OBSERVATIONS ON THE GROWTH AND MORTALITY OF THE LARGE-SCALED TONGUE SOLE, *CYNOGLOSSUS MACROLEPIDOTUS* (BLEEKER)

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Growth of *Cynoglossus macrolepidotus* has been studied by back-calculating the lengths from the zones on the scales. The relationship between body length and scale radius has been found to be linear in both sexes. A test of the two regression lines for homogeneity of regression coefficients by an analysis of covariance indicates that the relationship between body length and scale radius is different in the two sexes. Back-calculated data show that there is sexual difference in growth rate. Growth is rapid during the first year. Thereafter it decreases progressively. A von Bertalanffy growth equation has been fitted to the growth data of *C. macrolepidotus*. The theoretical and back-calculated lengths agree very closely. An estimation of mortality rate was made by combining the length frequency distribution and the growth rate of *C. macrolepidotus*. Since there is no regular fishery for this species in the area investigated, the calculated mortality rate gave a rough estimate of the instantaneous natural mortality coefficient.

INTRODUCTION

In the study of population dynamics of any fish the two important population variables to be estimated are the growth and mortality. Growth studies are mainly made from the markings on the hard parts of the body such as scales, otoliths, etc., on the assumption that these are laid annually. A large amount of literature is available, especially from the temperate regions, on the use of hard parts of fish in growth studies. In tropical waters, although the zonations on hard parts have not yet been definitely proved to be reliable indices of growth, there have been many successful attempts on the estimation of growth of fishes from the Indian waters. Papers by Jhingran (1959), Pantulu (1961, 1962), Pantulu and Singh (1962), Qasim and Bhatt (1964, 1965) and Radhakrishnan (1954, 1957) include some of the more important works on the estimation of lengths at different ages by using hard parts of the body such as scales, pectoral spines, opercular bones and otoliths.

Methods related to the estimation of mortality rate are less direct than those of the growth studies and these are often subjected to a greater source of error. The usual method of estimating the total mortality is by plotting the log frequency against the age of the fish or, less frequently, by plotting the log frequency against the length of the fish in cases where the annual increase in length is more or less uniform (Ricker 1958). Both these curves are called the catch curves and give an estimate of the total mortality, fishing plus natural ($p+q$). The separation of the total mortality rate into its components, i.e. fishing and natural, is only possible when there is adequate data on the fishing effort expended annually or enough information on the recovery of tagged fish (Beverton 1954).

In this paper an attempt has been made to estimate the growth of the large-scaled tongue sole, *Cynoglossus macrolepidotus*, from back-calculations, based on scale-reading and its mortality rate from a combination of the length frequency distribution and the rate of growth.

According to Day (1878) the species is widely distributed all along the seas and coasts of India as far as Malay Archipelago. Some species of the genus *Cynoglossus* are fairly common along the Kerala coast and, in places like Calicut and Cochin, they support a fishery of some importance. However, the contribution of *C. macrolepidotus* to the fishery is not as much as the more abundant and well-known species, *C. semifasciatus*.

MATERIAL AND METHODS

Samples which formed the basis of the present study were taken from January to May 1965 from the Government of India trawlers of the offshore fishing station within a range of about 15 miles off Cochin. They were brought to the laboratory in a fresh condition and kept refrigerated until all the specimens were examined. The examination of each fish included the measurement of the length from the tip of the snout to the longest caudal fin ray and the removal of the scales from the middle part of the body in between the lateral line and the dorsal fin. This position was chosen simply for the sake of convenience as the scales from other parts of the body are generally lost during trawling operations which often take about one-and-a-half hours. In a few cases where it was difficult to procure scales from the specified region collection of scales was made along the lateral line.

The scales were placed on a glass slide with a few drops of water and examined under a binocular microscope (magnification $12{\cdot}5\times1$) by using subdued light. On examination the scales show a nucleus or centre and clearly alternating wide and narrow zones (Fig. 1). The zones were generally very clear in fresh scales but soon became indistinct as the scales dried. For this reason all scale-readings were done in fresh specimens only. Scale studies included the estimation of the age of the fish by counting the number of narrow zones and the measurement of the distance of each zone from the nucleus along a predeterminate axis with the help of a micrometer eyepiece. No measurements were taken when the annuli were found to be indistinct. Out of all scales examined only about 50 per cent were found to be readable.

