisms, increases specific and non-specific resistance of the body, regulates and stimulates digestion [3, 4, 82, 83].

The main positive qualities of this preparation are reduction of feed costs, improvement of physiological condition and ensuring high survival rate and active productive growth of fish.

Advantages of Subalin in comparison with antibiotics and nitrofurans used in fish farming practice - zero waiting period; strengthens rather than suppresses the immune system of fish; effective at low dosages and frequency of application; no addictive effect; economically cost-effective; environmentally safe, harmless even in concentrations much higher than recommended for use, as well as in the ability to significantly increase the nonspecific resistance of the macroorganism. The optimal therapeutic daily dose of Subalin is 25 million spores per 1 kg of carp 2-3 -year-old carp with a course of treatment of 5-7 days [1, 13, 57, 78, 79, 83, 84].

This probiotic preparation has widely proven itself in carp pond and industrial farms, sturgeon and salmon reproduction plants [9]. A method of preparing feed with the inclusion of the preparation «Subalin» has been developed [1, 13, 57, 83].

Currently, the preparation "Subalin" is widely spread and is produced under a new commercial name "SUB-PRO". Proper use of the probiotic preparation "SUB-PRO" provides a high economic effect in commercial fish farming, and in breeding - release of high-grade viable fish products into natural water bodies.

Probiotic preparation "Biokorm-Pioneer" is a combination of two unmodified genetically lyophilized cultures of *Bacillus subtillis*. It prevents the development of dysbacteriosis, promotes stimulation of cellular and humoral immunity factors.

The advantage of the preparation is the use of spore-forming microorganisms [3]. However, when determining the qualitative and quantitative composition of the intestinal microflora of Russian sturgeon using the drug "Biocorm-Pioneer", it was noted that this probiotic has selective activity against some groups of pathogenic and opportunistic microorganisms and further research is required to clarify the positive effect of this preparation.

Probiotic "Azogilin" is created on the basis of a live culture of nitrogen-fixing bacteria *Azomonas agilis*. The praparation has proven itself in the fight against aeromonosis in pond farms [79].

The basis of the Az-28 preparation is also *Azomonas agilis*, isolated from water and capable of inhibiting pathogenic microflora of the fish intestine. It is produced in the form of granules with a weak smell of acid - a product of bacterial fermentation. It is used with feed for all age groups of fish susceptible to aeromonosis. Belarusian specialists have obtained positive results under production conditions [1, 13, 57, 76].

Spore-forming probiotics for fish farming are a new direction. In particular, the conducted studies of the possibilities of using the probiotic "Subtilis" in the early stages of fish farming have shown that the treatment of trout eggs, embryos and larvae with the probiotic increases the survival rate and reduces the natural mortality of fish at the larval stage of development, promotes stimulation of fish viability in the early stages of ontogenesis and the tension of natural immunity [3, 4, 61].

The main feature of the probiotic "Subtilis" is the combination of anaerobic *Bacillus licheniformis* and aerobic *Bacillus subtilis* forms of bacteria. *Bacillus subtilis* is a source of digestive enzymes, and *B. licheniformis* exhibits a pronounced antagonistic effect on gram-positive and gram-negative bacteria [61].

The introduction of a dry form of probiotic into the composition of the production feed has a positive effect on the healing of sturgeon skin, increasing its speed, and also leads to an increase in the survival rate of traumatized fish.

The preparation promotes the production of vital digestive enzymes and vitamins directly in the intestine, thus having a pronounced growth-stimulating effect.

As a result of growing young Russian sturgeon, the advantage of introducing a probiotic into the OT-7 feed was established, consisting in the highest value of average daily gain, survival rate and the lowest feed costs. The positive effect of using "Subtilis" can be explained by the fact that the probiotic preparation contains enzymes that promote rapid breakdown, as well as better absorption of food.

Normal natural intestinal microflora is necessary for fish, since it serves not only as a protective barrier against pathogens, but also promotes digestion and is a possible producer of vitamins and probiotics.

Thus, for fish farms, it seems promising to use bacterial preparations that represent either the endogenous intestinal microflora of fish of the same species [55], or bacteria that combine the properties of probiotic producers and pathogen antagonists.

The experience of “feeding” live feed (rotifers, brine shrimp, Californian worms) used in fish farming with probiotics is interesting. [7].

The use of compound feeds with probiotic additives allows farms to reduce feed consumption for fish production by up to 25% [85].

Based on domestic and foreign experience, it is recommended to add probiotics not according to indications, but daily to the diet, including it in production compound feeds.

Combined feeds with probiotics are intended to increase fish productivity (by 20% and higher), which consists of the prevention and treatment of fish diseases of infectious and alimentary etiology, normalization of the body's condition due to the intensive use of antibiotics, mitigation of stress caused by a change in feed, as well as traumatic injuries associated with the technological movement of fish.

Such feeds are a unique complex of a large number of feed components and spore-forming aerobic and anaerobic bacteria.

Once in the body, the bacteria form fast-growing colonies in the intestines and displace pathogenic and opportunistic microorganisms, promoting the colonization and development of the fish's own beneficial microflora. At the same time, biologically active substances are produced, digestive enzymes and amino acids are synthesized. The anti-stress properties of the probiotic are also clearly expressed. As a result, specific and non-specific defense systems of the body are activated, digestion is normalized, feed absorption is improved, the immune status and resistance to diseases, as well as the growth rate, are increased. In traumatic operations associated with grading, transportation, sorting, and transplantation of fish, the probiotic has regenerative properties.

The mechanism is that bacteria in the lesion release biologically active substances (antibiotics, proteolytic and saccharolytic enzymes, immunomodulators, etc.) that exhibit a therapeutic effect, and when destroyed, serve as a source of antigens to maintain normal antibody levels. [85].

In the practice of animal husbandry, more than 100 names of probiotics for veterinary purposes are registered, most of which are classified as therapeutic and prophylactic drugs, some as starters and some as microbiological feed additives. With a wide choice of probiotic preparations, the development of this direction seems promising, allowing for the production of environmentally friendly aquaculture products.

An analysis of the studied literature sources in the field of fish feeding shows the prospect of creating a special feed for sturgeons intended for fish-breeding and recirculation systems. It should be distinguished by a lower level of ballast, polluting substances, high resistance to erosion and destruction of granules. It should include antibacterial drugs and drugs that restrain the expansion of microbial communities in the feed, intestines and maintain non-specific resistance to possible adverse factors of the aquatic environment of closed water supply systems.

CHAPTER 2. THE TECHNOLOGICAL FEATURES OF STURGEON FISH KEEPING IN CLOSED WATER SUPPLY SYSTEMS

2.1 Growing and feeding conditions of sturgeon fish

Scientific work in Zhangir Khan WKATU was carried out using a closed water supply system with fully adjustable control of the aquatic environment (Fig. 1). The water temperature and water exchange were stable (water temperature - 20-24°C, water exchange - 5 l/min, with a dissolved oxygen content of 7.5-10 mg/l).

The material for the research was individuals of different ages of Russian sturgeon (*Acipenser gueldenstaedtii* Brandt et Ratzeburg, 1833). The aquarium complex is located in a room on an area of 100 m^2. All experimental work was carried out in the water recycling unit, which was a module including working blocks. The unit consisted of 2x0.7 pools with rounded corners, a storage tank, a mechanical and biological unit for cleaning and water treatment.

For growing fish, fish-breeding pools were used, made of fiberglass-reinforced polyester used in the food industry, equipped with a pit for removing food residues and excrement.

The Italian-made sand mechanical filter with a capacity of 16 m^3/h was designed for mechanical water purification, equipped with a control unit with such functions as: backwash, rinsing, which minimized the effort for its maintenance.

Quartz sand of 0.8-1.0 mm fraction was used as a loading of the mechanical filter. The biological treatment unit consisted of a tray with a volume of 1.5 m^3 divided into 6 sections, in which nitrification processes took place. Construction expanded clay of a strictly defined shape and size was used as a loading (20-30x10-15 sm).

The choice of expanded clay as the most optimal loading is determined by the following: large surface area (100 m^2/m^3), significant efficiency, ease of maintenance during washing.

The scheme of water filtration in the biofilter is presented in Figure 2. At such scheme of water movement there is a maximum contact of filtered water with the surface of expanded clay, and, consequently, with bacterial flora, which increases the efficiency of filtration.

For the convenience of working with expanded clay, when washing the biofilter, it was packed into polymer grids of 15-20 kilograms.

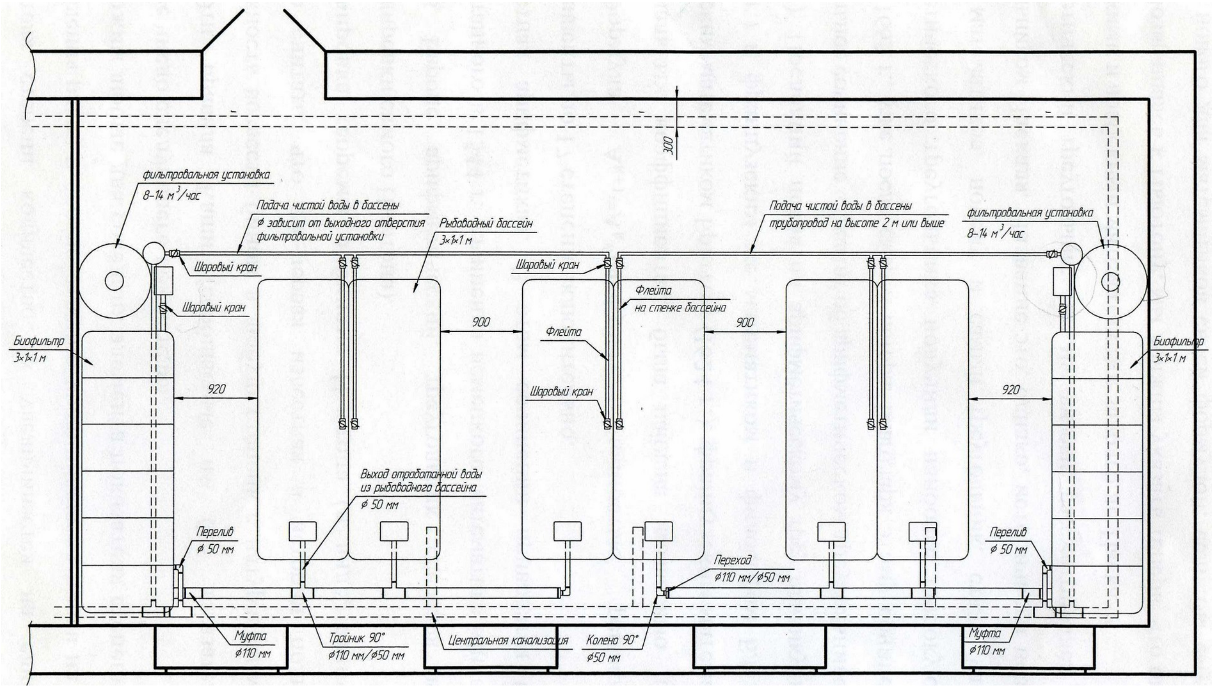
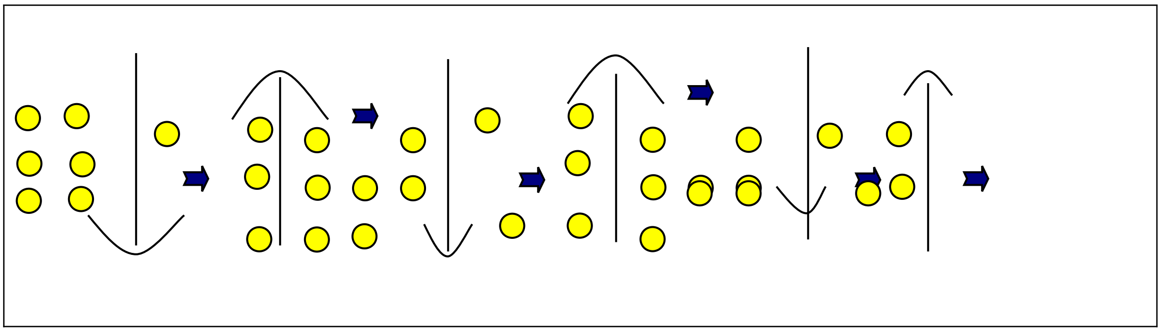


Figure 1 - Scheme of closed water supply of Zhangir Khan WKATU



- direction of water flow in the biofilter (from mechanical filter to fish basins);
- clay bags

Figure 2 - Water purification scheme in the biological unit

In the last compartment of the biological filter (water purification block) there was no filling. It contained a bactericidal lamp and atomizers connected to a cylinder with technical oxygen (for emergency cases). After processing, water flowed by gravity to the fish basins.

The temperature in the aquarium complex was maintained at 20-24°C all year round. In winter it was realized at the expense of heating, in summer period at the expense of air conditioning by split-systems.

The principle scheme of the installation is shown in Figure 3.

Water from the fish-breeding pools flowed by gravity through the receiving pipe into the receiving basin, where partial sedimentation of suspended solids took place. In this receiver it is necessary to clean sedimented substances, because one of the key positions in the favorable functioning of the whole system is timely cleaning and cleaning of fish-breeding and auxiliary tanks.

Then, from the receiving basin, the water was supplied by an electric pump to the pressure sand filter, then the water, cleaned from mechanical suspended solids and clarified, was fed to the biological purification block.

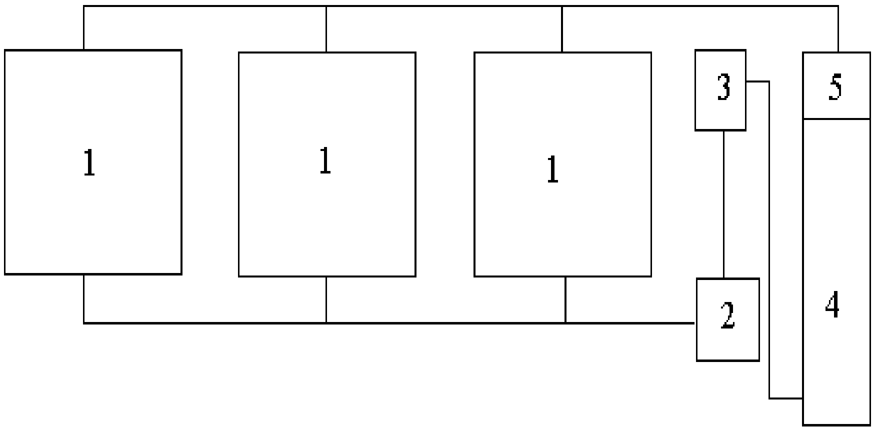


Figure 3 - The principle scheme of the closed water supply installation

Note: 1- fish basins; 2- basin receiver; 3- mechanical filter; 4- biological filter; 5- water preparation block.

The characteristics of experimental basins, flow rates and names of instruments for control of water environment parameters are given in Chart 3.

Chart 3- Volume of basins, flow rates, age of fish and name of hydrochemical recorders

Name	**Indicators**
The volume basin, m^2	2,1
The water flow, l/sec.	5-30
The experiment period, day	30-900
The age of fish (month)	12-48
The model of thermooximeter (Handy Polaris)	
The model of pH-meter (Mettler toledo)	

Based on biomass data, daily and single feeding rates were calculated (Chart 4, 5) [15].

Chart 4 - Size of coarse grains and pellets for sturgeon mixed fodder production

Fish body weight, g	Granule size, mm
1	2
3-50	1,2-1,4
50-250	1,4-2,0
250-500	2,0-3,0
500-1500	3,0-4,0
1500-3500	3,0-4,5
3500-4500	4,5-6,0

Chart 5 - Daily feeding rates for sturgeon fish depending on body weight and water temperature with product feeds [15].

Fish body weight, g	Daily norm, %	
	17-20°C	20-24°C
3-50	10-5	10-8
50-100	5-4	5
150-200	5-4	5
200-250	4-3	4
250-300	4-3	4
350-400	4-3	4
450-500	3	4
500-800	2	3
800-1000	2	3
1000-1200	2	3
1200-1500	2	3
1500-4500	2	2,5

Feeding was carried out manually, according to calculated norms. The feed was added in portions, monitoring the palatability, as the fish grew, the norms were adjusted.

For feeding the fish, we used variants of the OT-UZVprod compound feed recipe containing various high-protein components with a protein content in the recipes of up to 50%.

The following types of probiotic preparations were studied:

Probiotic «Lactobifid». Ingredients: complex of lyophilically dried cultures of probiotic bacteria - bifidobacteria, lactobacilli, streptococci; skim milk powder, lactose, starch, calcium stearate.

100 g of feed contains (at least): Carbohydrates 93 g, proteins 3,2 g, fats 0,9 g. The total number of probiotic bacteria is not less than 1·103 CFU in 1 tablet. Energy value in 100 g: 390 kcal.

The Instruction was developed by VEDA LLC, Moscow region, Russia.

Probiotic «Bifitrilac». Highly effective probiotic preparation. It contains bifidumbacteria and lactobacilli on natural adsorbent. Promotes the elimination of poisons, toxins, alkaloids and heavy metals from the body of animals. Does not have contraindications for use.

Ingredients: bifidumbacteria - at least 0,5·106, lactobacilli - at least 1,5 - 106, adsorbent - up to 1 g.

The prepation «OLIN»- is used for all types of farm animals, poultry, fish, horses, fur-bearing animals.

It is a biomass of sporogenic aerobic and anaerobic bacteria *Bacillus subtilis* and *Bacillus licheniformis* at a concentration of at least 2*109COU/g, with well-defined enzymatic and antagonistic activity.

The active substance of the probiotic "OLIN" is probiotic strains *Bacillus subtilis* (ВКПМ-10172) and *Bacillus licheniformis* (ВКПМ-10135) in proportion 1:1 [86].

«Antibac –100» is administered to fish for therapeutic and prophylactic purposes in case of aeromonosis, pseudomonosis, bacterial branhionecrosis, flexibacteriosis, corynobacteriosis, fin rot, citrobacteriosis, furunculosis, vibriosis, mycobacteriosis, streptococcosis, as well as in diseases complicated by bacterial infection [86].

Antibacterial preparation for fish, containing ciprofloxacin as an active ingredient, as well as auxiliary components. It is a light brown powder containing 100 mg of ciprofloxacin in 1 g.

