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BIOLOGY OF *STOLEPHORUS DEVISI* (WHITLEY) FROM MANGALORE AREA, DAKSHINA KANNADA

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ABSTRACT

The growth parameters of *Stolephorus devisi* are estimated by Gulland and Holt Plot as L_∞ 113 mm, K 0.0056/day and t_0 at—36 days. The species reaches 101 mm total length at the end of one year. The length-weight relationship is found to be $w=0.00000\,625\,L^{3.0108}$. The species attains first maturity at a length of 62 mm. The major spawning is from October to February. Juveniles are found from February to May. Fecundity estimates are correlated to the length of the fish. A steep fall in relative condition (Kn) at 62 mm coincides with the length at first maturity. The low Kn values beyond the length at first maturity appear to be due to protracted spawning season of this species.

INTRODUCTION

SPECIES of the genus *Stolephorus* Lacépède form an important component in the pelagic fishery resources of southwest coast of India. On an average they contributed to about 35% of the total pelagic fish biomass (Anon., 1975). *Stolephorus devisi* forms about 95% of the *Stolephorus* landings at Mangalore by purse-seines and trawlers. Information on the biology of this species is very scanty (Anon., 1975, 1976; Luther, 1979). Practically there is no published account on *S. devisi* from this area. The present account deals with some important aspects of biology of *S. devisi* from the Mangalore area.

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MATERIAL AND METHODS

The material for this study was collected at weekly intervals from the landings of purse-seines and trawlers during 1979-85. Length weight relationship was determined by least squares method separately for males and females. Depending upon the availability, monthly, between 11 to 700 fish were examined for sex ratio and spawning. The differences in the distribution of males and females were tested by the Chi-square (X^2) test.

The following classification of intra-ovarian eggs corresponding to the standard maturity scale adopted by the International Council for the exploration of the Sea, with slight modification was followed here.

Stage I	Virgin, ovary slender, ova round measuring less than 0.15 mm.
Stage II	Ovary small, ova attain ova shape, not visible to the naked eye, measure between 0.15 and 0.4 mm.
Stage III	Gonads more thick and swollen, ova visible to the naked eye, yolk deposition commenced, measure between 0.4 and 0.7 mm.
Stage IV	Gonads almost as long as body cavity, ova opaque, orange or pale yellow in colour, ova measure between 0.7 and 0.9 mm,

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Stage V	Gonads fillup body cavity, light yellow in colour, ova becoming transparent, measure between 1.0 mm and 1.3 mm.
Stage VI	Ova transparent, flowing row. (Oozing)
Stage VII a	Ovary blood red, shrunken in size, with developing ova of different sizes including few ripe ova.
Stage VII b	Ovary blood red, sac like very small in size, with very few ova. This stage is very rarely found in *Stolephorus* spp.

For the purpose of maturity studies 5 broad stages namely developing (I & II), maturing (III & IV), gravid (V-VI), partially spent (VII a) and spent (VII b) were categorised.

The fish in stage V and above were considered for determining the spawning season. For determining the length at first maturity, fish in stage III and above were considered as mature. The length group at which more than 50% of the fish attained maturity was considered as length at first maturity. The fish below the length at first maturity (immature) were considered as juveniles.

For the purpose of estimating fecundity, the total weight of ovary was taken to the nearest mg. A part of the ovary was removed, weighed and number of yolked ova were counted under a binocular microscope. The total number of ova in a ovary was estimated by raising the number of ova in the sample to the total weight of the ovary.

To investigate the food and feeding habits about 25 fish per month were observed at random during 1980 and 1981. The guts were opened and the contents were emptied into a dish. After pooling the contents of all the guts, they were qualitatively analysed by occurrence method under a binocular microscope.

The relative condition factor (Kn) of fish was calculated by using Le Cren's (1951) formula. The mean Kn values were worked out separately for juveniles and adults and different months and also in relation to various size groups.