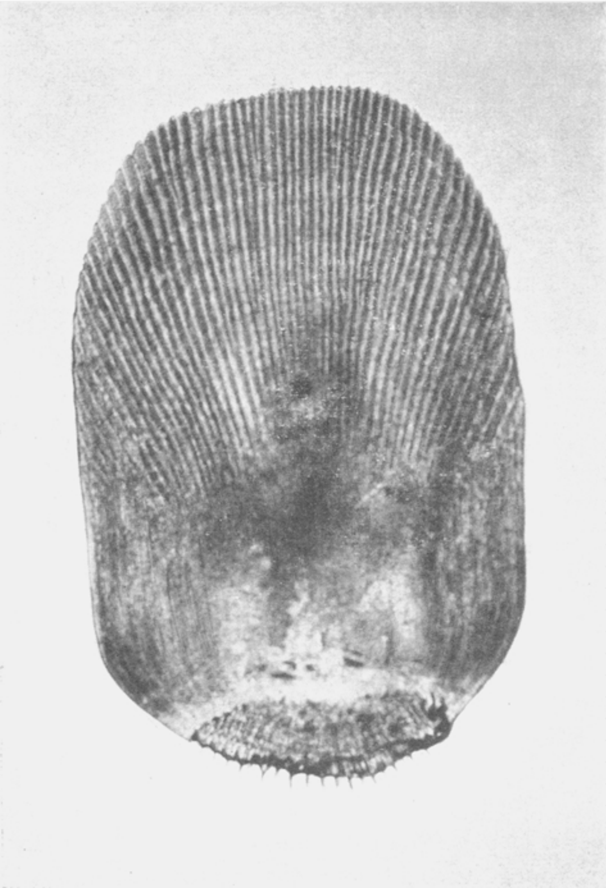

FIG. 1. Photograph of the scale of *C. macrolepidotus* showing alternating wide and narrow zones which correspond to the age of the fish.

An estimation of growth rate was made by back-calculating the lengths from 162 scales. To examine the validity of the back-calculated lengths, corroborative evidence was obtained from length frequency distribution of a sample of 540 fishes. Since the length frequency distribution did not reveal a polymodal curve, modal lengths of each sex were dissected separately by the probability paper method (Cassie 1954). The same length frequency data (Appendix I) were also used in drawing the catch curve for estimating the mortality rate.

GROWTH STUDIES

Seshappa and Bhimachar (1951, 1954, 1955) pointed out that the scales of *Cynoglossus semifasciatus* show clear annulations which could be used for studying the growth of the species. In this species these authors also attempted to establish the annular nature of the rings. *C. macrolepidotus* is a fish closely related to *C. semifasciatus* systematically and in habitat, for both species occur almost at the same depth and can be obtained in the same trawl. However, the scales of *C. macrolepidotus* unlike those of *C. semifasciatus* show up to a maximum of seven annuli. In *C. semifasciatus*, Seshappa and Bhimachar have termed the 'rings' on the scale as 'monsoon rings'. In the case of *C. macrolepidotus* the time and the duration of the formation of annuli on the scales could not be determined as the fish becomes very scarce during the monsoon months and consequently despite repeated efforts no fish could be obtained by trawling from June to September. For this reason sampling had to be discontinued after May.

Body length-scale radius relationship

Jones (1958) has pointed out that incorrect use of the body length-scale radius relationship in back-calculations might sometimes result in Lee's phenomenon or progressive decrease in the estimated length of an age group from scales belonging to successively older fish. This relationship has been