Probiotic feed additive "Bacell-M" is used to normalize digestive processes, increase productivity and safety of farm animals, birds and fish.

Probiotic feed additive Bacell-M (Bacell-M) consists of microbial mass of live bacteria *Bacillus subtilis* 945 (B-5225) at least -1×10^8 CFU/g (colony-forming units), *Lactobacillus paracasei* (B-2347) at least -1×10^6 CFU/g, *Enterococcus faecium* M-3185 (B-3491) at least -1×10^7 CFU/g, as well as auxiliary substances - sunflower meal or products of grain or legume crops processing (83.95%), feed chalk (10%). Does not contain genetically modified organisms [86].

Bacillus subtilis 2335 bacteria included in "SUB-PRO" are antagonistically active and produce antimicrobial substances with bacteriostatic action against pathogenic and opportunistic microorganisms, normalize the qualitative and quantitative composition of the intestinal microflora, activate wall digestion, contribute to the restoration of the population level of representatives of normal intestinal microflora.

Powder for oral administration "SUB-PRO" contains live lyophilized culture of bacterial strain *Bacillus subtilis* BKPM 2335 and auxiliary substance-lactose. 1 g of the preparation contains 5x1010 CFU (colony forming units) of live microbial cells of *Bacillus subtilis* strain VKPM 2335 in spore form.

“Monosporin increases feed digestibility and live weight gain. *Bacillus subtilis* decomposes sucrose, maltose, glucose, produces catalase, endoglu-conase and other enzymes (cellulase, cellobiase and pectinase) involved in the breakdown of cellulose and pectin substances. Stimulate the development of intestinal cellulolytic ruminococci, lactobacilli, hydrolyzes starch.

Industrially valuable strain of *Bacillus subtilis*, the basis of the preparation, has high antagonistic properties against intestinal pathogens: gram-negative representatives of genera *Klebsiella, Escherichia, Salmonella, Proteus, Pseudomonas;* gram-positive - *Staphylococcus, Streptococcus*. The preparation gets along well with intestinal normoflora and stimulates its growth.

“Prolam” is a liquid preparation, which consists of microbial mass of microorganisms *Lactobacillus delbrueckii subsp. bulgaricus, Lactobacillus acidophilus 43c, Lactococcus lactis subsp. lactis 574, Lactococcus lactis subsp. lactis 1704-5, Bifidobacterium animalis* 83, water, milk, beet molasses.

Designed “Prolam” for the prevention of dysbacteriosis and increase non-specific resistance of farm animals, birds and fish, including for increasing the natural resistance of the body, to normalize the activity of the gastrointestinal tract, stimulation of metabolic processes in the body, increasing the digestibility of feeds.

“Bifidum-SHZh"- is intended for the prevention and treatment of diseases associated with disruption of intestinal normoflora, increasing the natural resistance of the animal body.

The drug restores the functions of the gastrointestinal tract and provides optimal growth of farm and domestic animals, including poultry, fur-bearing animals and fish.

“Bifidum-SHZh” is a microbial mass of antagonistically active bifidobacteria of *Bacterium bifidum* strain in the culture medium with the addition of protective medium, 1 dose of the preparation contains at least 10 in 7 degrees of live bacteria.

“Zoonorm” has high inhibitory activity against opportunistic and pathogenic microorganisms (enteropathogenic Escherichia coli, Staphylococcus aureus, Proteus, Shigella, Klebsiella, Salmonella), normalizes intestinal microflora in a short period of time, activates wall digestion.

Zoonorm consists of lyophilized microbial mass of live bacteria of *Bifidobacterium bifidum* strain №1, sorbed on particles of ground activated carbon and lactose filler. One dose of the preparation contains 10 million colony-forming units of bifidobacteria (1x107 CFU).

“Sporothermin” is intended to increase nonspecific resistance of the organism of animals, poultry and fish, in case of disturbance of normal digestion processes associated with enzyme deficiency, to improve safety and increase weight gain. [87].

The feed additive contains lyophilically dried culture *Bacillus subtilis, Bacillus licheniformis.* Number of viable microorganisms *Bacillus subtilis* и

Bacillus Leciniformis КОЕ/г, at least 3-5x10^9. The presence of spore shell bacteria makes it possible to use the preparation in the preparation of pelleted feeds, premixes, BMVD, as spore bacteria *Bacillis subtilis* and *Bacillis licheniformis* withstand high temperature (140°C) and pressure, the impact of chemically aggressive substances.

The norm of introduction of probiotic preparations into the composition of mixed fodder was determined based on the analysis of scientific literature, it amounted to 100 mg/kg of mixed fodder. The preparations were introduced into mixed fodder in the process of preparation, at the stage of mixing of components.

Development of the composition of the compound feed recipe OT-UZVprod, balancing the composition of nutrients was carried out on the basis of the instructions of E.A. Gamygin and others, S.V. Ponomarev and others [15, 47], as well as literature data on the biological properties of probiotics, chitosan and other feed components.

The following feed ingredients and data on the nutritional quality of the resulting feed were used as the basis for the formulation of full-fed sturgeon mixed fodder OT-UZVprod for the conditions of ultraviolet water treatment facilities (chart 6).

Chart 6 – The composition of complete feed OT-UZVprod

Feed components	**Content, %**
Fish meal meat bloody wheat chitosan	up to 60,0 up to 10,0 up to 5,0 up to 5,0 up to 10,0
Soybean meal	up to 11,0
Fish oil	up to 8,0
Premix ВМП ПО-5	1,0
The nutrients, %	
Moisture	9-10
Crude protein	45-48
Raw carbohydrates	15-16
Crude fat	9-12,5
Crude fiber	0,75-0,9
Calcium	0,6-20
Phosphorus	0,5-1,3

In addition to the above-mentioned nutrients, the content of 10 essential amino acids in the feed composition was balanced based on the data of special feed tables [15].

To assess the composition of total chemical substances of fish flogging (fish without head and innards), methodological guidelines of the reference book of S.V. Ponomarev and others, recommendations of M.A. Shcherbin [15] were used.

Analysis of the total chemical composition of the fish body was carried out with determination of moisture content - by drying; fat - by extraction method in Soxhlet apparatus; protein content - by Kjeldahl; ash - by burning in a muffle furnace at a temperature of 500°C.

To analyze hematological parameters, blood was taken from the tail artery of young fish during life. The morphological picture of blood was evaluated by smears, which were processed under a microscope. Smears were fixed and stained according to Pappenheim. Blood cells were identified according to the classification of N.T. Ivanov.

For determination of hematocrit indices, a MHz 6-02 centrifuge or a Shklyar microcentrifuge was used. Heparin (1000 units in 1 ml) was used to treat capillaries. Capillaries were filled with blood and centrifuged immediately after blood collection at 9000 rpm for 1 minute. After positioning of the formations in the peripheral ends of the capillary and plasma in the center, the ratios between the volumes of plasma and formations were determined.

Hemoglobin content was determined by the cyanmethemoglobin method. For this purpose 5 ml of Drabkin's transforming solution (sodium bicarbonate - 1 g, red blood salt - 0.2 g, potassium cyanide or sodium - 0.05 g, the rest - distilled water up to 1 liter) was poured into a test tube with a measuring pipette. Using a pipette from a Sali hemometer, 20 µl of blood was added. The contents of the test tube were mixed well and left in a refrigerator for 20 minutes. After that, the working and transforming solutions were poured into cuvettes and, using a green light filter, measurements were performed on the FEC. The hemoglobin concentration was calculated according to the formula:

$$X = D540 \times 367{,}1 \text{ g/l},$$

where: D540 – indications of ФЭК;

367,1 – conversion factor, taking into account blood dilution, hemoglobin millimolar weight and other parameters.

Serum protein (SPP) levels were determined using a brand refractometer ИРФ-454 Б2М [15, 88].

Experimental probiotics were purchased from veterinary retailers, experimental batches of chitosan from waste from processing of king crab were obtained from CJSC “Fishing collective farm ‘Vostok-1’.

Fish growth rate was determined on the basis of body weight, absolute (g) and average daily growth (g/day). Feed coefficient and survival rate (mortality) expressed in % were determined. Feed ratio was taken as a derivative of the amount of feed, g/body weight gain, over a period of time [15].

The planting density of fish over 500 g was taken as 60 kg/m^3, lesser weight - according to G.G. Matishov and etc., 2007 [53].

In pilot tests, the planting density for fish weighing more than 500 g was set from 60 to 70 kg/m^3.

The scheme of experimental works is given in Figure 4.

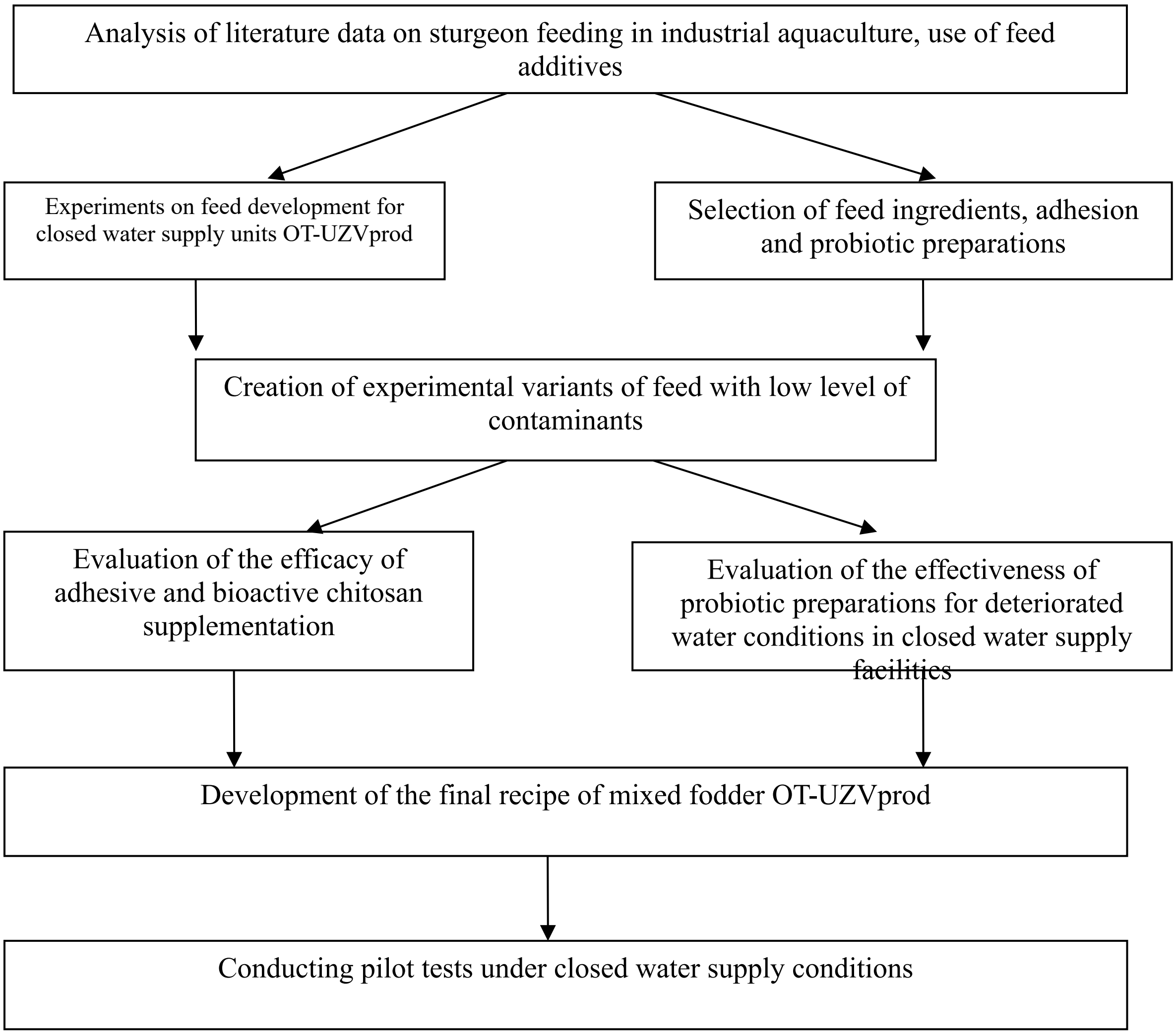


Figure 4 - Scheme of conducting experiments and pilot industrial tests of compound feed OT-UZVprod

The digestibility of the feed was determined using Artemia salina egg tags. [15].

Considering that the fish are fed in water, it was necessary to study their water resistance.

Water resistance was determined according to the generally accepted method. (State Standard 28758-97) [52]. Water resistance of granules B at water temperature from 18 to 24°C, min., was calculated using the formula:

$B = K_h T_{cp} K_t$,

where K_h - conversion factor for the corresponding accepted reference level: at h = 25 K_{25} = 1; at h = 15 K_{15} = 1,5; h = 5 K_5 = 3; T_{cp} – the arithmetic mean value of the time it takes for particles to reach the accepted reference level in three measuring tubes, min.; K_t – correction factor taking into account water temperature (K_t = 1).

The swelling rate was estimated by the gravimetric method and determined by the absolutely dry mass using the following equation::

$$A = (W - W_1) \times 100/W,$$

where W_1 – average initial mass, kg/h; W – average final weight, mg.

The complete swelling of the granules was determined from the moment they were immersed in water until they were completely softened [15].

Friability was determined using a laboratory setup according to the generally accepted method of State Standard 28497-90 [51]. Granule crumbling in percent for each grinder chamber (K_1, K_2 и K_3) calculated using the formula:

$$K = (m_1 - m_2/m_1) \times 100,$$

where m_1 – mass of granules before testing, g; m_2 – mass of granules after testing, g.

The experiments were carried out in duplicate, the data were subjected to statistical processing according to G.F. Lakin (1990) [89] using a personal computer. In this case, elements of statistical analysis with the definition of the average error were used. Comparative features were assessed using the Student's reliability criterion. Each of the options was compared with the others, and the difference was accepted as reliable at the first degree of probability of an error-free judgment. The number of fish in each series of experiments was not less than 25.

In total, about 3,000 sturgeon weighings and measurements were performed, about 200 blood samples and 240 biochemical samples were processed.

CHAPTER 3. THE REDUCING POLLUTANT LEVELS AND OPTIMIZING THE COMPOSITION OF STURGEON FEED DURING FARMING IN CLOSED WATER SUPPLY SYSTEMS

3.1 Creating a recipe taking into account solving the problem of reducing the level of ballast substances in feed

Complete feeds for sturgeon predominantly contain fish meal and other products of animal origin (meat, blood meal), as well as products of plant origin (meal from cereals and high-protein meal). [15, 47].

The amount of fish meal in modern feed recipes for commercial sturgeon varies from 30 to 60% [18]. In addition to pro-protein and lipids, fish meal also contains contaminants Ca and P (Ca - 4-8 %, P - 2.5-6.4 %) as part of bone residue. [15, 90].

The need for the composition of nutrients in complete feeds is substantiated by the works of S.V. Ponomarev and E.N. Ponomareva (2003). The optimal level of Ca (0.5 %), P (1.0 %) in sturgeon fish feeds was proposed by N.A. Abrosimova. (1997) [42, 91].

Feed components of plant origin contain another water pollutant that is not assimilated during digestion - fiber. For example, wheat contains 2.7 % of fiber, corn - 2.2 %, wheat bran - 9 %, sunflower meal - 15-16 %, soybean meal - 7 %, fodder yeast - 1.5 % [15, 90]. In this connection, a number of components of plant origin, which contain a lot of fiber, are excluded from the composition of sturgeon feed for sturgeons grown in a closed water supply facility.

At the same time, fish meal (and essential amino acids in its composition) have no substitutes, so in these studies were carried out to reduce the level of Ca and P in the composition of the experimental feed OT-UZVprod. To reduce the level of calcium and phosphorus in fishmeal use the method of sieving on a sieve with a hole diameter of 0.3 mm.

As a result of sieving of fish meal from pollock, the following indicators of the total chemical composition and calcium (Ca) and phosphorus (P) content were obtained (chart 7).

Chart 7 - Total chemical composition, calcium and phosphorus content in pollock fish meal before and after sieving on a sieve with mesh diameter 0.3 mm

Indicators, %	Before sifting	After sifting
The content of moisture	9,8±0,4	9,9±0,4
Crude protein	56,4±1,1	60,1±1,2
Crude fat	4,8±0,2	4,9±0,2
Calcium	6,2±0,3	2,1±0,1
Phosphorus	4,2±0,2	1,4±0,1

Differences are reliable at the value p≤0,01

The removed residue from the total mass of fish meal amounted to 10 %, visual inspection of the sift showed that it is represented by bone residue of vertebrae, head bones and ribs of the initial raw material. According to the data of Chart 8, it is noticeable that the sift allowed to reduce the level of Ca and P up to 3 times and to increase the crude protein content from 56.4 to 60.1 %, which is also a positive result.

In the finalized form, the composition of full-fed compound feed OT-UZVprod for sturgeon fish is presented in the Chart below. 8.

Chart 8 - Composition of the recipe of full-fed compound feed OT-UZVprod for sturgeon fish

Feed components	**Content, %**
Fish meal meat bloody wheat	60,0 10,0 5,0 5,0
Soybean meal	11,0
Fish oil	8,0
Premix ВМП ПО-5	1,0
The compposion of nutrients, %	
Moisture	9,0
Crude protein	49,2
Raw carbohydrates	15,4
Crude fat	12,5
Crude fiber	0,9
Calcium	2,0
Phosphorus	1,3
Total energy, MJ/kg	20,4

Thus, a recipe of high-calorie, highly nutritious feed with low values of contaminants (fiber - 0.9 %, Ca - 2.0 %, P - 1.3 %) was obtained. The composition of essential amino acids of the feed mixture corresponds to the known needs of fish, previously established by John Halver [92], the data are presented in Chart 9.

The data in Chart 9 correspond to the norms of fish requirements in such basic essential amino acids as lysine (3.73 %), methionine (1.12 %), tryptophan (0.52 %), arginine (2.46 %), histidine (1.21 %), valine (2.8 %), gly-cine (3.53 %), phenylalanine (2.1 %), threonine (2.02 %), leucine + isoleucine (6 %).

