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Abdullo R Kurbanov
Scientific Experiment Station for aquaculture development, Yangiyol, Tashkent region, 110808, Uzbekistan

Bakhtiyar G Kamilov
Institute of gene pool of plant and animal worlds, 232, Bogishamol St., Tashkent, 100125, Tashkent, Uzbekistan.

Correspondence
Bakhtiyar G Kamilov
Institute of gene pool of plant and animal worlds, 232, Bogishamol St., Tashkent, 100125, Tashkent, Uzbekistan.

Age and growth of bighead carp (*Hypophthalmichthys nobilis R.*) in Tudakul reservoir, Uzbekistan

Abdullo R Kurbanov, Bakhtiyar G Kamilov

Abstract
A study was carried out from November 2010 to October 2011 in Tudakul reservoir, Uzbekistan. A total of 126 bighead carps, *Hypophthalmichthys nobilis R.*, were sampled including 57 females and 69 males. The scale of bighead carp is cycloid with straight edges. Annulus on scale of immature bighead carp appear in March and of matured fish during the spawning period in second half of May-early June. The ages, total lengths and weights of the samples ranged between 1 to 4 years, 17 to 112 cm and 60 to 18000 g, respectively. The relation between the total length (TL) and weight (W) was described by equation $W = 0.0105*TL^{3.067}$ (r = 0.99). The relationship between the total length (TL) and the standard length (SL) was described by linear equation: SL = 0.872*TL (r = 0.99). The mean estimated total length of 1-year-old bighead carp was 27.1 cm; 2-years-old, 51, 7 cm; 3-years-old, 84, 4 cm; 4-years-old, 89.8 cm. The mean back calculated total length was 26.5 cm at age I; 55, 4 cm, II; 82, 2 cm, III; 89.8 cm, IV. R. Lee's phenomenon was not manifested as the fishing company is oriented to the catches of large fish.

Keywords: Bighead carp, *Hypophthalmichthys nobilis*, age estimation, fish growth, back calculation

1. Introduction
The fry of silver carp, *Hypophthalmichthys molitrix*, 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 R.*, was also introduced [1, 2, 3]. Already since 1960s fish farms began artificial reproduction of those Asian carps for fish culture and regular stocking of plain reservoirs and lakes all over the Uzbekistan for improving the commercial fish fauna. However, those species did not find favourable 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 [3].
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) his is an arid zone with an extremely continental temporary climate. Summer is hot (average monthly air temperature is about 29 ºC in July; it often reaches 35-42 ºC in daytime and can be even higher). Winter is rather cold (average monthly temperature in January is -2 ºC, water bodies with stagnant water are often covered with ice 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 bighead carp summerlins, common carp, *Cyprinus carpio*, silver carp and grass carp by "Aqua-Tudakul" Fishery Company each autumn since 2003. The stocking density of bighead carp was 5 - 10 fish/ha in 2004-2010 (or 7- 15 tons of bighead 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 bighead carp in Tudakul reservoir reached 70 – 201 tones 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.

