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Comparative Studies of Several Physiologic and Biochemical Indexes of Wild Type and Hatchery-Bred Sturgeons in the Early Ontogenesis

Qasimov RYU[1], Hashimova UF[1], Mamedov CHA[2], Gaisina AA[1], Vagabova GR[1] and Arif Mekhtiev[1*]

[1]*A.I. Karaev Institute of Physiology, National Academy of Sciences, 78 Sharif-zade St, AZ1100 Baku, Azerbaijan*

[2]*Baku State University, Baku AZ1141, 23 Z. Khalilov St, Baku, Azerbaijan*

***Corresponding author:** Arif Mekhtiev, A.I. Karaev Institute of Physiology, National Academy of Sciences, 78 Sharif-zade St, AZ1100 Baku, Azerbaijan, Tel: +99450 3360684; Fax: +99412 4326768; E-mail: arifmekht@yahoo.com

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Abstract

It was shown that, depending on the ways of breeding and living conditions, realization of food-seeking and defensive behavioural reactions as well as single biochemical indexes (pattern of neurotransmitters and levels of free amino acids in the brain) in the wild type and hatchery-bred sturgeon juveniles differ significantly. Basing on the studied indexes, the juveniles, bred in the ponds, are close to the wild type juveniles, whereas the juveniles, bred by pool technique, are quite different from them.

Keywords: Sturgeon; Wild type milieu; Food-Seeking behaviour; Defensive behaviour; Breeding in pond; Breeding in pool; Biogenic amines; Dicarboxylic amino acids; GABA

Introduction

Beginning since 50-ies of the past century, as a result of building construction of hydrological constructions on spawning routes of the sturgeons in the rivers, their natural reproduction declined drastically and, presently, is realized in small areas below the dams. In order to compensate cessation of natural spawning places, hatcheries were constructed in the lower portions of the rivers and presently increase of population of sturgeon fishes amount in the Caspian Sea is mostly (up to 90%) realized through reproduction solely on the hatcheries. The plot of this process concludes in that that breeders (males and females) caught in the natural ponds (rivers falling into the Caspian Sea) are subjected to stimulation with hormones, the obtained roe and sperm are fertilized, incubated and hatched larvae are bred through different techniques (pool, combined technique pool plus pond, pond) up to so-called vital stage of development (body mass of 2 g to 3 g or up to 2 months to 3 months old age) and thereafter released into the natural habitats (river or mouth of the river). Further, these juveniles move to sea pastures where they feed, grow and reach sexual maturity (8-20 year-old age depending on species), and after reaching this age they migrate into the rivers for reproduction.

Originally while elaborating biotechnical regulations on artificial hatchery's reproduction in determining so-called industrial return (i.e. amount of sexual matured specimens) it was assumed that in conditions of releasing of juveniles of 1 g mass industrial return will make 1%, 2 g-2%, 3 g-3%, etc. Issuing from such calculations, most researchers offered to release bigger sized juveniles (5 g-10 g) for the purpose of increasing values of industrial return.

In other words, reproduction of sturgeons in the hatcheries was based on the principle of getting as many progeny as possible and releasing big-sized and mature specimens in natural ponds to escape their extermination by predators and promote adaptation of the specimens to novel natural conditions. However, this approach did not have scientific basis. It should be emphasized that at the time of launching of sturgeon-breeding, most part of studies were directed to analysis of morpho-functional indexes of hatchery-bred juveniles [1-5]. Along with it, vitality and adaptation potential of the hatchery-bred juveniles to natural conditions were underestimated and poorly studied [6-8].

It was revealed later on that industrial return of sturgeons from amount of released juveniles appeared to be hundred and thousand times lower than the expected value [9-14]. The problem concluded in that that in defining the terms of breeding of sturgeon progeny neither their development in certain region, nor their biological peculiarities, first of all, such ones as degree of activity of determinative reactions and physiologic and biochemical status of the organism in a whole, which promote their survival in natural conditions, were not taken into consideration.

