Bull. Dept. Mar. Sci. Univ. Cochin, 1982, XIII, 81—95

ON THE AGE AND GROWTH OF THREE INDIAN MAJOR CARPS FROM HIRAKUD RESERVOIR

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ABSTRACT

Studies on the age and growth of three Indian major carps viz. *Catla catla* (Ham), *Cirrhina mrigala* (Ham) and *Labeo rohita* (Ham) based on scale and the length frequency data are presented. The markings on the scales of these fishes were used as indices of age, after ascertaining the annual nature of formation of growth checks. It was found that in these three fishes rings were laid down almost during the same period i.e. May to August. The result obtained from scale study is compared with Petersen Method. A close agreement can be seen in their values obtained. Von Bertalanffy's growth equation was used for fitting the growth data obtained by scale study and it adequately describe the actual growth of these fishes. The length at age and the rate of growth of these fishes were compared and it was found that rate of increase in length was faster during the initial periods of life and decrease when they become old.

INTRODUCTION

Investigation on age and growth of fish is of prime importance in management and forecast of their fisheries. Growth studies from Indian waters are largely based on length frequency distribution as age determination by other conventional methods are found difficult. In some fishes, though the hard parts like scales. otoliths and bones show clear zonations, it is difficult to conclude that these are formed annually only (Qasim, 1973).

Though considerable work has been done on the use of scales for age determination in marine fishes, studies on age and growth in freshwater fishes especially on Indian major carps are meagre. Except the works of Jhingran (1959), Yusuf Kamal (1969) and Rao (1974) on *Cirrhina mrigala* and that of Natarajan and Jhingran (1963) on *Catla catla,* no other attempt is made so far on the age and growth studies of the Indian major carps. So the present study was undertaken on three Indian major carps viz

Catla catla (Ham), *Cirrhina mrigala*(Ham), and *Labeo rohita* (Ham) by means of methods like scale studies and studies on length frequency distribution, and findings compared with the values obtained from von Bertalanffy's growth equation.

MATERIAL AND METHODS

The material for the present study was taken from the commercial fish landings of the Hirakud Reservoir,Orissa duringAugust 1978 to December 1979. Monthly collections were taken from six landing centers viz. Burla, Belpahar; Raigarh, Rengali, Jharsuguda and Hirakud. Six hundred and fifty six specimens of *Catla catla* (Ham) two hundred and forty five *Cirrhina mrigala* (Ham) and three hundred and one *Labeo rohita* (Ham) were examined and scales collected besides noting other morphometric characters like length, weigth, etc. As the fishes came from commercial catches the minimum length of the specimens collected was 28 cm. for *C. catla*, 24.8 cm. for *L. rohita* and 17.7 cm. for *C. mrigala*.

The scales for the study were collected from the region directly below the dorsal fin and above fhe lateral line. At the field they were cleaned and stored in seperate paper packets after proper labelling. In the laboratory they were first washed in tap water for about an hour and cleaned taking care not to damage the delicate margins. The scales were kept in a weak solution of caustic potash for half an hour and dried. Two or three scales from each samples were stained with a weak solution of alizarin red and they were placed in between two glass slides and observed under a binocular microscope.

The length frequency studies were based on the analiysis of 1656 specimens of catla, 1245 mrigala and 1385 rohu ranging of size 17.7 cm. to 92.0 cm. In order to eliminate several minor modes which may arise due to continueous recruitment and sampling errors, a class interval of 5 cm. length was found suitable. The length frequency of individual years were analysed for size frequency studies and the same data is pooled monthwise in each year to find out the age groups.

RESULTS

I) Age Determination

(A) From scales

Nature of rings

As shown by the previous authors like Jhingran (1959), Natarajan and Jhingran (1963), Yusuf Kamal (1969), Hanumantha Rao (1974), the present study also shows the presence of varying number of rings on scales of different sizes. Their number proportionally increases in large fish and vice versa. The nature of growth rings of these three fishes in the present study are as follows

Catla catla (Ham)

An examination of scale of *C. catla* revealed the presence of alternating fast and slow growth areas. A fast growth area (transparent) and a slow growth area (opaque) were together taken to indicate one year growth. Each slow growth zone consists of compactly packed continuous circuli preceded by a transparent zone which is represented by a number of comparatively widely spaced circuli. The number of rings and the corresponding age along with size frequency distribution at various ages for *C. catla* are shown in Table I.

