STUDIES ON THE AGE AND GROWTH OF ROHU, *LABEO ROHITA* (HAM.) FROM A POND (MOAT) AND RIVERS GANGA AND YAMUNA

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Studies on the age and growth of *Labeo rohita* (Ham.) obtained from a moat and rivers Ganga and Yamuna, were made. The scales of fish possessed certain carved-out grooves-like rings which were proved to be annual in nature. The rings on the margins appeared only once a year, from March to July. The body length and scale length relationship was linear. The number of fishes decreased as the age increased. The growth rate of the fish was very fast and rapid growth took place during the first and second years of life, thereafter the growth rate decreased gradually. Ninety-three per cent of the total growth was achieved by the end of 7th year of life. The fish attained the lengths of 310, 500, 650, 740, 800, 850, 890, 920, 940 and 960 mm at the end of 1st, 2nd, 3rd, 4th, 5th, 6th, 7th, 8th, 9th and 10th years of life respectively. von Bertalanffy's growth equation fitted well to length at age data. The theoretical growth equation is :

$$Lt = 1015\ (1 - e^{-0\cdot276\ (t + 0.333)}$$

The asymptotic length calculated (1015 mm) was very close to the observed length (960 mm). The theoretical, back-calculated and observed lengths at each age also agreed closely. Seasonal growth curve of the fishes of first year class was affected by feeding-intensity while the growth curve of the adults was influenced by maturation of gonads and feeding intensity.

INTRODUCTION

The age and growth of two important major carps of India, namely, *Cirrhina mrigala* (Ham.) and *Catla catla* (Ham.) have been investigated in detail, the former by Jhingran (1957 and 1959) and Kamal (1969) and the latter by Natarajan and Jhingran (1963). This aspect of *Labeo rohita* (Ham.), the other most important major carp, both from capture and culture fisheries viewpoint, has not been attempted in detail by any other worker except for a short publication of Das (1960) and nothing is known either about any valid method for age and growth studies or about its age, life span and growth rate. The present investigation was therefore directed (i) to work out a suitable method for age and growth studies, and (ii) to find out the length at various ages, maximum size and age, seasonal and annual growth rates of *L. rohita*. The samples were collected from two environments, moat (a stocking pond of 16 ha) and rivers (Ganga and Yamuna).

MATERIALS AND METHODS

Fishes from the moat were collected during the period September 1967 to June 1969, twice a month using cast net, gill net or drag net. Riverine fishes were collected

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from the local fish market, where the fishes are brought from River Ganga and River Yamuna, for the period September, 1967 to December, 1969. 785 fishes from moat and 801 fishes from rivers were used for the present study.

Total length was measured in mm, from the tip of the snout to the longest caudal fin ray. The scale samples were taken uniformly from the lateral side of the fish in the region directly below the dorsal fin and above the lateral line. Ten or twelve scales were taken from each fish. Scales were first washed in water and then scrubbed gently between the fingers to remove the mucus and other extraneous matters attached to the scales. They were then dried on a neat blotting paper. Scales of each fish were kept in separate envelopes.

Since the scales attain a fairly large size and are translucent, they were read with the help of a magnifying glass. However, the scales of smaller fishes for the study of marginal rings were observed under a microscope or a binocular. Larger scales were held against narrow light source and read with the help of a magnifying glass.

Ages were determined by counting the number of completed annuli (the annuli are defined latter in the text). Scale envelopes were mixed together and from the mixed lot envelopes were picked randomly one by one, scales were studied and ages were noted on a sheet against the number of the envelope. When all the scale envelopes were studied, the whole lot of envelopes was again mixed and the same procedure was repeated. Ages were again determined irrespective to the previous diagnosis. If both the observations tallied, the age of the fish was considered final, otherwise, such scales were kept aside and studied third time. After several attempts if any conclusion was not obtained, such scales were rejected.

Occurrence of rings on the margins of scales was noted throughout the year and percentage of scales with marginal rings during each month was calculated. Scales were measured with the help of paper rulers made from millimeter graph paper. The body length : scale length relationship was worked out by regression analysis (Least squares method). Length attained by the fish at the time of each annulus formation was back calculated for each fish separately using the direct proportion formula (Lee 1920). The mean monthly length of moat fishes was determined from the total fish captured in that month. The mean monthly length of riverine fishes was determined separately for each year class as revealed by the number of annuli on the scales.

Instantaneous or specific rate of growth (G) of riverine fishes was calculated separately for each age group as follows :

$$G = \frac{Log_e L_2 - Log_e L_1}{T_2 - T_1} \times 100 \text{ (Ball and Jones 1960)}$$

where L_2 and L_1 are the lengths at the times T_2 and T_1 respectively and G is the specific growth rate as the percentage increase per unit time. L_1 and L_2 are the lengths at the beginning and at the end of each year of life. Thus $T_2 - T_1$ is one, and G is expressed as percentage per annum.

von Bertalanffy growth equation was fitted to length at age data of riverine fishes as described by Beverton and Holt (1957).

RESULTS

Nature of annuli or true growth rings

Annuli or true growth rings appear as relatively broad grooves or bands which are carved-out spaces between circuli running alround the scale except for the posterior end and preceded by closely spaced circuli followed by widely spaced circuli. In the groove or annulus region circuli are broken, discontinuous and incomplete. The annulus is parallel to the general contour of the scale and can be traced around the sculptured part of the scale. Sometimes, it also extends to the posterior region or unsculptured part. A ring is considered annulus only when it is present in all the scales of the fish.