BIOLOGY

Length-weight relationship

The total length was measured in mm and weight in grams upto an accuracy of 10 mg, using a top-pan electric balance. The material included 434 specimens of *S. devisi* in the length range of 53-105 mm. Scatter diagram of weight on total length indicated that the relation conforms to the general allometric formula:

$$W = aL^b$$

where W = weight, L = length

and a and b constants.

The logarithmic regression equations fitted for both males and females are as under. The corresponding equations are given in parentheses.

Males: $\text{Log } W = -5.3913 + 3.1063 \text{ Log } L$

$(0.000004062\ L^{3.1063})$

Females: $\text{Log } W = -5.5563 + 3.1975 \text{ Log } L$

$(0.000002778\ L^{3.1975})$

TABLE 1. *Analysis of covariance to test the significance of difference between regression lines of sexes in the length-weight relationship of* S. devisi

Source of variation	Df	Deviation from regression sum of squares	mean squares
Due to regression within sexes ..	68	1.3340	0.00196
Difference between coefficients ..	1	0.0004	0.00040
Residuals due to regression pooled within ..	69	0.1330	0.00193
Difference between adjusted means ..	1	0.0002	0.00020

Comparison of slopes
F=0.2041 d.f. 1, 68 NS at 5%

Comparison of elevation
F=0.1036 d.f. 1, 69 NS at 5%

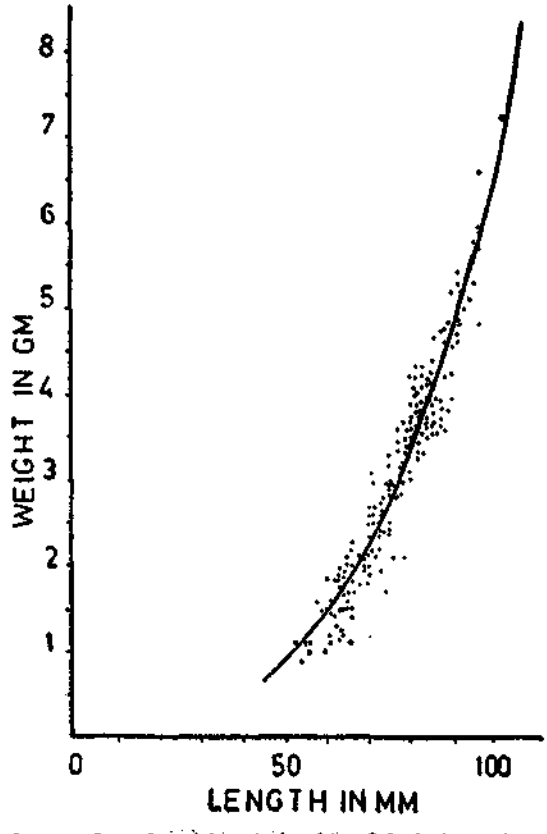

FIG. 1. Length-weight relationship of *Stolephorus devisi*.

Analysis of co-variance (Table 1) showed that there was no significant difference between the sexes at 5% probability.

Hence the data were pooled and a combined equation was fitted. It is described as

$$\text{Log } W = -5.2041 + 3.0130 \text{ Log } L$$
$$(0.00000625\ L^{3.0130})$$

The correlation coefficient was found to be 0.9642, which shows a high degree of correlation. The equation reveals that the weight of *S. devisi* increases almost at a rate equal to cube of length (Fig. 1).

Sex ratio

The monthly male to female ratios during the years 1979-85 are presented in table 2. The data for each month were subjected to χ^2 test in order to find out any significant difference from the expected equal distribution of males and females. Pooled data for the years 1979 - 85 indicate that in general, there was a significant dominance of males during January, March, October, November and December, coinciding with the spawning of *S. devisi*. Male to female ratio on an annual basis varied from 59 : 41 to 51 : 49 during the 7 year study. It is seen that the proportion of males was signficantly higher during November in all years except in 1980 and 1985. In the remaining months the sex ratio conformed to 1 : 1 ratio.

