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POPULATION DYNAMICS OF OTOLITHES CUVIERI (TREWAVAS) OFF BOMBAY WATERS

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ABSTRACT

Studies on the age and growth and population dynamics of *Otolithes cuvieri* (Trewavas) based on the data collected for a period of six years from 1979-80 to 1984-85 off Bombay waters are reported here. This species attains 170 mm, 260 mm and 318 mm at the end of first, second and third years of its life respectively. The von Bertalanffy's growth parameters estimated were as follows: $L\infty = 395$ mm, $K = 0.5331$ (annual), $to = 0.06246$ years. Using the length-weight relationship formula $W\infty$ was calculated as 615 gms. Instantaneous rates of total, natural and fishing mortality were estimated as $Z = 2.64$, $M = 1.30$ and $F = 1.34$. Exploitation ratio (E) and the exploitation rate (U) were found to be 0.50 and 0.47 respectively.

The annual average yield at the present rate of exploitation is 763.815 tonnes as compared to the total stock of 1619.66 tonnes and standing stock of 570.264 tonnes. The MSY was estimated as 788.13 tonnes. The investigation undertaken indicates that the stock of *O. cuvieri* is optimally exploited. Thus any further increase in the efforts would be detrimental to the fishery of this species.

INTRODUCTION

Sciaenids are the chief constituents of the trawl catch at Bombay contributing about 7% of the total trawl catch. Though it is a multispecies fishery, *O. cuvieri* contributes about 35% of the total sciaenids. Estimation of age and growth of Indian Sciaenids have been done on *Pseudosciaena diacanthus* by Rao [1961, 1971 a and 1971b] and Rao [1971]. *Otolithus brunneus* by Kutty [1961] and Jayaprakash [1978] and *Johnieops vogleri* by Muthiah [1982] from the west coast of India and on *Pseudosciaena coibor* by Rajan [1964] and *Johnius (Johnius) carutta* by Murty [1986] from the east coast of India.

The present investigation deals with the estimation of von Bertalanffy's growth parameters, mortality, and yield per recruit of *Otolithes cuvieri* based on the data collected from the year 1979-80 to 1984-85 at New Ferry Wharf Jetty, one of the major landing centres of Greater Bombay.

MATERIAL AND METHODS

Catch and effort data of commercial trawlers were collected from New Ferry Wharf landing centre of Greater Bombay by the field staff. Weekly observation was taken for length and species composition. The estimated numbers in each length group were raised to day's catch and subsequently to month's catch. Length data were grouped into 5 mm class intervals for growth study. Scatter diagram technique of Devaraj [1902a] has been employed for the present study. The modal lengths in the frequency data were first plotted in the form of a scatter diagram against the co-ordinates of length starting from zero upwards on the ordinates and the time in months on the abscissa. The trend of progression of modes through time was then indicated by the eye fitted line. The fitted line was extrapolated free-hand with reference to the intermodal slopes so as to intersect it on the time axis indicating thus the time of brood origin, the number of broods per year class and also the growth of each brood. Growth was expressed by employing von Bertalanffy's [1938] growth equation.

$$L_t = L\infty [1-e^{-k[t-t_0]}]$$

$L\infty$ and K were estimated by using Ford-Walford plot of $L_t + 1$ against L_t given by

$$L_t + 1 = L\infty [1-e^{-k}] + e^{-k} L_t$$

and t_o was calculated by using the following expression

$$-\text{Loge}\left[\frac{L\infty - L_t}{L\infty}\right] = -Kt_o + kt$$

Length-weight relationship was fitted using the well known formula-

$W = a.L^b$ or $\text{Log } w = \text{Log } a + b\ [\text{Log } L]$

Instantaneous rate of total mortality [Z] was estimated by [a] Length converted catch curve method of Pauly [1982] by using the relation-

$$\text{Log } e[N/\Delta t] = a + b.t$$

where Δ 't' is the time taken to grow from lower limit to upper limit in each length class, 'N' is the numbers caught in each length group, 'a' is the y-axis intercept and 'b' = Z with the sign changed and 't' is the mid-point in each length group. Here only the descending right limp is taken for the estimation of 'Z'.

