J. Mountain Res. ISSN: 0974-3030
Vol. 12, (2017) 1-12

Study of age and growth of *Labeo Calbasu* (Ham.) from the Ganga river system at Allahabad

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Received: 14.09.2017; Revised: 20.10.2017; Accepted: 07.11.2017

Abstract: Ageing biology of *Labeo calbasu* (Ham.) was studied by using scales. A linear relationship with high degree of correlation was observed between total length and scale radii of fish which shows significance of study. Formation of growth ring was annual in nature. The first annulus was formed at an average length of 16.49cm. Length increment was found decreasing with age. Phenomenon of growth compensation was observed in the age class eight. The spawning as the prime factor with low feeding intensity were the factors causing annulus formation. Fishes under examination belonged to 0 to 8 age classes. The maximum specimens were recorded for age class 2. It appeared that fishes of age class 1 and 2 were more vulnerable to the fishing gear. The mean back calculated length (in cm) obtained by the analysis of pooled key scale samples were 16.49, 25.65, 35.32, 43.09, 48.11, 51.36, 56.57, 69. 15 for the 1st to 8th age classes respectively. The growth rate (length increment in cm) was recorded 16.49, 9.16, 9.67, 7.77, 5.02, 3.25, 5.21 and 12.58 for 1st to 8th age classes respectively. The maximum annual increment had been recorded in the first year of life. Growth compensation was observed in age class eight. Specific rate of linear growth (C_1) has been recorded to be 55.79, 37.49, 21.99, 11.65, 6.75, 10.19 and 22.24 between different age classes. It showed a decreasing trend except in age classes seventh and eighth. The index of species average size (ϕh) was recorded 8.64, which indicated commercial importance of the fish. The maximum attainable size was recorded 80.5cm. The first maturity was attained after second year of life (at a size of 32.0cm and 34.0cm for males and females respectively) and the harvestable size was recorded after completion of third year of life at a length of 37.2cm.

Keywords: *Labeo calbasu* • ageing • growth rate • harvestable size • size at first maturity

Introduction

Growth is the change in size (length, weight) over time. This is one of the most intensively studied aspects of fishery biology. Study of age composition, rate of growth per year, longevity of fish is essential in understanding the dynamics of fish population and for prediction of fishery stocks. The annual variation in the fishery of aquatic bodies depends upon the growth pattern of fishes. Age of fish is determined by counting the number of periodic rings (markings) or zones on certain skeletal structures like scales, otoliths, operculi, vertebrae, cleithra, etc. Age thus calculated is verified by length-frequency distribution methods. Scale reading has been considered most reliable and employed universally. Hoffbaurer (1898) studied the scale of common carp, *Cyprinus carpio* of known age and established a close relationship between the favorable conditions of the environment and the rate of growth of the scales and used the scale markings in age determination. Thomson (1902) studied the Gobioid and Pleuronectoid scales and found that growth was accelerated in warmer months and diminished during the winter resulting in formation of annual marks which can be used for age determination. Lea (1910) described the growth history of Norwegian herring by measuring growth zones on the scales. He recorded the size of fish at each previous year of its existence and relation of the growth of fish and physical conditions. If the fish length and scale radius has linear relationship, the previous lengths can be calculated

Lee (1912) using the formula described by Lea (1910) found that in the Norwegian herring the average size of each group did not correspond closely to the average calculated length at the formation of winter ring. Due to the discrepancies between empirical and observed values, Fraser (1916) pointed out that scale appeared on the body of the fish after fish had attained some lengths, which is different in different fish species. The particular size when the scale appeared was described as a correction factor. Valuable contributions have been made on the ageing biology of fishes by a number of workers including Lee (1920), Van Oosten (1942); Chacko and Krishnamurty (1950); Raj (1951); Seshappa and Bhimachar (1951, 1954); Oliva (1955); Jhingran (1957); Balon (1963); Frost (1963); Natrajan and Jhingran (1963); Toor (1964); Qasim and Bhatt (1966); Hile (1970); Griffith (1975); Tandon and Oliva (1978); Frost and Kipling (1980); Dobriyal and Singh (1990); Casselman (1990); Rawat and Nautiyal (1996); Bhatt and Nursrat Jahan (2015) and Maunder et al. (2016). However, studies on the age and growth of *Labeo calbasu* have been few and fragmentary (Rao and Hora, 1972; Gupta and Jhingran, 1973, Tandon et al., 1989). The present study gave an account of age and growth rate determination in *Labeo calbasu* inhabiting the river Ganga at Allahabad.

