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MORPHOLOGY, AGE AND GROWTH OF PRUSSIAN CARP (CARASSIUS GIBELIO) IN TUDAKUL RESERVOIR IN UZBEKISTAN

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Abstract
Modern ststae of invasive prussian carp (Carassius gibelio) was studied in Tudakul reservoir (lower stream of Zarafshen River) in 2020-2022. Fins rays formula was D II (III) 16-18, A II 5-6; 26 - 28 scales in lateral line and 38 – 46 gil rakers were determined. Plastic indexes according to tradinional for cyprinids so as indexes of «truss protocol» are given. The ages of the samples ranged between 1 to 5 years, the total length 144.3 – 452.7 mm, the standard lengths 113.3 – 383.0 mm and total weights 99.0 – 703.0 g. The relationship between the total length (TL) and weight (W) was described by $W = 0{,}0192*TL^{2{,}957}$ (r = 0,95). The mean back calculated standard length was 10.7 cm at age I; 18.1 cm, II; 24.4 cm, III;26.1 cm, IV.

Keywords: Prussian carp, Carassius gibelio, fish morphology, age, growth, Tudakul reservoir, Uzbekistan

Methods of commercial ichthyofauna artificial formation as fishery activity are promising to increase the efficiency of complex water resources use. This is especially true for arid countries, where new reservoirs have been created for irrigation purposes. Uzbekistan is located in the Aral Sea basin in Central Asia, where natural fish resources are extremely poor and could provide the actual fish productivity of reservoirs at the level of 1-3 kg/ha/year. In this regard, since the second half of the 20th century, the introduction of valuable fish species into local water bodies has been used (Luzanskaya, 1965; Kamilov, 1973; Kamilov, Urchinov, 1995).

The prussian carp (Carassius gibelio (Bloch, 1782)) is a representative of the Cyprinidae family. It’s natural area of distribution cover inland water bodies of China, the islands of Japan, Taiwan and Hainin. The prussian carp for several centuries was widely settled in Eurasia from France and Spain to the Far East, accidentally introduced into North America (Atlas…, 2003, Elgin et al, 2014). In natural conditions of the Aral Sea basin (before 1960s), the prussian carp habituated in Aral itself and in deltas of Amudarya and Syrdarya rivers (Kamilov, 1973). During the period of large-scale irrigation construction period in second half of 20th century, a list of new reservoirs was created in the basin including plain zone of all large rivers. In such reservoirs, commercial ichthyofauna was artificially formed, including through the introduction of new for the region fish species. In the 1950s, the prussian carp was introduced to the pond fish farm of the Tashkent region from the Savvino fish farm near

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Moscow (where the prussian carp was introduced from the Amur River). With the resettlement of juvenile pond cultured fishes, the prussian carp also dispersed in all plain regions of Uzbekistan, including the Tudakul reservoir in the lower reaches of the Zarafshan River (Amanov, 1985; Salikhov et al., 2001; Yuldashov, Kamilov, 2018). The prussian carp has founded favorable environments begun reproduction and became part of the commercial fish species in this reservoir. The biology of the prussian carp in reservoir was studied until the 1980s; in the 2020s, this species began to be studied in the plain zones of the republic, starting from the middle reaches of the Syrdarya, where a slow-growing pond form and a fast-growing form in lakes live (Khalimova et al., 2022). The purpose of this work was to study the features of the morphology of the goldfish of the formed self-reproducing herd of the Tudakul reservoir at the present time.