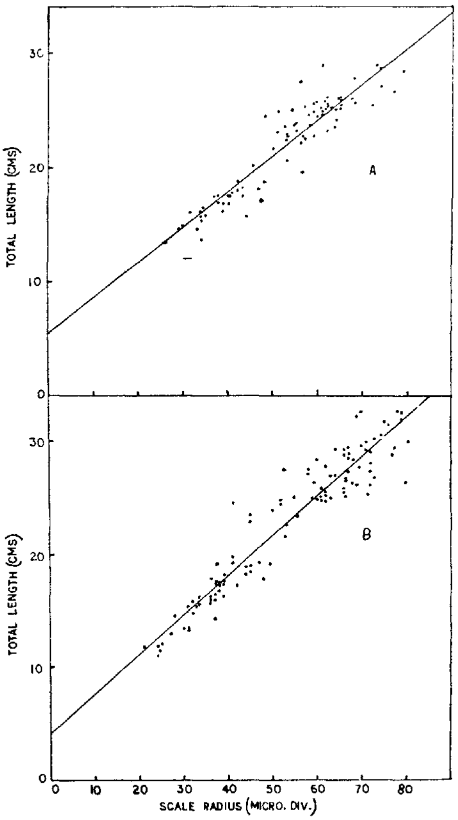

FIG. 2. Body length-scale radius relationship of *C. macrolepidotus*—(A) male, (B) female.

found to vary in different species and therefore to avoid errors in back-calculations it was found necessary to have an accurate estimate of this relationship. The estimated relationships for male and female based on 90 and 113 observations respectively are shown in Fig. 2. This relationship which was found to be linear can be expressed by the equation:

$$\text{length (cm)} = 5{\cdot}4473+0{\cdot}31206\ \mathrm{R}\ \ldots \text{for males}$$
$$\text{length (cm)} = 4{\cdot}2038+0{\cdot}34814\ \mathrm{R}\ \ldots \text{for females}$$

where R is the scale radius in micrometer divisions.

The two regression lines were tested for homogeneity of regression coefficients by an analysis of covariance and the results are presented in Table I. It can be seen from the table that the variance ratio for regression coefficient is significant at the 5% level suggesting that the body length-scale radius relationship is different for the two sexes. Similar differences in the regression coefficient of the two sexes were observed in *Ophicephalus punctatus* (Qasim and Bhatt 1965). Hence the back-calculations of lengths for each sex were done separately by using the respective regression equation.

TABLE I

Body length-scale radius relationship. Analysis of covariance among sexes to test the homogeneity of the regression coefficients

Source of variation		Residual S.S.	df	M.S.	F.
Common	..	592·981	200		
Within sexes	..	579·754	199	2·9133	4·5402
Reg. coef.	..	13·227	1	13·2270	

Estimation of the growth rates

Back-calculations of length from each recorded annuli were done from the relationship

$$L_x = a+\frac{(L_0-a)}{R_0}R_x \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

where L_0 and R_0 are the body length and scale radius of fish at capture respectively, L_x is the length to be estimated from the annulus (R_x) measured and a is the intercept in the body length-scale radius relationship. The above equation is derived from the relationship

$$\frac{L_0-a}{R_0} = \frac{L_x-a}{R_x} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

In equation (1), the ratio $\frac{(L_0-a)}{R_0}$ will remain constant in back-calculations from all annuli of each scale. For back-calculations, the use of equation

(1) implies that the intercept is constant but the slope varies for an individual scale to account for any deviation from the theoretical value. Therefore, back-calculation is done under two assumptions: (*a*) that the relative deviation of the observed scale radius from the theoretical value as described by the body length-scale radius relationship is constant for all the annuli, and (*b*) that the intercept is constant and any deviation of the scale radius from the 'normal' is brought about by a change in the slope.

TABLE II

Back-calculated lengths of C. macrolepidotus *at the end of each year of life*

Sex	Age at capture	Number of fish	1	2	3	4	5	6	7
Male	I	13	15·16						
	II	7	14·92	17·87					
	III	16	15·76	18·59	22·33				
	IV	27	16·48	18·65	21·26	23·64			
	V	11	16·58	19·02	21·27	22·98	25·48		
	VII	1	14·38	16·37	17·69	19·51	21·50	23·32	24·97
		Mean	15·55	18·10	20·64	22·04	23·49	23·32	24·97
		Increment		2·55	2·54	1·40	1·45	—	1·65
Female	I	17	14·79						
	II	6	14·34	17·65					
	III	8	17·51	20·63	23·64				
	IV	29	17·18	20·18	22·66	25·23			
	V	18	17·65	20·80	23·02	25·45	27·46		
	VI	8	16·54	19·85	22·17	24·18	26·48	29·02	
	VII	1	12·10	15·11	18·12	20·38	23·76	26·77	28·27
		Mean	15·73	19·04	21·92	23·81	25·90	27·90	28·27
		Increment		3·31	2·88	1·89	2·09	2·00	0·37

