

Use of scale for the growth study of Indian major carp (*Cirrhinus mrigala* Ham., 1822) in tropical freshwater

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Age and growth study provide detail information on the life history, ecology of fish and habitat which is important to manage the water body for fish production and optimization of harvestable size. Scale based age and growth of Indian major carp (*Cirrhinus mrigala*, Ham. 1822) from Vallabhsagar reservoir was studied and minimum (25.0 cm and 145.0 g) and maximum (82.0 cm and 6500.00 g) length and weight of fish were observed. In length-weight relationship, constant (a) -2.212, exponent of slope; (b) 3.141 and correlation coefficient (r) 0.937 were determined. The back calculations of scale study evident that the fish attains the length and weight (27.07 cm, 243.42 g) at 1st, (38.18 cm, 644.26 g) at 2nd, (46.78 cm, 1222.73 g) at 3rd, (53.30 cm, 1813.97 g) at 4th, (62.82 cm, 2811.34 g) at 5th and (71.39 cm, 4248.94 g) at 6th year of age. The growth parameters, such as index of species average size ($\bar{\phi}$) 11.86 and index of weight growth ($\bar{\phi}_{C_w}$) 81.78 were observed. Similarly, growth constant average (Clt_{av}) were (0.410 and 0.211) indicating for two growth phases existed in fish, first is fast growing phase up to 2 years shows sexual immaturity and second is slow growing phase 2 years onwards shows sexual maturity. The results of this studies concluded that the growth of studied fish was satisfactory and environment of Vallabhsagar reservoir is conducive for survival of Indian major carp (*Cirrhinus mrigala*).

Keywords: Mrigal, Nain, Vallabhsagar

Numerical expression of the time duration that an organism has lived refers as an age whereas change in body size between two points refers as growth. Similarly, growth rate is a measure of change in fish size as a function of time². Age determination provide the quality estimate of growth and other essential biological counts such as life span, mortality, sexual maturity, harvestable size, stock composition, etc. which are important for successful fishery management which are also correlates with biological process like productivity, recruit per yield, habitat suitability and even the feeding kinematics³. Several hard body parts like scale, opercula, vertebrae, frontal bones, fine spines cleithrum and otolith are used for the age estimation. Scales are widely used to determine the age of fish because the growth rings are more prominent on scales due to the seasonal fluctuation^{4,5}. Scale based age and growth study had been done on *Cirrhinus mrigala* from Pong reservoir (Himanchal Pradesh)⁶ and on *Labeo rohita* from six different drainage of Ganaga basin⁷. Age and growth profile of *Catla catla* from rivers of north India⁴ and

Cirrhinus mrigala from Rihand reservoir⁸ (UP) were reported successfully^{4,8}. Similarly, age and growth rate of Hill stream teleost from Shrinagar (Uttharakhand)⁹ and Silver carp from Tudakul reservoir, Uzbekistan were documented¹⁰.

Mrigal (*Cirrhinus mrigala*) is an indigenous major carp widely distributed in the inland water of Indian subcontinent is also known as 'Nain' or 'Mrigal'. This species belongs to the cyprinid family, bottom feeder and comparatively having less growth rate than other Indian major carps like catla and rohu though it forms remarkable contribution in inland fishery of India. Such kind of study on age and growth of *Cirrhinus mrigala* in Vallabhsagar reservoir was not conducted, while it is commercially important fish so, present study provides concise overview of quantified data based information on age and growth of mrigal in Vallabhsagar reservoir (Gujarat).

Materials and Methods

Study area

Vallabhsagar reservoir is popularly known as Ukai dam which is one of the largest reservoirs of Gujarat and situated on 73° 32' 25" to 78° 36' 30" East longitudes and 20° 5' 0" to 22° 52' 30" North

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latitudes geographical location and it was developed across the Tapi river for multiple purposes (irrigation, hydroelectricity industries, etc.) in 1972 (Fig. 1). The morphometric features of the reservoir includes height 80.772 meters, length 4972 meters, water storage capacity 7414.29 Mm³, surface area 612 km² and catchment area is 62,255 km².

