American Journal of Botany and Bioengineering
https://biojournals.us/index.php/AJBP
ISSN: 2997-9331

Dynamics of Morphological Features of Grass Carp in the Environments of a Fish Hattery in the Bukhara Region

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Received: 2024 29, Jul
Accepted: 2024 28, Aug
Published: 2024 30, Sep

Annotation: The meristic and plastic features of grass carp (Ctenopharyngodon idella), an important commercial fish introduced to Uzbekistan from China and cultured in new conditions since the 1960s, were determined. The meristic indices were: D III 7, A III 7-8 (8 on average), 39-45 (42) scales in the lateral line, 19-22 (21) rakers on the first gill arch. The indices of plastic features are given according to the classical scheme of measuring carp family fish, as well as by the method of geometric morphometry in grass carp fry and yearlings as important age groups in pond fish farming in Uzbekistan.

Keywords: Grass carp, Ctenopharyngodon idella, morphology, fry, fish seeds, hatchery, Uzbekistan.

Introduction

Grass carp, Ctenopharyngodon idella (Valenciennes, 1844) - a representative of the

Xenocyprididae family (East Asian minnows, East Asian minnows) (previously included in the carp family, Cyprinidae) - was introduced into the pond fish farm of Uzbekistan in the middle reaches of the Syr Darya River with three batches of larvae from the northern regions of China and one batch of larvae from the Amur River (Russia) in the early 1960s for the needs of developing pond fish farming. The offspring found favorable conditions in local ponds, reached sexual maturity, but in a natural state, spawning in ponds cannot occur due to the peculiarities of the biology of reproduction of grass carp. Since the mid-1960s, it has been artificially reproduced using gonadotropic stimulation of maturation, incubation of fertilized eggs and growing of juveniles in artificial conditions for further cultivation in pond polyculture of carp, where it is still an obligatory object of fish farming. Since the 1960s, offspring from fish farms in the Tashkent region have been annually and widely distributed to pond fish farms in all regions of Uzbekistan, and many regions have created their own fish hatcheries for the reproduction of white amur [3,4,9]. Currently, white amur is one of the most important objects of fish farming in the republic, but many issues of its biology have still been poorly studied, especially in the regions of its secondary settlement (from the middle reaches of the Syr Darya within the Aral Sea basin), including the Zarafshan River basin (including pond fish hatcheries in the Bukhara region). In particular, the morphological indicators of white amur have not been studied. In fish hatcheries, the main technologically important age groups are fry and yearlings/yearlings. The aim of this study was to determine the morphological characteristics of grass carp in the conditions of a fish hatchery in the Bukhara region of Uzbekistan.

Materials and methods

The material was collected at the full-system fish farm of Bukhorobalik LLC in the lower reaches of the Zarafshan River in 2022-2023 (Fig. 1).

Samples of white amur fry were collected during stocking of nursery ponds in June 2022. From the fishermen's catches, 25 white amur fry were taken with seines without selection and completely fixed in a 4% formalin solution. Samples of white amur yearlings were collected in March 2023 during the total catch of wintering ponds and stocking of fattening ponds. Also, 25 white amur specimens were taken from the seine catch without selection and fixed in a 4% formalin solution.