The back-calculated lengths from successive age groups are presented in Table II for the two sexes. The data given in Table II do not indicate the presence of Lee's phenomenon. However, there is an indication of considerable yearly variations in the growth rate. This may probably be due to variations in the environmental conditions year after year. The mean back-calculated lengths of each year class as indicated in Table II have been plotted in Fig. 3 in the form of growth curve of the two sexes. It can be seen from the figure that the growth in both sexes is rapid during the first year. Thereafter, it decreases progressively. The fish probably attains maturity after the completion of its first year of life and therefore the decline in growth rate after the first year may probably be an outcome of the onset of maturity. Presumably after attaining maturity more and more food resources are diverted towards gonad maturation and spawning and probably for this reason the growth in length decreases. Figure 3 also indicates that the growth rate is different in the two sexes. Females grow faster than the males although this does not become evident in the first year. Probably in the pre-maturity phase growth rate in both the sexes is the same but in the post-maturity phase each sex follows a different growth pattern.

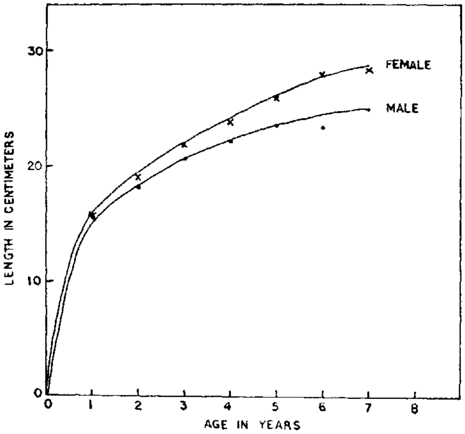

Fig. 3. Growth curve of *C. macrolepidotus*.

The per cent deviation of the back-calculated lengths from the mean at different years for age groups II to VI is shown in Fig. 4. It can be seen

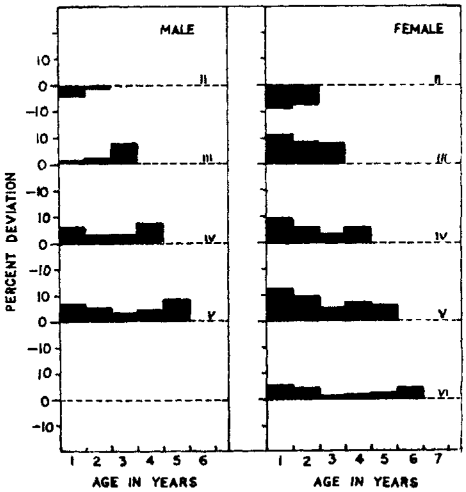

Fig. 4. Per cent deviation of the back-calculated lengths from the mean at different years. The roman numerals II–VI refer to age groups.

from the figure that in age group II the per cent deviation in both sexes records negative values. This signifies that the growth of this year class is below normal. From age group III onwards the per cent deviation shows positive values which indicates that the growth rate in these year classes is above normal. A close examination of the figure would also reveal that the per cent deviation shows a tendency of progressive decrease as the fish grows older although this is not evident in the males of the year class III which probably may be due to some errors in back-calculation. Moreover, the progressive decline in the per cent deviation is not uniformly reflected from all the years. In older years it tends to increase slightly which may again be due to some discrepancy in back-calculation. However, the over-all picture of the deviation in growth rate from the mean can be explained as follows: The general decrease from one year to the next in the per cent deviation from the mean, whether negative or positive, signifies that the species tends to attain the mean value when there is any deviation of growth from the mean. Probably such changes in the growth pattern of a year class are towards attaining the asymptotic length (L_∞). As will be seen later the von Bertalanffy growth equation fits the growth data of *C. macrolepidotus* and consequently it seems reasonable to suppose that the growth characteristics of this species are to attain a maximum size which is closer to its asymptotic length (L_∞).

