AGE AND GROWTH OF THE MARINE CATFISH *TACHYSURUS THALASSINUS* (RUPPELL) FROM MANDAPAM WATERS

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ABSTRACT

Employing six different methods, the age and growth of *Tachysurus thalassinus* at Mandapam are determined. By length-frequency, it is found to attain 250 mm at the end of first year, 370 mm the end of second year and 450 mm the end of third year. By the probability plot, four year-classes are recognized: I to IV, respectively at 256 mm, 360 mm, 454 mm and 522 mm. Transparent rings in the pectoral-spine sections showed that the species attains 258.3 mm at the end of one year, 347.4 mm at the end of two years and 441.6 mm at the end of three years. The lengths at age as derived from vertebral studies are 260.9 mm in one year, 355.9 mm in two years and 436.5 mm in three years. Based on alternating opaque and transparent zones in the opercular bone, the mean back-calculated lengths at the ages one to three are 251.3 mm, 345.5 mm and 445.1 mm, respectively. The embryos of *T. thalassinus* reared in the aquarium, under controlled conditions, showed, however, the rate of growth to be slightly higher. The von Bertalanffy growth equation for this species can be expressed as:

$$L_t = 848.5\ (1 - e^{-0.19885\ (t - 0.8113)})$$

INTRODUCTION

Catfishes of the family Tachysuridae form an important demersal fishery resource at Mandapam. The trawl fishery here consists of four commercially important species, they being, in the decreasing order of abundance, *Tachysurus thalassinus*, *T. dussumieri*, *T. caelatus* and *T. platystomus*.

Even though tachysurids form an important demersal group all along the Indian waters, the biological information available on them is fragmentary and confined only to a few species. Pantulu (1963) studied the age and growth of *Osteogeneiosus militaris* from the Hooghly estuary. The age and growth study of *Tachysurus sona* was attempted by Singh and Rege (1968). Mojumder (1977) determined the age of *T. thalassinus* from Waltair using the length-frequency technique. The age of *T. tenuispinis* from Waltair was determined by Dan (1980) based on length-frequency and skeletal hard parts. In the present study different methods, both indirect and direct, were employed to estimate the age and growth of *T. thalassinus* from Mandapam waters.

MATERIAL AND METHODS

The material collected from the trawl catches during the period 1969-1971 from the Palk Bay and Gulf of Mannar formed the data base. A total of 12741 specimens of *T. thalassinus*, of both sexes, were measured. The frequency polygons at size intervals of 2 cm for the two years are plotted in Fig. 1.

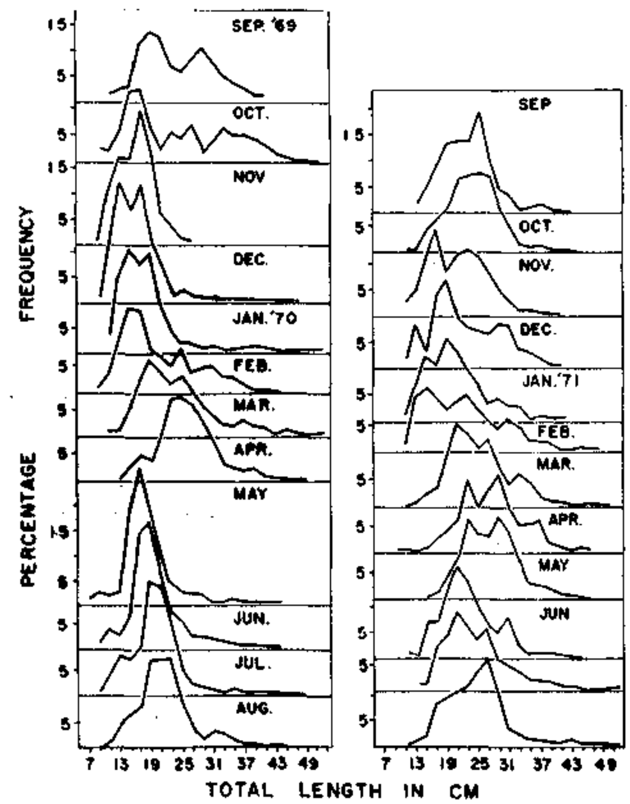

FIG. 1. Length-frequency distribution of *T. thalassinus* during 1969-1971.

