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AGE AND GROWTH OF THREATENED BRONZE FEATHERBACK *NOTOPTERUS NOTOPTERUS* IN GOMTI RIVER, LUCKNOW (INDIA)

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ABSTRACT : The bronze featherback, *Notopterus notopterus* is distributed in Ganga, Mahanadi, Godavari, Krishna and Cauvery river systems and supports commercial riverine fisheries throughout South India. Body growth is an important population process in fish because it has major impact on the biomass development and reproduction. Unfortunately population of the featherback is declining year-by-year due to monsoon failure and human impacts. Since report on age and growth of *Notopterus notopterus* is lacking, the present study was undertaken to determine the age and growth of the bronze feather back from wild habitats of river Gomti by using scales. This study showed a well-defined growth pattern in wild population of *Notopterus notopterus* which will help the agencies in formulation of the strategies for conservation and rehabilitation of this species.

Key words : *Age, growth, threatened Notopterus notopterus, Gomti river, Lucknow.*

INTRODUCTION

Body growth is an important population process in fish because it has major impact on population biomass development as well as reproduction. Strong geographic differences in age or size composition, if not reflective of fishing gear differences and other factors, suggest independence of recruitment or other biological or fishery factors as a basis for assuming discrete stocks (Begg and Waldman,1999). Growth in river and flood plain fish is strongly influenced by environmental conditions including hydro biology, food resources and population density (Halls,1998 and de Graf *et al.*,2001). The easiest way of ageing scaly fish is through their scales since the procurement of bones entails much time and killing of fish. The seasonal changes are reflected in the form of growth zones on checks on the hard parts of the fish. The growth zones may be of two types - narrow zones and wide zones. Under temperate conditions, most of the fishes have annual cycles of maximum growth corresponding to summer when temperature and food supply are most favourable but growth in these fishes slows down to a minimum during winter due to low temperature and scarcity of food. Contrary to this, in tropical waters, neither temperature nor food supply changes considerably with the seasonal rhythm and hence to presume that growth in tropical climates follows an annual patterns similar to that of temperate. The growth of fishes at various ages can be deciphered by back-calculating the distance between growth checks on a time scale basis provided the relation between the growth of hard parts and the liner growth of the fish is established. Gomti river is one of the major tributary of Ganges, flows through richly cultivated lands as well as densely populated areas in Uttar Pradesh. The river drains a catchments area of about 25,800 km^2. Kathna, Sarayan, Reth, Luni, Kalyani and Sai rivers are the tributaries of Gomti. Lucknow (population about 3.5 million), Sultanpur (population about 0.2 million) and Jaunpur (population about 0.2 million) are the three major urban settlements on the banks of the river. The river serves as a major source of domestic water supply of the Lucknow city (capital of Uttar Pradesh). Subsequently, the river receives back the untreated domestic wastewater from Lucknow city @ 450,000 m^3/day and effluents directly from a few industries (distilleries, sugar mills, chemical and others) during its course (Singh *et al.*, 2005a,b and Varshney *et al.*,2012).

The study on age growth of freshwater fishes of India is comparatively recent and the successful decoding of scale sculpture of marine fishes prompted to undertake such work among freshwater fishes too (Rao,1961,1966 and Sarkar *et al.*,2008). Jhingran (1959) successfully analyzed the age of *Cirrhinus mrigala* of Ganges at Allahabad. Das (1959) suggested the possibilities of age determination through scales in a number of freshwater fishes of India such as *Anabas, Mugil, Hilsa, Cirrhinus, Labeo, Barbus, Gudusia* and *Notopterus*. The age and growth of some commercially important freshwater fishes such as *Catla catla* (Natarajan and Jhingran, 1963), *Ophicephalus punctatus* (Qasim and Bhatt,1966), *Cirrhinus mrigala* (Kamal,1969), *Labeo calbasu* (Rao and Rao,1972 and Gupta & Jhingran,1973) and *Chitala chitata* (Sarkar *et al.*,2008) were recorded. The bronze feather back, *N.notopterus*, is distributed in Ganga, Mahanadi, Godavari, Krishna and Cauvery and supports commercial riverine fisheries throughout South India (Talwar and Jhingran,1991). Though literature on age and growth of Indian freshwater fishes is available, such report on *N.notopterus*, one of the threatened species (CAMP,1998 and Sarkar *et al.*,2010) is lacking. Therefore, the present study was undertaken to determine the age and growth of the bronze feather back from wild habitats of river Gomti by using scales.