Validity of the annuli as indicators of age

The reliability of age-readings from scales and otoliths have been studied by many workers (Bratberg 1956; Jensen and Clark 1958; Qasim 1957; Saetersdal 1958, and others). These authors have found that each zone is formed annually on the hard parts which allows the estimation of the fish age. It is yet to be established whether zones are formed annually in tropical fishes. In *C. macrolepidotus* this aspect has been studied by two methods: (*a*) by examining the correlation between the number of radii on scales and the length of the fish (Table III), and (*b*) by comparing the back-calculated length and the modal lengths determined by dissecting the length frequency distribution by the probability paper method (Table IV). That the rings on scales of *C. macrolepidotus* are not spawning checks is evident from the fact that these annuli occur on the scales of immature specimens that have not yet spawned.

Table III shows that there is a correlation between the increase in length of the fish and the increase in the estimated age. The older age groups are found to occur at progressively higher length groups. Table IV shows that there is an agreement between the back-calculated lengths and the modal lengths obtained by dissecting the length frequency distribution particularly in females of younger age groups 1+ to 3+. A slight disparity obtained from age 4+ onwards is probably because of errors involved in dissecting the

TABLE III

Distribution of fish of different ages as estimated from the scales with increase in size

Length in cm	Male						Female						
	Age in years						Age in years						
	1+	2+	3+	4+	5+	7+	1+	2+	3+	4+	5+	6+	7+
13	1						2						
14	0						0						
15	1	1					1						
16	1	0					4	1					
17	4	0					3	0					
18	4	1					4	0					
19	1	2					2	3					
20	0	1					0	1					
21	1	0					0	0					
22		1	3				1	0					
23		1	3	5				0	2	1			
24		0	3	3				0	1	2			
25		0	3	8	4			1	2	7	2		
26		1	2	9	1	1			1	5	3		
27			0	1	1				1	4	3	1	
28			0	1	2				0	4	2	1	
29			1		2				1	2	5	1	1
30					1					3	0	1	
31										0	1	1	
32										0	1	2	
33										1	1	1	

TABLE IV

Comparison of the back-calculated lengths at the end of each year of life and the modal lengths obtained by dissecting the length frequency distribution by the probability plot in the females of C. macrolepidotus

Age group	Modal length (cm)	Back-calculated length (cm)
0+	12·3	—
1+	15·7	15·73
2+	18·3	19·04
3+	22·9	21·92
4+	25·5	23·81
5+	28·2	25·90
6+	31·2	27·90

modal length groups, for at higher length frequencies there is a greater size overlap. However, a close agreement of age and growth in younger age groups derived independently from length frequency distribution and back-calculations gives some support that the annuli on the scales are probably laid down annually and hence these may be used for studying the growth rate of the fish. It has not been possible to dissect the length frequency distribution of the males by the probability paper method with sufficient accuracy for the overlap of the modal groups is greater in this sex.

Fitting of von Bertalanffy equation to the growth data

Many species of fishes have been found to follow different growth patterns and various mathematical equations have been developed to fit the respective growth curves. For sigmoid growth curves Yoshihara (1951, as quoted by Ricker 1958) fitted a logistic relationship. Bagenal (1955) found that the growth of the long rough dab conforms to another sigmoid relationship which could be better interpreted by the Gompertz equation. Parker and Larkin (1959) developed a new equation to describe a growth pattern where the decrease in length increments is so slow and protracted that it does not give any indication of a decrease in the growth rate with time. However, in many species growth rate decreases progressively as the fish becomes older and such a form of growth is best explained by the von Bertalanffy growth equation. In *C. macrolepidotus* the form of growth is of a decreasing nature (*see* Fig. 3) and for this reason it was thought best to fit the von Bertalanffy growth equation to the growth data.