The skeletal hard parts such as pectoral spines, vertebrae and opercular bones were collected from fish of various size groups. Pectoral spines were removed along with the bases and cleaned in boiling water. Each spine was held firmly by a vice and 2 to 3 sections of 0.5-1.0 mm in thickness were taken from the base with a fret saw from the point immediately behind the notch. The spine sections were ground on a carborundum stone, taking care not to damage the edges of the sections. The thin sections were cleared in xylol and mounted in canada balsam. Out of a 100 spines from fish of the size range 230-500 mm sectioned, only 88 were readable.

The fifth vertebra was separated from the fish, cleaned in boiling water. They were later cleared in ether to remove fat and placed in xylol until the growth rings became clearly visible. For this study 60 fish of the size range 260-480 mm in total length were utilized, of which 8% were unreadable.

The entire opercular assembly, including the large opercular bone and the small pre-opercular, was boiled in water to separate the operculum. The cleaned and dried opercula were immersed in ether and cleared in xylol. Out of 70 opercular bones examined, only 55 were readable.

AGE DETERMINATION

Petersen method of length-frequency analysis: Though there were a number of modes in the length-frequency plots (Fig. 2), only the conspicuous modes have been traced to study the rate of growh. As can be seen from the Figure 2, the 9 cm mode of October 1969 is not traceable in November, but has presumably

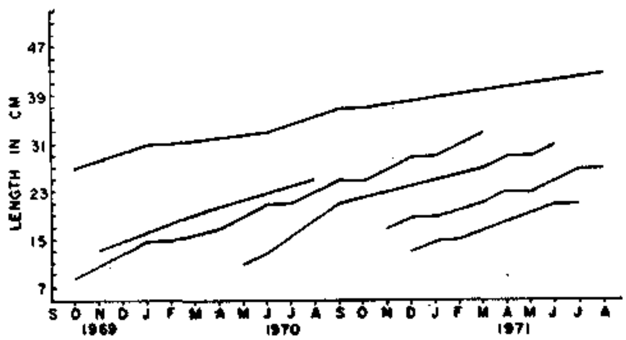

FIG. 2. Probable monthly modal progression of *T. thalassinus* during 1969-1971.

progressed to 13 cm in December, showing a growth of 4 cm in two months, or an average growth of 2 cm per month. By extrapolation, the 9 cm mode appears to have caused by the fish born in August 1969, showing a growth of 9 cm in the first two months. The 15 cm mode of January-February 1970 is probably derived from the 13 cm mode of the previous month. This mode is not traceable in March, but appears in April at 17 cm and progresses through May to reach 21 cm in June-July. This 21 cm mode, of June-July, progresses to 25 cm in August-September. The length-frequency analysis thus shows that the fish grows to 25 cm at the end of first year, with a growth increment of 2.1 cm per month. Similarly tracing the 25 cm mode of March 1970, it may be seen that the fish has grown to 37 cm by April 1971, by the time the fish has completed two years of life, indicating thereby a growth of 12 cm in 12 months, at an average rate of 1 cm per month. Again, the 37 cm mode of September 1970 can be traced to 43 cm in August 1971, showing a growth of 6 cm in 11 months in the third year of its life. A similar growth can also be seen in the 37 cm mode of

May 1970 progressing to 45 cm in April 1971. Thus it may be said that average growth for the third year is 0.66 cm per month and that the fish attains 45 cm when it completes the third year of life.

By probability-plot technique: In a fish with a single restricted spawning season, the modal lengths are considered to be annual. By following the probability-plot technique, described by Harding (1949) and later modified by Cassie (1954), the polymodal frequency distributions can be separated into their theoretical normal curves. As *T. thalassinus* breeds only once a year (during April to August; Mojumder 1978, Menon 1979), it may be possible to assign the modal lengths to the corresponding years.

