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BIOLOGY AND POPULATION DYNAMICS OF THE SILVERBELLY *SECUTOR INSIDIATOR* (BLOCH) FROM KAKINADA

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ABSTRACT

The biology and population dynamics of *Secutor insidiator* from the trawling grounds off Kakinada were studied. The estimated length at first maturity is 90 mm and the spawning season is protracted with a peak during January-March period. The von Bertalanffy parameters of growth in length are estimated as $L_\infty = 123$ mm, $K = 1.2$ per year and $t_0 = -0.01$ year. The estimated lengths on the completion of first and second years are 86 and 112 mm respectively. The length-weight relationship can be described by the equation : $\log W(g) = -5.73713 + 3.43654 \log L$ (mm). The instantaneous rate of total mortality during the period is estimated as 6.1 and the values of natural mortality rate, by different methods, are estimated as ranging from 1.8 to 2.6. Length and age at first capture are 80 mm and 0.87 year respectively. Under the present value of t_c, yield increases with increased F without reaching a maximum ; highest yield, however, can be obtained at t_c ranging from 0.5 to 0.7 with the present Z and different value of M considered.

INTRODUCTION

SILVERBELLIES or slipmouths (Family : Leiognathidae) are exploited in considerable quantities and form one of the major demersal fishery reasources of India. Though some information on the fisheries and biology of silverbellies from India is available (Arora, 1951 ; Balan, 1967 ; James, 1973 ; James and Badrudeen, 1975 ; 1982 ; Venkataraman and Badrudeen, 1974 ; Venkataraman *et al.*, 1982 ; Annam and Dharmaraja, 1982 ; Murty, 1983), there is no information on the biology of *Secutor insidiator* from the Indian Coast, excepting a brief account on spawning from Tuticorin (Pillai, 1972). Since this is one of the most dominant species in the trawl catches at Kakinada, a detailed study of its biology was taken up in 1979 and the results are presented in this paper. An attempt is also made to estimate the mortality rates and yield of this species from the trawling grounds off Kakinada.

The author is grateful to Dr. E. G. Silas, former Director and Dr. P. S. B. R. James, present Director of CMFRI for encouragement and to Mr. C. Mukundan for suggesting improvements in the manuscript.

MATERIAL AND METHODS

The study is based on data collected during 1979-83 from the catches of the commercial trawlers operating off Kakinada. Data on catch and effort were collected for 18-20 days in a month. Samples for studies on the species composition and biology were collected at weekly intervals. The data on species composition of siverbellies and length of *S. insidiator* collected on each observation day were weighted to get the day's and then the monthly estimates.

Three types of boats are operated in the area under study (CMFRI, 1981). As the

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Pomfret-Royya category of boats is most dominant in the fleet (CMFRI, 1981), this was considered as the standard unit and effort standardisation was made following Gulland (1969), by considering all the demersal group landed as one group since the trawl fishery is a multispecies one.

For biological studies the specimens in fresh condition were examined. Maturation stages were fixed following Murty (1983). Only females were considered for estimating length at first maturity and spawning. Fishes in stages IV-VI of maturation were taken as mature for estimating length at first maturity and fishes of and above length at first maturity only were considered to determine spawning season.

To examine whether the monthly sex ratio is 1 : 1 or not, the chi-square test was applied. A test of variance for homogeneity (Snedecor and Cochran, 1967) was used to find whether the sex ratio over a period of one year is uniform.

The length data were grouped into 5 mm class intervals and the mid points in these groups were considered to study growth. Parameters of growth in length were estimated by the 'integrated method' of Pauly (1980 a) and using the well-known von Bertalanffy equation for growth :

$$Lt = L\infty(1 - e^{-K}(t - t_0)$$

Estimates of $L\infty$ and K were obtained using the Ford-Walford plot (Ford, 1933 ; Walford, 1946) as adapted by Manzer and Taylor (1947).

Since Beverton-Holt yield equation assumes growth in weight with length to be isometric, computation of yield following this method results in erroneous estimates of absolute yield in species in which growth in weight with length does not follow cube law. Hence, Paulik and Gales (1964, as cited by Clark 1978) have recommended that 'a von Bertalanffy curve be fitted to the cube root of weight at each age and this fictitious length schedule used in computations [of yield] by the method of Beverton and Holt'. Hence, in the present study, the parameters of growth in weight were also estimated : the values of lengths at half yearly intervals, obtained by the integrated method were converted into weights at ages with the help of the length-weight relationship and the cube roots of these values were taken for fitting the von Bertalanffy equation.

Weight of each fish was taken to an accuracy of 0.5 g. The length-weight relationship was calculated with the help of the formula : $\log W = \log a + b \text{ Log } L$, where W=weight of fish in grams, L=total length in mm, a=a constant and b=exponent (Le Cren, 1951).

Instantaneous rate of total mortality (Z) was estimated by length-converted catch curve method of Pauly (1982), cumulative catch curve method of Jones (1981) and Jones and van Zalinge (1981), Ssentongo and Larkin (1973) method and Beverton and Holt (1956) method.

The estimation of natural mortality rate (M) was attempted by the relation : $Z = M + qf$ where q is the catchability coefficient and f=fishing effort, but the plot of Z against effort showed that the points are not well-represented by a straight line. The value of M, therefore, was estimated assuming that 99% of the fish by numbers would die, if there was no exploitation, by the time they attained t_{max} and by taking t_{max} as corresponding to L_{max} in the catch (Sekharan, 1976), or to $L\infty$-0.5 cm (Alagaraja, 1984) or to 95% of $L\infty$ (Pauly, 1983). It was also estimated with the help of the empirical relationship (Puly, 1980 b) :

$\log M = -0.0066 - 0.279 \log L\infty + 0.6543 \log K + 0.4634 \log T$ where $L\infty$ is in cm, K per year and T is mean water temperature in °C. For the purpose of this equation the value of T

was taken as 27.2°C from Ganapati and Murthy (1954) and La Fond (1958). Length at first capture (L_c) was estimated following Navaluna (1982).