Chart 9 - Composition of amino acids of full-feed OT-UZVprod for sturgeon fish with reduced level of pollutants

Aminoacids	Content, %
Lysine	3,73
Methionine	1,12
Cystine	0,82
Tryptophan	0,52
Arginine	2,46
Histidine	1,21
Leucine	3,54
Isoleucine	2,47
Phenylalanine	2,1
Tyrosine	1,41
Threonine	2,02
Valine	2,8
Glycine	3,53

Subsequent testing made it possible to establish the effectiveness of the new full-fed compound feed for sturgeon fish OT-UZVprod in the cultivation of commercial Russian sturgeon in a closed water supply installation.

3.2 The evaluation results of productive properties of mixed fodder OT-UZVprod with reduced level of pollutants

The experiments were carried out in the closed water supply system of Zhangir Khan West Kazakhstan Agrarian-Technical University during growing two-year-old Russian sturgeon. The duration of the experiments was 60 days, the variant of mixed fodder OT-UZVprod with fish meal without sieving was used as a control (chart 10).

Chart 10 - Fish-biological indicators of growing two-year-old Russian sturgeon juveniles

Growing indicators	OT-UZVprod with fish meal sieving (experiment)	OT-UZVprod with-out fish meal sieving (control)
Body weight, g initial final	 330,5±11,2 433,0±8,5	 325,6±13,1 365,2±9,7
Absolute increase, g	102,5	39,6
Average daily gain, g	1,7	0,7
Survivability, %	100	98,0
Feed coefficient, units	1,1	1,4
Duration of experiments, days	60	60

Fish growth rate, survival rate and feed conversion indices allow to establish higher efficiency of feed with fish meal sieve and reduced content of Ca and P. The data of differences in fish body weight are especially significant ($p<0.001$). At the same time, it is likely that a number of factors influence the growth of fish.

On the one hand, the feed OT-UZVprod with fish meal sieving contains less non-digestible ballast substances and more protein, on the other hand (in control) feed OT-UZVprod without sieving polluted water, which was established when evaluating the hydrochemical regime, the data are presented in the chart 11 below.

Chart 11 - Water environment indicators in two closed water supply systems (experiment and control) with separate biofilters

Name of indicators	**Technological norm (including OCT-15.372-87)**	**Experiment**	**Control**
Temperature, °C	not > 24	24,1-24,8	24,1-24,8
Transparency, %	-	100	70-80
Suspended solids, g/m^3	до 10	0,5	2,5-3,5
Hydrogen index	7,0-8,0	7,6	7,8-8,1
P_2O_5, mg/l	-	0,15	0,4-0,5
Phosphates, mg/l	до 0,3	0,15	0,4-1,2
Total iron, mg/l	до 0,4	0,05	0,05
Calcium, mg/l	40-260	30,0-40,0	80-320
Nitrogen:			
ammonium, mlN/l	1,0	0,4-1,0	0,4-1,0
nitrite, mlN/l	0,02	0,008-0,01	0,008-0,01
nitrate, mlN/l	2 - 3	0,8-1,1	0,8-1,1
Mineralization, ml/l	-	900-1200	1000-2400

To assess the health status of farmed fish, it is customary to use indicators of red and white blood composition [93].

The data on blood composition in two-year-old Russian sturgeon in the experiment and control are presented in the chart 12 below.

Chart 12 - Hematological indicators of Russian sturgeon

Indicators	**Experiment**	**Control**
1	2	3
Hemoglobin, g/l	64,1±2,5	52,3±2,4
Hematocrit, %	20,5±1,4	18,6±1,3
Erythrocytes,million/mm^3	0,741±0,05	0,526±0,04
Blood serum protein, g/l	28,6±3,6	20,5±2,8

1	2	3
Leukocyte formula, %		
Lymphocytes	48,6±4,6	58,4±5,8
Eosinophils	8,9±1,2	9,5±1,3
Neutrophils, incl.		
Promyelocytes	1,4±0,4	1,6±0,4
Myelocytes	2,5±0,5	2,2±0,5
Metamyelocytes	1,6±0,3	1,2±0,2
Banded	24,2±4,3	28,6±5,6
Segmentonuclear	4,6±0,4	6,8±0,3

In conditions of higher water pollution in the control fish showed a decrease in hemoglobin, hematocrit, number of erythrocytes, lymphocytes and an increase in neutrophils (differences are reliable at $p<0.01$). In general, the indicators, both in the experiment and in the control, are close to the previously established physiological norm [94].

The efficiency of feeding and growing fish in artificial conditions also affects the general chemical composition of the body, which was studied in the following experiments (chart 13).

Chart 13 - Composition of total body chemicals of Russian sturgeon, %

Indicators	**Experiment**	**Control**
Moisture	48,5±1,1	51,3±1,6
Dry substance	51,5±1,3	48,7±1,2
Protein	63,5±1,8*	58,4±1,6
Ash	8,6±1,4	9,1±1,5
Carbohydrates	2,8±0,6	2,6±0,5
Fat	25,1±2,1	29,9±2,8

Note - * the differences are significant at value $p\leq0{,}01$

In the control group, where the fish were fed with feed with an increased proportion of Ca and P, the protein content was significantly ($p<0.01$) lower. At the same time, in the experimental group, fat accumulation occurred to a lesser extent, which is a favorable indicator [47].

Thus, the results of the experiments confirmed the higher efficiency of the complete feed OT-UZVprod on the example of two-year-old Russian sturgeon with the removal of excess pollutants (Ca, P, fiber), which made it possible to obtain the highest growth rates, feed conversion (KK = 1.1), as well as the physiological state of the fish.

This ensures the practical application of the experimental results for the industrial development of production batches of the OT-UZVprod feed intended for recirculation water supply systems. Such feed not only has a high productive effect, but its use also reduces the level of pollution of the closed water supply system, water with organic compounds of Ca and P, as well as fiber.

CHAPTER 4. THE CHITIN AS AN ADHESIVE AND BIOACTIVE ADDITIVE TO FEED USED IN CLOSED WATER SUPPLY SYSTEMS

4.1 The chitin and its derivative chitosan as an adhesive and bioactive additive in fish feed

The chitin (pronounced KITE-in): a nitrogen-containing polysaccharide, chemically related to cellulose, which forms a semi-transparent rough substance and is a principal constituent of the exoskeleton or outer covering of insects, crustaceans and spiders.

The chitin is not a precise nomenclature, but most people are familiar with its sources. In nature, it is found in the shells of crustaceans such as crabs, shrimp, and lobsters, and in the outer coverings of marine zooplankton, including corals and jellyfish.

Insects such as butterflies and ladybirds contain chitin in their wings. The cell walls of yeasts, fungi and other moulds also contain this natural substance [95, 96].

The chitin is one of the most widely distributed polysaccharides in nature, in addition to cellulose and starch. It ranks prominently after cellulose as the most commonly occurring compound on earth.

Cellulose and starch are the main hydrocarbons that plants use as a source of food and to build cell walls. They also have a variety of industrial uses. Scientists and entrepreneurs see similar potential opportunities for chitin [97, 98].

Chemically, cellulose, starch and chitin are polysaccharides-polymers or large molecules composed of small molecules of sugars strung together like pearls on a string of beads. The chitin can be processed into many derivatives, among which the most readily available is chitosan, formed when chitin is heated in chemical solutions. Chitosan has several advantages in comparison to chitin because it is better dissolvable in water [99, 100].

The chitin and its derivatives have many properties that make them attractive for a wide range of applications from food, nutrition and cosmetics to biomedicine, agriculture and environmental protection [101, 102, 103].

Their antibacterial, antifungal and antiviral properties give them particular value for biomedical applications such as wound bandages, surgical suture materials, aids in cataract surgeries and for the treatment of dental diseases.

Investigations have shown that chitin and chitosan are non-toxic and non-allergenic, which is probably why the body does not reject these compounds as foreign invasions. The chitin's biodegradability and antifungal properties are a plus for the environment and agricultural use [100].

Unlike most polysaccharides, chitosan has a strong positive charge that allows it to bind to negatively charged surfaces such as hair and skin. This makes it a useful ingredient in skin and hair care products. Several researches have shown that the charge of chitosan also helps its binding to fats and cholesterol and initiates the coagulation of red blood cells [104].

Over the past decade, scientists from Japan, Europe and the United States have tested the chitin and its derivatives for their applicability in biomedicine. Researchers have besides targeted their applications in food and nutrition, including edible films and coverings to preserve the quality and texture of food. Today, more than one million people widely use the chitin and chitosan as dietary supplements [105, 106].

In many countries, the chitin and chitosan are already used in a variety of products, but many more materials of all kinds can be made from these compounds. In Japan, chitosan was first used in waste water treatment products because of its ability to bind metals, but today chitin and chitosan are found everywhere from antibiotics and surgical suture materials, to dietary supplements, food and cosmetics. It can also be incorporated into pet food and used to make material for underwear and socks. In the US, chitin and chitosan have been used in seed treatment products, animal food additives and water purification, as well as in hair care products and as dietary supplements. While synthetic compounds are losing their appeal, natural substances such as chitin and chitosan require closer scrutiny [107, 108].

For many years, chitin and its derivatives have been used for dietary and medicinal purposes in the Far East. In fact, many people use dietary supplements made from chitin and chitosan [100, 109].

The research has suggested that chitin and chitosan have a number of qualities that are beneficial to health, including the ability to enhance the proliferation of *Bifidobacteria*, gut-healthy bacteria, preventing disease. The chitin derivatives such as chitin oligosaccharides and chitosan oligosaccharides (smaller components of chitin and chitosan molecules) have also been suggested to have many important health dividends, including stimulation of the digestive tract, anti-tumour properties and stimulation of these very beneficial *Bifidobacteria* [110].

Oligosaccharides are among the most popular functional food additives in Japan, but they are relatively unknown in the United States. According to an article in Food Technology in October 1994, ingestion of oligosaccharides is beneficial to health. This article claims that oligosaccharides can improve the reproduction of *Bifidobacteria* and thus weaken harmful bacteria, help reduce toxins and deleterious enzymes, prevent diarrhoea and constinacea, protect liver function, reduce serum cholesterol, protect against cancer and aid in nutrient production [111].

Research has shown that a diet containing fructose, galactose and soy oligosaccharides is very healthy. Fructose oligosaccharides, for example, stimulate the growth of *Bifidobacteria*, thus healing the gut and stabilising its function, preventing Diarrhoea and other ailments. It has been suggested that chitin oligosaccharides may have similar beneficial qualities. Animal studies have shown that chitin oligosaccharides enhance intestinal function. Other animal studies have suggested that chitin, chitin oligosaccharides and chitosan stimulate an immune response in mice, expressed as the formation of T-cells that attack tumour cells. The researchers suggest that chitosan oligosaccharides may act in the same way [112, 113].

Investigations have shown that chitosan can be effective in lowering blood cholesterol levels. In 1980, Japanese scientists demonstrated that including chitosan in a diet designed to raise blood cholesterol levels in rats resulted in lower cholesterol levels in the animals. Subsequent work with animals has shown that chitosan can also bind cholesterol in the intestine. Preliminary results from additional trials conducted in Norway showed that blood cholesterol levels were reduced by approximately 25 per cent in adults who consumed chitosan daily for eight weeks in addition to their individual diets. Although the mechanism of blood cholesterol reduction is not fully elucidated, it is thought that the chitosan molecule acts as a fat remover from the digestive tract, capturing fat and dietary cholesterol, which are then excreted [114].

Scientists have also shown that overall bowel function and regularity is improved with the use of dietary chitin. In animal studies, it was demonstrated that gerbils given diets supplemented with chitin became stronger and healthier [115, 116, 117].

Other experiments showed that the same result of health benefits was obtained when chitin was added to bread and then fed to gerbils. Similar benefits have been reported for chitin additives to cattle diets [101].

Researchers suggest that improving bowel regularity could also produce results in people taking moderate amounts of chitin [118].

Chitosan films have been studied to help retain moisture, reduce bacteria and lengthen the skin life of perishable foods such as fruits and vegetables. In one research paper, it was demonstrated that the life of strawberry skins was extended from one to more than five days by coating the berry with a chitosan film. Cucumbers, melons and other mould-sensitive fruits can also be protected by chitosan film [119].

At the U.S. Department of Agriculture (USDA) Western Regional Research Centre in Albany, California, apples coated with chitosan derivatives and placed in cold storage retained freshness for more than six months because the coating protected the apples from oxidation and rotting. Scientific researchers from Argentina used edible films to protect cooked dough to increase its longevity [120].

At the University of Idaho, researchers have mixed potato starch with chitosan to make edible foils that can fight microbes that poison food. Both components, chitosan and potato starch, can be individually processed into foils for food. Researchers have shown that stronger and more robust foils are produced when the two are combined, but further research is needed to determine whether the chitosan in the combined product maintains its antimicrobial ability. Among other applications of edible foils, the US Army's Natick Research Center in Massachusetts has been experimenting with chitosan as a possible biodegradable packaging material for MREs (Meals Ready to Eat), a field food for soldiers [120, 121].

USDA's Western Research Center has also experimented with edible foils for bread, pizza, and ice cream cups to protect them from moisture. Chitosan-based packaging can be used to separate pizza dough from pizza garnish according to researchers who observed that pizza could be frozen for several months and would retain a fresh flavour [122, 123].

The chitin is a valuable mixing or stabilising agent for food products such as biscuits, breads and frozen foods. In bread dough, chitin has demonstrated the ability to improve loaf volume and crumb quality. The chitin helps to increase the preservation of food products prone to spoilage during freeze-thaw processes, such as low-calorie ice cream and frozen pizza dough. The chitin has potentialities in improving the solidification quality of frozen and dessert products [124, 125, 126].

The recent increased importance of environmental protection has inspired a new generation of scientists to take a closer look at natural materials such as chitin and chitosan. Increasing demands for non-polluting products and less wasteful industrial production have made these two materials, both non-toxic and biodegradable, most attractive [127].

The properties of chitosan to bind and eliminate various particles, are useful in ways to treat drinking water, swimming pools and reduce various types of water losses. Chitosan removes organic matter and heavy metals such as copper, mercury and zinc. Chitin is used in water treatment products in Japan and USA [49].

Due to their ability to bind metals, chitin and chitosan salts are also effective in the clarification of fruit juices and other beverages [124].

Among other agricultural applications, the Environmental Protection Agency (EPA) has approved chitosan as a seed treatment to increase yields in wheat, barley, oats, peas, beans, soya beans and maize. Seeds coated with chitosan produce seedlings with enhanced immune systems and are more resistant to disease. These plants have strong root systems, good tops, and strong stems that help the plant take up the maximum amount of nutrients and moisture, as well as lessen soil erosion. This seed treatment can also be used to form a film to minimise the use of pesticides and thus protect the environment [124].

The current and potential applications of chitosan and its derivatives in various fields such as biomedicine, food products, pharmacology, microbiology, agriculture and cosmetics are extensive and impressive. About 1000 scientific articles have been published on chitin and its derivatives and nearly 200 patents have been issued in the USA, not counting those issued in other countries around the world [108].

The source of chitin-chitosan is the products of marine crustacean processing.

To date, recommendations and technologies have been developed for the complex processing of Kamchatka crab to obtain food products, collagenase enzyme preparation, chitin, chitosan, and carotenoids [99, 100, 101, 102, 103].

Russia is the largest producer of crab products (they are harvested up to 60 thousand tonnes annually). The development of domestic technologies for the use of chitosan began in the 70s and has now reached the level necessary for industrial implementation [118].

The chitin and its derivative, chitosan, represent the structural basis of crustacean shell and are natural polymers with unique and useful properties that allow their use in various industries and medicine [122, 123].

Nowadays, the chitin and chitosan are obtained from shells of crustaceans (krill, shrimps, lobsters, langoustes). The mass source of chitin and chitosan is the shell of Antarctic krill, which is a waste product of food production. Chemical composition of krill meat (%): moisture 82-85, protein 12-13, fat 0.7-1.1, ash 1.9. The meat may contain 0.17 % of shell [105].

Studies on the use of shell-containing raw materials from krill for the production of chitin and chitosan were first initiated by Dalrybvtuz in 1977 [128]. [128]. On the basis of acid-alkaline hydrolysis, a complex technology was developed for processing krill shell-containing waste with the extraction of chitin, chitosan, and fodder protein paste [104].

The production of chitin from crab and shrimp shells has been established in the USA. Abroad, chitosan is used in the production of fish products, granulated fish feeds, as a stabiliser and coagulant, a means for treating wounds, accelerating their healing, a preparation used for the extraction of protein substances from the waste water of fish processing production.

The most suitable raw material for chitin production is the shell of the walking limbs of the crab, followed in importance by the shell of the clawed limbs and, finally, the shell of the cephalopod [98].

A derivative of chitin, the aminopolysaccharide chitosan, which has a spectrum of unique physicochemical properties and biological activity, is of considerable interest. Like chitin, chitosan is a long-chain molecule with a large molecular mass of up to several million daltons.

In their chemical structure and content they are identical, with one exception: in each ring of the chitin molecule at the second carbon atom there is an acetamide grouping, while in chitosan there is an amino group in this place. In other words, chitosan is chitin in which the acetyl group has been removed by alkali treatment (deacetylation) and replaced by an amino group [106].

Chitosan in combination with a complex of specially selected acids of organic origin (composition conditionally named ‘CC-13’) has a high adhesive effect, which is expressed in the increase of water resistance and reduction of crumbling of mixed fodder granules [124, 126, 129].

In addition, a number of studies indicate that chitosan has antibacterial properties and can be used as a bactericidal agent for the treatment of diseases caused by bacteria and products of their vital activity, as well as capable of stopping the growth of pathogenic species of mould, which will allow the use in feed production of a large amount of grain raw materials, for one reason or another infected with mould fungi [119, 120, 130].

The carotenoid astaxanthin (3,3-dihydroxy-8,8-carotene-4,4-diol) has become the most valuable by-product of chitin production. Currently, a number of crab species, such as the red king crab, which is the largest, serves as a raw material for the production of astaxanthin along with chitin [121, 131].

At present, additives of shrimp, crab, and river crayfish shell meal are used in compound feeds for aquaculture facilities. These components contain astaxanthin, which is necessary in feeds for trout and salmon, as well as various biologically active substances, chitin, chitosan and their compositions.

