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RELATIVE AGE AND GROWTH OF INDIAN MAJOR CARP, *CIRRHINUS MRIGALA*, FROM PENINSULAR RIVERS OF INDIA

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The age of Indian major carp, *Cirrhinus mrigala* (Hamilton, 1822) was determined from 208 specimens from five peninsular rivers (Mahanadi, Godavari, Kaveri, Narmada and Mahi) of India by observing the annual rings in scale. Using length-frequency method and scale study, it was found that only River Mahi holds 6+ year class of *C. mrigala* stocks. A strong linear relationship was found between fish length and scale radius of this species in all the riverine populations, with significant correlation coefficient. The first growth ring was found at an average length of 27.86, 28.86, 37.22, 26.77 and 25.59 cm in specimens from Mahanadi, Godavari, Kaveri, Narmada and Mahi, respectively. It is evident from our result that the fishes exhibited rapid growth rate during the first two years of their age but later, growth was moderate. Growth rate decreased successively at higher ages.

INTRODUCTION

Cirrhinus mrigala (mrigal) is a cultivable freshwater fish belonging to family Cyprinidae. Mrigal inhabits all the major river systems of India, Pakistan, Bangladesh, Myanmar, Lao's and Thailand. In India, it is one of the most commonly cultured species along with other Indian carps in polyculture system. However, capture fisheries of this species have exhibited a declining trend as evidenced from the comparison of survey data from 1958 to 1994 (FAO, 2004). The ability to perform age determinations based on examinations of hard anatomical parts is of fundamental importance in fisheries research. Age provides a means to understand the composition of fish population, while growth parameters differ from species to species and from stock to stock within the same species depending upon the habitat conditions. As for trees, for which an age may be determined by counting annual rings in a cross section of the trunk, certain structures of finfish taken from temperate waters also show alternating structural marks caused by changes in growth rates. Powel (1981) mentioned that the validity of any skeletal method for the study of growth depends on the occurrence of isometric growth between skeletal structure and body length of fish. The use of scales moved rapidly from discovery to application during the first quarter of the last century (Lee, 1920; Carlander, 1987). Several studies on scales for age and growth determination of Indian fishes have been undertaken (Kagwade, 1971; Hanumantha Rao, 1974; Singh and Sharma, 1995; Deepak *et al*., 2008; Khan and Khan, 2009 and Khan *et al*., 2011).

Analysis of fish scales has been shown to be a good discriminator of stocks using growth rings on the scale. This is evident from studies on age determination of several riverine fish species. In many cases, the rings have been shown to be annual, probably due to seasonal fluctuations in growth. The analysis of fish scale for age determination is inexpensive, quick, non-destructive and informative and, could easily be added to existing monitoring programmes. The present study highlights the potentially important and opportunistic information that can be gained from the analysis of fish scales. It is anticipated that this study will be fundamental in shaping future mrigal population assessments as well as conservation.

MATERIALS AND METHODS

A total of 208 mrigal samples were collected during 2009-2011 from peninsular rivers (Fig. 1). Fishes were caught by either gill net or cast net. From the total, 38 samples were from River Mahanadi, 49 from River Godavari, 49 from River Kaveri, 35 from River Narmada and 37 samples were from River Mahi (Table 1). Total length (TL) was measured to the nearest centimeter. Body weight was recorded to the nearest gram as total weight (TW). From each fish sample, 5-10 scales were removed from above the lateral line near the tip of the pectoral fin, preserved in normal saline water and stored in cool and dry place wrapped in paper. Before analysis, scales were dipped in 1% KOH solution and washed 2-3 times with tap water with gentle rubbing by fingertips to remove mucus and other dust materials. The scales were then observed under a profile projector (Sipcon Profile Projector SP-400, India).