Materials and Methods

Scales are excellent material for ageing and growth pattern studies. Key scales were collected from the region just below the dorsal fin and above the lateral line. Extraneous matter and mucous were removed by washing scales in tap water and rubbing in between the finger tips. Larger scales were made more clear and soft by dipping them in weak solution (1%) of KOH for about 5-10 minutes; then washed in tap water and dried in air. Finally scales were placed in an envelope containing information like date of collection, place and morphometrics. Prior to age determination, establishment of the fact that annual increment in the length of the scale maintains a constant ratio with the increase in fish length throughout the year is important. For this the scale radius from the focus to anterior margin were measured by Dokumator (microfilm reader). The data were fed into an electronic calculator (model EC-75) for obtaining the value of a, b and r. The fish length-scale radius relationship were established by the regression analysis and by extrapolating the regression line, correction factor was found out which was used for hack-calculations and other growth parameters.

Scale of *Labeo calbasu* has a focus which is sharp in the beginning, but as the scale grows it becomes less prominent. The scale has circular lines (circuli) and the radiating lines originating from the focus or any point away from the focus (radii). The circuli are formed periodically with the growth of scale showing closely and widely spaced arrangement representing slow and fast periods of growth. An annulus was formed at the outer border of closely spaced circuli. The annuli were termed as checks (Jhingran, 1957, 1959) or annual marks or monsoon rings (Menon, 1953; Seshappa and Bhimachar, 1954) or rings (Natrajan and Jhingran, 1963). After the confirmation and identification of growth rings (annuli), their distance from the focus was measured. The period of growth ring formation was recorded as the highest percentage of the minimum width in the terminal zone of the scale (occurrence of marginal annuli). The terminal zone i.e., the distance between anterior margin and the last annulus registered by the scale was recorded in millimeters to compute monthly average from which the value of annual average was considered as the minimum width in terminal zone. Monthly percentages were calculated and the high percentage of scales with minimum width in terminal zone represented the period of annulus formation. On the basis of the frequency of annulus formation within one year, the nature of annulus formation i.e., annual, biannual, etc., was assessed and the age of the fish estimated.

Based on the scale reading following formulae have been used for various growth parameters.

Back-calculation

$$l_{n-a} = \frac{S_n}{S}(l-a)$$ (Bagenal and Tesch, 1978)

Where, l_n = length of fish when annulus 'n' was formed

l = length of fish at the time of capture

S_n = length of scale radius to annulus 'n'

S = total scale radius

a = correction factor

The average back-calculated lengths of various annuli for different age classes were computed and various growth parameters were studied.

Annual increments (h): annual increments (in cm) were calculated by subtracting successive lengths from their previous lengths except for the first years.

Specific rate of linear growth (c_l)

$$C_1 = \frac{l_n - l_{n-1}}{l_{n-1}}.100$$ (Chugunova, 1963)

Index of species average size (ϕh)

$$\phi h = \frac{\sum_{h=1}^{n_{j+a}} h}{n_{j+a}}$$ (Balon, 1971)

Growth characteristic (C_{th})

$$C_{th} = \frac{\log l - \log l_{n-1}}{0.4343}.l_{n-1}$$ (Vasnetsov, 1934)

Growth constant (c_{lt})

$$C_{lt} = \frac{\log l_n - \log l_{n-1}}{0.4343} \cdot \frac{t_2 + t_1}{2}$$ (Chugunova, 1963)

Where, l_n and l_{n-1} are mean computed total length of fish at ultimate and penultimate years of life

j=juveniles, a = adults, n = number, h=absolute increase in length, l = length

t_2 and t_1 are time intervals between ultimate and penultimate age classes and the value of $(t_2+t_1)/2$ is equal to 1.5.

