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DOCTORAL THESIS

Research on the sustainable exploitation of aquatic bioresources of the Republic of Moldova

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INTRODUCTION

The Republic of Moldova is a country with a small area, located in South-east Europe. The total area of the republic is 33,846 km^2. In the North, East and South it is bordered by Ukraine, and in the West by Romania. The central and northern region of the Republic of Moldova is located on the Codru Plateau and the southern region of the country on the Buceag Plain.

Compared to a relatively small area, the Moldovan territory is rich in water resources with fish potential (ponds, rivers and lakes). The waters of Moldova are part of the Black Sea basin. The main rivers are the Dniester and the Prut, which spring from the Carpathians and flow into the Black Sea. To the south, on a small portion, the Danube represents the border of the Republic of Moldova with Romania and Ukraine.

In the Republic of Moldova there are over 4,600 lakes, populated with various species of fish, of which economic importance is the catfish (*Silurus glanis*), common carp (*Cyprinus carpio*), common bream (*Abramis brama*), silver carp (*Hypophthalmichthys molitrix*), bighead carp (*Aristichthys nobilis*), grass carp (*Ctenopharyngodon idella*) and zander (*Sander lucioperca*). As fish stocks in the natural environment are limited, it is very important to develop aquaculture, understand the aspects related to the reproductive biology of different native fish species and implement them in programs to improve and protect the natural fish population.

Fish are vertebrate animals that make up the most important link in food chains in water basins. Without fish, many animal species would not survive, and billions of people would be affected by a lack of food resources.

Fish has been part of the diet of the Romanian population since ancient times. The tradition of fish consumption continues on the national territory throughout the centuries, being a staple food for the country's population. The fishing industry has an old tradition in the Republic of Moldova, existing since the time of Stephen the Great, a well-developed system of ponds, which produced fish for consumption.

The first scientific information about the development of the aquaculture sector in the Republic of Moldova appeared since 1945. During the Soviet period, about 30 thousand hectares were created from various reservoirs of fishing ponds, of which 12 thousand hectares are ponds. As a result, fish farming has become one of the most important forms of aquaculture in the Republic of Moldova. Until 1957, 168 tons of fish were raised on pond farms, and as a result, state fish farming was created. In 1964, catch volumes in inland waters rose significantly to 1,500 tonnes. In 1970, the Central Authority of the fishing industry of the Republic of Moldova was targeted by the Department of Fisheries under the Council of Ministers of the RSSM. In order to carry out scientific research and experimental work, a new research station in the field of fisheries was created, called: “Research station in the field of fisheries in Moldova”. During this period, part of the collective basins and state farms, not used for fish farming were transferred to the State Fisheries Directorate, on the basis of which another 14 new fish farms were formed. Due to the development of fish farming in the Republic of Moldova in 1970, the production of fish in the pond was 1983 tons, in 1975 it increased to 4570 tons, and in 1980 - up to 6500 tons. Thus, the productivity of fish reached 1.5 tons/ha. Together with intensive fish farming in ponds, the development of complex reservoirs (small reservoirs), also managed by the State Fisheries Directorate, is carried

out. The use of extensive technology in these tanks allowed until 1985 to increase fish catches by 852 tons, with a fish productivity of 603 kg/ha. In 1985, fish catches from ponds and small reservoirs amounted to 8539 tonnes and by 1990 had increased to 9053 tonnes, with an average fish productivity of 1 t/ha. According to FAO data, the production volume during that period amounted to 7,141 tonnes. FAO data show that the development of fish farming has reached a major growth rate since 1968 and until 1987. In 1968, 5 tons of commercial carp were raised on the production sites of the Slobodzey fish factory, in 1971 the production of increased to 22 tonnes, and in 1987 catch volumes doubled (44 tonnes of fish).

At the end of the 1980s, on the banks of the Kuchurgan Reservoir, the construction of a pool farm with a capacity of 1 thousand tons, a fish farming system in cages, which as it developed will increase it to a capacity of 500 thousands of tons. Until Moldova's transition to a market economy in 1990, no such basin was built and fish farming in the cage fish farming system was stopped.

After 1990, ponds belonging to collective farms and state farms were no longer used for fish farming. However, in the early 2000s, ponds were used by farmers, who produced around 615 tonnes of fish in 2002 and 985 tonnes of fish in 2003. The estimate of the number of fish produced by farmers is incomplete because the accounts cover no more than 50% of the existing fish farms in the country. The current stage of development of pond fish farming is characterized by a sharp decline in pond fish production from 9053 in 1996 to 1042 tonnes in 2006.

Fish production in the former fish farms increased slightly from 1996 to 2002 and reached 1,643 tonnes, but by 2004 it fell to 1130 tonnes. Subsequently, the cultivation of fishponds became one of the main forms of aquaculture production in the republic. Thus, rivers, lakes and ponds cover 95,000 ha on the territory of the Republic of Moldova, but only 7.5% of this area is used in fisheries.

The vast majority of fish farms operate extensively, based on fish farming in a polyculture system. The practice of polyculture mainly aims at raising carp, phytophagous species and predatory species such as pike, willow, European catfish.

In recent years, the drying up of rivers and lakes, or the use of water for various industrial uses, has led to pollution and disruption of biological and aquatic balance.

Many species of fish with high economic value, such as zander (*Sander lucioperca*), common carp (*Cyprinus carpio*), common bream (*Abramis brama*) or asp (*Aspius aspius*) are in danger of extinction in national waters, and sturgeon is practically no longer found. Moldovan fishing specialists appreciate that the situation could be saved by building artificial breeding centres for valuable species for the maintenance and development of natural pools in the Republic of Moldova.

Commercially, fishery products can be purchased fresh (live or fresh fish), preserved in the cold (refrigerated or frozen fish) or processed (salted, smoked, sterilized products), with specialized shops or areas specially arranged in the markets for the sale of fishery products.

The thesis is structured in 5 chapters completed by conclusions, bibliography and annexes.

In the first chapter it was presented a general characteristic of the natural aquatic resources of the Republic of Moldova, with development potential. This chapter described the main aquatic ecosystems (rivers, lakes) of the Republic of Moldova, the structural-functional state of each ecosystem, the physical and chemical characteristics of the main rivers, the faunal diversity and the economic importance for the development of this sector on the national territory.

The second chapter presents the regulation of the fisheries sector in the main objectives of the country, the activity of the Fisheries Service of the Republic of Moldova to combat illegal fishing and poaching, regulations and controls, prohibited fish species and nationally protected fish species, control of reproduction and acclimatization of hydrobionts within the borders of the Republic of Moldova. Proper management of aquatic natural resources can allow the conservation and sustainable use of Moldovan biological resources, and the application of measures at the national level to regulate the fisheries sector is also necessary.

The third Chapter presents data on the development of fish farming in the southern part of the Republic of Moldova, a general description of ponds in the southern region of the country, causes and peculiarities that led to degradation of fish fauna, the main fish species found in ponds in the region, point sources of pollution that endanger fish fauna, research on the physical and chemical parameters of the pond water in the locality near Cahul, research on the common carp breeding (*Cyprinus carpio*) in fish farms in the southern region of the Republic of Moldova by introducing non-specialized feed.
This research allowed us to evaluate the economic efficiency of the growing activities in the aquaculture system of the common carp (*Cyprinus carpio*), by feeding it with non-specialized feed based on cereals. This allowed us to evaluate the effects of non-specialized feed (cereals), on the economic efficiency of fishery production and the development of methods for modelling and choosing the optimal structure of the food ration, for raising carp in farm conditions. The results of the research carried out had a practical importance not only for the breeding of the common carp (*Cyprinus carpio*), but also for other species of fish from the Cyprinidae family.

In Chapter Four, an analysis of functional ponds in the southern region of the Republic of Moldova was performed. This research allowed us to analyse the current state of fish farming in the area, determine the role of domestic production on the national aquaculture market, determine the influence of external and internal factors on economic efficiency, identify priority areas for fish farming development in the south.
A 32-question survey was conducted for this purpose. The questions were addressed to the owners of 5 fish farms in the southern part of the Republic of Moldova that operate continuously to raise indigenous fish in polyculture. This analysis allowed us to identify the factors that led to the decrease of local production in the area and will help us in the future to determine the criteria for long-term development of fish farming, which can be used in making organizational and investment decisions.

Chapter five presented methods for research and selection of high-yielding fish specimens as well as a process for obtaining optimized feed for growing common carp (*Cyprinus carpio*), by strengthening the diet of fish with the PM-2 complex, made from trace elements: iron and cobalt, introduced into the feed in the form of complex nanoparticles. The selection method is recommended for assessing the survival rate and obtaining the most resistant carp breeds. The research can also be widely used in breeding fish species of the Cyprinidae family, which show increased productive qualities, vitality and resistance to adverse growing conditions.

As a result of the experiment, only those specimens that had a strong protective reaction at the genetic level and that determined a superior stability throughout the monitored time survived. After selecting the most resistant carp breeds, a process was obtained to obtain a feed optimized for growing common carp (*Cyprinus carpio*) by fortifying the diet of fish with the PM-2 complex, based on trace elements: iron and cobalt, introduced into the feed in the form of complex nanoparticles. The research method was carried out in order to improve the resistance of fish, especially carp, against aggressive environmental factors, diseases or pests, as well as to obtain a qualitative and quantitative fish production in the area.

1.OVERVIEW OF THE FISHERIES SECTOR. NATURAL RESOURCES WITH FISH POTENTIAL OF THE REPUBLIC OF MOLDOVA

1. Natural resources favourable to the fishing sector in the Republic of Moldova

The natural aquatic ecosystems of the Republic of Moldova attribute to people food, drinking water and other activities such as: amateur fishing or sports, with a great tourist potential. From a geographical point of view, the territory of the Republic of Moldova includes three important areas:

- The Northern Area, which includes the districts: Sângerei, Dondușeni, Soroca, Drochia, Briceni, Râșcani, Ocnița, Edineț.
- Center Area: Calarasi, Anenii Noi, Criuleni, Ialoveni, Dubasari, Hincesti, Nisporeni, Soldanesti, Straseni, Rezina, Orhei, Ungheni and Telenesti
- Southern Area: Cahul, Cimișlia, Cantemir, Leova, Căușeni, Ștefan Vodă, Taraclia and Basarabeasca.

The hydrographic network of the country is represented by: Dniester river basin, located on the left bank of the country (on the border with Ukraine), on a band of 430 km, Danube river basin (on the border with Romania) and Prut river basin, located on the bank between Republic of Moldova and Romania.

The country's hydrological natural resources cover an area of 62.2 km^2, another 250 km2 are destined for artificial lakes that make up about 800 million m^3 of water. The entire area of the hydrological network occupies no more than 1% of the country's territory, due to the fact that in the Republic of Moldova there are few river arteries that have a high flow, instead there are many medium and small rivers that flow temporarily and permanently.