According to the data of Derzhavin et al [13,16], sturgeon juveniles in the Kura river migrate from natural spawning places at early stages (at the stage of larva or in body mass within 50 mg-800 mg). Bigger specimens in catches are found very seldom. So, study of adaptation potential of the wild type and same-aged sturgeon juveniles, bred in the hatchery conditions, appear to be important. It is known that important role in adaptation of the organism is referred to the level of development of defensive and food-seeking reactions, whose formation is mostly determined by the conditions of milieu. In this aspect, it was necessary to conduct comparative analysis of these reactions' activities and changes of physiological and biochemical indexes of the brain in the hatchery-bred and wild type juveniles of different ages that would promote revealing impact of milieu on degree of maturity of these functions in early ontogenesis.

It should be emphasized that depending on the region, breeding of progeny of sturgeon fishes obtained in the hatcheries prior to their release into natural milieu (river and sea pastures) is realized by different ways: in the pools; combined 15 days-20 days in the pools and 30 days-40 days in the ponds; and solely in the ponds.

In the pool method of breeding after hatching from the roe larvae are passed into the round pools (of VNRO type) and kept there till gaining body mass of 2 g-3g (50-60 days old and more). In pools fish is fed regularly, there are no predators, regulated oxygen regime is maintained. Under good quality of the utilized roe and sperm, indexes of survival reach 90%.

Breeding of larvae after hatching by combined method (pool-pond) differs a little from solely pool technique. In such model of reproduction specimens, that reached certain degree of maturity and transferred to active nutrition, are transduced into the ponds. In this case larvae should find fodder by themselves and, besides, their enemies-frogs, invertebrate predators, etc., dwell in these ponds. Survival of the bred larvae after their release into the river constitutes approximately 50-60%.

In reproduction by solely pond method, larvae, taken from the incubation premise, are transposed into fishpond located in the ponds and after transferring into active nutrition they are counted and released into the pond. Process of counting is very traumatic, for this reason it is often rejected and the amount of fish, released into the river, is taken into account. In such method of reproduction rate of survival of transposed larvae does not exceed 40%.

Presently, pool method of reproduction is taken as the most prioritized method by the most hatcheries.

Physiological maturities of juveniles has been evaluated traditionally by measuring blood indexes (haemoglobin, erythrocytes, etc.), while their adaptation potential to natural conditions, characterizing with very severe natural selection, still is not considered.

We are adhere to an opinion that this is incorrect approach, and in evaluating perspectives of survival of juveniles in the wild nature, in the first turn, the degree of maturity of food-seeking and defensive tasks as well as neurotransmitter profile (dopamine, noradrenaline and serotonin) and the levels of free amino acids and GABA, all playing an important role in realization and coordination of these tasks, in the brain of sturgeon fishes should be taken into consideration. In this case, it is important to conduct comparative analysis of these indexes with those of wild juveniles with taking into account age-related aspect. All these could reveal critical periods in formation of the studied indexes and characterize impact of environment on these functions.

Issuing from the above said, we put forward a goal of studying degree of maturity of food-seeking and defensive tasks as well as dynamics of free dicarboxylic amino acids, GABA and biogenic amines in the brain of sturgeon juveniles, bred by different methods, and of wild juveniles, caught in the river, depending on the dwelling conditions and age.

Comparative analysis of these indexes, playing an important role in adaptive reactions and survival, gives grounds to determine optimal conditions and time constraints of breeding of sturgeon fishes in hatchery conditions.

Materials and Methods

Objects of studies

The objects of studies were larvae and juveniles of the Kura river population of Russian sturgeon Acipenser güldenstädti natio Kurinsis Belyaeff of different ages and sizes, bred in the hatchery conditions and caught in the Kura River.

Hatchery-bred juveniles were taken from pools and ponds of Kura Experimental Sturgeon Hatchery. Natural juveniles were caught by small-meshed trawl from motor boat at the end of May and beginning of June of (2001-2003) year. Species were determined, quantity of caught specimens was counted and their length and mass were measured.

