AGE AND GROWTH IN THE CATFISH *TACHYSURUS TENUISPINIS* (DAY)

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Abstract

At Waltair, the average size of *Tachysurus tenuispinis* during 1973-76 was 17.5, 23.7, 29.5, 35.5 and 39.5 cm at the end of 1.0, 1.5, 2.0, 2.5 and 3.0 years respectively. The back-calculated lengths of fish at the time of formation of rings in the opercular bone were 11.16, 18.74, 24.64, 30.03, 35.70, 40.09 and 44.01 cm at the end of 0.5, 1.0, 1.5, 2.0, 2.5, 3.0 and 3.5 years respectively. The mean lengths of fish with II to VII rings in the otolith were 17.9, 25.2, 30.4, 35.4, 39.7 and 42.6 cm respectively. There was, thus, a close agreement in the lengths derived from all the three methods at different ages. The growth rings in the opercular bones and otoliths are formed twice a year in June and December and poor feeding is probably the causative factor for the formation of rings. von Bertalinffy growth data obtained from the present studies and the calculated values were in close agreement with those observed.

Introduction

Both the species of catfishes viz., *T. tenuispinis* and *T. thalassinus* form important fisheries along the Andhra, Orissa and West Bengal coasts contributing about 20.8% of the demersal fish catches (Sekharan 1973a, & b). Maturity, fecundity and spawning (Dan 1976); length-weight relationship (Dan and Mojumder 1975) and the food and feeding (Mojumder and Dan, MS) of the species have been studied. Pectoral spines in a few catfishes (Pantulu 1961, 62) were used in the study of their age and growth. The present paper deals with the study of age and growth with the help of opercular bones, otoliths and length-frequency data in the catfish, *T. tenuispinis*.

Material and Methods

The material for this study was obtained from the landings of the two Government of India trawlers operating at Visakhapatnam coast as well as from the boatseine catches. Altogether, 6586 fish were measured during 1973-76. Length of the fish referred to in the following pages is the total length in cm from the tip of the snout to the tip of the upper lobe of the caudal fin. Presented in the monthly length-frequency polygons are the percentages of fish in each 2 cm size group. The opercular bones removed after boiling the heads in water were alternately washed in 8-10% caustic potash and running water. When viewed against light, contrasting layers of ossification were observed giving the impression of rings between two layers. The contrasts are clearer in wet bones. The measurements of distances from the inner edge to the rings (l_1, l_2 etc.) and to the opposite open edge of the bone (total length) were made with the help of a divider and transferred to a millimeter scale, with 0.25 cm accuracy.

The otoliths were removed from the fish by breaking the cranium across the head with a bone cutter and then removing the pro-otic with the help of a forceps. The distances between the nucleus and the edge of the otolith and those of the last ring and the edge only were measured (Fig. 1, A and B). The number of rings in each otolith was also counted.

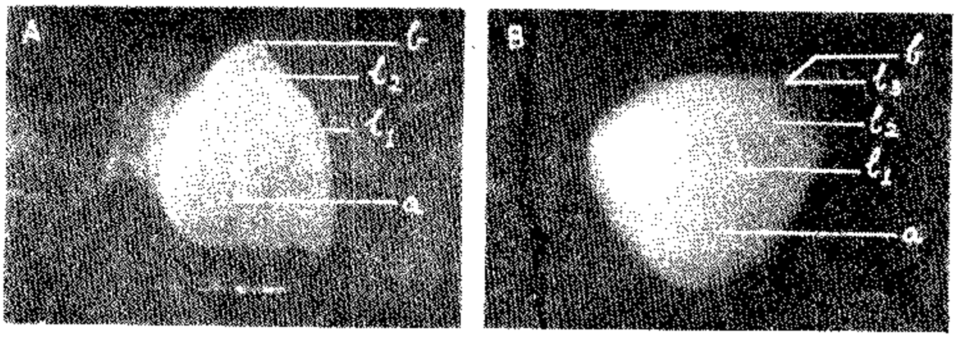

FIG. 1. A. Otolith of a one-year old 20.2 cm long fish showing 2 rings.
B. Otolith of a one-and half-year old 25.0 cm long fish showing 3 rings.
(a = nucleus; b = outer edge; A-B = radius; l1, l2, l3 = rings formed each half year)

Results

Monthly length-frequency distribution during 1973-76

It was shown earlier that May to September is the spawning season for *T. tenuispinis* (Dan 1976). It is at the end of about one year that the fish appears in the fishery, during May-July, at a modal length of 17-19 cm (Dan 1975). The size range observed during 1973-76 period was 12.8-46.0 cm. The monthly length-frequency distributions for the years 1973, 74, 75, and 76 are shown in Figs. 2 and 3.