Sample collection

Scale samples were collected from 140 specimens of selected fish species during the period March to August 2013. About 5-6 scales from each fish were collected in paper envelop with keynote information (total length in cm, standard length in cm, weight in gm, date of collection fish species, etc.)¹¹.

Scale analysis

For the study, scales were dipped in 1 % KOH solution for 5-10 min and rub with fingertip to remove extraneous matter and mucous, clean and transparent scales were examined for scale radius (S) and radius of each annual rings (S₁, S₂, S₃ S₄.....S_n) was measured with the help of 4P scale reader¹¹

Calculation

The back calculation for the length, age and growth were estimated to follow methodology described as below:

- (i) Length calculation^{12,13}

$$L_n = a + \frac{S_n}{S} \times (L-a)$$
- (ii) Specific rate of linear growth¹⁴

$$Cl = \frac{L_n - L_{n-1}}{L_{n-1}} \times 100$$
- (iii) Growth characteristic¹⁵

$$C_{th} = \frac{\log L_n - \log L_{n-1}}{0.4343} \times L_{n-1}$$
- (iv) Growth constant¹⁴

$$Cl_t = \frac{\log L_n - \log L_{n-1}}{0.4343} \times \frac{t_2 + t_1}{2}$$
- (v) Specific rate of weight increase¹⁴

$$C_w = \frac{W_n - W_{n-1}}{W_{n-1}} \times 100$$
- (vi) Index of species average size¹⁶

$$\emptyset h = \frac{\sum h}{n_j + a}, h = n_j + a$$

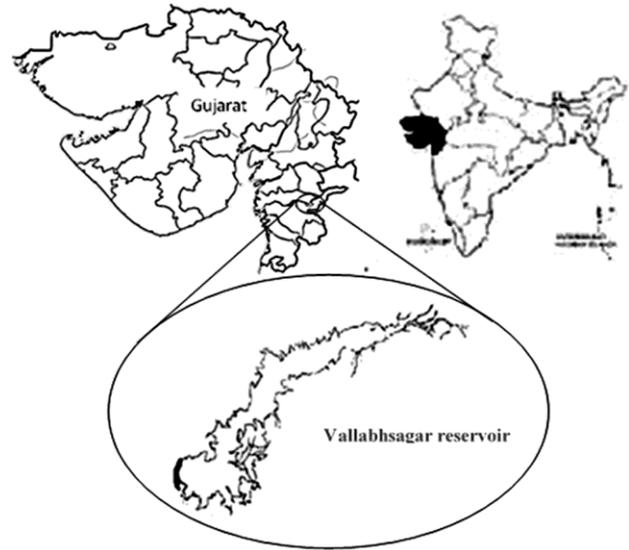


Fig. 1 — Map showing the location of study area

(vii) Index of population weight growth intensity¹⁶

$$\emptyset C_w = \frac{\sum C_w}{n_j + a}, C_w = n_j + a$$

where:

L_n, L_{n-1} = total length of fish at ultimate and penultimate age; W_n, W_{n-1} = weight of fish at ultimate and penultimate age; j = juveniles; a= adult; h= absolute increase in length; and t₁, t₂ = time intervals between ultimate and penultimate age.

Results and Discussion

LWR and LSRR

In present study length and weight relationship (LWR) and length and scale radius relationship (LSRR) were studied and correlation coefficient (r², 0.878), intercept (a, -2.212) and slop (b, 3.141) were observed from LWR (Fig. 2A) whereas, coefficient (r², 0.820), intercept (a, -0.818) and slop (b, 1.186) were found from LSRR (Fig. 2B). The linear relationship between fish length vs. scale radius and total length vs. weight were analyzed for *Cirrhinus mrigala*⁵ from Pong reservoir Himanchal Pradesh and for *Channa marulius* Harike wetland¹⁶ Punjab, respectively.

Scale based back-calculation and growth parameters

The structural details of scale were characterized by distinct markings or annulus that represents the growth pattern of mrigal in studied waterbody. In the present study total 6+ age groups were observed which is dominated by 1+ age group. The back calculated mean length (27.079 cm, 38.182 cm, 46.788 cm, 53.303 cm, 62.829 cm, and 71.395 cm)

and mean weight (243.429 gm, 644.265 gm, 1222.739 gm, 1813.979 gm, 2811.347gm and 4248.949 g) were observed for age group 1+, 2+, 3+, 4+, 5+ and 6+, respectively (Table 1 and Fig. 3).