Harvestable size: The minimum theoretical harvestable size has been calculated from the crossing point of the curves of length increment (h) as the percentage of length of first growth season and average length at each age class as the percentage of the length of the final growth season, based on the back-calculated lengths (Tandon and Johal, 1996).

Maximum attainable size: Maximum size or asymptotic length to be attained by fish was determined by plotting Walford’s graph (Walford, 1946). The l_n in each age class was plotted along X-axis and l_{n+1} along Y-axis and line was drawn touching maximum points. Another line was drawn at an angle of 45º from the ‘O’ mark. The intercept of the two lines gave the maximum attainable length (this size should be more than the largest specimen in the sample).

Results and Discussion

Labeo calbasu possesses cycloid scales. The anterior face is comparatively transparent, embedded in skin and posterior exposed face bears chromatophores. Scales are elongated and each scale has a focus or nucleus which represents the origin of growth and becomes inconspicuous as scale grows. Around the focus the scale has circular concentric lines called circuli originating from the focus and extending the margin in a regular pattern. The circuli are formed periodically with the growth of the scale. These circuli, when exhibited a tendency of discontinuity, were identified as annuli or growth rings. Thus each annulus comprised continuous and widely spaced (fast growing phase) and closely and discontinuous circuli. The radiating lines are formed due to scarcity of space on the body of the growing scale. Radii have radial deposition and are categorized as primary (originating from focus), secondary (originating midway between focus and margin) and tertiary (originating between primary and secondary radii) radii.

Body length-Scale radius relationship

Linear relationship with high degree of correlation coefficient has been observed when total fish lengths were plotted against scale radii. The equation obtained can be expressed as follows:

$SR= -0.2489 + 0.2046\ FL\ (r=0.9179)$

Where, SR= scale radius, FL= fish length, and r= correlation coefficient.

The regression line based on the above equation when extrapolated cut X-axis at 15mm (Fig.1). It was evident that scales appeared for the first time on the body of fish, when fish attained a length of 15 mm. This value has been considered as correction factor and used for back calculations (Bagenal and Tesch, 1978).

Time and causative factors of annulus formation

During the investigation the maximum occurrence of marginal annuli was observed in July, August and September. The highest percentage of the scales possessing minimum width in terminal zone was found to occur during these months (Fig. 2). Thus it showed that annulus was formed during these months. The fish spawned during July, August and September which probably disturbed the normal growth causing the discontinuity in the growth of circuli (identified as annulus). During these months very low feeding intensity was recorded and most of fishes were observed with empty gut. From the above observation it would appear that spawning and low feeding intensity were responsible for annulus formation. Growth rings were annual in nature and appeared once a year (Fig. 3).

Back-calculations

During the period of investigation scale sample of 162 specimens of *Labeo calbasu,* ranging in length from 12.2 to 75.0cm and belonging to 0 to 8 age classes were examined. The maximum number of specimens belonged to age class two. From the data it appeared that age classes one and two were more vulnerable to the fishing gear. The mean back calculated lengths (in cm) obtained by the analysis of pooled key scale samples were 16.49, 25.65, 35.32, 43.09, 48.11. 51.36, 56.57 and 69.15 for first to eighth age classes respectively (Table 1).

Growth parameters Growth rate (length increment)

The growth rate (in cm) was recorded 16.49, 9.16, 9.67, 7.77, 5.02, 3.25, 5.21 and 12.58 for one to eight age classes respectively. The maximum annual increment had been recorded in the first year of the life which generally decreased with the increase in the age. However, its value showed sudden increase in the age class eight. Specimens after completion of seven years of life showed a very fast growth rate; this phenomenon is known as growth compensation.

Specific rate of linear growth (C_l)

Specific rate of linear growth had been recorded to be 55.79, 37.49, 21.99, 11.65, 6.75, 10.19 and 22.24 between different age classes. It showed a decreasing trend except in age classes seventh and eighth. A sudden increase in C_t, value was observed in age class eighth.

Index of species average size (ϕh)

Index of species average size, i.e., average increase in length for *Labeo calbasu* was observed to be 8.64 (Table 2). A high value of ϕh indicated better growth and suitability of environment.