1973 : The length-frequecey distribution for 1973 (Fig. 2(A)) is trimodal (a, b and c) in June; unimodal from October to December; while in other months it is bimodal. Mode a at 19 cm in June 1973 is about one year old which is the product of 1972 spawning. This mode could not be traced through successive months of the year; and the mode at 25 cm in February of the following year appears to be a continuation of this mode. Mode b which appeared at 25 cm in February, could be traced to 35 cm in December registering a progression of 10 cm growth in eleven months. The mode c at 35 cm in February can be traced to 39 cm in June showing a progression of 4 cm in four months. The mode b appears to have come from late spawners of the same spawning season as mode b since the difference in their age is about 4 months. From the rate of growth observed in this year, it appears that there is a difference of one year in age

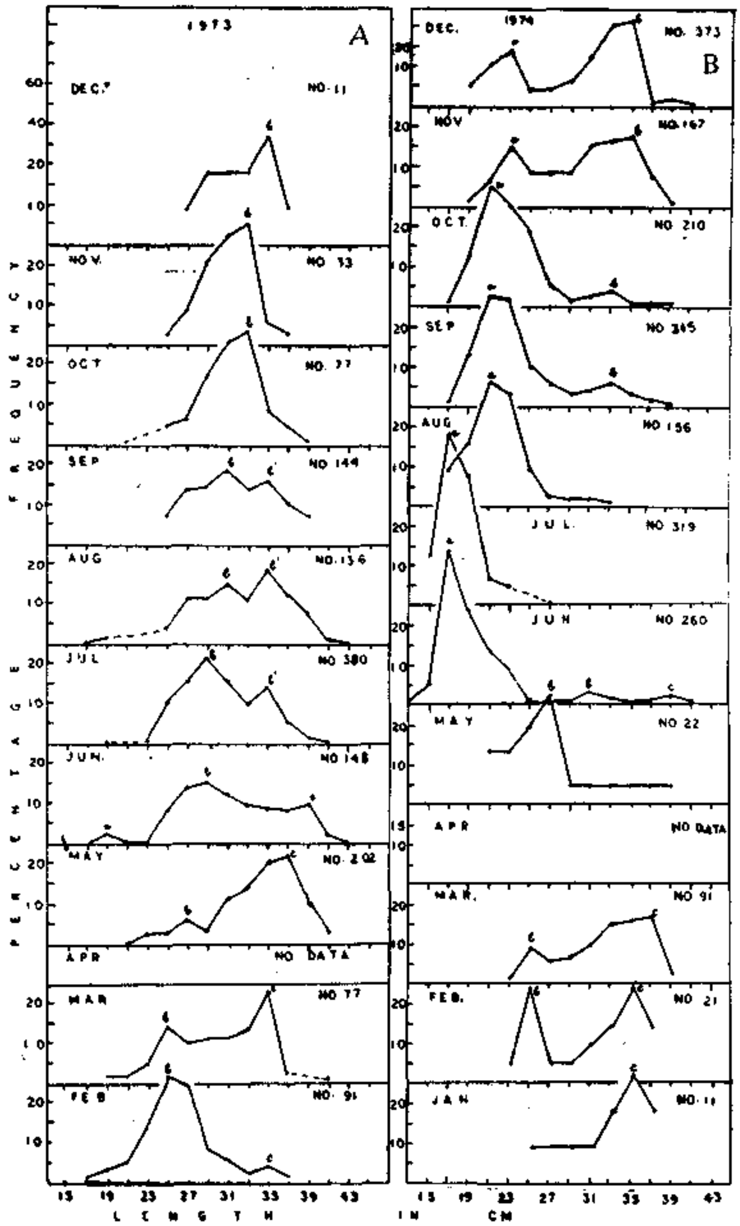

FIG. 2. Length-frequency distribution in *T. tenuispinis*, during different months of the year 1973 (A) and 1974(B).

between the fish of mode a and b. It follows, therefore, that fish at mode b are the products of 1971 spawning. Similarly mode c appearing at 35 cm in February may have come from the 1970 spawning season. The time interval