It was noted that the chitin content in some parts of crustacean shells increases with decreasing mineral content. The most mineralised parts of the shell are claws, and the richest in chitin content is the abdomen. The chitin content in the total sample is 25 %. The conducted studies indicate that due to its physical and biological properties, chitosan can be successfully used in the feed industry for valuable aquaculture objects. The high effect of chitin and chitin-containing products has been established, which contribute to the improvement of physical and mechanical properties of fish fodders - reduction of their crumbling and increase of water resistance. Failure to provide fish farming with a necessary set of feed additives, lack of effective binding agents for feed manufacturers, consumer claims to low water resistance and increased crumbling of granular feeds during transportation, storage and feeding to fish are convincing arguments in favour of organising the production of feeds with the introduction of chitosan on a large industrial scale [132].

As mentioned above, crab waste can be divided into three fractions: chitin-containing (carapace of the cephalopod, walking and clawed limbs), protein-containing (abdomen), lipid-containing (viscera, mainly liver).

In dried crab shells mass fraction of chitin is 37-40 %; protein compounds - 38-40 %; mineral substances (mainly carbonic acid and phosphoric acid salts of calcium) - 11-13 %; fat - 0,36-0,4 %; moisture - 6-7 %. In terms of chitin content, crab shell waste is 3 times higher than krill and, taking into account the volume of crab fishing, is the most promising chitin-containing raw material.

Crab waste is a valuable raw material for the production of natural red spectrum colourants, the deficit of which is acutely felt in the domestic food, pharmaceutical and cosmetic industries. Carotenoid pigments of shell-containing raw materials are indispensable components in starter feeds for salmonid fish.

Depending on the physiological state of the crab, its liver contains 8.7-28 % lipids and 8-16 % proteins. In terms of fatty acid composition, crab liver lipids are close to fish fats (Ivashi, pollock, saira, etc.), but in terms of phospholipid content (5-15 % of the lipid sum) they exceed them. The phospholipid fraction of crab liver includes long-chain fatty acids of the omega-3 group, which exhibit high biological activity. Such phospholipids can be used in medicine, pharmacology, perfumery and cosmetic industry.

The protein fraction contains more than 40 % of essential amino acids with predominance of leucine, arginine, valine and threonine; glutamic, asparagic acids and glycine dominate among essential amino acids. On the basis of protein substances it is possible to obtain flavouring food additives, and in combination with shell trace elements, chitin and carotenoids they can be used as components of therapeutic and prophylactic nutrition for humans, veterinary preparations for animals and young fish [100].

The products of crab waste are chitin-containing shell and viscera, which is successfully used in fish feeds.

The chitin is a polysaccharide (poly - N - acetyl - D - glucosoamine), similar in physicochemical properties to cellulose, but differs from it by the presence of an acetamide group, which gives this biopolymer valuable properties. Chitin is found in many animals and plants, mainly in crustaceans, and is the second most abundant organic substance after cellulose [127].

Chitosan is a naturally occurring polysaccharide (1-4-2-amino-2-deoxy - β-D-glucone) with the empirical formula $C_{12}H_{22}O_8N_2$. It is obtained from shell-containing raw material from the cutting of commercial crustaceans or from uncut small commercial crustaceans. In appearance, it is a powder or flakes of white to cream or pink colour with greyish or yellowish tinge, humidity not more than 10%, ash content up to 1%, pH - not more than 8 [49].

The wide applications of chitin and its derivatives are due to their unique physicochemical properties. The uniqueness of these biopolymers, especially chitosan, consists, first of all, in their selective sorption ability. Thus, chitosan does not sorb potassium, sodium, calcium, magnesium ions, but forms strong complexes with metals of variable valence (heavy and rare earth) - mercury, cadmium, lead, copper, nickel, etc. Chitosan derivatives sorb radioactive elements, at the same time they are radiation-resistant and are not destroyed by γ-radiation [125].

In shell-containing raw materials, chitin is firmly bound to proteins and mineral substances. Production of chitin is based on the sequential separation of protein substances and mineral components, their conversion into a soluble state with subsequent removal of solutions.

Biochemical, histological and morphological studies on animals showed that chitin as an enterosorbent is a non-toxic preparation with good sorption properties and has therapeutic effect in endogenous toxicosis of different nature.

It was noted that chitin and chitosan due to biocompatibility with living tissues, bioinertness and bacteriostaticity are promising for wide application in medical practice.

The administration of chitosan solutions intramuscularly and intraperitoneally to farm animals increases the organism's non-specific resistance to infections, contributing to health improvement, increase in weight gain and their survival rate [127].

Chitosan compounds (CC), which are mixtures of chitosan proper and some other products, are used in fodder production and fish feeding.

So, the CC-13 structure includes chitosan, ascorbic acid and methionine, the CC-18 combination additionally includes soya meal. Amino acids of compositions strengthen the action of chitosan, soybean meal contributes to the improvement of chitosan distribution in the structure of mixed fodders, performing the functions of filler.

Chitosan-containing preparations have a pronounced adhesive effect and, being introduced into the composition of pelleted feeds, contribute to a significant improvement in their physical and mechanical properties [124].

One of the directions for the use of chitosan and its derivatives in the last few years is becoming fish farming under managed or controlled conditions. At this stage, this is related to key components of aquaculture such as feed production, water treatment in recirculation systems, fish health, transport and storage of live fish.

The chitin and a number of its derivatives, recognized as the greatest scientific and technical discovery of the twentieth century, have a rather long history.

Treatment of chitin under harsh conditions with strong alkalis allows to replace acetyl groups of chitin with amino groups and obtain chitosan. From easily modifiable chitosan it is possible to obtain its derivatives with useful properties for the selected application.

Traditionally, the shell of walking limbs of commercial crab species was used as a raw material for chitosan production in the Far East. However, the current state of crab fishing and processing has changed the situation.

As a raw material for chitosan production it has become possible to use the shell of cephalopods of sea crabs, which are harvested in the Pacific Ocean more than 100 thousand tons annually.

CJSC “Vostok-MTD” analyzed the shell of king red crab for general mineral composition. It was found that the shell contains a significant amount of protein, ash and chitin, which determines its nutritional and physical-mechanical properties. The mineral part of crab shell contains a significant amount of macronutrients that play an important role in metabolism, including phosphorus, calcium, iron, magnesium, and potassium.

The production of chitosan is based on obtaining chitin from crab shell and its subsequent deacetylation.

Since chitin contained in the raw material has high chemical resistance, its production is based on selective dissolution of impurities of calcium carbonate and protein, sequential treatment of crab shell in hydrochloric acid and caustic soda solution.

Depending on the purpose of further processing of chitin into chitosan, the process can be carried out either in hot or cold mode.

The process of control demineralization in cold mode is carried out to obtain high molecular weight chitosan and is carried out at normal temperature for 6-8 hours with continuous mixing.

Hot mode is applied at 50-60°C for 2-3 hours and is used to obtain chitosan with lower molecular weight.

A method of resource-saving processing of shell-containing crab production waste based on the treatment of raw materials with a complex preparation of digestive enzymes obtained by fractionation of the hepatopancreas of the king crab has been developed [123].

Crabs are the most abundant and available chitin raw material, but cause serious environmental problems on seashores where seafood is processed. Coastal pollution from such waste is an urgent environmental problem that requires special costs to solve. In the USA, consideration has been given to offsetting these costs by providing subsidies for the production of feed protein from chitin. Therefore, great interest is shown to chitin and its derivative - chitosan in connection with the need to utilize the waste generated during crustacean processing to prevent environmental pollution [120].

Literature analysis has shown that the chitin (chitosan) is very promising for use in the formulation of special feeds in fish farming closed systems. As a biopolymer, it is able to glue the feed mixture particles together, simultaneously being a bacterial antagonist and a biologically active agent, potentially improving the production properties of such feeds. At the same time, as a means of controlling saprophytic bacteria and microscopic fungi in feeds, it is important to evaluate the prospects for the use of such an important feed additive as probiotic agents.

4.2 The adhesion properties of chitosan in the composition of mixed fodder OT-UZVprod

In hydrobionts, carbohydrates are bound to proteins and lipids and are represented by complex biopolymers. These include chitin, which is the second natural biopolymer (after cellulose) belonging to polysaccharides.

When freed from proteins or $CaCO_3$, chitin is a proteinaceous substance resembling paper pulp [97, 98].

The chitin and chitosan have the ability to stimulate the growth of *Bifidobacterita* (bifidobacteria), a beneficial intestinal bacteria that helps control disease. The chitin derivatives, such as chitin oligosaccharides and chitosan oligosaccharides (smaller components of chitin and chitosan molecules), are also considered to have many important benefits, including anti-tumor properties. [133].

In the organism of fish, chitin is partially broken down by chitinase. According to a number of authors, chitinase is found mainly in species that consume large quantities of crustaceans [134, 135]. Chitinase cleaves chitin to dimers and trimers of N-acetyl-D-glucosamine (NAG), which can be further cleaved by glucose aminidase (NAGase). This enzyme is found in the digestive tract of fish along with chitinase. NAG, the end product of the chitinolytic process, may be of nutritional value as it is resorbed by the gut faster than glucose [136].

Chitosan is obtained by treating chitin with alkalis, it becomes water-soluble and its adhesion is improved. Chitosan is used in agriculture, food and cosmetic industries [137].

In experiments to evaluate the effectiveness of adhesive and biologically active additive, chitosan obtained from CJSC "Vostok", which is engaged in processing of Kamchatka (king) crab, was used. Chitosan in this case is obtained from waste - crab shells. By appearance it is a powder or flakes of white to cream or pink color with grayish or yellowish tint, humidity not more than 10 %, ash content up to 1 %, pH - not more than 8 %.

In the experiments, chitosan was introduced into the composition of OT-UZVprod mixed fodder in the amount of 1% and 5% (instead of wheat flour) and 10% (instead of 5% wheat flour and 5% soybean meal). The obtained recipes of mixed fodder are presented in Table 14.

With the increase of chitosan from 1 to 10 % in the feed mixture, some slight decrease in protein, fat, carbohydrates, increase in calcium, but up to the maximum level of 2.2 % was observed. As biological tests showed, all variants of compound feed formulations differed in adhesive and productive properties.

The most important properties of mixed feed pellets, when used in fish farming, are water resistance and crumbability. When getting into the water of fish breeding tanks pellets should be resistant to erosion and extraction of nutrients, crumbling is important for transportation to the place of storage of feed and its using.

Chart 14 - Composition of experimental variants of mixed fodder OT-UZVprod with chitosan

Composition, %	Experiment options			
	I 1 % of chitosan	II 5 % of chitosan	III 10 % of chitosan	Control without chitosan
1	2	3	4	5
Fish flour	60,0	60,0	60,0	60,0
meat	10,0	10,0	10,0	10,0
blood	5,0	5,0	5,0	5,0
wheat	4,0	-	-	4,0

1	2	3	4	5
Soybean meal	11,0	11,0	6,0	11,0
Fish oil	8,0	8,0	8,0	8,0
Premix ВМП ПО-5	1,0	1,0	1,0	1,0
Nutrient composition				
Moisture, %	9,0	8,8	8,7	9,0
Crude protein, %	49,2	49,1	47,9	49,2
Crude carbohydrates, %	15,4	15,3	15,2	15,4
Raw fat, %	12,5	12,1	11,8	12,5
Crude fiber, %	0,9	0,9	0,8	0,9
Calcium, %	2,0	2,1	2,2	2,0
Phosphorus, %	1,3	1,3	1,3	1,3
Total energy, mJ/kg	20,4	20,3	20,1	20,4

The results of testing the water resistance of granules with a diameter of 6 mm are presented in Fig.5.

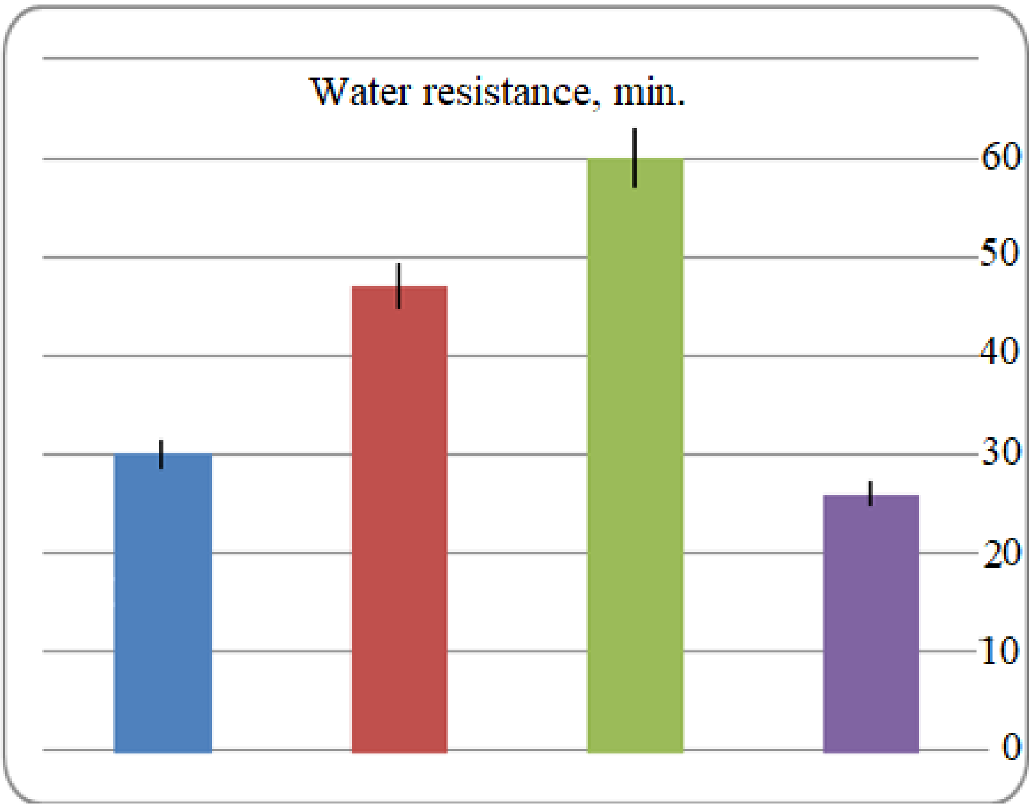


Figure 5 - Water resistance of OT-UZVprod mixed fodder granules with chitosan

Note: 1, 2, 3 – Experiment options (see chart), differences are reliable at P≤0,001

It follows from the data in Figure 5 that the maximum water resistance of 60 minutes was obtained in variant III with 10% chitosan as a result of the OT-UZVprod compound feed, in variant II - 47 minutes, in variant I - 30 minutes, in the control without chitosan in the feed - only 26 minutes. The control variant does not meet the requirements of the regulations for the technological process of closed water supply systems, since the destruction of the granule leads to intensive extraction of nutrients into the water and contamination of the system. The period from 40 to 60 minutes is sufficient for complete consumption of the granules by the fish and maintaining the quality of water in the closed water supply systems.

The crumbling of the feed in variant 1 was 15%, in variant 2 - 5%, in variant 3 - 1%, in the control - 25%.

4.3 The biological evaluation of the chitosan influence on the productive properties of mixed fodder OT-UZVprod

It was necessary to study the biological effect of chitosan in the composition of OT-UZVprod compound feed granules, since the growth of fish and feed conversion are affected by the cementing effect of this component, which changes the ability to digest feed in the gastrointestinal tract of sturgeon fish. For this purpose, during a period of 30 days, Russian sturgeon were fed with OT-UZVprod compound feed granules with different chitosan content, the results are presented in chart 15.

Chart 15 - Results of biological evaluation of feeding two-year-old Russian sturgeon with OT-UZVprod compound feed with different levels of chitosan

Indicators	**Experiment options**			
	I	**II**	**III**	**Control**
Body weight, g Initial Final	 425,6±18,6 481,3±12,8	 442,0±8,6 542,6±10,1	 435,6±12,0 465,3±17,4	 415,1±12,0 460,2±10,8
Absolute increase, g	55,7	100,6	29,7	45,1
Average daily gain, g	0,92	1,68	0,5	0,75
Feed coefficient, units	1,1	1,0	4,5	1,2
Speed of food passage, h	1,9	2,0	1,5	2,2
Survivability, %	100,0	100,0	95,0	100,0
Feed digestibility, %	76,0	86,0	54,0	78,0
Duration of experiments, days	30,0	30,0	30,0	30,0

Biological assessment of productive properties revealed maximum results in variant II (with 5% chitosan in the feed mixture). In this variant, high growth rates were noted. Thus, the average daily growth was higher than in the control by 38%, with the same 100% survival rate.

In variant III (with 10% chitosan), biological indicators significantly worsened, 5% of individuals died, the feed coefficient increased to 4.5 units with a low growth rate.

The data on feed digestibility are quite indicative. In variant II, digestibility was 76%, while in variant III (with excess chitosan) - 54%, and in the control without chitosan 78%.

In variant III, the rate of passage of food through the intestine was the highest (1.5 h), which indicates the need for the organism to evacuate poorly digestible feed. In variant II - 2 h. The lowest rate of food passage was found in the control (2,2 h).

Thus, the cementing adhesive effect of chitosan has been demonstrated. The optimal amount of this substance introduced into the OT-UZVprod compound feed has been established – 5%.

As a result, the maximum weight gain was obtained – 1.68 g/day, with the lowest feed coefficient (1.0 units), better feed digestibility (76%) and a longer period of food passage (2 hours).

At the same time, the water resistance of the granules was quite high and amounted to 46 min. In the variant with excess chitin in the feed, all biological parameters of cultivation worsened, since the cementing effect of such an amount of the preparation was excessive.

In additional experiments, it was necessary to evaluate the physiological parameters of the health of the fish grown on diets with different levels of chitosan in the feed (0.5 and 10%). For this, data on the composition of red and white blood were used, which flexibly respond to the experimental conditions and the composition of food. Since the environmental conditions in the experimental pools were the same, the composition of the feed had a decisive effect on the composition of the blood, which is reflected in Chart 16.

As indicated in the scientific literature [94], during fasting in Russian sturgeon, a decrease in the content of whey protein to 1.8 g/l, hematocrit to 30%, hemoglobin to 62 g/l is observed, the intensity of erythropoiesis increases to 5.8, and the number of eosinophils to 9.7%.