Maturity and spawning

As the periods of occurrence of juveniles and adults as well as of immature and mature fish did not reveal any noticeable variations during the study period, the data were pooled and analysed (Fig. 2). Although mature fish were observed almost throughout the year, the period from October to February can be

considered as the major spawning season, as majority of fish were in mature condition (Fig. 2 a). The peak spawning activity takes place during October-November, which happens to be the peak fishery season. The composition of immature fish increased gradually from January to June. The juveniles of *S. devisi* are common only during February-May period, and are completely absent during he rest of the months (Fig. 2 b). A few ferti-

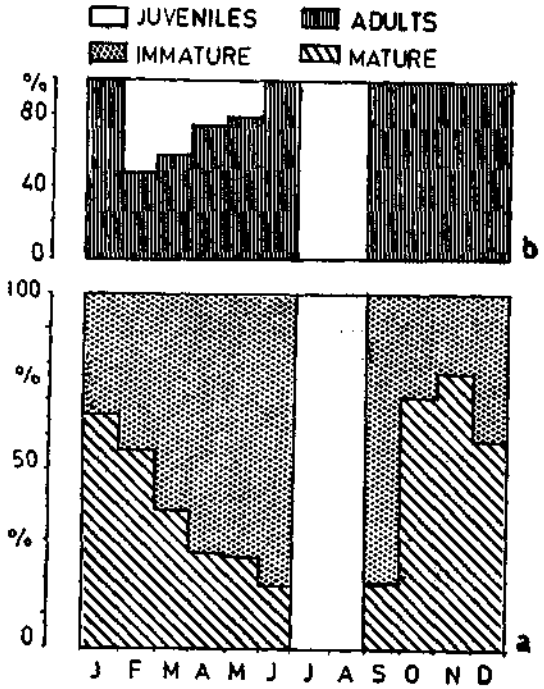

FIG. 2. a. Distribution of mature and immature *Stolephorus devisi* in different months and b. Abundance of juveniles and adults of *S. devisi* in different months. No fishing during July and August (data pooled for the years 1979-85).

lized and developing eggs of *S. devisi* were observed in the stomach contents of the species during October-November, indicating that the present fishing grounds are also the spawning grounds of this species. Length frequency distribution of intra-ovarian eggs indicates that they spawn more than once during the spawning season (Fig. 3).

Size at first maturity

Both males and females attain maturity at the same length and hence they were treated together. A plot of length and frequency distribution of mature fish indicated that at

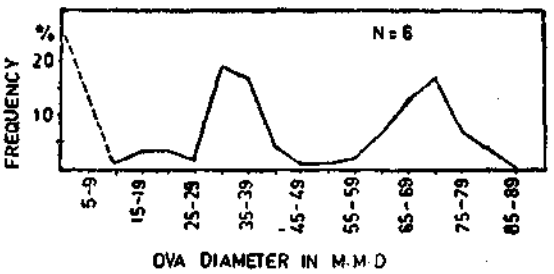

FIG. 3. Ova diameter frequency distribution of mature *S. devisi*.

60-64 mm length-group more than 50% of the fish were in mature condition. Hence the length at first maturity may be fixed at 62 mm total length which is the mid point of this group (Fig. 4).

Fecundity

The total number of ripe ova found in the mature ovaries of *S. devisi* varied from 670 to 3166 (Table 3). The fully mature specimens contained more number of ova and partially

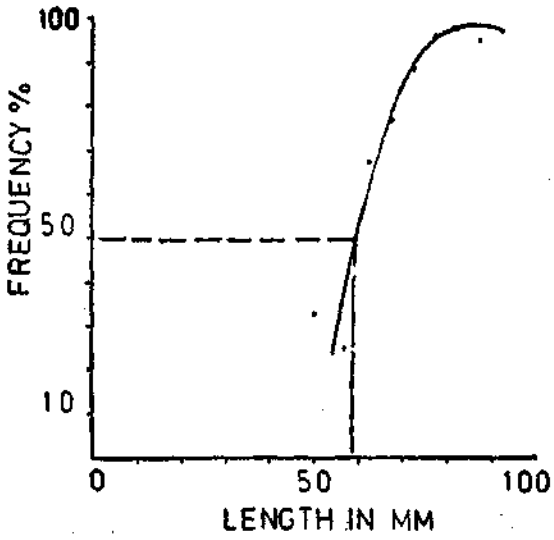

FIG. 4. Size at sexual maturity of *Stolephorus devisi*.