The richest fish fauna in the Republic of Moldova are the natural aquatic ecosystems, Dniester and Prut rivers, representing ichthyofauna areas of the country. The fauna of Dniester River is represented by 70% species of lithospheric fish. Due to factors such as anthropogenic factor, riverbed control works, climate change and excessive pollution, the bud has become much rarer and is found only in the Danube, and the Russian sturgeon and its smaller relatives, such as trout and blind only in large quantities. reduced. In the Prut River, due to deep pits, trees, meanders, lived many species of fish, including catfish, but frequent floods in recent years have led to the destruction of a large number of individuals of this species.

Small rivers ensure the flow regime of large rivers, serving as biological filters in the process of self-purification of water, providing buoys for many species of fish. The fish fauna of small rivers is represented by species such as: perch, pike and non-food species, such as: Loach spined, etc. Decades ago, species such as flax, eel lived in natural aquatic ecosystems, which today are extremely rare, dominating the species "depreciated for food" which have an insignificant importance on nutrition of the riparian population.

Data on the fish potential of the Republic of Moldova, the state of the environment, the existence and use of natural aquatic resources for the period 2009-2015 are presented in the statistical collection "Natural resources and environment", developed by a team from the National Bureau of Statistics.

The research was made on the basis of reports submitted by Moldovan economic agents to national statistics, reports of the Ministry of Environment and the National Agency for Land

Relations. The monography does not contain information about the Transnistria, the national territory located on the left bank of the Dniester and Bender.

The research on the fish fauna from the Stânca - Costești lake was carried out in the period 2013-2014 by a team of the Institute of Zoology of the Academy of the Republic of Moldova and the "Alexandru Ioan Cuza" University of Iasi, Romania.

The research has highlighted the important fishing potential of the reservoir, the need for the involvement of the authorities of the two countries to improve the management of fish stocks and for a better use and conservation of the natural aquatic biological potential.

Republic of Moldova has significant aquatic resources, which have ensured, in conditions of sustainable exploitation, sufficient food resources for the population, the need for drinking water and the needs of the agricultural sector. The Research on the evolution of fish species in the Republic of Moldova has shown that last period, the reduction of natural and artificial waters resources in the country has occurred due to excessive pollution and irrational exploitation or poaching, widespread nationwide. The instability of environmental conditions in natural ecosystems can affect the development of valuable fish species, and the food chain can be disrupted in short-lived species.Poaching during the ban, non-selective cutting of trees (with intensification of riverbed erosion processes), burning of reeds, extraction of sand and gravel from the riverbed (under the pretext of deepening and straightening), oil pollution, illegal acquisition of game animals, storage of garbage in the floodplain or the extension of land for agricultural purposes to the bottom of the river, without respecting the protection strips are factors that have significantly affected the fish populations in the Prut River and the Dniester River.

The construction of ports or other industrial investments performed without a proper assessment of the impact on aquatic resources, can lead to ecological disasters, with the disappearance of valuable fish species and promote the development of others with a short life cycle.

In the aquatic basins of these rivers, the reduction of water quality and the disturbance of the natural balance were also favoured by eutrophication phenomena, specific to stagnant waters, manifested by the enrichment of water in compounds with nitrogen and phosphorus, the accelerated growth of algae or other higher organic forms.

Many rivers in the country are affected by clogging and drying during the hot season. Moldova's main source of drinking water is groundwater sources, which supply water to about 65% of the country's population (100% of the rural population and about 30% of the urban population).

In order to provide the necessary water, especially for agriculture and fish farming, 53 water reserves and about 1,600 lakes (ponds) have been built on the national territory, which joins the 3,500 natural lakes in the hydrographic network.

Investigations on fish fauna of the rivers and lakes in the Republic of Moldova are long-term studies that require significant financial and personal resources. Although there is a lot of research in the field, the complete characterization of fish fauna is still a topic of interest to academia.

Determining the diversity of fish fauna can be done using different methods. A widely used variant for assessing the diversity of fish fauna is the general degree of anthropogenic damage and the presence of species or certain species at a certain collection point. By this method, certain ecological niches can be highlighted, which have been reserved by different species from an evolutionary point of view. The method is useful, but the results have a higher degree of confidence in less polluted areas. Another method used to assess the quality of the aquatic ecosystem is to superimpose an unaffected anthropogenic biotope, with a specific structure, on

another biotope, with a real structure. The comparison allows the evaluation of the structural-functional evolution in natural conditions, respectively in those affected by different factors.
Dniester River basin represent more than 57% of the country's territory, the river having an annual flow of about 10 km³, marks on a portion of 630 km the border between the Republic of Moldova and Ukraine. Dniester River, called since ancient times "amber road", is characterized by a specific zoning of fish diversity.
The results of research made on the lower sector of the Dniester highlighted the presence of only 39 species and subspecies of fish from 12 families (pike, pike, bream, silver carp, blood carp, pikeperch, perch and others).

1.2. Evolution and potential

Water quality monitoring within the borders of the Republic of Moldova has been carried out since the 1980s, with a significant focus on the country's cross-border rivers, the Dniester and the Prut. The main objective of monitoring these rivers is to determine the degree of water contamination, which leads to damage to wildlife and the fish population in the ecosystem.
Following the Decision of the Government of the Republic of Moldova, the Register for Protected Areas of the Country was developed, which includes all areas located within river basins, to highlight the status of aquatic ecosystems, protection of surface and groundwater, and conservation of aquatic habitats and species directly by water quality.
Monitoring of surface water quality in the Republic of Moldova is based on legislative acts. The most important are Law No. 193 of 03.06.1997, aims to protect natural resources within the Republic of Moldova, Law No. 59 of 21.02.2003 on environmental protection and Water Law No. 96 of 12.06.2014 coordinate the conditions of use and surface water management, supervised by the country's public health authorities.

1.3 Partial conclusions

Republic of Moldova has a considerable potential represented by 95,000 ha of water, over 2,500 km of rivers and 4,600 lakes, naturally populated with various species of freshwater fish (catfish, crucian carp, carp, blood carp, pike, perch). Almost half of the fish species in the natural environment are not economically important, and of those of economic importance a large part is endangered. The existence of a high number of endangered species requires widespread measures at national level to protect vulnerable fish species. For a sustainable recovery of aquatic resources, it is recommended to restore the natural wetlands of the rivers, clean the riverbed of the main tributaries of the Dniester and Prut rivers, both to facilitate fish migration and to prevent the harmful consequences of floods, which can lead to changes in the share of local species. Systematic monitoring of water quality will remove negative processes such as: mineralization of water and their subsequent pollution, which occur due to anthropogenic factor, and the population with valuable seedlings of moderate size will solve the problems caused by the rarity of many fish species during this period.

2. REGULATION OF THE FISHING SECTOR IN THE REPUBLIC OF MOLDOVA

The richest and most diverse fish fauna is located in the river basins of the south of the Republic of Moldova, fishing areas that are also the most affected in the country due to anthropogenic factor, excessive pollution and the use of illegal fishing methods. The ichthyocenosis of the country's natural aquatic ecosystems has been severely affected in the last 10 years, especially under the direct action of the human factor. Excessive fishing, in areas protected by illegal methods, insufficiency or lack of systematic controls by the competent institutions, have greatly affected the fish fauna of the Republic of Moldova. The use of illegal fishing gear, lack of permits and non-compliance with prohibited periods of the year in naturally protected areas are the main offenses found in the sector. The correct management of the aquatic natural resources can allow a conservation and sustainable use of the Moldovan biological resources, being necessary also the application of some measures at national level for the regulation of the fishing sector.
Ensuring the protection of aquatic resources and regulating fishing in natural fisheries in the Republic of Moldova are the responsibility of the Fisheries Service, the Inspectorate for Environmental Protection and Public Control Units, institutions with responsibilities in the field, according to law. The State Fisheries Service of the Republic of Moldova has specific attributions regarding the protection of biological resources and the regulation of fishing in natural aquatic areas. The Inspectorate for Environmental Protection may inspect, control fishing authorizations and sanction contraventions. Carrying out fisheries controls in border areas can also be the attribute of the border police, in partnership with the Fisheries Service and with the partners of the cross-border cooperation agreements.
For the authorization of water basins, the sale of live fish and fishery products in markets and shops, the control attributions belong to the National Agency for Food Safety.

2.1. The activity of the State Fisheries Service in the Republic of Moldova

Annually, the State Fisheries Service makes a series of reports on its activity, with the aim of providing access to relevant information on the state of natural aquatic resources, within the territory of the Republic of Moldova. The competencies of the State Fisheries Service extend only to the country's natural water basins, such as Danube, Dniester, Prut rivers and its tributaries, spread over the territory of the Republic of Moldova on an area of 24,000 ha.
For the correct and efficient management of natural aquatic resources, currently on the Dniester River and the Prut River (including Lake Costești-Stânca), there are restrictions on industrial fishing. An alternative solution for rational fish exploitation would be a selective industrial exploitation, the capture of Asian cyprinids for limited periods of time and only on the Costești-Stânca and Dubăsari accumulation lakes. In these regions there are systematic populations with juvenile fish (cyprinids), and over time due to systematic populations can be obtained a number of advantages related to the generation of high quality and quantity fish production, as well as a biological improvement of the ecosystem with a regulation efficient use of the fish population.
Argument can be supported by the fact that although fish species such as silver carp blood and mackerel, although not targeted by amelioration fishing, are characterized by high demand on the food market in the Republic of Moldova.

Fishing for small fish species (bream, slug, shore perch) could cause negative consequences for the natural aquatic ecosystem, resulting in the disappearance of juveniles and economically valuable fish species, dependent on food with small fish species.
Despite all the restrictions imposed, there are also violations by some economic agents or individuals, which led to major imbalances in the natural aquatic ecosystems of the Republic of Moldova. The National Fisheries Agency, in cooperation with the Border Police sanctioned several cases of fish poaching on the national territory, being inspected the main river basins within the Republic of Moldova, where people were frequently found who violated the rules of protection of fisheries and fishing resources.

2.2 Regulations and public controls

Current information on the Moldovan fisheries sector was collected from official databases (National Bureau of Statistics of the Republic of Moldova).
According to the official data, the results obtained regarding the national economy of the country in 2013 were very good, being materialized in a high value of the Gross Domestic Product of 73.3 mild lei. Between January and September 2014, GDP by resource categories increased by 19.5%. The highest growth was recorded in agriculture, forestry, fishing and fisheries with 36%, with a contribution of 11% to GDP growth of 11.9% and 3.7% to the increase of Gross Value Added. According to data provided by the National Bureau of Statistics, Moldovans recorded in the period 2006-2018 an average annual consumption of fishery products between 11.7 and 16.9 kg / inhabitant. The evolution of fish consumption in the Republic of Moldova registered an upward trend in the period 2006-2018, with slight fluctuations between 2009-2011 and 2014-2018. In a top of the average annual consumption of fishery products per capita at European level, the Republic of Moldova occupies superior positions to Romania, which registered in 2014 an average of only 5 kg / inhabitant; The Czech Republic, with 9.5 kg, or Poland, with 12 kg / capita, being overtaken by Belgium where an average of 25 kilograms of fish meat is consumed per year, Italy (25 kg) or Spain (42 kg).