For this study, the cumulative percentages of different length-groups for the years 1969-1970 and 1970-1971 are plotted on the arithmetic probability paper to note the points of inflexion. For the year September 1969-August 1970 the graph shows four distinct points of inflexion, at 72%, 94%, 99.6% and 99.9%. The first mode is at 180 mm, which should be representing the '0' year class, and the second, third, fourth and fifth modes at 268 mm, 365 mm, 455 mm, and 518 mm, respectively, representing the age-classes I, II, III, and IV (Fig. 3). For the year September 1970-August 1971 the probability graph

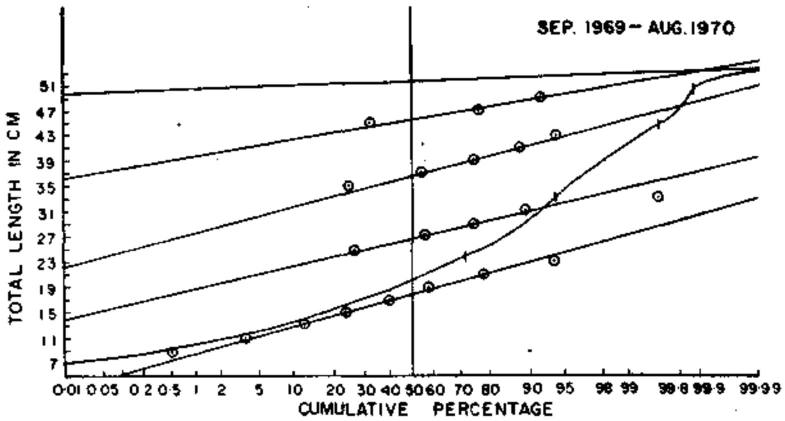

FIG. 3. Probably plot of length frequency distribution of *T. thalassinus* during 1969-1970

shows four distinct points of inflexion, at 30%, 90%, 99.1% and 99.87% and were at 170 mm, 248 mm, 341 mm, 440 mm and 511 mm, respectively, representing age-classes 0, I, II, III and IV (Fig. 4). Since the two years values are identical, the data are pooled, wherein the mean lengths at the successive ages 0 to 4 are 180 mm, 256 mm, 360 mm, 454 mm and 522 mm. The average growth increments per month are therefore 21 mm during the 1st year, 8 mm the 2nd year 7 mm the 3rd year and 5 mm the 4th year.

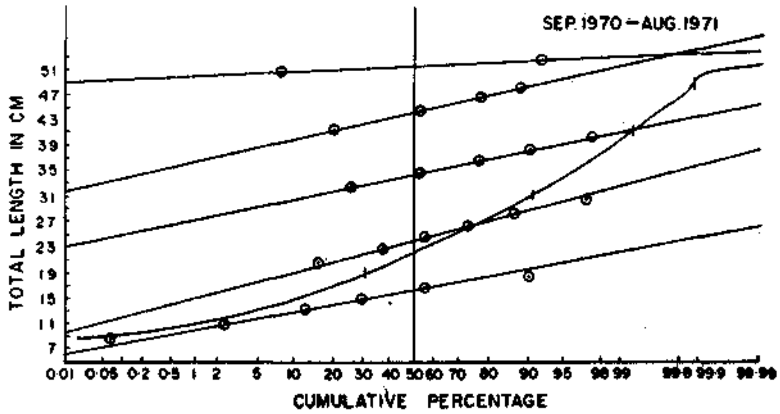

FIG. 4. Probability plot of length frequency distribution of *T. thalassinus* during 1970-1971

Using skeletal hard parts: *Pectoral spine sections*: Cross section of the pectoral spine of *T. thalassinus* shows a central medullary cavity, and, in the region around the medullary cavity, there are concentric opaque and transparent rings. In many species of tachysurids, such as *T. dussumieri T. caelatus* and *T. sona*, the central medullary cavity enlarges as the fish grows and, as such, they are unsuitable for age determination. But, in *T. thalassinus* the medullary cavity remains the same irrespective of its growth and is fit for growth studies. So, the point of commencement of the bony region at the periphery of the medullary cavity taken as the point of origin of growth, the measurements of the spine radius and ring radii were made.

For any growth calculation based on measurements of a skeletal part, it is essential to establish a relationship between the growth of the skeletal part and the growth of the entire body. In *T. thalassinus* the relationship between the spine radius and the fish length was linear in the logarithmic scale (Fig. 5), the regression equation being:

$$R = -0.2309 + 0.7955\ L$$

Which can be conversely expressed as:

$$L = 0.6395 + 1.0607\ R$$

where R = log spine radius and L = log total length of fish. The correlation coefficient 'r' of the two variables was 0.9186.