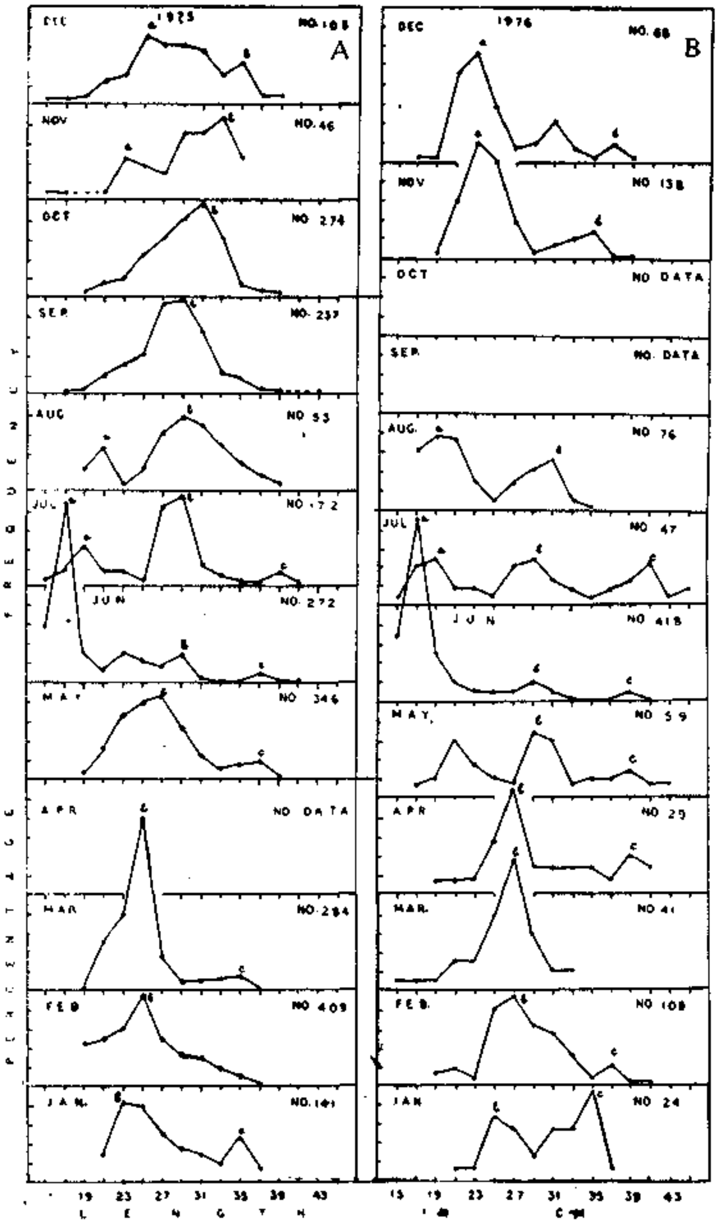

FIG. 3. Length-frequency distribution in *T. tenuispinis* during different months of the years 1975 (A) and 1976 (B).

between modes a, b and c is one year. The yearly growth increment recorded from the progression of modes appears to be 19, 10 and 10 cm for the I, II and III years respectively.

1974 : In this year also (Fig. 2(B)) three modes a, b and c could be seen. The mode a appears at 17 cm in June and progresses to 23 cm in December recording a growth of 6 cm in 6 months. This mode represents the 1973 year class. The mode b appears at 25 cm in February and progresses to 35 cm in December thereby recording a growth of 10 cm in 10 months. The mode c which appears at 35 cm in January grows to 39 cm in June and indicates a growth of 4 cm in 5 months. This mode cannot be traced thereafter. Mode c is a continuation of mode b in 1973. From the progression of modes a, b and c it appears that the sizes attained at the end of I, II and III years are 17, 29 and 49 cm, respectively.

1975 : There modes a, b and c are observed (Fig. 3(A)). Mode a representing the 1974 year class makes its appearance at 17 cm in June and progresses to 25 cm in December thereby showing a growth of 6 cm in 6 months. Mode b which is a continuation of mode a of the previous year, appears at 23 cm in January and grows to 35 cm in December indicating a growth of 12 cm in one year. The third mode c appears at 35 cm in January and progresses to 39 cm in July recording a growth of 4 cm in 6 months. This mode is a continuation of mode b of the previous year. Unlike that observed in the previous years, when this mode could be traced up to June only, during this year it was observed up to July. The growth increment during I, II and III year 17, 10 and 10 cm, respectively.

1976 : This year also three modes a, b and c (Fig. 3(B)) were observed. Mode a which is the product of the 1975 year class appeared in June at 17 cm and grew up to 23 cm in December showing a growth of 6 cm in 6 months. The second mode b which can be traced from mode a of the previous year, appeared in January at 25 cm and progressed up to 37 cm in December recording a growth of 12 cm in one year. The third mode c, a continuation of mode b of 1975 appeared at 35 cm in January and could be traced to 41 cm in July recording a growth of 6 cm in 6 months. The growth increment appeared to be 17, 12 and 12 cm at the end of I, II and III years.

Modal position during breeding period: June is the peak breeding month for the catfish *T. tenuispinis* and the modal positions read off from the monthly length-frequency distribution (Fig. 2 and 3) for the years 1973, 74, 75 and 76, in this month are shown in Table 1. The sizes attained by different year classes in December, i.e., when they add 0.5 years to that year class are also shown in Table 1.

