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Determination of scale based growth parameters of *Labeo rohita* (Ham. 1822) from Vallabhsagar Reservoir, Gujarat (India)

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Abstract
The Indian major carp, *Labeo rohtia* (Ham. 1822) is the popular and commercially important freshwater fish. The objective of present study, elucidate the growth performance of fish and different growth parameters based on the scale analysis of rohu in Vallabhsagar reservoir. For this study about 662 fish scale samples were randomly collected from May 2013 to June 2014 and analysed which shows that these fishes containing 40.67-85.05 cm and 770-5591 gm back calculated length and weight respectively were directly proportionate to the age. The computation of growth parameter, annual length increment (H), annual weight increment (w), specific rate of linear growth-length (C_l), growth characteristic (C_{th}), Growth constant (C_{lt}) and specific rate of increase in weight (C_w) resulted inversely proportionate to the age of studied fish. The findings of the growth constant average ($Clt_{(av)}$) shows three life stages of fish in that one growth phase was before sexual maturity (0.25) and two growth phases were after sexual maturity (0.07 and 0.03). The study concluded that the growth of *Labeo rohita* was uniform and satisfactory in the reservoir due to the conducive aquatic environment and less rivalry for food and place in intra-species and inter-species.

Keywords: Rohu, age, growth parameters, scale, Vallabhsagar

1. Introduction
Labeo rohita (Ham.1822) is locally known as rohu, rui or roho and inhabitant of inland water resources like rivers, canals, lakes etc. The fast growth, high market price, high people demand, survive in different habitats and herbivorous feeding habit are the important reasons for popularisation of the farming of rohu. The information on fish biology and ecological needs are the requirements to improve the carp culture [1-2]. Among the fish biological information, determination of age and growth parameters are the important scientific tool to know the age at first maturity, population dynamics, growth estimation and harvestable size of the fish [3-12]. Age of fish can analysed by several hard parts like scale, opercula, vertebrae, fine spines cleithrum and otolith but among these hard parts scales are widely use and suitable because it shows high degree of polymorphism in tropical environment [13-15] and clear seasonal growth rings are more prominent [16-18]. Age and growth of Indian major carps were investigated to resorting the scale studies [19-22]. Recently, Mir [2], Ujjania [6] and Soni [12] studied the age and growth parameters of Indian major carps including rohu form six drainage of Ganga basin, different water bodies of southern Rajasthan and Vallabhsagar reservoir (Gujarat) respectively, Age and growth profile of *Catla catla* was reported from rivers of north India [16], *Cirrhinus mrigala* from Rihand reservoir (UP) [23], hill stream teleost from Srinagar (Uttharakhand) [24], silver carp from Tudakul reservoir, Uzbekistan [25] and *Cirrhinus mrigala* from Pong reservoir (Himachal Pradesh) [26]. In the view of the importance of such biological parameters for fisheries management, the present investigation was undertaken for rohu from Vallabhsagar reservoir, Gujarat.

2. Materials and Methods
2.1 Study area
Vallabhsagar reservoir is popularly known as Ukai dam and was constructed across Tapi river of Gujarat in 1971 on $73^0$32'25" to $78^0$36'30" E longitudes and $20^0$5'0" to $22^0$52'30" N latitudes (Fig. 1). The important morphometric features of the reservoir is including height 80.772 meters, length 4972 meters, water storage capacity 7414.29 Mm^3, surface area 612 km^2 and catchment area is 62,255 km^2.

2.2 Scale sample collection

Scale samples (5-6 scales) were randomly collected from 662 fish specimens from June 2013 to May 2014. These scales samples from each specimen were collected in paper envelop with keynote information like total length in cm, standard length in cm, weight in gm, date of collection, name of fish etc.

2.3 Scale Analysis

Scales were analyzed to follow the treatment in 1 % KOH solution and wash with freshwater by fingertip rubbing to remove the extraneous matter and mucous. Dried, clean and transparent scales were used to measure the scale radius (S) at diagonal transect from the focus point of scale edge and similarly radius of each annual rings (S_1, S_2, S_3 S_4…….S_n) on the scale with the help of 4P scale reader [8].