In order to ascertain the time of formation of the transparent zone, the edges of the pectoral spine sections of fish collected during the different months of the year 1970 were compared. It was found that in the months of May and June the margins of all the sections were transparent, and in April, July and

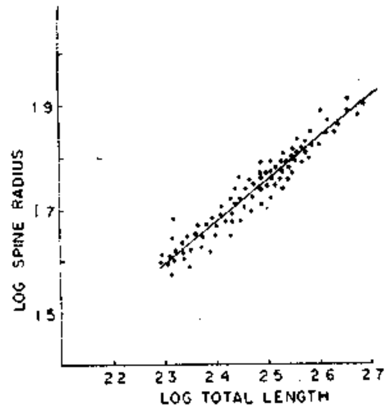

FIG. 5. Relation between pectoral spine section radius and total length of fish.

August 72%, 88% and 67% were transparent. Therefore, it can be reasonably presumed that the transparent zone of the pectoral spine is generally laid during April-August and is annual in nature. Further, in all the sections examined, there was an additional narrow transparent ring close to the medullary cavity. It is found on back-calculation that this thin transparent ring is formed when the fish is in size 70-80 mm, the size at which the juveniles normally leave the parent's month.

A direct-proportion formula for back calculation (van Oosten, 1929) of length at ages might be inadequate in the case of *T. thalassinus*, since the present data do not permit the assumption that fish length and aging structure are linearly related with an intercept at the origin. In view of this difficulty, a formula wherein estimates of length at age 'n' is independent of the actual size but dependent on the ratio of the total radius of spine to the radius at age 'n' is used in the present investigation. Thus, the length of fish at the time of formation of transparent zone is estimated by back calculation using the formula:

$$\text{Log } L_n = \text{Log } L_t + b\ (\log r_n - \log R_t) \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ 1$$

where, L_n = length at age 'n'; L_t = length at the time of capture; b = 1.0607; r_n = radius of the hard part at age 'n'; R_t = radius of the hard part at the time of capture.

Lengths at age of formation of rings are calculated using the above formula in each case, and the results are given in Table 1. The mean back calculated lengths during the first, second and third years are estimated to be 258.3, 347.4 and 441.6 mm respectively.

Vertebra: An examination of the outer margins of vertebrae showed that only during May-July the margins were transparent, indicating the annual nature

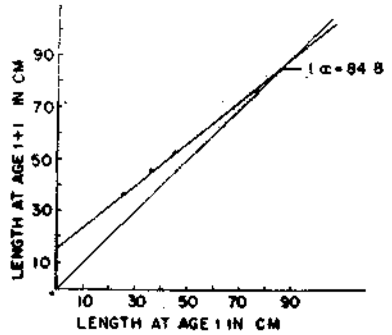

FIG. 6. Ford-Walford plot of the growth of *T. thalassinus*

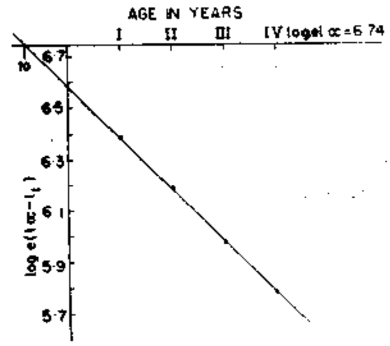

FIG. 7. Log $(L_\infty - l_t)$ plotted against age 't' for estimation of t_0.

TABLE 1. *Mean back calculated lengths of all age groups of* T. thalassinus *using pectoral spine sections.*
(Measurements in mm)

