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THE CONTENT OF MICROELEMENTS IN THE *ACIPENSER STELLATUS* PALLAS EARLY DEVELOPMENT STAGES UNDER ARTIFICIAL AND NATURAL REPRODUCTION CONDITIONS

ZAWARTOŚĆ MIKROELEMENTÓW WE WCZESNYCH STADIACH ROZWOJU *ACIPENSER STELLATUS* PALLAS W WARUNKACH SZTUCZNYCH I NATURALNEJ REPRODUKCJI

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The microelements content in the main components of water ecosystems as well as in the ripening fish eggs, fish larvae and fish fry at natural spawning ground and at fish farm was studied. The deficiency of Mn and Co in the fish farm ponds and accordingly low levels of these elements in the fish larvae and fries of *Acipenser stellatus* Pallas in comparison with their contents in fish flesh on the redd was noticed.

INTRODUCTION

One of the quick ways of growth in pisciculture efficiency is to use microelements as biostimulants at different stages of fish ontogenesis (Vorobyov, 1979).

It need to be underlined that only scientific advices based on propositions of biogeochemistry may give good results in freshwater aquaculture. It is necessary to take into account the microelements content in fish habitats as well as possibilities of their utilization by living organisms (Vorobyov, 1983; Zaitsev et al., 1980; Kovalsky, 1974).

Studying problems of freshwater aquaculture including hatching fish eggs, rearing larvae, acclimatizing water organisms, getting commercial fish products and so on we kept fish and other water organisms under various ecological conditions often different from those in their natural habitats. All that, naturally, influenced the

metabolic processes of fish. Insufficient knowledge on physiological requirements of fish for microelements at the early stages of ontogenesis – one of the most important periods of fish life cycle – is one of the reasons preventing from using microelements in freshwater aquaculture on a large scale.

The objective of our work was:

1. To study the metals contents in the main water ecosytems (ground, water, plankton, benthos) in which *Acipenser stellatus* Pallas lives under natural conditions, during its early stages spawning grounds ontogenesis. The of the fish are situated in the Volga delta, near Kamenny Yar village and at the Bertyul commercial sturgeon fish farm in the Astrakhan area.
2. To reveal the peculiarities in the microelements dynamics at different stages of early ontogenesis of *Acipenser stellatus* Pallas under natural and artificial conditions.

The studies were held carried out between June and July 1986–1988. Samples of ripening eggs of *Acipenser stellatus* Pallas were collected, either, daily by a drag at the spawning grounds and every hour at the hatching farm.

As to estimate concentrations of the microelements in water samples were collected, either, daily, when (1 l) from the hatcheries and nurseponds or 10 days when from the rearing ponds. Water temperature and oxygen content were measured as well. Grounds, water and water organisms samples were collected from 3 rearing ponds (9 stations) and at the natural spawning ground 3 stations.

The metals concentrations within the biological objects were measured by atomic absorption method with "Hitachi" spectrophotometer, model 180–50. Results were statistically treated, and expressed in mg/kg of dry weight of the object analysed. Through the period of studies the average Volga water temparature spawning ground was 20.5° ± 1.85°C. For hatcheries was 19.8° ± 1.64°C and for ponds 23.8° ± 1.93°C. Oxygen content in water was 8.3 ± 0.63 mg/l, 8.1 ± 0.57 mg/l and 6.9 ± 0.52 mg/l respectively (table 1).

At the spawning ground copper and zinc in water content turned to be about the same as that at the sturgeon fish farm whereas manganese and cobalt content in water of hatcheries and ponds was lower (by 1.7–2.0 times) when compared to that for the river is water (table 2).

The studies of grounds, plankton and benthos revealed rather high levels of copper and zinc and low manganese and cobalt levels at the fish breeding farm comparing to those for natural spawning grounds. As for grounds samples these data appeared to be lower than the mean ones throughout the USSR (Ryzshkov, 1984).

The deficiency in manganese and cobalt in the water ecosystem of farms proved biogeochemical conditions of the artificial fish farming not to correspond fully with natural ones. Furthermore it is important to reveal the peculiarities of the microelements contents and their dynamics in the early ontogenesis of *Acipenser stellatus* Pallas during commercial reproduction.

