STUDIES ON THE COMPARATIVE GROWTH RATES OF THREE MAJOR CARPS OF THE GOVINDGARH LAKE

SHREE PRAKASH AND R. A. GUPTA
Central Inland Fisheries Research Institute, Allahabad 211002.

ABSTRACT

Comparative growth rates of *C. catla, L. rohita* and *C. mrigala* of the Govindgarh lake are studied by means of scales. The relationship between fish length and scale length and time of formation of annuli are estimated. Instantaneous and absolute growth rates of fishes have been calculated separately for each age group. August to October and February to April have been observed as the periods of highest growth and winter months as the period of least growth. The growth curve of first year class fishes was affected chiefly by intensity of feeding and of adults by feeding and maturation of gonads.

INTRODUCTION

Following Jhingran (1957), who had established that scales were valid age indicators in *C. mrigala* from the river Ganga, scales have been used by various workers for age studies in the case of other Indian major carps in detail. The present paper deals with the growth comparison as revealed by the scale studies of *Catla catla, Labeo rohita* and *Cirrhinus mrigala* of the Govindgarh lake during the period from 1975 to 1976. The work is based on the examination of 702 scales of catla, 1818 scales of rohu and 951 scales of mrigal collected from 234, 606 and 317 specimens, respectively.

MATERIAL AND METHODS

The fishes *C. catla, L. rohita* and *C. mrigala* were collected from the Govindgarh lake. The total length of fish was measured from the tip of the snout to the longest tail-fin ray and the scale samples were taken uniformly from directly below the dorsal fin and above the lateral line. Scales were studied under magnification, with the help of a photographic enlarger. The scales were throughly washed and dried before being projected for the magnification.

The Instantaneous, or the Specific, rate of growth (G) of fish was calculated separately for each age group as follows:

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

where L_2 and L_1 are the lengths at time T_2 and T_1 respectively, and G is the Specific growth rate as the percentage increase per unit time. Von Bertalanffy's growth equation was also fitted to the data of length at age, as described by Beverton and Holt (1957).

Observations and Results

Table 1 shows the length-frequency distribution of *C. catla*, *L. rohita* and *C. mrigala* at each age group as revealed by annuli. From this it may be seen that the age group III, IV and V in the case of *C. catla*, II, III and IV in the case of *L. rohita* and II and III in the case of *C. mrigala* were dominant in the commercial catches. Specieswise total lengths, plotted against the corresponding scale radii on an arithmatic graph, gives a straight line on fitting the points of scatter diagram (Fig. 1). The straight line thus obtained shows a direct relationship between the growth rate of fish and its scale.

For ascertaining the time when the rings are laid down on the scales, the scales showing rings at the margin, or very close to it, were studied and their percentage of frequency was calculated for different months. It is observed from this calculation that the maximum number of scales with marginal rings are found during the months of May and June, indicating thereby that the rings are mainly laid down during this period every year.

Table 2 shows the average lengths of the three species at each annulus (at the end of each year of life) as determined by the back calculation of lengths at different annuli by using the formula $L_i = (L - a) \times l_i/l$, where L = the length of fish from whch scale was taken, L_i = the length of fish at the time of annulus formation, l = length of scale from the focus to the anterior apex, l_i = distance between focus and each annulus and 'a' is the intercept of the line. From the average lengths thus derived, it is seen that a rapid growth in length occurs during first four years of life in all the three species and that this period is followed by a period of slow growth.

Absolute Growth and Growth Increment

Plotting the average lengths at annuli for each species, absolute growth curves are obtained (Fig. 2). A progressively declining growth rate with increasing age is also visible in each case from the growth (empirical) increment (Fig. 3). The maximum size of fish recorded in the present study was 1049 mm in the case of *C. catla*, 867 mm in the case of *Labeo rohita* and 753 mm in the case of *C. mrigala*.

The percentage increase in the relative growth rates of I to VIII year age groups are found to diminish from 28.3 to 4.9 in *C. catla*, 33.3 to 2.9 in

TABLE 1. *Length-frequency distribution of age groups of* C. catla, L. rohita *and* C. mrigala.