2.4 Data analysis

The back calculation of length, weight and different growth parameters following methodology were followed:

Length and weight calculation [27, 28].

$$L_n = a + \frac{S_n}{S} \times (L-a)$$

$$\text{Log } W = \text{Log } a + b \text{ Log } L$$

Specific rate of linear growth-length [29].

$$Cl = \frac{Ln - Ln\text{-}1}{Ln\text{-}1} \times 100$$

Growth characteristic [30].

$$Cth = \frac{\text{Log } Ln - \text{Log } Ln\text{-}1}{0.4343} \times Ln\text{-}1$$

Growth constant [29].

$$Clt = \frac{\text{Log } Ln - \text{Log } Ln\text{-}1}{0.4343} \times \frac{t_2 + t_1}{2}$$

Specific rate of increase in weight [29].

$$Cw = \frac{Wn - Wn\text{-}1}{Wn\text{-}1} \times 100$$

Index of species average size [31].

$$Øh = \frac{\sum h = 1}{nj + a}, \quad h = nj + a$$

Index of population weight growth intensity [31].

$$ØCw = \frac{Cw = 1}{nj + a}, \quad Cw = nj + a$$

2.5 Where

L_n, L_{n-1} are total length of fish at ultimate and penultimate age, W_n, W_{n-1} are weight of fish at ultimate and penultimate age, j is juveniles, a is adult, h is absolute increase in length and t_1, t_2 are time intervals between ultimate and penultimate age.

3. Result and Discussion

The growth parameters of *Labeo rohita* from Vallabhsagar was determined on the basis of scale analysis and the correlation between total length and scale radius was established which shows the linear relationship and significant correlation coefficient (r) 0.916 of the variables (Fig. 2) may be attributed to the satisfactory growth, food availability and favourable aquatic environment. High degree of correlation between fish length and scale radius were also documented for mrigal from Southern Rajasthan [6], for *Labeo rohita* from Jaisamand lake Rajasthan [32] and for *Channa marulius* in Harike wetland, Punjab [33] whereas, weak relationship between these variables was reported for *Cirrhinus mrigala* from Tanda dam (Pakistan) [34].

Scale analysis based back calculation of growth parameters were resulted (40.67 cm, 770g), (51.56 cm, 1559g), (61.15 cm, 2307 g), (67.57 cm, 3015 g), (72.18 cm, 3599 g), (76.19 cm, 4163 g), (79.06 cm, 4600 g), (81.32 cm, 4958 g), (83.35 cm, 5296 g) and (85.04 cm, 5591 g) in total length and weight for 1+, 2+, 3+, 4+, 5+, 6+, 7+, 8+, 9+ and 10+ year age of fish respectively (Table 1 and Fig. 3 A & B) which was directly proportionate to the age whereas annual length increment (H) and annual weight increment (w) was inversely proportionate to the age (Table 1). The present study indicated uniformity in the growth pattern of studied fish might be due to the similar ecological factors and probably reflection of similar life history traits which was phenotypically same in the respective stocks. The present findings in consonance with similar study for tilapia from Jaisamand Lake (Rajasthan) [35] and for *Hucho hucho* from five different rivers of Europe [36]. However, the difference in observed and back calculated length weight was reported in Salmon fish from Portland Alaska due to adverse climatic condition [37]. Johal and Tandon [38] were also reported more growth rate of Carps early stage of life in water bodies of north India.

The scale based growth parameters of fish generate the growth history of fish and valuable tool for fish biologist and ecologists [39]. The specific rate of linear growth-length (C_l), growth characteristic (C_{th}), Growth constant (C_{lt}) and specific rate of increase in weight (C_w) are the important growth parameters to establish growth periods of the fish and in study it was 26.76, 9.64, 0.35 and 89.42 for 1st year and 2.02, 1.67, 0.03 and 5.54 for 10th year of age of fish respectively which were found inversely proportionate to age (Table 1). These observations may be attributed to the availability of space and food for older fishes. These observations are analogous with the observation for tilapia from Jaisamand lake Rajasthan [7] and similar trend of growth parameters of rohu was reported from Jaisamand Lake, Rajasthan [32]. Comparative growth rates of *C. catla, L. rohita* and *C. mrigala* of Govindgarh Lake was studied and the rapid growth in these species was reported at the first year after that it was diminutive whereas growth increment was maximum in *C. catla*, followed by *L. rohita* and *C. mrigala* [40]. The specific rate of weight was increase in decreasing trend with age for catla in Yamuna, Bhagirathi and Saryu rivers but it was irregular in case of Ganga river [41].