TABLE 2. *Distribution of males and females of*

	1979				1980				1981				1982			
	M	F	T	X^2	M	F	T	X^2	M	F	T	X^2	M	F	T	X^2
JANUARY	—	—	—		9	7	16	0.25	20	16	36	0.11	8	12	20	0.8
FEBRUARY	—	—	—		22	18	40	0.40	27	18	45	01.8	9	10	19	0.05
MARCH	10	10	20	0	8	8	16	0	29	18	47	2.6	49	32	81	3.6
APRIL	8	7	15	0.66	10	9	19	0.05	63	64	127	2.57	11	7	18	0.90
MAY	—	—	—		6	5	11	0.05	44	24	68	1.28	28	20	48	1.3
JUNE	—	—	—		—	—	—		—	—	—		—	—	—	—
JULY	—	—	—		—	—	—		—	—	—		—	—	—	—
AUGUST	—	—	—		—	—	—		—	—	—		—	—	—	—
SEPTEMBER	—	—	—		—	—	—		41	34	75	0.65	—	—	—	—
OCTOBER	24	24	48	0	348	352	700	0.02	44	39	83	0.30	380	96	486	154.4*
NOVEMBER	53	26	79	0.22*	356	344	700	0.21	84	41	125	14.79*	96	54	150	11.8*
DECEMBER	6	7	13	0.76	32	28	60	0.27	41	24	65	4.44*	62	38	100	5.8*
TOTAL	101	74	175	4.16*	791	771	1,562	0.26	393	278	671	19.70*	643	589	1,230	2.5

M = Males F = Females, T = Total

spent ovaries had invariably less number of ova. An attempt was made to study whether the fecundity is related to length of the mature fish (stage V). A regression equation was fitted which is described as follows :

$$\text{Fecundity} = 0.000165252\ L^{3.676906871}$$
$$(r = 0.9136)$$
$$d.f. = 14$$

TABLE 3. *Fecundity of* S. devisi

Length (mm)	Weight (gm)	Stage of maturity	No. of ova
91	5.1	V	2820
96	6.0	V	2640
90	5.2	V	2164
68	2.0	V	670
76	2.9	V	657
74	2.6	V	1508
61	1.4	V	782
90	4.9	V	3166
87	4.4	V	3144
86	4.3	V	2902
86	3.2	V	1959
83	3.0	V	2073
87	3.7	V	2183
79	3.4	V	2698
83	4.0	V	1265
83	4.3	V	1640
90	5.6	VII a	660
90	4.7	VII a	162
91	5.9	VII a	674
90	4.7	VII a	1010
76	3.3	VII a	348
80	3.5	VII a	430
83	3.8	VII a	1452
88	4.6	VII a	970
82	3.7	VII a	1272
80	4.0	VII a	698

The correlation coefficient between the parameters studied is highly significant.

Food and feeding

It is evident from Table 4 that this species feeds on a wide variety of zooplankton and