Juveniles breeding method		Age in days	Body mass (mg)	Body length (cm)
Hatchery-bred	Pool-bred	30	350-362	2.7-3.1
		90	3900-4300	12.0-14.2
		180	35000-37000	21.3-23.5
	Pool plus pond-bred	30	320-335	2.9-3.3
		90	3800-4000	12.3-13.6
		180	28000-295000	20.8-21.6
	Pond-bred	30	312-325	2.9-3.2
		90	4200-4400	11.6-14.1
		180	31000-32000	20.9-24.0
River		30	275-310	3.5-3.8
		90	3000-3150	10.9-14.5

Table 1: Mass and length of the body of surgeon juveniles used in the studies.

Trawling catches were conducted on the level of 40 km-50 km beyond the mouth of the Kura River, near villages Uzunbabaly and Abbasly. These points are located 10 km-15 km higher than Kura Experimental Sturgeon Hatchery and were chosen basing on such considerations that hatchery-bred juveniles are not ever caught here, because they do not move against the river current.

This period they have instinct of slipping down the current into the mouth of the river. So, all larvae and juveniles of sturgeon fishes, caught in this portion of the river, are the result of natural spawning maintained on natural spawning places below the dams.

Totally, during 3 days 10 trawling catches a day were accomplished. Each trawling lasted for 20 min-35 min. For this period 44 specimens of sturgeon juveniles of natural generation were caught. The caught larvae and juveniles were transferred into the special tanks with water aeration and transported to the experimental hatchery, where they were placed in the pools with running water. Further, basing on sizes and body masses, fish was divided into age groups (Table 1).

Sturgeon natural juveniles for 4 days-5 days were kept in the pools for adaptation and as well as hatchery-bred juveniles they were fed with daphnia (*D. magna*) and white flour worms-oligochaetes.

Behavioural studies

To evaluate food-seeking behaviour, time of food seeking by juveniles was fixed in the specific fishery container, designed for the studies of food-seeking behaviour by Kasimov [17]. The fishery container was separated into two sections by partition. The juveniles were present permanently in section 1. During the experiment the door was opened and allowed juveniles to move to section 2 and began to fix time of finding food (Figure 1). The time was measured since passing through the door into section 2 till finding food [3]. Each juvenile was taken for the experiments not less than 5 times.

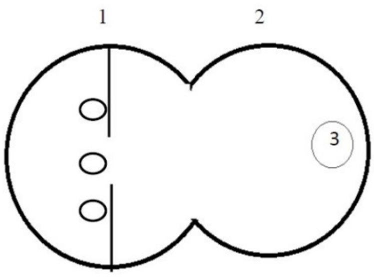

Figure 1: Scheme of experimental fishery container to elaborating conditioned food-seeking tasks on the larvae and juveniles of sturgeon fishes. 1 and 2 sections of the fishery container; 3 is point of finding food.

Manifestation of defensive reaction to predator was examined through intrusion of several specimens of different ages to a predator (river zander) with following observation of their behaviour for 30 min (Figure 2). In this case, time interval of avoidance and freezing of juveniles in the presence of predator was registered. Two specimens of zander (of 30 cm-40 cm size) were placed into the container and 10 specimens of the wild type or hatchery-bred juveniles of different ages and ways of breeding were intruded to them and 24 h later number of fish left alive or devoured by predators was counted. The experiments were run with sturgeon juveniles of 30 days-90 days and 180 days old ages, each series was repeated 4 times-5 times. This method was elaborated by Kasimov et al. [14,17].

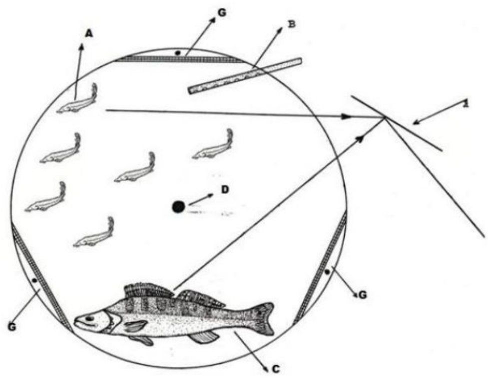

Figure 2: Device to studying defensive tasks.