Growth characteristic (C_{th}) and growth constant (C_{lt})

Growth characteristic indicated that *calbasu* has three distinct periods in the life. Values of growth characteristic (Table 2) showed that fish enters second period of life after fourth year and third period of life after seventh year. There was a regular pattern between first and second periods. Major parts of growth took place in the first period.

Values of growth constants and average growth constants of *Labeo calbasu* reflected different phases of life, i.e., asexual, sexual and an old age. The fish had an active sexual phase then entered in old age. Growth constants were affected by rate of exploitation, vulnerability of the gear for different size groups, emigration, etc.

Harvestable size

Crossing point of the length increment (h) in percentage of the length of first growth season and average length at each age class in percentage of the length of the final growth season was considered as harvestable size. By plotting these two lengths along the Y-axis and age classes along X-axis, gave the point of intersection which was considered as the theoretical harvestable size. In case of *Labeo calbasu* point of intersection lied between age classes three and four. The graph (Fig. 4) clearly indicated that the fish should be harvested after completion of the third year of life. The average length at this time was recorded approximately 37.2cm. The point of intersection advanced in those populations, where the growth rate was slow. The first maturity was attained after second year of life thus minimum theoretical harvestable size was after the first maturity of fish.

Maximum attainable size

Maximum attainable size was determined by Walford's graph (Walford, 1946). Maximum size to be attained by *Labeo calbasu* in Ganga was recorded 80.5cm.

Age and growth studies of commercially important fishes are of vital significance in evolving policies for the management and conservation of their fisheries (Jhingran, 1959). Growth in fishes is not uniform throughout the year and the fluctuations in the growth express itself on the scales and other skeletal parts. These expressions (growth marks) in *Labeo calbasu* were annual in nature and used for ageing studies.

Linear relationship with high degree of correlation coefficient were observed when total lengths were plotted against scale radii (Fig. 1). The fish length-scale radius relationship has already been studied by Sarojini (1957); Pillay (1958); Hile (1970); Hanumantharao (1974); Prakash and Gupta (1986); Tandon et al. (1989) and Dobriyal and Singh (1990). Thomson (1902) observed the formation of annulus from April to June in *Gadus pollachius* and in July in *Gadus minutus* due to low temperature and low food supply. Cutler (1918) considered scarcity of food and not the temperature responsible for annulus formation. Starvation was found to be the factor of annulus formation by Pillay (1954) in *Mugil tade,* Sarojini (1957, 1958) in *M. persia and M. cunnesius*, Seshappa *(*1958) in *Rastrelliger conagurata.*

Spawning was found the most important factor for annulus formation and growth rings were considered to be the spawning mark by Hutton (1923) in grayling, Fry (1936) in *Hesperolucus venustus,* Blackburn (1949) in Australian pilchard, Chacko and Krishnamurty (1950) in hilsa, Seshappa (1958) in mackeral, Natrajan and Jhingran (1963) in catla, Grant (1974) in striped bass and Fagade (1974) in tilapia. In the present study it was observed that in *Labeo calbasu* the maximum percentage frequency of scales possessing minimum width in terminal zone was recorded during July August & September thus due to presence of marginal annuli it becomes clear that annulus was formed during these months. Fish spawned during these months and feeling intensity was recorded quite low, most of the mature fishes were found with empty gut. Thus spawning was the prime factor of annulus formation and low feeding intensity may be also considered of secondary importance.

The first annulus was liad at an average length of 16.49cm. Length increment was found decreasing with age. A sudden increase in annual increment was observed in age class eight (growth compensation). Van Oosten (1939, 1942) reported growth compensation in the age class four in *Coregonus clupeaformis* and age class three in *Lepibema chrysops.* Growth compensation is common in almost all natural populations. Fish compensates for the loss of growth at the return of favourable conditions.

Table 1 Back calculated lengths (cm) of *Labeo calbasu* during Jan-Dec' 1999 from river Ganga at Allahabad.