Exploitation rate (U) was estimated by the equation of Sekharan (1976) and the total annual stock (Y/U) and average standing crop (Y/F) were estimated by taking the average annual catch of the species (Y) during 1979-'83. The value of Y/F thus obtained was taken as the average biomass (B) during the exploited phase of the species in the trawling grounds.

The yield in weight per recruit (g) was estimated from the equation of Beverton and Holt (1957). Since growth in weight with length in *S. insidiator* is not isometric, yield per recruit was also estimated following the method recommended by Paulik and Gales (1964).

The biomass per recruit (B/R) was estimated from the formula: $B/R=(YW/R)/F$ and recruitment in numbers (R) was estimated by the relation $R=B/(B/R)$. Since the estimation of biomass was made under the present level of fishing mortality rate (considering different values of M) and age at first capture, recruitment was also estimated taking these values into account. The values of recruitment thus obtained were assumed to be constant.

The expected yield at different levels of fishing mortality was estimated by the relation: yield in weight = Recruitment (Nos) X yield in weight per recruit (g).

MATURATION, SPAWNING AND SEX RATIO

Length at first maturity: The data of the three-year period (1980-'82) were pooled for the purpose. Fishes of 72 mm and above showed mature gonads and the percentage of mature fish in each length group showed increase with increased length. It was observed that at 92 mm length, about 50% of the fish were mature. Hence the lower limit of this length group at 90 mm was taken as the length at first maturity at Kakinada.

Spawning: Fishes in stages III-V of maturation occurred in almost all months (Fig. 1). The percentage of gravid and ripe (St. V+VI) adults in different months (Fig. 2) shows that the spawning season of *S. insidiator* is protracted running almost throughout the year, with a peak during January-March period.

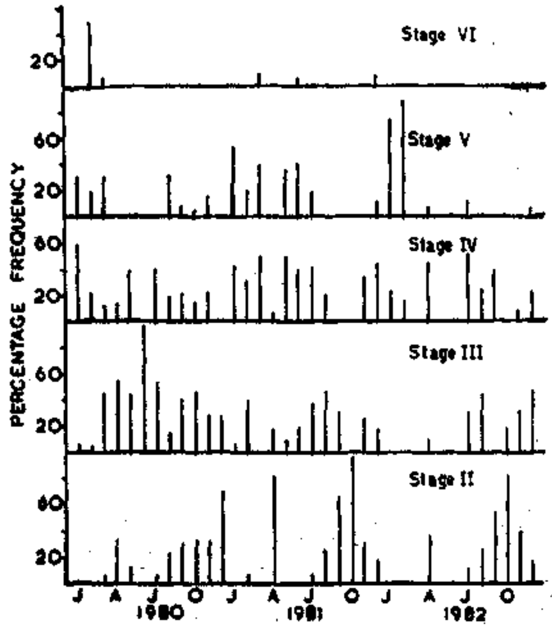

FIG. 1. Monthly percentage frequency distribution of ovaries of *S. insidiator* in each stage of maturation during 1980-82.

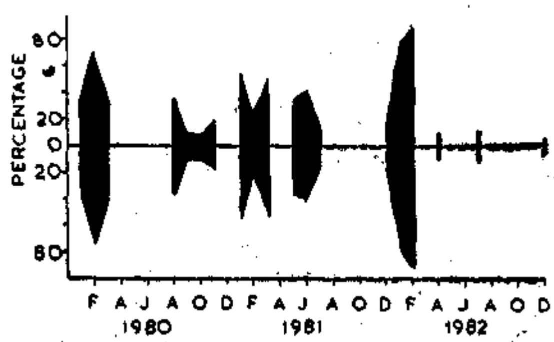

FIG. 2. Percentage composition of gravid and ripe females (St. V+VI) of *S. insidiator* in the total number of adult females examined in each month during 1980-82.

Sex ratio: 1374 specimens (606 males, 768 females) ranging from 72 to 112 mm were examined. Females outnumbered males in majority of the months (Table 1) while the reverse was true in January, June and October 1980; April, September and October 1981 and January, September and November 1982. In the annual total, females outnumbered males in all years.

At 5% probability level, the ratios are not significantly different from 1 : 1 in all months except February 1980, May and December1981 and July 1982 (Table 1). The test of variance for homogeneity of sex ratio (Table 2) reveals that the X^2 values are significant at 5% in 1980 and 1981, but in 1982 it is not significant. It may be noted that data were available only for 9 months in 1982. It was felt that the non-uniform nature of sex ratio in 1980 and 1981 could be due to greater predominance of females in one or two months as mentioned above. When the test of variance for homogeneity was applied after eliminating the data of those months (February 1980, May and December 1981) where the sex ratio was significantly different from 1 : 1, the chi-square value did not show significant difference.

TABLE 1. *Monthly sex ratio in* S. insidiator

	1980		1981		1982	
	♂	♀	♂	♀	♂	♀
January ..	28	24	24	30	12	10
February ..	7*	28*	43	55	7	14
March ..	24	24	10	12	—	—
April ..	7	13	23	20	16	16
May ..	27	44	5*	24*	—	—
June ..	10	5	12	17	—	—
July ..	8	17	18	21	28*	49*
August ..	13	13	9	11	13	20
September ..	32	41	10	7	7	6
October ..	34	20	7	6	7	10
November ..	46	46	44	44	20	17
December ..	7	16	17*	45*	31	43
Pooled ..	243	291	222	292	141	185

* Sex ratio significantly different from 1: 1 at 5%.

