ARTIFICIAL BREEDING IN PISCICULTURE, AND BREEDING OF RARE AND ENDANGERED SPECIES OF FRESHWATER FISH

Bagrov Alexei Mikhailovich
All-Russian Research Institute of Freshwater Fish Culture, corresponding member of Russian Academy of Agriculture,Russia

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Summary

The important role of aquaculture (pisciculture) is demonstrated using data on development of the world fishery. It is noted that the present-day level of harvesting biological resources of the World Ocean has reached its upper limit. Against this background, the proportion of the global fish catch contributed by pisciculture has almost doubled (from 13.4% up to 26.3%) since the early 1990s. According to information from FAO, more than 180 countries in the world have taken initiatives in pisciculture.

Using such important indicators as efficiency of transformation of forage into human food, the fecundity of fishes, and productivity per unit area, the biological advantages of pisciculture over other producers of animal food products is clearly demonstrated.

Specific features of pisciculture in Russia are described. The wide variety of soil and climate conditions, which have determined the different directions of commercial fish culture are indicated. The theory and practice of restoration of natural resources of sturgeons are given particular emphasis. A radically new approach for solution of this problem is proposed with consideration for current social and economic conditions. The case in point is artificial reproduction of sturgeons under completely controlled conditions at every stages of their ontogeny. A method of conservation of genetic material of wild, rare and endangered animals is described.

1. Introduction

Commercial fish culture is now a widespread form of human activity aimed at meeting

the requirements of the human population for food of animal origin. The most developed form of commercial fish culture is artificial breeding and growing of fish under controlled conditions, through all stages of the production, i.e. selection-pedigree work with brood fishes (spawners), production of juveniles, and growing on until they are marketable fish. Methods of commercial fish culture can also be used to help restock wild populations of rare and endangered species.

The best prospects of increasing world production of fish products is connected with aquaculture. Since the early 1990s, aquaculture has been the most quickly developing sector of world food production and it is becoming an increasingly important branch of the global economy, while helping food provision of the World's population (see Table 1).

Years	Russian Federation			World catch (harvest) of fish		
	Total (with algae, i.e. seaweed)	Internal water bodies	Food fish culture (marketable)	Total	Aquaculture	Percentage of total
1990	7.9	0.53	0.19	103.4	16.3	15.8
1991	6.9	0.46	0.14	102.4	13.7	13.4
1992	5.6	0.38	0.11	105.0	15.4	14.7
1993	4.5	0.24	0.07	108.6	17.8	16.4
1994	3.8	0.22	0.06	112.3	20.8	18.5
1995	4.4	0.22	0.06	124.9	30.8	24.7
1996	4.7	0.28	0.06	129.9	34.2	26.3
1997	4.7	0.28	0.06	131.0	36.1	27.6
1998	4.6	0.30	0.06	127.0	30.5	24.0
1999	4.3	0.37	0.07	137.0	33.4	24.4
2000	4.2	0.32	0.07	142.0	35.6	25.1
2001	3.7	0.29	0.09			
2002	3.2	0.29	0.10			

Table 1. Total catch of fish and sea products in the Russian Federation and in the World

Aquaculture continues to expand as a result of increasing awareness and information, particularly on health aspects of farmed fish. It is only through artificial cultivation that quality control can be assured through the course of production. The leading producers of aquaculture products, together with their types and volumes, are shown in Table 2.

Types of production	Production, (thousands of tons)	Main countries, and percentage of the whole
Fishes	23,068	China – 65.8; India – 8.8; Indonesia – 2.8; Bangladesh – 2.6; Norway – 2.1; Vietnam – 1.6.
Crustaceans	1,647	China – 42.9; Thailand – 18.4; Indonesia – 8.9; Vietnam – 5.8; Bangladesh – 3.9; India – 3.2; Ecuador – 3.1; the Philippines – 2.8; Mexico – 2.0;
Mollusks	1,073	China – 80.2; Japan – 4.0; Spain – 2.4; R. Korea – 2.4; France – 1.9; Italy – 1.2.
Algae	1,130	China – 77.6; the Philippines – 6.5; Japan – 5.2; PDR. Korea – 3.9; R. Korea – 3.7; Indonesia – 2.0.