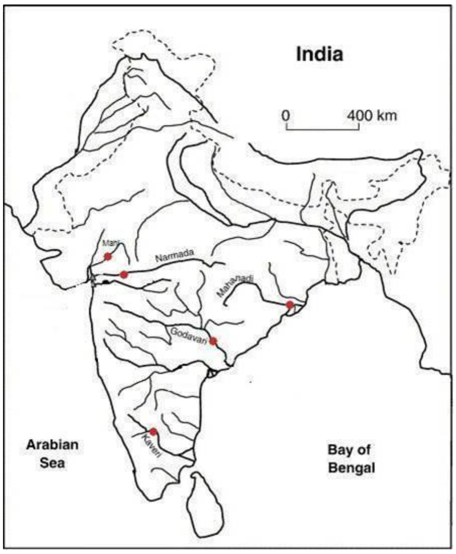

Fig. 1. Sampling sites (marked) of mrigal from five peninsular rivers (Mahanadi, Godavari, Kaveri, Narmada and Mahi).

Table 1. Sampling sites along with geographical co-ordinates, sample size and year of sampling from peninsular rivers of India

Rivers	Sampling sites	Sample size (n)	Year of sampling
Mahanadi	Cuttack (20.27ºN85.52ºE)	38	2009 (round the year)
Godavari	Rajahmundry (16.59ºN81.47ºE)	49	2010 (April)
Kaveri	Mysore (12.18ºN76.38ºE)	49	2011 (April)
Narmada	Varuch (21.7ºN72.97ºE)	35	2011 (March)
Mahi	Anand (22.57ºN72.93ºE)	37	2011 (March)
	Total	208	

Age determination through scale reading

In the scales of mrigal the presence of alternating fast- and slow-growth areas were identified and only the complete and bright lines were considered as annuli. A fast-growth area (transparent zone) and a slow-growth area (opaque zone) were taken together to indicate one year's growth (Fig. 2). Each slow-growth zone consisted of compactly packed continuous circuli preceded by a transparent zone which is represented by a number of comparatively widely spaced circuli. The distance between the successive annuli decreases in fish of older age groups due to close spacing of annuli on scales. The scale measurements comprised of radius of scale and radius of all the annuli from the focal point, which were studied under the scale reader/profile projector (Sipcon Profile Projector SP-400, India). The total scale radius from the focal point of the scale to the edge was measured to establish the relationship between the fish length and total scale radius. The distance between the focus of the scale and each annulus was measured for back-calculation and growth rate analysis.

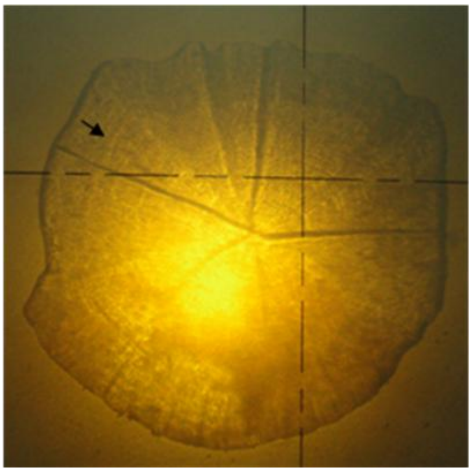

Fig. 2. Arrow showing one growth check on mrigal

The existence of a relationship between fish length and scale radius (or other hard structures) is a key assumption underlining back-calculation. This assumption was tested on data collected for the species for each river (population). Data collected from multiple sites within the same river were combined because of the short distance between sampling points. Linear least square regression analysis was performed to establish whether a relationship exists between fish length and scale radius at the time of capture. Regression coefficient values for individuals from each river were calculated. Scales and Petersen's method of length-frequency analysis was employed for the age and growth studies in mrigal. Assuming that relationships are linear, length was then estimated for each age by the following formula (Fraser-Lee Method or Direct proportion method):

$$Le = Dr/Dm*LT$$

Where, Le = Estimated length, Dr = Distance from focus to the chosen annuli, Dm = Radius of the scale and LT = Total length of the fish at capture

RESULTS

The scales of mrigal were examined from five peninsular rivers of India to check the relative age and growth of the fishes from different water bodies. The scales with less than one or no complete ring are considered to be within one year or zero year class fishes, respectively. When there is a single complete annuli formed in the scale the fishes are said to attain one year class. By doing this, maximum of 6+ yr fishes were observed. From the length frequency distribution pattern the 0-1 yr class fishes were found abundantly in every riverine resource of peninsular India (Fig. 3).

