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AGE AND GROWTH OF SILVER CARP (*Hypophthalmichthys molitrix* Val.) IN TUDAKUL RESERVOIR, UZBEKISTAN

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ABSTRACT

A study was carried out from November 2010 to October 2011 in Tudakul reservoir, Uzbekistan. A total of 142 silver carps, *Hypophthalmichthys molitrix* Val., were sampled including 65 females and 77 males. The scale of silver carp is cycloid with straight edges. Annulus on scale of immature silver carp appears in March and of matured fish during the spawning period in the second half of May. The ages, total lengths and weights of the samples ranged between 1 to 5 years, 15 to 105 cm and 35 to 17,500 g, respectively. The relation between the total length (TL) and weight (W) was described by equation $W = 0.0065xTL^{3.1572}$ (r=0.99). The relationship between the total length (TL) and the standard length (l) was described by a linear equation: $l = 0.8973xTL - 1.571$ (r = 0.99). The mean estimated total length of 1-year-old silver carp was 25.25 cm; 2-year-old, 49.81 cm; 3-year-old, 68.91 cm; 4-year-old, 89.94 cm; 5-year-old, 94.47 cm. The mean back calculated total length was 28.2 cm at age I; 56.2 cm, II; 71.18 cm, III; 89.56 cm, IV; 98.9 cm, V. R. Lee's phenomenon was not manifested as the fishing company is oriented to the catches of large fish.

INTRODUCTION

Silver carp *Hypophthalmichthys molitrix* (Valenciennes) is one of the most important species of cultured fish in the global fish production; it is also a commercial fish for fisheries in inland waters. The fry of silver carp and grass carp, *Ctenopharyngodon idella*, were introduced to fish culture ponds in Tashkent region (Uzbekistan) from China and the Amur River (Russia) in 1961-1963. Accidentally, bighead carp, *Hypophthalmichthys nobilis*, was also introduced (Kamilov, 1973; Kamilov and Urchinov, 1995; Salikhov et al., 2001; etc.). In early 1960s, fish farms began artificial reproduction of those Asian carps for fish culture and regular stocking of plain reservoirs and lakes all over Uzbekistan for improving the commercial fish fauna. However, those species did not find favorable conditions for natural reproduction in most of reservoirs and lakes of the country. Only big rivers like the Syrdarya and Amudarya in the middle stream provide spawning conditions for the establishment of wild stocks (Salikhov et al., 2001).

Tudakul reservoir was created for water storage and transition in the lower stream of the Zerafshan River, Uzbekistan (39°51'15"N 64°50'29"E) (Figure 1). This is an arid zone with an extremely continental temporary climate. Summer is hot (average monthly air temperature is about 29°C in July; it often reaches 35-42°C in daytime and can be even higher). Winter is rather cold (average monthly temperature in January is -2°C, water bodies with stagnant water are often covered with ice for up to 1.5 months). The total area of the reservoir is 22,000 ha; the average depth is about 5 m; the maximal depth, 22 m. Tudakul reservoir has been stocked with silver carp summerlings, common carp, *Cyprinus carpio,* bighead carp and grass carp by "Aqua-Tudakul" fishery company each autumn since 2003. The stocking density of silver carp was 15-25 fish/ha in 2004-2010 (or 15-20 tons of silver carp summerlings). "Aqua-Tudakul" is a single company carrying out fishing activities in the reservoir; it uses five commercial seines with large mesh (70-90 mm mesh in wings of the seine net) because catch is oriented to the catches of large fish (of more than 1 kg). The catches of silver carp in Tudakul reservoir reached 100-201 tons in years 2009 and 2010. Besides, the fry from wild spawning of Asian carps move to Tudakul reservoir from the mid-part of the Amudarya River through Amu-Bukhara canal, however, their number is not high because the water flows through a pump station and through the network of irrigation channels.

Fig 1. Tudakul reservoir

Many aspects of silver carp biology were studied in conditions of pond fish culture in the region, including fish growth (Kamilov, 1985; Aliev et al., 1994). However, the growth of silver carp in wild environments was studied poorly. The study of age and growth is essential for fisheries and management. Age and growth determination of silver carp encountered some difficulties (Kolar et al., 2005). The goal of this research is to study the age and growth of silver carp in Tudakul reservoir.