[b] Alagaraja's [1984] method by the equation given as-

$$\log\,[Nt + \Delta t/Nt] = \frac{Z}{K} = \text{loge}\left\{\frac{L\infty - L_t + \Delta t}{L\infty - L_t}\right\}$$

Where L_t and $L_t + \Delta t$ are successive mid values of each length class whose frequencies are Nt and $N_t + \Delta t$. It was considered that 'Z' is constant for the entire size range of the catches in numbers at successive age, Ct and Ct Δt are proportional to N_t and $N_t + \Delta t$.

[c] Beverton and Holt's [1956] formula

$$\frac{Z}{K} = \frac{[L\infty - \bar{L}]}{\bar{L} - Lc}$$

Where $L\infty$ and K are the parameters of von Bertalanffy's growth equation, L is the mean length in the range Lc to $L\infty$. Natural mortality coefficient 'M' was estimated by Cushing's [1968] formula using the expression

$$Z = M = \frac{1}{t_{max} - t} = \text{Log } e\,\frac{No}{N_t\,max.}$$

Where N_t is the number of one year old fishes and N_{tmax} the numbers at maximum age in a fish population. The second method employed for the estimation of 'M' was that of Pauly [1980 b] given as-

$$\text{Log}_{10}\,M = 0.0066 - 0.279\,\text{Log}_{10}\,L\infty + 0.6543\,\text{Log}_{10}\,K + 0.4634\,\text{Log}_{10}\,T$$

where $L\infty$ is in cm, K is annual and T is in temperature in °C. Here T of 28.2°C was taken from Bapat *et al.* [1982]. The rate of exploitation [U] and the exploitation ratio [E] for different years were estimated.

The yield in weight per recruit was estimated by using dynamic pool model of Beverton and Holt [1957].

Maximum sustainable yield [MSY] was calculated by using Corten's [1974] method given as

$$Y_1 = \frac{X_2 - Y_1}{X_1}$$

where X_1 is the Yw/R in gm at present value of F and Y_1 is the corresponding yield in tonnes and X_2 is the Yw/R in gm at F_{max}.

MSY was also estimated by using Gulland's [1979] formula given as

Py = Zt X0.5 XBt in the usual notation.

Potential yield per recruit and optimum age of exploitation was estimated by the equation developed by Krishnan Kutty and Qasim [1968].

RESULTS

Age and Growth: This is based on the data collected for a period of five years from 1980-81 to 1984-85 at New Ferry Wharf landing centre. Since smaller fishes were not represented in the trawl catch samples were also collected from 'dol' netters from 1981-83 in order to supplement the data [Fig. 1]. The smallest fish obtained from trawl and dol net were 95 mm and 26 mm respectively. The K, $L\infty$ and t_o were estimated as 0.5331 [annual], 395 mm and - 0.06246 years. Plotting of $L_t + 1$ against L_t Ford [1933] and Walford [1946] gave a linear relationship [Fig.2]. This fish attains 170 mm, 260 mm and 318 mm at the end of its first, second and third year of it life. The actual