Site description. Tudakul reservoir (fig. 1) was created for irrigation purposes in the lower reach of Zarafshan River, Uzbekistan (39°51'15"N 64°50'29"E). Climate is temporary and extremely continental. In the region, summer is very hot (average monthly air temperature in July is about 29^{o}C, in daytime period with air temperature 35-42^{o}C lasts for 1.5 months). At the same time, winter is rather cold (average monthly air temperature in January is about -2^{o}C, standing water bodies often are covered by ice for 1.5 months). The Tudakul reservoir is very big, it's total area is about 22 000 ha, average depth is about 5 m, maximal depth is 22 m. The main function of the reservoir is irrigation for agriculture. In 2004 - 2015, additionally the reservoir was used as water body with culture based fisheries. Fishery enterprise - tenant of the reservoir has created local hatchery and every autumn reservoir was stocked by culture cyprinids summerlings (silver carp, Hypophthalmichthys molitrix, bighead carp, H. nobilis, common carp, Cyprinus carpio, and grass carp, Ctenopharyngodon idella). The stocking rate was 50-120 summerlings/ha. In that regime commercial fishermen used only seines with large mesh (70 – 90 mm mesh in wings of seine net) because catch is oriented to large fishes (more than 2 kg). Total fish catch in reservoir was 500-1500 tones/year in 2009-2018 years. Since 2017, the new tenant of the reservoir has actually stopped stocking of the reservoir with cyprinids summerlings, stopped using seines, and transferred fish capturing to coastal teams equipped only with gill nets (with mesh 36 - 60 mm). Fish catches from the reservoir have been reduced to 150-300 tons/year including 5 – 15 tons/year of prussian carp. Stocks of local fish found themselves in new conditions.

Fig. 1. Tudakul reservoir and it's location in Uzbekistan

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Material and Methods

The prussian carp samples were collected from November to April in 2020 – 2021, 2021 – 2022 in the Tudakul reservoir by using gill nets with 16, 24, 32, 36, 40, 50, 60, 70 mm in mesh size. Morphological identification and systematic status of snowtrout were made, using characters given by Ribi … (1988) and Salikhov et al. (2001).

The total length (TL), standard length to the end of scale coverlet (SL) in the nearest 1 mm and weight (W) in the nearest 0.1 g were recorded for each fish. Scales (3-4 samples) were taken from 1st row above lateral line under 1st ray of dorsal fin. Scales were cleaned in water and examined under binocular microscope for the age determination. Scales were measured with the aid of a microfiche under magnification 10.0* and growth was back calculated. Sex andgonads stage of maturation were determined by using routine methods for cyprinids (Pravdin, 1966).

The length-weight relationship was determined according to the equation given by Ricker (1975): $W = a*TL^b$, where W = fish weight in grams, TL = total length in centimeters, 'a' and 'b' are constants.

Correlation and regression analyses were done to describe fecundity equations; statistical significance was tested to $p < 0.05$.

Meristic characters were counted in each fish. Plastic characteristics were measured according to the measurement scheme for cyprinids (Pravdin, 1966). Ten landmarks along the fish body perimeter were identified (Fig. 2). Each fish was photographed at a strict right angle using a fixed tripod. The photographs were used to measure the distances in a straight line between landmarks, i.e. made up the so-called. "truss" protocol (Strauss, Bookstein, 1982; Strauss, Bond, 1990). The sounding lines are specified in the following format: for example, "2–4" indicates a straight line measurement between landmarks 2 and 4. The absolute plastic feature characters were converted into indexes in %% of the standard body length.