2.3 National legislation on the quality of fishery products

The national legislation in the field of quality is correlated to the acquis communautaire in the field of internal / managerial control that recommends for implementation the requirements of the management systems ISO 9001 and ISO 17020. At national level, the main legislative regulation in the field of fisheries is Government Regulation 435/2010. The document stablishes quality rules for the quality of the fishery products and working practices for producers and processors, specific rules and requirements for the marketing of aquatic products, hygienic requirements for processing units in order to avoid non-conformities that would endanger consumers.
Moldovan legislation on the quality of fishery products is being harmonized with European legislation. The main normative acts in the field are: Law no. 10/2009 on public authority supervision of public health [78], Law no. 113/2012 on establishing the principles and general requirements of food safety legislation, Law no. 50 / 2013 on official controls to verify compliance with feed and food law and animal health and welfare rules.

2.4. Legislation and official bodies in the field of fisheries in the Republic of Moldova

The economic operators involved in the food chain must ensure the conformity of fishery and aquaculture products marketed for human consumption.
The hygienic quality of the products is essential so that they do not make consumers ill. A sector-specific priority is the existence of the cold chain, a mandatory requirement for maintaining product quality. The quality risks for aquatic products are represented by the presence of chemical pollutants (lead, mercury, dioxins), biological contaminants, bacteria, viruses, parasites and the production of allergens during the degradation of the product. Compliance with the conditions for handling and transporting fish and fishery products must be ensured in the supply chain. For each production batch, it is mandatory to have the documents / certificates of origin, with the elaboration of the validity term.

2.5 Partial conclusions

To protect the aquatic biological resources, it is important to closely monitor fishing and tighten existing sanctions for identified offenses. Although under state protection through decisions and laws, ponds have been affected in recent years by numerous cases of illegal or illegal fishing. Commercial or recreational fishing for any fish species is prohibited during the prohibition period, but there are also people who violate these regulations during the prohibited periods, significantly affecting local ecosystems. In order to determine the quantity and quality of fish and to regulate fishing, control fishing will be carried out annually to target the health of the fish population. Systematic monitoring of the state, structure and conditions of development in natural aquatic ecosystems would improve the current situation. Ministry of Environment and the Agency "Waters of Moldova" provide protection measures by blocking various anthropogenic effects, in particular the fight against illegal fishing, which endangers aquatic biodiversity. To prevent and combat poaching and illegal fishing, systematic checks will be carried out to increase the penalty, imposing fines as high as possible, as these actions greatly affect the natural fish fauna, leading to a major imbalance in the country's natural water basins. A better collaboration of the control bodies with different fields of action, the education of the citizens, the increase of the living standard of the population can act positively on the reproduction of the fish fauna, favouring a sustainable use and the biological conservation of the fish resources. Therefore, protecting these resources is very important for their sustainable use. For some rivers, adjacent areas can be transformed into eco-tourism areas or aquaculture farms can be set up, with increasing quantities of fish available on the market and reducing the availability of imports. The development of production is possible through the development and implementation of various new technologies and by expanding the range of fishery products available on the market of Cahul, Moldova. In addition to the adopted laws and legislative constraints, it is also necessary for local operators to assimilate the need for basic hygiene rules to exclude disease risk factors. In each public food and processing unit, different control mechanisms must be implemented to ensure the quality and safety of food so as not to affect the health and safety of the population.

3. DEVELOPMENT OF FISH FARMING IN THE SOUTHERN PART OF THE REPUBLIC OF MOLDOVA

This chapter presents data on the development of fish farming in the southern part of the Republic of Moldova, a general description of ponds in the southern region of the country, causes and peculiarities that led to the degradation of fish fauna, the main fish species found in ponds in the region, point sources of pollution that endanger fish fauna, research on the physical and chemical parameters of the pond water in the locality near Cahul City, research on common carp breeding (*Cyprinus carpio*) in fish farms in the southern region of Moldova by introducing non-specialized feed.

The research allowed an evaluation of the economic efficiency of the growing activities in the aquaculture system of the common carp (*Cyprinus carpio*), by feeding it with non-specialized grain-based feed. This experiment allowed the evaluation of the effects of non-specialized feed (cereals), on the economic efficiency of fishery production and the development of methods for modelling and choosing the optimal structure of the food ration, for raising carp in farm conditions. The results of the research carried out had a practical importance not only for raising carp (*Cyprinus carpio*), but also for other species of fish from the Cyprinidae family.

The aquatic ecosystem consists of two main components: the biotic component of the ecosystem and the abiotic component. Each of these factors, depending on the type of aquaculture production, has a different effect on the state of the ecosystem and, as a result, affects the productivity of farm hydrobionts. Almost all abiotic factors, in particular, the temperature of the water in fish farms in ponds depends entirely on climatic and meteorological conditions and cannot be regulated by humans. Fish development is characterized by the zonal principle of distribution, in connection with which its productivity is severely affected by the soil and climatic conditions of the farm, which is based on the temperature factor.

The biotic component, which includes fish breeding and development, namely feeding, prevention and treatment methods, as opposed to abiotic, is almost completely influenced by humans, and the optimization of these parameters depends primarily on scientific and technological achievements. Most of the environmental factors that determine the productivity of ponds, with the exception of water temperature, are semi-controlled, and do not require significant costs for habitat optimization, which allows fish farming to be a leading destination in freshwater aquaculture. In the Republic of Moldova, most of the aquaculture production (over 85%) is destined for ponds, for the cultivation of indigenous fish species in polyculture.

In recent decades, due to anthropogenic factors that have directly and indirectly influenced the fish fauna, in connection with which significant changes have occurred in the structure of ichthyocenosis, the proportion of species such as *Cyprinus carpio*, *Aspius aspius*, *Abramis brama*, decreased significantly, and the dominant species being the roach (*Rutilus rutilus*) and the Prussian carp (*Carassius gibelio*).

At the end of the 1970s, the ponds represented 55-65% of the surface, at the end of the 1990s it decreased to 30-40%, and in 2005 the area of the ponds in the Southern Region of the Republic of Moldova represents 15-20%.

This situation has occurred due to the drought of recent years for which many ponds have dried up, and have been abandoned, or used for other purposes (expansion of agricultural land), in

which no rehabilitation and cleaning measures have been taken, and so the viability of many ponds in the area has been lost.

The productivity of a pond is often hampered by pollution. due to the uncontrolled penetration of manure, pesticides, fertilizers from agricultural lands, as well as industrial waste, in which an insufficient self-cleaning leads to the negative impact as well as to risk factors on the tank ecosystem. In this respect, it is relevant to apply and improve the systematic control of water, taking into account the rules and requirements of world standards.

One of the acceptable and universal ways to control pollution is to use a human-controlled biological process, namely the formation of basic ideas regarding the mechanism of metabolic adaptation of plants and animals to anthropogenic impact, the degree of damage to the pond, taking into account the conditions regional nature, nature and concentration of pollutants in the pond. Another extremely harmful factor is the use of water from the pond as a source of irrigation of agricultural land, which is a direct anthropogenic pollution, being a combination of supply and drainage sources with water used in a vicious circle, because by -a circuit, the water reaches the pond again, which again affects fish farming. A pond is considered bio-effective when it contains a variety of plants and aquatic vegetation, which, in addition to being food for many species of herbivorous fish, are also able to perform oxidative functions, in which the detoxification of organic pollutants takes place. (plants accumulate toxic substances and turn them into non-toxic substances) - photosynthesis, as a result the water is enriched with oxygen. The cause of the degradation of the aquatic fauna of some ponds in the Republic of Moldova is their location near some metallurgical enterprises, machine constructions, and oil waste - mineral pollution (Giurgiulesti locality).

Those that have nearby livestock farms, polluted with waste that drains into the pond, have a high nitrogen content - organic pollution. Individual characteristics are important for each hydrobiont, which allows us to assess the ecosystem to the extent that it has been directly or indirectly affected by anthropogenic pollution.

In turn, wastewater contains two main groups of pollutants:

- preservative pollutant that hardly enters into chemical reactions and is practically not biodegradable (examples of this kind are heavy metals, phenols, pesticides);
- non-conservative pollutant, pollutants that can undergo self-cleaning processes.

The mass development of cyanobacteria of the genus: Microcystis, Anabaena, Nodularia, Nostoc, Aphanizomenon, Oscillatoria, causes great damage to eutrophic ponds, making it difficult to supply water and fishing, when in the pond are over 40-50% of cyanobacteria, fish populations and waterfowl die as a result of toxin poisoning. The problem can be solved by adding, for example, nitrogen compounds, to suppress cyanobacteria and microalgae blooming in the pond, or introducing fish that consume phytoplankton, for example the silver carp (*Hypophthalmichthys molitrix*) and bighead carp (*Aristichthys nobilis*). Some microorganisms such as bacteria, aquatic fungi and also some algae can participate in the decomposition of organic substances, using them as a food source through a self-cleaning process. For example, Protozoa (Ciliates) feed on bacteria, and each can destroy up to 30,000 bacterial cells. Filters (molluscs, daphnia, etc.), although small in size, can filter large volumes of water through its body, filtering suspended particles from the pond, and leaving particles in the form of lumps that settle on the bottom of the pond - natural fertilizer.

Intensive and continuous pollution of water sources in the Republic of Moldova has become a serious problem among fish exploitation. The research showed that only 1% of the waters (ponds) in the southern region of the Republic of Moldova correspond to quality class I, and 17% do not correspond to quality class III for intensive capitalization and fish farming (polyculture).

Manure is growing from year to year due to the practice of agriculture near the pond, as well as the widespread use of fertilizers, pesticides and other harmful products, which endangers the pond. With the annual rains, these substances are washed from the treated surface of the land and drain into the pond, endangering the ichthyofauna, and as a result mortality occurs among fish populations, and the resistant ones endanger human health, by the accumulation of toxic substances in the meat of the fish. In different localities in the southern part of the Republic of Moldova, the composition of the pond waters will be different.

For the analysis, water samples were collected from the pond from two localities of the southern region of the Republic of Moldova: Pelinei (pond 1) and Libidenco (pond 2), to determine the condition and quality of aquatic ichthyofauna, eliminating the risk of disease or fish mortality in the area - factor of development of fish productivity in the South region.

The analyses were performed in the Laboratory for Research and Exploitation of Aquatic Resources within the "Dunărea de Jos" University, Faculty of Food Sciences and Engineering.

The analyses were performed using Merck kits read on the Spectrophotometer, Spectroquant NOVA 60.

The following physical and chemical parameters of pond 1 (from Pelinei locality) and pond 2 (from Libidenco locality) were analysed: phosphates, nitrates, nitrites, ammonium, and organic matter.

Table no. 3.1. Physical and chemical parameters of pond water 1, Pelinei locality.