Similar blood composition indices were established in the OT-UZVprod feed variant with 10% chitosan. This allows us to assume that the Russian sturgeon was in a state of starvation. In the experimental variant with 5% chitosan and in the control, on the contrary, the blood composition indices corresponded to the accepted norm. [94].

Chart 16 - Blood composition of two-year-old Russian sturgeon fed with OT-UZVprod compound feed with different chitosan content

Indicators	**Experiment options**		
	5 % of chitosan	**10 % of chitosan**	**0 % of chitosan (control)**
Serum protein, g/l	2,1±0,41	1,7±0,62	2,2±0,4
Hematocrit, %	31,2±1,16	27,4±0,82	32,4±1,17
Hemoglobin, g/l	78,3±6,12	63,4±3,41	76,2±5,91
Erythropoiesis intensity	5,4±0,12	5,9±0,61	5,4±0,13
Leukocyte formula, %			
Lymphocytes	64,21±4,41	57,61±2,45	61,41±4,52
Eosinophils	9,25±1,68	9,84±2,11	9,34±1,78
Neutrophils, including:			
Promyelocytes	1,52±0,41	1,72±0,53	1,58±0,38
Myelocytes	1,65±0,95	1,2±0,88	1,65±0,89
Metamyelocytes	1,6±0,44	1,3±0,28	1,7±0,55
Banded	25,11±6,12	29,52±6,14	24,9±5,77
Segmentnucleur	5,0±1,1	5,5±1,28	5,1±1,2

Thus, based on the results of the experiments, the composition of the recipe for complete sturgeon compound feed for the conditions of closed water supply systems OT-UZVprod should contain 5% chitosan with the replacement of wheat flour. It included the following feed components (%): fish meal - 60.0; meat - 10.0; blood - 5.0; soybean meal - 11.0; fish oil - 8.0; chitosan - 5.0; mineral and vitamin premix VMP-PO5 - 1%. The feed contains nutrients (%): protein - 46.1; carbohydrates - 25.4; fat - 12.1; crude fiber - 0.9; calcium - 2.1; phosphorus - 1.3. The total energy is 20.3 MJ/kg.

In the closed environment of a recirculation plant, it is very important to maintain the immunity of cultured fish at a high level. In this regard, special microbial preparations are used in fish farming as part of compound feed, which reduce the influence of saprophytes on the digestion process and increase the non-specific resistance of fish.

CHAPTER 5. THE SELECTION OF ANTIBACTERIAL PREPARATIONS AND PROBIOTICS FOR THERAPEUTIC AND PROPHYLACTIC TREATMENT OF FISH IN CLOSED WATER SUPPLY SYSTEMS

5.1 Nosological characteristics of sturgeon pathologies in closed water supply system

In the aquaculture of Zhangir Khan West-Kazakhstan Agrarian-Technical University and LTD "Educational and scientific complex for experimental industrial production of aquaculture" a fairly extensive collection of various species of sturgeon fish has been formed and bred. The collection of sturgeon species of fish includes: Russian sturgeon, Siberian sturgeon, sterlet, beluga, ship, as well as their hybrids (figure 6, 7).

Figure 6 - Aquarium complex of Zhangir khan West-Kazakstan Agrarian-Technical university

Figure 7 - LTD "Educational and scientific complex for experimental industrial production of aquaculture"

Sturgeon fish, despite their evolutionary stability and ability to tolerate high concentrations of pollutants of various natures for a short time, are susceptible to diseases of various etiologies. If in the natural environment, due to obvious circumstances, such pathologies are not always possible to visualize, then in closed water supply installations they are clearly visible.

Based on the results of retrospective and operational epizootological monitoring and analysis of the registration of pathologies in closed water supply installations, the nosological profile of fish diseases is represented by invasive and infectious pathologies (chart 17).

Chart 17 - Nosological profile of sturgeon pathologies in closed water supply installations

Nozoform	**2015 – 2016**			**Incidence (AI per 1,000 fish specimen)**	**Proportion of total fish pathology**
	Fish specimen examined	**Fish specimen detected**	**%**		
Aeromonosis	345	79	22,8	228	14
Pseudomonosis	405	85	20,9	209	12,9
Myxobacteriosis	372	57	15,3	153	9,4
Saprolegniosis	15	2	13,3	133	8,2
Argulosis	50	5	10	100	6,1
Piscicolosis	10	1	10	100	6,1
Diclibothriosis	70	9	12,8	128	7,9
Ichthyophthyriasis	350	150	42,8	428	26,4
Nitrite poisoning	57	5	8,7	87	5,3
Mechanical trauma	18	1	5,5	55	3,4
Total	1692	394	23,2	232	100

Based on the obtained results, a linear-radial scheme was developed - a model of the nosological profile of the main pathologies of fish in pools closed water supply in-stallations (figure 8).

The data of the linear-radial model of the nosological profile of pathologies among sturgeon fishes clearly represent the structure and types of pathologies depending on the etiological origin.

The greatest proportion is occupied by infectious pathology diseases of bacterial and fungal nature. They are represented by the following nosological units: aeromonosis, pseudomonosis, myxobacteriosis and saprolegniosis.

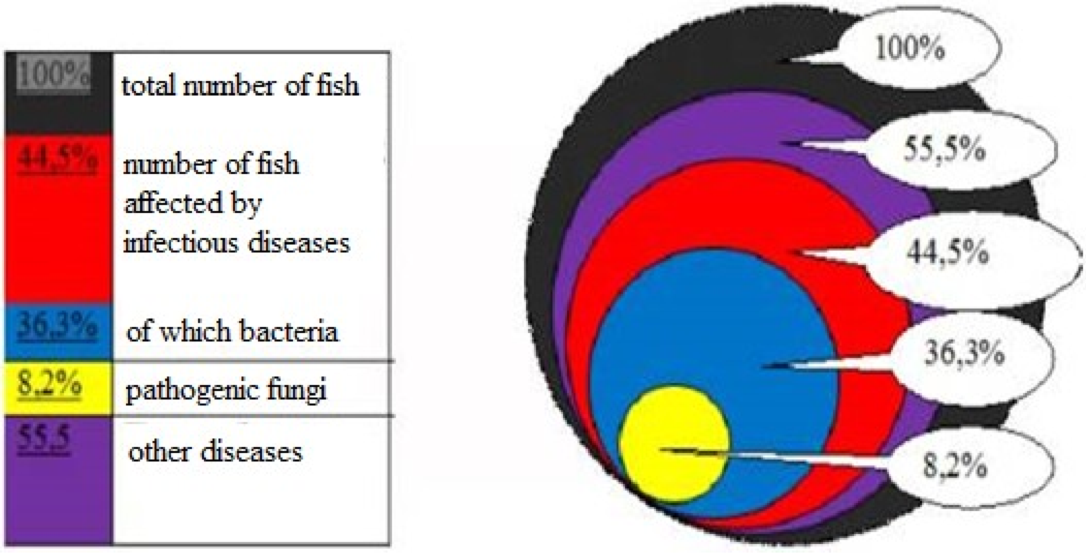


Figure 8 - Linear-radial scheme - a model of the nosological profile for the main groups of fish pathologies

As a result of research, the following most frequently registered diseases of bacterial etiology have been identified.

Aeromonosis is an infectious disease of many fish, including sturgeon species. The causative agent of aeromonosis is mobile aeromonads belonging to the genus *Aeromonas*, family *Vibrionaceae*. Infection occurs through damaged skin and gills of fish. Sick fish become lethargic, immobile, weakly react to external stimuli, lie on the bottom of the pool, stop eating. Acute form is expressed in rapid reddening of the cover of sick fish, with redness mainly develops on the ventral side of the body. The anus is swollen and also reddened (figure 9, 10).

Figure 9 - Ulcerative lesions on the abdominal part of a Siberian sturgeon

Figure 10 – Redness in the anal area and damage to the base of the anal fin

As a result of the studies of the ulcer surface wash and subsequent cultivation on the MPA nutrient medium, a culture of the pathogen was isolated. Microscopy revealed morphologically characterized as gram-negative, non-motile microorganisms of coccoid form (figure 11).

Figure 11 - *A. hydrophila,* secreted from the wound (x 900)

Studies have also noted the spread of various species of pseudomonads in closed water supply systems, which can initiate fish diseases. In this case, clinical signs can be diverse and depend on the degree of development of the pathological process. In the initial stage of development of the pathological process are noted more often lesions of dorsal bugs and sickle-shaped pupil (figure 12, 13).

Figure 12- Dorsal bug infestation Figure 13- Sickle pupil and hemorrhage

At a medium degree of affection in diseased fish are noted slight reddening of rostrum, anus, spot hemorrhages on the abdominal surface of the body. In the conditions of the pool of closed water supply installations, it is not always possible to notice in time. More often in the conditions of production are faced with a strong degree of lesion, which is characterized by the following clinical signs. The sick fish is passive, is more near the surface of the water. On examination, lesions on the fins are noted. Lesions in the form of hemorrhages and ulcers are more often observed at the base of the fins, the so-called “fin rot” (figure 14, 15).

Figure 14 – Fish with pectoral and anal fin lesions

Figure 15 - Hemorrhages and ulcers at the base of the fins (fin rot))

Severe pseudomonosis may manifest as bloating of the abdomen and the presence of ulcers that penetrate deep into the muscle tissue layers (figure 16).

Figure 16 - Abdominal bloating and ulceration in Russian sturgeon

Ulcers may be solitary or there may be several. Parallel ulcers on the lateral surface of the peritoneum of sick fish have been recorded. On palpation, fluctuation is noted in the area of swelling (figure 17).

Figure 17 - Swelling and ulcers on the lateral surface of the abdominal wall

With slight pressure on the swollen area, a mucous suspension including red-colored destructed muscle tissue is released from the wound. The said suspension can be drawn through a bleeding needle for subsequent microbiologic examination. When opening the wound, decomposition of muscle tissue with the formation of deep pockets is noted under the skin (figure 18).

Figure 18 - Wound suspension sampling and the presence of deep cavities in the wound

Microscopy of Gram stained smears made from wound suspension revealed Gram-negative bacilli morphologically identified as bacteria belonging to the genus *Pseudomonas* (figure 19).

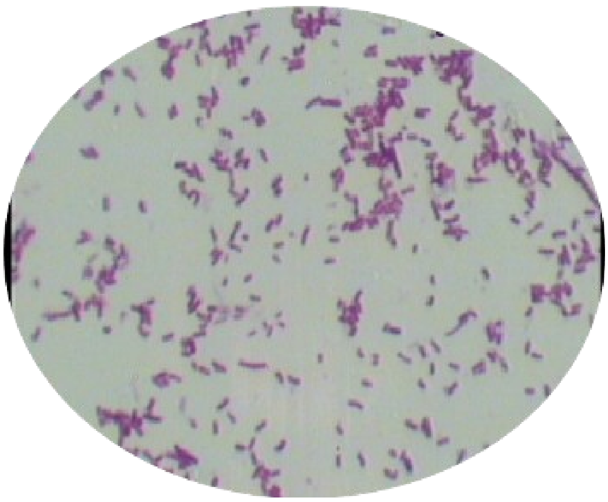


Figure 19 – Pseudomonas causative agent from wound suspension (x 900)

In addition to bacterial pathologies, sturgeon species of fish also have invasive diseases caused by various species of parasites.

Among the helminthic diseases in sturgeons, the studies have encountered monogenean suckers of the genus *Diclybothrium*, family *Diclybothriidae*. The causative agents of this class caused diclybothriosis. Sick fish affected by

Diclybothrium armatum monogenes were lethargic, inactive. Their gills are pale, abundantly covered with mucus. The pathogen can be seen with the naked eye, located on the periphery of the gill lobes, mobile. At the ends of the gill petals gill epithelium is destroyed, gill tissue destruction is noticeable. Emerging changes in the structure of gill tissues lead to disruption of their functions and, as a consequence, fish death occurs as a result of asphyxia (figure 20, 21).

Figure 20 - Localization *D. armatum*

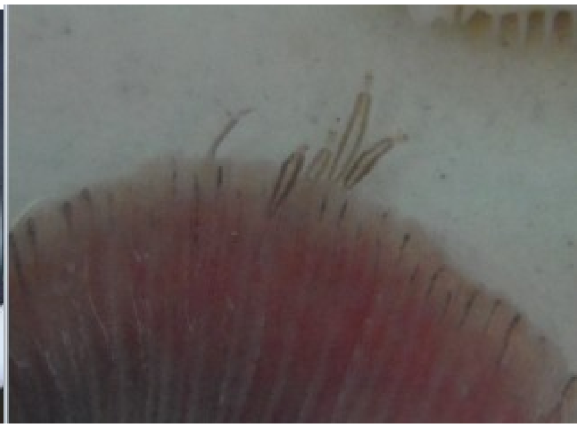


Figure 21 - High level of AI gills on gill lobes

In addition to helminthoses, sturgeon fish species in closed water supply installations have registered invasive pathologies, the causative agents of which are representatives of arthropods (*Arthropoda*) and crustaceans (*Crustacea*) - crustaceosis.

Occurrence and spread of mass fish diseases depends on different reasons. Each disease has peculiarities, but for most diseases there are some common causes of their occurrence and laws of development and spread. The main ones are:

- introduction of the pathogen with fish planting material imported during breeding of valuable fish breeds;
- presence of the causative agent of the disease;
- susceptibility of the organism, i.e. lack of species-specific and acquired immunity;
- non-compliance with the level of fish density in the reservoir;
- unfavorable changes in the environment (hydrobiological, meteorological, hydrochemical, ecological, biocenological factors, conditions and quality of nutrition).

In connection with the pathologies encountered in sturgeon fish growing in closed water supply conditions, it became necessary to develop and implement therapeutic and preventive measures. Various methods were tested in the process of research.

5.2 Evaluation of the effectiveness of probiotics application in the composition of complete mixed fodder

The term “probiotic” was first coined by D. M. Lilly and R. H. Stilwell in 1965 as an “antonym” of antibiotic to denote microbial metabolites that have the ability to stimulate the growth of any microorganisms [60]. In 1971, the term was used to refer to various tissue extracts that have a stimulatory effect on microorganisms. Subsequently, the original definition of probiotics underwent changes.

The positive effect of probiotics on the body is due to the fact that they stimulate the growth of your own microflora. Therefore, the main purpose of taking probiotics is to restore your own microflora. Once in the intestine, beneficial bacteria begin to compete with pathogenic bacteria and displace them from the intestine, making room for the growth of their own microorganisms.

In the course of research work, a method of including antibacterial components in the feed composition was tested.

To prevent leaching of the antibacterial preparation from the feed composition and, thus, to prevent reduction of the preventive and therapeutic properties of the preparation, a pilot batch of therapeutic feed was prepared in the laboratory according to the accepted technology. Sturgeon production fodder was used as a filling material «CTC-1» [138].

Experimental samples of production fodders were prepared in the laboratory of Research Institute of Zhangir Khan West Kazakhstan Agrarian-Technical University. In the preparation of dry pellets and coarse fodder were used electric meat grinder, drying cabinet, set of multi-cell sieves, mixers and extruders.

5.2.1 Evaluation of the effect of the probiotic “OLIN”

The probiotic “OLIN” was tested for therapeutic and prophylactic purpose, which was used on the repair group of thorns. Probiotic “OLIN” was used according to the following scheme: probiotic “OLIN” was used in the pool on 25 individuals of thorn at the age of 3 years for therapeutic and prophylactic purpose. The mentioned probiotic was used in the recommended dose - 6 g per 10 kg (complete feed “Coppens”) of feed during 7 days, followed by 7 days break. The efficacy of the recommended dose and single application was not quite satisfactory: feed intake increased slightly, but no noticeable therapeutic and prophylactic result was achieved [139].

Subsequently, we increased the dose of probiotic to 10 g per 10 kg of feed and conducted two courses of 10 days with 7 day intervals between them. The results of the application of this scheme methodology are shown in chart 18.

Chart 18 - Fish-breeding - biological indicators of spike rearing in closed water supply installations on mixed fodder with probiotic addition «OLIN»

Indicators	Experiment with probiotics	Control without probiotics
Initial weight, g	2530±51,27	2527±47,43
Final weight, g	2785±53,44*	2743±52,35*
Absolute growth, g	255	216
Relative growth rate, %	9,59	8,19
Mass accumulation coefficient	0.044	0.037
Average daily gain, g/day.	8,5	7,2
Feeding coefficient, units.	1,6	1,7
Survivability, %	100	100
Duration of growing, days.	30	30

* The difference is not statistically significant (P≥0,5).

The best growth indicators were observed in the experiment variant with the addition of probiotic "OLIN", slightly worse in the control without probiotic (final body weight was 2785±53.44 g and 2743±52 g, respectively). Average daily weight gain, respectively, was equal to: 8.5 and 7.2 g/day; feed coefficient - 1.6 and 1.7 units. Survivability in all variants was 100 %.

In the experiments conducted, it was important to determine blood parameters to assess the general physiological condition of individuals in control and «OLIN» probiotic supplemented experiments.

The blood composition confirmed the obtained effect when «OLIN» probiotic was used in full-fed mixed fodder (chart 19).

Chart 19 - Composition of blood parameters of three-year-old spikelets on mixed fodder with probiotic addition «OLIN»

Indicators	**The experiment variants**	
	The control without probiotic	**With probiotic «OLIN»**
1	2	3
Serum protein, g/l	2,1±0,7	2,4±0,8
Hematocrit, %	31,3±2,2*	34,7±1,3*
Hemoglobin, g/l	67,1±2,9*	76,4±5,7*
Intensity of erythropoiesis	5,7±0,8	5,5±0,4
Leukocyte formula, % Lymphocytes Eosinophils	 57,8±6,5 9,7±3,4	 63,8±6,1 9,2±1,6

1	2	3
Neutrophils, including:		
Promyelocytes	1,7±0,6	1,4±0,4
Myelocytes	2,8±0,4	3,1±0,7
Metamyelocytes	1,8±0,5	2,1±0,7
Bacilli	29,4±6,9	28,2±6,4
Segmentonuclear	5,5±1,3	5,3±1,2

* The difference is not statistically significant (P≥0,5)

The fish that consumed mixed feed with probiotic “OLIN” had higher hemoglobin and hematocrit content compared to the control.

The results of probiotic application according to this scheme were encouraging.