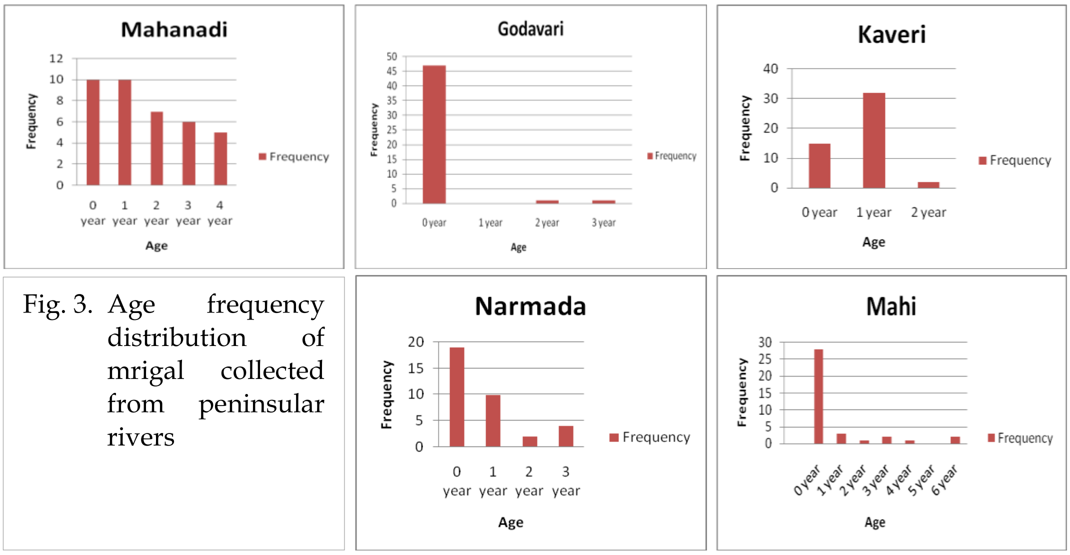

Fig. 3. Age frequency distribution of mrigal collected from peninsular rivers

Relationship between fish length and scale length

The scatter diagram in Fig. 4 denotes the straight line relationship between fish length and scale length. Relationship was expressed as Y = a + bX, Where Y = Scale length

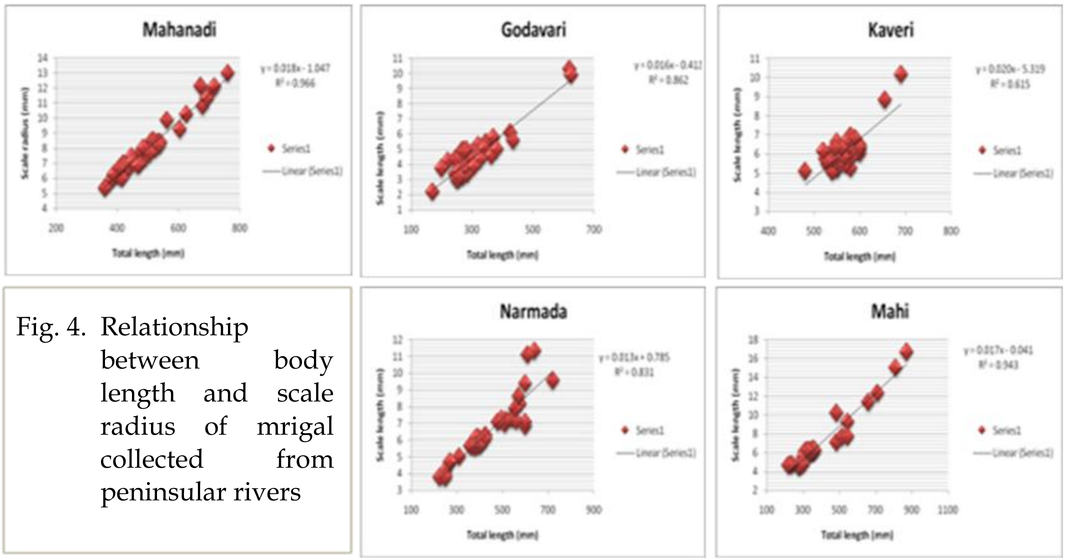

Fig. 4. Relationship between body length and scale radius of mrigal collected from peninsular rivers