Physical and chemical parameters / Station	**pH unit PH**	**P-PO_4^{3-} (mg/L)**	**N-NO_3^- (mg/L)**	**N-NO_2^- (mg/L)**	**N-NH_4^+ (mg/L)**	**C-CoCr (mg/L) Organic substance**
Feeding	7.57	0.70	0.6	0.11	0.01	**152**
Evacuation	7.56	0.42	0.7	0.08	0.05	40
Middle basin	7.73	0.68	1.1	0.10	0.07	
Interior basin	7.66	0.33	0.6	-	-	
Basin surface	7.41	0.44	0.8	0.07	0.00	
Regulations of the Republic of Moldova * Romanian standards	6.5-8.5 SR ISO 10523-97	5.0 STAS 10064-1975	10.0 SR EN ISO 13395:2002	1.0 SR EN 26777:2002	2.0 SR ISO 5664: 2001	500.0 SR ISO 6060/96

** Decision no. 352 of April 21st 2005 on amending and supplementing the Government Decision no. 188/2002 for the approval of some norms regarding the conditions for discharging wastewater into the aquatic environment.*

Source: Personal research

The water samples of pond 1 from the Southern Region of the Republic of Moldova, from Pelinei locality, comply with the Norm on establishing the limits for loading pollutants of industrial and urban wastewater at the discharge into natural receptors, NTPA-001/2002; The norm regarding the wastewater discharge conditions in the sewerage networks of the localities and directly in the treatment plants, NTPA-002/2002 respectively Decision no. 352 of April 21st 2005 on amending and supplementing Government Decision no. 188/2002 for the approval of some norms regarding the conditions of discharge of aquatic waste in the aquatic environment (with the subsequent modifications) for the indicators provided in the section "control monitoring" - exception loading with organic substances of the supply source, C-CoCr – 152 mg/l.

Table no. 3.2. Physical and chemical parameters of pond water 2, Libidenco locality.

Physical and chemical parameters / Station	pH (pH units)	P-PO_4^{3-} (mg/L)	N-NO_3^- (mg/L)	N-NO_2^- (mg/L)	N-NH_4^+ (mg/L)	C-CoCr mg/L Organic substance
Feeding	7.38	0.38	7.6	0.14	0.25	31.0
Evacuation	7.43	0.34	1.1	0.08	0.03	49.0
Middle basin	**8.77**	0.46	2.1	0.07	0.01	
Interior basin	7.10	0.30	2.1	0.06	0.01	
Basin surface	7.38	0.60	2.1	0.09	0.04	
Regulations of the Republic of Moldova	6.5-8.5	5.0	10.0	1.0	2.0	500.0
Romanian standards	SR ISO 10523-97	STAS 10064-1975	SR EN ISO 13395:2002	SR EN 26777: 2002	SR ISO 5664: 2001	SR ISO 6060/96

**Decision no. 352 of April 21st 2005 on amending and supplementing the Government Decision no. 188/2002 for the approval of some norms regarding the conditions for discharging wastewater into the aquatic environment.*

Source: Personal research

The water samples of pond 2 comply with the Norm on the establishment of pollutant loading limits for industrial and urban wastewater at the discharge into natural receptors, NTPA-001/2002; The norm regarding the wastewater discharge conditions in the sewerage networks of the localities and directly in the treatment plants, NTPA-002/2002 respectively Decision no. 352 of April 21st 2005 on amending and supplementing Government Decision no. 188/2002 for the approval of some norms regarding the conditions of discharge in the aquatic environment of the wastewater (with the subsequent modifications) for the indicators provided in the section "control monitoring" - exception: Middle basin station - regarding the pH value (8,77).

This study was based on the development of a system of control and efficient use of water resources in the Republic of Moldova, which aims to reduce the anthropogenic factor by at least 10% for each pond. For this it is necessary to analyse the necessary conditions for increasing the quality fish production; to determine basic technological methods for increasing safe production; as well as the calculation of anthropically affected areas and surroundings.

From the total number of ponds in the Republic of Moldova, the eutrophic type predominates, in which the ichthyofauna is dominated by Cyprinids (Prussian Carp, Silver Carp, Bighead Carp, Common Carp, Common Bream, Common Roach). Regarding the nutrition of fish in the natural

environment, predominates benthos and zooplankton which are specific food especially for seedlings (until the transition to specific food). Zoobenthos resources (oligochaetes, *chironomidae* larvae and some insects) are completely consumed by native fish. The main nature reserves represented by macrophytes, detritus and phytoplankton allow to increase the productivity of a pond by 25%. In the ichthyofauna of ponds in which bream (*Abramis brama*) predominates, a fish species from the Cyprinidae family, the proportion of bentophagous fluctuates between 57.9% and 88.4%, with an average of about 72%. This suggests that in some ponds in the Republic of Moldova the zoobenthos from the natural environment is very necessary for many species of fish as many ponds are fed in a smaller proportion or the abandoned ones are not fed at all. Currently, the increase in costs related to feed, vitamins, maintenance of filtration and water supply systems, amendments to capitalize on the potential of the pond limits the possibility of increasing large volumes of fish production through traditional farming methods.

In this chapter, an evaluation was made of the economic efficiency of the growing activities in the aquaculture system of the common carp (*Cyprinus carpio*), by feeding it with non-specialized feed based on cereals.

The aim of the research was to evaluate the effects of non-specialized feed (cereals), on the economic efficiency of fishery production and the development of methods for modelling and choosing the optimal food ration structure when raising carp in farm conditions. The results of the research are of practical importance not only for growing common carp (*Cyprinus carpio*), but also for other fish species in the Cyprinidae family, because the share of feed costs in the cost structure of fishery products is constantly increasing. The largest fish farm, “Post Brat”, with an area of 50 ha, in the South of the Republic of Moldova, deals with the breeding of indigenous fish, especially carp (*Cyprinus carpio*). The fish farm has been active for 8 years and uses non-specialized feed (a mixture of cereals with the addition of vitamins) on its territory.

During the years 2012-2014, the fish farm “Post Brat” used a mixture of feed (barley, wheat, sunflower meal and other mixtures), without added vitamins, (figure no. 3.1). This mixture caused a more difficult growth of the carp (*Cyprinus carpio*), and a lower resistance to diseases, especially during the spring.

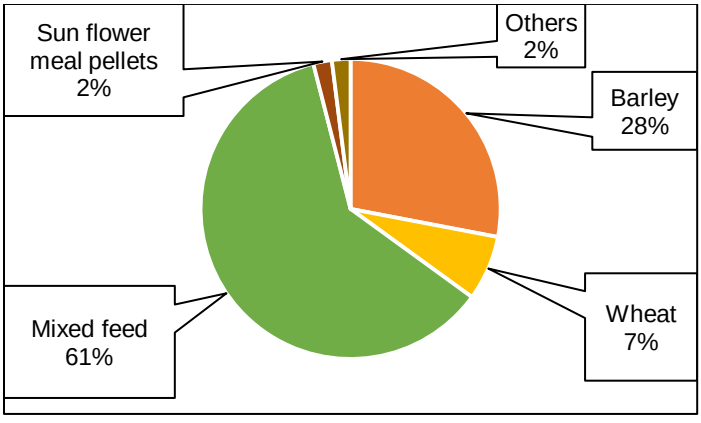

Figure no. 3.1. Composition of fish feed for the period 2012-2014

Source: Personal research

According to the data from Figure no. 3.1, the private enterprise “Post Brat” used in 2012-2014 a mixture of non-specialized cereal feed for the commercial growth of *Cyprinus carpio*. Of which combined feed (61%), which occupies the largest share in the structure of feed, barley (28%), wheat (7%), sunflower meal (2%), and others (fish oil 2%). Starting with 2015, the private fish farming company “Post Brat” began to gradually increase the share of cereal feed, produced independently on the farm and to reduce the share of compound feed (figure no. 3.1), in the carp diet, thus the farm has completely switched to non-specialized feeds of its own production.
The feeding structure of the commercial carp *Cyprinus carpio* in the private fish farming enterprise “Post Brat” for the period 2015, is presented in figure no. 3.2. This feed is cost-effective, allowing high-quality marketable fish production to be achieved, increasing the profitability of fish farming in the area.

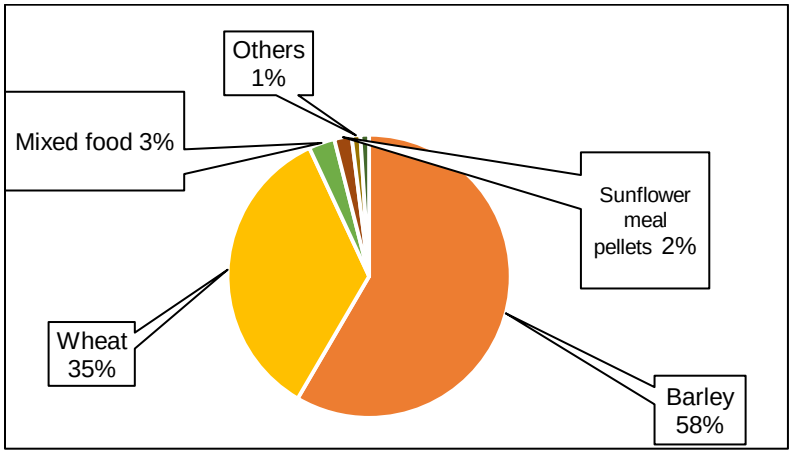

Figure no. 3.2. Composition of fish feed during the period 2015-2019
Source: Personal research

Ingredients: Barley 58%; wheat 35%; sunflower meal pellets 2%; combined feed 3%; fish oil 1%;
Vitamines: Vitamine A 25000 I.U. Vitamine D3 2000 I.U. Vitamine E 25 mg Vitamine C 750 mg.

Composition:

- Extruded feed for fish, made on the farm, with a high content of quality cereals: barley, wheat and fish oil.

Contains an addition of vitamins for a high survival rate and for the rapid development of a healthy brood.

Figure no. 3.23. Extruded fodder, made on the farm
Source: Personal research

Feeding fish on aquaculture farms seems to be one of the main and most difficult aspects in the organization of fish farming, as achieving a proper diet and rapid weight gain depends on food ration, quality and volume, relative to productivity and area. In order to determine the economic productivity of the 'Post Brat' farm, the following indicators were analysed, such as: average

weight of a carp (on the market), average weight gain of a carp after forage, productivity of cyprinids in tonnes per hectare and of carp in kg/ha, annual profit. Due to the administration of vitamins in feed, the farm had a higher production during the years 2015-2019 with 4.61 %. The effect of the amount of feed on the average weight of a fish and its productivity is presented in Table no. 3.3.