Age class	No. of specimens examined	Total length (cm) Average	Length of fish (cm) at the time of annulus formation							
			l_1	l_2	l_3	l_4	l_5	l_6	l_7	l_8
0	10	18.35								
		(12.2-24.5)								
1	46	25.57	17.72							
		(15.2.-31.5)	(12.37-26.22)							
2	50	31.99	18.38	25.47						
		(24.3-41.1)	(13.11-28.44)	(18.36-36.29)						
3	21	38.34	17.91	26.12	32.77					
		(29.8-50.0)	(12.79-23.37)	(20.93-32.72)	(26.32-42.66)					
4	25	47.3	18.63	28.31	35.44	42.19				
		(39.2-70.0)	(12.04-23.25)	(21.87-37.49)	(28.70-49.86)	(35.64-62.96)				
5	8	50	15.41	25.08	34.07	41.11	47.65			
		(43.0-59.0)	(13.44-16.34)	(23.05-27.49)	(28.92-39.11)	(35.34-47.99)	(40.66-56.49)			
7	1	53.5	10.01	18.49	30.81	37.75	42.76	46.61	50.07	
8	1	75	17.39	30.44	43.49	51.32	53.93	56.1	63.06	69.15
Total/ average	162	42.51	16.49	25.65	35.32	43.09	48.11	51.36	56.57	69.15
		(12.2-75.0)	(12.04-28.44)	(18.36-37.49)	(26.32-43.49)	(35.34-62.96)	(40.66-53.93)	(46.61-56.10)	(50.07-63.06)	

Values in parenthesis indicate range

Table 2 Growth data of *Labeo calbasu* (Ham.).

Parameters	Years of life							
	1	2	3	4	5	6	7	8
L (cm)	16.49	25.65	35.32	43.09	48.11	51.36	56.57	69.15
(h)	16.49	9.16	9.67	7.77	5.02	3.25	5.21	12.58
C_l	55.79	37.49	21.99	11.65	6.75	10.19	22.24	
ϕh				8.6437				
C_{th}	7.3084	8.1797	7.0181	4.7528	3.146	4.9665	11.3423	
$Av.\ C_{th}$		7.5021			4.2884		11.3423	
C_{lt}	0.6648	0.5526	0.2981	0.1655	0.0981	0.1451	0.3007	
$Av.\ C_{lt}$		0.6087		0.2318		0.1216	0.3007	

Table 3 Harvestable size (age class and size) and maximum size to be attained by the fish (with maximum size of the fish in sample).

Name of fish	Age classes	Harvestable size (cm)	Max. size to be attained by the fish		Locality	Authors
Labeo dero	2-3	21.00	62.50	(24.22)	Gobindsagar, Himachal Pradesh	Tandon et. al., 1989
L. dero	2-3	29.50	65.00	(51.10)	-do-	Singh, 1978
Tor putitora	2-3	38.62	135.00	(100.02)	-do-	Johal and Kingra, 1988a
Cirrhinus mrigala	1-2	45.00	90.00	(72.49)	-do-	Johal and Tandon, 1987
Catla catla	2-3	59.21	120.00	(100.02)	-do-	Johal and Tandon, 1987
Labeo rahita	2-3	50.78	85.00	(79.11)	-do-	Johal and Tandon, 1987
Cyuprinus carpio	1-2	42.27	95.00	(80.48)	-do-	Bhandari, 1990
Hypophthalmichthys molitrix	2-3	45.00	110.00	(92.45)	-do-	Kukreja, 1989
Labeo calbasu	3-4	37.20	80.50	(75.00)	Ganga River system, Allahabad	Present investigation