and X = Fish length. The linear agreement of the relationship was supported by high correlation coefficient (r^2) in Mahanadi followed by Mahi, Godavari, Narmada and Kaveri. The intermediary fish lengths were thus back-calculated from the above regression equation for all the specimens and mean lengths at the ages were computed for every population sample in the size range of 29.36–84 cm.

Growth rate

Growth rate of individual fish from every population was assessed by back-calculation. The first growth ring was laid down at an average length of 27.86, 28.86, 37.22, 26.77 and 25.59 cm in Mahanadi, Godavari, Kaveri, Narmada and Mahi, respectively. The annual increment in length was calculated to be 27.86, 12.03, 5.50 and 9.33 cm for 1st, 2nd, 3rd and 4th year class, respectively for River Mahanadi, 28.86, 14.95 and 6.34 cm for 1st, 2nd and 3rd year class for River Godavari, 37.22 and 9.88 cm for 1st and 2nd year class for River Kaveri, 26.77, 7.12 and 10.84 cm for 1st, 2nd and 3rd year class for River Narmada and 25.59, 12.58, 10.90, 7.23, 4.27 and 7.11 cm for 1st, 2nd, 3rd, 4th, 5th and 6th year class, respectively for River Mahi. The 4th year class in River Mahanadi, 3rd year class in Narmada and 6th year class in Mahi showed high growth rate over its previous age group. The phenomenon is referred to as growth compensation (Table 2).

DISCUSSION

This study is principally concerned with the annulus marks on the scales of fish. The growth of a fish is not uniform throughout its total life span, it shows alternating fast and slow rates of growth depending on favorable or adverse ecological conditions. Incomplete rings may sometimes occur which are not clear and may be associated with external factors such as the dry season, non-availability of food, disease, water temperature variation and loss of condition (Seshappa, 1999).

In the present study six annual rings were observed in scales from mrigal population from Mahi and 4 from Mahanadi whereas 3 each in Godavari and Narmada and 2 rings in Kaveri were observed. Various reasons have been put forward by various authors regarding ring formation in the scales. Fage and Veillet (1983) described that maturity of gonads may cause decrease in feeding activity leading to decrease in growth rate. Non-availability of food was suggested as the major cause for clear annuli formation by Natarajan and Jhingran (1963). Sunder and Subla (1987) however, reported temperature as the most important factor for annulus formation.

In the present study, fish lengths plotted against the total scale radius produced a straight line relationship. Linearity between body length and scale radius should always be tested as an assumption of back-calculation. Similar observations were made in several other Indian fish species such as *Labeo calbasu* (Tandon *et al*., 1989), *T. putitora* (Pathani,

Table 2. Back-calculated lengths and growth rates of mrigal collected from peninsular rivers