Table 1

The microelements contents in the Bertyul commercial sturgeon fish farm water. mg/l

Sampling area	Date	Water t°C	O_2 Contents mg/l	Cu	Zn	Mn	Co
Hatcheries	10.06.84	19.7	8.4	0.003	0.021	0.004	0.001
	20.06.84	20.2	8.5	0.004	0,018	0.003	0.001
	21.06.84	19.7	7.8	0.005	0.028	0.002	not discovered
	22.06.84	19.4	7.6	0.004	0.023	0.001	not discovered
	23.06.84	20.0	7.9	0.003	0.016	0.004	0.001
Nurseponds	24.06.84	20.8	7.7	0.005	0.033	0.002	0.002
	25.06.84	21.0	7.8	0.006	0.025	0.005	0.001
	26.06.84	21.4	7.6	0.006	0.038	0.004	not discovered
	27.06.84	22.6	7.7	0.004	0.021	0.003	0.001
	28.06.84	21.8	7.4	0.005	0.019	0.005	0.002
	29.06.84	22.3	7.5	0.004	0.022	0.004	0.001
Rearing ponds 12, 39, 41	1.07.84	22.4	7.1	0.005	0.034	0.001	0.001
	10.07.84	23.7	6.8	0.003	0.038	0.004	0.002
	20.07.84	25.6	7.0	0.008	0.027	0.004	0.002
	29.07.84	24.8	6.8	0.006	0.024	0.003	0.001
Mean		21.6 ± 1.8	7.5 ± 0.9	0.005 ± 0.0005	0.025 ± 0.003	0.003 ± 0.0002	0.001 ± 0.0001

Table 2

The microelements contents in the main components of water ecosystem of the spawning ground and the Bertyul commercial sturgeon farm

Object of studies		Cu	Zn	Mn	Co
Water; mg/l	spawning ground	5.0 ± 0.30	18.0 ± 2.0	5.0 ± 0.40	1.0 ± 0.10
	farm	5.0 ± 0.90	25.0 ± 1.0	3.0 ± 0.20	0.5 ± 0.03
Ground; mg/kg	spawning ground	24.8 ± 1.80	49.6 ± 3.40	637.0 ± 44.50	8.5 ± 0.75
	farm	26.7 ± 2.10	58.3 ± 4.20	373.0 ± 38.60	6.7 ± 0.56
Benthos; mg/kg	spawning ground	10.6 ± 1.0	96.4 ± 6.8	79.2 ± 6.22	5.8 ± 0.61
	farm	8.6 ± 0.73	118.9 ± 10.70	35.6 ± 2.77	3.2 ± 0.27
Plankton; mg/kg	spawning ground	6.7 ± 0.55	136.3 ± 11.20	30.8 ± 2.33	3.0 ± 0.22
	farm	7.4 ± 0.64	156.6 ± 12.20	20.2 ± 1.91	1.8 ± 0.09

It must be stressed that *Acipenser stellatus* Pallas embryogenesis is characterized by rather intensive microelements exchange between an embryo and the environment. Concentrations of elements assimilated by the ripening eggs at different developmental stages vary a lot this impede the discovery of the general law. That's why it is convenient to use the mean data for each of these developmental steges: cell--division, gastrulation, development before heart pulsation begins, development before hatching (fig. 1).

After fecundation an intensive absorption of the most water elements by the ovule is observed. As a result quanfity of copper and cobalt in the embryo increases almost twice during first 10 minutes. Zinc absorption is somewhat retarded but 15–20 minutes after fecundation, at the non-adhesive stage it its utilization by the ripening eggs starts.

Appearence of first cell-division furrows, formation of blastomers and then blastula well coincide with the noticeable reduction in manganese, zinc and cobalt levels in the embryo. It seems to be the result of active metabolic processes undergoing within the cell, such as nucleic acid synthesis and protein, carbohydrates and fats oxidation catalized by enzymatic systems requiring microelements for normal functioning. These microelements are either part of enzymes molecules or are coenzymes (Voinar, 1960; Vorobyov, 1983). During embryogenesis in sturgeons and carps are reduced carbohydrates level is reduced by 3–5 times while proteins and fats by 20–40% and 10–20% respectively. Fatty acidi spectrum and the quantity of nucleic acids are changing; at the same time the protein aminoacids are varying greatly (Vorobyov, 1979).