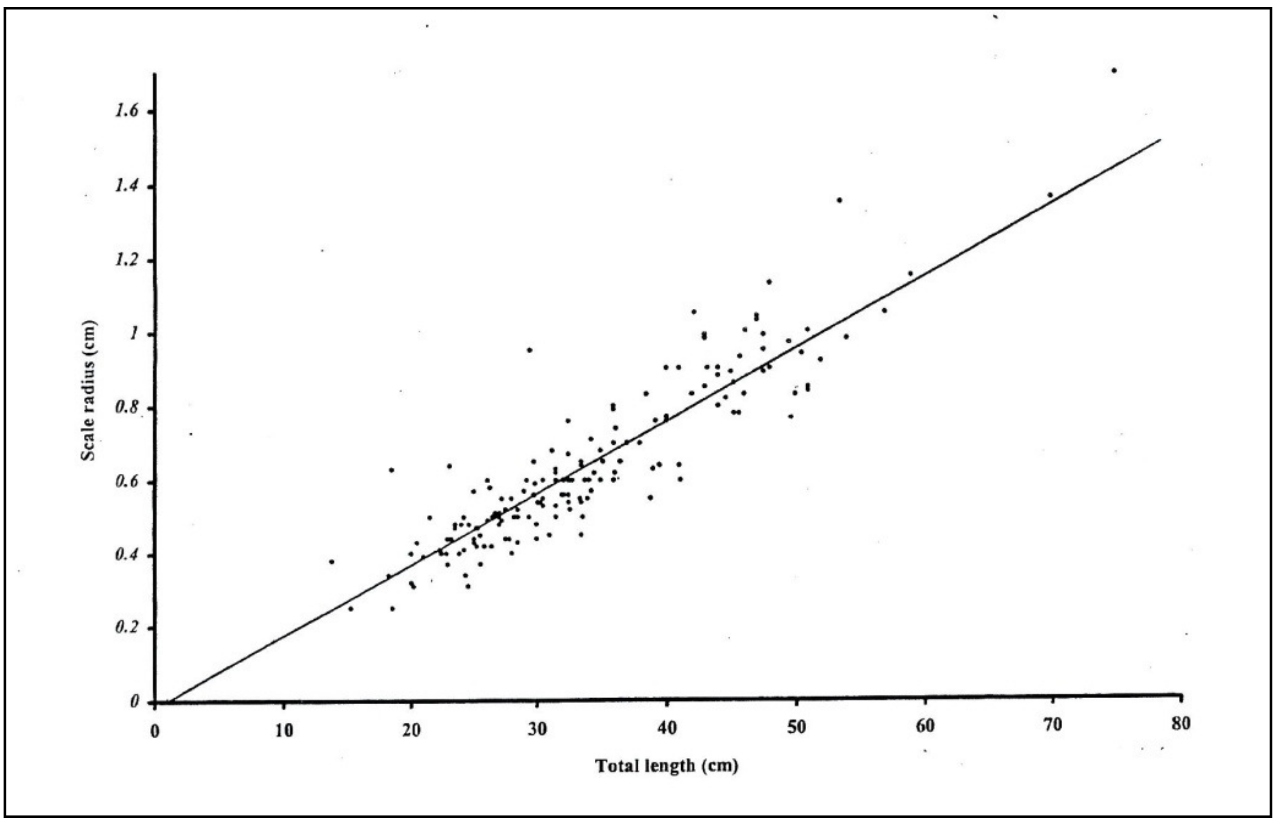

Figure 1 Regression analysis between total length of fish and scale radius in *Labeo calbasu.*

Specific rate of linear growth (C_l) in general showed downward trend with age except in age class eight. Index of species average size (*ϕh*) depends on the growth in size and the occurrence of maximum age classes. Balon (1971) observed high values of index of species average size (*ϕh*) in *Cyprinus carpio* from pond population. High values of *ϕh* has been reported in *Puntius sarana* by Johal and Tandon

(1983) from the river Ghaggar and minimum from Sukhna lake, Chandigarh. A comparison of ϕh values has been made for fishes from different localities of India. Its higher values indicated suitability of environment. ϕh value of *Labeo calbasu* from the Ganga at Allahabad was recorded 8.64. Values of ϕh for *Labeo calbasu* from different localities indicated that *calbasu* has higher values of 4h in rivers, indicating that *calbasu* is certainly a riverine fish.