Table no. 3.3. Comparison of productivity over the period (2012-2014) and (2015-2019)

Characteristic	2012-2014	2015-2019	Evolution
Tradable fish, total (tonnes)	28,57	45,55	+60%
Crap (kg/ha)	10	15	+50%
Profitability (%)	2,84	4,61	+38,39%
Average amount of feed administered, May-November period (kg /)	585.71	585.71	-
Average weight of marketable carp (g)	1.800-2.400	2.200-5.000	+100%
Cost 1 kg, carp (Euro)	1.75	2	+15 %
Annual profit from sale carp (Euro)	12.000	20.000	**+66,67**%

Source: Personal research

The performed analysis allowed to determine the influence of the feed composition on the carp growth yield. Thus, the recipes for 2 types of fodder were established for breeding carp and obtaining high economic results. The results obtained indicated a high degree of reliability (more than 75%), a major criterion for increasing carp productivity (more than 15 kg/ha). The improvement of the technical and economic parameters will gradually lead to positive results in obtaining a higher productivity of carp, up to 25 kg/ha, due to the nutritional efficiency of the feed. After performing the comparative analysis of the administration of the two types of feed, a stronger effect of the compositional recipe 2 (figure no. 3.2) was observed, consisting of 59% barley, 35% wheat and addition of vitamins. In this case, the influence of barley and the addition of vitamins for live weight gain of commercial carp was significant.

The use of non-specialized feed in the fish farming farm “Post Brat” offers the possibility of obtaining high quality fish production at low costs and will ultimately allow the competitiveness of the economic unit to increase in the market. An increase in the proportion of barley in the diet, with an addition of vitamins (feed 2), led to an increase in fish productivity by 1.77%. The realization of non-specialized fodder at the farm level determined a reduction of production costs, respectively an increase of farm incomes by 8%, and an increase of the profit mass (in the first fodder recipe - 1.3 times, in the second - by 1 , 5 times), which was represented in Table no. 3.3. This led to an increased profitability in the first case, by 2.84%, and in the second case, by 4.61%. Therefore, fish productivity in the coming years will increase to 60 tons/ha for cyprinids and 25 kg/ha for carp *(Cyprinus carpio)*, respectively.

4. CASE STUDY. ANALYSIS OF THE CURRENT STATE OF FISH FARMS IN THE SOUTHERN AREA OF THE REPUBLIC OF MOLDOVA.

In this chapter, an analysis of functional ponds in the southern region of the Republic of Moldova was performed. This research allowed us to analyse the current state of fish farming in the area, determine the role of domestic production on the national aquaculture market, determine the influence of external and internal factors on economic efficiency, identify priority areas for fish farming development in the south.

A 32-question survey was conducted for this purpose. The questions were addressed to the owners of 5 fish farms in the southern part of the Republic of Moldova that operate continuously to raise indigenous fish in polyculture. This analysis allowed us to identify the factors that led to the decrease of local production in the area and will help us in the future determine the criteria for long-term development of fish farming, which can be used in making organizational and investment decisions.

The data obtained from the processing of the collected questionnaires allowed by calculating the minimum, maximum and average statistical coefficients, the evaluation of the economic, competitive, fish, ecological, food, risk profiles of the fish farms as follows:

4.2.1 Economic risk profile

Fish farming systems can be characterized in several ways, including depending on the species raised, the culture medium, the intensity of production and the type of production system used. The analysis of these elements is essential to identify the interactions of aquaculture operations with the environment.

Risk is an inevitable aspect, which intervenes in economic activities at all levels. The emergence of economic risks is based on a complex of factors. Due to a significant potential of these risk factors on the economic results of the company, as well as the impossibility of full control by the company's management, risk analysis is an important dimension of the strategic management of an enterprise. Carrying out a risk analysis at the level of fish farms requires a series of steps: *risk identification, risk analysis and assessment, determination of priority interventions for risk limitation; risk assessment.*

Based on the answers of the decision makers from the five fish farms analysed to the questions in the questionnaire, an analysis of the economic risks identified in the aquaculture production in the south of the Republic of Moldova was performed. The analysis was relatively affected by the small number of functional farms in the analysed region, but the model can be extended nationally. The economic risk expresses the variability of the operating result in relation to the variation of the company's turnover, being generated by the company's inability to adapt its cost structure to the variation of the turnover. This type of risk is directly dependent on the company's economic activity. The interpretation of the information collected, from the perspective of economic risk analysis by the score method is presented in Table no. 4.1.

Table no. 4.1. Economic risk analysis at the level of the analysed aquaculture farms.

Item in the questionnaire	Risk/ Non-risk	Minimum options	Minimum score	Average	Rounded average score	Maximum of options	Maximum score	Risk/Non-risk
What system of fish farming culture do you practice?	Economic risk	Microsystem (less than 3.000 l)	1	Average capacity system (less than 10.000 l)	2	Large/commercial capacity system (more than 10.000 l)	3	Non-economic risk
Calculated productivity for the crop system ?	Economic risk	Up to 500 kg fish/year	2	Up to 2.000 kg fish/year	3	More than 2.000 kg fish/year	4	Non-economic risk
Is productivity estimated or designed according to system rules?	Non-economic risk	Yes	1	No	2	No	2	Economic risk
What difficulties do you encounter in order to increase production on the farm?	Economic risk	Lack of qualified personnel	1	Lack of qualified personnel	1	Unavailability of adjacent land for expansion of the holding	4	Economic risk
Compared to the annual production, please specify what would be in your opinion the optimal productivity for the peak years?	Economic risk	Up to 4.000 kg fish/year	3	More than 4.000 kg fish/year	4	More than 4.000 kg fish/year	4	Economic risk
Compared to the annual production, please specify which in your opinion would be the optimal productivity for the peak years?	Non-economic risk	Yes	1	Yes	1	No	2	Economic risk
Is there collaboration with educational institutions in the area?	Economic risk	No	2	No	2	No	2	Economic risk
Are there regular trainings on occupational safety, including first aid in the event of an accident?	Non-economic risk	Yes	1	No	2	No	2	Economic risk
Is protective equipment provided to employees?	Non-economic risk	Yes	1	Yes	1	Yes	1	Non-economic risk
Have you accessed non-reimbursable funds to create, develop or improve firm activity??	Economic risk	No	2	No	2	No	2	Economic risk
Total		**10**		**10**		**10**		
Economic risk		6 (60%)	**1,5**	7 (70%)	**2**	7 (70%)	**2,6**	
Non-economic risk		4 (40%)		3 (30%)		3 (30%)		

Source: Personal research

- Following the analysis, it can be found that 60-70% of fish farms develop an economic risk profile with medium and long term implications on sustainable economic development.
- The main causes of the economic risks faced by farms are:
- The fish farming culture system is microsystem (less than 3,000 l) or medium capacity system (less than 10,000 l)
- Calculated productivity for the cropping system up to 500 kg fish/year or up to 2,000 kg fish/year
- Productivity is NOT estimated or designed according to system rules
- Lack of qualified staff and unavailability of adjacent land to expand the farm are difficulties in increasing production on the farm
- Compared to the annual production (up to 500 kg fish/year) the optimal production for the peak years can reach up to 4,000 kg fish/year
- Compared to the annual production (up to 2,000 kg fish/year) the optimal production for the peak years can reach over 4,000 kg fish/year
- Markets, local or nearby farms are not supplied with fish from the farm
- There is no collaboration with schools in the area
- Are there no regular occupational safety training, including first aid in the event of an accident?
- No methods of obtaining non-reimbursable funds for the creation, development or improvement of the farm were accessed
- All these causes require urgent remedial action

4.2.2 Competitive risk profile

Free competition between companies, manifested in a liberalized market, can play a positive role among consumers, by achieving an optimal distribution of existing resources and in streamlining economic parameters such as price, production, quality, variety or innovation. At the level of the analysed region, however, there may also be the possibility of manifesting competitive risks, given the relatively small number of competitors on the market. (Table no. 4.2).

Table nr. 4.2. Competitive risk analysis at the level of fish farm in the Southern Region of the Republic of Moldova

Item from the questionnaire	Risk/Non-risk	Minimum of options	Minimum score	Average	Rounded average score	Maximum of options	Maximum score	Risk/Non-risk
What species of fish is the pond supplied with?	Competitive risk	Common carp, Bighead carp, Silver carp	1	Common carp, Bighead carp, Silver carp	1	Common carp, Bighead carp, Silver carp	1	Competitive risk
Total		**1**	**1**	**1**	**1**	**1**	**1**	
Economic risk		1 (100%)		1 (100%)		1 (100%)		
Non-economic risk		0 (0%)		0 (0%)		0 (0%)		

Source: Personal research

The competitive risk in the case of the study is generated by the increase of the same type of fish in all farms. Following the survey, 5 farms in the southern region of the Republic of Moldova deal with the breeding of common carp (*Cyprinus carpio*), bighead carp (*Aristichthys nobilis*), silver carp (*Hypophthalmichthys molitrix*), which represents a share of 100%. Only 3 fish farms are present. The farm in Taraclia also grows the grass carp (*Ctenopharyngodon Idella*), a herbivorous fish, in order to self-clean the phytoplankton in the pond. The zander and perch are in the farm in Taraclia de Salcie in very small quantities.

4.2.3 Fish risk profile at the level of aquaculture farms in the south region of the republic

Following the analysis, it was found that 46-53% of fish farms develop a fish risk profile with medium and long term implications on sustainable fish development. The results of the fish risk analysis are presented in Table no. 4.3

Table no. 4.3. Farm risk analysis at farm level in the Southern Region of the Republic of Moldova

Item in the questionnaire	Risk/ Non-risk	Minimum options	Minimum score	Average	Rounded average score	Maximum of options	Maximum score	Risk/Non-risk
Are the species used for populations native?	Non-fish risk	Yes	1	Yes	1	Yes	1	Non-fish risk
What feed do you use to raise fish?	Non-fish risk	Shredded feed at the mill with mallets	2	Shredded feed at the mill with mallets	2	Shredded feed	3	Non-fish risk
Does the amount of feed administered meet the physiological needs of the fish?	Non-fish risk	Yes	1	Yes	1	Yes	1	Non-fish risk
Are there any documents regarding the origin, quality and composition of the feed or ingredients?	Non-fish risk	Yes	1	Yes	1	Yes	1	Non-fish risk
Does the water source normally provide enough water to allow you to fish all year round?	Non-fish risk	Yes	1	No	2	No	2	Fish risk
Is there a procedure for monitoring water quality inside the farm?	Non-fish risk	Yes	1	Yes	1	No	2	Fish risk
Is there a proper management of domestic wastewater to avoid contamination of surface and groundwater?	Non-fish risk	Yes	1	No	2	No	2	Fish risk
Are organic fertilizers used on the farm?	Non-fish risk	Yes	1	Yes	1	Yes	1	Non-fish risk

Item in the questionnaire	Risk/ Non-risk	Minimum options	Minimum score	Average	Rounded average score	Maximum of options	Maximum score	Risk/Non-risk
Is the storage of fuels, oils, fertilizers and other chemicals in places for your own purpose?	Fish risk	No	2	No	2	No	2	Fish risk
What methods do you use to harvest fish from the pond?	Fish risk	Other methods.	4	Other methods.	4	Other methods.	4	Fish risk
How often is the fish taken out of the pond to be transported?	Fish risk	Monthly	1	Monthly	1	Monthly	1	Fish risk
Compared to the standard specified in aquaculture, which is the size of the fish obtained by production:	Fish risk	Less	1	Less	1	Equal	2	Non-fish risk
Is there a plan of measures to avoid hypoxia or algal blooms?	Non-fish risk	Yes	1	Yes	1	No	2	Fish risk
Total		**13**		**13**		**13**		
Fish risk		**4 (30,77%)**	**1,384615**	**6 (46,15%)**	**1,538462**	**7 (53,85%)**	**1,846154**	
Non-fish risk		9 (69,23%)		7 (53,85%)		6 (46,15%)		

Source: Personal research

The main causes of the fish risks faced by farms are:
• Normally the water source does NOT provide enough water to allow fish farming all year round
• NOT in all cases there is a procedure for monitoring the quality of water inside the farm
• NO in all cases there is a proper management of domestic wastewater, to avoid contamination of surface and groundwater
• The storage of fuels, oils, fertilizers and other chemicals is NOT done in places with their own destination
• Non-standard methods are used to remove fish from the pond
• The fish is taken out of the pond monthly to be transported
• Compared to the standard specified in aquaculture, which is the size of the fish obtained by production is smaller.
• NOT in all cases is there a plan of measures to avoid hypoxia or algal blooms.
These identification causes require a plan of urgent remedial measures at the level of each fish farm.