Size groups (mm)	*C. catla*								*L. rohita*								*C. mrigala*							
	I	II	III	IV	V	VI	VII	VIII	I	II	III	IV	V	VI	VII	VIII	I	II	III	IV	V	VI	VII	VIII
240-300									12	14														
301-420	11									34							11	21						
421-480	11									54								45	12					
481-540	12	12								20	32							35	13					
541-600		11								16	86							12	22					
601-660			13								28	76							17	5				
661-720			14								42	68	14						11	11				
721-780			12									8	44	14					11	12	13			
781-840				12								2	8	13	11						12	15		
841-900				19	12										4							12	16	
901-960					25	19									3	11								11
961-1020						16	16																	
1021-1080							8	11																
Total No.	34	23	39	31	37	35	24	11	12	138	188	154	66	27	18	11	11	113	86	28	25	27	16	11
Percentage of total	14.7	9.3	17.7	13.9	15.1	14.9	9.8	4.6	2.1	21.1	31.0	25.4	11.3	4.4	2.9	1.8	3.1	36.3	27.1	8.8	7.9	8.5	5.2	3.1

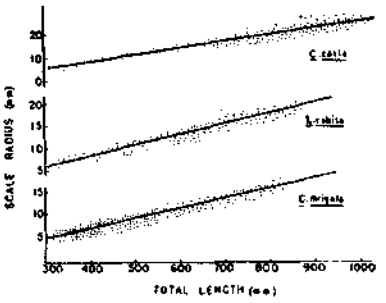

FIG. 1. Relationship between scale radius and total length.

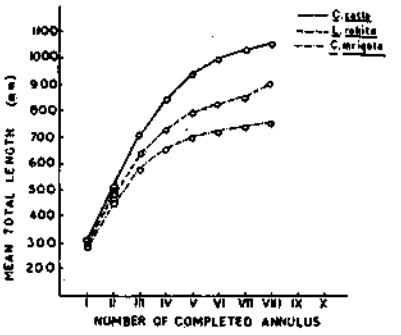

FIG. 2. The absolute growth curves of *C. catla, L. rohita* and *C. mrigala* representing the average length at each age.

L. rohita and 34.0 to 3.5 in *C. mrigala* (Table 3). The growth in terms of length is mainly covered in the first five years of life in all the three species (*C. catla* 86.8%; *L. rohita* 90.6%; and *C. mrigala* 88.0%).

Fitting of Von Bertalanffy Growth Equation

From von Bertalanffy's (1938 and 1949) growth model $l_t = L_\infty \left\{ 1 - \exp\left[-k(t - t_0) \right] \right\}$ The parameters involved were estimated in the usual way.

The equations so obtained for each species are:

$$l_t = 1147 \left[1 - e^{-0.324(t + 0.029)} \right] \textit{Catla catla}$$

$$l_t = 912 \left[1 - e^{-0.382(t + 0.132)} \right] \textit{L. rohita}$$

$$l_t = 771 \left[1 - e^{-0.007(t + 0.007)} \right] \textit{C. mrigala}$$

Lee's Phenomenon of Apparent Change in Growth Rate

Lee's phenomenon of apparent change in growth rate (Lee 1920) is observed in all the three species (Table 2). The variation in the calculated length at annulus 1, between I year and VIII year specimens is as great as 20 mm in *C. catla,* 11 mm in *L. rohita* and 26 mm in *C. mrigala.* At annulus 2, the variations are 26 mm in *C. catla,* 27 mm in *L. rohita* and 31 mm in *C. mrigala.* Variation is also observed during the third year, the variation being 30 mm in *Catla catla,* 10 mm in *L. rohita* and 15 mm in *C. mrigala.*

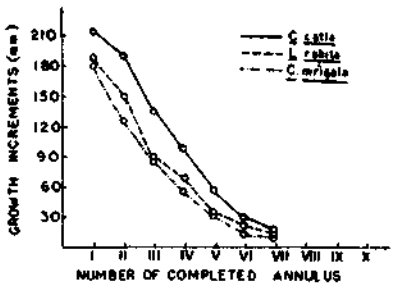

FIG. 3. Growth curves showing average growth increment at each age.

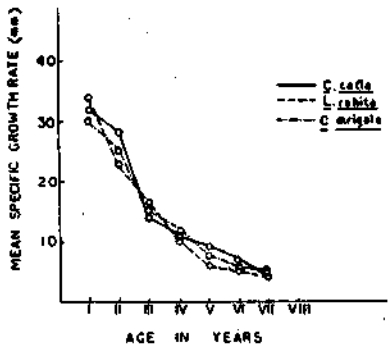

FIG. 4. Change in specific growth rate with age.