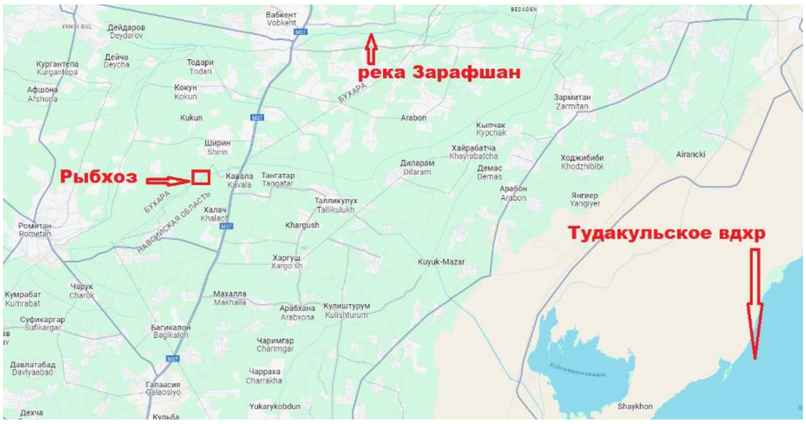

Fig. 1. Fish farm OOO Bukhorobalik (left) and the lower reaches of the Zarafshan River on Google maps, 2023

In laboratory conditions, the total (TL, cm) and standard (SL, cm) body lengths of fish were measured with an accuracy of 0.1 mm. Meristic features were calculated. After washing with water, the fish were placed on their right side, straightened and photographed with a Cannon digital camera, and the photos were sent to a computer. Plastic features were measured using the Ruler tool in Photoshop. Plastic features were measured using the classic measurement scheme adopted for the carp family [6]. In addition, 10 landmarks were identified along the perimeter of the body of the fish lying on its side, and the distances in a straight line between the landmarks were measured, i.e. the so-called “truss” protocol was compiled [12,13]. The measurement lines are indicated in the following format: for example, "2 – 4" means a measurement between landmarks 2 and 4 in a straight line (Fig. 2). To level out the influence of allometric growth of fish, indices (%) of plastic traits were calculated in relation to the standard body length.

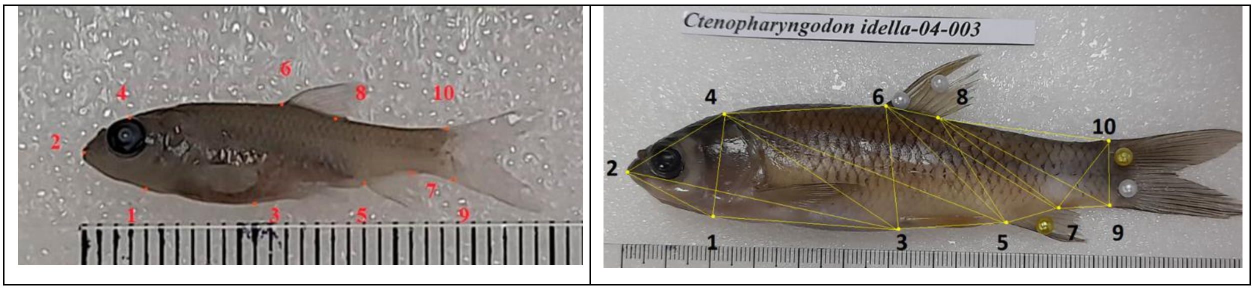

Fig. 2. Photo of white amur: on the left is a fry, on the right is a yearling (landmarks and directions of measurements according to the truss protocol are shown).

Results

The white amur fry in the samples had a total length of 2.5–3.7 cm, with a standard length of 1.9–2.9 cm. The yearlings of white amur had a total body length of 12.6–15.2 cm, with a standard body length of 10.0–12.3 cm.

White amur has an elongated body, and the cross-section of the body of yearlings is already cylindrical, almost not compressed from the sides. The scales of white amur are large. The mouth is terminal and small. All these morphological features of adult white amur are already clearly visible in yearlings.

The following meristic features were found in white amur in a fish hatchery in the Bukhara region: D III 7, A III 7-8 (on average 8), 39–45 (42) scales in the lateral line, 19–22 (21) rakers on the first gill arch. No reliable differences in meristic features were found between age groups.

Plastic features of fry and yearlings according to the classical scheme of measurements for carp fish are given in Table 1, indices of geometric morphology indicators (truss-protocol) are given in Table 2.