False rings

Sometimes accessory checks or false rings were found to occur in the scales of *L. rohita.* Such rings are usually incomplete, irregular in outline and not parallel to the margins. In case of such rings, the grooves generally appear as folds in the sculptured pattern and circuli crossing such folds show a continuity and regularity rather than the discontinuity and irregularity of the defined age ring. Further, they usually occur at irregular intervals between clearly marked age rings. Such rings are not found in all the scales of an individual. The false rings of *L. rohita* resemble very much to the accessory rings of the Atlantic menhaden described by June and Roithmayr (1960). False rings have also been reported in other major carps viz., *Cirrhina mrigala* (Jhingran 1959 and Kamal 1969) and *Catla catla* (Natarajan and Jhingran 1963).

Abnormalities

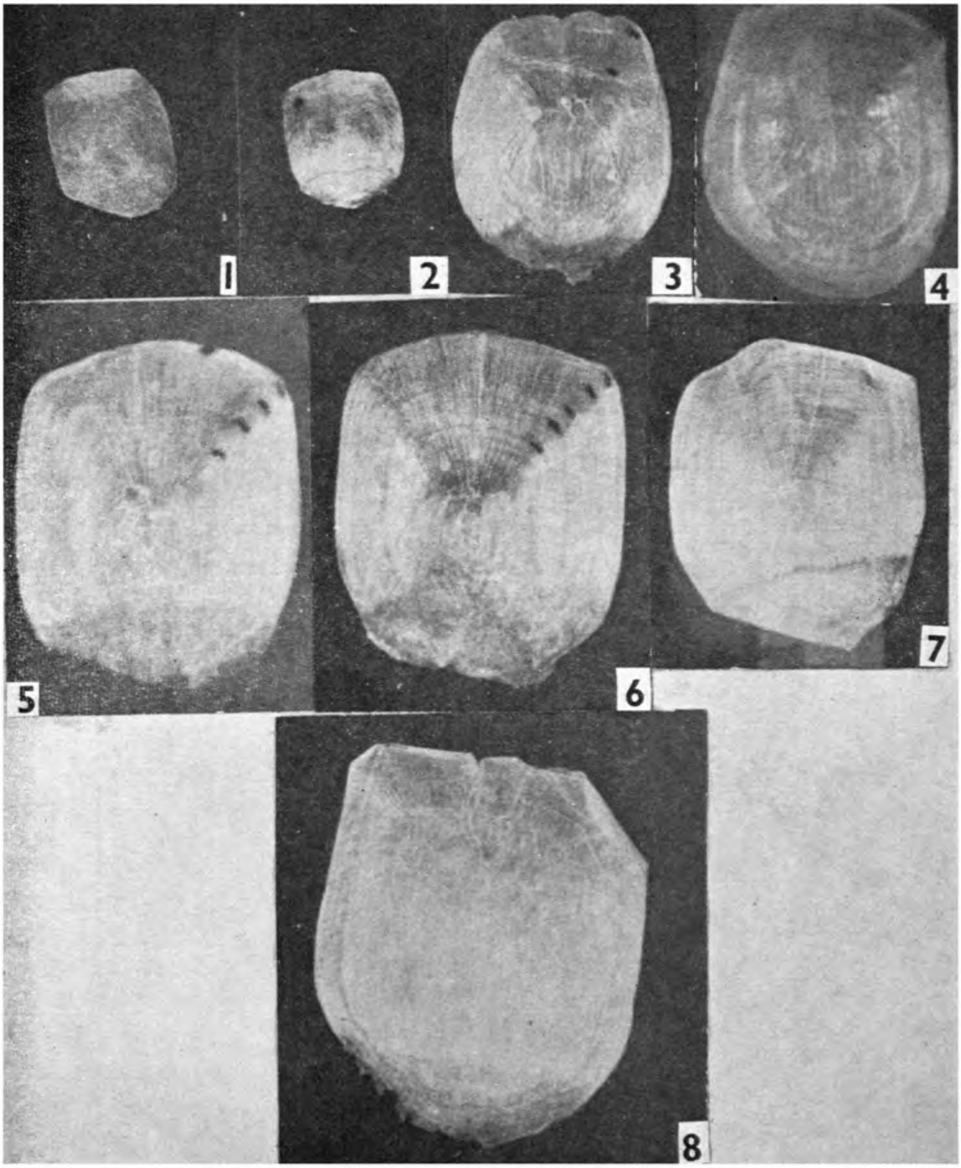
Fifteen per cent of the scales were abnormal. Most of the abnormal scales were asymmetrical, regenerated with a large-fused focus with either no clear ring (Scale 8) or with one or two rings or with a number of ridge-like rings (Scale 7) which in no way represented the annual rings. Careful examination of the scales of different regions revealed the differences in size and shape and the most symmetrical scales with least amount of abnormality were found just below the dorsal fin and above the lateral line.