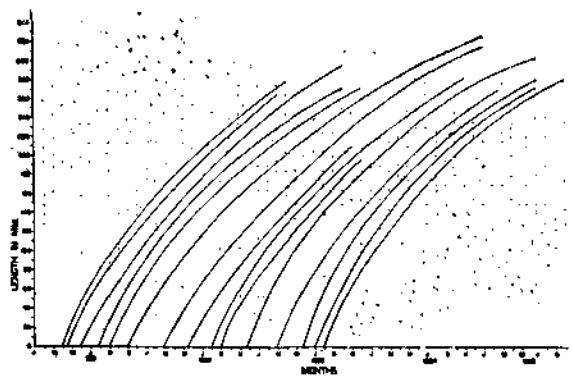

Fig: 1 Scatter diagram of modal length for *O. cuvieri*

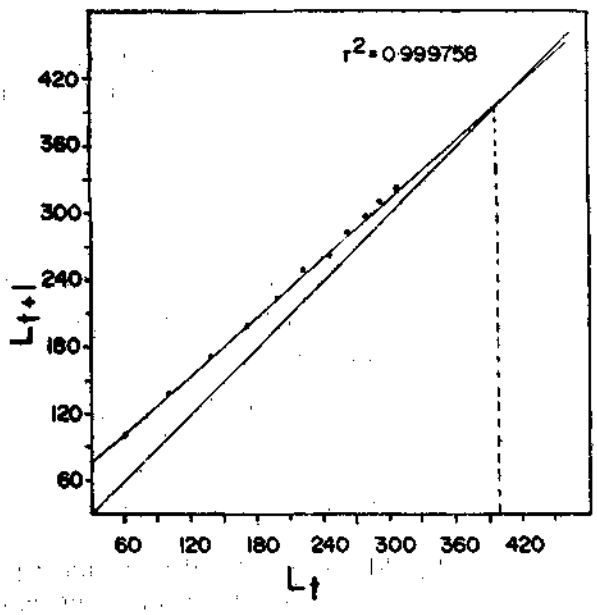

Fig: 2 Ford-Walford plot of Lt against Lt+1

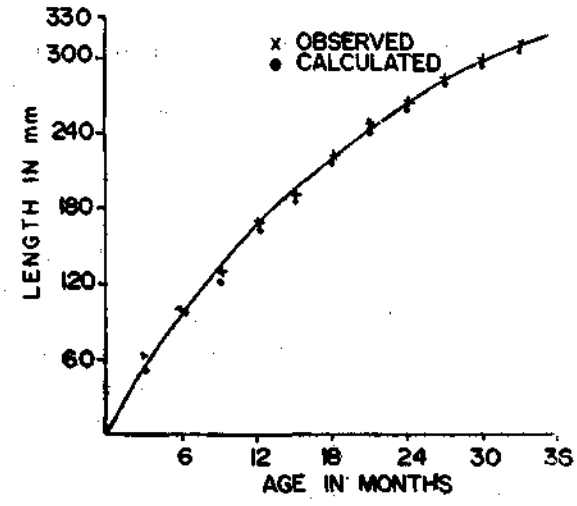

Fig: 3 Calculated and observed length at age t

growth obtained by modal progression and the calculated growth obtained by VBGF is given in Fig. 3.

Length-weight relationship: Individual length and weight of 336 males 326 females were analysed separately for both the sexes. The formula obtained thus is-

Males Log W = -5.237499 + 3.0831 Log L

Females Log W= -4.7195719+3.0341 Log L

The differences between the regression coefficients of sexes were tested for its significance by analysis of covariance following Snedecor and Cochran [1967]. The difference was found to be not significant at 5% level. Hence the data of both the sexes were pooled together and a common formula was obtained for the calculation of W ∞.

Log W ∞ = 5.3311 X L ∞ x 3.127248
giving W ∞ of 615 gms.
[r^2 = 0.966 and S. E. = 0.0623]

Mortality Estimates: Estimation of total mortality coefficient [Z] by three methods and their average is given in table 1. The Z estimated by length converted catch curve [Fig. 4] and Beverton and Holt's methods was slightly higher as compared to Alagaraja's method. Average estimate of Z = 2.64 obtained by these three methods was taken into consideration for further calculations.

Fishing mortality coefficient was obtained by substracting M from Z given as-

F = 2.64 - 1.30 = 1.34

Total stock and Standing stock: Year-wise annual yield in tonnes, F, M, Z, E, total stock (Y/U) and standing stock (Y/F) are given in table 2. The average yield during this period was 762.815 tonnes as compared to total and standing stocks of 1619.56 tonnes and 569.264 tonnes respectively.