TABLE 2. *Test of variance for homogeneity of sex ratio in* S. insidiator

Year	Df	χ^2
1980 ..	11	27.83*
1981 ..	11	20.13*
1982 ..	8	6.23
1980-1982 Pooled ..	32	55.13*

* Significant at 5%.

The data on sex ratio in different length groups (Table 3) showed predominance of males upto 87 mm group and of females from and above 92 mm. The mean lengths of fishes in the sexes over the period did not show marked differences.

ESTIMATION OF GROWTH PARAMETERS

The monthly modal lengths during 1979-83 are plotted in Fig. 3. While drawing the

TABLE 3. *Sex ratio in different length groups of* S. insidiator*

Length groups(mm)	N	♂	♀
72	4	50.0	50.0
77	19	57.9	42.1
82	45	66.7	33.3
87	173	58.4	41.6
92	347	46.1	53.9
97	255	36.5	63.5
102	150	35.3	64.7
107	47	27.6	72.4
112	8	25.0	75.0
Pooled	1048	44.3	55.6
Mean length (mm)	—	92.5	95.0

* Data of 1980 and 1981 only were considered

growth curves, the points that were likely to fall in a curve were joined first and then the curve was extended further both upwards and downwards. The curves thus drawn are parallel to each other. The lengths attained at intervals of six months were read off these growth curves for purpose of estimating the growth parameters : the smallest modal length in a curve was taken as the initial length (Lt) and from there, the curve was marked at an interval of six months (irrespective of occurrence of a modal point at that point) and the length at that point was taken as length attained after six months (L_t+1) and so on for estimation of $L\infty$ and K (Fig. 4). The smallest modal length in the growth curves was 47 mm in July 1982 (Curve *K*, Fig. 3) whose age was read off as 6 months from the origin of the curve.

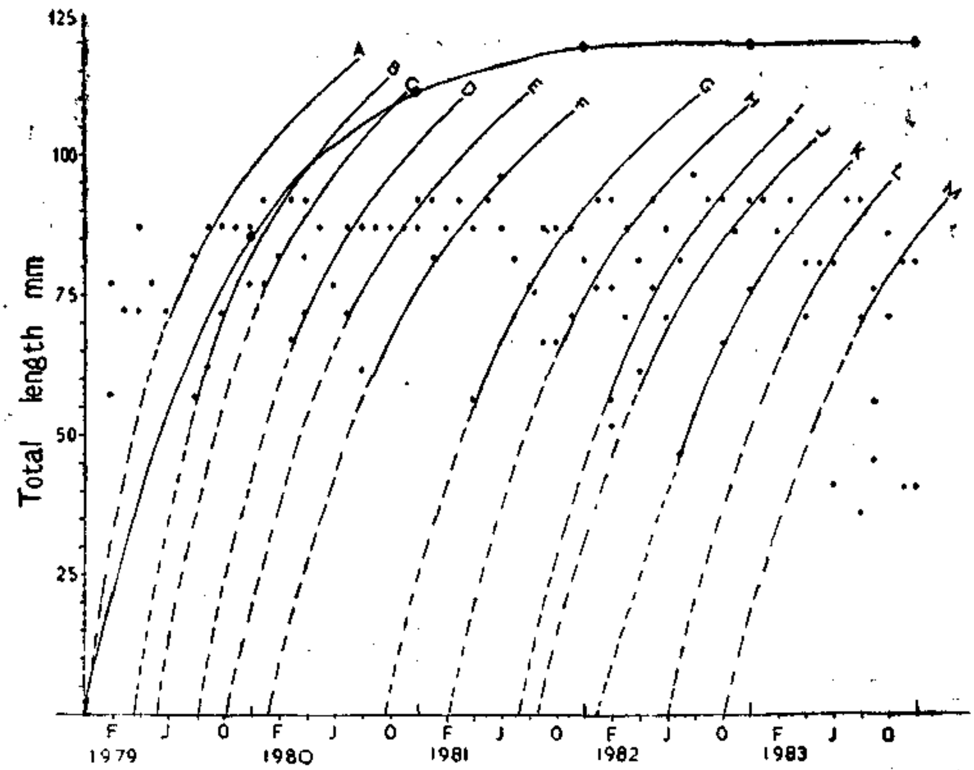

FIG. 3. Monthly modal lengths and growth curves drawn through them in *S. insidiator* (Integrated method of Pauly 1980 a). The von Bertalanffy growth curve is also shown.

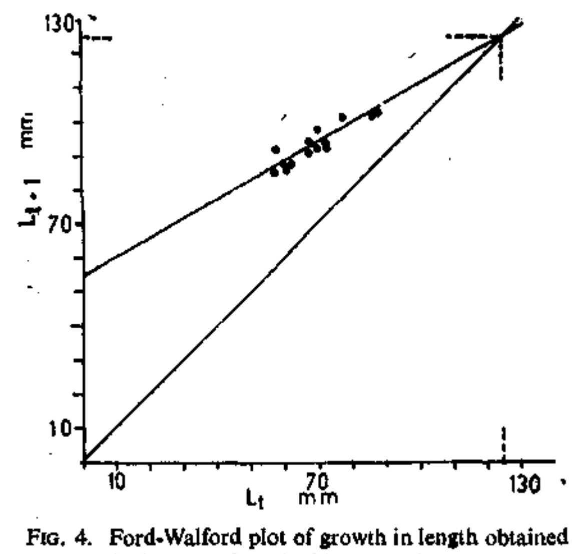

FIG. 4. Ford-Walford plot of growth in length obtained by integrated method in *S. insidiator*.