4.2.4. Ecological risk profile

Raising fish in aquaculture systems must take into account the reduction of ecological risks. The activity must be carried out in high safety conditions, in order to achieve high quality fishery

products with a minimal impact on the aquatic environment. The systematization of the ecological risk analysis is presented in Table no. 4.4.

Table no. 4.4. Ecological risk analysis at farm level in the Southern Region of the Republic of Moldova

Item in the questionnaire	Risk/ Non-risk	Minimum options	Minimum score	Average	Rounded average score	Maximum of options	Maximum score	Risk/Non-risk
Is the farm located outside the protected area?	Non-ecological risk	YES	1	YES	1	YES	1	Non-ecological risk
Are there situations of discomfort generated by the activity for the inhabitants of the area?	Non-ecological risk	No	2	No	2	No	2	Non-ecological risk
Are measures for the protection of ecosystems, biodiversity and nature protection respected?	Non-ecological risk	Yes	1	Yes	1	Yes	1	Non-ecological risk
Total		3	1,33	3	1,33	2	1,33	
Ecological risk		0 (0%)		0 (0%)		0 (0%)		
Non-ecological risk		**3 (100%)**		**3 (100%)**		**3 (100%)**		

Source: Personal research.

Following the risk analysis, no elements of ecological risk were identified. The potential for sustainable development is maximized at the level of the analysed farms.

4.2.5. Food risk profile

Following the analysis, it is found that the vast majority of fish farms due to several economic factors develop a maximized profile of food risk with long-term implications on the health of the population (Table no. 4.5).

Table no. 4.5. Food risk analysis in aquaculture production in the Southern Region of the Republic of Moldova

Item in the questionnaire	Risk/ Non-risk	Minimum options	Minimum score	Average	Rounded average score	Maximum of options	Maximum score	Risk/Non-risk
What is the fish transported to markets/shops?	Non-food risk	With the company's own vehicles	1	With the company's own vehicles	3	With the company's own vehicles	3	Food risk
Is the transport intended only for the delivery of fish?	Non-food risk	Yes	1	No	2	It does not carry fish	3	Food risk
Is the duration of the transport of live fish closely related to the technical equipment of the specialized vehicle?	Non-food risk	Yes	1	No	2	No	2	Food risk
Are there any records of mortality during transport?	Food risk	Yes	1	Yes	1	No	2	Non-food risk
Is the fish that is sick or unfit for sale killed in proper conditions and is it following a legal path?	Non-food risk	Yes	1	No	2	No	2	Food risk
Total		**5**		**5**		**5**		
Food risk		1 (20%)	**1**	5 (100%)	**2**	4 (80%)	**2,4**	
Non-food risk		4 (80%)		0 (0%)		1 (20%)		

Source: Personal research

- The main causes of food risks induced to the population by the consumption of fish sold by farms are:
- Sick or unfit fish is NOT killed under proper conditions and does NOT follow a legal path.
- Transport of fish in markets/shops With personal vehicles.
- Is the transport NOT intended only for the delivery of the fish?
- Is the duration of the transport of live fish NOT closely related to the technical equipment of the specialized vehicle?
- • There are records of mortality during transport.

The identified issues require urgent remedial measures, which must be applied at the level of each fish farm analysed.

5. RESEARCH METHODS, SELECTION OF SPECIMENS OF HIGH FISH PRODUCTION YIELD.

In this chapter were presented methods of research and selection of fish with high production yield as well as a process for obtaining a feed optimized for growing common carp (*Cyprinus carpio*), by strengthening the diet of fish with the PM-2 complex , made from trace elements: iron and cobalt, introduced into the feed in the form of complex nanoparticles. The selection method is recommended for assessing the survival rate and obtaining the most resistant carp breeds. The research can also be widely used in breeding fish species of the Cyprinidae family, which show increased productive qualities, vitality and resistance to adverse growing conditions.

In order to obtain specimens of fish that show high productive qualities, vitality and resistance to adverse growth conditions, a comparative assessment of several groups of Carp (*Cyprinus carpio*) breeders was performed, by the common or separate breeding of two different breeds: mirror carp (*Cyprinus carpio specularis*) and leather carp (*Cyprinus carpio nudus*), followed by the evaluation of a set of traits, such as viability, growth rate, degree of resistance to aggressive environmental factors, essential aspects of industrial fish farm productivity.

Compared to the classical selection method, the proposed method allows to reduce the additional durations and costs, through a quick selection and evaluation of the carp specimens from the larval stage, offering residual resistance until maturity.

The selection method is based on experimental conditions of stress induction in growth groups and elimination of less resistant specimens. The selected specimens will be characterized by superior technological characteristics: increased longevity, high productivity and increased resistance to less favourable production conditions.

For this method, groups of 200 fry from each group (*Cyprinus carpio specularis* and *Cyprinus carpio nudus*) were selected. The fry were exposed to a complex of aggressive factors: lack of oxygen, harsh temperature conditions (16-18 ° C), lack of water and immobilization. The analysed specimens were placed on a fine, damp net, located at a distance of 1 cm above the water, at a temperature of 16-18 ° C and at a humidity of 100%, for a period of 35-40 minutes.

The selection of resistant specimens is carried out after a duration of 20-26 hours from their placement in the aquatic environment, being determined the survival rate of the examined specimens.

Under these stressful conditions, only juveniles survive that have a strong protective reaction at the genetic level and that determine a superior stability of the fish, with the subsequent development.

The method allows to reduce the selection time and the selection of the most resistant specimens. The selection of specimens in the early stages of development will allow the preservation of groups of fish with stable development indicators, and with an increased survival rate compared to repeated exposure to stressors. This method is simple to implement, does not require special equipment, significant materials and additional costs for fish farmers.

Experiments performed

Lots of 200 mirror carp (*Cyprinus carpio specularis*) and 200 leather carp (*Cyprinus carpio nudus*) fry, respectively, were evaluated for a period of 24-36 hours, until the passage of the specimens to active swimming and natural feeding (benthos).

The survival rate of carp fry during dehydration was determined according to formula 1.5:

$$R = (Ax100)/S \qquad \text{Formula 1.5}$$

where

R – the survival rate of carp fry due to dehydration (%),
A - the number of fry that survived 20-26 hours after dehydration,
S - total number of carp fry selected for dehydration (200 fry).

At first, the survival rate of carp fry after the experiment was examined. As a result of the experiment, an average of 98 specimens of *Cyprinus carpio specularis* survived, and 92 specimens of *Cyprinus carpio nudus* from each experimental group of 200 juveniles for each species.
The fry specimens that survived the experiment were monitored until reaching the maturity phase, over a period of 3 years.
In order to evaluate the productivity of the analysed species, the following parameters regarding the evidence of development and growth after the experiment were monitored: the weight of the seedlings during the period of active growth and fattening, the weight of the specimens reached maturity.
The data regarding the evolution of the selected specimens are presented in Table no. 5.1. The survival rate was calculated using formula 1.5

Table nr. 5.1. Indicators of growth of experimental specimens of fish that survived dehydration (average values)

Species subjected to experiments	Survival rate of carp fry after dehydration (%)	Yeast weight after experiment (g)	Weight seedlings after a summer (g)	Carp weight at maturity (g)
Cyprinus carpio specularis	49±2%	14,39±2,4	49,95±0,8	2,880±3,500
Cyprinus carpio nudus	46%±2%	17,54±0,9	55,97±21,3	3,100-4,200

Source: Personal research

Cyprinus carpio specularis and *Cyprinus carpio nudus* reacts differently to temperatures specific to the summer and winter period. Thus, during the winter, the Mirror Crack (1,100 g) recorded higher body weight losses, compared to those of the Leather carp (1,210 g), which underlines the general biological theory of a higher support for this breed (Table 5.2).
Both breeds of carp had a good dynamics of growth and development in the pond, throughout the monitored period. The fry with a better survival of dehydration, were raised during the summer to an average mass of 49-55 g (Table no. 5.1), and kept in the winter in the winter basin to monitor the dynamics of growth and development (C1 +).

Moreover, in addition to survival, the physiological index of development, body weight until reaching maturity, circumference, and the ratio between the length and height of the fish's body were evaluated. The results are presented in table no. 5.2.

Table no. 5.2. Carp rearing dynamics after selection (average values)

Species / Characteristics	*Cyprinus carpio specularis*				*Cyprinus carpio nudus*			
	Spring I	Autumn I	Spring I	Autumn I	Spring I	Autumn I	Spring I	Autumn I
Body weight (g)	150,09	600	1,100	2,100	164,60	660	1,210	2,300
Physiological indices of development (g/cm)	9,9	14,5	12,5	17,6	15,9	11,8	11,2	13,1
Height h (cm)	2,7	4,5	7,1	8,5	3,1	3,6	5,2	8,1
Circumference index (cm)	2,9	3,1	6,7	6,9	2,6	4,0	4,5	4,7
Fish body length/height ratio L/h	5,7	7,2	7,7	7,5	3,1	3,6	5,0	7,3

Source: Personal research

These examples illustrate the high efficiency of the proposed method for the evaluation and selection of resistant fish according to the method of dehydration of fry, a method of rapid selection that determines their survival and productivity from the earliest stage of development. In order to raise the fry that have obtained resistance according to the applied selection method, a fodder recipe for growing and fattening the common Carp (*Cyprinus carpio*) was also implemented.
Thus, a process was implemented to obtain a feed optimized for growing common carp (*Cyprinus carpio*), by fortifying the fish diet with the PM-2 complex, made of iron and cobalt, introduced into the feed in the form of complex nanoparticles. Currently, there is a large number of fish feed used for growing in natural (ponds, rivers) and artificial (farms) water bodies. The choice of a specific feeding system is determined by the breed, the characteristics of the tank and the expected effect. Usually, the diet in aquaculture consists of feed mixtures with the addition of a complex (vitamins, additives), in this case the PM-2 premix complex (iron-cobalt). One method of producing fish feed involves mixing fishmeal (3%), sunflower flour (21%), soybean meal (20%), vegetable oil (2%), wheat flour (16%), and PM-2 Premix with iron-cobalt complex nanoparticles. The percentage of iron and cobalt in the complex is 70:30. The complex is introduced by the method of stepwise mixing and extrusion in an amount of 30 mg per kilogram of the remaining components of the feed. The crushing of each food component is done separately.