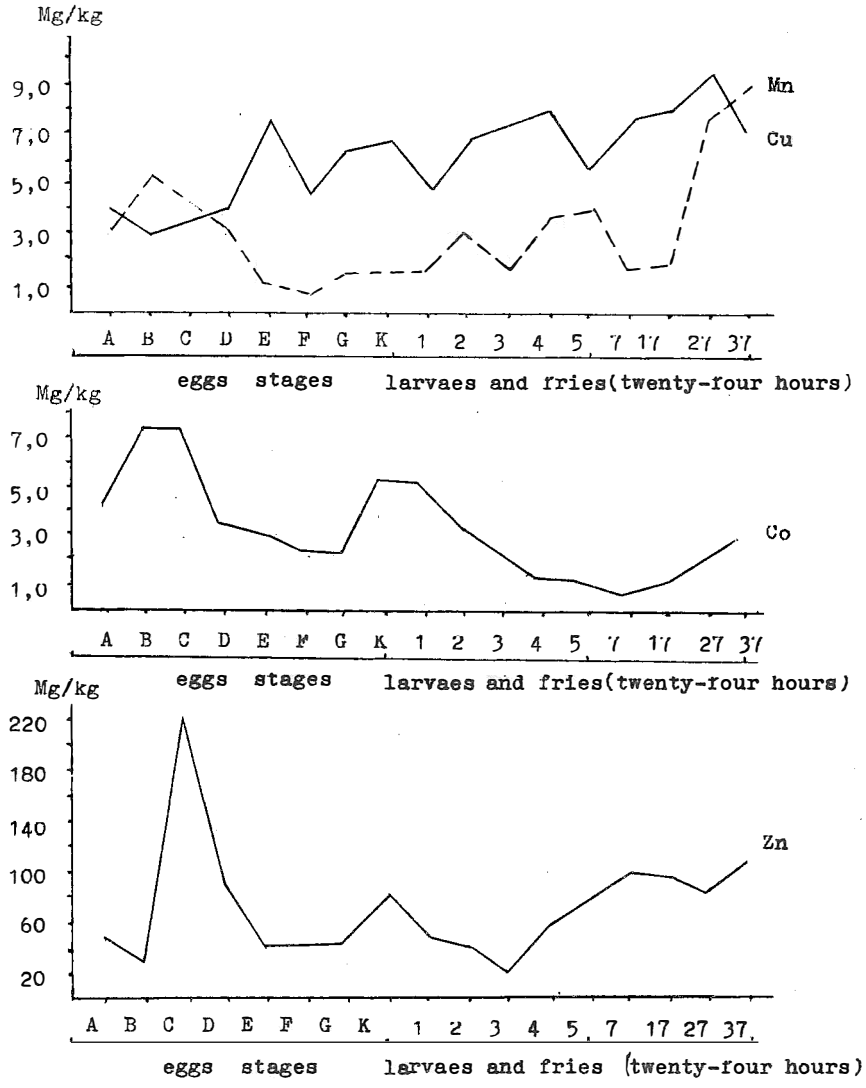

Fig. 1. The microelements dynamics in the developing embryos, larvae, and fries of *Acipenser stellatus* Pallas. A – nonfertile eggs; B – fertile eggs; C – the egg after the turn and secretion of hydrophilic colloid; D – non-adhesion stage; E – the stage of late blastula (cell-division); G – the stage of slit blastonosis (gastrulation); G – the stage of straight elongated heart tube (development up to heart pulsation); K – larvae at the moment of hatching

Further embryos development up to larvae hatching is characterized by only slight changes in the metals levels. It is necessary to underline here the very low manganese and cobalt concentration in the embryos during the last embryogenesis stages (0.6–1.4 and 0.2–0.3 mg/kg respecitively). Copper content in the eggs at the cell-division stage is times higher then in the nonfertile eggs and stays at a rather

Table 3

The comparison of the microelements contents in the ripening *Acipenser stellatus* Pallas eggs at the spawning ground and at the Bertyul commercial sturgeon farm; mg/kg dry substance