TABLE I.* Size Frequency Distribution of *Catla catla* of various ages as revealed by scale study

Length range in cm.	No, of completed annuli								Total
	0	1	2	3	4	5	6	7	
21-25		2							2
26-30	1	8							9
31-35	20	4							24
36-40	22	4	16						42
41-45	9	1	50						60
46-50			20	27					47
51-55			12	34					46
56-60				24	56				80
61-65				2	142				144
66-70				12	86				98
71-75					21	33			54
76-80					4	20			24
81-85						6	3		9
86-90							2		2
91-95								1	1
Total	52	19	98	99	309	59	5	1	642
Average length in cm.		29	43.42	55.17	63.35	76.38	84	92	

Cirrhina mrigala (Ham)

The annuli on the scales comprised closely deposited circuli constituting the opaque zone which is preceded by relatively more widely deposited circuli constituting the transparent zone. The deposition was found to be uniform, clear and continuous all round the scale (Table II)

Labeo rohita (Ham)

The annual markings on the scales of *L. rohita* are very clear and well defined. The annuli on the scale are very similar to that found on the scales of *C. catla* and *C. mrigala*, as the annuli comprised closely deposited circuli constituting the opaque zone which is preceded by relatively more widely deposited circuli constituting the transparent zone (Table III).

TABLE II. Size Frequency Distribution of *Cirrhina mrigala* of various ages as revealed by scale study

Length range in cm.	Number of completed annuli							Total
	1	2	3	4	5	6	7	
15–20	2							2
21–25	1							1
26–30	4							4
31–35		4	2					6
36–40		15	4					19
41–45		11	4					15
46–50		2	5	3				10
51–55			10	6				16
56–60			12	5	1			18
61–65			1	15	1			17
66–70				10	7	8	4	29
71–75				1	18	9	2	30
76–80					1	6	5	12
81–85							2	2
86–90							3	3
Total	7	32	38	40	28	23	16	184
Average length in cm.	24.42	39.71	51.8	61.25	71.03	74.03	76.52	

Time of formation of annulus

For justification of the determination of age from checks, it is necessary to establish the annual nature of their deposition. For this the outer margin of the scales during different months of the year were examined.

TABLE III. Size Frequency Distribution of *Labeo rohita* of various ages as revealed by scale study

Length Range in cm	Number of completed annuli 1	2	3	4	5	6	7	Total
15-20								
21-25	1							1
26-30	9							9
31-35	2	14						16
36-40	1	19	5					25
41-45		15	1					16
46-50		26	6					32
51-55		17	2					19
56-60		13	14	6				33
61-65			4	22	8			34
66-70				11	9	9	4	33
71-75					5	17	5	27
76-80					2	2	5	9
81-85						2	4	6
86-90							1	1
Total	13	104	32	39	24	30	19	261
Average length in cm	29.15	45.84	52.41	60.72	66.16	73.08	77.78	

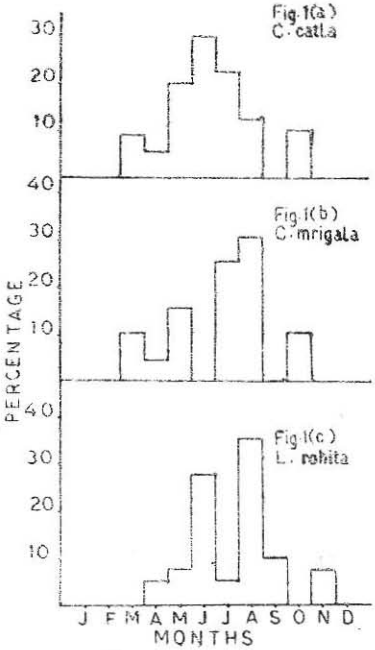

Fig. 1. Percentage of scales with marginal rings during different months (a) *Catla catla;* (b) *Cirrhina mrigala;* (c) *Labeo rohita.*