Taking this length, the length, at successive half years were estimated using the Ford-Walford relation, for purpose of estimating t_o. The estimated values of parameters are shown in Table 4.

TABLE 4. *Parameters of growth and mean lengths (mm) at ages in* S. insidiator

Particulars		Growth in length	Growth in weight
L_∞ (mm)/W_∞ (g)	..	123	3.07764*
K (per year)	..	1.20	1.11
t_o (year)	..	−0.01	−0.07
Length at 1 year	..	86	—
Length at 2 years	..	112	—
Length at 3 years	..	120	—

* $\sqrt[3]{W_\infty}$

Since the maximum length recorded during the study period was 117 mm, the maximum age of the species in the fishing ground works out to 2.5 years.

Estimation of parameters of growth in weight : The estimated values of parameters are given in Table 4. The cube root value of W_∞ is 3.07764; this value was used in yield studies following Paulik and Gales (1964) and Clark (1978).

LENGTH-WEIGHT RELATIONSHIP

Data from 253 males ranging from 57 to 109 mm and from 2 to 19 g and 264 females ranging from 62 to 114 mm and from 3 to 22 g were used for this study. The relationship for fishes in the sexes separately are :

Males : $\text{Log } W = -5.62499 + 3.37829 \text{ Log } L$ ($r = 0.96$)

Females : $\text{Log } W = -5.86469 + 3.50201 \log L$ ($r = 0.89$)

The values of slope and elevation of males and females when tested by analysis of covariance (Table 5) did not show significant difference at 5% level. The data of both sexes were, hence, pooled and the relationship for the species from Kakinada was calculated as :

$$\log W = -5.73713 + 3.43654 \log L \quad (r = 0.93).$$

The value of the regression coefficient was tested against the theoretical value of 3 by the t-test and it was found that it differed significantly. Hence growth in weight with length in *S. insidiator* is not isometric.

MORTALITY RATES

Total mortality rate : A plot of $\log_e (N/\Delta t)$ against 't' for different years is shown in Fig. 5. Only those points which represented the straight descending part of the catch curve were considered for estimation of Z. Similarly in the cumulative catch curve method (Fig. 6), those points which represented a straight line were used. The departure from linearity at either end in the above graphs (Fig. 5 and 6) is likely to be due to non-representativeness of smaller individuals in the catches, resulting from incomplete recruitment of fish in these

TABLE 5. *Analysis of Covariance to test the significance of difference between regression lines of sexes in the length-weight relationship of* S. insidiator

Source of variation	Df	Deviation from regression Sum of squares	Mean squares
Due to regression within sexes ..	513	2.024169	0.003946
Due to difference between regression coefficients	1	0.003972	0.003972
Residual due to regression pooled within ..	514	2.028141	0.003946
Difference between adjustmented means ..	1	0.000801	0.000801
Total: ..	515	2.028942	

Comparison of slopes : F=1.0066, df 1,513 : not significant.
Comparison of elevations : F=0.2029, df 1,514 ; not significant.

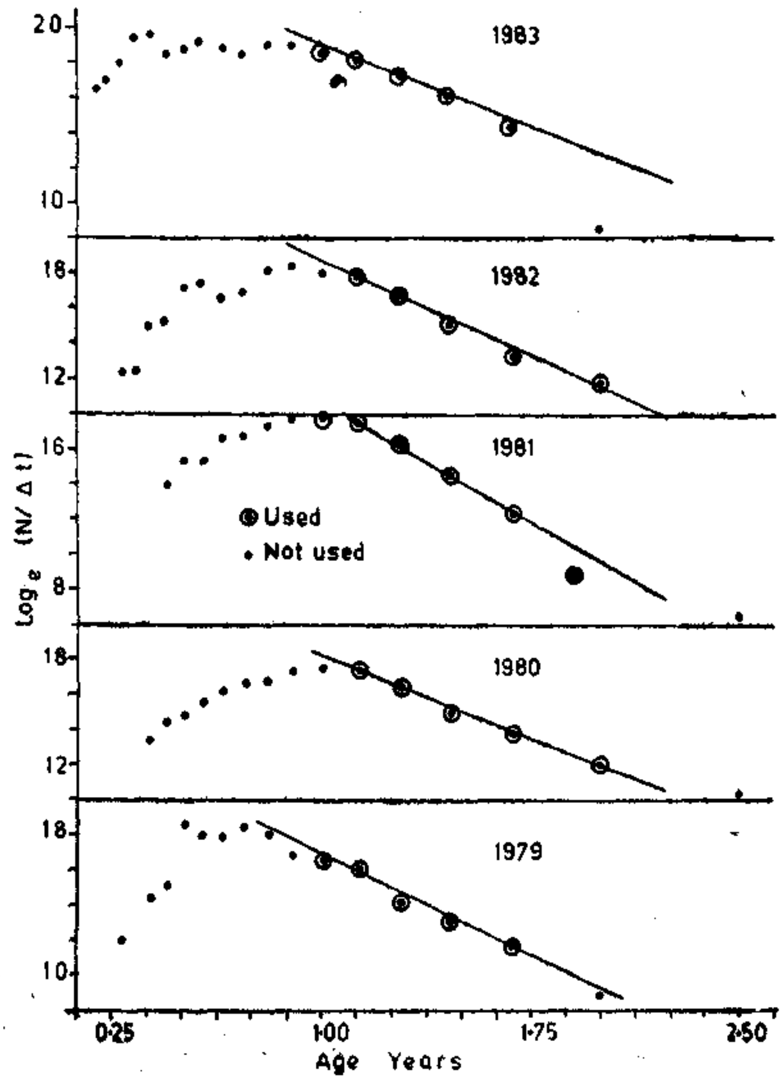

FIG. 5. Estimation of Z by length-converted catch curve method of Pauly (1982) in *S. insidiator*.