Fish activity increased, feed digestibility increased, and cases of bug infestation on the abdominal surface of the fish body decreased.

At the same time, control over hydrochemical parameters of aquatic environment was strengthened and control over microbiocenosis of aquatic environment was carried out. Microbial landscape by quantitative indicators and species composition does not exceed the norms.

5.2.2 Experience of use the antibacterial drugs ciprofloxacin and sulfadimethoxine

In the experiment, the broad-spectrum antibiotic ciprofloxacin and a preparation from the sulfonamide group - sulfadimethoxin - were chosen as antibacterial preparations. 3 g (0.6 %) of ciprofloxacin and sulfadimethoxin powder were added to 1000 g of prepared crude full-fed sturgeon fodder and mixed thoroughly.

The prepared full-fed raw sturgeon feed with antibacterial preparations was extruded. In order to reduce the possible negative effect of high temperatures on the feed components, the minimum temperature was set to. [140].

Prior to pelleting, all components of the diet were additionally ground and sieved so that the particle size of the starter feed did not exceed 0.3 mm (with a sieve residue of up to 10 %). First, a mixture of dry ingredients was made according to the recipe.

After adding premix and antibacterial preparations, the mixture is thoroughly mixed and added through a doser in the extruder 7-10 % of water and the feed mixture is passed through the extruder (figure 22).

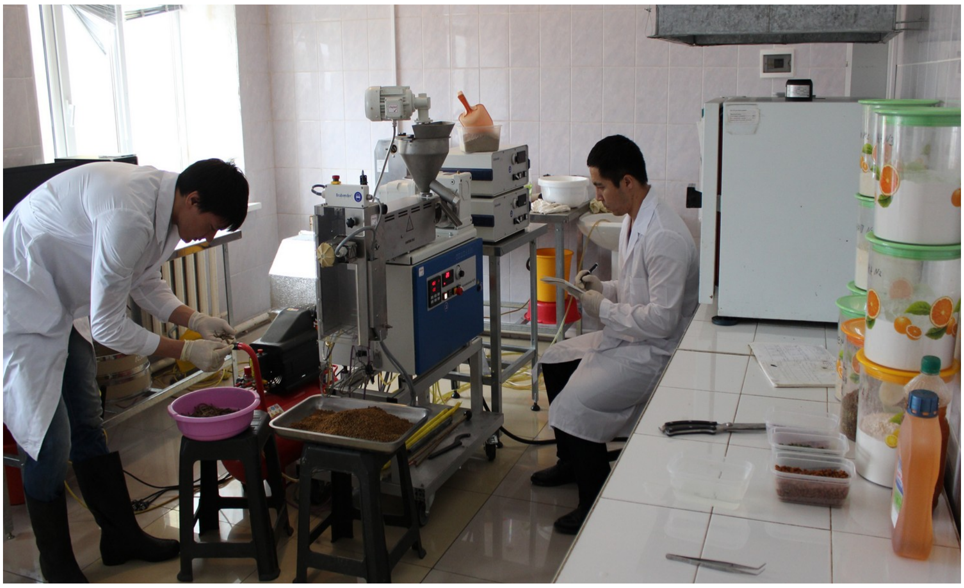


Figure 22 – The preparation of product feed by extruding method.

The main purpose of the extruder is to ensure that the screw continuously develops the appropriate temperature and pressure. On this basis, the following operations must be carried out in the extruder:

- transportation of the material to be processed to the pressing zone;
- heating of the material to the required temperature through layer-by-layer mixing and internal conversion of mechanical energy into thermal energy;
- homogenization;
- pushing the homogenized mass through the holes of the forming head.

The feed mixture comes out of the extruder in the form of a filament, the thickness of which depends on the nozzle diameter, the extruder cutting blade cuts the filament according to a preset program. After the extruder, the feed acquires its final form in the form of pellets.

The prepared feed was fed to 25 young Russian sturgeon for 5 days. In the control with the same signs of disease, under the same conditions, 25 Russian sturgeon were given feed without the addition of antibacterial preparations (chart 20).

Chart 20 - Fish-breeding and biological parameters of Russian sturgeon breeding in conditions of closed water supply on mixed fodder with the addition of antibacterial preparations ciprofloxacin and sulfadimethoxine (0.6 % of feed weight))

Indicators	**Experiment with probiotics**	**Control without probiotics**
1	2	3
Initial weight, g	2545±70,5	2550±68,4
Final weight, g	2740±78,6	2736±81,3
Average relative growth rate, %	7,3	7,0

1	2	3
Mass accumulation coefficient	0,034	0,032
Absolute gain, g	195	186
Average daily gain, g/day.	6,5	6,2
Feeding coefficient, units.	1,6	1,6
Survival rate, %	100	100
Duration of the experiment, days.	30	30

According to the data of Chart 20, it follows that fish breeding indices were slightly higher in the variant with the addition of antibacterial preparations (relative growth rate -7.3%), slightly worse in the control without antibacterial preparations (relative growth rate-7,0 %).

In the experiment, the absolute gain was 196 g against 186 g in the control, the final body weight was equal to 2740±78.6 g and 2736±81.3 g, respectively. The average daily weight gain was respectively equal to: 6.5 and 6.2 g/day. Survival rate in the experiment and control was equal to 100 %.

Relatively high fish performance in the experiment is explained by the fact that the physiological parameters of fish under the influence of antibacterial drugs slightly improved and fish begin to gain weight.

Blood composition data confirmed that the physiological condition of fish in the experiment compared to the control is slightly better (chart 21).

Chart 21 – The blood composition parameters of three-year-old Russian sturgeon fed with antibacterial preparations of ciprofloxacin and sulfadimethoxine

Indicators	**Experiment variants**	
	The experiment with antibacterial preparations	**The control without antibacterial preparations**
Serum protein, g/l	2,1±0,4	1,9±0,6
Hematocrit, %	33,2±1,2	29,4±1,0
Hemoglobin, g/l	67,2±1,2	61,2±2,4
Intensity of erythropoiesis	5,7±0,5	6,1±0,3
Leukocyte formula, % Lymphocytes Eosinophils	 55,3±4,4 9,8±1,6	 57,3±5,1 9,5±1,8
Neutrophils, including: Promyelocytes Myelocytes Metamyelocytes Bacilli Segmentonuclear	 1,7±0,4 2,4±0,2 1,2±0,3 28,8±7,6 5,5±1,2	 1,6±0,3 2,5±0,3 1,4±0,3 28,3±6,6 5,4±1,3

Analysis of chart 21 shows that serum protein, hematocrit, hemoglobin were higher in the experiment compared to the control.

The results of application of feed prepared according to the above recipe were positive. Feed digestibility increased, wounds on dorsal beetles began to acquire a grayish tint, indicating regenerative processes and wound healing. Affection of bugs on the ventral side practically stopped (chart 22). When weighing the fish after 30 days, the weight gain of 195 g was noted.

Thus, a comparative evaluation of various therapeutic and prophylactic methods showed the effectiveness of feed with the addition of ciprofloxacin and sulfadimethoxin at a dose of 0.6% of the feed weight.

A recipe for therapeutic feed was prepared, which allows to reduce the time of exposure of fish to the therapeutic feed and thereby reduce the degree of toxic effects of the therapeutic preparation.

Chart 22 - Results of combined use of ciprofloxacin and sulfadimethoxine

The name of the group	The number of fish	Clinical and physiological parameters					
		The bug infestation at the beginning of the experiment		The forage digestibility	The bug infestation at the end of the experiment		The forage digestibility
		side	abdominal		side	abdominal	
Experimental	25	14	6	65 %	10	3	80 %
Control	25	14	4	65 %	17	8	58 %

5.2.3 Fish-breeding and biological parameters of growing young Siberian sturgeon at feeding with the addition of probiotics “Bacel-M”, “SUB-PRO”, “Monosporin”, “Prolam”

Several probiotics were tested for feeding young sturgeon fish in the experiment: «Bacel-M», «SUB-PRO», «Monosporin», «Prolam».

To evaluate the effect of feeding mixed fodders with probiotics on growth intensity, we used weight gain and body length of fish, and also determined survival rates.

Measurement of these parameters was carried out after every 10 days of feeding mixed fodders with probiotics.

The dynamics of the results of the effect of feeds with different probiotics on the intensity of weight gain and body length are presented in Charts 23-25.

Chart 23 - Fish-biological parameters of growing young sturgeon after 10 days

Indicators	**Experiment options**				
	I Bacel -M	**II SUB-PRO**	**III Monosporin**	**IV Prolam**	**Control**
Initial weight, g/individual	90 ±0,04	108±0,06	109±0,03	107±0,06	103± 0,04
Weight after 10 days, g/individual	120±0,02	140 ±0,00	146 ±0,02	131 ±0,06	147 ±0,03
Absolute gain, g/individual	30,0	32,0	37,0	24,0	44,0
Body length, initial, cm/individual	27 ±0,023	30 ±0,01	31 ±0,00	30 ±0,03	29 ±0,03
Body length after 10 days, cm/individual	31 ±0,02	34 ±0,01	33 ±0,02	32 ±0,01	33 ±0,02
Absolute gain, cm/individual	4,0	4,0	2,0	2,0	4,0

Measuring the results of body weight gain of fish individuals are different, slightly higher these indicators in the control group and 3rd group, where the probiotic "Monosporin" was used. Below all noted weight gain in the 4th group, which received feed with probiotic "Prolam". Such difference in the first decade of the experiment can be explained by the process of adaptation of fish to the conditions of housing and feeding. As for body length gain, these indicators were the same in groups 1, 2 and control, which were 2 times higher than in groups 3 and 4.

Chart 24 - Fish-biological parameters of growing young sturgeon after 20 days

Indicators	**Experiment options**				
	I Bacel -M	**II SUB-PRO**	**III Monosporin**	**IV Prolam**	**Control**
1	2	3	4	5	6
Initial weight, g/individual	90 ±0,04	108±0,06	109±0,03	107±0,06	103±0,04
Weight after 20 days, g/individual	148 ±0,03	164 ±0,02	176 ±0,04	170 ±0,05	171±0,01

1	2	3	4	5	6
Absolute gain, g/individual	58,0	56,0	67,0	63,0	68,0
Body length, initial, cm/individual	27 ±0,023	30 ±0,01	31 ±0,00	30 ±0,03	29 ±0,03
Body length after 20 days, cm/individual	35 ±0,03	37 ±0,01	36 ±0,04	36 ±0,03	37 ±0,02
Absolute gain, cm/individual	8,0	7,0	5,0	6,0	8,0

After the 2nd series of experiments, the measurements of growth intensity were also different between groups. Thus, absolute weight gain was higher in the 2nd, 4th and control groups. Practically the same and slightly lower these indicators were noted in the 1st and 2nd groups.

Chart 25 - Fish-biological parameters of growing young sturgeon after 30 days

Indicators	**Experiment options**				
	I Bacel -M	**II SUB-PRO**	**III Monosporin**	**IV Prolam**	**Control**
Initial weight, g/individual	90 ±0,04	108±0,06	109±0,03	107±0,06	103± 0,04
Weight after 30 days, g/individual	173±0,01	189±0,03	200±0,005	171±0,03	178± 0,03
Absolute gain, g/individual	83,0	81,0	91,0	64,0	75,0
Body length, initial, cm/individual	27±0,023	30 ±0,01	31 ±0,00	30 ±0,03	29 ± 0,03
Body length after 30 days, cm/individual	35±0,02	37±0,01	38±0,01	36±0,002	36± 0,001
Absolute gain, cm/individual	8,0	7,0	7,0	6,0	7,0
Survivability, %	98,0	97,4	98,0	96,0	88,0

However, the final stage of studying the growth intensity of fish productivity indicators indicates the need for long-term feeding of feed with probiotics.

This may be associated with changes in the microbiocenosis of the fish organism, contributing to the increase of general resistance, strengthening of immunity and increase of feed coefficient.

Experiments on feeding fodder in combination with probiotics determined the group of effective probiotics by the growth of absolute weight and body length of fish (figure 23).

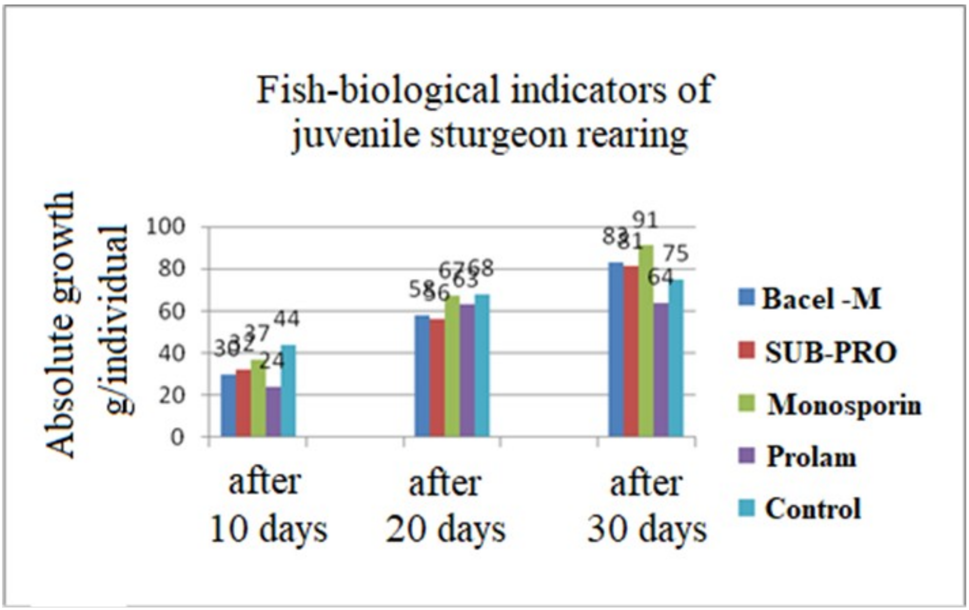


Figure 23 - Effects of probiotics on fish weight gain

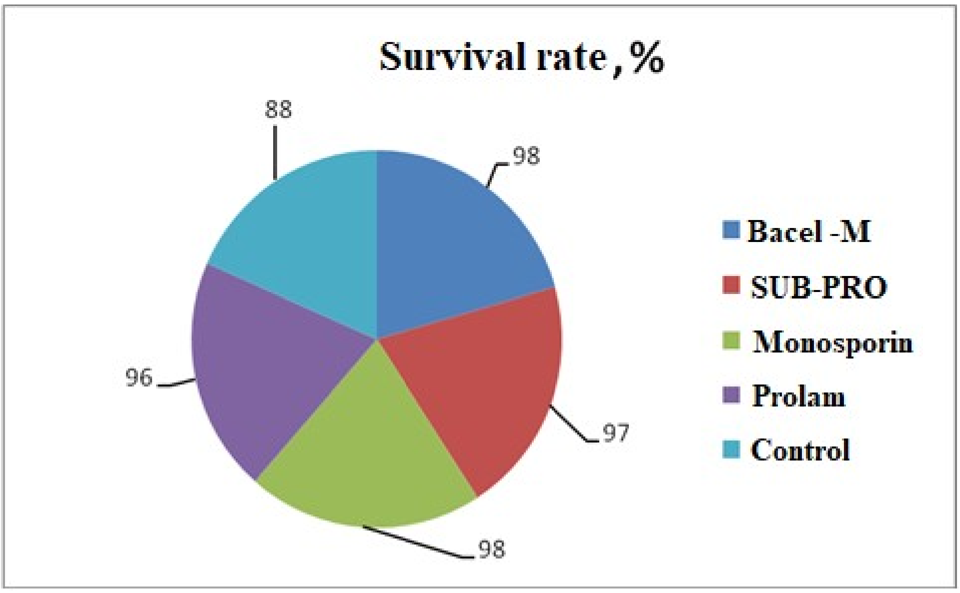


Figure 24 - The effect of probiotics on fish survival

According to the results of the research, the following were effective in increasing the productive qualities of fish «Monosporin», «Bacel M», and «Sub-

Pro», the absolute increase in body weight of fish amounted to 92 %, 75 % and 83 %.

The average daily body weight gain of fish was 9.1 g/day; 8.3 g/day; 8.1 g/day, respectively.

In groups of fish with application of these probiotics a pronounced safety of fish was observed in comparison with the control group (figure 24).

Absolute growth of body length by groups had insignificant difference.

5.2.3.1 Hematological parameters of juvenile sturgeon fish farmed on mixed fodder with the addition of different probiotics

In the studies, it was important to determine blood parameters to assess the general physiological condition of individuals in control and probiotic supplemented experiments (chart 26).

Chart 26 - Composition of blood parameters of young Siberian sturgeon on mixed fodder with probiotics addition

Indicators	Experiment options				
	I Bacel -M	II SUB-PRO	III Monosporin	IV Prolam	Control
Serum protein, g/l	2,3±0,4	2,2±0,4	2,4±0,5	2,0±0,3	2,1±0,7
Hematocrit, %	33,2±2,1	32,3±1,8	34,5±1,6	33,1±1,9	31,3±2,2
Hemoglobin, g/l	67,2±2,4	67,1±2,7	76,3±3,1	64,8±4,8	67,1±2,9
Intensity of erythropoiesis	5,4±0,7	5,6±0,5	5,3±0,6	5,2±0,8	5,7±0,8
Leukocytic formula, % Lymphocytes Eosinophils	57,4±6,7 9,6±3,1	57,8±6,4 9,5±3,2	61,8±5,8 9,4±2,6	61,8±6,2 9,6±1,4	57,8±6,5 9,7±3,4

It was revealed that when using with the addition of probiotics “Monosporin” III-variant and “Bacel-M” I-variant on the feed “STS-1” fish-water-biological, physiological and biochemical indicators of growth of experimental groups were at a high level compared to the control group without probiotics. The worst result was shown by variant IV with the addition of probiotic “Prolam” - the indicators of serum protein and hemoglobin were lower than the control group.

Thus, the best physiological condition in experimental fish was observed in variant III with probiotic addition «Monosporin».