Table no. 5.2. Carp rearing dynamics after selection (average values)

Species / Characteristics	*Cyprinus carpio specularis*				*Cyprinus carpio nudus*			
	Spring I	Autumn I	Spring I	Autumn I	Spring I	Autumn I	Spring I	Autumn I
Body weight (g)	150,09	600	1,100	2,100	164,60	660	1,210	2,300
Physiological indices of development (g/cm)	9,9	14,5	12,5	17,6	15,9	11,8	11,2	13,1
Height h (cm)	2,7	4,5	7,1	8,5	3,1	3,6	5,2	8,1
Circumference index (cm)	2,9	3,1	6,7	6,9	2,6	4,0	4,5	4,7
Fish body length/height ratio L/h	5,7	7,2	7,7	7,5	3,1	3,6	5,0	7,3

Source: Personal research

These examples illustrate the high efficiency of the proposed method for the evaluation and selection of resistant fish according to the method of dehydration of fry, a method of rapid selection that determines their survival and productivity from the earliest stage of development. For the growth of young fish that have gained resistance according to the applied selection method, a fodder recipe for growing and fattening the carp (*Cyprinus carpio*) has been implemented.

Thus, a process was implemented to obtain a feed optimized for growing common carp (*Cyprinus carpio*), by strengthening the fish diet with the PM-2 complex, based on trace elements: iron and cobalt, introduced into the feed in the form of complex nanoparticles. Fish feeding is one of the important ways to increase the yield of fish production in ponds, ponds and the main method of obtaining fish farming on industrial farms (cage, pond, etc.). The effectiveness of feeding the fish depends on the composition and quality of the feed used, the feeding technique and the environmental conditions of the tank. In fish farming, feed costs represent between 30 and 50% of total feed costs, so that insufficient use of feed systems can seriously affect the overall economic performance of production. Currently, there are a large number of fish feed used for their growth in natural bodies of water (ponds, rivers) and artificial (farms). The choice of a specific feeding system is determined by the breed of fish, the characteristics of the tank, and the expected effect. Usually, the fish feed in aquaculture consists of feed mixtures with the addition of a complex (vitamins, additives), in this case the PM-2 premix complex (iron-cobalt). The composition of feed mixtures for fish raised in ponds includes sunflower meal, soybean meal, barley, corn, wheat, alfalfa, food industry waste, etc.

One method of producing fish feed involves mixing fishmeal (3%), sunflower flour (21%), soybean meal (20%), vegetable oil (2%), wheat flour (16%), and PM-2 Premix with iron-cobalt complex nanoparticles. The percentage of iron and cobalt in the complex is 70:30. The fortification complex is introduced by the method of stepwise mixing and extrusion in an amount of 30 mg per kilogram of the remaining components of the feed. The crushing of each food component is done separately. Extrusion is performed at a humidity of 25-30% and at a temperature of 60-800C. After extrusion, the resulting feed is dried at a temperature of 20-300C to a moisture content of 12-15%.

The quality of feed depends on the content of nutrients (proteins, fats, carbohydrates), as well as vitamins. At the same time, the nutrient needs for each species of fish are individual, depending on certain factors such as the type and age of the fish, body weight and mobility, etc. The technical task of the research is to increase the metabolism rate of fish and increase the body's natural resistance against various diseases and pests. Thus, this complex feed was introduced, as a method of dynamic evaluation of carp growth, following the effect of metal nanoparticles on fish.
For the experiment were used specimens of carp brood aged 25 days, C (0+), weighing 10-15 g, bred in the conditions of a fishery specializing in aquaculture - pond in Pelina, Cahul district. During the research, the analogical method was used, through which six batches of 15 specimens were formed (n = 15), the specimens being prepared under the same conditions during the preparatory period, which lasted seven days. The experiment period lasted 35 days, during which the use of mixed feeds with different composition in feeding fish was experimented with.

Table no. 5.3. Experimental scheme for introducing iron and cobalt into the diet of fish.

Lots of fish analysed	**Preparation period (7 days)**	**Total period of the experiment (30 days)**
I (witness)	-	(DP)
II	-	DP+$CoSO_4$*7H_2 O și $FeSO_4$*7H_2O
III	-	DP + iron microparticles
IV	Main diet (DP)	DP+$FeSO_4$*7H_2 O
V	-	DP+$CoSO_4$*7H_2 O
VI	-	DP + iron + cobalt nanoparticles

Source: Personal research

Compound feeds differ in the content of trace elements iron and cobalt:

- **Lot I** – witness lot (control group),
- **Lot II** - DP + CoSO4 * 7H2O (0,08 mg/kg feed) and FeSO 4 * 7H2O (30 mg/kg feed);
- **Lot III** - DP + iron microparticles (30 mg/kg feed);
- **Lot IV** - DP + FeSO4 * 7H 2O (feed 30 mg/kg); group V - OP + CoSO4 * 7H 2O (0,08 mg/kg feed)
- **Lot VI** - DP + nanoparticles of the iron-cobalt complex (30 mg/kg feed).

The main components of complex feed (PD) were: fishmeal (3%), sunflower flour (21%), soybean meal (20%), vegetable oil (2%), wheat flour (16%), PM-2 Premix. These feeds were administered according to certain factors. Given the relationship of metabolic processes in fish and digestion from water temperature, during the research period, water temperature was controlled and monitored. The mean water temperature during the experiment was maintained at 26 ± 10C. The experiments were performed in pools, in recirculating system.
The duration of the main examination period was 35 days (5 weeks). For the study, intensive growth tanks with recirculating system, with volumes of 300 litters (125 × 70 × 40 cm) were used. Each basin was equipped with a system for filtering and saturating the water with atmospheric oxygen, maintaining the water temperature in the mentioned range. Weekly weighing of experimental batches of fish was performed to monitor the dynamics of live weight change (Table no. 5.4).

Table no. 5.4. Dynamics of growing experimental batches of carp

Period	Lot I (M)	Lot II	Lot III	Lot IV	Lot V	Lot VI
Beginning of the experiment (T_0)	12,8±2,0	12,9±2,2	12,9±2,7	12,9±2,7	12,9±2,4	12,9±2,2
Week 1	13,6±2,0	14,1±1,5	14,1±2,7	14,1±2,5	13,7±2,3	15,6±2,7
Week 2	15,3±2,2	16,2±2,0	16,0±3,4	16,1±2,4	15,2±2,5	18,2±3,3
Week 3	17,2±2,3	19,0±2,5	17,7±3,5	17,5±2,2	17,3±2,2	20,7±3,2
Week 4	19,1±2,5	21,7±3,1	20,5±4,3	20,1±2,1	19,1±2,2	23,2±3,2
Week 5	22,0±2,6	24,2±3,5	22,6±4,2	21,6±2,1	21,1±3,1	26,0±3,4

Source: Personal research

During the examination, there were no deviations from the norm by external signs. All specimens showed characteristic coloration, with bright eyes that were not sunk into orbit, whole wings, dense and elastic body.

The analysis of the obtained data shows that the presence of iron-cobalt complex nanoparticles in the diet is associated with an increase in live weight compared to the control (control) group.

The inclusion of iron and cobalt trace elements in various chemical forms in the carp diet had an improving effect on the exchange of individual macro-elements (Table 5.5) and essential trace elements (Table no. 5.6).

Table nr. 5.5. The content of macro-elements (µg/individual) in the body of the fish.

	Lot I	Lot II	III	IV	V	VI
Ca	89225±9782	100264±9944	80792±10065	81736±12381	74441±11855	112161±10165
K	32160±3721	33784±5410	31108±6426	33028±3637	32598±4263	38516±4894
Mg	5818±656	5615±828	4603±938	5196±632	4938±682	6696±907
Na	13242±1475	13996±1931	12342±2476	13414±1808	13176±1954	16008±2257
P	53999±5998	69586±9232	48272±9669	45491±6045	43712±6413	81608±11850

Source: Personal research

The research results confirmed that nanoparticles stimulate the accumulation of essential macro-elements and microelements.

Table no. 5.6. Content of microelements (µg)/individual) in the body of the fish.

	Lot I	Lot II	Lot III	Lot IV	Lot V	Lot VI
Cr	24,5±2,86	28,8±4,57	21,4±4,51	23,3±2,35	31,2±4,21	25,9±3,12
Fe	152,9±17,28	198,9±28,13	152,1±30,77	151,9±18,62	141,2±19,52	235,6±32,82
Zn	577,5±63,7	596,8±79,1	455,0±90,8	525,1±73,4	504,6±76,7	734,9±107,1
I	2,25±0,258	1,44±0,271	2,29±0,470	3,19±0,397	2,67±0,365	2,19±0,267

Source: Personal research

In group VI, in the diet of which nanoparticles were introduced, an increase in the content of elements was observed: calcium by 25.7% ($P < 0.05$), potassium by 16.4% ($P < 0.05$), magnesium with 13.1%, sodium with 17.3% ($P < 0.05$), phosphorus with 33.7% ($P < 0.001$), chromium with 5.5%, iron with 35.1% ($P < 0.001$), zinc by 21.4% ($P < 0.05$). The additive effect obtained as a result of the interaction of cobalt and iron significantly affects the balance of these metals in the organs and tissues of fish. Cobalt, interacting with iron, causes a synergistic effect, contributing to the inclusion of the iron atom in the haemoglobin molecule, improving the ionization and resorption of iron, accelerating the maturation of red blood cells.

CONCLUSIONS

The Republic of Moldova is a country with a small area, located in Southeast Europe. The total area of the republic is 33,846 km2. In the North, East and South it is bordered by Ukraine, and in the West by Romania. The central and northern region of the Republic of Moldova is located on the Codru Plateau and the southern region of the country on the Buceagul Plain. The Republic of Moldova has a considerable potential of 95,000 ha of water.

In the Republic of Moldova there are over 2,500 rivers and 4,600 lakes, naturally populated with various species of freshwater fish: Carp (*Cyprinus carpio*), Wels Catfish (*Silurus glanis*), Prussian carp (*Carassius gibelio*), asp (*Aspius aspius*), common bream (*Abramis brama*), bighead carp (*Aristichthys nobilis*), silver carp (*Hypophthalmichthys molitrix*), Zander (*Sander lucioperca*), Northern pike (Esox lucius).