Specific (Instantaneous) Rate of Growth

Figure 5 shows the percentage changes in the Specific growth rate 'G' (in length) as age progresses. The changes in growth rate observed are 32% in *L. rohita* and 30% in *C. mrigala*, between ages 1 and 2 years. They drop to 28% in *C. catla*, 23% in *L. rohita* and 25% in *C. mrigala* in the next year, and, ultimately, between ages 7 and 8 years, the changes come down to 4.5% in *C. catla*, 4% in *L. rohita* and 5% in *C. mrigala*. The pattern of changes in 'G' with the mean length at each age is different from the pattern of change in 'G' with age (Figs. 4 & 5). Decrease in 'G' values with increasing length is fairly uniform. The length at ages worked out by the above growth equation (Table 3) showed a good degree of agreement with those derived by the scale method in the case of *C. catla* and a very high degree of agreement in the case of both *L. rohita* and *C. mrigala*.

Monthly Growth

The monthly growth increments for the three species during their II, III and IV years are shown in Fig. 6 (trend for I year could not be included because of inadequate number of specimens). From this it may be seen that the pattern of monthly growth are similar in all the three species except that the II year has the highest growth recorded in November in the case of *C. catla*, in September, March and April in the case of *L. rohita* and in March and April in the case of *C. mrigala*. The III year has the highest growth in March and April in *C. catla*, in October, March and April in *L. rohita* and in March in *C. mrigala*. It may therefore be stated, in general, that while in their years from II to IV, these fishes have their highest growth during the periods October-November and March-April. The drop in growth rate during winter is well marked in all the cases.

TABLE 2. *Calculated length of each annulus as determined by back calculations.*

Age	Calculated length at different annuli I	II	III	IV	V	VI	VII	VIII
				C. Catla				
1	321							
2	318	538						
3	310	459	725					
4	308	526	712	857				
5	300	526	714	856	959			
6	300	523	699	835	962	1003		
7	299	514	695	828	909	999	1041	
8	304	512	719	844	942	1001	1021	1049
Grand mean (mm)	307	514	709	844	943	1001	1031	1049
				L. rohita				
1	303							
2	302	489						
3	300	487	664					
4	298	482	634	732				
5	295	480	627	730	795			
6	293	479	617	715	798	806		
7	292	478	616	714	798	840	847	
8	293	500	656	734	793	844	855	867
Grand mean (mm)	297	485	635	725	796	830	850	867
				C. mrigala				
1	299							
2	295	486						
3	295	482	585					
4	289	482	585	690				
5	288	463	582	687	745			
6	280	463	580	646	695	723		
7	273	458	579	641	688	726	732	
8	272	455	575	639	686	721	744	750
9	267	435	570	635	687	720	744	756
Grand mean (mm)	284	485	579	656	700	722	740	753

TABLE 3. *Mean calculated length at each annulus, growth increment and relative growth rate of major carps.*

Age groups	Back calculated length (mm)	Length determined by growth equation (mm)	Growth increment (mm)	Relative growth (%)
		C. catla		
I	307	325	307	28.3
II	514	553	207	19.7
III	709	717	195	16.6
IV	844	836	135	12.8
V	943	922	99	9.4
VI	1001	940	58	5.5
VII	1031	1029	30	2.8
VIII	1049	1062	18	4.9
		L. rohita		
I	297	320	297	33.3
II	485	508	188	21.6
III	635	636	150	17.3
IV	725	723	90	10.3
V	796	783	71	8.1
VI	830	824	34	3.8
VII	851	852	21	2.4
VIII	867	871	16	2.9
		C. mrigala		
I	284	289	284	34.0
II	465	468	181	22.0
III	579	581	124	15.7
IV	656	652	87	11.2
V	700	696	54	5.1
VI	722	724	32	4.4
VII	740	741	28	3.9
VIII	753	752	23	3.5

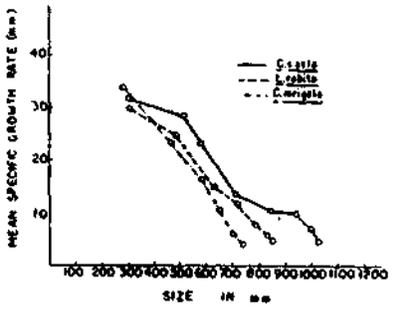

FIG. 5. Change in specific growth rate with size.