5.2.4 Evaluation of the efficiency of the use of antibacterial preparation "Antibac-100" in the composition of production fodder

In the initial period, traditional antibacterial preparations "Antibac-100" were used. For preparation of therapeutic feed 200 g. "Antibac-100" was diluted in 1 liter of water and thoroughly mixed. The resulting suspension was used to wet 10 kg of mixed fodder "Coppens" (distributed in a thin layer on plastic trays) with the help of a bulletizer and stirred for uniform moistening. Then the feed was dried in a dark place and fed to 25 young Siberian sturgeon (experimental) at the rate of 1 kg of prepared feed per 20 kg of fish weight per day. In the control, 25 Siberian sturgeon were kept under the same conditions, but without the addition of antibacterial preparations. The course of feeding with therapeutic mixed fodder was 10 days. The results of "Antibac-100" application are presented in chart 27.

These charts indicate some positive effect of using the preparation "Antibac-100". Firstly, the eatability of daily feed ration improves, secondly, the process of regeneration of lateral and abdominal bug lesions increased by 29.5 % and 37.5 %, respectively. Also, the process of complication and spread of bug lesions on the abdominal surface of the fish body was not observed.

Chart 27 - Results of using the preparation Antibac -100

<table>
<tr><th rowspan="3">Name of groups</th><th rowspan="3">Number of fish</th><th colspan="9">Clinical and physiological parameters</th></tr>
<tr><th colspan="2">Bug damage at the beginning of the experiment</th><th rowspan="2">Feed digestib ility</th><th colspan="2">Bug damage in 5 days</th><th rowspan="2">Feed diges tibility</th><th colspan="2">Bug damage in 10 days</th><th>Feed diges tibility</th></tr>
<tr><th>sided</th><th>abdo minal</th><th>sided</th><th>abdo minal</th><th>sided</th><th>abdo minal</th><th></th></tr>
<tr><td>Experi ment</td><td>25</td><td>17</td><td>8</td><td>60 %</td><td>15</td><td>7</td><td>68 %</td><td>12</td><td>3</td><td>80 %</td></tr>
<tr><td>Control</td><td>20</td><td>15</td><td>5</td><td>60 %</td><td>15</td><td>7</td><td>55 %</td><td>15</td><td>8</td><td>55 %</td></tr>
</table>

However, using the preparation in this way does not always solve the problem. Firstly, humidification disturbs the original structure of granules, while stirring during drying, surface layers of granules with attached drug crumble. Secondly, since the recommended therapeutic dose does not reach the consumer (fish), in addition, sick fish, as a rule, have a reduced appetite, this method gives a short-term effect, thirdly, the anthropogenic and technogenic load on fish habitat increases, and this leads to increased variability of pathogens, the development of drug resistance and intestinal microorganisms pathogenicity factors increase.

5.2.5 Efficiency of using lactobifid and bifitrilac in the composition of full feed OT-UZVprod

In recent years, new approaches to keeping fish in dense aquaculture have become widespread in aquaculture, which are related to the restoration of the natural ecology of the organism and based on the use of active biological products. One aspect of this approach is the normalization of the altered microbial landscape of the organism in the aquatic environment of closed water supply facilities using bacterial and biopreparations [8].

The most significant group of bacterial preparations are eubiotics - medicines containing as an active ingredient certain strains of representatives of the microflora of a healthy organism.

It is known that bacteria, normally inhabiting mucous membranes, have an antagonistic effect against pathogenic and opportunistic microflora, provide vitamin-forming and enzymatic functions.

One of the most common and widely used drug - eubiotic is “Bifidumbacterin”. The preparations based on bifidobacteria most often include *Bifidobacteium adolescentis, B. animalis, B. bifidum, B. infantis, B. longum, B. thrmophilum* [76].

There is information about the use of the preparation “Bifidum-SHZh” for the prevention of bacterial and nutritional diseases in sterlet of the Oka population. It contains bifidobacteria that provide therapeutic effect, detoxification of fish organism and increase of body weight [1, 12, 57].

The preparation “Zoonorm” is a lyophilized microbial mass of live gonistically active bacteria of *Bifidobacteium bifidum strain* № 1, immobilized on particles of crushed activated carbon [3, 61, 74, 79].

The activity of the preparation “Zoonorm” is determined by bifidobacteria microcolonies contained in it - antagonists of a wide range of pathogenic and opportunistic microorganisms, due to which the intestinal microflora is normalized, gastric tract activity, metabolic processes are improved, feed digestibility is increased. Colonies of bifidobacteria, sorbed on activated carbon, contribute to the excretion of toxic metabolites, activate the process of wall digestion, physiological protection of the intestinal barrier from the penetration of microbes and toxins in the internal environment of the body by association with the intestinal mucosa. Zoonorm promotes the increase of nonspecific resistance of the organism, stimulation of growth and development of fish. One dose of the preparation contains at least $1x10^7$ CFU of bifidobacteria. The drug is harmless, does not cause any side effects [10, 12].

The preparation “Intestivit” contains a complex of cultures of bifidobacteria *Bifidobacteium globosum,* streptococci *Enterococcus faecium* and *Bacillus subtilis.* These two groups of bacteria included in the preparation are capable of active colonization of the intestinal mucosa and formation of biofilm on it. Metabolites formed by bacteria actively participate in the processes of food digestion, synthesis of vitamins, amino acids and other vital elements, increase the natural resistance of the body and contribute to the restoration of the population level of representatives of normal intestinal microflora [140].

Lactobacillus family preparations are also widely used in medicine and veterinary medicine.

Lactobacilli along with bifidobacteria are the main representatives of normal microflora. The first attempts of therapeutic use of lactobacilli for the correction of biochemical processes occurring in the intestine were made by I.I. Mechnikov, who in 1903 for the first time proposed the targeted use of fermented milk products and preparations containing special cultures of lactobacilli with high antagonistic activity for the normal functioning of the digestive tract [12, 61, 141].

Lactobacilli are currently divided into three phylogenetic groups: *L. delbrueckii, L. casei – Pediococcus, Leuconostos*. The genus Lactobacillus has 56 species, 11 genera (*Lactobacillus, Lactococcus, Leuconostos, Camobacterium, Enterococcus, Streptococcus, Pediococcus, Tetragenococcus, Vagococcus, Oenococcus, Veissella*).

Lactobacilli are sporeless Gram-positive, facultative and strictly anaerobic bacilli. High adhesiveness to mucous membranes and weakly expressed antigenic load of lactobacilli promote the development of their close association with mucous membranes, up to the formation of a superficial protective biolayer.

Lactobacilli are very strong acid formers. By creating an acidic environment, they have a detrimental effect on pathogens.

In addition, the antibacterial activity of lactobacilli is associated with the formation of antibiotic-like substances (bacteriocins), the production of lactic acid, alcohol, hydrogen peroxide, lysozyme in the process of hydrolysis of carbohydrates [142].

The reparative properties and immunomodulatory role of lactobacilli are also revealed. The role of lactobacilli in reducing blood cholesterol levels, in preventing the production of carcinogens and in breaking down oxalic acid, thus preventing the formation of oxalates in the body is discussed [8].

In clinical practice, the preparation "Lactobacterin", created in the early 70s on the basis of the *Lactobacillus plantarum* or *L. fermentum*, antagonistic effect against pathogenic and conditionally pathogenic microorganisms. Preparations based on lactobacillus bacteria also contain *L.casei*, *L.acidophilus*, *L.delbeuckii subsp.*, *bulgaricus*, *L.brevis*, *L.cellobiosus*, *L.lactis* [11, 13, 143, 144,145].

Introduction of lactobacillus into fish feed promotes quantitative distribution of different groups of microorganisms. Lactobacilli have antagonistic effect in relation to pathogenic and conditionally pathogenic microorganisms, preserve and regulate the physiological balance of intestinal microflora [5, 43].

In this series of experimental studies, the efficacy of two probiotic preparations, lactobifidum, was evaluated ($1x10^6$ KOE in 1 tablet) and bifitrilac (2×10^9 KOE in 1 tablets). Lactobifid contains a complex of lyophilically dried bacteria - bifidobacteria, lactobacillus. Bifitrilac contains bifidumbacteria and lactobacilli [146].

Under the conditions of the closed water supply unit of Zhangir khan West Kazakhstan Agrarian Technical University (Uralsk), experiments were conducted on long-term evaluation (188 days) of the effectiveness of the addition of lactobifid and bifitrilac (in the complex 1:1) in the cultivation of two-year-old Russian sturgeon of the Ural population.

The complex use made it possible to include various probiotic preparations in the compound feed. As the results showed, the growth of fish in the control (without probiotics) was significantly lower.

Probably, probiotics contributed to the improvement of digestion and increased nonspecific immunity in fish during the period of experiments.

Under the conditions of the University's closed water supply system, similar studies were conducted on Russian sturgeon when rearing three-year olds for 90 days (chart 28).

Chart 28 - Fish-breeding and biological indicators of Russian sturgeon breeding in closed water supply installations on mixed fodder with addition of probiotics “Lactobifid” and “Bifitrilac” (in complex 1:1)

Indicators	**Experiment with probiotic**	**Control without probiotic**
Initial weight, g	193,4	200
Final weight, g	1218,8	1096,6
Initial average length, cm	34,26	34,36
Final average length, cm	61,2	60,4
Absolute gain, g	1025,4	896,6
Average daily gain, g/day.	5,45	4,48
Feeding coefficient, units.	1,1	1,3
Survivability, %	100	100
Duration of the experiment, days	188	188

The best growth performance was observed in the experiment variant with bifitrilac addition, somewhat worse with lactobacillin and even lower in the control without probiotics (final body weight respectively was equal to 2820,4, 2690,3 and 2621,3 g.).

Average daily weight gain, respectively, was equal to: 4,89; 6,33; 4,11 g/days; feed coefficient - 1,1; 1,0 and 1,1 units. The survivability in all variants with bifitrilac was 99 % (chart 29).

Chart 29 - Fish-breeding and biological indicators of Russian sturgeon breeding in closed water supply installations on mixed fodder with separate addition of probiotic preparations “Lactobifid” and “Bifitrilac” to the formulation

Indicators	Feed with lacto-bifid (variant I)	Feed with bi-fitrilac (variant II)	Feed without probiotics (control)
Body weight, g: initial final	 2250,6±68,3 2690,3±74,6	 2110,4±53,2 2680,2±61,8*	 2340,0±71,4 2710,7±66,5
Absolute gain, g	439,7	569,8	370,7
Average daily gain, g/day.	4,89	6,33	4,11
Feeding coefficient, units.	1,1	1,0	1,1
Survivability, %	98,0	99,0	96,0
Period of experiments, days	90	90	90

Note* differences are reliable at the value of P≤0,01

To fully assess the effectiveness of these probiotic preparations in the composition of the complete compound feed OT-UZVprod, the total chemical composition of the body of farmed fish at the end of the experiment was analyzed (Table 30), followed by a full assessment of red and white blood.

As a result of evaluation of the obtained results, it was shown that when growing three-year-old Russian sturgeon in closed water supply facilities and feeding with OT-UZVprod feed with bifitrilac, there was more protein in the body of fish (by 5 %), the differences were reliable at P≤0,01.

Chart 30 - Total body chemical composition of three-year-old Russian sturgeon reared in closed water supply facilities on compound feed OT-UZVprod, %

Composition	Experiment options		
	With lactobifidum	With bifitrilac	Without probiotics
Moisture	46,7±1,0	45,4±1,1	46,5±1,1
Dry substance	53,3±1,2	54,6±1,3	53,5±1,1
Protein	56,6±2,1	72,4±3,6*	66,8±2,4
Fat	18,8±2,1	13,0±1,1*	18,7±2,0
Ash	10,6	10,6	10,5

Note* differences are reliable at the value of P≤0,01

This variant also had 6% less body fat, which is a favorable sign, as well as lower body moisture content. Blood composition data confirmed these established results (chart. 31).

Chart 31 - Blood composition parameters of three-year-old Russian sturgeon fed OT-UZVprod in closed water supply systems with probiotic preparations

Indicators	**Experiment options**		
	With lactobifidum	**With bifitrilac**	**Without probiotics(control)**
OCB, g/l	2,2±0,12	2,4±0,14*	2,2±0,11
Hematocrit, %	34,1±0,5	36,1±0,6*	33,4±0,4
Hemoglobin, g/l	75,2±1,2	75,4±1,2	75,7±1,2
Intensity of erythropoiesis	5,6±0,3	5,5±0,3	5,6±0,3
Leukocyte formula, %			
Lymphocytes	64,1±4,1	68,2±3,2*	63,5±3,8
Eosinophils	9,3±1,21	9,4±1,28	9,4±1,25
Neutrophils, incl.			
Promyelocytes	1,5±0,22	1,5±0,21	1,4±0,31
Myelocytes	2,6±0,51	2,6±0,54	2,7±0,61
Metamyelocytes	1,6±0,48	1,5±0,48	1,6±0,48
Bacilli	24,8±4,28	25,6±4,54	25,1±4,49
Segmentonuclear	4,8±1,12	4,8±1,15	4,7±2,0

Blood composition in all variants of the experiment corresponded to that of healthy fish [94]. The values of serum protein and hematocrit were significantly higher ($P \leq 0.01$) in variant II.

At the same time, the maximum effect of nonspecific resistance of the organism was to be expected in conditions of deteriorated (indicators below the accepted norm) hydrochemical regime of closed water supply installations.

5.2.6 Effectiveness of probiotic preparations in deteriorated conditions of aquatic environment

When operating closed water supply systems in fish farming, the quality of the aquatic environment is monitored using industry standards as a criterion. Such a criterion is the industry standard for water OCT-15.372-87 [31].

In case of increase of polluting organic substances in closed water supply installations, ammonia intoxication is noted in the influence of ammonia, ammonium ions (ammonium nitrogen), phosphates and increased microbial number. All this in complex depresses fish immunity, leads to manifestation of non-contagious gill necrosis, so the role of feed substances that increase nonspecific resistance becomes evident [147].

Under conditions of closed water supply facilities, the conditions of aquatic environment were intentionally worsened with termination of feeding (10 %) with fresh water of biofilter system and excessive excessive (2 times daily feeding rate with mixed fodder) feeding. As a result, after 10 days indicators of water quality in the aquatic environment in fish breeding experimental tanks became lower than technological norms (chart 32).

Chart 32 - Indicators of water environment under conditions of deteriorated regime operation of closed water supply installations

Indicators	**Units of measurement**	**Technological norm**	**Factual data**
pH	Unit	7,0-8,0	8,2 ±0,2
Oxygen	mg/l	6,0-8,0	7,5±0,1
Temperature	°C	no more than 24	22-24
BOC_5	mg O_2/l	up to 3	4-6±0,3
Oxidizability: permanganate bichromate	 mg O_2/l mg O_2/l	 up to 10 up to 30	 18-24±1,0 55-62±1,5
Ammonia	mg N/l	up to 0,05	0,02±0,0001
Nitrogen: ammonium nitrite nitrate	 mg N/l mg N/l mg N/l	 1,0 up to 0,02 2-3	0,7-4,3±0,03 0,02-0,04±0,009 1,2-1,4±0,6
Phosphates	mg/l	up to 0,3	0,4-0,5±0,05

According to table 32, pH, $БПК_5$, acidification, ammonium nitrogen and phosphate values increased under deteriorated conditions above the standards established by OCT-15.372 -87.

Under these conditions, the effectiveness of probiotic preparations was evaluated for 50 days on three-year-old Russian sturgeon with individual weight over 2 kg, with subsequent analysis of all biological and physiological-biochemical indicators of growth, development and health of farmed fish.

General fish-biological indicators of fish breeding are presented in chart 33.

Chart 33 - Fish-breeding and biological parameters of growing three-year-old Russian sturgeon in closed water supply installations on mixed fodder OT-UZVprod with probiotics under conditions of deteriorated hydrochemical regime

Indicators	**Feed with lacto-bifid (variant I)**	**Feed with bi-fitrilac (variant II)**	**Feed without probiotics (control)**
Body weight, g: initial final	2865,2±21,4 2912,5±48,3	2796,3±22,5 3048,4±36,1*	2712,4±20,8 2810,5±28,6
Absolute growth, g	47,3	252,1	98,0
Average daily gain, g/day	0,95	5,04	1,96
Feed coefficient, units	2,8	1,4	4,5
Survivability, %	75,0	95,0	82,0
Period of experiments, days	50	50	50

Note: * - differences are reliable at the value of P≤0,01

Under the conditions of deteriorated water environment in closed water supply facilities, the best fish-biological indicators of growing three-year-old Russian sturgeon were observed when using mixed fodder OT-UZVprod with bifitrilac. Absolute weight gain of fish in this variant was 2.5 times higher compared to the control and more than 5 times higher compared to variant I.

Final weight was significantly ($P \leq 0.01$) by 252.1 g. (for 50 days of experiment) was higher from the beginning of rearing. The average daily gain was 5 g/day. In control - 1,96 g and on feed with lactobifid - 0,9 g/day.

The composition of total chemical substances of the fish body reliably reflects the physiological state of the research object under the influence of environmental factors of exogenous and endogenous origin.

Table 34 shows the effect of feed with probiotics on the composition of total chemical substances in the body of three-year-old Russian sturgeon under conditions of deteriorated hydrochemical regime of closed water supply facilities. Under deteriorated conditions of aquatic environment (increased content of nitrogenous substances, phosphates, increased oxidizability, BOD_5) the composition of total chemical substances of fish body significantly ($P \leq 0.01$) differed in the variant with bifitrilac. The increase in protein and dry matter content should be considered positive [148].

Chart 34 - Composition of total body chemicals of three-year-old Russian sturgeon fed OT-UZVprod with probiotic preparations under deteriorated environmental conditions of closed water supply facilities, %

Composition	**Experiment options**		
	I with lactobifid	**II with bifitrilac**	**Control without probiotics**
Moisture	47,7±0,6*	37,6±0,5*	54,2±0,7
Dry matter	52,3±0,8*	62,4±1,1*	50,8±0,7*
Protein	67,2±2,8	70,6±3,6*	62,3±2,5
Fat	18,6±2,6	18,7±2,6	18,2±3,1*
Ash	10,2	10,7	10,5

* - differences are reliable at the value of $P \leq 0,01$

Blood composition confirmed the obtained effect when using in mixed fodder OT-UZVprod probiotic bifitrilac (chart 35).

Fish that consumed feed with bifitrilak had significantly higher hemoglobin content and hematocrit values ($P \leq 0.01$) compared to the control and the variant with lactobifid.