Yield per recruit studies: By using the length-weight relationship W∞ of 615 gms was estimated at L_∞ of 395 mm. The length of the smallest fish observed in the trawl catch was 95 mm and its age was estimated as 0.5 years. This was taken as age at first recruitment [tr]. Average of the annual length, length

TABLE 1

Estimation of Z by three methods and their averages

Year	Alagaraja's method	Length converted catch curve Method	Beverton and Holt's method	
1979-80	1.53	2.15	2.16	1.94
1980-81	1.20	3.17	2.25	2.20
1981-82	1.32	2.37	1.73	1.80
1982-83	2.71	3.22	3.15	3.02
1983-84	3.60	4.11	2.98	3.56
1984-85	2.59	3.11	4.26	3.32
	2.15	3.02	2.75	2.64

TABLE 2

Year-wise details of annual yield, fishing mortality, exploitation ratio, exploitation rate, total and standing stock

Year	Catch in tonnes	F	M	Z	E	U	Y/U	Y/F
1979-80	729.637	0.64	1.30	1.94	0.329	0.282	2587 365	1140.057
1980-81	1047.603	0.90	1.30	2.20	0.409	0.363	2885.958	1164.003
1981-82	709.718	0.50	1.30	1.80	0.277	0.231	3072.37	1419.436
1782-83	474.86	1.72	1.30	3.02	0.569	0.541	877.74	276.081
1983-84	870.403	2.26	1.30	3.56	0.634	0.161	1411.388	385.134
1984-85	744.665	2.02	1.30	3.32	0.608	0.638	1167.186	368.646
Average	762.815	1.34	1 30	2.64	0.507	0.471	1616.56	569.264

'E' and 'U' have been estimated from 'F' and 'Z' in average column.

TABLE 3

Estimation of MSY by Corten and Gulland's method

Year	Z	Yield in tonnes	MSY by Gulland's Method (in tonnes)	Yw/R at Present F	Yw/R at Fmax	MSY by Corten's Method (in tonnes)
1979-80	1.94	729 637	1105.856	17.9721	24,0832	976.6505
1980-81	2.20	1047.603	1280.403	21.2989	24.0832	1184.55
1981-82	1.80	709.718	1277.492	17.9821	24.0832	950.516
1982-83	3.02	474.86	416.882	23.9045	24.0831	478.405
1983-84	3.56	870.473	685.593	24.0415	24.0832	871.982
1984 85	3.32	744.665	0611.952	24.0618	24.0832	745.327
Average	2.64	762.815	*751.429	*23 3096	*24.0832	*788.131