S. devisi *in monthly samples during* 1979-'85

1983				1984				1985				Pooled			
M	F	T	X^2	M	F	T	X^2	M	F	T	X^2	M	F	T	X^2
23	11	34	4.2*	53	47	100	0.4	61	39	100	4.8*	174	132	306	5.8*
1	3	4	1.0	98	102	200	0.08	70	60	130	0.40	227	211	438	0.6
5	8	13	0.70	153	102	255	10.2*	67	33	100	11.5*	321	211	532	22.7
—	—	—		54	46	100	1.0	49	51	100	0.02	195	184	379	0.31
45	55	100	1.0	102	98	200	0.8	42	58	100	2.6	267	260	527	0.09
40	46	86	0.41	—	—	—		—	—	—		40	46	86	0.41
—	—	—		—	—	—		—	—	—		—	—	—	
—	—	—		—	—	—		—	—	—		—	—	—	
—	—	—		—	—	—		—	—	—		41	34	75	0.65
—	—	—		87	113	200	3.4	—	—	—		883	624	1,507	44.5*
453	347	800	14.0*	470	330	800	24.5*	264	236	500	1.6	1,776	1,378	3,154	50.22*
105	95	200	0.5	98	102	200	0.08	177	123	300	9.7*	521	417	938	11.53*
672	565	1,237	9.2*	1,115	940	2,055	14.9*	730	600	1,330	12.70*	4,445	3,497	7,942	113.15*

* Significant at 5%.

occasionally on phytoplankton like *Coscinodiscus*. Zooplankton, dominated by copepods, appears to meet most of the food requirements of *S. devisi*.

Relative condition factor (Kn)

As the monthly values of relative condition factor between years were found to be comparable, the data for different years were pooled. The monthly values of relative condition factor (Kn) of adult *S. devisi* were lowest during February. They remained high (above unity) in April, May, June, September and December. During the remaining period the Kn values were low (less than unity). In juveniles, which were available only during February-May, the Kn values were above unity during February only (Fig. 5 a).

A plot of the average Kn values against the respective length groups (Fig. 5 b) show that

TABLE 4. *Seasonal variation in the composition of stomach contents of* S. devisi *(Occurrence)*

Month	Composition	%
Jan.	Gastropods, copepods and fish larvae	12
	Digested matter	88
Feb.	Copepods, *Coscinodiscus*	13
	Digested crustacean matter	87
Mar.	Copepods, *Lucifer*, *Coscinodiscus* and *Sagitta*	32
	Digested crustacean matter	68
Apr.	Copepods	40
	Digested crustacean matter	60
May	Copepods	5
	Digested crustacean matter	95
June	—	
July	—	
Aug.	—	
Sep.	Copepods, *Coscinodiscus*	10
	Digested crustacean matter	90
Oct.	Cladocera, Ostracoda and diatoms	8
	Copepod remains and digested matter	92
Nov.	Copepods and *Coscinodiscus*	3
	Digested matter	97
Dec.	Copepods	11
	Digested crustacean matter	89

the Kn is high at 52 and 57 mm, and has a steep fall at 62 mm. Thereafter it increases steadily till 87 mm and after a fall at 92 mm it rises sharply to touch a peak at 102 mm.

Age and growth

For the purpose of growth studies, the total length measurements were grouped into 2 mm class intervals. It was not possible to trace the broods continuously over the whole length range of the species due to irregular shifting of the modes and lack of data over the monsoon period (June-September). Hence Gulland and Holt (1959) method was applied, which allows the tracing of growth at short and irregular intervals of time, at different length ranges. Each mode in a length frequency distribution is taken as the average length of one group (brood) of fish. Some samples had only one mode, whereas others had many modes. All the modes were plotted on graph paper with length in mm as the vertical axis and time in days on the horizontal axis. Those modes which appeared to represent one distinct brood of growing fish were linked together to form a mode chain, so that each mode chain represented one brood of growing fish (Tham, 1967).

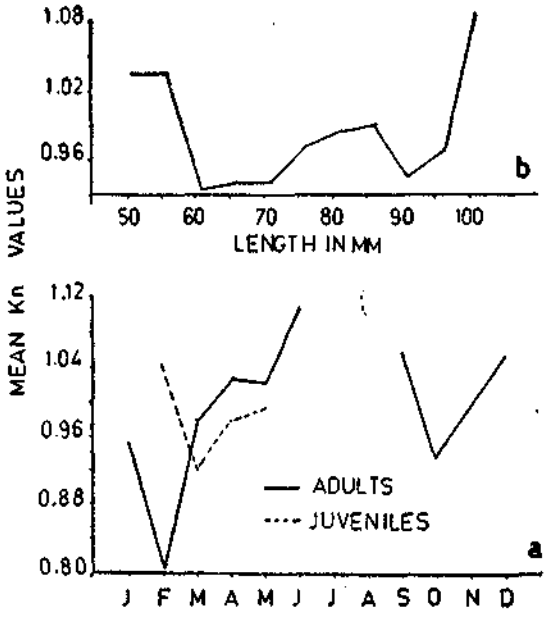

FIG. 5. a. Mean Kn values of *Stolephorus devisi* in different months and b. Mean Kn values at different lengths of *S. devisi*.