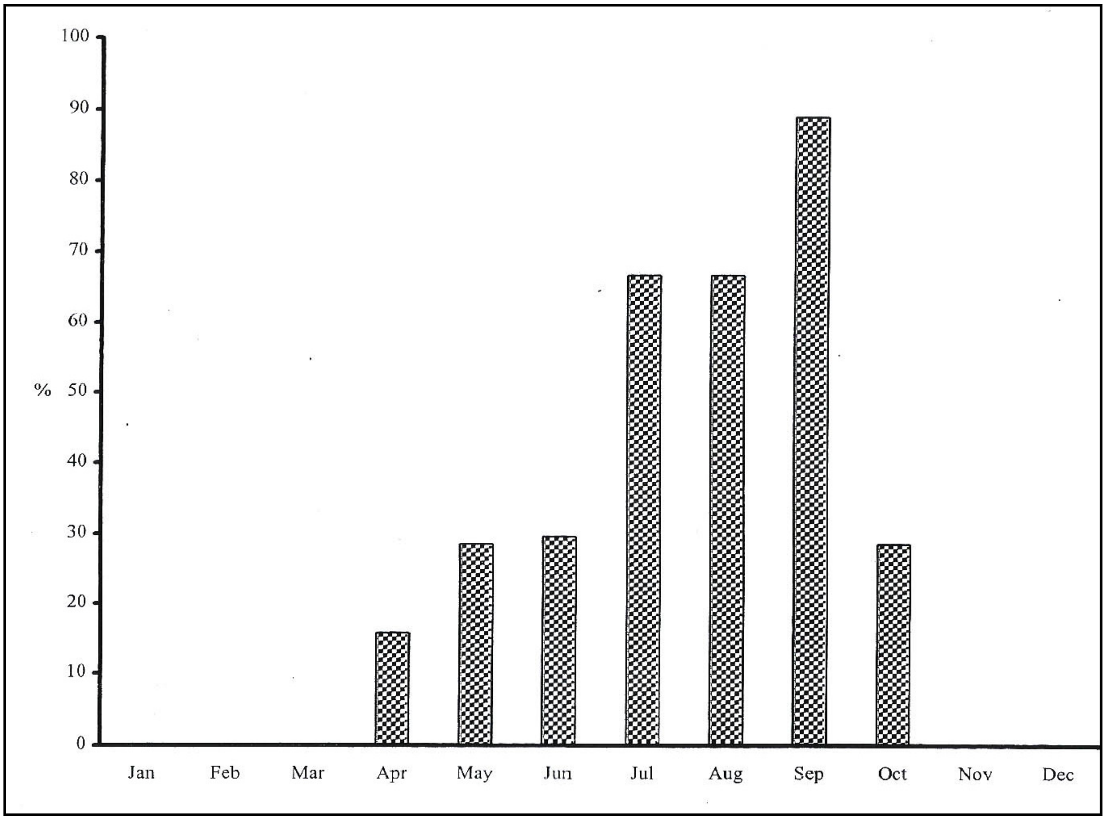

Figure 2 Minimum width in terminal zone on scale of *Labeo calbasu.*

Figure 3 Scale of *Labeo calbasu* showing number of annuli.