Biochemical studies

Determination of biogenic amines (dopamine, noradrenaline and serotonin) was realized by fluorometric technique with application of spectrophotometer MPF-4 (Hitachi, Japan). The levels of free amino acids in the fish tissues were evaluated in the automatic amino acid analyser of two models of 6020 A and AAA-881 (manufactured in Czechoslovakia). The principle of determination concludes in chromatographic elution of single amino acids from the columns filled with the ion-exchanging resins with application of lithium and sodium citrate buffers with different pH values (Li-buffers with pH 2.8 to 4.15 and Na-buffer with pH 4.26). The data were analysed with statistical method for little amount of samples by Fisher-Student.

Results

Behavioural studies

The important role in organism's adaptation to environmental conditions is due to degree of its maturity and realization of food-seeking and defensive tasks as well as levels of biogenic amines and amino acids in the brain.

Methods of breeding		Mean number in percents (M ± m) of juveniles (5-8 specimens in each experiment, with 4-5 repeats), devoured by the zander (body mass 1.2-1.4 kg) in 24 h. Total amount of specimens in each age group made 20-34 ones.	
		30-day-old	90-day-old
Hatchery-bred	Pool-bred	30.2 ± 1.33	18.6 ± 1.02
	Combined method – 20 days in the pool plus 70 days in the pond	16.3 ± 1.01	5.2 ± 0.82*
	Pond-bred	14.2 ± 1.12*	5.0 ± 0.86*

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Wild type juveniles (caught in the mouth of the river)	10 ± 0.90*	0

Table 2: Number of the sturgeon juveniles (90-day-old), bred by different methods and devoured by the predators.

Our earlier conducted studies [14] have shown that formation of food-seeking and defensive tasks in the juveniles of sturgeon fishes occurs on the early stages of ontogenetic development at the age of 30 days-55 days depending on the fish species. In this case, degree of maturity of these reactions is defined by the conditions of their breeding.

As we have mentioned above, presently in different regions different methods of breeding of sturgeon juveniles have been applied. For this reason, study of formation and manifestation of defensive and food-seeking tasks and dynamics of biogenic amines and amino acids in the brain of the sturgeon fishes, depending on conditions of their living and age, appeared to be important. Analysis of food-seeking tasks on the sturgeon juveniles from different environmental conditions showed that (Figure 3) in the 50 days old sturgeon juveniles these tasks are formed slower relatively to the other age groups (90 days), i.e. they need more time to getting food than in older age.

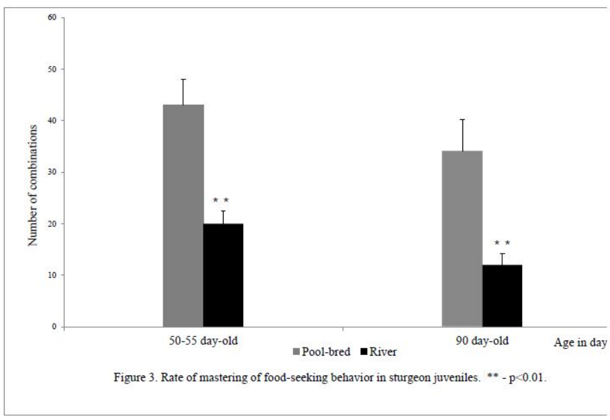

Figure 3: Development of food skills in the hatchery-bred juveniles (hatchery).

Between 90 days and 180 days old age groups differences in the rate of formation of food-seeking behaviours are less profound that indicates to maturity of morphological structure of the brain supporting stabilization of these functions.

Our studies showed that methods of breeding significantly effects on manifestation of food-seeking behaviours in the studied age groups of sturgeon juveniles (Figure 3). At the age of 50 days these tasks in the sturgeon juveniles, caught in the river and bred solely in the pond conditions, are formed nearly two times faster than in the juveniles, cultured by breeding in the pool and by the combined methods (pool-20 days plus 10 days in the ponds).