Length at capture	No. of specimens	Age in Years 1	2	3
270-280	15	205.4		
285-295	13	256.5		
307-317	4	257.4		
322-332	12	278.3		
350-360	6	269.5		
371-381	8	270.5	366.7	
390-400	9	262.2	341.8	
405-415	5	270.0	367.6	
415-425	7	278.3	377.9	420.0
425-435	2	292.7	392.1	—
455-465	3	270.0	382.3	451.1
475-485	2	292.2	403.5	466.5
495-505	2	262.3	386.0	477.8
Total	88	—	—	—
Weighted Mean		258.3	347.4	441.6

of the rings and May-July to be the period when the various rings are laid. This closely agrees with the observation based on spine sections. Also, in all the vertabrae examined there was a thin transparent 'juvenile ring', similar to the one in pectoral spines. The length of fish at the time of formation of each of these rings is back calculated by making use of the relationship between the radius of vertebrae and the fish length. The regression equation is calculated to be:

$$R = -1.9780 + 1.4806\ L$$

which can conversely be expressed as:

$$L = 1.3945 + 0.6425\ R$$

where R = log vertebral radius and L = log fish-length. The correlation coefficient 'r' of the two variables is 0.9753, which is highly significant.

Lengths at intermediate ages of *T. thalassinus* are calculated for each fish, substituting the value 0.6425 for the constantant 'b' in the formula 1, and the results are given in Table 2. The mean back-calculated lengths at ages 1 to 3 are 260.9 mm, 355.9 mm and 436.5 mm, respectively.

TABLE 2. *Mean back calculated lengths at the end of each year of life* T. thalassinus *using vertebrae.* (Measurements in mm)

Length at capture	No. of specimens	Age in Years 1	2	3
260-280	2	269.1		
280-300	6	275.0		
300-320	8	267.7		
320-340	5	268.9		
340-360	8	244.3	351.6	
360-380	7	274.3	367.4	
380-400	4	249.8	355.7	
400-420	2	238.3	340.5	
420-440	5	250.4	367.3	429.0
440-460	6	255.1	343.5	437.1
460-480	2	270.3	358.3	453.7
Total	55	—	—	—
Weighted Mean		260.9	355.9	436.5

Operculum: The operculum of *T. thalassinus* had alternating opaque and transparent zones. In several instances, one narrow transparent zone could also be noticed near the fulcrum, similar to the one found in the spine sections and vertabrae. On back-calculation, it is found that this zone is formed when the fish reaches a total length of 70-80 mm. Generally, the transparent zone in the operculum is laid annually during May-July.

A linear relationship is observed between the opercular length (0) and the fish length (L) in the logarithmic form, which can be expressed as:

$$\text{Log } 0 = -2.0418 + 1.1909 \log L$$

To calculate the intermediate lengths, the regression of fish length (L) on opercular length (0) is calculated and found to be

$$\log L = 1.6506 + 0.8776 \log 0$$

Substituting the value 0.8776 for the exponent in the formula 1, the intermediate fish lengths at different ages are back-calculated (Table 3). The mean

TABLE 3. *Mean back calculated lengths at the end of each year of life of* T. thalassinus *using opercular bones.* (Measurements in mm)

Length at capture	No. of specimens	Age in Years 1	2	3
240-260	4	255.0		
260.280	4	262.8		
280-300	6	250.8		
300-320	6	256.4		
320-340	7	244.3		
340-360	6	285.3	320.0	
360-380	5	258.4	365.2	
380-400	2	213.4	314.8	
400-420	4	257.4	379.9	
420-440	2	221.2	344.2	
440-460	3	229.5	378.2	445.0
460-480	6	233.9	359.5	445.2
Total	55	—	—	—
Weighted Mean		251.3	345.5	445.1

back-calculated lengths at ages 1 to 3 are 251.3 mm, 345.5 mm, and 445.1 mm, respectively. These agree very closely with the results obtained from spine sections and vertebrae.

Rearing experiments: In order to test the above observations, an attempt was also made to rear the fish from early embryonic stage. A sample of 6 eggs in a very early stage of development, probably within a few days of fertilization, was collected from the mouth of a gestating male landed at Mandapam on 17-3-1970. The live eggs were placed on a piece of sagging plastic wire-netting that was tied around the mouth of wide trough. The sea water in the trough, which just covered the eggs, was kept aerated and changed twice daily.