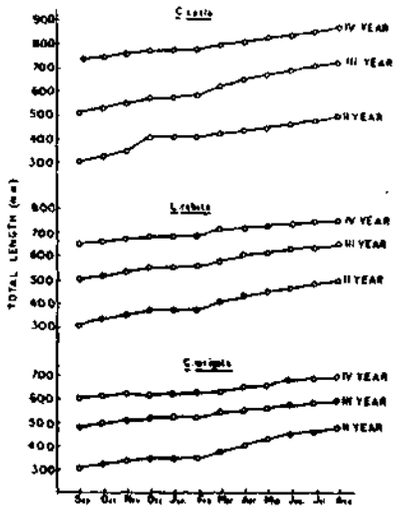

FIG. 6. Monthly growth increments (in mm).

Discussion

Taking the average for all the year classes, the growth increment is maximum in *C. catla*, less in *L. rohita* and least in *C. mrigala*. The growth rate in all the species is rapid for the first five years of life, after which growth increment is very little. The growth rate, which is maximum during first year, decreases thence forward gradually. The comparatively slow growth rate observed after the second year may be attributed to the fish's generally attaining maturity after second year of life, since it is well known that on the attainment of maturity most of the growth potential is used for gonad building and little is spent for dimensional growth.

Lee's phenomenon of apparent change in growth rate is manifest in these fishes, may be because the fast growing fishes are caught early in life and, in later years, slow-growing fishes are taken. A wide range of sizes is observed within the same year-class. The cause of this may be either that the spawning of all the individuals of the population does not take place at one time (Frost and Kipling 1967) or that the comparatively longer fishes grow faster to begin with and get removed first, and thus resulting an improvement of the growth rate of the smaller fishes that lagged behind, which in turn results in the slow growth rate of fishes smaller to them, causing this way a size-hierarchy to develop (Brown 1946). Khan and Siddiqui (1973) had observed that seasonal growth curves were very much influenced by the feeding intensity and spawning cycle of the fish. The growth curves in the present study shows two maxima, first in August-September-October and second in February-March-

April. In mature fishes the sharp drop in growth rate during the months of May and June may be due to the enlargement of gonads and subdued feeding taking place in these months. Thus, it may be concluded that while the growth of the fish in first year class is influenced by the intensity of feeding, the growth rate of adult fish is influenced both by the feeding and by the maturation of gonads. During the present observations, the retardation or check in growth is observed only during winter months (December-January) and premonsoon months (May-June) because of the fact that majority of the specimens studied were males.

Acknowledgement

The authors are grateful to Dr. V. G. Jhingran, Director, Central Inland Fisheries Research Institute and Dr. A. V. Natarajan, Head, R. & L. Division, CIFRI, Allahabad, for providing facilities to carry out this work.

References

Ball, J. N. and J. W. Jones. 1960. On the growth of brown trout, *Salmo. truta fario Tegid. Proc. Zool. Soc. Lond.*, 134: 1-41.

Bertalanffy, L. Von. 1938. A quantitative theory of organic growth (Inquiries on growth laws II). *Human Biology*, 10(2): 181-213.

Bertalanffy, L. Von. 1949. Problems of organic growth. *Nature*, 163: 156-158.

Beverton, R. J. H. and S. J. Holt. 1957. On the dynamics of exploited fish populations. *Fishery Invest.*, Lond. Ser., 219, 533.

Brown, M. E. 1946. The growth of brown trout (*Salmo trutta Linn.*) I. Factors influencing the growth of the fry, *J. exp. biol.*, 22, 118-129.

Frost, W. E. and C. Kipling. 1967. A study of reproduction, early life, weight-length relationship and growth of pike, *Esox lucious* L. in Windenmere. *J. Anim. Ecol.*, 36, 651-693.

Jhingran, V. G. 1957. Age determination of Indian major carp, *Cirrhina mrigala* (Ham.) by means of scales. *Nature*, London 179, 468-469.

Khan, R. A. and A. Q. Siddiqui. 1973. Studies on the age and growth of *Rohu, Labeo rohita* (Ham.) from a pond (moat) and rivers Ganga and Yamuna. *Proc. Ind. natn. Sci. Acad.*, 39B, 542-597.

Lee, R. M. 1920. A review of the methods of age and growth determination in fishes by means of scales. *J. Cons.*, 4(2): 1-32.