MATERIAL AND METHODS

The fishes were procured twice in a month from the fish landing centre of Khadra and Daliganj stations of river Gomti, Lucknow (26°52'22"N; 80°54'58"E), Uttar Pradesh. They were captured by large meshed gillnets. Scales for age

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determination were invariably taken from the area above the lateral line and below the dorsal fin, from either side of the fish in fresh condition. The scales removed from either side of the body were kept separately inside an envelope, on which were super scribed the relevant information. A total of 3,900 scales taken from 200 fishes, ranging between 145-360 mm in total length, were studied. The examination of the scales for ageing the fish was done under a microscope with a magnification of 5 x and 10 x. The distances between the annuli were measure with the help of an ocular micrometer in such a manner that the zero of the micrometer coincided with the focus of the scale. The foci of all the scales were considered the first circuli which were found invariably in the centre of the scale. The measurements were taken from the focus to the outer margin of the scale for recording its total length and the distance between the successive annuli in transverse plane for back calculation of the intermediate lengths.

Methodology :

The length attained by fish at the time of formation of various annuli was back calculated for each individual using the direct proportion formula :

$l_t = Lx \ 1/L$ (Lea 1910,1913)

Where, L is the length of scale from the focus to end of scale in transverse plane and L, the distance between focus and an annulus.

The mathematical expression of growth in terms of von Bertalanffy (1938,1957) equation was also derived by using the lengths at ages obtained by scales studies.

$lt = l\infty \ [1 - e - k(t-t_0)$

Where, lt = length of the fish at age t, l∞ = Maximum size toward which the length of the fish is tending, k = a measure o the rate a t which length approaches l00, e = base of the Naperian logarithm, t = age of the fish and t_0 = a parameter indicating the hypothetical time (age) at which the fish length would have been zero.

Growth patterns were determined using size at age data from counts of inner layer in scales. Since scales have been found very convenient and authentic in use for age and growth, the following formula given by Le Cren (1947, 1951) have been used for calculating back calculation based on the scale readings as:

$L_n\text{-}a = S_n / S\,(L\text{-}a)$

Where 'a' is the correction factor, L = Total length (mm) of the fish at the time of scale removal, L_n = Total length (mm) of the fish at the time of annulus "n" formation, S_n = Scale radius (mm) from nucleus to the annulus "n" and S = Total radius (mm) the scale.

RESULTS AND DISCUSSION

A careful examination of scales of *N.notopterus* showed a series of circular corrugations (stria, ciruil, sclerite, ridges) confined mainly to the anterior part of the scale. Bands of circuli are alternately widely-spaced changes in growth throughout the year. The widely-spaced bands of circuil represent the growth zone. In the present work, closely- spaced circuli are called the "annual ring." An annual is defined as the narrowly-spaced band of circuli immediately preceding more widely-spaced band of circuli, the latter region being the new growth zone.

Table. 1 Percentage of the fish scale with marginal rings and average number of circuli after ring formation in deferent months.

Month	Percentage of scales with marginal rings	Average number of circuli after ring formation
June	10.3	25.3
July	85.6	3.4
August	70.4	8.5
September	60.8	10.2
October	15.5	20.3
November	Nil	25.7
December	Nil	30.5
January	Nil	32.5
February	Nil	34.5
March	Nil	36.8
April	Nil	39.2
May	Nil	43.6

Table. 2 Calculated length in (mm) at the end of year, increase in length for each year of life of *N.notopterus*.

Age group	Av. length, L (mm)	ΔL	100. ΔL/L
1.	101	101	--
2.	155.70	54.7	54.15
3.	215.80	60.1	38.59
4.	269.6	53.8	24.93
5.	314.3	44.7	16.58
6.	331.0	16.7	5.31
7.	345	12.0	3.75

Table. 3 Calculated lengths of each age group of *N.notopterus* determined from scales.