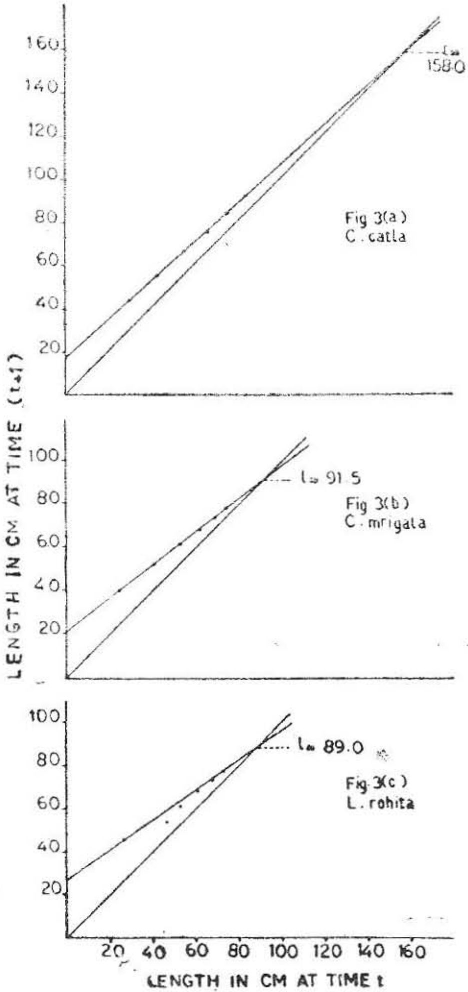

Fig. 3. Ford-walford plot of growth, length at age t plotted against t + 1 showing the ultimate length (l_∞) attained by the fish. (a) *Catla catla;* (b) *Cirrhina mrigala;* (c) *Labeo rohita.*

Figs. 1 a, b and c show the persentage frequency of opaque margin during different months for the fishes *Catla catla, Cirrhina mrigala* and

Labeo rohita. The maximum number of scales with opaque margin was recorded in the months of May, June, July and August. The avarage width of transparent zone was narrowest in July and broadest in April. The appearance of both transparent and opaque zone within a period of 12 months indicated that the rings were annual in nature and were found during May to August, peak being in June - July.

(B) From length frequency polygon analysis

Nirmal (1967) pointed out that in preference to the usual practice of pooling size frequency data for the entire year, data pertaining to the monsoon months of July to October are enough. Since differences in model progression between monsoon months of two consecutive years could be considered as representing the growth attained in 12 months as spawning takes place in the monsoon months. The pre-monsoon months represent the end of biological year for these species and thus it can be argued that model length of size frequency distribution attained during these months represents more or less the length of one year old fishes. The probable lengths that could be attained by the fishes *C. catla*, *C. mrigala* and *L. rohita* at the age of one to seven years, derived from Petersen method is given in tables IV, V and VI respectively.

Table IV. Comparison of mean lengths of *C. Catla* in cm at various ages as estimated by different methods

Age in years	Length at age (scale method) cm	Length at age (Petersen's method) cm	Length at age (Von Bertalanffy's fit) cm
1	29.0	32.5	30.352
2	44.42	40.14	43.385
3	55,17	57.5	55.125
4	63.55	62.72	65.70
5	76.38	77.5	75.22
6	84.0	82,5	83.8130
7	92	92	91.909

Table V. Comparison of mean lengths of *C. mrigala* in cm at various ages as estimated by different methods

Age in years	Length at age (scale methods) cm	Length at age (Petersen's method) cm	Length at age (Von Bertalanffy's fit) cm
1	24.42	22.5	25.383
2	39.71	37.25	41.190
3	51.8	52.5	53.189
4	61.25	60.5	62.296
5	71.03	71.26	69.208
6	74.47	76.5	74.455
7	76.52	78.5	78.438

Table VI. Comparison of mean lengths of *L. rohita* in cm at various ages as estimated by different methods

Age in years	Length at age (scale method) cm	Length at age (Petersen's method) cm	Length at age (Bertalnaffy's fit) cm
1	28 575	29.15	27.741
2	43.15	45.84	46.660
3	52.585	52,47	52.709
4	60.04	60.72	61.1545
5	67.33	66.16	67.697
6	72 79	73.08	72.767
7	77.79	77.78	76.695

Catla catla (Fig. 2a.)

In 1978 the single mode at 32.5 cm in August constitute the 1st year age group and the mode at 42.5 cm in August represents the 2nd year group of fishes. The 3rd year group is represented in the histogram by a single prominent mode at 57.5cm in September, the modes at 62.5cm in November and December can be considered of fish consisting of 4th year age group.