	Age Class	n	Avg Length	L1	L2	L3	L4	L5	L6
Mahanadi	0 yrs	10	41.4 cm						
	1yr	10	44.35 cm	22.79					
	2yrs	7	55.54 cm	31.20	44.21				
	3yrs	6	58.03 cm	27.93	37.97	45.73			
	4yrs	5	67.76 cm	29.52	37.49	45.06	54.73		
	Total	38	53.416	27.86	39.89	45.40	54.73		
Annual increment in length (cm)				27.86	12.03	5.50	9.33[a]		
Godavari	0 yrs	47	29.36						
	2yrs	1	62.0	41.19	48.52				
	3yrs	1	62.5	16.53	39.12	50.16			
	Total	49	51.28	28.86	43.82	50.16			
Annual increment in length (cm)					14.95	6.34			
Kaveri	0 yrs	15	56.45						
	1yr	32	56.60	47.62					
	2yrs	2	67.25	26.82	47.10				
	Total	49	60.10	37.22	47.10				
Annual increment in length (cm)				37.22	9.88				
Narmada	0 yrs	19	34.52						
	1yr	10	54.32	36.15					
	2yrs	2	58.5	22.71	34.47				
	3yrs	4	65.66	21.44	33.32	44.74			
	Total	35	53.25	26.77	33.89	44.21			
Annual increment in length (cm)				26.77	7.12	10.84[a]			
Mahi	0 yrs	28	31.20						
	1yr	3	51.5	26.57					
	2yrs	1	54.5	18.99	32.26				
	3yrs	2	57.25	26.87	37.06	50.43			
	4yrs	1	71.0	33.00	50.83	55.54	59.77		
	6 yrs	2	84.0	22.53	32.55	41.37	52.86	60.59	67.71
	Total	37	58.24	25.59	38.18	49.08	56.32	60.59	67.71
Annual increment in length (cm)				25.59	12.58	10.90	7.23	4.27	7.11[a]

[a] Growth compensation
n, number of specimens in each age class
L1-L6, length in successive years

1981, Nautiyal, 1990; Tandon *et al*., 1993), *Barilius bendelisis* (Dobriyal and Singh, 1990) and *Schizothorax richardsonii* (Singh and Sharma, 1995). In the present investigation, strong linear relationship was found between fish length and scale radius of mrigal population from Rivers Mahanadi (r^2 = 0.966), Godavari (r^2 = 0.862), Narmada (r^2 = 0.831) and Mahi (r^2 = 0.943). The relationship however, was relatively weaker for the specimens from River Kaveri (r^2 = 0.615). This type of variations in regression coefficient might be due to the different environmental conditions. Ibanez *et al.* (2008) suggested that when the proportionality between the body length and scale radii is weak, back-calculation methods were poor in determining length at check formation. However, it could be presumed that any changes in the rate of the body growth would lead to a similar increase in scale size. Thus any great deviation from an r^2 of 1 is likely when the scale samples were removed from different body regions, scales might have suffered erosion or were unsymmetrical, or errors associated with inaccurate measurement of a fish or its scales. In our study, there was no significant deviation seen in the r^2 values because the samples were removed from the same body region for all the samples. The weak relationship between fish length and scale radius in Kaveri population is due to the marginal difference in average lengths as evidenced from Table 2. In the present study, the length frequency distribution showed model increments with fish size, assuming that mrigal in the peninsular region have single natural spawning season. It is evident from our result that the fish exhibited rapid growth rate during the first two years of its age but later growth was moderate. This indicated that mrigal attains the maturity at the age of two and, after the maturity and spawning the growth rate gets moderated. This is in agreement with the general maturity behavior of Indian major carps including mrigal.

Growth rate declined successively in higher age classes. The fish specimens of the first year group showed the highest growth rates i.e., 27.86 cm growth in Mahanadi, 28.86 cm in Godavari, 37.22 cm in Kaveri, 26.77 cm in Narmada and 25.59 cm growth in Mahi populations. Growth compensation has been detected in the 4th year class in Mahanadi, 3rd year class in Narmada and 6th year class in Mahi of mrigal. Similar findings have also been reported in other Indian fish species such as *Catla catla* (Johal and Tandon, 1992), *L. rohita* (Tandon and Johal, 1993), *T. putitora* (Tandon *et al*., 1993) and *S. richardsonii* (Singh and Sharma, 1995).

The growth estimation on the basis of scale studies of mrigal performed in the peninsular rivers showed that the growth was the fastest in Mahanadi and Mahi Rivers followed by Godavari, Narmada and Kaveri Rivers. It is apparent that biological performance of any fish in a particular water body may depend on the environmental stability, which was better in Mahanadi River and Mahi River, whereas natural food source scarcity or poor quality of planktons did persist in River Kaveri. This variation could be attributed to environmental changes of the water bodies.

The present findings on the age and growth analysis of *C. mrigala* from peninsular rivers of India should be useful for future fishery management of this species and also to effect good conservation and restoration planning.

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