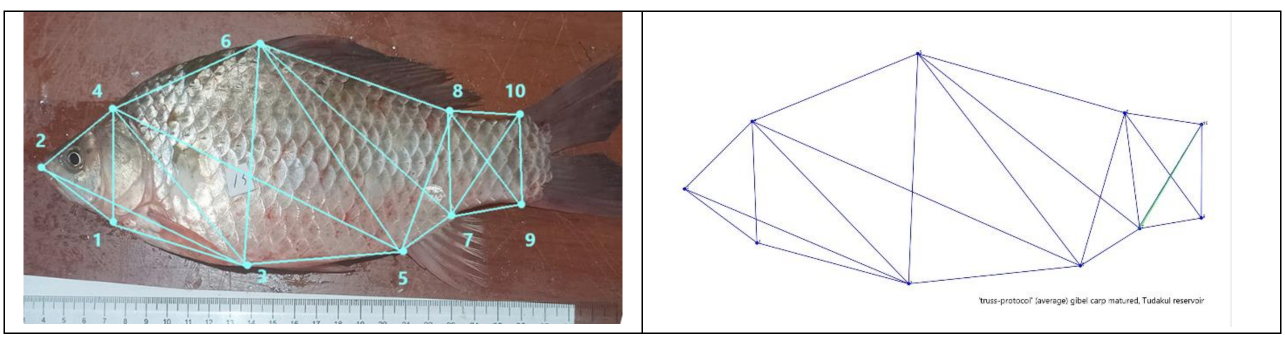

Fig. 2. Landmarks and 'truss-protocol' (on the left) and average 'truss-protocol' of indexes (on the right) of the prussian carp from Tudakul reservoir, 2023 (n=50 species)

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Results

A total 150 the prussian carp were sampled. The ages of the samples ranged between 1 to 5 years, the total length 144.3 – 452.7 mm, the standard lengths 113.3 – 383.0 mm and total weights 99.0 – 703.0 g.

The prussian carp has cycloid scales with flat edges. During the colder months the sclerites (ridges) are crowded together on scales; during the warmer months sclerites are spaced further apart (wide to each other). Annuli (true year mark) are characterized by crowdedsclerites. Annuli on scale of immature european bream appears in March and of mature fish appears in May.

A strong positive correlation was found between the standard length and the total body length of the bream (r_{SL-W} = 0,99), this relationship could be reliably characterized by the regression equation: SL(cm) = 0.8143 * TL(cm) + 0,2461 (к = 0,99).

Length – weight relationship. The relationship between weight and total length could be described by regression equation $W = 0{,}0192 * TL^{2{,}957}$ (r = 0,95) (fig.3).

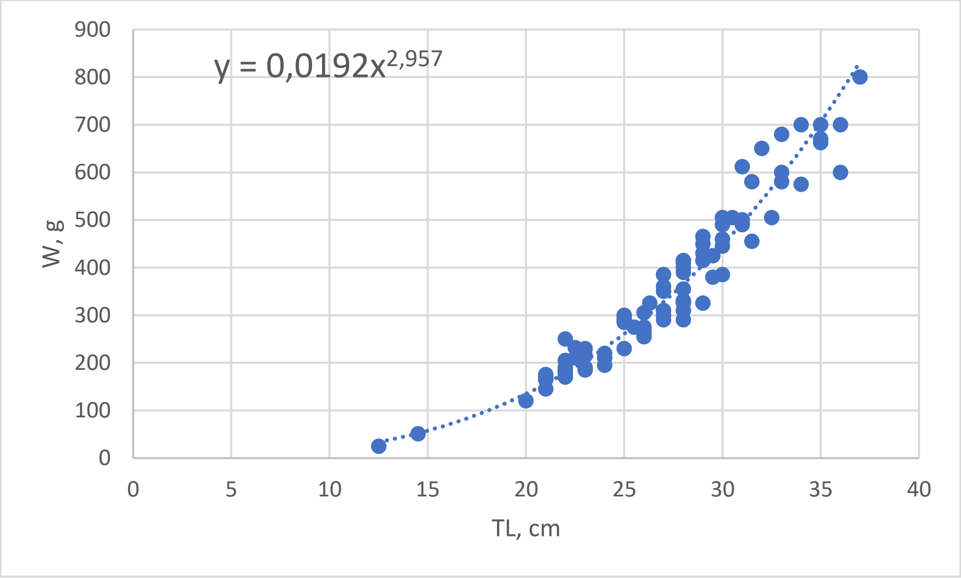

Fig.3. Weight - total length relationship of the prussian carp in Tudakul reservoir, Uzbekistan, 2023

Meristic characteristics. In prussian carp, the formula of the rays of the dorsal fin was determined as II (III) 16 - 18, the formula of the rays of the anal fin II 5 - 6. In the lateral line 26 – 28 (average 27) scales were identified; on the first gill arch there were 38 – 46 (41) rakers.