Validity of scales as age and growth indicator

Jhingran (1957, 1959), Kamal (1969) and Natarajan and Jhingran (1963) pointed out that the scales of *C. mrigala* and *C. catla* show clear annulations which could be used for studying age and growth of these fishes. These authors have also established the annual nature of these rings. Since *L. rohita* is closely related to these species, its scales have also been found to bear certain rings. The validity of the scale method for age and growth studies of *L. rohita* has been based on the proposition of van Oosten (1929).

Constancy in the number of scales

The number of scales along the lateral line of *L. rohita* was found to vary between 39 to 41 and within this range the number was almost constant. The size and



Scales 1–8. Description of scales (Total length of the fish is given in parenthesis). 1, shows no ring (170 mm) ; 2, shows one ring (390 mm) ; 3, shows two rings (560 mm) ; 4, shows three rings (690 mm) ; 5, shows four rings (750 mm) ; 6, shows five rings (820 mm) ; 7. shows accessary rings which are misleading (680 mm) ; 8, shows no clear ring (840 mm).

shape of the scales and sculptural characteristics differed from one region to other, but remained almost constant throughout the life in one part. The highest degree of constancy in the shape of scales was found from the region just below the dorsal fin and above the lateral line.

Time of annulus formation

Observations were made on the occurrence of rings on margins during different months. In case of moat fishes, the time of ring formation was directly observed for first and second year classes. It was found (Fig 1 A) that up to January very few scales showed the ring formation on the margins. From February onwards the percentage of scales with marginal rings increased and maximum number of scales with marginal rings appeared in the months of March and April in case of first year class and in April and May in case of second year class. By the end of July all of the scales of first year class fishes possessed growth rings and as the scales grew further in size, these rings progressed inwards. No further ring formation was noted till the next February when the rings of second year class started their formation. In case of riverine fishes (Fig. 1 B). where the sample contained all the age groups, examination of the margins of scales indicated that new growth rings began to appear from March and by August all the fishes of first year class developed new growth rings while in cases of adults (all year classes except first year class) ring formation started from March and continued till September. The maximum number of scales with marginal rings were noted during April and May in case of first year class and during May and June in case of adults. Ring formation took place earlier in smaller fishes and latter in larger fishes.

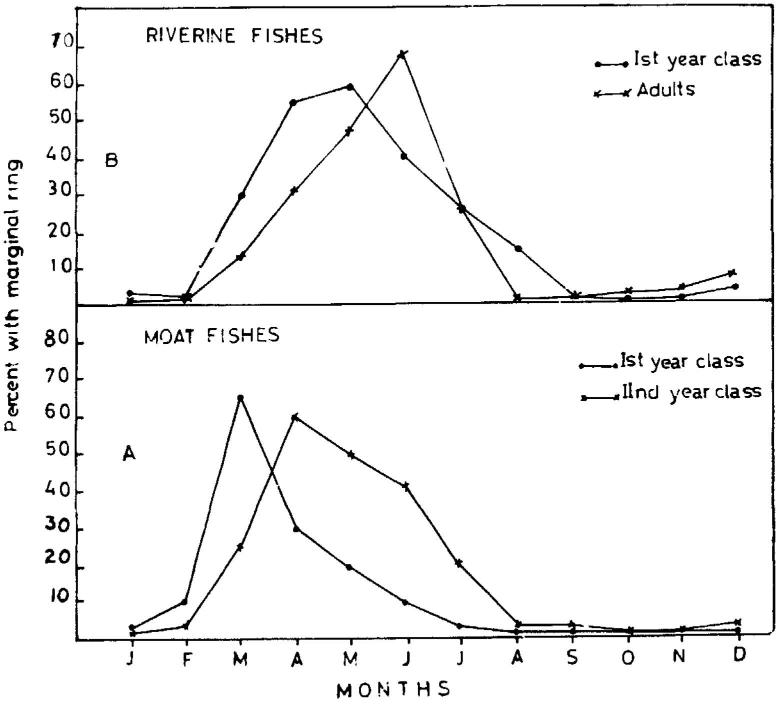


FIG. 1. Percentage of scales of *L. rohita* with marginal rings during different months. A, moat fishes; B, riverine fishes.