Growth parameters, annual length increment (h) was depicted irregular pattern as it decreases up to

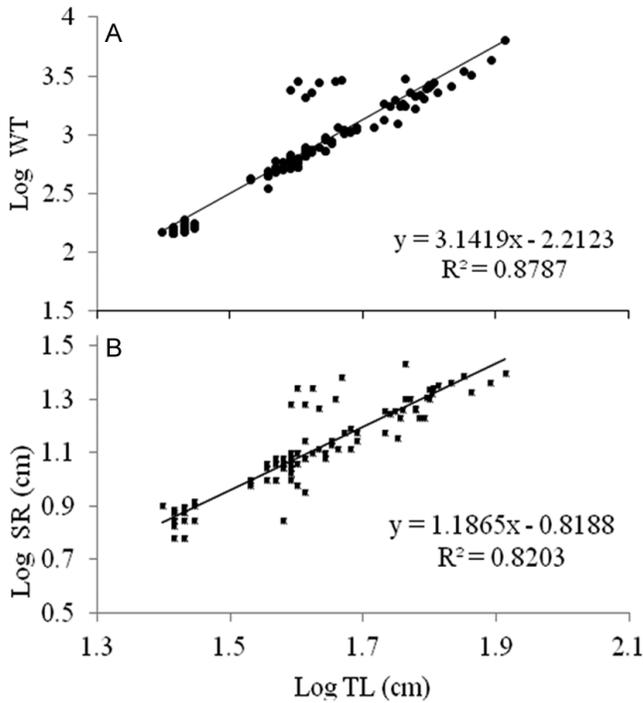


Fig. 2 — Linear relationship between (A) total length (cm) and weight (g); and (B) total fish length (cm) and scale radius (cm)

4+ age group and after that start to increase whereas annual weight increment (w) observed regular increasing trend from 1+ age group to 6+ age group. Specific rate of linear growth (C_l), specific rate of

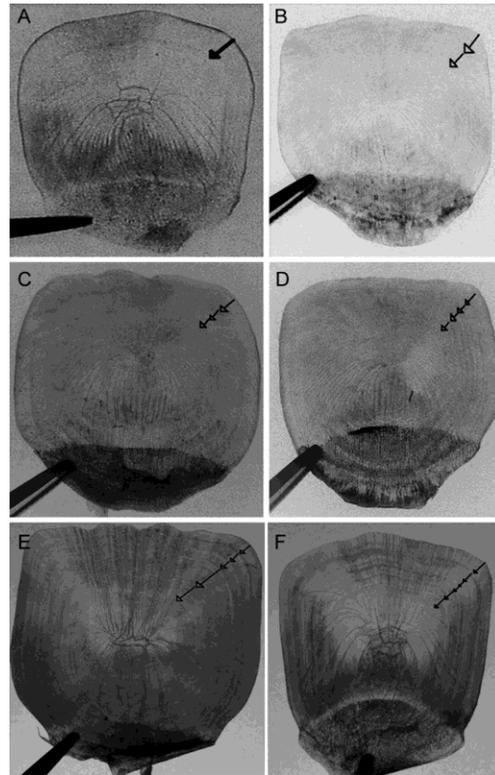


Fig. 3 — Image of typical scale of mrigal. [(A-F) +1, +2, +3, +4, +5 and +6 year class, respectively]