It can be seen that the modal sizes attained by the different year classes at different ages, i.e., at different years of capture are more or less the same. Since June happens to be month of birth, the modal positions observed in this

TABLE 1. *Sizes in cm (modal position) of different year classes of* T. tenuispinis *at different ages.*

Year Class	Age in years: 1.0	2.0	3.0	1.5	2.5
	Modal position in June			Modal position in December	
1970	—	—	39.0 (1973)	—	—
1971	—	29.0 (1973)	39.0 (1974)	—	35.0 (1973)
1972	19.0 (1973)	31.0 (1974)	39.0 (1974)	—	35.0 (1974)
1973	17.0 (1974)	29.0 (1975)	41.0 (1976)	23.0 (1974)	35.0 (1975)
1974	17.0 (1975)	29.0 (1976)	—	25.0 (1975)	37.0 (1976)
1975	17.0 (1976)	—	—	23.0 (1976)	—
Mean	17.5	29.5	39.5	23.7	35.5

month may be considered to be fairly accurate for knowing the growth attained by this species at the end of I to III years. Also, the modal positions in December (6 months after birth) may be considered to be the sizes attained at the end of 1.5 and 2.5 years. Thus, the sizes attained by *T. tenuispinis* at the end of 1.0, 1.5, 2.0, 2.5 and 3.0 years are 17.5, 23.7, 29.5, 35.5 and 39.5 cm, respectively.

OPERCULAR BONES

Out of opercular bones from 325 fishes (14.0 to 45.0 cm in length) studied, 231 were used for back-calculation.

Time of formation of the rings: A necessary pre-requisite to establish the validity of periodic markings in the estimation of age and growth is the need to ascertain the annual nature of their deposition. The accepted procedure of measuring the width of the marginal open zone was followed. The marginal open zone had minimum width during June-July and December-January period indicating that the bands may have been laid in the seasons immediately preceding these months (Fig. 4). The values for both the sexes showed similar results.

Also shown in Fig. 4 are the values of intensity of feeding during 1973-75. Since the values of the feeding intensity fall sharply during the period of lowest percentage of marginal open edge to the opercular length, it may be assumed that the feeding intensity may be the causative factor for the formation of rings in the opercular bones of *T. tenuispinis* during June-July and December-January periods.

Relationship between fish length and opercular length.

The scatter of points between the opercular length and fish length of 245 fish (varying from 14.6 to 45 cm) showed a linear relationship (Fig. 5) of the

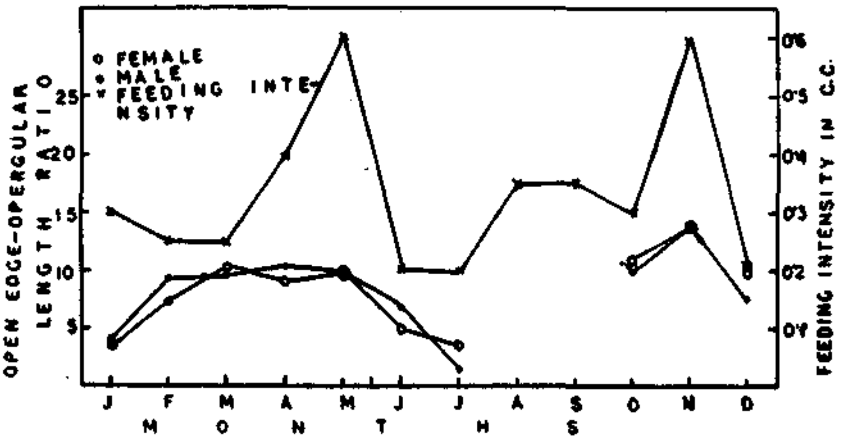

FIG. 4. Average width of open margin of the opercular bones as percentage of its total length.

form L = a+b X (Where L = fish length; X = opercular length; a and b are constants). The regression equations are: L = 27.019 + 18.280 X for males and L = 18.981 + 19.646 X for females. The co-efficients of correlation (r) were 0.8312 and 0.9253 for males and females respectively indicating a fairly high correlation. An analysis of covariance showed the values of constants between males and females were not significantly different at the 5% level (Table 2). Hence the combined formula for both the sexes was L = 24.162 + 18.982 X. All the measurements are in mm.

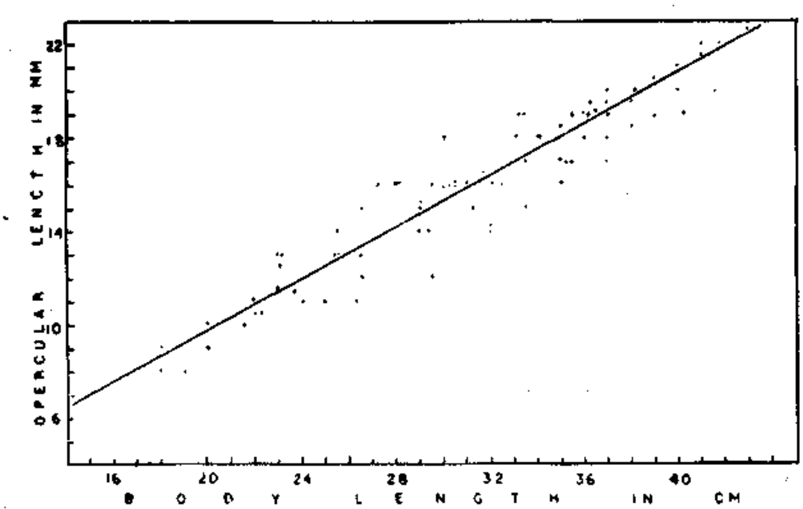

FIG. 5. The relationship between opercular bone length and body length.