The growth rate was calculated for each brood (mode-chain) and the growth rate of fish between adjacent modes (Fig. 6) was taken as the growth rate at the mean length of two modes. Thus growth rates at different length intervals were obtained. The Gulland and Holt (1959) method provided for the estimation of growth constants L_∞ and K by the method of least squares as follows :

$$\frac{L_2 - L_1}{t_2 - t_1} = a - K.\,\bar{L}$$

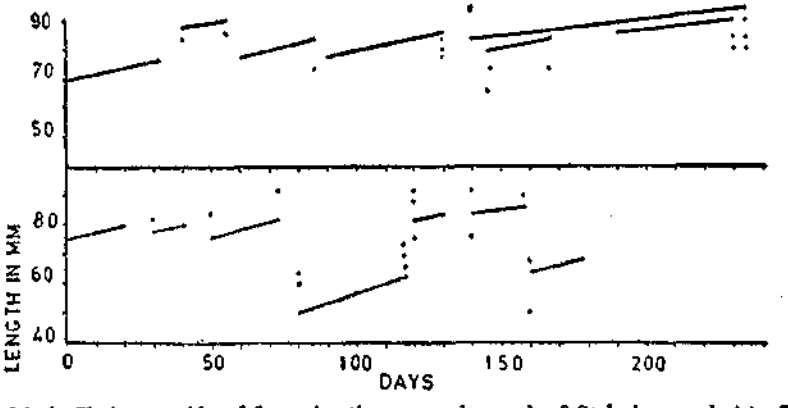

FIG. 6. Mode-Chains considered for estimating age and growth of *Stolephorus devisi*. The dots indicate the untraced modes.

The above equation may be written as

$$\frac{L_2 - L_1}{t_2 - t_1} = K\left(L_\infty - \frac{(L_1 + L_2)}{2}\right)$$

where

L_1 = Length of fish at any mode of mode-chain

L_2 = Length of fish at the following mode of mode-chain

$t_2 - t_1$ = Interval in days between the two modes,

K = catabolic growth coefficient

and L_∞ = asymptotic length of fish.

The growth rates derived at different mean lengths were utilised to get the regression equation (Fig. 7) by the least square method as given below.

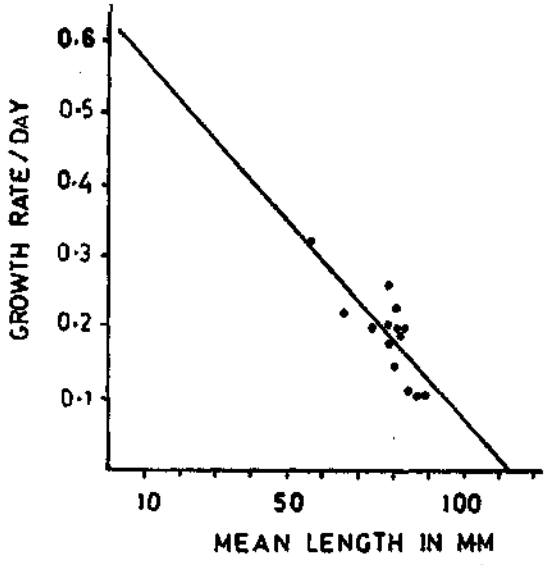

FIG. 7. Regression of instantaneous growth rates on mean lengths of *Stolephorus devisi*.