Table 1 — Growth rate of *Cirrhinus mrigala* from Ukai reservoir Gujarat

Parameters		Age group					
		1+	2+	3+	4+	5+	6+
Length (cm)	N	55	30	22	14	10	9
	Minimum	15.600	23.243	25.568	38.182	55.061	60.857
	Maximum	46.951	50.549	60.545	67.464	67.826	78.720
	Mean (L)	27.079	38.182	46.788	53.303	62.829	71.395
	H	27.079	10.890	8.606	6.515	9.526	8.566
	Øh				11.864		
	C_l	40.217	22.540	13.924		17.871	13.634
	C_{th}	9.305	7.761	6.099		8.764	8.030
	C_{lt}	0.515	0.305	0.196		0.247	0.192
	$C_{lt(av)}$		0.410			0.211	
Weight (g)	N	55	30	22	14	10	9
	Minimum	34.419	120.477	162.540	573.051	1810.246	2479.173
	Maximum	1097.235	1383.812	2439.442	3427.312	3485.368	5565.438
	Mean (W)	243.429	644.266	1222.739	1813.979	2811.347	4248.949
	W	243.429	400.837	578.473	591.240	997.368	1437.602
	ØC _w				81.784		
	C _w	164.663	89.788	48.354		54.982	51.136

[Where 'L' is back calculated length (cm); 'h' is annual length increment (cm); Øh is index of species average size; C_l is specific rate of linear growth; C_{th} is growth characteristic; C_{lt} is growth constants; $C_{lt(av)}$ is growth constant average; 'W' is back calculated weight (g); 'w' is annual weight increment (g); ØC_w is index of weight growth intensity; and C_w is specific rate of weight increase]

weight (C_w), growth characteristic (C_{th}), growth constant (C_{lt}) shows irregular trends. The life span of mrigal is divided in two phases based on the growth constant average [$C_{lt(av)}$]. It observed 0.410152 up to 2+ age group and for +2 age group onwards it was 0.21129. Index of species average size ($\bar{\phi}_h$) and index of population weight growth intensity ($\bar{\phi}C_w$) were observed as 11.863 and 81.784, respectively.

The maximum annual increment in length is found to occur in the first year of life. In the subsequent years, it decreases with increase of age except in 5th year of age indicating the phenomenon of growth compensation. The irregular pattern of annual length increments, linear relationship between fish length and scale radius were reported for *Cirrhinus mrigala* from pong reservoir (HP)⁶ and on *Channa marulius* from Harike wetland (Punjab)¹⁷. Specific rate of linear growth (C_l) and specific rate of weight increase (C_w) used to compare the growth rates of different species in the same water body or same species of different water bodies and reported notable decline during the study except life span of 4th and 5th year¹⁸. Similar trend of growth was also observed in *Labeo calabasu* from Jawahar Sagar dam Rajasthan¹⁹, in *Salmophasia balookee* from Krishna river, Sangli²⁰ and in *Labeo rohita* from Dehradun²¹.

Growth characteristic (C_{th}) is a very helpful parameter to establish growth periods²² while growth constant (C_{lt}) is useful to determine the period of life span of the fish⁷. In the present study both parameter shows the regularity in the growth from 1st to 2nd year which is first growth phase also termed as growth before sexual maturity while irregular trends in the subsequent period that is second growth phase or growth after sexual maturity. Similar growth pattern of *Cirrhinus mrigala* was observed from Pong reservoir Himanchal Pradesh⁶ and on *Catla catla* from selected water bodies of southern Rajasthan⁵. Age and growth of *Cirrhinus mrigala* from tributary of Ganga reveal that growth increment of female fishes higher compared to male while 2+, 3+ and 4+ male fishes showed higher growth increment compared to female²³.

The index of species average size ($\bar{\phi}_h$) is helpful to classify the fish based on its commercial importance and index of population weight growth intensity ($\bar{\phi}C_w$) indicate that the fish follow the general growth pattern. In current study, index of species average size ($\bar{\phi}_h$, 11.864) and index of population weight growth intensity ($\bar{\phi}C_w$, 81.784) were satisfactory and

similar observations were documented on mrigal from Rang Mahal, Harike and Govindsagar²⁴, on *Catla catla* and *Labeo calabasu* from different water bodies of Rajasthan^{5,19}. Growth performance study of *Schizothorax waltoni* in Yarling Tasngpo river China based on different growth parameters reveal similar growth rate in male and female up to 8 year of age²⁵. The results on LWR, LSRR and age and growth studies depicts that the growth of studied fish was satisfactory and environment of Vallabhsagar reservoir is conducive for Indian major carp (*Cirrhinus mrigala*).

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