TABLE 2. *Analysis of covariance to test the difference in regression in fish length - opercular length data of* T. tenuispinis.

Sex	Degree of freedom	Corrected sum of sqares and products x^2	xy	y^2	Deviation from regression Degree of Freedom	$\Sigma y^2 - \frac{\Sigma (xy)^2}{\Sigma x^2}$	Mean Square	F Value	Remarks
Female	149	2687.3121	52795.9750	1293703.5000	148	256453.3138			
Male	94	1795.4803	32821.3026	735006.5263	93	135034.5248			
Within					241	391487.8386	1624.4309	1.2384	Not significant at 5%
Difference due to reg. co-efficient					1	2010.0399	2010.0399		
Common	243	4482.7924	85617.2776	2028710.0263	242	393497.8785			

Back calculation: For each opercular bone, back calculation was done by using the direct proportion formula (Dahl - Lea method), $L_t = LX_t / X$ (referred to us method A) and the corrected method formula (Lee method), $L_t = LX_t / X + a\ (1 - X_t / X)$ (referred to as method B) where L and X are the lengths of the fish and the opercular bones respectively; L_t is the calculated length at age t; X_t is the length of the opercular bone upto the $_t$th ring, a is the constant in the equation for regression (Lagler, 1956; Saetersdal, 1953 Jones, 1958). The above formula devised to find the age of fish on the basis of scale study was found to work well for finding the age from opercular bone also (Nilson 1914).

The average lengths of fish at the time of formulation of rings 1-7 indicating ages 0.5, 1.0, 1.5, 2.0, 2.5, 3.0 and 3.5 years obtained by opercular bone (back calculation) method using the corrected formula (method B) are 11.27, 18.85, 24.86, 30.36, 35.80, 40.88 and 44.01 cm respectively for females and 10.98, 18.55, 24.25, 29.51, 35.41 and 40.20 cm respectively for males (Table 3). The values being identical at age for the sexes, they were combined and the

TABLE 3. *Mean back-calculated lengths (cm) from opercular bones at the end of each year of the life of* T. tenuispinis.

Age of Capture	No. of fish	Mean	Mean back calculated length $l_{0.5}$	$l_{1.0}$	$l_{.15}$	$l_{2.0}$	$l_{2.5}$	$l_{3.0}$	$l_{3.5}$
Females									
1.0	32		11.0722	18.4081					
1.5	40		11.3005	18.4534	24.6360				
2.0	46		11.3745	19.1450	24.7954	30.1399			
2.5	15		11.5513	19.5158	25.5373	30.8340	35.6546		
3.0	9		10.8409	19.6236	25.1706	30.7530	36.0183	40.0816	
3.5	1		11.3162	18.9627	24.1660	30.1795	36.0837	46.0465	44.0095
Total	143	Mean	11.2707	18.8544	24.8630	30.3648	35.8027	40.0781	44.0095
Males									
1.0	14		10.8087	18.5685					
1.5	35		10.8280	18.3396	24.0913				
2.0	32		11.0381	18.6841	24.2756	29.3900			
2.5	6		11.6702	18.8999	25.0375	30.0596	35.3665		
3.0	1		12.3475	19.3105	24.2842	30.2526	35.2263	40.2000	
Total	88	Mean	10.9760	18.5505	24.2503	29.5151	35.3465	40.2000	
Males and Females combined									
1.0	46		10.9920	18.4569					
1.5	75		11.0799	18.4003	24.3818				
2.0	78		11.2365	18.9559	24.5821	29.8323			
2.5	21		11.5853	19.3398	25.3946	30.6127	35.5723		
3.0	10		10.9915	19.5922	25.4820	30.7030	35.9391	40.0935	
3.5	1		11.3162	18.9627	24.1660	30.1795	36.0837	40.0465	44.0095
Total	231	Mean	11.1584	18.7386	24.6395	30.0636	35.7029	40.0892	44.0095

$l_{0.5}$, $l_{1.0}$ .... etc. = length at age 0.5 years, 1.0 years etc.

average lengths attained at the end of 0.5, 1.0, 1.5, 2.0, 2.5, 3.0 and 3.5 years were 11.16, 18.74, 24.64, 30.03, 36.70, 40.09 and 44.01 cm respectively. The lengths at ages 0.5 to 3.5 years back calculated from opercular bones were in close agreement with values derived from length frequency studies. The differences in the mean back calculated lengths (L_t) at ages 0.5 to 3.5 years between the two methods diminished gradually from the ages 0.5 to 3.5 years; and for the older age groups with 6 or 7 rings the differences in the back calculated lengths at the time of formulation of the 6th or 7th rings by the two methods are negligible.

