The role of the silver carp in increase fish productivity and the reducing the level of eutrophication of eutrophication of reservoirs of Kuban basin

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Annotation. The data on the nutrition of silver carp and its role in reducing the level of eutrophication and increasing the fish productivity of the reservoirs of the Kuban basin are given.

Introduction

Silver carp (Hypophthalmichthys molitrix (Valenciennes, 1844) is the only representative of the ichthyofauna in reservoirs of Kuban, feeding on primary products (phytoplankton) and transforming it into valuable high-quality fish products.

Studies on the role of a silver carp – fitoplanktona in reservoirs of Kuban basin (Krasnodarskoe, Kryukovskoe and Varnavinskoe) ware carried out in 2000-2013. Until that time such studies on the role of the silver carp in reservoirs of Kuban basin have not been conducted. Therefore, our studies have great scientific and practical interest.

It should be noted that studies on the nutrition of fish has not been done recently. There are very few works devoted to this important issue in the literature.

Knowledge of fish nutrition is necessary to solve a lot of fisheries issues, namely: analysing the causes of fluctuations in the number and rate of growth, the establishment of the optimal fishing size, the development of measures for the most rational use of feed resources, increasing fish production and reducing the level of eutrophication in reservoirs, etc.

Materials and methods of studies

The study of fish nutrition was given according to the «Manual for studying fish nutrition in natural environment» [14] and «Manual for studying nutrition and food relations of fish in natural environment» [9]. Collecting and processing of hydrobiological samples (phytoplankton, zooplankton) was carried out according to generally accepted methods. 494 samples of phytoplankton and 84 zooplankton were collected and processed, as well as the content of the intestines of 357 silver carp of different ages was studied.

Results and discussions

It is known that silver carp in the diet is fitoplankton, but in case of lack of phytoplankton, it actively consumes detritus [3,4]. According to E. V. Borutsky [3], in spring and early summer the main component the silver carp food is detritus (over 90 %). The same data were obtained from fish living in Kuban estuaries [10]. At the same time, Omarov O. M. [12] notes that in the nutrition spectrum of
the silver carp phytoplankton was occupied 95 %, the zooplankton - 3 %, and detritus – 2% from the total food.

The content of phytoplankton in the intestinal tract of silver carp ranges from 45.9 to 59.0%, on average 52.43±0.82 % of the mass of the food lump. The maximum content of phytoplankton in the food lump of the silver carp is observed in July and August, which coincides with the maximum biomass of phytoplankton in this period.

Detritus is an essential component of nutrition of different age groups of silver carp.

Detritus is found in the intestines of all the studied fish from 40.2% to 53.8%, on average 46.95±0.86 % of the mass of the food lump, including mineral particles, in the intestines of the fish was noted in spring, when the phytoplankton biomass was minimal (table 1).

Table 1-S Seasonal changes in the abundance and biomass of phytoplankton in reservoirs of Kuban basin

| Reservoir       | Spring        | Summer        | Autumn        | Average for season |
|-----------------|---------------|---------------|---------------|--------------------|
| Krasnodarskoe   | 3.20 ± 0.42   | 26.63 ± 1.34  | 17.63 ± 0.76  | 15.82 ± 0.76       |
|                 | 3.64 ± 0.36   | 23.84 ± 0.98  | 12.21 ± 1.15  | 13.23 ± 0.48       |
| Krukovskoye     | 10.43 ± 0.76  | 29.36 ± 0.67  | 9.54 ± 1.23   | 19.77 ± 0.56       |
|                 | 10.10 ± 0.98  | 27.70±1.26    | 13.80 ± 1.76  | 17.20 ± 0.21       |
| Varnavenskoe    | 12.75 ± 1.21  | 24.99 ± 1.43  | 15.78 ± 1.17  | 17.84 ± 0.36       |
|                 | 9.30 ± 0.76   | 26.80 ± 1.54  | 13.00 ± 1.98  | 16.36 ± 0.78       |

Note: the top row is numbers, thousand cells/l; bottom line-biomass, g / m3

Perogitive, blue-green, golden, yellow-golden, disminuye, apparently, are junk food for the silver carp. Blue-green and ductal algae in the plankton are almost at the same level (26.65±0.42% and 26.82±0.72%), however, the index of selection of ductal is 1,33, and blue-green algae is 0,54. In the food lump of the silver carp, the ductus is 2,46 times higher than the blue-green.