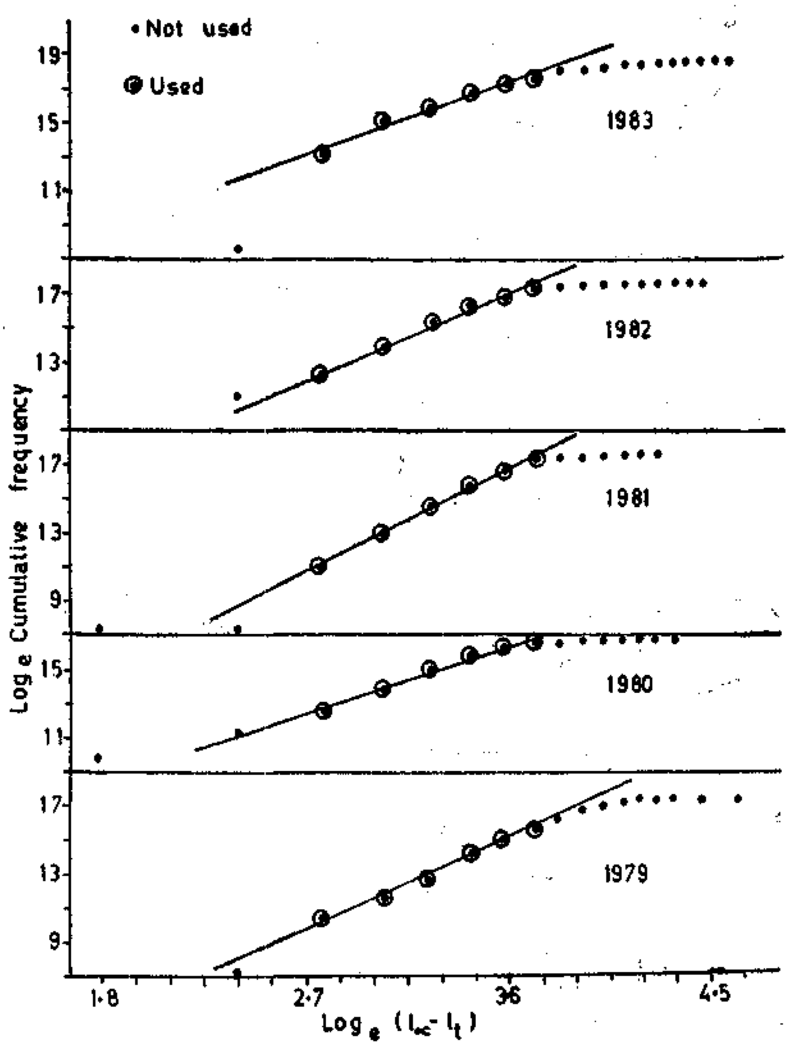

FIG. 6. Estimation of Z by cumulative catch curve method in *S. insidiator*.

lengths and of the larger individuals due to the variations in growth rates (Jones, 1981) or due to the possible over-estimation of age of these individuals (Pauly, 1983). The estimated values of Z by different methods (Table 6) show that the values obtained by Pauly's method for each year are the highest and those obtained by Beverton-Holt method are the lowest. The average (Z=6.1) of all these values for all years was taken as the total mortality rate during the period (Table 6).

Natural mortality rate : The estimates obtained by different methods are shown in Table 7. It may be noted that except the value by Sekharan's method, all the values are more or less the same.

SELECTION PATTERN

The selection pattern (Fig. 7) shows that the mesh sizes used during different years are not much different; the 50% selection length

TABLE 6. *Estimated values of Z in* S. insidiator *by different methods in different years*

Year	Pauly's method	Cumulative catch curve method	Ssentongo-Larkin method	Beverton-Holt method	Average
1979 ..	8.0329	7.0856	6.6093	6.0274	6.9388
1980 ..	6.1908	5.1765	4.5160	3.9425	4.9565
1981 ..	9.1357	8.0029	5.7397	5.1606	7.0097
1982 ..	7.1845	6.4493	5.4458	4.8678	5.9869
1983 ..	6.2143	5.8505	5.5254	4.9471	5.6343
Average ..	7.3516	6.5130	5.5672	4.9891	6.1052

TABLE 7. *Estimation of M Following different methods and estimation of F, U, Y/U, Y/F, Yw/R, B/R and R in* S. insidiator (Z=6.1 and annual average catch : 331 t)

Method of estimation of M	M	F	U	Y/U (t)	Y/F (t)	YW/R (g)	B/R (g)	Recruitment (Nos)
Sekharan, 1976 ..	1.8	4.3	0.70	473	77	0.19671	0.045746	1682704499
Alagaraja, 1984 ..	2.3	3.8	0.62	534	87	0.124975	0.032889	2648453890
Pauly, 1983 ..	2.4	3.7	0.61	543	89	0.113915	0.030788	2905673370
Pauly, 1980 b ..	2.6	3.5	0.57	581	95	0.094432	0.026981	3505161135