Table 1. Plastic indicators (classical measurement scheme) of white amur of the studied age groups of the fish hatchery of the Bukhara region, 2022-2023 yy

Indicator	*Fry*		*Yearlings*	
	Min – Max $X_{aver.} + S_x$	*Cv, %*	*Min – Max* $X_{aver.} + S_x$	*Cv, %*
Total body length	124,4 – 133,5 128,81 + 0,45	1,8	123,1 – 130,1 127,15 + 0,38	1,5
Torse length	63,9 – 71,6 67,18 + 0,32	2,4	64,4 - 89,2 72,7 + 0,89	6,1
Snout length	6,9 – 10,1 8,20 + 0,17	10,3	3,6 - 7,3 5,65 + 0,20	17,7
Eye diameter	8,4 – 12,0 10,13 + 0,19	9,1	5,3 – 11,3 6,83 + 0,24	17,7
Postorbital region of head	12,4 – 17,9 15,39 + 0,27	8,7	10,7 – 18,6 14,04 + 0,32	11,3
Head length	29,5 – 35,0 32,64 + 0,25	3,9	21,0 – 29,2 25,83 + 0,44	8,5
Head height at occiput	20,5 – 23,4 21,96 +0,15	3,4	15,2 – 20,6 17,44 +0,27	7,7
Greatest body height	21,2 – 26,7 24,61+ 0,25	5,0	20,2 – 25,2 22,70 + 0,25	5,4

Smallest body height	9,9 – 13,7 11,25 + 0,19	8,3	9,6 – 13,2 11,90 + 0,16	6,6
Antedorsal distance	53,1 – 60,1 57,95 + 0,31	2,7	53,2 – 56,6 54,80 + 0,18	1,7
Postdorsal distance	21,8 – 31,8 28,04 + 0,55	9,8	29,8 – 37,0 33,02 + 0,46	7,0
Caudal peduncle length	8,9 – 16,3 11,91 + 0,43	18,0	7,1 – 14,3 10,88 + 0,41	18,9
Base length D	16,3 – 26,7 21,57 + 0,54	12,4	12,2 – 18,8 14,72 + 0,31	10,4
Greatest base length D	21,4 – 27,1 23,91 + 0,32	6,7	17,9 – 24,2 21,35 + 0,29	6,9
Base length A	13,9 – 21,7 17,60 + 0,37	10,6	9,5 – 15,9 13,9 + 0,29	10,4
Greatest height A	11,9 – 24,2 18,56 + 0,46	12,3	13,1 – 19,3 16,07 + 0,34	10,5
Length P	14,5 – 28,8 18,99 + 0,60	15,8	11,7 – 23,2 19,38 + 0,50	12,9
Length V	13,5 – 20,5 16,34 + 0,34	10,3	13,1 – 20,3 15,17 + 0,34	11,1
Distance P-V	25,1 – 36,3 32,83 + 0,51	7,7	28,8 – 35,9 31,71 + 0,40	6,3
Distance V-A	15,2 – 30,4 19,98 + 0,67	16,7	16,8 – 21,6 19,42 + 0,23	5,8

Table 2. Plastic indices of white amur (truss – protocol) of the studied age groups of the fish hatchery of the Bukhara region, 2022-2023