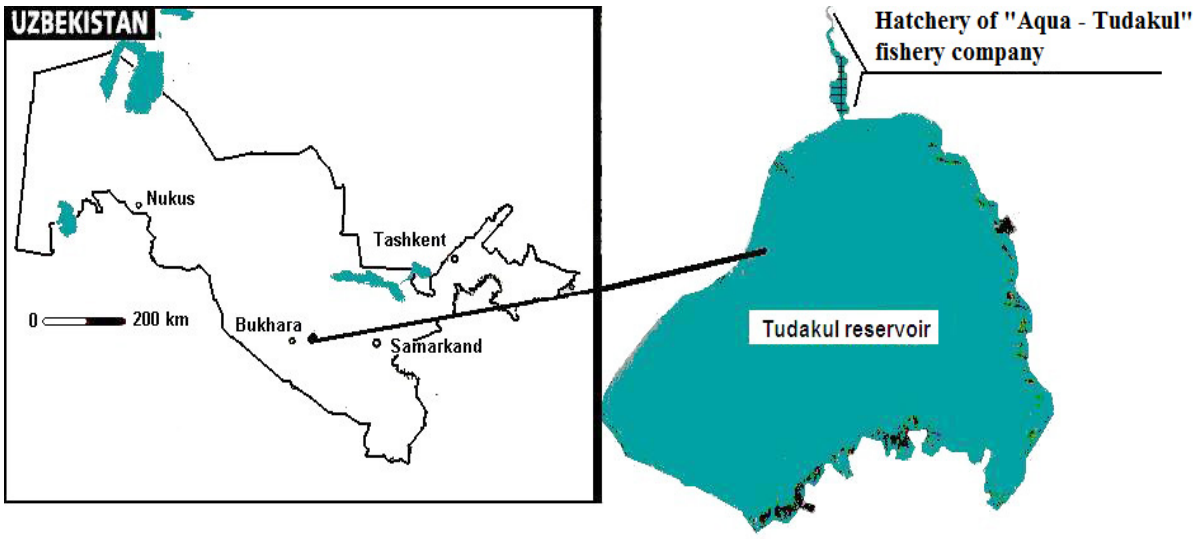

Fig 1: Tudakul reservoir

In spite of high commercial importance of bighead, many aspects of its biology were not studied in the country including age and growth. The study of age and growth is essential for fisheries and management. Age and growth determination of bighead carp encountered some difficulties [4, 5]. The goal of this research is to study the age and growth of bighead carp in Tudakul reservoir.

2. 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 the age determination. 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 "Microfot 5 PO – 1" under 10.5x magnification. Besides, vertebrae under the first ray of dorsal fin were removed from 20 fish and cleaned; vertebrae were used for age determination as 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): $W = a * TL^b$, where W = fish weight in grams, TL = total length in centimeters, 'a' and 'b' are constants.

3. Results

A total of 126 bighead carps were sampled including 57 females and 69 males. The overall sex ratio between females and males was 1: 1.2.

The scale of bighead carp is cycloid with flat edges. Bighead carp belongs to fishes with small scale; quantity of scales in lateral line varied from 100 to 108 (mean 104.1).

The zone of the annual growth on the scales finishes at the belt (ring) of 2-5 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 = 20 fish) age estimation was the same by three readers.

The annuli on the scales of immature bighead carp appear in March (beginning of vegetation season), while those of mature fish appear during spawning period in second half of May - early June.

The total length of bighead carp – scale size relationship had strong positive significant correlation ($p > 0.05$) Figure 2. Back-calculations can be performed by using E. Lea's modification of the direct proportional method [6]. A diagonal radius between lateral and back sectors of bighead carp scale was used for age estimation, scale and annulus measuring and back-calculation of growth rate.

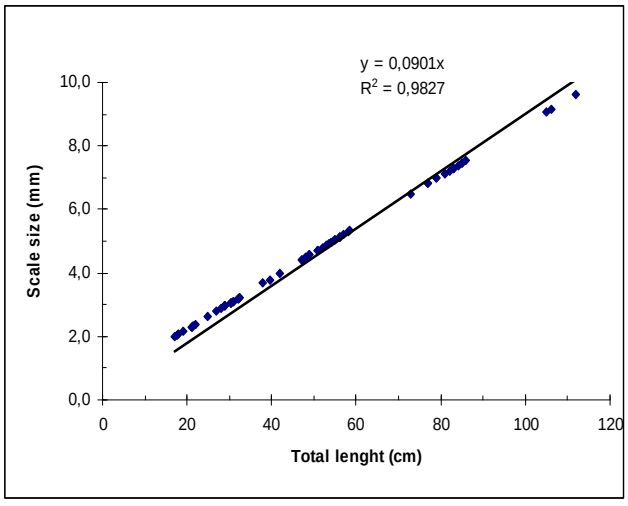

Fig 2: Total lengths – scale (diagonal radius between lateral and back sectors) size relationship of bighead carp

The ages, total lengths and weights of the samples ranged between 1 to 4 years, 17 to 112 cm and 60 to 18000 g, respectively. There were no significant differences between lengths of the sexes, so all of calculations were made using combined date (female + male). The relation between total length and weight were plotted for combined sexes (Figure 3)

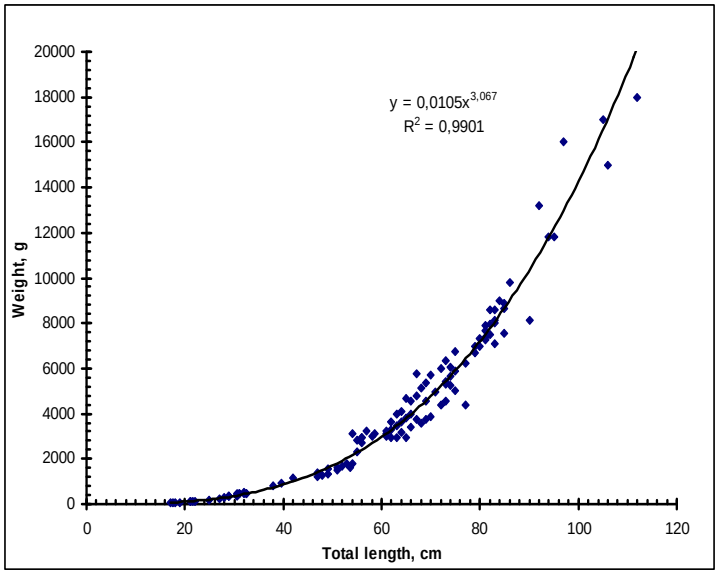

Fig 3: Total length – weight relationship of bighead carp

The relationship between the total length and the standard length was described by linear equation: SL = 0.872*TL (r = 0.99, n = 126).