Table 2. Leading countries as producers of aquaculture products, in the year 2000.

According to the latest data, the world production of fish and invertebrates has reached 26.3 million tons that makes up 23% of the total fish production and fisheries (115.9 million tons). The data shows that China is the world's leading producer of aquaculture products, and that it is steadily increasing its share of world production. In 1994 the Chinese contribution to total aquaculture production was 57%, but in the late 1990s it was not less than 70%.

Russia has tremendous fishery potential for development of different forms of fish culture, but it is currently underused. Even in the best years, total volume of fishery yield and production in Russia did not exceed 550 000 tons. In the pre-reform period, production of marketable fish had reached 187 300 tons. Most of this was from mass production units. It was in the 1980s that aquaculture production in Russia first exceeded the catch of wild fish from internal seas. This became possible through application of science, new research and development of new technology, and state support for aquaculture.

Regions	Lakes (22,5 millions of ha)	Water reservoirs (4.6 mln ha)	Ponds (141,600 ha)
Caucasian	-	-	44
West-Siberian	28	-	-
East-Siberian	26	18	-
North-Western	25	23	2
Far-Eastern	18	-	-
Volga basin	-	31	11
Ural	-	9	4
Central	-	8	22
Others	3	11	17

1. Length of rivers make up more 523,000 km
2. Water bodies for agriculture purpose – 2.6 million ha
3. Irrigation canals – 10,000 km

Table 3. Distribution of water resources in Russia, by percentage

Russia not only has very favorable conditions for fish breeding but also production of great diversity of species. This is because of the wealth of water resources in different soil-climatic zones (see Table 3). In the Russian Federation, they can be provisionally divided onto six fish breeding zones, each with its own specific character being taken into account when aquaculture is being developed. It seems that no other country has such abundance and diversity.

2. Commercial fish culture

Three basic principles of commercial fish culture have already been established and brought into successful operation. The main systems are pond, industrial and pasturable (feeding) fish culture. The most ancient form of fish breeding is pond fish culture, which is very widespread. With a moderate rate of intensification (feeding, fertilizing) it is possible to obtain 100 tons of carp per yearfrom 100 ha of pond area. Under polyculture, i.e. with mixed herbivorous fishes, pike (*Esox*), whitefishes (Coregonidae), and other fish species, the yield is higher than this. When using intensive technologies, fish productivity of ponds can reach 5 to 7 tons/ha. Pond fish culture is based on breeding and growing of fish in specially made ponds of different categories, differing from each other in area, depth, and exploitation conditions. Globally, pond fish culture is most common in the countries of Asia and Central Europe.

Industrial fish culture is considered the highest form of commercial fish culture. Fish are grown in systems similar to battery production of poultry. One development is the use of waste heat from industrial and power-generation plants. By degree of technological and technical complexity, the industrial farms are arranged as follows: cages – pools – closed cycle water supply plants. Fishes of the most valuable species including salmons and sturgeons, as well as eel (*Anguilla*) are the main species raised. A complex of technical means affords optimization of the fish environment. There are various pool and cage methods for growing, and all-year-round growing of different species of fishes and crustaceans is performed in closed cycle water supply plants, independent of the climatic conditions. This is the most promising form of industrial fish culture. It permits efficient use of land and water, and concentration of production within a limited space. Depending on the fish species, the productivity may be from 30 to 200 kg/m^2. Industrial farms successfully produce young stock of valuable species in order to meet requirements of the other types of fish culture (pond and pasturable). Industrial fish culture is primarily in the most developed industrial countries of Europe, North America, Japan, and Russia. Industrial enterprises are distinguished by the use of modern equipment, means of control and optimization of water media, and high-calorie feeds which are efficient for fish health and growth.