MATERIAL AND METHODS

Fish samples were collected every 15 days from November 2010 to October 2011 from Tudakul reservoir by using gill nets with 24, 32, 36, 40, 50, 60, 70, 90, 100, 110 and 120 mm in mesh size. Data of fish catches were kindly provided by the administration of "Aqua-Tudakul" fishery company, which carried out stocks and fish catches in Tudakul reservoir.

The total length (TL) to the nearest 1 mm and body weight (W) to the nearest 1 g were recorded for each fish. Because standard length was the main body size parameter in the former USSR, its relationship with total length was studied. Standard length (SL) was also measured to the nearest 1 mm for each fish.

Scales were taken from the area in the mid-part of the body above the lateral line, just behind the first ray of dorsal fin. Scales were cleaned in water and examined under a binocular microscope for age determination (Kamilov, 1985). Scale radius and annuli measurements were taken along the diagonal radius (drawn between lateral and back sectors of scale) using a projector for microfiche reading "Mikrofot 5 PO – 1" under 10.5× magnification. Besides, vertebrae under the first ray of the dorsal fin were removed from 25 fish and cleaned; vertebrae were used for age determination as additional calcified structure. The annulus quantity was counted on cleaned and dried vertebrae.

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

RESULTS

A total of 142 silver carps were sampled including 65 females and 77 males. The overall sex ratio between females and males was 1 : 1.18.

The scale of silver carp is cycloid with flat edges. Silver carp belongs to fish with small scales (Kamilov 1985). The zone of the annual growth on the scales finishes at the belt (ring) of 3-7 open-ended sclerites that are not closed in the zone between lateral and back sectors of scale. First sclerite of a new-year growth zone is closed. Those unclosed sclerites are good morphological characteristics of the annulus. The number of rings on the vertebras with the number of annulus on the base of rings of non-closed sclerites was compared; in all cases (n = 25 fish) age estimation was the same by three readers.

The annuli on the scales of immature silver carp appear in March (beginning of vegetation season), while those of mature fish appear during the spawning period in May.

The total length of silver carp – scale size relationship had a strong positive significant correlation (Kamilov, 1985). Back-calculations can be performed by using E. Lea's modification of the direct proportional method (Chugunova, 1963). A diagonal radius between lateral and back sectors of silver carp scale was used for age estimation, scale and annulus measuring.

Length-weight relationship. The ages, total length and weight of the samples ranged between 1 to 5 years, 15 to 105 cm and 35 to 17,500 g, respectively. There were no significant differences between the lengths of the fish of dif-

ferent sexes, so all calculations were made using combined data (female + male). The relation between the total length and weight were plotted for combined sexes (Figure 2).

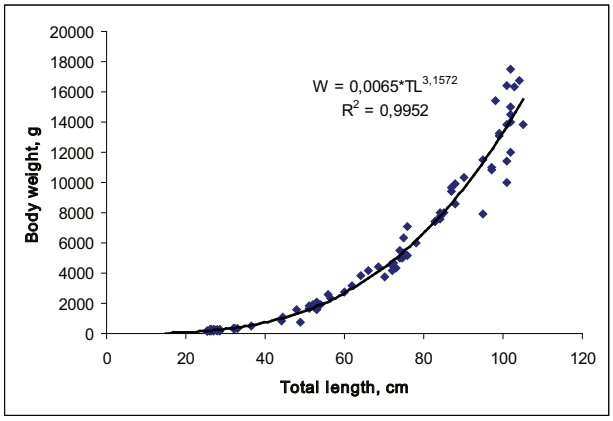

Fig 2. Total length-weight relationship of silver carp

The relationship between the total length and the standard length was described by linear equation: SL = 0.8973*TL – 1.571 (r = 0.998, n = 142).

Growth. The observed mean lengths and weights of different ages of silver carp are given in Table 1. Back-calculated growth of silver carp is given in Table 2. Phenomenon of R. Lee was not manifested.