The von Bertalanffy growth equation can be expressed as

$$l_t = L_\infty(1-e^{-k(t-t_0)}) \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

where l_t is the length at time t, L_∞ is the asymptotic length, k is the rate of deceleration in growth increments and t_0 is the age at which fish is of zero length, had it been growing throughout with the adult pattern of growth. For estimating the parameters of the Bertalanffy equation, Beverton (1954) has shown that the latter can be written in the form

$$l_{t+1} = L_\infty-(L_\infty-l_t)e^{-k} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (4)$$

where l_t and l_{t+1} are the lengths of fish at any two successive years of life t and $t+1$. Further rearrangement of equation (4) gives

$$l_{t+1} = L_\infty(1-e^{-k})+l_t e^{-k}. \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

Equation (5) is a linear relationship between l_t and l_{t+1} and by plotting l_{t+1} against l_t and fitting a line of least squares to the data, K and L_∞ can be estimated.

Figure 5 shows the plot of l_{t+1} against l_t for the two sexes. It can be seen from the figure that the points fall on a straight line indicating that the von Bertalanffy equation represents adequately the growth pattern of *C. macrolepidotus*. For estimating t_0, the Bertalanffy growth equation is written in the following form

$$l_n(L_\infty - l_t) = (l_n L_\infty + K t_0) - kt. \quad .. \quad .. \quad .. \quad (6)$$

This is also a linear equation and fitting the points by least square method gives the value of t_0. The plot of l_n $(L_\infty - l_t)$ against age is shown in Fig. 6.

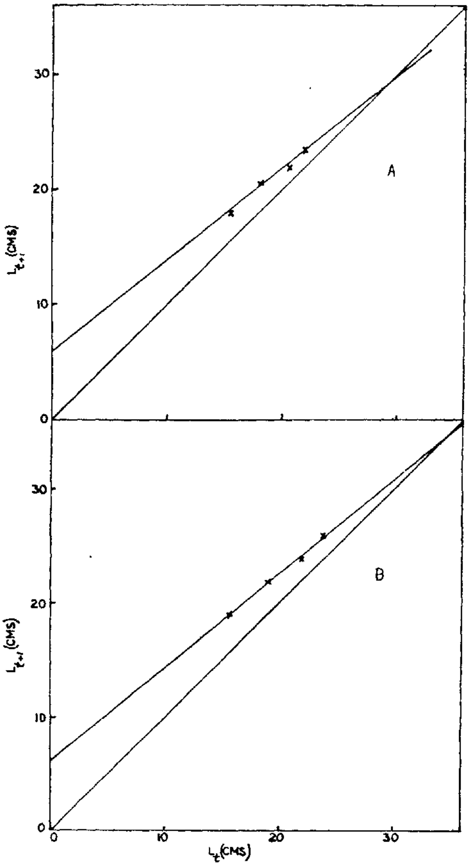

FIG. 5. Walford plot of the back-calculated lengths of *C. macrolepidotus*. (A) male, (B) female.

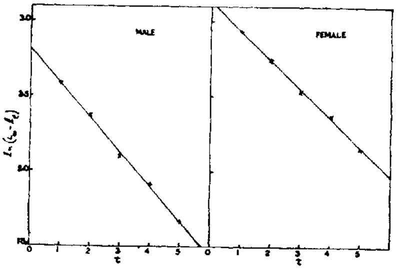

FIG. 6. Log $(L_\infty - l_t)$ plotted against age, t.

The fitted von Bertalanffy equation reads

$$\text{Male: } l_t = 28{\cdot}7882(1-e^{-0{\cdot}228817(t+2{\cdot}38806)})$$

$$\text{Female: } l_t = 34{\cdot}5399(1-e^{-0{\cdot}194048(t+2{\cdot}16751)})$$

The estimated values of L_∞, k and t_0 are given in Table V for the two sexes. By using the three parameters given in Table V, the theoretical lengths of successive year classes 1–7 were calculated. These are given in Table VI together with the mean back-calculated lengths. A comparison of the mean back-calculated lengths and the lengths estimated from the Bertalanffy growth equation would reveal that the two sets of values agree remarkably well. It may, therefore, be concluded that the von Bertalanffy growth equation gives a good fit to the growth data of *C. macrolepidotus.*