Not averages

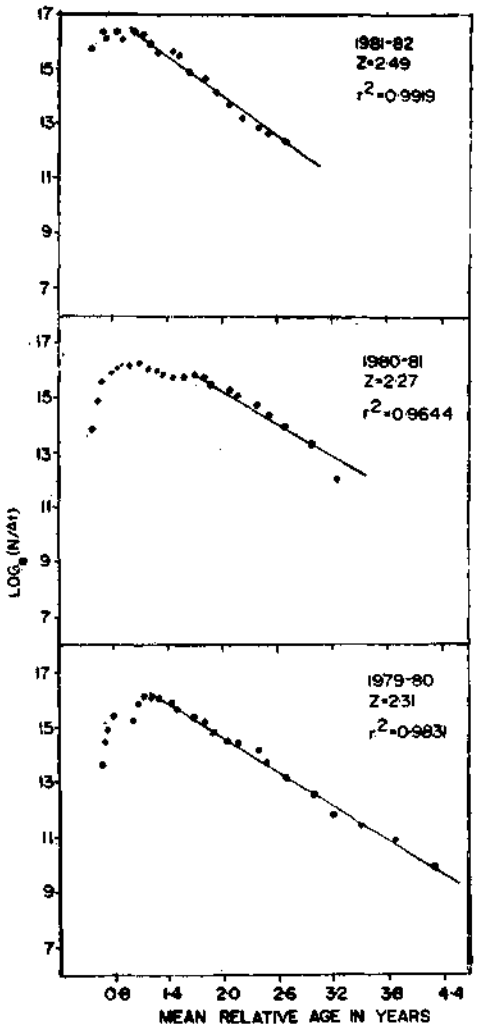

Fig: 4 Estimation of Z by length converted catch curve method

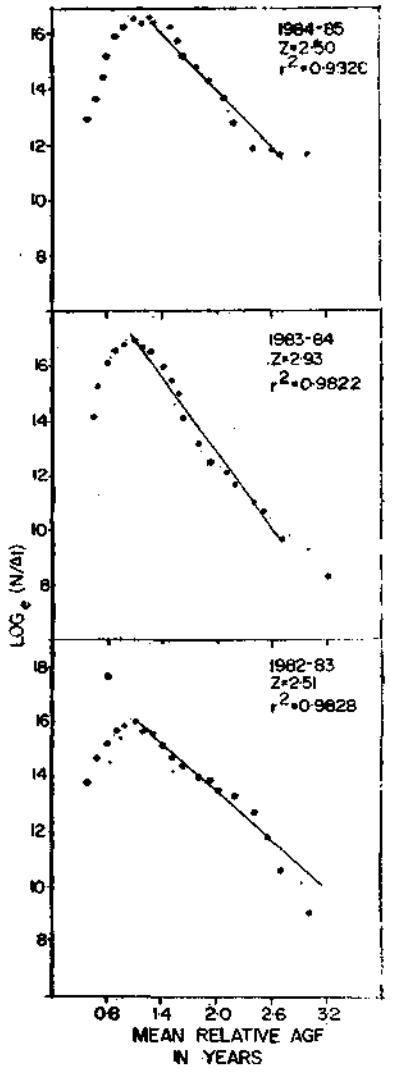

Fig 5 Yield curve of O. cuvieri at different values of F

frequency distribution of six year period showed the smallest mode at 149 mm. This was taken as the length at first capture [tc] the corresponding age being 0.8 years.

The yield curve (Fig.5) shows that Yw/R at the present F of 1.34 is 23.30944 gms as compared to Yw/R of 24. 0832 gms at Fmax of 1.95 gms.

The yield isopleth diagram depicting the isolines of yield for varying levels of tc on the t_c on the y-axis and E on the x axis was prepared from the yield table [Fig 6]. Both eumertric fishing curve (BB') and MSY curve AA' converge at a point on the yield isolpeth diagram vertically above F∞ giving potential yield per recruit of 27.4725 gms.

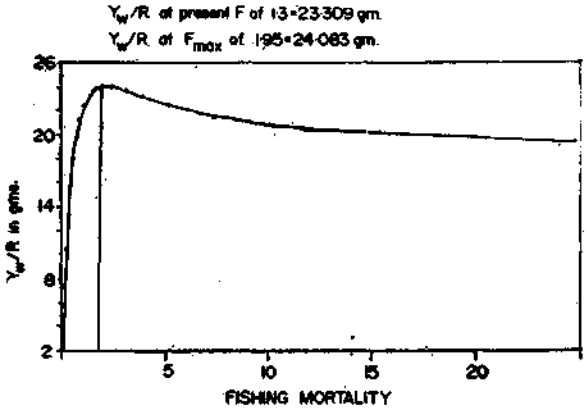

Fig: 6 Yield isopleth diagram of *O. cuvieri*

Following the formula developed by Kutty and Qasim [1968] the potential yield per recruit of 28.1384 gms was estimated at optimum age of exploitation of 1.4856 years.