DISCUSSION

Silver carp, together with bighead carp, is the most important species in the world of aquaculture (FAO, 2012). In Uzbekistan, silver carp is also the most important species whose production reached 75-85% of aquaculture in 1994-2012. Pond culture uses such advantages of silver carp as feeding on phytoplankton and fast growth. At the same time, the role of silver carp in fish catches is not so high, though all marked advantages are the same in this south region (high primary productivity of local water bodies). In Tudakul reservoir, fisheries management has been using regular stocking of silver carp with the density of 15-20 summerlings per ha since 2003. The idea was to produce bigger fish (of more than 2 kg), so they would not compete with cultured silver carps (0.8-1.5 kg) and be more valuable at the same time.

Fish growth studies, including back-calculation models, are important tools in fisheries research and management as they are used to determine past lengths and growth from the bony structures of fish. The growth data provide confidence to fisheries biologists about the fish population under environments in different ecosystems or management manipulations (Klumb et al., 1999).

A few studies have been conducted on the aging of silver carps by using calcified structures. Shefler and Reich (1977) noticed the presence of pseudo-annuli, missing annuli and blurred circuli on the scales of silver carps and did not use scale for aging. The first rays of pectoral fin were used for aging and back-calculation of growth (Williamson and Garvey, 2005). Several calcified structures were used to study silver carp age and growth in Gobindsagar Reservoir, India (Johal et al., 2001); in addition to scales, the cleithrum and urohyal bones were proposed for age determination. The major benefits in the use of cleithra and urohyal bones are verifying scale readings and improving confidence in age determination, especially for older fish. Disadvantages associated with the use of cleithra and urohyal bones are the need to sacrifice the fish and the greater time required to collect and clean the bones.

In this study, our previous observation (Kamilov, 1985) that unclosed sclerites are good morphological characteristic of annulus, the same as rings on vertebra, has been confirmed. Scales and vertebra can be used for aging. Scales grow only when the fish grows. Therefore, the scale size should be proportional to the fish length. Some other calcified structures, for example otoliths, were shown to continue growing with age regardless of the fish growth (Beamish and McFarlane, 1987). We recommend using a diagonal radius (drawn between lateral and back sectors of the scale) for measurement for back-calculation purpose, because of a better marking of annuli.

For silver carp, both linear (Tandon et al., 1993; Johal et al., 2001) and non-linear (Kamilov, 1985) equations have been used to describe the relationship between the body length and scale radius. The direct propor-

Table 1. Mean length (TL) and weight (W) of silver carp by age groups (Min – Max / Mean)

	Age groups				
	I	II	III	IV	V
TL (cm)	15 - 33	36.5 – 56.5	51 – 78	64 – 105	76 – 104
	25.25	49.81	68.91	89.94	94.47
W (g)	35-373	518-2325	1875-6000	3800-14000	7050-17500
	187.5	1548.6	4264.8	9646.8	11855.3
Fish number	30	17	49	41	5

Table 2. The mean calculated total length (cm) determined by back-calculation method according to age groups of silver carp (males and females combined)

Year class	Age group	Number fish	Back-calculated length according to age group				
			I	II	III	IV	V
2011	I	30	29.5				
2010	II	17	25.8	52.4			
2009	III	49	27.2	51.7	70.3		
2008	IV	41	29.9	53.7	72.3	89.9	
2007	V	5	24.7	48.2	69.9	87.0	98.9
Mean total length			***28.20***	***56.20***	***71.18***	***89.56***	***98.90***
Mean annual increment			***28.20***	***28.00***	***14.97***	***18.39***	***9.34***

tional method is based on the hypothesis that the scale grows in exact proportion to the total length of the individual. In this study, the direct proportional method was used for silver carp.

There were no significant sexual differences in both length and weight growth in Tudakul reservoir; the same was found by Jingrong (1986) for China.

In long-term studies, the standard length (length without tail) was used to estimate growth parameters of inland fishes including silver carp in the former USSR, and the total length in many other countries. All the comparisons were made disregarding this situation (Table 3).

Fish growth can be affected by such factors as temperature, stocking density, food availability, and food quality (Gasaway, 1978; Bonar et al., 1993). In Tudakul reservoir, growth for ages 1 through 4 years is faster in comparison with the other areas of the temporary climate zone, including the Amur River from where silver carp was introduced to Uzbekistan (Nikolsky, 1956), the neighboring Kazakhstan (Dukravets, 1986) and Russia (Muhamedova, 1982). In Tudakul reservoir, growth is faster than in the Middle Mississippi River Drainage (Williamson and Garvey, 2005) and Gobindsagar Reservoir, India (Johal et al., 2001).