All the eggs hatched between the 12th and 13th day, and the newly emerged youngones measured 29-31 mm in total length. The yolk sac was completely absorbed within 15 days after hatching, when they were 70-76 mm in TL. In nature, this is the length at which the youngones usually become independent of the parent's mouth. The rearing experiment conducted in the laboratory thus showed that the 70-76 mm growth was attained in about 30 days. All the 6 youngones were now removed to large aquarium tanks, and were fed on flesh of bivalves, prawns, polychaetes and fishes and measured every month to study the rate of growth. Only four fish survived till 16-4-1971, and their growth rate is given in Table 4. Thus, the growth was 315-320 mm in 13 months, which, being only negligibly higher, confirms the calculated value.

TABLE 4. *Rate of growth of four aquarium-reared* T. thalassinus. (Measurements in mm)

Date of Measurement	Total length of fishes			
	1	2	3	4
17-3-1970	4	5	3	4
17-4-1970	73	76	70	72
2-5-1970	95	98	92	93
2-6-1970	110	115	112	117
2-7-1970	128	129	126	130
2-8-1970	150	154	153	156
2-9-1970	172	175	170	177
2-11-1970	193	194	205	196
2-11-1970	220	228	230	223
2-12-1970	245	250	247	245
2-1-1971	270	272	278	273
2-2-1971	290	295	293	291
2-3-1971	305	303	306	310
16-4-1971	315	316	320	318

The theoretical lengths at different ages as calculated by the above equation, are 256.5 mm, 363.8 mm, 451.7 mm and 523.6 mm at the end of 1, 2, 3 and 4 years, respectively. These values are in very close agreement with those estimated by the length-frequency, pectoral-spine, vertebral and opercular-bone methods (Table 5).

TABLE 5. *Mean lengths of* T. thalassinus *at the end of successive years of life as obtained by different.* *(Measurements in mm)*

Method	Age in years			
	I	II	III	IV
Petersen method	250.0	370.0	450.0	—
Probability plot	256.0	360.0	454.0	522.0
Pectoral spine	258.3	347.4	441.6	—
Vertebrae	260.9	355.9	436.5	—
Opercular bones	251.3	345.5	445.1	—
Mean	255.3	355.8	445.4	522.0
Increments	255.3	100.5	89.6	76.6
Von Bertalanffy's growth equation	256.5	363.8	451.7	523.6

Empirical growth curve: Applying von Bertalanffy's growth equation as modified by Ricker (1958), the parameters were calculated as follows:

L_∞ = 848 (Fig. 6); k = 0.19885; t_0 = —0.8113 (Fig. 7)

Substituting the above values, the von Bertalanffy's growth equation for *T. thalassinus* can be expressed as:

$$L_t = 848\,(1 - e^{-0.19885\,(t-(-0.8112))})$$

DISCUSSION

Mojumder (1977) found that *T. thalassinus* at Waltair attained 180 mm in the first year, 350 mm in the second year and 420 mm in the third year.

The present observation more or less agrees with this for the second and third years but not the first. The rearing experiments as well as observations based on length-frequency and skeletal hard parts have shown that the growth during the first year is much faster than the subsequent years, as is generally the case in fishes. This is especially so in the very early stage, when they are in the mouth of the parent, the growth then being more than 70 mm in one month.

Fairbridge (1951), Kothaus (1958) and Rao (1963) noticed larval rings in the skeletal parts of several demersal fishes. Very clear larval rings have been noticed also in the skeletal parts of *T. thalassinus*. These are formed when the fish is 70-80 mm in total length. The stress due to the sudden change in habitat caused by the youngones leaving the mouth of the male parent after about a month of incubation, when they attain 70-76 mm length, to take up the free-swimming life may be the factor causing this juvenile ring.

With regard to the normal rings subsequently formed it is generally difficult to give the proper interpertation as is the case in almost all tropical fishes. However, Singh and Rege (1968) had suggested that the annual stress of spawning might be the causative factor for the formation of rings in vertebrae in female *T. sona*. In males, the peculiar habit of oral gestation and total cessation of feeding for a long period, which can sufficiently retard growth to leave an imprint on the skeletal parts, may be the causative factor.

Acknowledgements

I wish to express my deep sense of gratitude to Dr. P. S. B. R. James, Director, C.M.F.R. Institute, for constant encouragement and to Dr. P. V. R. Nair, Scientist, C.M.F.R. Institute, for supervising this work. I am also thankful to Shri. C. Mukundan and Shri. K. V. N. Rao for going through the manuscript and offering valuable suggestions.

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