According to the index of selection, blue-green algae are in the fifth place (0.54%). But in general, in the food lump of the silver carp all groups of algae which are part of the phytoplankton of the reservoirs are found.

The intensity of silver carp nutrition in all age groups during the growing season (April-October) is at a fairly high level (table 1). The average index of intestinal filling of silver carp is 284±0.93%. High index of intestinal tract filling indicate high feeding of silver carp in the reservoirs of Kuban basin. This ensures the intensive growth of fish of all age groups (table 3).
Table 2 – The balance of groups of algae in the plankton and in the diet of the silver carp, %

| The divisions of algae | In plankton | In the food | The index of selection |
|-----------------------|-------------|-------------|-----------------------|
| Green, including      |             |             |                       |
| Ductal                | 26.82±0.72  | 35.77±0.61  | 1.33                  |
| Volvox                | 9.84±0.34   | 11.27±0.34  | 1.14                  |
| Desmidium             | 1.25±0.24   | 0.39±0.02   | 0.31                  |
| Diatom                | 16.32±0.61  | 17.04±0.92  | 1.04                  |
| Euglenid              | 14.81±0.73  | 20.67±0.98  | 1.40                  |
| Perogitive            | 1.56±0.24   | 0.16±0.05   | 0.10                  |
| Blue-green            | 26.65±0.42  | 14.55±0.32  | 0.54                  |
| Golden                | 1.92±0.01   | 0.12±0.01   | 0.06                  |
| Yellow-green          | 0.83±0.01   | 0.03±0.01   | 0.04                  |

Table 3 - Linear and weight growth of silver carp in the reservoirs of Kuban basin

| Age | Reservoir       | Average index | n  |
|-----|-----------------|---------------|----|
|     | Krasnodarskoe   | Krukovskoe    | Varnavskoe |
|     | cm | gr | cm | gr | cm | gr | cm | gr |
| 1+  | 35.4 | 680 | 30.5 | 520 | 31.8 | 495 | 32.5 | 565.0 | 250 |
| 2+  | 52.2 | 2240 | 44.2 | 1950 | 40.5 | 1650 | 45.6 | 1946.0 | 220 |
| 3+  | 63.5 | 3670 | 52.5 | 1960 | 48.4 | 2670 | 54.8 | 2766.6 | 180 |
| 4+  | 65.4 | 4500 | 56.8 | 3280 | 57.6 | 4100 | 59.9 | 3960.0 | 148 |
| 5+  | 69.3 | 5900 | 62.5 | 3850 | 61.5 | 5250 | 64.4 | 5000.0 | 154 |
| 6+  | 72.6 | 7600 | 66.4 | 5140 | 69.8 | 7480 | 69.6 | 7843.3 | 167 |
| 7+  | 75.5 | 8900 | 69.5 | 7150 | 74.5 | 8950 | 73.2 | 8333.3 | 123 |
| 8+  | 79.4 | 10100 | 71.6 | 8850 | - | - | 75.5 | 9475.0 | 80 |
| 9+  | 82.2 | 11300 | - | - | - | - | 82.2 | 11300.0 | 36 |
| 10+ | 84.8 | 12450 | - | - | - | - | 84.8 | 12450.0 | 28 |

As it can be seen from the data in table 3, the annual increase of weight of silver carp ranges from 490.0 to 2843.3 gr. The intensive growth of silver carp in the reservoirs of Kuban basin is due to good conditions of feeding (high food supply, long growing season, more than 200 days with water temperature of 20-25 ºC and the lack of competitors in the nutrition).

However, despite the high rates of fish forage and growth, the fish productivity of the reservoirs is low and in most cases does not meet their potential opportunities.

Over the past 10 years, the average fish productivity of the reservoirs of Kuban basin is on average 1.6 kg/ha, with a fluctuation of 0.6 to 2.5 kg/ha, and for herbivores (white and motley carp) – 0.2 kg/ha. This fish production is very low and can not serve as a reference point for south reservoirs of the country. In this regard, having long-term data on the number and biomass of phytoplankton, we have attempted to determine the potential fish production of reservoirs for feed resources.