Plastic characteristics of the prussian carp according to traditional scheme for cyprinids are shown in Table 1. Indexes for "truss-protocol" in relation to the standard body length are given in table 2.

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Table 1. Indexes of plastic morphological characteristics of the prussian carp (%% of standard length), Tudakul reservoir, Uzbekistan, 2023

Index	Min	Max	$X_{mean} + S_x$
Body length	61.2	84.9	78.39 + 1.00
Snout length	2.3	5.0	3.70 + 0.15
Eye diameter	2.7	5.0	3.97 + 0.12
Postorbital length of the head	10.1	14.9	12.45 + 0.21
Head length	15.7	23.4	19.88 + 0.39
Head height at the back	17.8	25.0	22.92 + 0.30
Maximum body height	32.9	46.7	41.61 + 0.78
The smallest body height	12.3	18.7	16.76 + 0.31
Antedorsal distance	38.9	54.2	48.40 + 0.69
Postdorsal distance	16.7	29.5	22.24 + 0.58
Caudal – peduncle length	11.3	19.0	16.31 + 0.38
Dorsal- fin base length	31.4	48.5	42.05 + 0.73
Dorsal- fin the greatest height	5.5	16.6	10.61 + 0.72
Anal- fin base length	7.0	16.9	12.72 + 0.38
Anal- fin the greatest height	6.6	16.8	14.21 + 0.51
Pectoral- fin length	6.9	19.9	17.52 + 0.53
Ventral- fin length	15.2	22.2	19.53 + 0.31
Pectoral – pelvic fins distance	17.2	26.1	22.61 + 0.40
Ventral – anal fins distance	23.1	35.3	31.52 + 0.49

Table 2. Indexes of «truss-protocol» morphological characteristics of the prussian carp (%% of standard length), Tudakul reservoir, Uzbekistan

Index	Min	Max	$X_{mean} + S_x$
2 - 4	13,7	21,5	18,69 + 0,31
4 - 6	14,7	33,2	30,25 + 0,76
6 - 8	30,5	47,2	41,74 + 0,72
8 - 10	8,8	19,3	12,48 + 0,53
9 - 10	11,8	19,4	17,40 + 0,36
7 - 9	7,0	14,3	11,52 + 0,37
5 - 7	8,3	17,0	13,01 + 0,35
3 - 5	22,3	34,5	30,98 + 0,50
2 - 3	32,9	47,9	44,57 + 0,56
1 - 2	12,6	20,0	17,39 + 0,31
1 - 4	17,5	25,6	23,48+ 0,31
1 - 3	21,2	30,7	28,01 + 0,38
3 - 4	30,9	44,5	41,41 + 0,53
5 - 6	36,3	55,4	49,09 + 0,70
7 - 8	15,7	24,2	20,27 + 0,33

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4 - 5	48,2	68,8	64,95 + 0,76
3 - 6	32,1	46,4	41,87 + 0,68
6 - 7	38,4	55,5	51,71 + 0,67
5 - 8	21,6	32,7	29,03 + 0,40
7 - 10	17,4	24,7	22,33 + 0,39
8 - 9	16,4	27,2	22,27 + 0,50

Growth. The determined back-calculated growth of the prussian carp in Tudakul reservoir is given in Table 2.

Table 2. The mean standard length determined by back-calculation method according to age groups of the prussian carp

Age group	N	Back-calculated standard length according age group, cm			
		SL_1	SL_2	SL_3	SL_4
1	49	17,9			
2	40	10,7	20,7		
3	38	10,5	19,1	25	
4	23	9,6	16,2	22,8	26.1
Mean SL_i, cm		**10.7**	**18.1**	**24.4**	**26.1**
Annual increment, cm/year		**10.7**	**7.4**	**6.3**	**1.7**