Body length-Opercular length ratio in different size groups: To find out whether there was much variation in the ratios of body length/opercular length in different size groups, the entire length was divided into 6 size groups (16-20, 20-25, 25-30, 30-35 35-40 and 40-45 cm) and from each size group the body length/opercular length ratios for 15-20 fish were determined. The mean body length/opercular length ratios for the above size groups were 21.0, 20.8, 21.4, 21.8, 21.0 and 20.6 respectively. The ratios showed little variation and can be said to be fairly constant since majority of the points lie within a narrow range (19.5-21.0).

In *T. tenuispinis*, the lengths of fish when 0.5 year old (l_1) calculated from older age groups increase gradually which is opposite of what is expected if there were Lee's phenomenon. The same holds good for the back calculated lengths of fish at higher ages (Table 3). It, therefore, appears that the Lee's phenomenon is not evident in the growth calculations from the opercular bones of *T. tenuispinis* and in fact a reverse trend is indicated. There are several instances in which the Lee's phenomenon is not recorded (Nall 1930, Saetersdal 1953, Subba Rao 1966).

OTOLITHS

The otoliths when observed against transmitted light are found to have alternating opaque and translucent bands or rings. The nucleus is opaque lying near one extremity and the rings are arranged in eccentric layers round the nucleus. Measurements are taken from the nucleus to the extreme edge opposite the side where the nucleus is situated. The scatter diagram between otolith lengths and body lengths for 324 fish (14 to 45 cm), showed a linear relationship of the form $L = a + b X$ (where L = fish length; X = otolith length and a and b are constants) (Fig. 6). The regression equation is $L = 2.1617 + 5.3118 X$. The coefficient of correlation (0.8) was fairly high.

Time of formation of hyaline rings: The percentage of open edge of the otolith to the total otolith length in different months is shown separately for males (125 Nos.) and females (189 Nos.). The values fell sharply in June-July and once again in December-January for both sexes. The nature of this curve was similar to that observed in the study of opercular bone. It appears that as in

TABLE 4. *Frequency distribution of*

	MALES									
Size group in cm	No. of fish examined	No. of rings in the Otoliths I	II	III	IV	V	VII	No. of fish examined	No. I	II
14.0-15.9	3	—	3	—	—	—	—	5	—	5
1.60-17.9	9	—	9	—	—	—	—	17	—	17
18.0-19.9	7	—	7	—	—	—	—	6	—	5
20.0-21.9	4	—	3	1	—	—	—	14	—	4
22.0-23.9	7	—	—	7	—	—	—	15	—	2
24.0-25.9	21	—	—	21	—	—	—	22	—	—
26.0-27.9	16	—	—	9	7	—	—	20	—	—
28.0-29.9	15	—	—	9	6	—	—	21	—	—
30.0-31.9	9	—	—	2	7	—	—	22	—	—
32.0-33.9	4	—	—	—	2	2	—	16	—	—
34.0-35.9	5	—	—	—	2	3	—	11	—	—
36.0-37.9	2	—	—	—	—	2	—	7	—	—
38.0-39.9	—	—	—	—	—	—	—	2	—	—
40.0-41.9	1	—	—	—	—	—	1	5	—	—
42.0-43.9	—	—	—	—	—	—	—	3	—	—
44.0-45.9	—	—	—	—	—	—	—	1	—	—
Total	103	—	22	49	24	7	1	187	—	33
Average length of the fish with rings	—	—	17.9	25.9	29.8	35.0	40.2	—	—	17.8

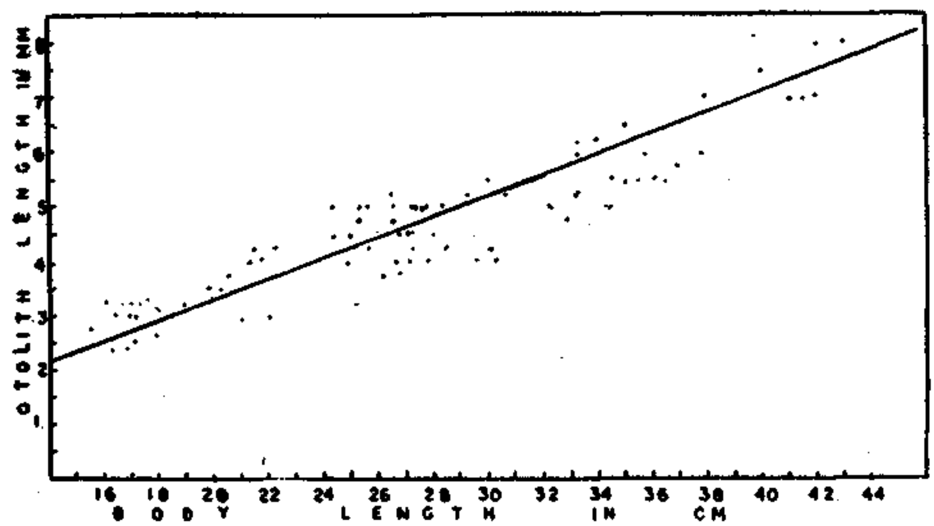

FIG. 6. The relationship between body length otolith length.

rings in the otoliths of T. tenuispinis.