Pasturable (feeding) fish culture includes the purposeful growing and extraction of fishes from different water bodies. Its purpose is to increase the profitable use and productive potential of water bodies. It is particularly effective in countries well blessed with surface water resources such as lakes, reservoirs, and rivers.

This is the most promising direction for rational use of inland water bodies. According to expert estimates verified by theoretical calculations, it is possible to obtain 1 to 3 million tons of fish per year from inland water bodies of Russia. Polyculture is a leading

factor in intensification and development of pond and pasturable fish culture. Polyculture is the combined growing of several fish species with different nutritional requirements to optimize use of the natural food resources of a water body. China is considered the home of polyculture. Here, a unique form of polyculture is applied, the basis of which is herbivorous fishes, particularly silver and variegated carp, (*Hypophthalmichthys molitrix*) and grass carp (*Clenopharyngodon idella*). These are called the Far Eastern phytivorous fishes. As a result of acclimatization, the geographic range of these fishes has been significantly extended: they have been introduced to many countries of Asia, Europe, Africa, and North and South America. The main abiotic factor determining the geographic limits for phytivorous fishes in fresh water bodies is the thermal regime. They are thermophilic species, with a temperature optimum of 25 to 30 ºC, but they can live under ice for 2 to 5 months, and in terms of resistance to cold they are as good as most species of carp. There are three main issues in culture of herbivorous fish. These are concerned with technical aspects of the fishery, and socio-economic, and socio-ecological aspects. Sound management of fishery in Russia permits annual production of not less than 1 million tons of marketable herbivorous fishes. Pond farms produce not less than 100 000 to 200 000 tons, and the rest comes from polyculture.

The socio-economic aspect is related to the economics of herbivorous fish production. In total volume of marketable production of these species, silver carp (*Hypophthyalmichthys molitrix*) comprises more than 90%. Their basic fodder is phytoplankton and detritus. The phytoplankton resources in different water bodies are very large, and increase of phytoplankton production occurs as a result of anthropogenic eutrophication, which is mostly attributable to agriculture. Every year, a significant proportion of the fertilizer applied to the fields is washed out into water bodies. This adversely affects the national economy. But extensive use of herbivorous fish ensures that a significant part of the seemingly irretrievable losses is recovered. Also, by growing herbivorous fishes in water bodies that receive cooling water from power stations, a lot of energy, that would otherwise be wasted, is to productive use. The socio-ecological aspect is mainly concerned with ecological restoration, which is required in a great number of water bodies. The above fishes are highly effective biomeliorators. By removing aquatic vegetation and filtering out a significant amount of the phytoplankton, detritus and other organic substances, herbivorous fishes exert a favorable influence on water quality and stabilize the hydrochemical regime.

Development of systems for culture of herbivorous fishes is one of the greatest achievements of Russian scientists in the field of aquaculture. Large-scale adoption of these systems has been achieved. On average over the country, they produce about 40% of commercial production, and in the south of the country it is up to80%. Natural fish productivity of ponds is increased by a factor of two to three, while that for reservoirs is three to five. These fishes have become an integral part of pond polyculture, fattening, and biological amelioration of multi-purpose water bodies. The systems have been adopted in more than 40 countries. This is a main focus for federal research programs and federal ecological programs up to 2010. The realization that it is possible in Russia to produce more 1 million tons of marketable production gave impetus to development of a number of interdisciplinary sciences. More that 6000 papers, books, and textbooks have been published on this subject.

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Biographical Sketch

Alexei Mikhailovich Bagrov was born in 1946. He is a well-known Russian pisciculturist. He has a DSc in biology, and is a corresponding member of the Russian Academy of Agriculture. He is a leading specialist in fish breeding and rearing. For about 40 years, he has been involved with biological investigation of species used in aquaculture and breeding of ecologically specialized fish species. He is now the Director General of the All-Russian Research Institute of Freshwater Fish Culture.