Average MSY obtained for this six year period by Corten's [1974] and Gulland's (1979) method was 788.131 and 751.42 tonnes respectively.

DISCUSSION

Gulati [1987] estimated the first and second year growth of *O. cuvieri* as 183 mm and 282 mm respectively, which are higher, to those estimated in the present study. The growth parameters estimated by him were $L\infty = 330.66$ mm, $K = 0.93034$ [annual] and $t_o = -0.00269$ years. $L\infty$ of 395 mm estimated in the present study is close to the largest size of 359 mm observed in nature.

'Z' estimated by Gulati for the year 1972-73 and 1983-84 by Jackson's method was 1.45 and 1.64 while the 'M' estimated by him was 1.45 and 1.64 respectively. In the present investigation 'M' of 1.30 and 1.1 was estimated by Cushing's and Pauly's method respectively.

Stock assessment studies undertaken by Gulati are based on the data of 1983-84 and the total and standing stock of 56,294 tonnes and 27,572 tonnes was estimated by him as compared to 1619.56 tonnes and 569.284 tonnes in the present investigation for a six year period from 1979-80to 1984-85. The vast difference is due to the fact that Gulati has estimated the total and standing stock of whole of Maharashtra state based on his observation at New Ferry Wharf Moreover, 'F' is 0.19 for the year 1983-84.

From the present study it is seen that the average annual yield of *O. cuvieri* during this period is 762.81 tonnes as compared to the total stock of 1619.56 tonnes and standing stock of 569.26 tonnes. The yield per recruit curve shows that Yw/R in gms is at 23.30944 gms at the present level of $F = 1.34$, $t_c = 0.8$ and E of 0.507. It can be increased to 24.0832 gms at $F = 1.95$ gms and $E = 0.60$. The catch may increase beyond $E = 0.60$ with further increase in fishing efforts though the same may not be economical. Moreover, from the biological point of view it would be detrimental to the fishery leading to its virtual collapse.

Gulland [1971] has stated that optimum exploitation ratio [E] gives a rough idea if a stock is overfished or not on the assumption that the optimum value of E [E opt] is about or equal to 0.5. The present E of *O. cuvieri* is 0.507 which indicates that the stock of this species is optimally exploited and any further increase in the fishing effort may be harmful for the general health of the stock.

It can thus be concluded that the stock of *O. cuvieri* is at present being optimally exploited and at the present E there is no threat for the depletion of stock.

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REEERENCES

ALAGARAJA, K. 1984. Simple methods for estimation of parameters for assessing exploited fish stocks. *Indian J. Fish.* 31 [2] : 177-208.

BAPAT, S. V., V. M. DESHMUKH, B. KRISHNAMOORTHI, C. MUTHIAH, P. V. KAGWADE, C. P. RAMAMIRTHAM, K. J. MATHEW, S. KRISHNA PILLAI AND C. MUKUNDAN, 1982. Fishery resources of the exclusive economic zone of north-west coast of India. *Bull. Cent. Mar. Fish. Res. Inst.* 33 : 85 p.

BERTALANFFY, L. VON. 1938- A quantitative theory of organic growth. *Hum. Biol.* 10 : 181-213.

BEVERTON, R. J. H. AND S. J HOLT, 1956- A review of methods for estimating mortality rates of exploited fish populations with reference to source of bias in catch sampling. *Rapp. P. V. Reun. CIEM,* 140 : 67-83.

BEVERTON, R. J. H. AND S. J. HOLT. 1957- On the dynamics of exploited fish populations. *Fish. Invest. Minist. Agri. Food G. B. (2 Sea Fish)*, 19 : 533 p.

CORTEN, A. 1974. Recent changes in the stock of Celtic Sea herring *(Clupea herrungus L.) J. Cons. Perm. int. Explor. Mer.* 35 : 194-201.

CUSHING, D. H. 1968. *Fisheries biology - A study of population dynamics.* Univ. Wiscons Press, Madison, Wis. 200 p.