Age	No. of fish	Calculated Total Length (mm) at the end of year of life						
		1	2	3	4	5	6	7
I		4	108	X	X	X	X	XX
II	5	95	154	X	X	X	X	X
III	24	120	164	221	X	X	X	X
IV	60	113	157	218	253	X	X	X
V	91	97	163	227	261	309	X	X
VI	21	91	149	205	277	312	326	X
VII	2	84	146	208	287	322	337	345
Average		**101**	**155.70**	**215.8**	**269.6**	**314.3**	**331.0**	**345**
Increment		**101**	**54.70**	**60.1**	**53.8**	**44.7**	**16.7**	**8.0**
No. of fish		**207**	**205**	**200**	**176**	**116**	**25**	**2**

Table. 4 Calculation of asymptotic length (l∞) and coefficient of catabolism (k) based on average length at successive ages derived by scale method.

T(x)	Lt+1(y)	xy	X^2
101	155	15655	10201
155	215	33325	24025
215	269	57838	46225
269	314	84466	72361
314	331	103934	98596
331	345	114195	109561
1385	1629	409410	360969

The percentage of scales having a newly-formed annulus and average number of circuli representing the new growth on the margin of scales (Table.1). It is evident from the above table that the annuli were formed during June-October with a peak in July when 85% of the scales examined showed marginal rings. However, scales examined in other months either showed negligible marginal rings or no marginal rings at all. Generally, the scales without marginal rings showed a wide portion of new growth represented by thin circuli. Annular formation was indicated when the percentage increase of circuli beyond the outer most mark dropped suddenly and then began to increase. The widely-spaced circuli on the scale margin were observed maximum in May (average 43.2) and minimum (average 3.5) in July when in most of the fishes annuli had already formed.

The disposition of rings and average number of circuli on the margins of scales indicated the annual nature of their deposition. It may, therefore, be surmised that the time of annulus formation in *N.notopterus* ranges from June-October. It was also observed that in young fishes, annulus formed as early as June and in old fishes as late as October. For evaluating the growth histories of the age groups and the general growth curve, the data in respect of individual samples were pooled together.

Table.2 shows the calculated length at the end of each year of life and the absolute and percentile increased in length in different ages. The table indicates that the growth rates, beyond age group V, show only small differences and the fish attained its fastest growth during the first year of life (C 101 mm). The growth rate, thereafter, declined to 62 mm, slightly more than half of that in the first year. The gradual decline of growth rate in later years results in extremely low values of length increments, being only 8.0 mm in the 7^{th} year, indicating that the differences in size of the adult fish in the population depend upon the pattern of growth during early years of its life. Table.3 compares the average of the calculated intermediate length of individual samples together with their grand average. Thus, an estimate of mean lengths attained by *N.notopterus* in successive seven years of its life was computed.

Estimation of the catabolic coefficient (K) : The value of 'K' (e-k) has been estimated at 0.2219 as given in Table.4 which is equal to b, the slope of the regression line, the 'K' has a physiological significance and is the measurement of 'catabolic coefficient" which varies for different species of fish inhabiting different ecosystems.

Estimation of 't_0' : The method of estimation is shown in Table.5, 'K' and L∞ are independent of time units or in other words, they could be estimated if length at specific uniform intervals o time is know but the estimation requires actual time units. The assessment of age, for determination of is based on scale studies. Its value was calculation to be -0.1360 (Table.5). Thus, the three parameters calculation for von Bertalanffy's growth equation is :

$L\infty = 443$ mm, $K = 0.2219$ and $to = -0.1360$.

Finally, the equation may be written as

$L_t = 443[1\text{-}e\text{-}0.2219\,(t\text{-}0.1360)]$

Estimated length at different ages by van Bertalanffy's growth more or less conform to the values obtained by other method (Table.7) providing that the theoretical growth equation describes values by this method are depicted in Table 6 and empirical growth curve.

The use of scale for age determination has depended upon the appearance of recognizable yearly growth ring in different species but, generally speaking, they are identified by a change in the growth configuration of the scale and two kinds of ring were found in *Caspian shad, Caspialosa saposhnikovi* (*Alosa caspia caspia*) (Zamnakhaev,1940 and Chougounova, 1940), *C.catla* (Natarajan and Jhingran,1963), *Gangetic anchovy*, *Setipinna phasa* and *G.chapra* (Jhingran,1971, 1977).