Indicator	*Fry*		*Yearlings*	
	Min – Max $X_{aver.}$ + S_x	*Cv, %*	*Min – Max* $X_{aver.}$ + S_x	*Cv, %*
2-4	20,5 – 30,6 27,60+0,46	8,2	20,8 – 28,3 23,98+0,31	6,5
4-6	28,1 – 35,3 30,86+0,44	7,0	31,6 – 36,0 33,58+0,20	3,0
6-8	16,3 – 26,7 21,57 + 0,54	12,4	12,2 – 18,8 14,72 + 0,31	10,4
8-10	19,4 – 31,6 26,34+0,79	14,7	28,5 – 38,3 31,70+0,50	7,8
9-10	11,7 – 14,7 13,25+0,15	5,5	11,7 – 14,8 13,39+0,17	6,5
7-9	6,4 – 16,5 11,29+0,42	18,4	7,0 – 13,3 10,47+0,32	15,4
5-7	13,9 – 21,7 17,60 + 0,37	10,6	9,5 – 15,9 13,9 + 0,29	10,4
3-5	19,5 – 36,4 27,50+0,94	16,7	22,1 – 39,4 25,75+0,75	14,5
2-3	44,9 – 57,7 51,08+0,72	8,7	49,2 – 60,5 24,48+0,51	4,7
1-2	17,7 – 30,9 25,95+0,64	12,0	18,0 – 42,7 24,18+0,93	21,2
1-4	20,9 – 27,1	5,7	20,5 – 22,8	3,0

	23,51+0,27		21,52+0,13	
1-3	19,3 – 34,3 26,31+1,00	18,6	31,6 – 43,5 35,48+0,59	8,3
3-4	30,3 – 39,3 34,40+0,48	6,8	35,7 – 45,0 39,79+0,56	7,0
5-6	25,1 – 34,7 31,02+0,45	6,7	30,6 – 35,1 33,10+0,21	3,2
7-8	18,1 – 29,4 22,53+0,65	14,1	24,0 – 32,8 28,11+0,46	8,2
4-5	31,4 – 64,1 55,72+1,28	11,3	57,7 - 65,2 61,26+0,38	3,1
3-6	23,3 – 31,1 26,76+0,48	8,7	20,4 – 25,1 22,99+0,26	5,7
6-7	31,1 – 43,0 37,31+ 0,81	10,6	34,1 – 43,8 39,88+0,51	6,4
5-8	16,8 – 24,4 19,52+0,40	10,0	20,0 – 29,5 23,52+0,46	9,8
7-10	13,0 – 38,6 17,57+1,07	29,9	11,9 – 17,8 15,55+0,29	9,2
8-9	20,6 – 36,1 30,38+0,63	10,1	31,9 – 39,2 35,96+0,41	5,7

Discussion

In its natural state, white amur inhabited freshwater bodies of Asian rivers flowing into the Pacific Ocean, from the Amur River in the north and further - the rivers of China [2]. However, for the needs of fish farming, it was widely distributed across many continents. This was facilitated by its features such as feeding on higher plants (macrophytophage), very rapid growth and high fertility. In the 20th century, white amur was introduced into more than 80 countries around the world for fish farming purposes. In many of these countries, white amur was included in the list of important commercial fish species [11]. In world aquaculture, white amur occupies a leading place among the objects of cultivation [8]. In particular, white amur was introduced into Uzbekistan in the early 1960s as larvae from China and the Amur River [4, 9]. White amur was brought to the new pond fish farm "Kalgan-Chirchik" for the needs of developing pond fish farming. Since the mid-1960s, Uzbekistan has mastered the technology of artificial reproduction using gonadotropic stimulation of maturation. In the republic, 4-5-year-old fish are mainly used in breeding. Thus, more than 12 complete generation changes have taken place in new conditions for the species.

Research on the characteristics of the species in the new conditions of Uzbekistan was carried out fragmentarily, although the species has become an important pond object. Since the mid-twentieth century, significant changes have occurred in the Aral Sea basin that affect fish: irrigation construction, water pollution, and other anthropogenic factors that affect, among other things, the gene bank of the species. It is important to track the changes that occur with the species in new conditions compared to the parent reservoirs. Morphological studies provide quantitative characteristics controlled by polygenes. It is important to record phenotypic changes in the species during their ontogenesis. This is given much attention in the world's leading fisheries sector country - China constantly conducts research on the morphology and growth of the main fish farming objects to create a standard for their natural populations [10,14]. One of the main methods of quantitative characteristics controlled by polygenes is morphometric studies, which reflect not only genetic conditions, but also the adaptive potential of species.