Growth rate $(Y) = 0.6325 - 0.0056$ Length (X), $r = 0.8166$

The intercept a and slope b provide values of K and L_∞ through the relationships

$K = -b$: 0.0056/day

and $L_\infty = \frac{a}{k}$: 112.9464 (113 mm)

For estimation of t_0 in the application of von Bertalanffy growth equation

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

the method suggested by Pauly (1979) was followed as given below:

$$\log 10 (-t_0) = -0.3922 - 0.2752 \log_{10} L_\infty - 1.038 \log_{10} K.$$

This relation gave the t_0 value of *S. devisi* as -36 days. Hence the von Bertalanffy growth equation for *S. devisi* may be expressed as

$$L_t = 113 (1 - e^{-0.0056 (t+36)}$$

Where the estimates of K and t_0 are per day and in days respectively. According to the above growth equation *S. devisi* grows to 57.2 mm in 3 months, 79.3 mm in six months. 92.6 mm in 9 months and 101 mm at the end of one year (Fig. 8).

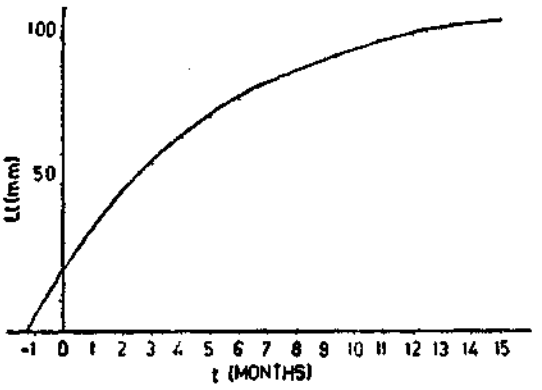

FIG. 8. Growth curve of *Stolephorus devisi* obtained by fitting von Bertalanffy equation.

DISCUSSION

From the von Bertalanffy growth equation, it is deduced that *Stolephorus devisi* reaches a total length of 101 mm at the end of one year of its life. In *S. pseudohetrolobus* studied from Singapore, Tham (1967) estimated L_∞ at 89 mm (standard length) and K at 0.0059/day. On the other hand in *S. heterolobus* from Palau, Muller (1978) obtained a

L_∞ value of 91 mm (S.L.) and a K value of 0.0058/day. It may be mentioned here that *S. pseudoheterolobus* Hardenberg, which is a synonym of *S. heterolobus* (Rüppell) is very closely related to *S. devisi* (Luther, 1979). The estimated L_∞ at 113 mm total length and K at 0·0056 (daily basis) obtained in this study compare favourably with the above studies. An earlier estimate (Anon, 1976) indicates that *A. heteroloba* (= *S. heterolobus*) seems to grow to an average length of 80 mm within six months, which is quite close to the present observation. The largest specimen recorded in the catches during the period of study was 105 mm which is close to the value of L_∞ obtained. It is well known that in short lived species the K value is known to be high(Beverton and Holt, 1957). Interestingly a high K value of 2.04 (per year) is obtained in this study which is in agreement with the statement of Beverton and Holt (1957).

S. devisi attains first maturity at a length of 62 mm and the estimated age at this length is 3.7 months. Since the mature fish are available almost throughout the year (Fig. 3) it is possible that *S. devisi* spawns at frequent intervals releasing batches of ova during the spawning season.

Low Kn values were obtained in October and February which coincided with the commencement and completion of major spawning period respectively. The relative condition factor (Kn) reached the lowest value at 62 mm length which is the observed length at first maturity. Pantulu (1961) and Devaraj (1973) opine that the number of 'peaks' and 'valleys' in the relative condition factor curve may be an index of the number of spawnings during the life-span of the fish. The persistently low Kn values fluctuating between 57-97 mm length groups of *S. devisi* probably related to the protracted spawning habit of the species. The low Kn value at 92 mm indicates that the fish may commence the second set of protracted spawning when the fish attains 90 mm length. But the duration of this period seems to be very short. As fish beyond 90 mm forms only a very small fraction of the commercial catches, bulk of the fish seems to complete only one set of spawning during an lindividual's life time.

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