A careful study of the scale of *N.notopterus* showed the four characteristics futures of the ring. (a) There are two kinds of ring *viz.* the true "annual rings" and the "spawning rings". The appearance of the spawning ring suggests sharp break in the scale material and a subsequent resumption of growth which is manifested chiefly on the sides. (b) In mature and maturing fishes one ring of each kind is formed per year at about the same season but the 'true annual rings' appear earlier than the "spawning rings" collection of fishes of progressively mature stages indicated that the percentage of those scale with "spawning rings" mainly formed at the margins was highest in the spent fishes. (c) "Spawning rings" are not laid down on the scale of virgin fishes. (d) "Spawning rings" not occur on all the scale a fish and their sharpness also scale to scale. Therefore, the nature of the ring observed on the scales of *N.notopterus* is in accordance with the observation of Zamakhaev (1940), Chougounove (1940) and Natarajan and Jhingran (1963).

Temperature of the temperate water is an important annual ring forming factor as a drop in temperature cause reduction in metabolic rate leading to cessation of or reduced feeding (Beckman,1942). In tropical waters, Seshappa and Bhimachar (1951) observed that the disturbance of benthic fauna due to southwest monsoon deprived Malabar sole (*Cynoglossus semifaciatus*) of its food resulting in formation of growth-check on scales which they designated as "monsoon rings". Pillay (1954) reported that the upwelling of bottom floor from floods caused reduced feeding in Mugil tade and the consequent growth checks. Sarojini (1957) in grey mullets, Jhingran (1959) and Kamal (1969) in mrigal and Rao and Rao (1972) in *Labeo calbasu* observed that the non-availability of food was a probable factor causing annulus formation. van Oosten (1923) stated that growth of body and scale are closely correlated and any factor affecting the growth rate of body may be of inherent significance in appearance of growth check or "annuals". Fage and Veillet (1938) observed that maturation of gonads, accompanied by decreased feeding, was generally followed by retardation in growth rate.

Seshappa (1958) observed the occurrence of growth checks associated with the spawning of *Rastrelliger canagurta*. Spawning stress was found by Natarajan and Jhingaran (1963) and Jhingran (1971,1977) to be main causative factor for the formation of growth checks on the scales of *Catla catla, S.phasa* and *G.chapra*, respectively. In *N.notopterus*, it has been demonstrated that the annual appears during period of maturation and spawning as the feeding intensity in e fish slackens significantly during maturation phase. Zamakhaev (1940), Natarajan & Jhingran (1963), Thakur (1967), Jhingran (1971,1977) and Rao & Rao (1972) collected scales from fish of progressively maturity stages and observed that the proportion of those spawning rings formed at the margin of scales increased to maximum in the spent fishes, the formation of annuals during the monsoon month can thus be accounted in light of these observation. A retardation in the ingestion of food, on account of enlargement of go-

Table. 5 Estimation of "C_0" for von Bertalanffy's equation of growth.

T (x)	lt	lσσ -t	Log_e (l-lt) (y)	T^2 (x^2)	Log_e (l-l_t) xt (xy)
1	101	342	5.8348	1	5.834
2	155	288	5.6630	4	11.3260
3	215	228	5.4230	9	16.2690
4	269	174	5.1591	16	20.6364
5	314	129	4.8473	25	24.2365
6	331	112	4.7185	36	28.3110
7	345	98	4.5850	49	32.0950
28			**36.2307**	**140**	**138.7087**

Table. 6 Calculation of empirical values of length at age on *N.notopterus* through von Bertalanffy's equation.

Age (t)	(t + t0)	e - k (t + t0)	1-e-k (t+ t0)	lt
1	1.136	0.779	0.221	97.9
2	2.136	0.625	0.375	166.1
3	3.136	0.497	0.505	222.8
4	4.136	0.398	0.602	266.7
5	5.136	0.319	0.681	301.7
6	6.136	0.257	0.743	329.1
7	7.136	0.206	0.794	351.7

Table. 7 Length and age of *N.notopterus* derived by different methods.