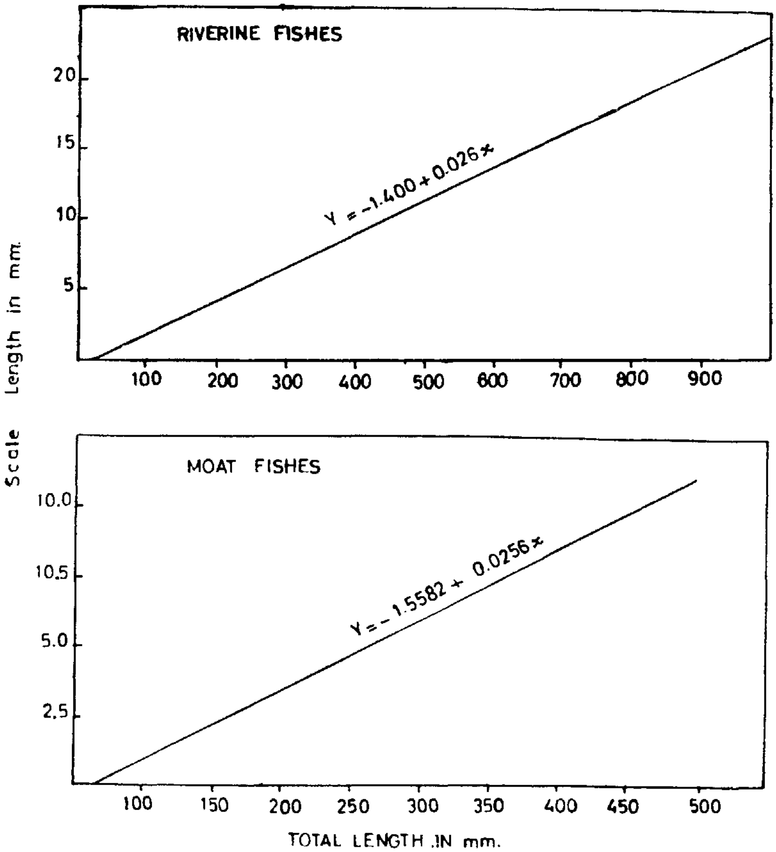


FIG. 2. Body length : scale length relationship of *L. rohita* A, moat fishes; B, riverine fishes.

The constant appearance of new growth rings at one season of the year is an evidence that these rings are true annuli. Additional evidence appeared from the fact that rings are added systematically along with the growth of the fish. Increasing number of annuli was found with increasing size of the fish (Scales 1 to 6). The decreasing distance between the adjacent annuli as the fish grew also revealed that these are true growth rings because the growth of the fish itself decreased as the age increased. Similar evidence has been cited by Jhingran (1959) and Kamal (1969) in case of *C. mrigala*. Further evidence of the reliability of these rings on the scales was available in the comparison of the sizes attained by the moat fishes and riverine fishes. The sizes at first and second annuli of moat fishes corresponded well to the sizes at similar annuli of riverine fishes. Further length derived at each age from von Bertalanffy growth equation and length determined by back calculations (both described latter in the text) and emperical length showed no significant differences.

Body length : scale length relationship

When the regression of scale length on total body length was carried out, a straight line relationship was observed with a high degree of significance in case of both, (Fig. 2 A) and (Fig. 2 B) fishes. The relationships are expressed as :

$$Y = -1.5582 + 0.0256 \times \text{ (Moat fishes)}$$

$$Y = -1.4000 + 0.0260 \times \text{ (Riverine fishes)}$$

where X is total length of the fish and Y is the scale length.

AGE AND GROWTH RATE

Detailed study on the age and growth was only possible in case of riverine fishes where the samples contained almost all the age and size groups of the fish found in natural population.

Age composition

Table I shows the length frequency distribution of *L. rohita* at each age group as revealed by annuli. It may be seen that the fishes of first year class formed the dominant group but their number decreased unexpectedly in age group II. However, the fishes of age group II, III and IV were also in moderate numbers but the percentage decreased considerably as the age increased. The number of the fishes of higher age groups was very small. Though the sample did not represent the actual composition, even then it gave an approximate age composition of the population. It is also apparent that the variation in lengths at any age group was quite high.

Calculated annual growth

Average calculated length at each annulus, absolute growth and growth increment —Table II represents the average length of *L. rohita* at each annulus (at the end of each year of life) as determined by the back calculation of lengths from the fishes of different ages. At the beginning of the study attempts were made to study the growth of the two sexes separately but later on only combined growth rate was studied because, firstly there appeared no significant difference in the growth rate of males and females and secondly, the determination of sex was not possible for most of the large-sized fishes.

The average length at each annulus has also been plotted in Fig. 3 (absolute growth curve). *L. rohita* was found to attain the lengths of 310, 500, 650, 740, 800, 850, 890, 920, 940 and 960 mm at the age of 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10 years respectively. Occurrence of rapid growth in length was found during the first 4 years of life, followed by a period of slow growth rate up-to 7 years and slowest in the rest of life. A progressively declining growth rate with increasing age is also clearly visible from the lower curve of Fig. 3 (growth increment). The maximum size of the fish recorded was 960 mm at the end of 10th year of life.

The percentage annual increment (relative growth) varied from 32 per cent during the first year of life to 2.1 per cent during the 10th year of life (Table III). About 93 per cent of the total growth was covered in the first seven years of life.

TABLE I

Length frequency distribution of age groups of L. Rohita *(riverine fishes)*

Size groups (mm)	Age groups									
	I	II	III	IV	V	VI	VII	VIII	IX	X
51 — 100	78	–	–	–	–	–	–	–	–	–
101 — 200	197	–	–	–	–	–	–	–	–	–
201 — 300	73	2	–	–	–	–	–	–	–	–
301 — 400	36	5	–	–	–	–	–	–	–	–
401 — 500	2	72	1	–	–	–	–	–	–	–
501 — 600	–	47	11	–	–	–	–	–	–	–
601 — 700	–	–	55	14	2	–	–	–	–	–
701 — 800	–	–	2	59	62	5	1	–	–	–
801 — 900	–	–	–	–	2	49	32	13	2	1
901 — 1000	–	–	–	–	–	8	26	22	13	9
Total number of fishes	286	126	69	73	66	62	59	35	15	10
Per cent of total	35.7	15.7	8.6	9.1	8.2	7.7	7.4	4.5	1.9	1.2

TABLE II

Calculated length at each annulus as determined by back calculation (riverine fishes)