Chart 35 - Composition of blood parameters of three-year old Russian sturgeon fed OT-UZVprod in deteriorated conditions of water environment of closed water supply facilities

Indicators	**Experiment options**		
	I with lactobifid	**II with bifitrilac**	**Control without probiotics**
Serum protein, g/l	2,0±1,0	2,2±1,1	1,9±1,0
Hematocrit, %	31,1±1,1	34,4±1,2*	29,5±1,0
Hemoglobin, g/l	65,1±1,2	75,4±5,3*	61,4±5,4
Intensity of erythropoiesis	5,8±0,3	5,6±0,2	6,0±0,4
Leukocyte formula, % Lymphocytes Eosinophils	58,1±5,0 9,6±1,7	63,8±6,1 9,2±1,6	56,4±4,9 9,9±1,8
Neutrophils, incl. Promyelocytes Myelocytes Metamyelocytes Bacilli Segmentonuclear	 1,6±0,4 2,6±0,4 1,3±0,4 28,4±6,8 5,3±1,2	 1,3±0,3 2,9±0,6 1,6±0,5 27,1±6,2 5,2±1,2	 1,8±0,5 2,3±0,2 1,1±0,3 29,6±7,1 5,4±1,3

* - differences are reliable at the value of P≤0,01

Thus, in conditions where the aquatic environment of the closed water supply system operates outside the technological regulations, feeding sturgeons with complete feed without organic pollutants allows maintaining high fish farming and biological indicators of cultivation, physiological and biochemical state of fish with the possible effect of non-specific resistance of the research object.

CHAPTER 6. FISH-BREEDING AND BIOLOGICAL EVALUATION OF OT-UZVprod COMPOUND FEED IN GROWING THE MAIN OBJECTS OF COMMERCIAL STURGEON FARMING

The results obtained and the finalized version of the full feed OT-UZVprod, with reduced level of ballast substances, chitosan and probiotic supplementation, should be tested on other objects grown in closed water supply facilities: bester (beluga/sterlet hybrid), sterbella (sterlet/beluga hybrid), beluga and Siberian sturgeon.

During 60 days of experiments with yearlings of different objects, the following results were obtained (Chart 36). As a result of this series of experiments, the high productive effect of compound feed OT-UZVprod was confirmed when growing the main objects of commercial sturgeon farming in a closed water supply facility.

It was shown that the maximum growth was established for beluga and its hybrids (respectively 6.8 - beluga, 6.0 - bester, 5.7 g/day - sterbel), slightly lower for Siberian sturgeon (5.0 g/day) and even lower for Russian sturgeon (5.0 g/day). At the same time, all growth rates of these objects should be considered high [16,17].

Survivability in all variants of the experiment amounted to 100 %, feed costs were low (from 1.0 to 1.1 units).

Thus, high fish-biological parameters of rearing were shown in all experimental objects.

Chart 36 - Fish-breeding-biological parameters of growing yearlings of bester, sterbel, beluga, Siberian and Russian sturgeon in conditions of closed water supply on full-fed compound feed OT-UZVprod (final variant of the developed formulation)

Indicators	Species and hybrids				
	Bester	Sterbel	Beluga	Siberian sturgeon	Russian sturgeon
1	2	3	4	5	6
Body weight, g: initial final	2100,5±41,2 2461,0±81,3	1830,1±36,1 2170,2±43,4	2560,3±54,8 2971,1±63,8	1780,4±41,1 2081,8±45,6	1560,2±21,3 1810,6±38,5
Absolute gain, g	360,5	340,1	410,8	301,4	250,4
Average daily gain, g/day.	6,0	5,7	6,8	5,0	4,2

1	2	3	4	5	6
Feeding coefficient, units	1,0	1,1	1,0	1,1	1,1
Survivability, %	100,0	100,0	100,0	100,0	100,0
Period of experiments, days	60	60	60	60	60

To assess the physiological state of the fish at the end of the experiments, a complete analysis of the composition of red and white blood was carried out. (chart 37).

Chart 37 - Composition of red and white blood of yearlings of bester, sterbel, beluga, Siberian and Russian sturgeon in closed water supply systems on complete feed OT-UZVprod when grown in a closed water supply system

Indicators	**Species and hybrids**				
	Bester	Sterbel	Beluga	Siberian sturgeon	Russian sturgeon
Serum protein, g/l	2,2±0,5	1,9±0,4	2,0±0,4	2,1±0,5	2,2±0,7
Hematocrit, %	30,1±1,2	29,8±1,1	31,6±1,3	30,5±1,1	31,4±1,6
Hemoglobin, g/l	69,1±5,1	72,3±6,2	70,4±6,8	73,5±7,0	71,8±6,9
Intensity of erythropoiesis	5,2±0,2	5,6±0,5	5,3±0,4	5,0±0,4	5,3±0,6
Leukocyte formula, %					
Lymphocytes	62,8±4,1	63,1±5,2	58,6±3,6	61,4±5,2	60,5±4,9
Eosinophils	9,6±1,7	9,3±2,0	9,4±1,5	9,2±1,6	9,5±1,6
Neutrophils, incl.:					
Promyelocytes	1,4±0,3	1,5±0,4	1,3±0,3	1,6±0,5	1,5±0,4
Myelocytes	1,6±0,8	1,5±0,7	1,9±0,8	1,5±0,6	1,6±0,7
Metamyelocytes	1,5±0,3	1,4±0,3	1,5±0,3	1,6±0,4	1,5±0,3
Paloconuclear	24,8±5,3	25,6±6,1	23,1±4,8	25,1±5,9	24,8±4,3
Segmentonuclear	4,8±1,0	5,1±1,3	5,0±1,2	4,7±0,9	5,1±1,1

Blood composition parameters in all groups of fish were high, close to the physiological norm for normally feeding and developing individuals [94], the data are statistically homogeneous, the differences are not reliable. During the period of experiments there were no cases of fish mortality and presence of pathologies, diseases of alimentary character.

To estimate the effective conversion of feed into body weight of fish, the calculation of fatness coefficient according to Fulton was carried out (chart 38).

Chart 38 - The fatness coefficient of yearlings of bester, sterbel, beluga, Siberian and Russian sturgeon in closed water supply systems on complete feed OT-UZVprod

Commercial growing objects in closed water supply systems	**Value of the fatness coefficient, units**	
	At the beginning of the experiment	**At the end of the experiment**
Hybrids: Bester (beluga x sterlet) Sterbel (sterlet x beluga)	 0,57 0,52	 0,61 0,56
Beluga	0,58	0,60
Siberian sturgeon	0,52	0,55
Russian sturgeon (control)	0,51	0,54

According to the data of table 38 it is noticeable that for 60 days of experiments, when feeding all experimental groups in closed water supply facilities with compound feed OT-UZVprod, high values of fatness coefficient (FC) were obtained, consistent with those for normally developing and feeding fish [16, 17, 94]. The maximum values of the fatness factor were observed in the fastest growing species (beluga) and hybrid forms (bester, sterbel).

Based on the results of all the experiments, it is necessary to note the absolute leaders in terms of weight growth; in this respect, the tested objects can be ranked as follows: beluga>Bester hybrid>Sterbel hybrid>Siberian sturgeon>Russian sturgeon.

The results obtained on the growth of mass of commercial fish farming objects in experiments are in agreement with the data of other specialists [16, 17, 18, 94, 149, 150, 151, 152, 153].

During the period of experiments (60 days), we analyzed the fluctuations of water environment parameters in closed water supply installations when using the final variant of the compound feed OT-UZVprod (chart 39).

Chart 39 - Indicators of water environment in closed water supply installations at use of the final variant of mixed fodder OT-UZVprod

Name of indicators	**Technological norm (OCT 15.372-87)**	**Fluctuations of values for 60 days of experiments**
Water temperature, °C	not > 24	18-24
Transparency, %	-	95-100
Suspended solids, g/m3	up to 10	0,3-1,0
Hydrogen index	7,0-8,0	7,6-7,7
P_2O_5, mg/l	-	0,15-0,25
Phosphates, mg/l	up to 0,3	0,15-0,2
Total iron, mg/l	up to 0,4	0,05
Calcium, mg/l	40-260	30,0-40,0
Nitrogen:		
Ammonium, mgN/L	1,0	0,4-2,5
Nitrite, mgN/L	up to 0,02	0,008-0,02
Nitrate, mgN/l	2 - 3	0,8-2,1
Mineralization, mg/l	400-900	900-1300

When adding 10% of fresh water per day to the closed water supply system (according to the technological regulations for the operation of this installation), all indicators of the aquatic environment, including the level of Ca, were within the accepted norms.

Undigested chitin from fish feces did not dissolve in water, but was removed during daily cleaning of the pools. Its presence in the fish-breeding pools did not lead to pollution of the aquatic environment, or a change in the level of organic compounds polluting the water.

In its final form, the recipe for the developed complete feed for sturgeon fish OT-UZVprod, applicable to the conditions of a closed water supply system, is presented in the following chart 40.

Chart 40 - Composition of the final recipe for complete feed OT-UZVprod with a reduced level of ballast pollutants in relation to the conditions of a closed water supply system, %

Ingredients	**Composition**
Fish flour meat blood	60,0 10,0 5,0
Chitosan	5,0
Soybean meal	11,0
Fish oil	8,0
Probiotic Bifitrilac	0,1 (over 100%)
Premix ВМП ПО-5	1,0
Nutrient composition, %	
Moisture	8,8
Crude protein	49,1
Crude carbohydrates	15,3
Crude fat	12,1
Crude fiber	0,9
Chitin	4,8
Calcium	2,1
Phosphorus	1,3
Total energy, MJ/kg	20,3
Amino acid composition, %	
Lysine	3,71
Methionine	1,13
Cystine	0,83
Tryptophan	0,53
Arginine	2,47
Histidine	1,22
Leucine	3,53
Isoleucine	2,46
Phenylalanine	2,0
Tyrosine	1,42
Threonine	2,01
Valine	2,8
Glycine	3,52

The developed recipe for the new complete granulated feed OT-UZVprod for sturgeon fish, as applied to the conditions of closed water supply systems, should be recommended for use in industrial fish farms. It is promising for factories producing fish granulated feed to master the production of its industrial batches for farms using recirculation systems. [154].

CONCLUSION

When sturgeon fish are grown in artificial conditions, an increase in the level of organic pollution and the number of pathogenic bacteria in the aquatic environment is observed. At a certain concentration of microorganisms in the water of fish breeding tanks their sharp increase in fish organs and tissues occurs. At the same time there are cases of weakening of general condition of fish and occurrence of various diseases, in this regard, research aimed at the development of therapeutic and prophylactic feeds for the prevention and treatment of fish pathologies, are a necessary task when growing fish in closed water supply conditions.

In the process of the conducted research work, it was possible to obtain a new innovative product - the composition of full-fed mixed fodder OT-UZV prod, as well as technological recommendations for the use of adhesive and probiotic additives and a method of removing ballast and pollutants.

Productive mixed fodder for commercial sturgeon fish farming in closed water supply conditions with a reduced level of ballast substances, increased digestibility of nutrients and resistance to granule erosion contains 49.1 % protein, 15.3 % carbohydrates, 12.5 % fat, 0.9 % fiber, calcium and phosphorus, accordingly 2 and 1,3 %.

As a result of application of sieving of fish meal before pelleting of mixed fodder OT-UZVprod the level of undigestible, polluting water UZV ballast substances was reduced. The content of Ca also decreased from 6.2 to 2.1 %, phosphorus - respectively from 4.2 to 1.4 %, total protein level on the contrary increased from 56.4 to 60,1 % ($p<0,01$).

As a result of the evaluation of fish-biological indicators of OT-UZV feed efficiency, the best productive effect of the variant with fish meal sieving and bone residue removal was confirmed when growing two-year old Russian sturgeon. At the same time, indicators of pollution of the aquatic environment were lower with the experimental variant (suspended solids < 5 times, P205 < 3 times, Ca < 2 times, mineralization < up to 2 times, transparency 20-30 % higher). In the experimental variant, three-year-old sturgeon grew faster (average daily gain in the experiment was 1.7, in the control - 0.7 g), with a lower feed coefficient (1.1 vs 1.4)

In conditions of application of mixed fodder OT-UZVprod without sieving of fish meal in the blood composition of fish there was a slight decrease in hemoglobin, hematocrit, number of erythrocytes, lymphocytes and an increase in bacillary and segmented neutrophils ($p \leq 0,01$).

In experiments on introduction in the formulation of mixed fodder OT-UZVprod adhesion additive chitin (instead of wheat flour) obtained improved water resistance and lower crumbliness of pellets (water resistance is higher by 70% in the experiment with 5% chitosan in the feed mixture).

Fish-biological evaluation of feed variants with chitosan addition in growing two-year-old Russian sturgeon revealed the best result of this variant. As a result of these studies, rapid weight growth, high survival rate (100%), the lowest feed coefficient (1.0 unit), low rate of food passage through the intestine (2 h), and high digestibility (76% vs 78% in the control and 54% in the chitosan excess (10%) variant) were established. These indicators were confirmed by the data on the composition of white and red blood of fish.

In experiments to evaluate the use of probiotic preparations lactobifid and bifitrilak higher efficiency of feeding and rearing was shown in the variant of feed OT-UZVprod with bifitrilac. Higher body weight gain (6.3 vs 4.9 g/day), low feed coefficient (1.0 vs 1.1 units) were observed in this variant. Fish-biological parameters were confirmed by the data on the composition of total chemicals and blood.

As a result of research works the prospectivity of using probiotic “OLIN”, antibacterial preparations “Antibak -100”, ciprofloxacin, sulfadimethoxin was shown. When analyzing samples of pelleted mixed fodders, conditionally pathogenic forms of microorganisms *E. coli, St. Saprophyticus* were isolated. The total microbial contamination of mixed fodders did not exceed the normative indicators

The positive influence of using the preparation “Antibak-100” was found out: the eatability of daily feed ration was improved; the process of regeneration of lateral and abdominal bug lesions was noticeable, respectively by 29,5% and 37,5%. Also the process of complication and spreading of bug lesions on the abdominal surface of the fish body was not noted.

“Monosporin”, “Bacel M” and “Sub-Pro” were effective in increasing the productive qualities of fish, absolute weight gain of fish was 92%; 75% and 83%, respectively. The average daily body weight gain of fish was 9.1 g/day; 8.3 g/day; 8.1 g/day, respectively. Absolute body length gain by groups had insignificant difference.

When probiotic “OLIN” was added to the feed, increased growth performance was observed, slightly worse in the control without probiotic (daily body length gain was 2785±53,44g. and 2743±52g.). The average daily weight gain, respectively, were: 8.5 and 7.2 g/day; feed factor - 1.6 and 1.7 units. Survival rate in all variants was 100%.

As a result of the performed research and conducted pilot tests of new full-fed granulated mixed fodders, proposals for the use of the results in practice were developed for industrial enterprises for fish breeding in closed water supply systems and plants.

CONSEQUENCE

1. A recipe has been developed for a full-fed UZV-prod mixed fodder for commercial sturgeon fish farming in UZVs with a reduced level of ballast substances, increased digestibility of nutrients and resistance to granule erosion.

It contains 46.2 % protein, 26.2 % carbohydrates, 12.5 % fat, 0.9 % fiber, calcium and phosphorus, respectively, 2 and 1.3 %.

2. The application of fish meal sieving before pelleting of mixed fodder OT-UZVprod allowed to reduce the level of non-digestible, polluting water of closed water supply installations, ballast substances.

Ca content significantly decreased from 6.2 to 2.1 %, phosphorus content decreased from 4.2 to 1.4 %, respectively. The total protein level increased from 56.4 to 60.1 % ($p \leq 0,01$).

3. Evaluation of fish-biological indicators of the efficiency of compound feed OT-UZV, when growing two-year-old Russian sturgeon, allowed us to confirm the best productive effect of the variant with sieving of fish meal and removal of bone residue. Indicators of pollution of the aquatic environment were lower with the experimental variant (suspended solids < 5 times, P_2O_5 < 3 times, Ca < 2 times, mineralization < up to 2 times, transparency - higher by 20-30 %). Three-year-old sturgeon in the experimental variant grew faster (average daily gain in the experiment - 1.7, in the control - 0.7 g) with a lower feed coefficient (1.1 vs. 1.4).

In conditions of application of mixed fodder OT-UZVprod without sieving in the blood composition of fish there was noted a decrease in hemoglobin, hematocrit, number of erythrocytes, lymphocytes and an increase in bacillary and segmented neutrophils ($p \leq 0,01$).

4. When feeding three-year-old Russian sturgeon under closed water supply conditions with mixed fodder OT-UZVprod, with fish meal sifting, the amount of protein (63.5% vs. 58.4%) and dry matter (51.5% vs. 48.7%) in the fish body was higher ($p \leq 0.01$), which confirms that the composition of the diet is complete in the absence of other food sources.

5. Introduction of chitin adhesive additive into the formulation of mixed fodder OT-UZVprod, instead of wheat flour, allowed to improve water resistance and crumbliness of pellets (water resistance is 70 % higher in the experiment with 5 % chitosan in the fodder mixture).

6. When using preparations of lactobifid and bifitrilac, higher efficiency of feeding and rearing was established in the variant of feed OT-UZVprod with bifitrilac in the amount of 100 mg/kg of mixed fodder. Higher body weight gain (6.3 vs. 4.9 g/day), low feed coefficient (1.0 vs. 1.1 units) were observed in this variant. Fish-biological parameters were confirmed by the data on the composition of total chemicals and blood.

7. When adding the probiotic “OLIN” to the main mixed fodder, blood parameters of sturgeon fish noticeably increase. During the conducted experi-

ments, the fish consuming the mixed fodder with probiotic “OLIN” had higher hemoglobin and hematocrit content, compared to the control, which corresponded to 34.7±1.3 vs. 31.3±2.2 (hematocrit), 76.4±5.7 vs. 67.1±2.9 (hemoglobin).

8. Application of “Antibak-100” promotes regeneration of damaged lateral and abdominal bugs, improvement of eatability of daily feed ration.

9. “Monosporin”, “Bacel M”, and “Sub-Pro” were effective in increasing the productive qualities of fish, absolute weight gain of fish was 92%; 75% and 83%, respectively. In the groups of fish with the use of these probiotics there was a pronounced safety of fish compared to the control group.

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