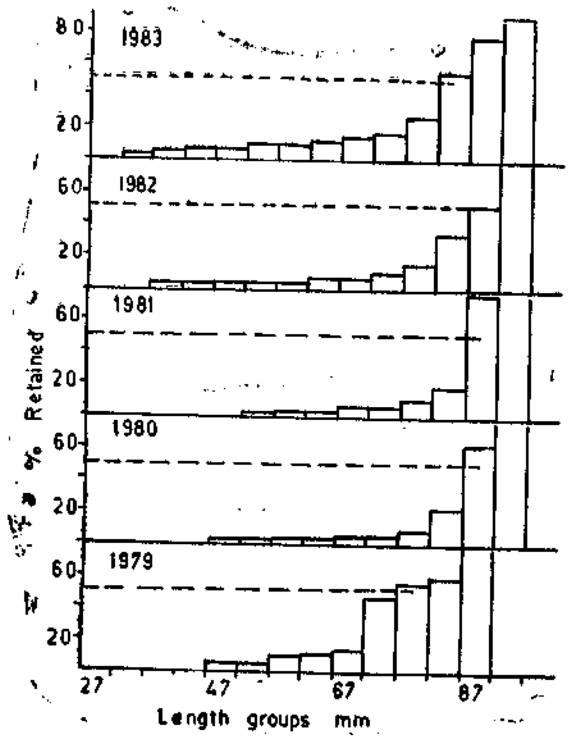

FIG. 7. Selection pattern in *S. insidiator*.

ranges from 77 to 87 mm in different years and their average works out to 84 mm. Hence the lower limit of this length class (80-84 mm) was taken as length at first capture (L_c) whose estimated age (t_c) is 0.86 year.

CATCHES OF SILVERBELLIES

The estimated catches of silverbellies and *S. insidiator* during the period 1979-83 (Table 8) show continuous increase in successive years and an annual average of 904 tonnes of silverbellies was landed at Kakinada, with 331 tonnes of *S. insidiator*, contributing to about 37% of silverbelly landings.

EXPLOITATION RATE AND STOCK SIZE

Taking the *Z* value as 6.1 and different values of *M*, the exploitation rate (*U*) was estimated as ranging from 0.57 to 0.70 (Table 7). The corresponding values of total annual stock (*Y/U*) and average standing crop (*Y/F*) are also shown in Table 7.

TABLE : 8 *Estimated effort (Trawling hours) and catch (tonnes) of Silverbellies in different years*

Year		Effort	Total Silverbelly catch	% of *S. insidiator* in silverbelly catch
1979	..	396864	535	34.3
1980	..	322655	569	29.5
1981	..	384436	605	41.7
1982	..	459599	969	33.4
1983	..	328461	1843	39.3
Average	..	378403	904	36.6

ESTIMATION OF YIELD PER RECRUIT

Beverton and Holt method: The value of $W\infty$ corresponding to $L\infty$ was calculated as 28 g on the basis of the length-weight relationship; the value of t_r was estimated as 0.2 taking 27 mm (the smallest length in the catch) as the length at recruitment. As stated earlier, 80 mm was taken as length at first capture, whose estimated age (t_c) is 0.87 year.

The yield in weight per recruit taking all possible values of M as given in Table 7 and 3 values of t_c at 0.69, 0.87 and 1.09 corresponding to L_c values of 70, 80 and 90 mm respectively (Fig. 8 a-c) against F, show that yield

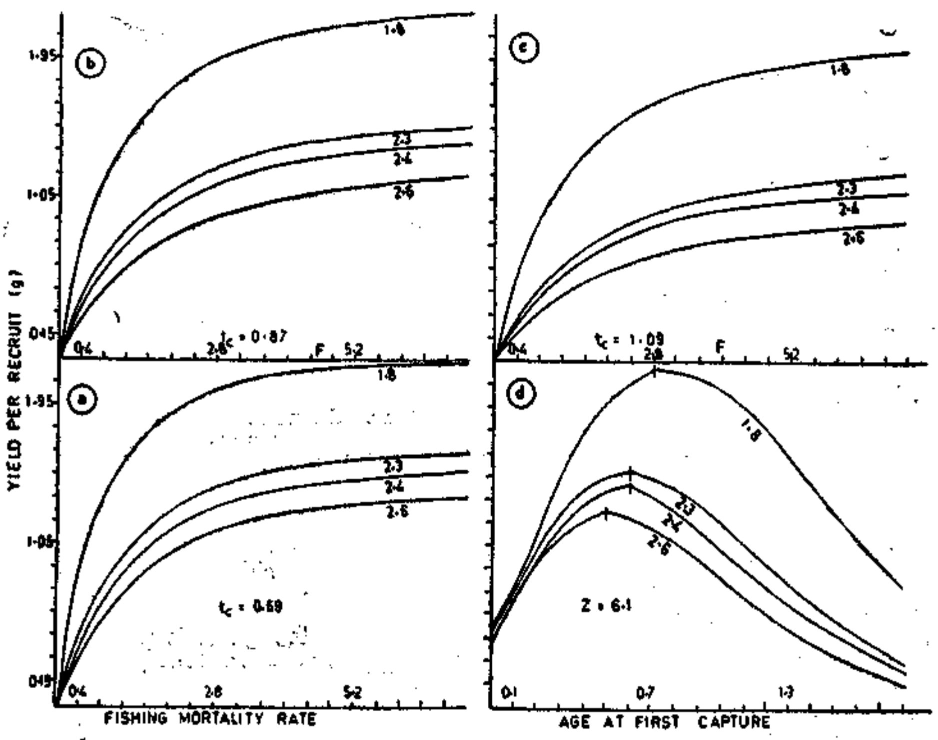

FIG. 8 a-c. Yield per recruit as a function of fishing mortality rate in *S. insidiator* under different values of t_c and M (Numerals refer to different values of M) and d. Yield per recruit as a function of age at first capture in *S. insidiator* with Z at 6.1 and different values of M (Numerals refer to M values).

per recruit increases with increased F without reaching a maximum; the curves also show that yield per recruit increases by decreasing the age at first capture.