Age	Calculated length at different annuli (mm)									
	I	II	III	IV	V	VI	VII	VIII	IX	X
1	330	–	–	–	–	–	–	–	–	–
2	325	516	–	–	–	–	–	–	–	–
3	320	510	663	–	–	–	–	–	–	–
4	315	505	660	750	–	–	–	–	–	–
5	310	513	657	747	814	–	–	–	–	–
6	310	505	650	742	810	861	–	–	–	–
7	305	507	651	740	802	860	900	–	–	–
8	308	496	642	740	795	850	900	928	–	–
9	290	483	638	731	791	848	889	920	943	–
10	285	473	632	730	782	840	872	912	936	960
Grand mean	310	500	650	740	800	850	890	920	940	960

Lee's phenomenon of apparent changes in growth rate

Lee's phenomenon of apparent changes in growth rate (Lee 1920) was observed in case of *L. rohita* (Table II). Variation in calculated length at annulus II was

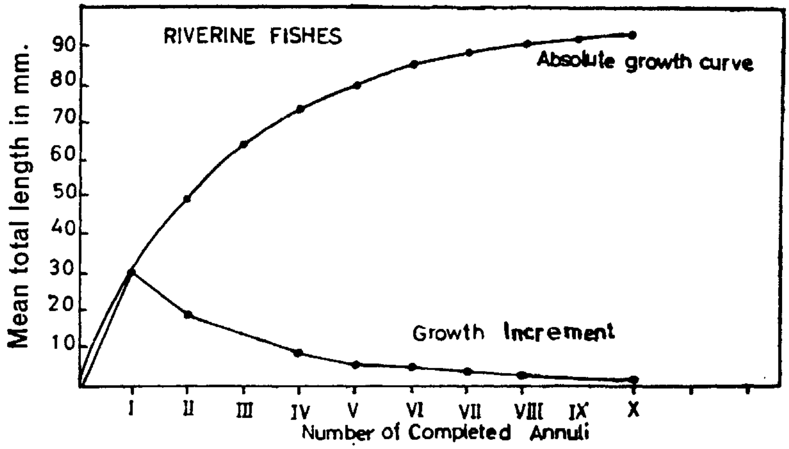


FIG. 3. The growth curves of riverine *L. rohita* (The upper curve represents the average length at each age and the lower curve represents the average growth increment of each age).

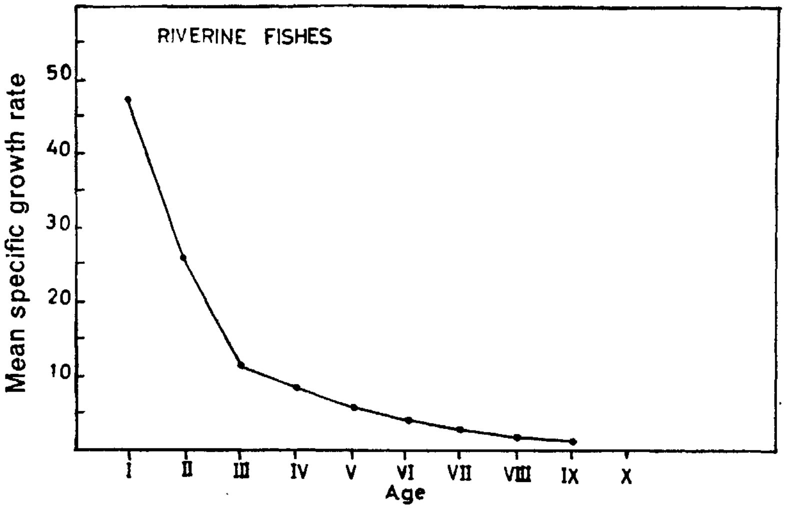


FIG. 4. Changes in specific (instantaneous) growth rate (expressed as per cent of total length per annum) of riverine *L. rohita* with age.

as great as 37 mm between the fishes taken at 3rd and 10th year of age. Similarly calculated length at annulus III showed a difference of 28 mm between the fishes of 4th and 10th year of age.

Instantaneous (specific) rate of growth

Fig. 4 shows the changes in specific growth rate (*G*) (percentage length per year) in length with age. It may be seen that the resulting growth rate commenced at 47 per cent (0.47) between ages 1 and 2, dropped to 26 per cent (0.26) in next year and ultimately it was only 2 per cent (0.02) between ages 9 and 10. The patterns of changes in 'G' with the mean length at each age were different from the pattern of changes with age (Fig. 5). Decrease in *G* values with increasing length was also fairly uniform.