CONCLUSION

A conclusion can be made that the environment of Tudakul reservoir, its fisheries management in total and stocking rate in particular, is at present favorable for silver carp population. R. Lee's phenomenon was not manifested because "Aqua-Tudakul" fishing company is oriented to the catches of large-sized fish. So, fish of first two-three years escape seines and all fish with different growth are presented in the reservoir. Growth analysis shows that stocking rate can be increased noticeably and this is the subject for future experiments in management manipulation in Tudakul reservoir.

The experience of fisheries management in Tudakul reservoir done by 'Aqua-Tudakul' company (with a significant attention to creation of a local hatchery for the direct stocking into the reservoir) can be useful for other plain waterbodies of Uzbekistan.

Table 3. Growth of silver carp in different regions

Region	Length*	Mean length in each age (cm)							Authors
		I	II	III	IV	V	VI	VII	
Russia, Amur River	***l***	12.3	26,6	36.1	44.5	50.3	54.6	59.4	Nikolsky, 1956
Russia, Tsimlyan reservoir	***l***	26	35.8	47.5	56	62.5	66.4	-	Muhamedova, 1982
Kazakhstan, Kapchagay reservoir	***l***	11.2	21.7	30.6	40	48.5	56.6	64/2	Dukravets, 1986
India, Gobindsagar Reservoir	***TL***	28.8	50.7	59.9	71.5	82.8	89.1	90.4	Johal et al., 2001
USA, Middle Mississippy River drainage	***TL***	31.7	53.1	65	70.4	72/3			Williamson and Garvey, 2005
Uzbekistan, Tudakul reservoir	***TL***	26.5	55.4	82.2	89.8				This study
	l	23.1	48.3	71.7	78.3				

* ***TL*** – total length, ***l*** – length without tail

Sažetak

ODNOS STAROSTI I RASTA BIJELOG GLAVAŠA (*Hypophthalmichthys molitrix* Val.) IZ REZERVATA TUDAKUL U UZBEKISTANU

Ovo istraživanje provedeno je od studenog 2010. do listopada 2011. godine u rezervatu Tudakul u Uzbekistanu. Uzorkovano je ukupno 142 primjeraka bijelog glavaša (*Hypophthalmichthys molitrix* Val.), od čega 65 jedinki ženki te 77 jedinki mužjaka. Ljuska bijelog glavaša je cikloidna s ravnim rubovima. Prsten na ljusci nezrelog bijelog glavaša pojavljuje se u ožujku, a kod zrele ribe pojavljuje se tijekom mrijesta u drugoj polovici svibnja. Dob glavaša kretala se od jedne do pet godina, ukupne dužine od 15 do 105 cm, a mase od 35 do 17500 g. Odnos između ukupne dužine (TL) i mase (W) opisan je jednadžbom: $W = 0{,}0065 \times TL^{3{,}1572}$ ($r = 0{,}99$). S druge strane, odnos između totalne (TL) i standardne dužine (l) opisan je linearnom jednadžbom: $l = 0{,}8973 \times TL - 1{,}571$ ($r = 0{,}99$). Srednja procijenjena dužina jednogodišnjeg bijelog glavaša je 25,25 cm, dvogodišnjeg 49,81 cm, trogodišnjeg 68,91 cm, četverogodišnjeg 89,94 cm te petogodišnjeg 94,47 cm. Ipak, stvarnim mjerenjem glavaša potvrđene su sljedeće vrijednosti dužine – jednogodišnji: 28,2 cm, dvogodišnji: 56,2 cm, trogodišnji: 71,18 cm, četverogodišnji: 89,56 cm, petogodišnji: 98,9 cm. Fenomen R. Leeja nije uočen jer su ribolovne kompanije usmjerene isključivo na ulov velikih riba.

Ključne riječi: bijeli glavaš, *Hypophthalmichthys molitrix*, procjena dobi, ponovni izračun, rast

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