In the sturgeon juveniles at the age of 90 days food-seeking behaviours in the wild type juveniles are revealed noticeably quicker than in the hatchery-bred juveniles independently on the way of reproduction. However, it should be noticed that between sturgeon juveniles, bred solely in the pools, and juveniles, taken from the ponds and bred by the combined method (pool plus pond), differences in the rate of formation of food-seeking tasks are significant. At the same time, in the both age groups (90 days) differences between sturgeon juveniles bred from hatching in the ponds, and juveniles bred by the combined method (pool plus pond) are not valid, i.e. the rates of formation of these tasks are almost similar (Figure 3).

So, the studies showed that conditions of dwelling have significant effect on acquisition and formation of food-seeking tasks in the sturgeon juveniles.

Surrounding milieu has as well an effect on formation and degree of manifestations of defensive reactions in the sturgeon juveniles. For the purpose of evaluation of defensive reactions we have chosen simple method of studying behaviour in restricted space in presence of the predator and with counting number of the juveniles devoured by the predator (Figure 2).

The experiments showed (Table 2) that at the age of 50 days sturgeon juveniles independently on the dwelling conditions, in presence of the predator behave somehow uncertainly in comparison to the older age group. It was noticed that if at the age of 50 days juveniles respond to advent of the predator with inadequate behavioural reactions, then at the age of 90 days they clearly react to the predator demonstrating freezing or escaping behaviour. However, in relation to conditions of breeding in the early ontogenesis, degrees of manifestations of these reactions are distinct. For instance, if the wild type and pond-bred juveniles react actively and correctly to the predator, pool-bred juveniles, inversely, drift towards predator, sometimes straight to his mouth and, finally, becomes an easy victim.

Our observations have shown (Table 2) that, while intruding the pool-bred juveniles at the age of 50 days to the predator (Figure 2), in 24 h 30% of these juveniles are caught and devoured by the predators. In the same conditions predators catch uneasily the juveniles, taken from the river (wild type) and bred solely in the ponds. Number of the wild type juveniles devoured by the predator at the age of 30 days made nearly 10%, while of the pond-bred juveniles 14-15%.

At the age of 90 days in the all experimental groups number of devoured juveniles is less than at the age of 50 days. However, in this age the pool-bred juveniles are as well oftener devoured by the predator than the pond-bred juveniles. Along with it, predators cannot catch any specimen taken from the river (Table 2).

Age-related differences on manifestation of food-seeking and defensive reactions in the sturgeon juveniles are due to the level of maturity of nervous system.

At the age of 50 days, as a result of incompleteness of morpho-functional maturation of the brain, behavioural reactions are manifested in more chaotic way, than at the age of 90 days.

So, our studies showed that the sturgeon juveniles, bred in the hatchery conditions by the pool method, at the moment of releasing from the hatchery into the natural conditions on degree of maturity of behavioural reactions differ from the similar-sized wild type juveniles, caught in the river, and from the juveniles, bred solely under the pool conditions. This means that informational complexity of the hatchery conditions, especially the pool conditions, differ from such index of the natural milieu of sturgeon fishes.

As behavioural reactions are governed by the nervous system, in particular by the brain, defining the role for brain biogenic amines and amino acids in these processes appeared to be very important. Besides, it should be noticed that biogenic amines (dopamine, noradrenaline and serotonin) constitute biochemical basis of adaptive and behavioural reactions of the organisms.

Biochemical studies

Our studies of dynamics of biogenic amines in the brain of the sturgeon juveniles in relation to the age and breeding conditions showed that in the brain dopamine and serotonin downregulate significantly in the age-related manner, whereas noradrenaline, inversely, upregulates (Table 3).

Up regulation of noradrenaline mostly occurs between 50 days and 90 days old ages, while between 90 days and 180 days old ages its level is stabilized and its differences are insignificant.