DEVARAJ, M. 1982 a. Age and growth of three species of seer fishes *Scomberomorus commerson, S.guttatus* and *S. Ineoletus. Indian J. Fish.;* 28 [1 and 2] 1981 : 104-127.

FORD, E. 1933. An account of herring investigattons conducted at Plymouth during the years 1924-1933. *J. Mar· Biol. Ass. U. K.* 19 : 305-384.

GULLAND, J. A. 1971. *The fish resources of the oceans.* West Byfleet, Surrey News (Books), Ltd., for FAO 255 p.

GULLAND, J. A. 1979. Report of the FAO/IOP workshop on the fishery resources of the Western Indian Ocean South of the Equator. *Rome, FAO, IOPC/DEVI79/45*: 1-37.

GULATI, DEEPAK, K. 1987. Morphometry, biology and stock assessment of *Otolithes cuvieri* [Trewavas, 1974] off Bombay coast. M. Sc. Thesis, University of Bombay.

JAYAPRAKASH, A. A. 1978. Age and growth of juveniles of 'Koth' *Otolithoides brunneus* [Day] in the Bombay waters. *Indian J. Eish,* 23 : 86-96.

KUTTY, M. K. AND S. Z. QASIM. 1968. The estimation of optimum age of exploitation and potential yield in fish populations. *J. Cons. perm. inst. Explor. Mer.,* 32 [2] : 249-255.

KUTTY, M. N. 1961. Scales and Otoliths of 'Koth' *Otolithoides brunneus* as age indicator. *Indian J. Fish.,* 8 : 145-151.

MURTY, V. SHRIRAMACHANDRA 1986. Growth and yield per recruit of *Johnius* [*Johnius*] carutta [Bloch] in the trawling grounds off Kakinada. *Indian J. Fish.,* 33 (2) : 163-170.

MUTHIAH, C. 1982. Study on the biology of *Johnieops vogleri* [Bleeker) of Bombay waters. *Indian J. Fish.,* 29[1-2] : 118-133.

PAULY, D. 1980 b On the linear relationship between natural mortality, growth parameters and mean environmental temperature of 175 fish stocks. *J. Cons. CIEM,* 39 [2] : 175-192.

PAULY, D. 1982. Studying single species dynamics in tropical multispecies context pp 33-70. In Pauly, D. and G. I. Murphy [Eds.) *Theory and Manegement of tropical fisheries* ICLARM conference Proc. 9, 360 pp ICLARM, Manila, Philipines and CSIRO, Cronulla, Asutralia.

RAJAN, S 1964. The biology and fishery of *Pseudosciaena coibor* [Hamilton] from Chilka lake. *Indian J. Fish.,* 11]1] : 659-662.

RAO, K. S. 1971. Studies on the scales of *Pseudosciaena diacanthus* [Lacepede] for estimating growth parameters. *Indian J Fish.,* 15 : 127-144.

RAO , K. V. S. 1961. Studies on the age determination of 'Ghol' *Pseudosciaena diacanthus* [Lacepede] by means of scales and *Otoliths. Indian J. Fish.,* 8 : 121-125.

RAO, K. V. S 1971 a. Age and growth of 'Ghol' *Pseudosciaena diacanthus* Lacepede in Bombay and Saurashtra waters. *Indian J. Fish.,* 13 : 251-292.

RAO, K. V. S. 1971. b- Estimates of mortality and yield per recruit of 'Ghol' *Pseudosciaena diacanthus* [Lacepede] *Indian J. Fish.,* 15 : 88-98.

SNEDECOR, G. W. AND W.G. COCHRAN, 1967. *Statistical Methods.* Sixth Edition. Oxford and IBH Publishing Co., New Delhi, 533 p.

WALFORD, L. A. 1946. A new graphic method of describing growth of animals. *Biol. Bull.* 90 [2] : 141-147.