FEMALES					No. of fish examined	BOTH SEXES						
of rings in the Otoliths						No. of rings in the Otoliths						
III	IV	V	VI	VII		I	II	III	IV	V	VI	VII
—	—	—	—	—	8	—	8	—	—	—	—	—
—	—	—	—	—	26	—	26	—	—	—	—	—
1	—	—	—	—	13	—	12	1	—	—	—	—
10	—	—	—	—	18	—	7	11	—	—	—	—
13	—	—	—	—	22	—	2	20	—	—	—	—
20	2	—	—	—	43	—	—	41	2	—	—	—
13	7	—	—	—	36	—	—	22	14	—	—	—
5	16	—	—	—	36	—	—	14	22	—	—	—
—	21	1	—	—	31	—	—	2	28	1	—	—
—	13	3	—	—	20	—	—	—	15	5	—	—
—	5	5	1	—	16	—	—	—	7	8	1	—
—	—	6	1	—	9	—	—	—	—	8	1	—
—	—	2	—	—	2	—	—	—	—	2	—	—
—	—	—	3	2	6	—	—	—	—	—	4	2
—	—	—	1	2	3	—	—	—	—	—	1	2
—	—	—	—	1	1	—	—	—	—	—	—	1
62	64	17	6	5	290	—	55	111	88	34	7	5
24.6	30.6	35.8	39.6	42.6	—	—	17.9	25.2	30.4	35.4	39.7	42.6

the case of opercular bones, bands are formed twice a year in otoliths also and they are laid in seasons immediately preceeding June-July and December-January (Fig. 7).

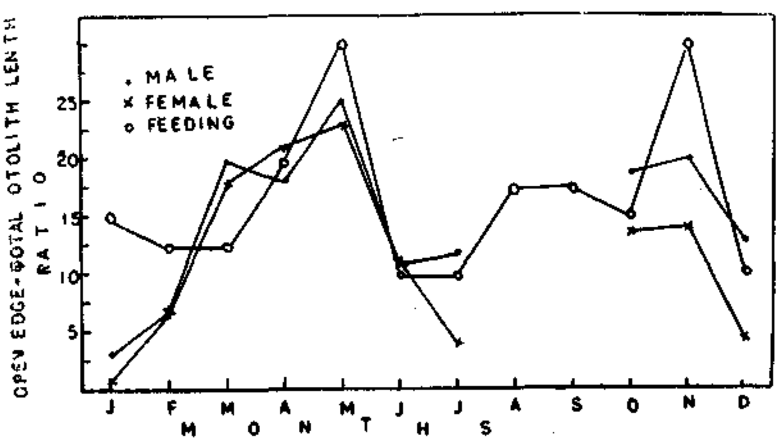

FIG. 7. Average width of open margin of the otoliths as percentage of total radius.

Cross examination of otoliths: The distribution of hyaline rings (290 pairs) in different size groups and for each sex are shown in Table 4. The mean length of the fish with 2 to 7 rings did not show appreciable difference between sexes and the combined mean value obtained was 17.9, 25.2, 30.4, 35.4, 39.7 and 42.6 cm. Otolith with only one ring could not be observed. The first five values are in close agreement with those derived from the opercular bone and from the length frequency study.

Growth curve of the fish: The sizes attained at different ages as obtained from the length frequency, opercular bone and otolith studies were used and fitted by the method of least squares to von Bertalanffy growth equation:

$$L_t = L_\infty \ (1\text{-}e^{-K(t\text{-}t_0)})$$

Where L_t + length at age t; $L\alpha$ = the asymptotic length of the fish; K = a constant equal to 1/3 of catabolic coefficient; e = base of Naperian logerithm, t = age of the fish, t_o = age at which L_t theoretically zero.

The parameters K $L\alpha$ were estimated from For-Walford Plot (Beverton and Holt, 1957, Walford, 1946) of L_t +1 against L_t where L_t and L_t + 1 are lengths at age t and t + 1 years, which gives a straight line relationship. This is shown in Fig. 8. The regression line was fitted by the method if least squares. The intersection of this line with the bisector through the origin gives $L\alpha$ defined in von Bertalanffy equation (Beverton and Holt, 1957).