TABLE V

The estimated parameters of the von Bertalanffy growth equation for C. macrolepidotus

	L_∞ (cm)	k	t_0 (years)
Male	28·7882	0·228817	–2·38806
Female	34·5399	0·194048	–2·16751

TABLE VI

Comparison of the mean back-calculated lengths and the lengths estimated from the Bertalanffy growth equation

	Male		Female	
Age in years	Back-calculated length (cm)	Theoretical length (cm)	Back-calculated length (cm)	Theoretical length (cm)
1	15·55	15·53	15·73	15·86
2	18·10	18·24	19·04	19·16
3	20·64	20·40	21·92	21·87
4	22·04	22·12	23·81	24·10
5	23·49	23·48	25·90	25·94
6	23·32	24·56	27·90	27·46
7	24·97	25·43	28·27	28·71

ESTIMATION OF MORTALITY RATE

So far no estimate of the mortality rate of any Indian fish has been made. This may partly be due to the difficulties encountered in ageing the fish from the hard parts and partly because of the difficulties in obtaining correct information on fishing effort. In *C. macrolepidotus* also despite the fact that data on fishing effort are lacking, an attempt has been made to obtain an estimate of the mortality rate by combining the information on its length frequency distribution and the rate of growth. Ricker (1958) has pointed out that this method is less attractive than the other method where an estimate of the mortality rate is obtained from the catch curve by plotting the log frequency against age. However, the former technique has also been used successfully by many workers for estimating the total mortality rates (*see* Ricker 1958). This method is generally applicable when the growth rate of successive ages is uniform and when the successive year classes overlap thoroughly to make a smooth unimodal curve. In such cases the catch curve based on a plot of log frequency against length is normally a straight line and the slope in log units per centimetre multiplied by the annual growth rate and again by a factor 2·3026 gives an estimate of the mortality rate.

In *C. macrolepidotus*, the length frequency distribution above 23 cm is unimodal because of the complete overlap of the various age groups. Beyond 25 cm the catch curve is sloping downwards, the points up to 29 cm lie more or less in a straight line and the mortality rate is estimated for this section of the catch curve. The logarithm of the number of fish taken at one cm length interval between 25 and 29 cm (Appendix I) was plotted against successive one cm length group as shown in Fig. 7. A line of least squares is fitted to the data to obtain a slope of —0·12488 log units per centimetre. Since the rate of growth per year ranges from 1·5 to 2·0 cm at these length groups, the estimated mortality range would be 0·431 and 0·575. The corresponding annual mortality rates and survival rates are:

Annual mortality rate = 0·350–0·437
Survival rate .. = 0·650–0·563

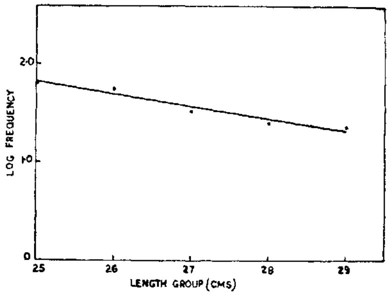

FIG. 7. Plot of the logarithm of the number of fish against one centimetre length groups.

If the older sizes, i.e. 30 and 31 cm length groups, were also included in the estimation of the mortality rate, the resulting slope will be slightly steeper and will increase the estimated mortality rate. The reason for the exclusion of these length groups from the calculation of mortality rate is because the rate of increase in length of these older fishes may be different from that of the younger fishes which have been used in the present estimate. Since the Bertalanffy growth equation is found to represent adequately the growth pattern of *C. macrolepidotus*, the absolute increase in length might be decreasing even in the size groups used in the present study and, if so, this will result in a low estimate of the mortality rate (Ricker—private communication). It is, therefore, possible that the mortality rate calculated above is only a conservative estimate of the actual mortality rate.