In 1979 the modes at 27.5 cm in March and 32.5cm in April constitute the first year group of fishes. The peaks at 37.5 cm in May and 42.5 cm in June represent 2nd year fish group while the modes at 52.5 cm in February and 57.5 cm in March can be considered as fish consisting of 3rd year age group. The 4th year group can be recognised from the modes at 62.5 cm in May and 67.5 cm in August. The peak at 77.5 cm in March represents the 6th year group of fishes. The single mode at 92 cm in August represents the 7th year group of fishes.

Cirrhina mrigala (Fig. 2b)

In 1978 the single peak at 32.5cm in August constitutes the fish of first year age group. The modes at 37.5cm in September and 42.5 cm in August represent the 2nd year group of fishes. The mode at 57.5 cm in September in the histogram represents the fishes of 3rd year age groups and the 4th year group can be recognised from the mode at 67.5 cm in October. The 5th year group of fishes is represented by a single mode at 72.5 cm in December.

In 1979 the peak at 22.5 cm in May represent the 1st year group of fishes. The modes at 32.5 cm in April, 37.5 cm in June and 42.5 cm in August constitute the 2nd year group and a single mode at 52.5 cm in March represents the 3rd year group of fishes. The 4th year age group can be recognised from the histogram by a single mode at 62.5 cm in September. The mode at 72.5 cm in Ferbuary can be considered as fish consisting of 5th year age group. The mode at 77.5 cm in November represents 6th year age group and the 7th year age group is represented in the histogram by a single mode at 82.5 cm in September.

Labeo rohita (Fig. 2c)

In 1978 the mode 42.5 cm in October can be interpreted as the fish consisting of 2nd year age group. The peak at 52.5 cm in November constitute 3rd year group of fishes. The 4th year class can be recognised from the mode at 57.5 cm in December. The mode at 67.5 cm in December represents the 5th year age group while the peak at 72.5 cm in September can be considered as fish consisting of 6th year age group.

In 1979 the single mode at 32.5 cm in April represents the 1st year age group. The 2nd year age group can be recognised from the modes at 37.5 cm ;n May and June and 47.5 cm in December. The modes at 52.5 cm in February and April represent the 3rd year group of fishes and the modes at 62,5 cm in July and August represents the fishes of 4th year age