At national level, concerted action is needed to reduce pollution and conserve natural habitats that are directly dependent on water quality.

As the anthropogenic impact far outweighs the positive ecological effect of the ecosystem, the functions of conserving and restoring fishery resources are degraded and unbalanced by abusive and uncontrollable exploitation by the riparian population. The development of complementary fishing activities in different areas related to aquatic resources, environment and cultural heritage, can be the basis of local sustainable development, being important a balanced capitalization of the fishing potential of the area.

This research focused on the analysis of ponds in the southern region of the Republic of Moldova, in order to determine the structural-functional state of ichthyocenoses, as well as to find solutions for the improvement and development of the fishing sector in the area.

In the southern region of the Republic of Moldova there are 31 ponds, of which 19 are not functional (damaged), 3 ponds have dried up and been abandoned, and another 9 ponds are intended for intensive fish farming (polyculture).

In addition to rivers and fishponds, they face significant anthropogenic stress, which is the cause of environmental degradation of various bodies of water, and as a result the destruction of their biocenoses. It should be noted that the ponds in the southern region, as well as the rivers in the area, face a high anthropogenic load.

Fish production in natural reservoirs is an essential part of biological productivity in relation to the formation and maintenance of aquatic biomass. The qualitative and quantitative aspects of a pond depend on the characteristics of the reservoir, including the behaviour and structure of ichthyocenoses. The risk analysis performed at the level of aquaculture production of the Southern Region of the Republic of Moldova highlighted the following aspects:

• the analysed fish farms may be affected by economic risks, which may have medium and long term implications on sustainable economic development;

• fish farms due to several economic factors develop a maximized profile of food risk with long-term implications on the health of the population;

• At the level of the analysed region, however, there may be the possibility of manifesting competitive risks, given the relatively small number of competitors on the market.

These causes of identification require a plan of urgent remedial measures at the level of each fish farm in the southern part of the Republic of Moldova, in order to reduce the risks that may

endanger human health. The activity must be carried out in safe conditions, in order to achieve high quality fishery products.

Given that many valuable fish species are endangered due to anthropogenic or environmental factors (drought), it is recommended to obtain resistant fish breeds, through different methods of obtaining as: the method of selection of the most resistant fish as and by introducing vitamins and a PM-2 complex into the feed, made on the basis of essential trace elements). The research given in order to know the nutritional spectrum and the nutritional relations of the carp (*Cyprinus carpio*), was carried out in the breeders of fish species, from the Cyprinidae family, which show increased productive qualities, vitality and resistance to adverse growth conditions. The selection method is recommended for assessing the survival rate and obtaining the most resistant carp breeds. The research method allows to reduce the evaluation time, as well as the additional costs, by a quick selection of the specimens, offering resistance until maturity. After selecting the most resistant breeds of scrapers, a process was obtained to obtain a feed optimized for growing common carp (*Cyprinus carpio*), by strengthening the diet of fish with the PM-2 complex, made from trace elements: iron and cobalt, introduced into the feed in the form of complex nanoparticles.

The research method was carried out to improve the resistance of valuable fish, especially carp, against aggressive environmental factors, diseases or pests, as well as to obtain a qualitative and quantitative fish production in the area.

We carried out the research work in the field as a specialist. In order to determine the potential effects of the research, the potential risks at the level of production, economic or environmental risk on fish production in the Southern Region of the Republic of Moldova were assessed. The experiments performed on farms in the Republic of Moldova had a positive impact, the applications being very important for the production units affected by the environment.

The research was hampered by a lack of statistical information on domestic production, farmers' reluctance and fear of excessive control by the authorities.

Lack/insufficiency of bibliographic resources is another important issue that has affected the development of research. With the exception of a few prestigious authors from the classical school of fish farming of Soviet origin (such as Usatii), the local scientific literature is very poor in specialized data.

International statistics on the fisheries sector of the Republic of Moldova are mainly represented by FAO data, which are reported with a gap of 2 years from the current situation.

It can be considered that the research results, with absolute novelty in the Republic of Moldova, are of scientific importance, these being the first tests performed at farm level, after the disappearance of the Soviet regime, for selecting specimens of cyprinids with superior viability.

Although the research methods were at the level of experimental testing, they can be extended to other functional farms within the Republic.

The realization of scientific inventories of functional water reserves, with the obtaining of real information and of economic importance, can represent an impulse for the realization of well-argued economic investments, from national or external investors, to increase the aquaculture production at national level and to reduces dependence on imports.

Another interesting aspect of the research conducted at the level of Moldovan fish farms highlighted the dependence of the aquaculture sector on brood imports, made from Ukraine. The essential ingredients needed to make high-performance feed are also mainly imported, as well as equipment used in their processing and distribution.

The specialized technical analyses, performed on water or juvenile fish, are mainly performed in Ukraine, the specialized laboratories in the Republic not being available to farmers.
The research carried out, with important applicative impact, can be extended to other fish farms, there are still a number of theoretical and practical aspects that can be detailed and addressed in different ways.

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4. Patents

1. **Munteanu Pila, M.,** Stanciu, S., 2020, Procedeu de obținere a unui furaj optimizat pentru creșterea crapului comun (*Cyprinus carpio*), prin fortifierea dietei peștilor cu complexul PM-2, realizat pe bază de oligoelemente : fier și cobalt, introduse în furaj sub formă de nanoparticole complexe. OSIM.

2. **Munteanu Pila, M.,** Stanciu, S., 2020, Procedeu de selecție a unor exemplare cu randament de producție ridicat, din rasele de Crap (*Cyprinus carpio specularis*) și Crap golaș (*Cyprinus carpio nudus*), prin inducerea unor factori de stres hidric, termic și de lipsă a oxigenului asupra alevinilor. OSIM.

5.Awards

1. 2020, Certificate of Excellence in Reviewing, Uttar Pradesh Journal of Zoology, Certificate No MBIMPH/PR/Cert/486/MIH

2. 2020, Premiul I "Excelența academică și valori antreprenoriale - sistem de burse pentru asigurarea oportunităților de formare și dezvoltare a competențelor antreprenoriale ale doctoranzilor și post doctoranzilor – ANTREPRENORDOC"

3. 2020, Premiul I - CSSD-UDJG, Galati, România, 18-19 iunie 2020.

4. 2020, Certificate of Excellence in Reviewing, Asian Journal of Fisheries and Aquatic Research, Certificate No SDI/HQ/PR/Cert/58039/MUN2020, Reviewer Certificate, Jurnal Natural Resource Forum, Sustenability.

5. 2020, Certificate of appreciation, in recognition of services to the academic comunity by serving on the International Committee Board of the 35 IBIMA International Conference, IBIMA USA (Seville, Spain, April.1-2, 2020) https://ibima.org/conference/35th-ibima-conference/#ffs-tabbed-13

6. 2019, Membru Comitetul științific 35 IBIMA, IBIMA International Conference, IBIMA USA (Madrid, Spain, Nov.13-14, 2019) Membru Comitetul științific 32 IBIMA, IBIMA International Conference, IBIMA USA (Seville, Spain, April.1-2, 2020) https://ibima.org/conference/35th-ibima-conference/#ffs-tabbed-13

7. 2019, Florea, A.M.; Capatina, A.; Radu, R.I.; Serban (Bacanu), C.; Boboc, M.G.; Stoica (Dinca), C.; **Munteanu Pila, M.,** Ion (Dumitriu), I.M.; Stanciu, S., Resurse Umane - Premierea rezultatelor cercetării - Articole, Subprogram 1-1, Competitia 2019_Actualizat 14.11.2019, https://uefiscdi.gov.ro/resource-823615%20?&wtok=&wtkps=XY5dDoIwEITv0mfBLqXQLHcwJp4AaMEKWqEF/Il3t8UHo0872cw3MyVm+LTIkFgtSWExpUiW8jR1rjPDozKpoMdb4xgdTNtH0PD5TocIKuoEC35AosNNkHAIwkfV0pJCI8vyYMiRSHm97A9bltNEJIJysRIe/X42CQBnAAw+sXyldn8M+HW/Rt+7qLXXq7ORU69iM7bxpBpta6njWasILkena9OT4vUG&wchk=74ca48f9dcb100afbf47e591e1d0a598c5120cc5

8. 2019, Premiul I -CSSD-UDJG, Galați, Romania, 13-14 iunie

9. 2019, Certificate of Best Presentation Award - ICAFSBCM 2019: International Conference on Advanced Food Science, Bioactive Constituents and Micronutrients, Barcelona, Spain.

10. 2019, IBIMA Certificate of appreciation, in recognition of services to the academic comunity by serving on the International Committee Board of the 34 IBIMA International Conference, IBIMA USA (Madrid, Spain, Nov.13-14, 2019) https://ibima.org/conference/34th-ibima-conference/#ffs-tabbed-13

11. 2019, Membru Comitet științific 34 IBIMA, IBIMA International Conference, IBIMA USA (Madrid, Spain, Nov.13-14, 2019) Membru Comitetul științific 32 IBIMA, IBIMA International Conference, IBIMA USA (Seville, Spain, Nov.13-14, 2019) https://ibima.org/conference/32nd-ibima-conference/#ffs-tabbed-13.

12. 2018, Premiul III - CSSD-UDJG, Galati, România, 7-8 iunie 2018

13. 2018, IBIMA Certificate of appreciation, in recognition of services to the academic comunity by serving on the International Committee Board of the 32 IBIMA International Conference, IBIMA USA (Seville, Spain, Nov.14-15, 2018) https://ibima.org/conference/32nd-ibima-conference/#ffs-tabbed-13.

14. 2018, Membru Comitet științific 32 IBIMA, IBIMA International Conference, IBIMA USA (Seville, Spain, Nov.14-15, 2018) https://ibima.org/conference/32nd-ibima-conference/#ffs-tabbed-13.

6. Projects

1. 2019-2020, Excelența academică și valori antreprenoriale - sistem de burse pentru asigurarea oportunităților de formare și dezvoltare a competențelor antreprenoriale ale doctoranzilor și postdoctoranzilor - ANTREPRENORDOC, Universitatea "Dunărea de Jos", Galați, membru

2. 2019-2020, Excelență, performanță și competitivitate în activități CDI, al Universității "Dunărea de Jos" din Galați-Expert-CTR.14 PFE, membru

3. 2018, Contract PN-III-P1-1.1-MC-2018-32443, Proiecte de mobilitate pentru cercetători - MCI", Competiția 2018, Valoare 14960 lei, Director de contract Munteanu Pila, M., 2018, Director de proiect

4. 2017, Contract PN-III-P1-1.1- PN-III-P1-1.1-MC-2017-0673, Proiecte de mobilitate pentru cercetători - MCI", Competiția 2017, Valoare 13.200 lei, Director de contract Munteanu Pila, M., 2017, Director de proiect.