The yield per recruit as a function of age at first capture (Fig. 8 d) with the present value of Z at 6.1 and different values of M shows that maximum yield per recruit can be obtained at t_c=0.5 if M is 2.6; at 0.6 if M is 2.3 or 2.4 and at 0.7 if M is 1.8. The observations, thus, suggest that the cod end mesh size has to be reduced because the present estimated value of t_c=0.87.

Paulik and Gales method: The curves of yield per recruit against F (Fig. 9) taking the present value of t_c at 0.76, corresponding to

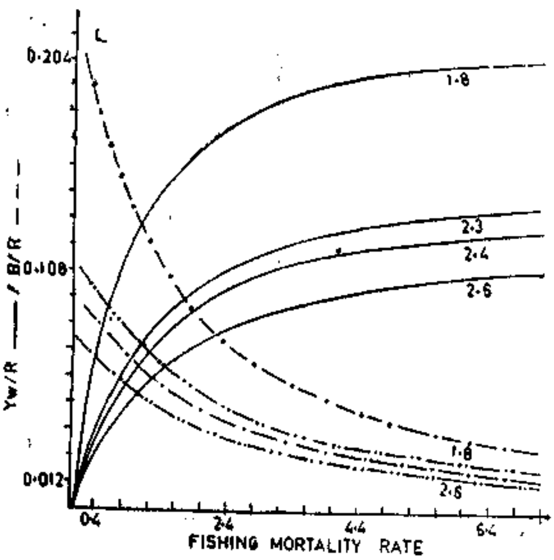

FIG. 9. Yield per recruit and Biomass per recruit as functions of fishing mortality in *S. insidiator* following Paulik and Gales method. (Numerals refer to M. values.)

the cube root of weight of fishes of the present L_c value of 80 mm, show trends comparable to those obtained by assuming isometric growth (Fig. 8 b) though the absolute values of yield per recruit are different.

ESTIMATION OF RECRUITMENT AND YIELD

Recruitment and yield were estimated taking YW/R values obtained by Paulik and Gales (1964) method.

At the present values of t_c and Z and taking different values of M the estimates of yield per recruit, biomass per recruit and recruitment were obtained (Table 7). The expected yield (Fig. 10) at different levels of fishing mortality with the present cod end mesh size

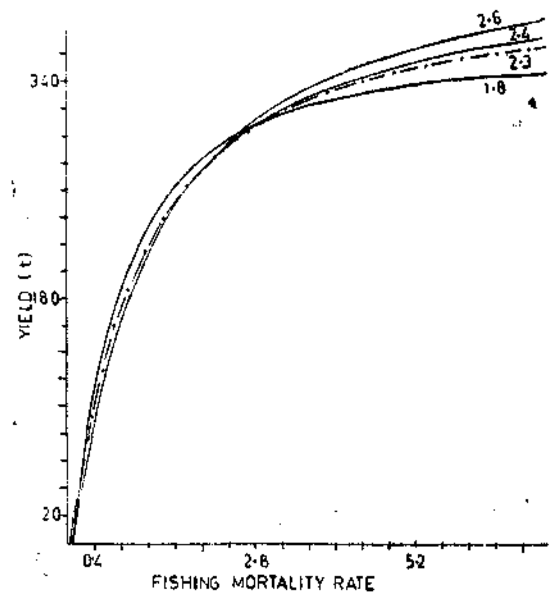

FIG. 10. Estimated yield of *S. insidiator* as a function of fishing mortality rate (Numerals refer to M values).

shows that the yield increases with increased F without reaching maximum, suggesting, that the yield can be increased by increasing the effort. Though it is possible to increase the yield by increasing the effort, the increased yield will not be remunerative because, for example, when M=2.6, a yield of 115% of the present can be obtained by expending an effort equivalent to 200% of the present (*i.e.*) only 15% increase in catch with 100% increase in effort (Fig. 11). On the other hand, if the effort is 97% of the present (*i.e.* if decreased by 3%) the yield will be 99% of the present (*i.e.* a decline of 1% only in the catch). For economic reasons, therefore, the effort should not be increased.

Discussion

The study on spawning shows that *S. insidiator* spawns throughout the year with a possible peak during January-March. Pillai (1972) examined the ova-diameter frequency

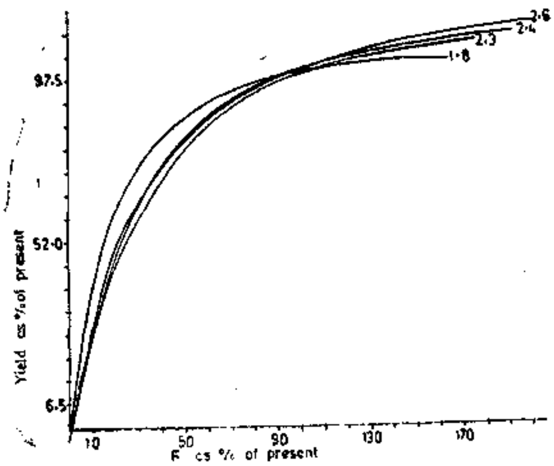

Fig. 11. Yield of *S. insidiator* as per cent of present against F which is also as per cent of present (Numerals refer to M values).

distribution from ovaries of mature adults of this species from Tuticorin during April-June 1970 and stated that the species spawns more than once in a year and that the spawning season is protracted. According to James and Badrudeen (1975), *Leiognathus brevirostris* spawns throughout the year in the Palk Bay and Gulf of Mannar near Mandapam with peaks during May-June and October-November. It was tentatively concluded that *L. dussumieri* in the sea off Mandapam spawns during April-May and November-December (James and Badrudeen, 1982) According to Murty (1983), *L. bindus* spawns almost throughout the year in the sea off Kakinada. Thus, the Indian silverbellies spawn round the year with one or two peaks.