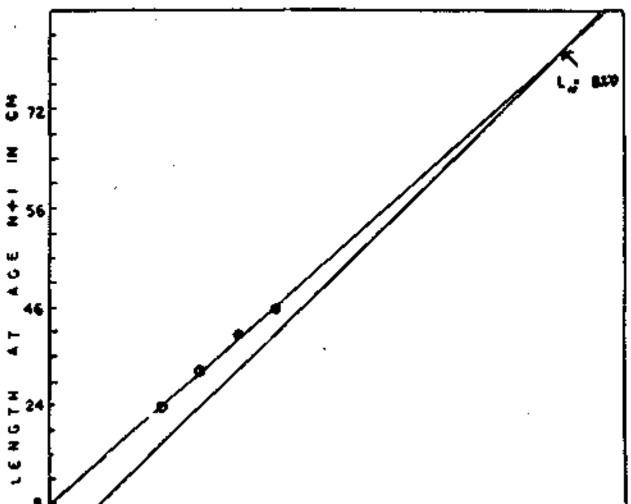

FIG. 8. Ford-Walford plot of growth of *T. tenuispinis*.

The value of to was estimated by two methods; (1) by plotting Loge (L∞ − L_t) against t as shown in Fig. 9 and (2) by estimating t_o from the equation:

$t_o = 1/K \, Log_e \, (1 - L_t / L\ ) - t$

The estimated values of various parameters of von Bertalanffy growth equation are:

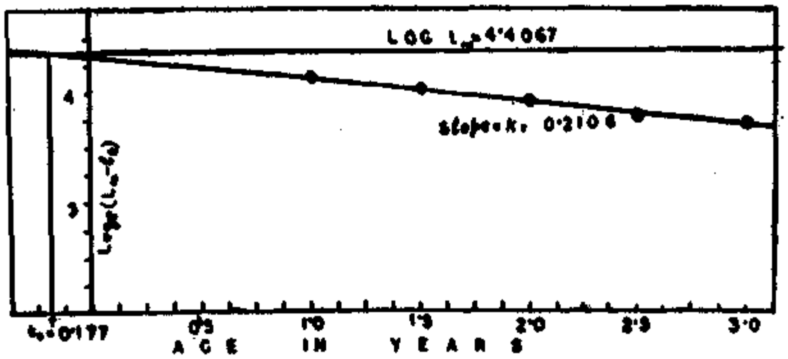

FIG. 9. Loge (L∞ -Lt) plotted against t for calculation of t_o in *T. tenuispinis.*

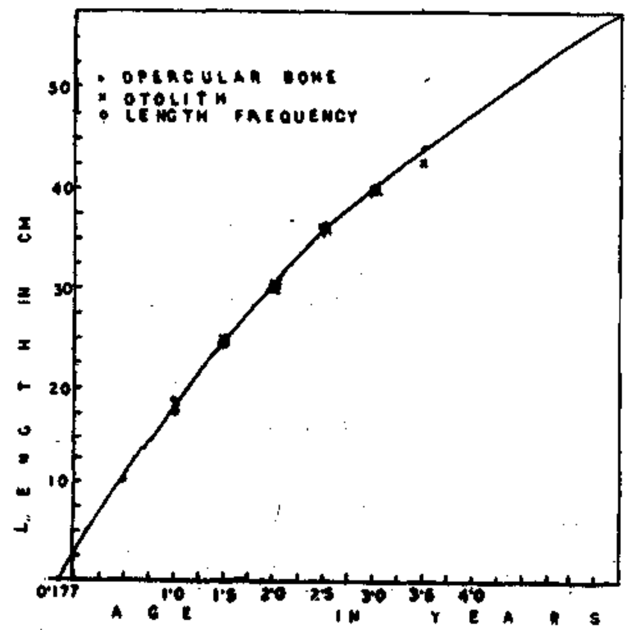

FIG. 10. Growth curve in *T. tenuispinis.*

$K = 0.2106, L\infty = 82.0, t_o = 0.177$

Hence von Bertalanffy growth equation of t*T. tenuispinis* may be expressed as $L_t = 82(1-e^{-0.2106(t+0.177)})$. The estimated growth is represented by continuous growth curve in Fig. 10.

The theoretical lengths at different ages as calculated from von Bertalanffy growth equation (Table 5) showed a very high degree of agreement with lengths at ages derived from length frequency, opercular bones (back calculation) and otoliths.

TABLE 5. *Comparison of estimates of lengths at different ages by various methods*

Age (Years)	Length frequency	Otoliths	Opercular bone	value for working out growth equation	Calculated value from growth equation
0.5	—	—	11.16	—	9.7
1.0	17.5	17.9	18.74	18.0	18.7
1.5	23.7	25.2	24.64	24.0	24.4
8.0	29.5	30.4	30.03	30.0	30.0
2.5	35.5	35.4	35.70	36.0	35.6
3.0	39.5	39.7	40.09	40.0	40.0
3.5	—	42.6	44.01	—	44.3
4.0	—	—	—	—	47.9
4.5	—	—	—	—	51.4
5.0	—	—	—	—	54.4

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