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

Table 1: Mean length (TL) and weight (W) of bighead carp by age groups (Min – Max / Mean ± standard error)

	Age groups			
	I	**II**	**III**	**IV**
TL (cm)	17 – 38 26.9±1.83	39.5 - 77 54.2±2.22	62 - 85 72.3±2.78	73 – 112 90.5±5.5
W (g)	60 – 826 305.5±61.99	903 – 4400 2326.4±282.77	2925 – 9000 5589.3±692.66	5319 – 18000 10787±2069.92
Fish number	37	39	35	15

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

Year class	Age group	Number fish	Back-calculated length according to age group			
			I	**II**	**III**	**IV**
2011	I	37	27.1			
2010	II	39	25.3	51.7		
2009	III	35	26.9	60.9	84.4	
2010	IV	15	27.1	52.54	77.2	89.8
Mean total length			26.5	55.4	82.2	89.8
Mean annual increment			26.5	28.9	26.8	7.6

4. Discussion

A few studies have been conducted on the aging of bighead carp by using calcified structures. Schrank and Guy (2002) [7] have analyzed scales, dorsal fin rays and pectoral fin rays of bighead carp from the lower Missouri River. They have founded that scales above the lateral line and dorsal fin rays have precision in aging. But they did not describe peculiarities of those calcified structures for fish aging. We have found that unclosed sclerites are good morphological characteristic of annulus the same as rings on vertebrae. The annuli on the scales of immature bighead carp appear in March, while those of mature fish appear during spawning period in second half of May-early June.

Significant positive linear relationship existed between the scales radius and the fish length was showed in our study the same as for bighead carp form the lower Missouri [7]

In previous studies, the standard length was used to estimate growth parameters of inland fishes including bighead carp in the former-USSR, and the total length in many other countries. All the comparisons were done ignoring this situation (Table 3). Population's habitat in more south regions of area and zones of introduction has faster growth rate than populations from northern regions. Data determined in this study shows high growth possibility of bighead carp in environments of Tudakul reservoir, Uzbekistan.

Table 3: Growth of bighead carp in different regions

Region	Length*	Mean length in each age (cm)						Authors
		I	II	III	IV	V	VI	
Russia, Amur River	*SL*	7	18	30	46	59	64	[8]
Kazakhstan, Chardara reservoir	*SL*	37	46	66	79	90	98	[9]
Turkmenistan, Khauzkhan reservoir	*SL*	20.1	41.1	51.2	60.5	70.5	77.4	[10]
Poland, lake Diel Wielki	*TL*	12.5	24.2	39.2	50.3	58	66.7	[11]
Lower Missouri River, USA	*TL*	-	-	55	-	70		[7]
China, Laojianghe Lake	*TL*	22.7	37.3	49.3	57.4	71		[12]
Uzbekistan, Tudakul reservoir	*TL*	26.5	55.4	82.2	89.8			This study
	SL	23.1	48.3	71.7	78.3			

* - *TL* – total length, *SL* – standard length

The age, length and weight distributions of the bighead carp captured in Tudakul reservoir (Uzbekistan) ranged between 1-4 years, 17 to 112 cm and 60 to 18000 g relatively. Probably bigger and older individuals habitat in reservoir. In this water body regime of culture based fisheries is operated and bighead carp is one of main objects of stocking and capturing.

The total length (cm) –wei [6ght (g) relationship of the bighead carp was $W = 0.0105*TL^{3.067}$.

Fast growth rate of bighead carp was estimated in Tudakul reservoir. Total length of 3-years-old bighead carp was 62-85 cm; this age group is the main group in commercial capture.

Phenomenon of R. Lee did not showed because "Aqua-Tudakul" fishing company is oriented to the catch of large size fish. So, catch do not take away fish of first two-three years, all fish with different growth are presented in reservoir.

5. Conclusion

A conclusion can be made that the environment of Tudakul reservoir, its culture based fisheries management in total is at present favorable for bighead carp. 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.

The experience of fisheries management in Tudakul reservoir done by 'Aqua-Tudakul' as a culture based fisheries can be useful for other plain water bodies of Uzbekistan.

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