Breeding conditions	Age in days	Level of biogenic amines in the brain (mg per 1 g of fresh tissue)		
		Dopamine	Noradrenaline	Serotonin
Pool-bred	30	289 ± 1.22	28 ± 1.19	121 ± 1.33
	90	242 ± 1.55	44 ± 1.08	106 ± 1.63
	180	208 ± 1.43	37 ± 2.03	81 ± 1.12
Pond-bred	30	304 ± 1.92	38 ± 1.08	125 ± 1.47
	90	291 ± 1.84	69 ± 1.47	102 ± 0.76
	180	282 ± 1.65	71 ± 1.26	98 ± 1.13
River (wild type)	30	318 ± 2.04	41 ± 1.01	109 ± 0.82
	90*	287 ± 1.05	74 ± 0.68	82 ± 0.44
	180*	293 ± 0.98	76 ± 132	69 ± 0.92
*caught in the pre-mouth portion of the Kura river.				

Table 3: Dynamics of biogenic amines in the brain of sturgeon of different ages, bred in different conditions (n=6-7).

Significant differences in the values of biogenic amines in the brain are observed in the same-aged sturgeon juveniles bred by different methods (pool, pond, and river). In this case the levels of dopamine in all studied age groups in the brain of sturgeon juveniles, caught in the river, are higher than in the juveniles, bred in the pools. The similar dynamics is noticed in the levels of noradrenaline in the brain (Table 3). The levels of serotonin in the brain of the sturgeon juveniles, bred in the pools, are higher than in the wild type juveniles caught in the Kura River. Such character of differences is observed in all studied age groups. In the pond-bred juveniles values of serotonin level in the brain are close to the analogous indexes of the pool-bred juveniles.

These differences increase in one-year-old age. The studies showed that in the one-year-old age levels of biogenic amines in the brain of sturgeon differ significantly, depending on the dwelling conditions. The levels of dopamine, noradrenaline and serotonin in the brain of sturgeon juveniles, caught in the sea, are higher than in the juveniles, bred in the ponds and pools. In this case serotonin, whose level in the brain of the pond-bred sturgeon juveniles higher than in the wild type juveniles, makes exclusion.

Breeding conditions	Dopamine	Noradrenaline	Serotonin
Pool-bred	157 ± 2.31	30 ± 1.56	78 ± 1.52
Pond-bred	232 ± 1.92	57 ± 1.83	97 ± 1.21
	P<0.001	<0.01	<0.01
Sea	254 ± 1.87	68 ± 1.19	92 ± 1.08
	P<0.001	<0.001	<0.001
	P1<0.001	<0.005	>0.05
Notice: P-statistical significance relatively to the fish, bred in the pools; P1-significance relatively to the fish, bred in the ponds.			

Table 4: Effect of conditions of milieu on the levels of biogenic amines in the brain of the Kura river sturgeons in one-year-old age (ng per 1 g of fresh tissue; n=7).

Important role in numerous functions of nervous system belongs to amino acids. Such processes as de novo synthesis of proteins on the stage of differentiation and tissue growth, their degradation and re-synthesis in the process of renewal of tissue structures, regulation of brain functions, formation and metabolic transformations of many bioactive agents, including neuro-hormones, are tightly related to amino acids and their metabolites.

Taking into account the above said, we studied changes of the levels of dicarboxylic amino acids in the brain in the sturgeon juveniles from different living conditions. Age-related dynamics of dicarboxylic amino acids was analysed in two age groups of 30 days and 90 days old juveniles (Table 4).

Analysis of the levels of glutamine, asparagine amino acids in the brains of the sturgeon juveniles of different ages (30 days and 90 days old), taken from different breeding conditions, showed that the glutamine acid downregulates in age-related manner and in the both age groups the levels of glutamine acid are higher than in the wild type sturgeon (Table 5).

The levels of asparagine amino acid upregulate in the brain in the pool-bred juveniles in age-related manner, whereas in the juveniles, bred in the ponds or caught in the river, these indexes downregulate in age-related manner (Table 5).