Though the predominance of females in certain months and in the larger length groups may suggest a faster growth rate in females (Qasim, 1966), the growth rate in both the sexes may be taken as the same because : the departure in the sex ratio from 1 : 1 is restricted only to one or two months in different years (Table 1) and both sexes are represented in all length-groups (Table 3). It appears, therefore, that the estimated length at first maturity for females (90 mm) can be taken for the species as a whole. On the basis of the growth parameters, the age at first maturity for the species becomes 1.09 years.

The predominance of females above the length at first maturity suggests a possibility of greater natural mortality rate in males after attaining first maturity. Supporting evidence, however, is not available to corroborate this view.

The estimated values of parameters of growth in length of *S. insidiator* in the present study appear to be realistic when compared to those of other silverbelly species (Table 9) from different localities, except *L. equulus* which is the largest known silverbelly species (maximum recorded length from India 242 mm James, 1973) and *L. jonesi*. It appears that Venkataraman *et al.* (1982) underestimated the growth rate of *L. jonesi* because the values of *M* and *K* at 2.28 and 0.528 respectively lead to an *M*/*K* value of 4.3 which is very much beyond the range (1-2.5) known in fishes (Beverton and Holt, 1959); similarly in the case of *L. bindus* from Calicut the value of $L\infty$ obtained (122 mm, Pauly and David, 1981), appears to be an underestimate since the maximum known length of this species from India is 155 mm (CMFRI, 1977) and also since it is known that the fish 'will not grow' beyond $L\infty$ (Gulland, 1983).

An examination of values of Z estimated by different methods reveals that the value obtained by Pauly's method is the highest followed by Cumulative catch curve, Ssentongo-Larkin and Beverton-Holt methods (Table 6). According to Pauly (1983) the equation of Ssentongo and Larkin 'Produces estimates of Z which are higher than those obtained using equation' of Beverton and Holt, and Per Sparre (*in litt.* to Dr. Pauly, 1983) suggests that Ssentongo-Larkin equation is 'biassed upward'. There is, thus, an indication that the Beverton-Holt equation is *not* a biassed one. There is no indication in the literature whether the other two methods (Pauly's and Jones and van Zalinge's) are not biassed and presently it is not possible to explain the disparity between the Z values obtained; hence it was preferred to consider the average value.

Though the value of Z at 6.1, considered in the present work, appears to be very high, it could be a reasonable estimate because, the bulk of silverbellies (including *S. insidiator*) occur in shallow waters (Pauly, 1977) where intensive trawling takes place for prawns, thus resulting in high fishing mortality. Further, since the maximum length and life-span are observed to be small, mortality due to predation and other natural causes could also be very high, which too would have contributed to a greater Z.

Since the trawl fishery is a multispecies one, apportioning of fishing effort with reference to a particular species is not possible (Pauly, 1983) and apparently this resulted in the lack of good correlation between effort and Z. The M values obtained by different methods are close to each other except the one obtained by Sekharan's method (Table 7); the M/K value in all the four cases is within the known range in fishes. In this connection it is worthwhile to quote Cushing (1981): '.... a precise separation of fishing and natural mortality remains inaccessible, and yet is one of the central problems of fisheries research.'

TABLE : 9 *Parametres of von Bertalanffy growth formula of different species of silverbellies*

Species	Locality	Source	$L\infty$ mm	K per year	to year
S. insidiator	Kakinada	Present work	123.0	1.20	—0.01
L. bindus	Calicut	Pauly & David, 1981	122.0	1.30	—
L. jonesi	Mandapam	Venkataraman *et al.*, 1982	161.2	0.53	0.111
L. splendens	Philippines	Pauly, 1983	143.0	1.04	—
L. equulus	Madagascar	Pauly, 1983	212.0	1.75	—

The yield per recruit analysis at the three values of t_c against F (Fig. 8 a-c and 10) and the yield per recruit against t_c (Fig. 8 d) show that maximum yield can be obtained by increasing F greatly, but with a maximum to of 0.7 only, thus indicating that t_c has to be reduced from the present 0.87 (thus reduction in mesh size) and that F can be increased to get higher yield. Decreasing the mesh size results in increased production of smaller fishes. Since the adult size of the fish under study is itself a small one, the increase in yield so obtained will not be of consequence to the industry. Further, the present age at first capture is close to the age at first maturity and it is not desirable to have the age first capture less than the age at first maturity, as otherwise the fishery takes away prospective spawners and increased effort in such a situation can result in the collapse of the fishery due to recruitment overfishing (Ursin, 1984) at certain higher effort level. Since at higher values of t_c also, the yield did not show a fall with increase in *F*, it is desirable to have the current t_c retained, if not increased a little, to avoid possible fall in the stock size and to get increased yield of *S. insidiator* by increasing the effort. The analysis has also shown that though theoretically it is possible to increase yield by increasing effort increased effort will not be remunerative (Fig. 11).

Since the trawl fishery is a multispecies one, regulation of effort including mesh regulation has to take into account other species taken by the fishery, as otherwise any change in the number of units or mesh size is likely to result in the loss of a particular resource for the fishery or in overexploitation of another resource. Still, such a study as the present one on the yield of any one component species is not an exercise in futility, for it must be stressed, in addition to enabling an understanding of the state of a particular single species resource in a multispecies fishery, such studies when conducted an all or most of the dominant species, will help in arriving at more meaningful decisions for the management of a multispecies fishery.

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