Development stages	Researched areas	Cu	Zn	Mn	Co
Nonfertile eggs	spawning ground	4.4 ± 0.35	86.6 ± 7.63	3.7 ± 0.42	0.4 ± 0.03
	farm	3.8 ± 0.50	57.6 ± 4.4	2.9 ± 0.30	0.4 ± 0.05
Cell-division	spawning ground	15.5 ± 2.10	715.0 ± 67.33	11.4 ± 1.77	3.1 ± 0.25
	farm	7.4 ± 0.60	59.2 ± 5.10	0.8 ± 0.07	0.3 ± 0.02
Gastrulation	spawning ground	5.9 ± 0.62	128.0 ± 10.12	12.9 ± 1.65	1.4 ± 0.88
	farm	4.5 ± 0.50	62.6 ± 4.80	0.6 ± 0.04	0.2 ± 0.01
Development prior to heart pulsation	spawning ground	8.0 ± 0.70	9.4 ± 0.61	21.4 ± 2.04	7.9 ± 0.84
	farm	5.8 ± 0.40	64.0 ± 5.10	1.2 ± 0.2	0.2 ± 0.01
Development prior to hatching	spawning ground	7.3 ± 0.72	94.4 ± 8.68	11.3 ± 1.28	1.1 ± 0.09
	farm	6.0 ± 0.5	96.0 ± 7.30	1.4 ± 0.2	0.5 ± 0.04

until the end of embryogenesis (fig. 1). It can be explained by the specific role of copper in an organism: it is part of the oxidating enzymes – cytochrome oxydase and ceruloplasmin. Besides copper takes part both in the erythropoiesis and the cell respiration.

An important feature of the larvae stage is the great dynamics in metals content (fig. 1). Freed from embryonic membranes and internal liquid, embryos are gradually losing part of the microelements. This is particulary clear in *Acipenser stellatus* Pallas after yolk sac is being resorbed after 3 days in nurseponds levels of zinc, copper, manganese and cobalt in larvae turned to be respectively 2.5, 1.6, 1.2, 1.6 times lower than at the beginning of hatching. One seys fish experience "critical" moment during the period prior to full yolk sack resorption (Voinar, 1960; Zaitsev et al., 1980; Ryzhkov, 1984).

Mixed dict due to an active feeding by larvae causes more microelements to enter fish body. That is why after 4–5 days of active feeding, concentration of the manganese and zinc in fish body increases visibly (fig. 1).

Concentration of zinc, copper, manganese and cobalt during the first 10–15 days is 2.8, 1.7, 6.6, 2.0 times higher than that for 3 days old *Acipenser stellatus* Pallas fries. The accumulation of the metals in fry bodies continues up to their release into river.

The studies on the microelements dynamics throughout development stages of *Acipenser stellatus* Pallas at spawning ground near Kamenny Yar village proved in changes in microelements level during process of embryogenesis to be constant in the area. Nevertheless, concentration of the most metals in fish embryos from the spawning ground appeared to be higher than those at the commercial fish farm (table 3). The hatchlings at the spawning ground had the manganese and cobalt, respectively 8.0 and 2.0 times higher than at the hatcheries. The difference is explained by the biogeochemical peculiarities of the reproduction conditions in the Volga river and at the sturgeon farm studied.

SUMMARY

1. An important peculiarity characterizing the microelements dynamics at the early ontogenesis stages of *Acipenser stellatus* Pallas is their periodical changes of physiological and biochemical indices (Vasnetsov, 1953; Ryzshkov, 1984).
2. Growth and reduction in metals utilization by developing organism of *Acipenser stellatus* Pallas depend upon the physiological role played by each element.
3. Microelements content in the developing embryos, larvae and fry directly depends upon their levels in the environment and strictly corresponds to the principles of geochemical division into districts (Vorobyov, 1983; Kovalsky, 1974).
4. The manganese and cobalt deficiency in the main ecosystem components of the commercial farm is proved by low levels of these elements in the farm producing *Acipenser stellatus* Pallas. It is necessary to use cobalt and manganese salts in biotic concentrations for *Acipenser stellatus* Pallas reproduction of such valuable fish species as *Acipenser stellatus* Pallas.

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ZAWARTOŚĆ MIKROELEMENTÓW WE WCZESNYCH STADIACH ROZWOJU *ACIPENSER STELLATUS* PALLAS W WARUNKACH SZTUCZNYCH I NATURALNEJ REPRODUKCJI

STRESZCZENIE

Badano zawartość mikroelementów w podstawowych komponentach ekosystemów wodnych oraz w poszczególnych stadiach rozwoju zarodka, larw i narybku w warunkach tarliska i podchowalni. Stwierdzono deficyt manganu i kobaltu w stawach gospodarstwa i odpowiednio niski poziom tych pierwiastków w ciele narybku i larw wyhodowanych w zakładzie w porównaniu z ich zawartością w ciele ryb na tarliskach.

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