As it is known, the yield of fish products is determined not by the residual biomass of forage organisms, but by the value of their annual (seasonal) production. Therefore, it is important to study defined production values of individual species and groups of aquatic organisms that play a major role in the food of fish.

To determine the production of phytoplankton in the reservoirs of the Kuban basin, we used the available in the literature P/B coefficients, which range from 40-71 for the Khakhovskoe reservoir [16], to 350-400 generations per year for the world ocean [2]. For the Azov sea of V. G. Datsko [7] uses P/B-coefficient 340. In the Tsimlyanskoe reservoir [13] it was found that the biomass of algae is renewed during the growing season 240 times. This P/B - coefficient is used by I. Lapitsky [8] for calculation of phytoplankton production in the Tsimlyanskoe reservoir. To determine the production of
Phytoplankton in reservoirs of Kuban basin, we used the minimum P/B-coefficient – 40, defined for the Khakovskoe reservoir for the summer period [16]. With average for the vegetation period of phytoplankton biomass and taking P/B-coefficient equal to 40, we obtained the value of phytoplankton production for the reservoirs of the Kuban basin (table 4).

**Table 4 – Average annual biomass and production of phytoplankton in the reservoirs of Kuban basin**

| Reservoir      | Biomass | Production P/B – 40 |
|----------------|---------|---------------------|
|                | gr/m³   | kg/ha   | total, m | kg/ha   | total, m |
| Krasnodarskoe  | 13,23±0,48 | 463,0  | 13891     | 18520    | 555660   |
| Krukovskoe     | 17,20±0,21 | 481,6  | 1686      | 19264    | 67424    |
| Varnavskoe     | 16,36±0,78 | 458,1  | 1603      | 18324    | 64120    |

The obtained data on the production of phytoplankton are indicative, but on their basis it is possible to approach the direct determination of potential fish production (table 5).

**Table 5- Potential and commercial fish productivity in reservoirs of Kuban basin**

| Indicators                        | Krasnodarskoe | Krukovskoe | Varnavskoe |
|-----------------------------------|---------------|------------|------------|
| Phytoplankton production, kg/ha  | 18520         | 19264      | 18324      |
| Product utilization rate (25%), kg/ha | 4630       | 4816       | 4581       |
| Feed ratio, u                     | 30            | 30         | 30         |
| Potential fish production, kg/ha | 154           | 161        | 153        |
| The fish return rate, %           | 15            | 20         | 20         |
| Commercial fish production, kg/ha | 23           | 32         | 31         |

The data of table 5 show that due to the rational use of natural resources of the reservoir (phytoplankton) can be obtained in average per hectare water areas of the Krasnodarskoe reservoir 23 kg/ha, Kryukovskoe – 32 kg/ha, Varnavinskoe – 31 kg/ha of fish products.

To obtain the above-mentioned fish products, it is necessary to carry out the annual stocking of the reservoirs by fingerlings or yearlings of silver carp from the calculation: Krasnodarskoe reservoir-85 copies/ha, Kryukovskoe reservoir – 60 specimens/ha, Varnavinskoe reservoir – 55 specimens / ha.

Fishing for carp should be start on the second or third year after stocking, when the individual weight of fish will reach more than 2 kg. For 5-7 years of fishing the fish population of the first stocking will be almost completely removed. The total potential catch of silver carp in Krasnodarskoe reservoir will be more than 700 tons, in Kryukovskoe – 84 tons, in Varnavinskoe – 77 tons.

In addition, annually the silver carp, utilizing a significant part of the production of phytoplankton (21,000 tons in Krasnodarskoe reservoir, 2520 tons in Kryukovskoe reservoir, 2310 tons in Varnavinskoe reservoir), significantly reduce the level of eutrophication of reservoirs.

Thus, the calculations carried out by us in relation to the reservoirs of Kuban basin are very approximate, and, nevertheless, they show quite real values of the planting material of the silver carp, which can ensure the removal of a significant part of the seston, including phytoplankton production and its transformation into valuable fish products.

Whereas there are no appropriate conditions for the natural reproduction of silver carp in the reservoirs of Kuban basin [11], their stocking is possible only on the basis of artificial breeding and cultivation of fish planting material in pond farms.
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