Breeding conditions	Age in days	Amino acids		
		Glutamine amino acid	Asparagine amino acid	GABA
Pool-bred	30	2.45 ± 0.28	0.56 ± 0.06	2.08 ± 0.16
	90	1.05 ± 0.12	0.73 ± 0.11	2.24 ± 0.18
Pond-bred	30	2.50 ± 0.17	0.50 ± 0.10	1.62 ± 0.14
	90	1.82 ± 0.19	0.32 ± 0.09	1.40 ± 0.31
River (natural conditions)	30	2.70 ± 0.32	0.80 ± 0.05	1.55 ± 0.23
	90	2.05 ± 0.79	030 ± 0.04	1.05 ± 0.84

Table 5: Levels of dicarboxylic amino acids and GABA in the brain of the sturgeon juveniles, bred in different conditions (μM per 1 g of fresh tissue; n=12).

Analogous pattern is observed in the dynamics of GABA in the brain of different-aged sturgeon juveniles. In this case, independently on the age, the levels of GABA in the brain in the sturgeon juveniles, bred by the pool method, are higher than in the pond-bred or wild type juveniles.

So, our experimental data show that values of the levels of biogenic amines and dicarboxylic amino acids change prominently depending on the age and dwelling conditions.

Discussion

Our earlier studies showed that formation of behavioural reactions and stabilization of morpho-physiological indexes in the sturgeon juveniles start at the age of 18 days-22 days and stabilize to the age of 35 days-55 days. During this period juveniles succeed in formation of stable food-seeking and defensive behavioural reactions [17,18].

Unfortunately, in hatchery reproduction of the sturgeon fishes, biological peculiarities of the species and directional influences of the milieu on formation of the most important functions of the organism including behavioural reactions have not earlier been taken into consideration. It should be noticed that level of structural and functional development of central nervous system is mostly determined by intensities of sensor stimulation in animals in the very time of its maturation [19-22].

Comparative analysis of the food-seeking and defensive reactions in the juveniles, bred by different methods in the hatcheries, and wild type sturgeon juveniles on the early stages of development showed that on this period of ontogenesis formation and manifestation of these reactions differ significantly from each other depending on conditions of dwelling.

The point concludes in that, that juveniles in the hatchery conditions in the pools effortless and without restriction find food and in the period, when morpho-functional formation and maturation of the most important functions of the organism is being realized, no predators and juveniles' enemies are met in the milieu of their living.

In the very period of development juveniles, taken from the ponds as well as from the rivers, find food uneasily and they permanently meet with predators. In other words, hatchery pools and conditions of natural milieu on multiplicity and complexity of sensor stimuli and on the severity of natural selection differ drastically.

For this reason, apparently, in the pool-bred fish juveniles these reactions are expressed in lesser degree than in the wild type (natural) and pond-bred juveniles.

It was shown that breeding of fish sturgeons in the sensor-impoverished milieu brings to retardation of brain development, downregulation of synthesis of DNA/ RNA in the neurons, worsening of adaptive properties of CNS, revealing in changing rate of formation of a number of conditioned tasks and capability to their maintenance [17,22-25].

Our studies [14,17] have shown that the juveniles, bred in the hatchery conditions, should be released into natural ponds at the age of 28-35 days, when morpho-functional maturation and formation of behavioural reactions of these species of fish begins. Such approach will permit formation of these functions purposely in accord to the dwelling conditions that will support better survival of the juveniles and adaptation to the natural conditions.

Breeding of sturgeon juveniles in the pools, in the hatchery conditions beyond 90 days brings to formation of reaction types which may promote their survival under favourable hatchery conditions and/or in aquaculture. Due to better supply with fodder, in absence of predators, specimens grow well; they are fattier and have high levels of vitality. However, these juveniles, being released into the natural conditions with severe struggle for existence and enriched informational complexity, perhaps, cannot adapt to novel milieu.

It should be emphasized that hatchery-bred juveniles possess with insufficient set of morpho-functional reactions to dwelling in the natural conditions. The hatchery-bred juveniles, being even fattier relatively to the wild type juveniles, in absence of fodder and subjected to starvation perish earlier than the wild type animals [13,14].

Apparently, under unrestricted amount of food in the pools metabolic processes in the hatchery-bred juveniles have higher rate than in the wild type juveniles, which find food uneasily and their metabolism forms more reasonably, in accord to their living conditions. Furthermore, later on a number of researchers confirmed differences between wild type and hatchery-bred juveniles basing on several indexes.