Age in year	Length at ages (mm)			
	Scale	Petersen	Polymodal frequency dissection	Von Bertalanffy's growth fit
1	101.00	-	150	97.9
2	155.70	150	205	166.1
3	215.80	210	267	222.8
4	269.68	270	315	266.7
5	314.30	310	340	301.7
6	331.00	340	-	329.1
7	345.00	-	-	351.7

nads in the spawning months constricts the alimentary c considerably. This cause a decrease in the growth rate of the fish, consequently, appearing on the scale in the form of growth check which based on their characteristic feature, can be called as spawning rings. However, in immature fishes in monsoon month an account of turbid condition of water of reservoir and the dilution caused by incoming freshets.

The spawning period of *N.notopterus* is spread over as period of four months, if the annuals occur due to spawning stress, it may be taken into cognizance that the period of annulus formation will also be of above duration coinciding with spawning months such was the case in *N.notopterus*. The higher frequency of occurrence of marginal rings was observed during June-September when fish has its peak spawning rings was found to be in July and during this month maximum percentage of spent fishes occurred. This is in fair agreement with the observation of Zamakhaev (1940), Thakur (1967), Natarajan & Jhingran (1963), Jhingran (1971,1977) and Rao & Rao (1972) who found the highest frequency of marginal rings in spent specimens of *Caspialosa=Alosa saposhnikovi, Catla catla, Mugil cephalus, S.phasa, G.chapra* and *L.calbasu*, respectively. On the strength of above evidences, it appears that the present observations on retardation of feeding due to lesser availability of food in monsoon months and the closely following spawning season are jointly responsible for the formation of growth checks.

Lea (1910) first utilized the scale marks to calculation growth rate of the fish which has been used over and over and has also been criticized. Yet it has remained the basis of back calculation of fish growth. The modification of the same have been given by Lee (1920), van Oosten (1929), Hile & Jones (1941), Shuck (1949) and Saeterdal (1953, 1958). In all these works, the main consideration was whether the fish length, scale length ratio is constant throughout the life of the fish and whether it can be described by a straight line. In such computations, use of theory of regression and correlation has been made. Lee (1920) showed that the coefficient of correlation and regression line are likely to give highly variable and misleading information depending upon the material used. Buchanan-Wollaston (1924) did not accept the Dahl-Lea formula, $L = hs$, as it was based on the assumption that the growth of body and scale are directly proportional. Therefore, this method provides an approximation, since the body scale regression rarely passes through the zero intercept, on account of the fact that the fish has attained same body length before the scales are laid down. Therefore, the intercept will be negative and a positive intercept would indicate that the calculation of body length would be higher than the empirical length.

Since then, attempts have been made to improve it by introducing various correction factors. Lee (1920) introduced a correction factor in the direct proportion formula which used in the present study for the calculating the intermediate lengths. Making use of the present material in *N.notopterus*, it was observed that the scales appear relatively late on the body of fish when it has grown to a size of 15 mm. The scales grow at first faster than the fish body and later nearly at the same rate. Fortunately, this does not affect the L/s relationship as no annual rings are formed during this period. A careful examination of the regression fit, in respect of *N.notopterus*, indicates that the fish length and the scale length are not in direct proportion but their increments are von Bertalanaffy growth equation contains a function which not only provides a satisfactory representation of the growth in a mathematical form but can also be used for analytical studies of growth phenomenon.

Beverton and Holt (1957) showed that it gave a good fit for a number of commercial fishes of USA. In India, Pantulu (1961), Natarajan & Jhingran (1963), Kamal (1969), Thakur (1967), Jhingran (1971,1977), Singh (1972) and Rao & Rao (1972) have successfully applied this equation to *Pangasius pangasius, Catla catla, C.mrigala, M.tade, S.phasa, G.chapra, R.carsula, L.calbasu*, respectively. This study showed a well-defined growth pattern from wild population and important information has been generated on the age and growth pattern of *Notopterus notopterus* inhabiting Gomti river. The present study will therefore be useful for the fishery biologists and conservation agencies for successful development, management, production and conservation of the species.

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