TABLE III

Mean calculated length at each annulus, growth increment, relative growth and specific growth rate of L. rohita

Age groups	Riverine fishes				
	Back calculated length (mm)	Length determined by growth equation (mm)	Growth increment (mm)	Relative growth (%)	Specific growth (%)
I	310	309.8	310	32.2	47.80
II	500	489.0	190	19.8	26.24
III	650	610.5	150	15.6	11.51
IV	740	700.9	90	9.4	9.26
V	800	789.0	60	6.3	6.06
VI	850	840.0	50	5.2	4.61
VII	890	885.0	40	4.2	3.25
VIII	920	915.0	30	3.1	2.20
IX	940	937.0	20	2.1	2.12
X	960	950.0	20	2.1	–

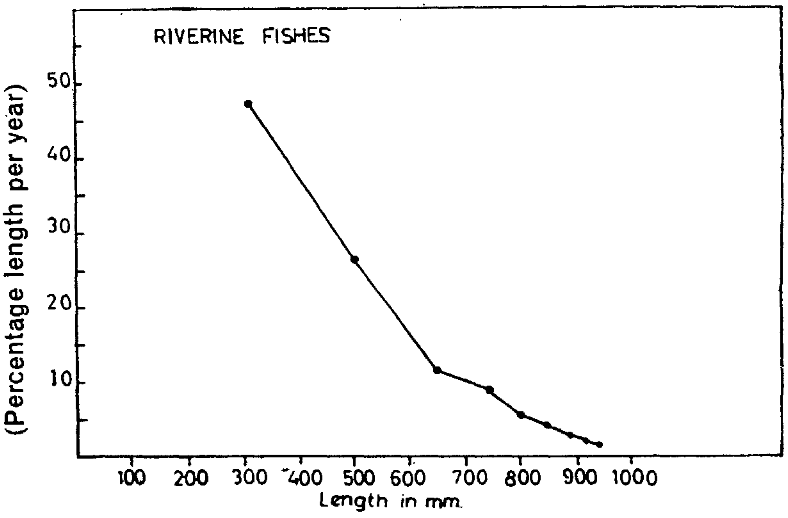


FIG. 5. Changes in specific (instantaneous) growth rate (expressed as per cent of total length per annum) of riverine *L. rohita* with size.

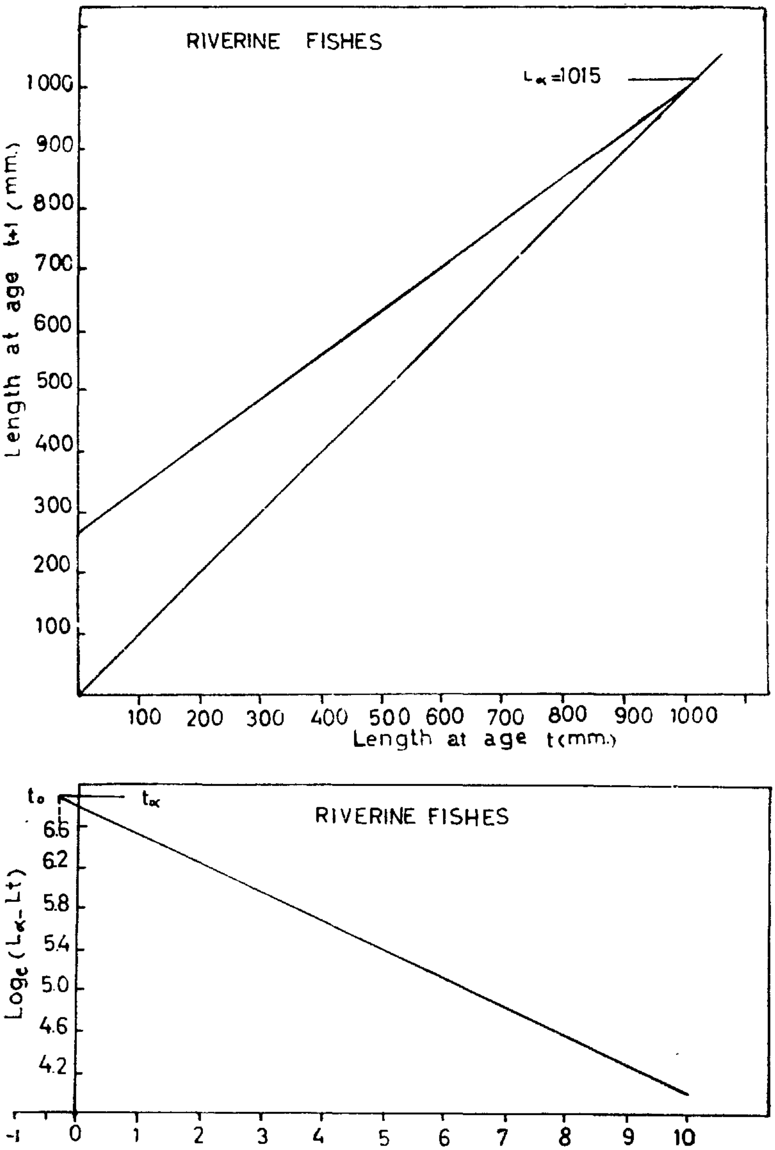


FIG. 6. A, Ford-Walford plot of 'Lt+1' against 'Lt' and B, Plot of Log$_e$ (Lα—Lt) against age 't' of riverine *L. rohita*.

Fitting of von Bertalanffy growth equation to length at age data of L. rohita

von Bertalanffy growth equation (von Bertalanffy 1938 and 1949) can be expressed as :

$$Lt = L\alpha(\ 1-e^{-K}\ t-t_0\ )$$

where Lt is the total length (mm) at age t, $L\alpha$ is asymptotic length e is the base of neparian logarthims, K is the coefficient of catabolism, t is the age of the fish and t_0 is the age at which the fish is of zero length.