Differences in the levels of highly saturated fatty acids in the muscles, liver, ovaries and testis in the wild type and domestic silver eel were found as well by Japanese scientists [25].

Differences on single morpho-functional indexes between the wild type and hatchery-bred populations of other fish species are revealed in a number of studies [26-29].

All three studied neurotransmitters constitute fundamental part of evolutionary-conservative mechanism of regulation of behavioural and social activity as well as stress-adaptive response in all representatives of vertebras including fish [30,31]. Pattern of expression of serotonergic system is formed in the early stages of embryogenesis and directly related to the conditions of the milieu, in which organism is developed [32-34]. Necessity to seeking food, contacts with more aggressive representatives of other fish species, presence of predators shape alert type of neurochemistry in the brains of the juveniles, bred in the ponds, and/or caught in the river.

The most demonstrative is a high level of noradrenaline in the brain structures of the juveniles, bred in the ponds and caught in the river. This level is upregulated in the course of their maturation, indicating to necessity of being in permanent state of activity and alertness to confront possible aggression [35]. Moreover, in the model experiments with artificial upregulation of noradrenergic system in the brain structures, linear correlation between level of noradrenalin in the brain and level of social avoidance was revealed [35,36]. In the juveniles, bred in the pools, in conditions of food abundance and lack of predators, low levels of noradrenalin in the brain, really suppressing completely the state of alertness and reaction of escape from predators, are noticed.

While considering the levels of serotonin in the brain of the sturgeon juveniles, its downregulation in the fish, caught in the river, relatively to the animals bred in the pool or ponds, is noticed. Such pattern is observed in all age groups; in this relation, age-related dynamics of downregulation of serotonin in the brain of the wild juveniles has more abrupt character, than in the fish, bred in the hatcheries. The results of different authors, carried out on different conditioning models, show that upregulation of serotonergic system in the brain structures disturbs formation of memory traces on acquired behavioural tasks [38-41]. So, delayed formation of food-seeking conditioning in the animals, bred in the hatcheries, in comparison to the indexes of the wild juveniles, is related to high level of serotonin in their brain structures.

Analysis of transmitter amino acids revealed upregulation of GABA, realizing functions of inhibitory neurotransmitter [42,43] in the brain of 30-day-old fish, bred in the pool, relatively to the specimens, bred in the ponds and caught in the river. Towards 90th day in the fish from the wild milieu and in the fish, bred in the ponds, the level of GABA declines, whereas in the fish, bred in the pool, it has a tendency towards higher upregulation. On the other hand, the level of glutamine acid, an excitatory neurotransmitter [42,44,45] being slightly higher in the brain of the 30-day-old fish, living in the river, than in the same-aged fish, bred in the hatcheries, had lesser abrupt dynamics of downregulation and in the 90-day-old age exceeded two times the level of glutamine acid in the brain of the fish, bred in the pool. It issues from the presented comparative data that inhibitory processes in the brain of the fish of the studied ages, bred in the pool, are stronger, while excitatory processes, in opposite, are weaker than in the animals in the wild milieu or bred in the ponds. Surely, that indicates to prevailing of inhibitory processes over excitatory processes in the central nervous system of the fish, bred in the pool, significantly disturbs realization of avoidance of predators and formation of food-seeking conditioning.

Up to one-year-old age in the species, caught from sea pastures, although of general tendency towards downregulation, the levels of all three amines are remained high relatively to the values of the hatchery-bred juveniles. Need in socialization and defence against aggression in this age in the sturgeons are considered as secondary issues [35] and, first of all, in this case changes of the level of salinity and hydrodynamic regime of living milieu have mostly their effects [46-49].

So, our studies have shown that while breeding of sturgeon fishes of certain region under the hatchery conditions, their biological peculiarities of development in natural conditions should be taken into consideration and it is important to reveal critical periods of formation of the most important physiological functions of the organisms and input of environmental factors in these processes.

Conflict of Interest Statement

All co-authors of the present article state that there is no conflict of interest between them.

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