Discussion

The introduction of new fishes could increase fish productivity of the water body. At the same time, new species invasions could impact local fish fauna biodiversity. The establishment success of an introduced species depends on its biological adaptability (Blanchet et al., 2007; Gozlan et al., 2010). During large-scale irrigation construction in the Aral Sea basin, program of artificial commercial fish fauna creation in new reservoirs was developed in Uzbekistan, including the one for Tudakul reservoir. But, in relation to prussian carp, it should be considered that the species spread in the Zarafshan river basin accidentally due to secondary resettlement from stocks formed in the middle course of the Syrdarya (pond farms of the Tashkent region), where they also were introduced accidentally (Kamilov, 1973; Yuldashov, Kamilov, 2018).

In natural conditions the prussian carp lived in China and the islands of Japan, Taiwan and Haining. Due to the anthropogenic factor, the species was widely dispersed. Currently, the prussian carp has a huge range that distributed in Eurasia and America. In Eurasia, the species lives from France and Spain to the Far East, going far into the northern regions (the basins of the Lena, Ob, Yenisei, Mezen, Pechora, Northern Dvina). In the south of Europe it is found in the basins of the Volga, Dnieper, Southern Bug, Dniester, Danube. There are points of view that there was a long-standing importation of the species from China and/or Japan, another point of view is that this species is autochthonous in Europe (Atlas, 2003). Interest was aroused by the use in fish farming, high taste qualities in particular. Initially, the

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prussian carp was of interest for pond fish farming. In Russia since the 17th century it was kept in the royal ponds. Goldfish were bred in fish farms of Kursk, Belgorod, Krasnodar and other regions (Atlas ..., 2003).

In the area, the fin formulas are: D III-IV, 14-19, A II-III 5-6 (Berg, 1949; Ribi..., 1988). The species is very plastic. High-bodied fast-growing and low-bodied slow-growing forms are noted in the species.

In the Savvino fish farm near Moscow, the prussian carp introduced from Amur river populations. In Uzbekistan in the late 1950s, the prussian carp was brought from in the fish farm Damashchi (the middle Syrdarya river) and in the Kattakurgan reservoir (Zarafshan basin) from the indicated fish farm Savino (Kamilov, 1973). But, the future aquaculture development was related with common carp, silver carp, bighead carp, and grass carp. So, since 1960s, the the prussian carp culture has not been developed. The species has adopted to such conditions and successfully occupied the niche of weed fish in carp polyculture. Due to the rapid development of pond polyculture, since the 1960s, the prussian carp have been widely resettled during regular stockings of fish ponds and lakes, reservoirs with yearlings of cultured cyprinids from the nurseries of the Tashkent region to all plain regions of Uzbekistan (Yuldashov, Kamilov, 2018). At the same time, weedy pond fish are also transported.

The prussian carp has one interesting peculiarity. In environments of aquaculture earthen ponds with cyprinids polyculture, the prussian carp has become a mass weedy fish, reaching its first sexual maturity in the second year of life when it reaches a standard body length of 9-10 cm, that form has slow growth. At the same time, in reservoirs and lakes, the prussian carp is a high bodied fish with fast growth and a valuable object of fishing. Features of the biology of silver carp of both forms are poorly understood, especially its morphological features.

The prussian carp studied by us in the Tudakul reservoir is quite homogeneous in terms of meristic features, it confirms the high variability of the species in the modern range. Fins ray formula was D II (III) 16-18, A II 5-6; 26 - 28 scales in lateral line and 38 – 46 gill rakers were determined.

Fish growth study including back-calculation models are important tools in fisheries research and management that are used to determine past lengths and growth from the calcified structure of fishes. Growth data provides confidence to fisheries biologists about fish population under environments in different ecosystems or management manipulations. Fish growth can be affected by such factors asannual water temperature rate, fish density in population, food availability and food quality, etc. Our data shows, that in Tudakul reservoir the prussian carp has rather fast growth rate. The mean back calculated standard length was 10.7 cm at age I; 18.1 cm, II; 24.4 cm, III; 26.1 cm, IV.

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