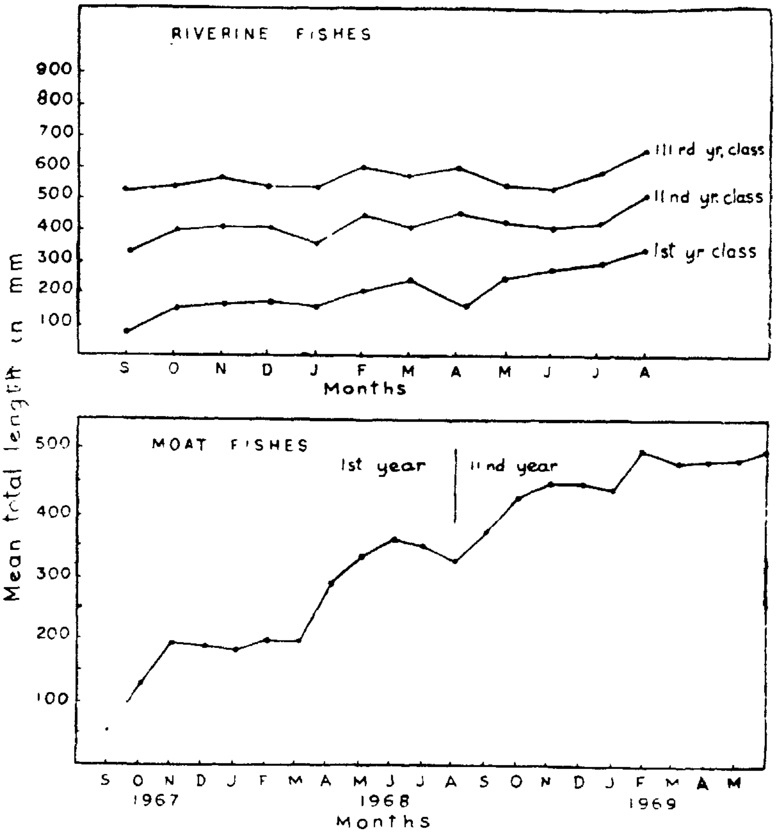


FIG. 7. Seasonal growth curve of *L. rohita*. A; moat fishes, B; riverine fishes.

To fit the growth equation, it may be written in the form :

$$Lt + 1 = L\alpha\ (1 - e^{-K}) + Lt e^{-K}$$

where Lt and $Lt+1$ are the length of the fish at age t and $t+1$ respectively. The equation shows a linear relationship between Lt and $Lt+1$.

When $Lt+1$ is plotted against Lt, a straight line relationship appeared (Fig. 6 A) with the resultant slope $K(=e^{-K})$ and the point where this line cuts the bisector, represents the asymptotic length ($L\alpha$). The estimated parameters are :

$$L\alpha = 1015 \text{ mm},\ k\ (e^{-K}) = 0.717$$

t_0 was estimated by plotting $\text{Log}_e\ (L\alpha - Lt)$ against age (Fig. 6 B) The value of t where it has an ordinate of $\text{Log}_e\ L$ is an estimate of t_0. The slope of the line again gives the value of k. The estimated values are :

$$t_0 = 0.333,\ k = 0.276$$

The values of $L\alpha$ K and t_0 have been substituted in the equation. Thus von Bertalanffy's growth equation for *L. rohita* is :

$$Lt = 1015\ (1 - e^{-0.276\ (t + 0.333)})$$

The values of Lt at different ages were calculated (Table III). It may be seen that there is a close agreement between the calculated length, observed length and length determined by growth equation which revealed that von Bertalanffy's growth equation represents adequately the growth of *L. rohita.*

Seasonal growth

First year growth—In moat when the fingerlings of *L. rohita* were released in September 1967, averaged 55 mm in length. An inspection of Fig. 7 A and Table IV indicates that growth in length took place throughout the year except during December, January and March. The growth rate was the highest during October (a month after stocking) which was 136 per cent increment to total length. Growth rate was also moderate during November but during December and January mean length of the sample decreased due to the domination of comparatively smaller fishes which showed that either no growth was taking place or little growth took place. An increase in February was observed which was followed by a decrease in growth rate in March. Fast growth was again observed during April. The two maxima in growth rate, first in October and the second in April were observed.

In case of riverine fishes, 3 peaks, first in October, second in February and third in May were noticed (Fig. 7 B) Like moat fishes, a drop in average length was observed in December, January and March. However, the growth of the first year class fishes was fairly good throughout the year in both moat and rivers.

Second year growth

The drop in growth rate during winter months was not so marked as in first year class. In both the environments, the growth rate decreased from March to May except in April when a slight increase was noted. During June, the decrease in growth

TABLE IV

Mean monthly growth rate of Labeo rohita

Months	First year				Second year			
	Moat fishes		Riverine fishes		Moat fishes		Riverine fishes	
	Mean length (mm)	% of total growth	Mean length (mm)	% of total growth	Mean length (mm)	% of total growth	Mean length (mm)	% of total growth
August	–	–	–	–	330	—5.7	330	13.8
September	55	–	70	–	375	14.8	330	0.0
October	130	136.0	140	100.0	430	14.8	400	23.1
November	190	46 2	160	14.3	450	4.7	405	1.2
December	185	—2.6	165	3.2	450	0.0	400	— 1.2
January	175	—8.1	150	—9.0	445	—1.1	360	—10.0
February	200	14.2	200	33.0	505	13.2	450	26.0
March	200	0.0	210	5.0	480	—5.0	400	—11.0
April	290	45.0	160	—23.8	485	—1.0	450	12.5
May	330	13.6	220	37.5	490	—1.0	420	—6.6
June	355	7.5	270	22.5	510	4.0	400	—4.2
July	350	—1.4	290	7.4	–	–	470	17.5

rate continued in riverine fishes while in moat an unexpected increase was observed which was due to the fact that during June, 1969 commercial fishing was done in moat and comparatively larger fishes were caught by the nets used which affected the mean length of the sample. In riverine fishes, a slight increase in mean length was observed in July.