A feature of white amur in Uzbekistan is that the majority of fish of the species are reproduced artificially in fish hatcheries. This greatly affects the gene bank: the species was brought to the republic by several batches of larvae in the early 1960s, i.e. a very limited gene bank, and in fish hatcheries the species is reproduced from a relatively small number of producer fish. It is important to monitor changes in the species.

To characterize the phenotypic changes of white amur during their ontogenesis, we measure the external morphological characteristics of different age groups of white amur in the center of the species' introduction into the Aral Sea basin - in a fish hatchery in the Tashkent region. It should be noted that in the Russian part of the native range of grass carp the following meristic characters have been noted: D III 7, A III 8, 39–47 scales in the lateral line, 12–18 sparse short rakers on the first gill arch [1, 2,5]. In Uzbekistan earlier (in the 1970s) the following meristic characters of silver carp were noted in the middle reaches of the Syr Darya: III 7 in the dorsal fin, III 7–8 in the anal fin. 38–45 scales in the lateral line. Gill rakers are short and sparse, with 13–16 of them on the first arch. (Salikhov et al., 2001). The individuals of the sample we studied had the following meristic indices: D III 7, A III 7-8 (8 on average), 39-45 (42) scales in the lateral line, 19-22 (21) rakers on the first gill arch. It is evident that the number of rakers on the first gill arch has increased somewhat.

Most studies on morphometric indices of fish species analyze mature fish. However, body proportions change with age in all organisms. In white amur, as an important commercial fish, the commercially important immature groups are fry and yearlings, which are an important mass product of fish hatcheries. Due to this, we, having not found similar data in the literature, analyzed the studied age groups of white amur (fry and yearlings/fish stock) in a pond fish hatchery in the lower reaches of the Zarafshan River. Many average values of the indices in these two age groups differ, and reliably according to the Student's t-criterion (the tabular value of the t-criterion for our samples is 2.00) (Table 3).

Table 3. The values of the actual t-criterion when comparing the average indices of plastic features of fry and yearlings of white amur, Zarafshan River, 2023 (negative value – the index was higher in fry)

Feature index	*t-criterion*	*Feature index*	*t-criterion*
Total body length	1,51	2-4	-2,16
Torse length	5,80	4-6	5,65
Snout length	-9,64	6-8	-11,33
Eye diameter (horizontal)	-10,74	8-10	5,76
Postorbital head	-3,23	9-10	0,64
Head length	-13,41	7-9	-1,53
Head height at occiput	-14,68	5-7	-3,19
Greatest body depth	-5,42	3-5	-1,46
Smallest body depth	2,61	2-3	-0,33
Antedorsal distance	-8,57	1-2	-3,65
Postdorsal distance	6,86	1-4	-6,55
Caudal peduncle length	-1,71	1-3	7,90
Base length D	-10,93	3-4	7,37
Greatest height D	-5,84	5-6	4,40
Base length A	-7,72	7-8	7,00
Greatest height A	-4,33	4-5	4,14
Pectoral fin length	0,49	3-6	-6,95
Pelvic fin length	-2,42	6-7	2,69
Distance between P and V	-1,72	5-8	6,57
Distance between V and A	-0,78	7-10	-1,82
		8-9	7,46

It is evident that the proportions of the white amur's body have changed significantly during the first year of life in the conditions of the lower reaches of the Zarafshan. With development, the proportions of the head size (including the size of the eyes, snout, horizontal length of the head, its postorbital distance), the length of the base and the length of the rays of the dorsal and anal fins have noticeably decreased in the white amur. The smallest height of the body has increased significantly and the body has become much higher both in the tail and in the chest (behind the head), the length of the tail part of the body has increased (i.e. white amur already in the first year significantly improves its commercial attractiveness as an object of fish farming). By the way, this makes it interesting to think over options for small-scale conservation of white amur in the event of a significant increase in the scale of production of yearlings.

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