The determination of growth constant average ($Clt_{(av)}$) shows the fish life span or growth phases of fish and in current investigation three growth phases were observed in that first phase (0.25) before sexual maturity while second and third phases (0.07 and 0.03) after sexual maturity (Table 1). Similarly, three growth phases were reported in Indian major carps from Mahi Bajaj Sagar, Surwania dam and Aasan pond Rajasthan [6], for exotic fish tilapia from Jaisamand lake [7] and for catla from Bhagirathi and Sutlej river [41] while two growth phases were reported for from Jaisamand lake, Rajasthan [32].

The index of species average size (Øh) and Index of population weight growth intensity ($ØC_w$) are the important growth parameter for general growth pattern and commercial importance of fish. The values of these indices was comparatively less (8.50 and 27.09) in current investigation which shows the less competition for food and shelter of rohu with other fishes in reservoir (Table 1). The similar findings were also reported within same age group of catla fish from Mahi Bajaj Sagar, Surwania Dam and Aasan pond from southern Rajasthan [17]. The species average size 12.49 was reported for Tilapia from Jaisamand lake Rajasthan [6] and 14.70 for *Channa marulius* from Punjab [33].

Table 1: Growth parameter of *Labeo rohita* from Vallabhsagar

Parameters	**1+**	**2+**	**3+**	**4+**	**5+**	**6+**	**7+**	**8+**	**9+**	**10+**
L	40.67	51.56	61.15	67.57	72.18	76.19	79.06	81.32	83.35	85.04
H	40.67	10.88	9.58	6.42	4.61	4.00	2.87	2.25	2.02	1.69
ØH	8.50									
Cl	26.76	18.59	10.50	6.82	5.55	3.77	2.85	2.48	2.02	
Cth	9.64	8.79	6.10	4.46	3.90	2.82	2.22	1.99	1.67	
Clt	0.35	0.25	0.14	0.09	0.08	0.05	0.04	0.03	0.03	
$Clt_{(av)}$	0.25			0.07			0.03			
W	770	1559	2307	3015	3599	4163	4600	4958	5296	5591
w	770	789	748	708	584	563	437	357	338	293
Cw	89.42	58.07	30.69	19.36	15.64	10.52	7.76	6.83	5.54	
ØCw	27.09									

Where

L is back calculated length (cm), H is annual length increment (cm), ØH is index of species average length, C_l is specific rate of linear growth (length), C_{th} is growth characteristic, C_{lt} is growth constants, $C_{lt(av)}$ is growth constant average, W is back calculated weight (gm), w is annual weight increment (gm), $ØC_w$ is index of species average weight and C_w is specific rate of increase in weight.