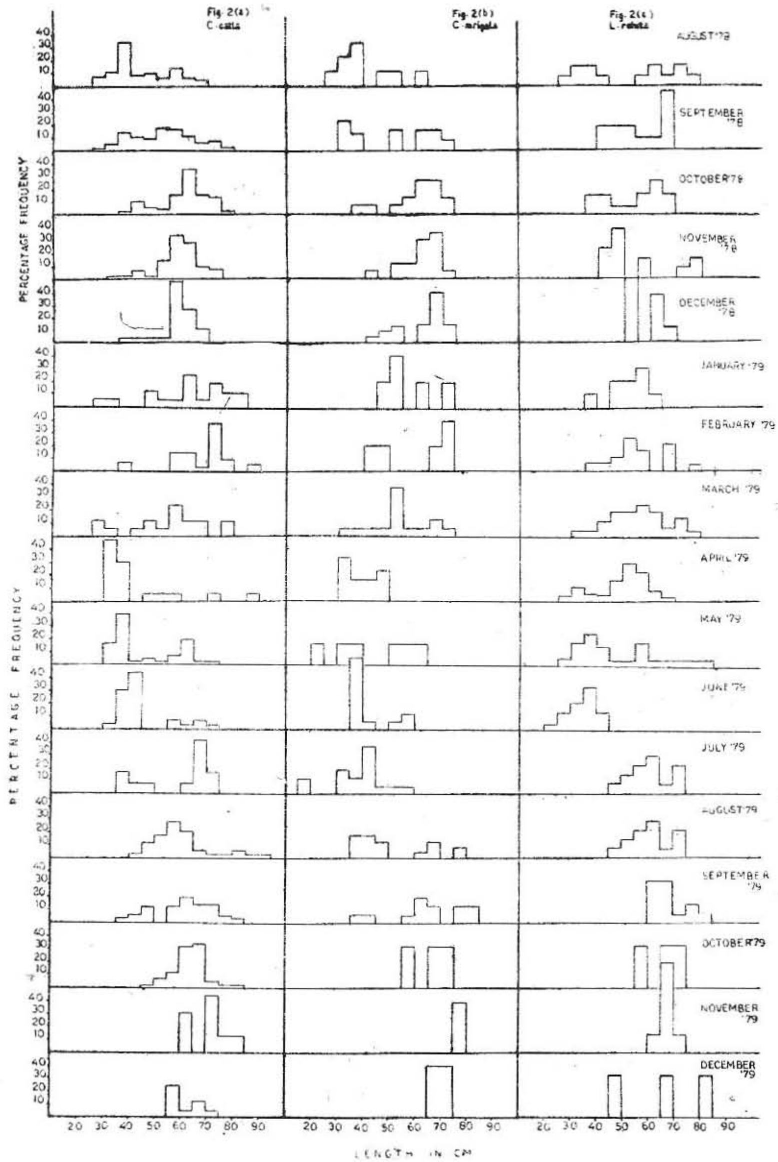

Fig. 2. Length frequency distribution pooled for corresponding months of the years 1978 and 1979. (a) *Catla catla;* (b) *Cirrhina mrigala;* (c) *Labeo rohita,*

group. The 5th year group is represented by a prominent peak at 67.5 cm in September and the 6th year age group can be recognised from the mode at 72.5 cm in October. The mode at 77.5 cm in December can be considered as fish consisting of 7th year age group.

2) Estimation of Growth Parameters

The various parameters in the von Bertalanffy's Model was estimated using the Ford – Walford Method (Ford, 1933; Walford, 1946)

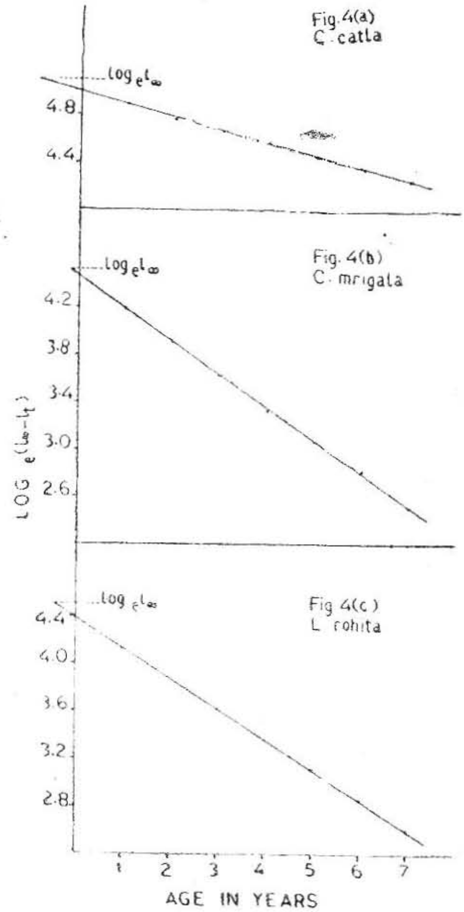

Fig. 4. $\log_e (l_\infty - l_t)$ plotted against age to determine t_0. (a) *Catla catla*; (b) *Cirrhina mrigala*; (c) *Labeo rohita*.

taking the length at time (t+1) as a linear function of length at time t (Figs. 3a, b, and c). Then the method of least squares was used for fitting the straight line, the slope of the line giving the value of e^{-k}. From this the parameter k was estimated. The Y intercept of the line being $l_\infty(1-e^{-k})$ is used for etsimating the value of l_∞. The estimation of t_o is as mentioned by Beverton and Holt (1957) by the plot of $\log_e (l_\infty - l_t)$ against t. The value of t where it has an ordinate of 1 gives the estimate of t_o (Figs. 4 a,b, and c).

The following are the values of l_∞, k and t_o calculated from the equation

Catla catla : $l_\infty = 161.8721$, $k = 0.1044$, $t_o = -0.9898396$
Cirrhina mrigala : $l_\infty = 90\ 984335$, $k = 0.275009$, $t_o = -0.186447$
Labeo rohita : $l_\infty = 90.21083$, $k = 0{:}255145$, $t_o = -0.4402277$

When substituting the values for these parameters, the growth equation for these fishes are as follows:

Catla catla $l_t = 161.8721\ [1 - e^{-0.1044(t+0.989839)}]$
Cirrhina mrigala $l_t = 90.98433[1 - e^{-0.275009(t+0.186447)}]$
Labeo rohita $l_t = 90.21083[1 - e^{-0.255145(t+0.440277)}]$

The theoretical lengths at verious ages as calculated by this growth equation showed a high degree of agreement with length at ages calculated both by scale studies and length frequency studies (Table VII).