Third and above year class growth—No apparent difference in the seasonal growth pattern of second and third and above year classes was observed (Fig. 7B).

DISCUSSION

The occurrence of growth checks similar to those found in temperate fishes has been sufficiently established (Hornell and Naidu 1944; Nair 1949; Seshappa and Bhimachar 1951; Menon 1953; Jhingran 1959; Pantulu 1961, 1963; Natarajan and Jhingran 1963; Qasim and Bhatt 1964; Thakur 1967; Krishnan Kutty 1967; Kamal 1969 and Jhingran 1971) in tropical waters. Periodicity in growth rate has been reported to be due to periodicity in the physical, chemical and biological characteristics of the tropical waters (Seshappa and Bhimachar 1951; Jhingran 1959 and Krishnan Kutty 1967) and the periodic rhythm in spawning (Menon 1953; Natarajan and Jhingran 1963 and Jhingran 1971). Fage and Veillet (1938) came to the same conclusions in other tropical fishes.

In case of *L. rohita* it was found that during first year of life ring formation took place during the months of March and April. It was observed that during these months the feeding intensity was lowest while during rest of the months the feeding intensity was high or moderate. Thus the ring formation during the first year of life can be correlated to the feeding intensity. During the second and subsequent years of life, ring formation took place during April, May and June which were apparently the spawning months of the fish. During this period, the gonads of adult fishes enlarge enormously and most of the growth potential is directed towards the gonad building. Thus the fishes are in the state of greatest physiological stress which causes growth retardation and ring formation on the scales. Hickling (1933) also attributed the formation of such rings on the otolith of hake to a physiological rhythm being laid down during the period of greatest physiological stress which in adult fishes is during maturation and spawning. Further due to the enlargement of gonads, only a little space is left for the gut. This also results in the low food-uptake. Thus it may be concluded that physiological stress imposed through maturation and spawning and low feeding intensity were the main causes of growth retardation and ring formation on the scales of adult fishes. The study of the margins of the scales revealed that rings on the margins appeared only once a year, during April to June which coincided with the spawning period of the fish. Therefore such rings are considered to be true annuli.

The growth rate of *L. rohita* is very fast and rapid growth occurred in the first seven years of life after which growth increment was very little. The growth rate was maximum during first year of life and then decreased gradually. The comparative slow growth rate after the second year of life may be attributed to the fact that the fish generally attains maturity after second year of life and it is well known that after the attainment of maturity most of the growth potential is used for gonad building and little is left for dimensional growth.

Lee's phenomenon of apparent changes in growth rate of *L. rohita* may be due to, as suggested by Smith and Pycha (1961), the fact that precocious fishes were caught early in the life and that in latter years of collections slower growing fishes were taken. This applies well to other commercially important fishes.

Wide range of sizes has been observed among the fishes of same age or year class. Causes of it may be, as suggested by Frost and Kipling (1967), that spawning of all the individuals of the population does not take place at one time and it may cover about one month to complete the spawning of all the fishes. Some fishes hatch earlier than the others and stand to gain a good start of life. It has also been reported by Brown (1946) that the size of the fish is the most important factor which affects the growth in the population. The comparatively larger fishes grow faster and their removal leads to an improvement of the growth rate of smaller fishes and addition results in slow growth rate of smaller fishes. In this way there develops a size hierarchy. This is attributed to the fact that in competition the larger fishes prove to be more efficient and they are able to obtain maximum food.

The growth of the fish is well described by von Bertalanffy's growth equation, perhaps the fish lives constantly in one habitat throughout the life leaving aside the chance of 'revising the ultimate length' (Beverton and Holt 1957).

The decrease in the number of fishes of second and above year classes was considerable and unexpected. The fish produces a large number of ova and even after considerable mortality a larger number of youngs are able to survive and consequently a dense population of its fingerlings and juveniles exists in the rivers during the post spawning period. However, due to indiscriminate and heavy fishing of the fingerlings and juveniles, the population is greatly affected and their number decreases considerably.

The seasonal growth curve of *L. rohita* in both, moat and rivers are very much influenced by the feeding intensity and spawning cycle of the fish. The growth curve of first year class showed two maxima, first in October and the second in April in moat fishes and first in October and second in May in riverine fishes. These two maxima are coincided with two peak periods of feeding. In mature fishes, the sharp drop in growth rate during the months of April, May and June in riverine fishes was due to enlargement of gonads. An increase in post-spawning months was due to better feeding. Thus it may be concluded that while the growth curve of first year class fishes was affected chiefly by intensity of feeding, the growth rate of adult fishes was influenced by feeding and maturation of gonads.

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