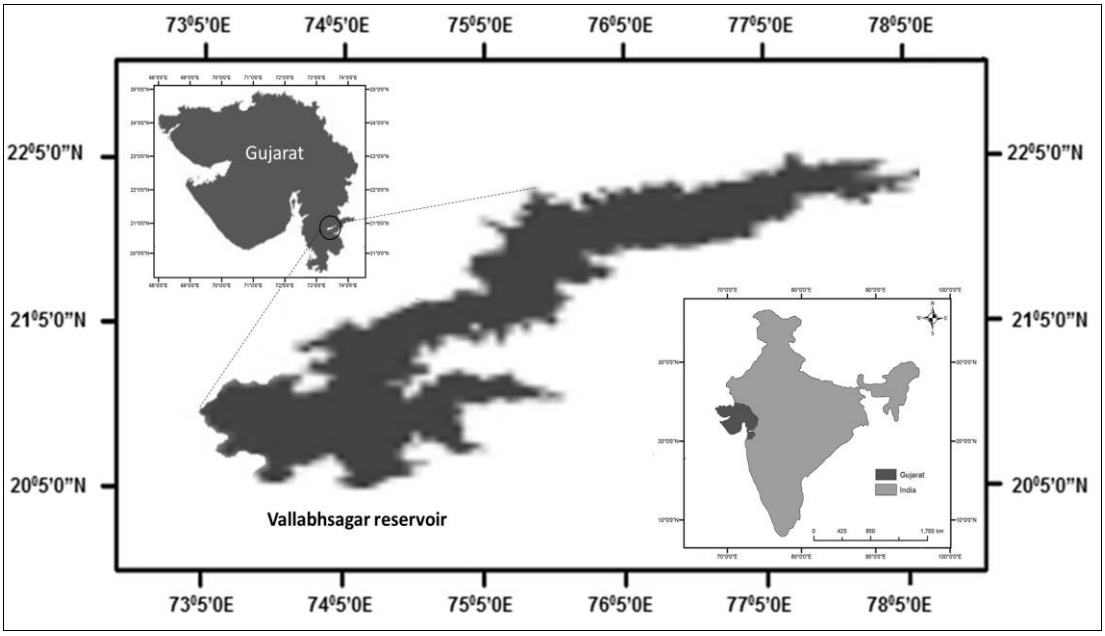

Fig 1: Map of study area

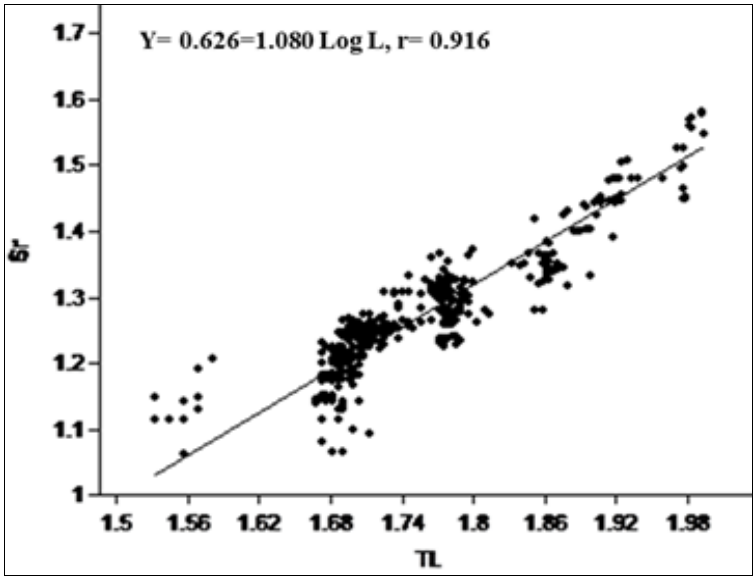

Fig 2: Total length and scale radius relationship of rohu

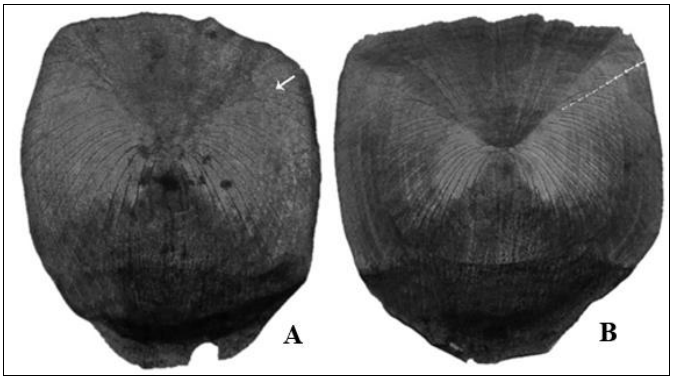

Fig 3: Typical scale of rohu from Vallabhsagar A is +1 year and B is +10 year

4. Conclusion

The present study concluded that growth (length and weight) of rohu was high during the initial years whereas it was low at the age of fishes advanced. The growth parameters, annual length increment (H) and annual weight increment (w) depicted uniformity in growth pattern whereas growth constant average ($Clt_{(av)}$) shows the three growth phases in that one at before sexual maturity and two at after sexual maturity of the studied fish. It was also concluded that the growth of rohu (*Labeo* rohita) in Vallabhsagar reservoir was satisfactory due to the conducive aquatic environment and in intra-species and inter-species rivalry for food and place was less.

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