Table VII. Lengths in cm at different ages of ***C. catla, C. mrigala*** **&** ***L rohita*** **as calculated by von Bertalanffy growth equation**

Age in years	Length			increments in length		
	C. Catla	*C. mrigala*	*L. rohita*	*C. catla*	*C. mrigala*	*L. rohita*
1	30.352	25.383	27.741	30.352	25.383	27.741
2	43.385	41.190	46.660	13.033	15.807	18.919
3	55.125	53.189	52.709	11.74	11.999	6.049
4	65.70	62.296	61.154	10.575	9.107	8.445
5	75.22	69.208	67.697	9.520	5.247	6.543
6	83.813	74.455	72.767	8.593	5.247	5.07
7	91.545	78.438	76.695	7.732	3.983	3.983

DISCUSSION

Till the work of Jhingran (1959) on *Cirrhina mrigala*, the scale method was not widely used for the determination of age for Indian fresh water fishes. The works of Natarajan & Jhingran (1963), Yusuf Kamal (1969) and Hanumantha Rao (1974) have suggested about the validity of the use of scales for age determination for Indian major carps. Yusuf Kamal (1969) found out that the period of annulus formation (May-August) coincides with reduced feeding activity of fish as plankton population during these months was poor in the river Yamuna. He stated that growth retardation in mrigal from river Yamuna was caused by want of required food in the environment. Hanumantha Rao (1974) found out that the period of annulus formation coincides with the high temperature and maturation of gonads and breeding activity of the fish. He concluded that the annulus formation resulted from a cumulative effect of lack of sufficient food, high temperature, maturation of gonads and breeding activity of the fish. While discussing the age and growth of *C. mrigala* from river Ganga, Jhingran (1959) mentioned starvation as probable cause for annulus formation, but Natarajan & Jhingran (1963), indicated that the growth check in *C. catla* was caused by maturation and spawning. In the present study it is all possible to think as the annulus formation coincides with low plankton production in the reservoir [Varghese, *et al* 1981]. The low availability of food, the physiological stress brought about by near starvation and the prevailing high temperature might have played an important role in retarding the growth of the species, thereby causing annulus formation.

In the present study the scale method is employed for age determination and the result is compared with Petersen Method. On the basis of the results obtained by the scale studies and length frequency studies it is observed that the growth of these fishes is very fast during the first 3 or 4 years of its life (Table VII), the first year having maximum growth. The gradual decrease in length is observed during the later years.

von Bertalanffy's (1957) growth equation was fitted after finding out the growth parameters like l_{∞}, k and t_0. Substituting the values for these parameters the growth equation for the three fishes are found to be as follows :

Catla catla, $l_t = 161.8721\ (1-e^{-0.1044\,(t+0.989836)})$

Cirrhina mrigala, $l_t = 90.98433\ (1-e^{-0.275004\,(t+0.186447)})$

Labeo rohita, $l_t = 90.21083\ (1-e^{-0.255145\,(t+0.44027)})$

The following conclusions can be made from the present study :

1. The theoretical lengths at various ages calculated dy the growth equation showed a high degree of agreement with length at age calculated both by scale studies and length frequency studies (Table IV, V and VI) and shows that von Bertalanffy growth equation supports actual growth in these three fishes.

2. Growth of these fishes are faster during the initial period and decreases gradually when it becomes old. While in *C. catla* the decrease in rate of growth is low during the later periods, in the other two fishes (*C. mrigala* and *L rohita*) the decrease is more when the fishes attain age.
3. The study of scale margin has established the annual nature of annulus formation.

ACKNOWLEDGEMENT

We are grateful to Dr. C. T. Samuel, Head, Department of Industrial Fisheries, University of Cochin for providing necessary laboratory faciiities to carry out this work. The authors are highly thankful to Shri V. C. George, Scientist, Central Institute of Fisheries Technology who collected and provided the material for the present study on personal request. One of us (PUZ) is indebted to the University of Cochin for providing a junior research fellowship during the tenure of which the present study was carried out. The help rendered by Shri T. M. Sankaran, Associate Professor, Fisheries College, Panangadu, for critically going through the statistical part is gratefully acknowledged.

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