From the same length frequency data another estimate of the mortality rate can be calculated by slightly modifying the equation (Ricker 1958) which states:

$$S=\frac{N_2+N_3+N_4+\ldots N_r}{N_1+N_2+N_3+\ldots N_{r-1}} \qquad \ldots \quad \ldots \quad \ldots \quad (7)$$

where S is the estimated survival rate and N_1, N_2, ... N_r are the numbers of fish of successive age groups. If we assume uniform growth, then the numbers of fish of successive age groups in the above equation can be replaced by numbers of fish at each one cm length interval. The above expression will then give an estimate of the survival rate of the fish in relation to time to grow one cm in length. The instantaneous mortality rate (i) for this period can be calculated from the relationship

$$S=e^{-i} \qquad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (8)$$

or by using Ricker's table (*see* Ricker 1958). Multiplying the value of instantaneous mortality rate (i) by one year's growth gives the mortality rate on a yearly basis.

By using the above method the calculated values of the mortality rate for *C. macrolepidotus*, assuming that the growth rate of the fish from 25 cm and above is between 1·5 and 2 cm per year, would be between 0·405 and 0·540.

As noted above the mortality rates obtained by the two methods agree remarkably well. The slight difference in the two estimates is mainly because the two methods give somewhat different weightage to the data (Ricker—private communication). While in the log method all length classes are given the same weight, the other method gives more weight to the smaller length classes because they contain more fish. Dr. Ricker also informs me that a choice between the two methods depends on the type of error. The log method is preferable if there are fluctuations in year class strength. On the other hand, the second method is suitable if recruitment and survival rate are constant from year to year and the error is mainly due to random sampling fluctuations. The log method is preferable because recruitment is seldom uniform.

It may be concluded that the mortality rate of *C. macrolepidotus* by taking into account both methods lies roughly between 0·400 and 0·575. Since there is almost no regular fishery around Cochin for *C. macrolepidotus* this value of the mortality rate may be treated as a rough estimate of the instantaneous natural mortality coefficient for the individuals larger than 25 cm.

DISCUSSION

In India not much work has been done on the estimation of population parameters such as growth, mortality and recruitment. Any study on the population dynamics including the preliminary analysis of drawing the yield isopleth diagrams and eumetric yield curves for populations of steady state conditions requires an estimate of the population parameters. It is, therefore, extremely desirable that attempts should be made to get at least rough estimates of these population variables. In tropical waters there are difficulties in getting accurate data on fishing effort and on tag recoveries. Therefore, the methods designed for enumerating the population parameters of the temperate regions cannot be often applied effectively. Hence, until new methods specific to the tropical conditions are developed we may have to satisfy ourselves with somewhat less accurate estimates of the population parameters.

Although some evidence is presented in this paper regarding the annular nature of the zones on the scale, more detailed study on the time of the formation of the annuli is necessary in order to confirm the use of scales for growth studies. Such a study is warranted since in the tropics a majority of the species do not show reliable growth zones on the hard parts probably because of the stability in the environmental conditions. It is possible that the zones on the scale of *C. macrolepidotus* are formed owing to its peculiar bottom-living habits and because of its association with mud banks of the Kerala coast. These mud banks are probably rich in food organisms. During the monsoon months induced by the upwelling in coastal waters, the demersal fishes disappear suddenly from the shallow areas (Banse 1959). Probably they migrate to off-shore waters where food organisms may not be as abundant as in the shallow areas. As suggested by Seshappa and Bhimachar (1951) for *C. semifasciatus* lack of food might be a contributory factor towards the formation of these annuli on the scales of *C. macrolepidotus*. Seshappa and Bhimachar (1955) have also indicated that by the end of the monsoon, i.e. by September, a majority of *C. semifasciatus* in the sample had developed rings at the margins of their scales. This suggests that in *C. macrolepidotus* also, which has more or less similar habits, the rings might be laid down during the monsoon period.

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APPENDIX I

Length frequency distribution of C. macrolepidotus *in the sample. Mortality rate is calculated using the length frequency data lying between 25 and 29 cm*

Length (cm)	Number of fish	Length (cm)	Number of fish
9	1	21	4
10	1	22	16
11	1	23	40
12	6	24	57
13	9	25	66
14	10	26	56
15	16	27	34
16	37	28	26
17	41	29	23
18	42	30	7
19	22	31	7
20	13	32	3
		33	2