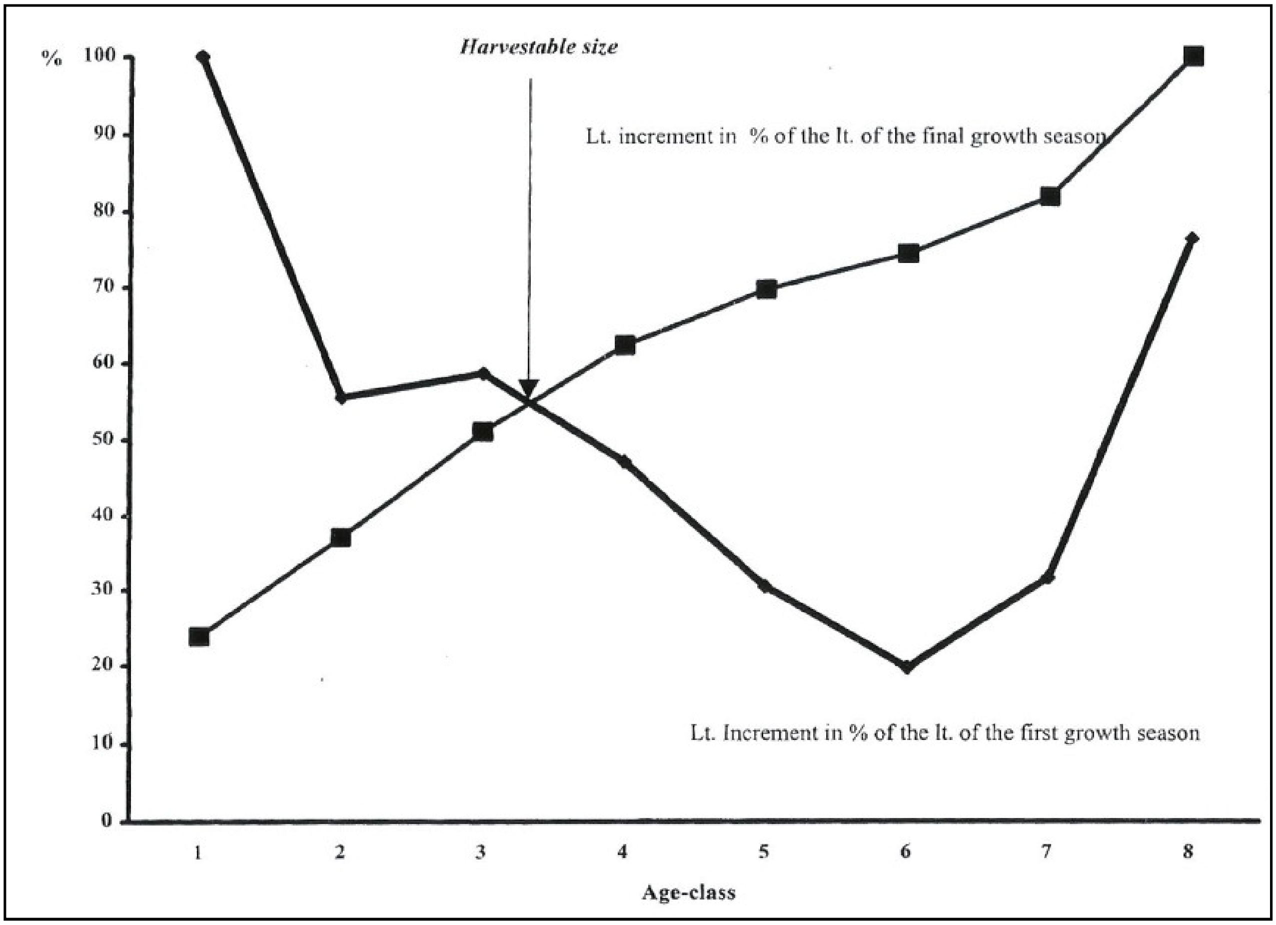

Figure 4 Harvestable size of *Labeo calbasu* (Ham.) from Ganga at Allahabad.

Vasnetsov (1958) was of the view that first period of growth characteristic varied considerably under the influence of external conditions and depends upon the changes in the lengths of fish of different species, whereas the second period characterizes the hereditary fixed growth rates. Chugunova (1963) found regularities of growth in using growth characteristics of cyprinids. Tandon and Johal (1996) described that *Cirrhinus mrigala* from Rangmahal, *Labeo rohita* from different localities and *Catla catla* from Rangmahal and Harike entered second period of life after third year, whereas *C. mrigala f*rom Harike and Gobindsagar (H.P.) and *Catla catla* from Gobindsagar in the fourth year.

The values of average growth constants are helpful in determining the periods of life in the life span of the fish (Chugunova, 1963). She advocated that the first period coincides with the asexual phase and the second with the sexual maturity. The occurrence of only first period in *Cirrhinus mrigala* from Sukhana lake, Chandigarh (Johal and Tandon, 1983) indicated that either the ideal conditions for further growth did not exist due to its shallowness, or there was an overexploitation in the lake. The occurrence of third period has been described in *Cirrhinus mrigala*, *Labeo rohita, Catla catla* from different localities of India by Tandon and Johal (1996).

In the present study of *L. calbasu* four periods of life have been observed. Different phases of life such as asexual, sexual, old age depends upon environmental conditions, the same fish species may include different age classes from different localities. Harvestable size of *Labeo calbasu* was determined from crossing point of the length increment (h) as percentage of the length of first growth season and average length at each age class as percentage of the length of the final growth season. This method is adopted by various authors (Tandon and Oliva, 1977; Singh, 1978; Tandon and

Johal, 1996). Present study revealed that rings were annual and formed during July-September due to cumulative effects of spawning and decreased feeding activity. The study of growth parameters indicated that *calbasu* population was not under stress and the riverine environment of the Ganga at Allahabad was quite favourable for the fish.

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