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Biology and exploitation of *Trichiurus lepturus* Linnaeus from Visakhapatnam waters

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ABSTRACT

Length-weight relationship, relative condition factor, growth, maturity, mortality, exploitation, fishery, food and feeding and sex ratio of *Trichiurus lepturus* from Visakhapatnam were studied. Length-weight relationship obtained for male and female was, male : $W = 0.000273\ L^{3245862}$ (r=0.9961) and female : $W = 0.000223\ L^{3298627}$ (r = 0.9950). Growth parameters estimated for von Bertalanffy's growth function were, L_M = 106.8251 cm, K = 0.6117 per year and t_o = -0.1399 years. The fish attained maturity at 42.5 cm and has a longevity of 4.9 years. The total mortality and fishing mortality were estimated as 2.4170 and 1.5236 respectively. The exploitation ratio, E = 0.6304 and exploitation rate, U = 0.5741, indicated overexploited state of the stock. The seasonal abundance in major gears and the annual abundance in the small trawler landings during the decade 1982-'91 are also presented. Growth performance index, PHI[1] (ϕ') for this species was calculated based on five sets of parameters given by different authors and a mean ϕ' value was arrived at. The fish was found to be a voracious carnivore, often exhibiting cannibalism. Incidence of differential fishing noticed in this case is briefly discussed.

Introduction

The total landings of ribbonfish in the country stood at 1,11,000 tonnes in 1992 which constituted 4.8% of the total marine fish production and 9.3% of the pelagic resources exploited during that year (Anon., 1994). Northwest region (63.2 %) and southeast region (19.5 %) together accounted for the bulk of the ribbonfish landings in India.

Trichiurus lepturus form the major component of the ribbonfish catches along Visakhapatnam coast while *T. russelli, Lepturacanthus savala, L. gangeticus, Eupleurogrammus muticus* and *E. glossodon* occur occasionally.

Studies on the biology, age and growth of *T. lepturus* from the Indian waters were made by Prabhu (1950, 1955); Tampi *et at.* (1971); Narasimham (1970, 1972, 1976) and James *et al.* (1983). Investigations on the population parameters, mortality and exploitation of this species were carried out by Narasimham (1983) from Kakinada waters, Somvanshi and Antony (1989) from northwest coast of India and Chakraborty (1990) from Mumbai waters. Results of a study on the length-weight relation, condition factor, sex ratio, maturity and spawning, food and

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feeding, growth, mortality and exploitation of *T. lepturus* from Visakhapatnam waters are presented in this paper.

Material and methods

Samples collected from private small trawlers at Visakhapatnam Fisheries Harbour during 1989-'92 (5,976 specimens) were used for this study. Data on catch and effort were collected by the field staff. Length (cm) and weight (g) measurements of 363 males ranging from 32 to 81 cm, and 406 females ranging from 29 to 101 cm were used for estimating the length-weight relationship with the formula : $W = aL^b$ by logarithmic transformation. ANCOVA on the linearised length-weight regression equations for males and females, t test on regression and correlation coefficients and Chi square test on sex ratios were carried out as per the standard procedures (Snedecor, 1961). Relative condition factor, K_n (Le Cren, 1951) for different body lengths as well as for different months was calculated for males and females using the formula : $K_n = W/W$ wjiere W is the observed weight and W, the expected weight obtained from length-weight relationship. Size at first maturity was arrived by plotting the percentage of mature specimens (stages IV and above) against total length as given in Thomas (1969). The length at age data obtained by modal progression analysis were used in determining the parameters for von Bertalanffy's growth function (VBGF), i.e., $L_{\_}$, K and t_o. The plot of L_{t+1} against L_t (Ford-Walford Plot) was used to estimate L_M and K as detailed in Pauly (1983), while t_o was estimated by plotting - In (1-L/LJ against t (Sparre *et al.,* 1989). Longevity was estimated using the formula $t_{mnx} = 3/K$ (Pauly, 1983). Pauly and Munro's (1984) length growth performance index PHI' (()) was computed from:

$$()^1 = \log K + 2 \log L,$$

where K and L^ are von Bertalanffy's growth parameters. The ⊀ values for the same species based on the parameters given by different authors were calculated, compared and an average value was arrived at. Age-at-lengths was calculated by the formula:

$$t = -(1/K)\ \text{In}\ (1-(L/LJ) + t_o$$

and was used to estimate mean relative age. In (N/At), values were plotted against relative age and slope of the resulting catch curve (with sign changed) and was taken as estimate of total mortality, Z. Value of Z was also computed from the mean size of the catch as per Beverton and Holt (1956):

where L' is the smallest size of the fish fully represented in the catch while L is the mean length of the catch. Natural mortality M was estimated by Pauly's empirical formula: Log M = -0.0066 - 0.276 log L + 0.6543 log K + 0.4634 log T.

Taking T as 27°C, exploitation ratio (E) and Exploitation rate (U) were computed using the formulae: E = F/Z (assuming F=Z-M) and $U = F/Z\ (1-e^z)$.

A qualitative assessment of food was made by examining the guts of 2,586 specimens. The number of specimens of either sex, for adults and pre-adults, were separately tabulated against each month for the purpose of Chi square test on sex ratio.

Results and discussion

Annual catch and abundance : At Visakhapatnam, over 421 tonnes of

ribbonfish are landed annually together by shrimp trawl (90.41 %) and boat seine (9.59 %). Landings of ribbonfish by gill nets and shore seine are negligible. The catch and effort data of shrimp trawl (Fig. 1 a,b) for the 10 year period 1982-'91 show a decreasing trend in catch and catch rates over the years, i. tonnes e., from the highest catch of 658.5 in 1983 to the lowest of 187.7 t in 1990 and the highest catch rate of 2.53 kg/hr in 1983 to the lowest catch rate of 0.59 kg/hr in 1992. The available data on boat seine landings for 1990-'91 and 1991-'92, on the other hand, show that the catch has improved from 31.6 t in 1990-'91 to 49.24 t in 1991-'92, an increase by 55.67 %.

The catch of ribbonfish in shrimp trawl is generally better during July - November with a peak catch rate of 3.59 kg/hr in September (Fig. 1 b). In the case of boat seine, the catch is better during August-December with a peak catch rate of 22.3 kg/unit in October. However, a major peak of 50 kg/unit was observed in March (Fig. 2 a).

The area of operation of both boat seine and trawl net is more or less the

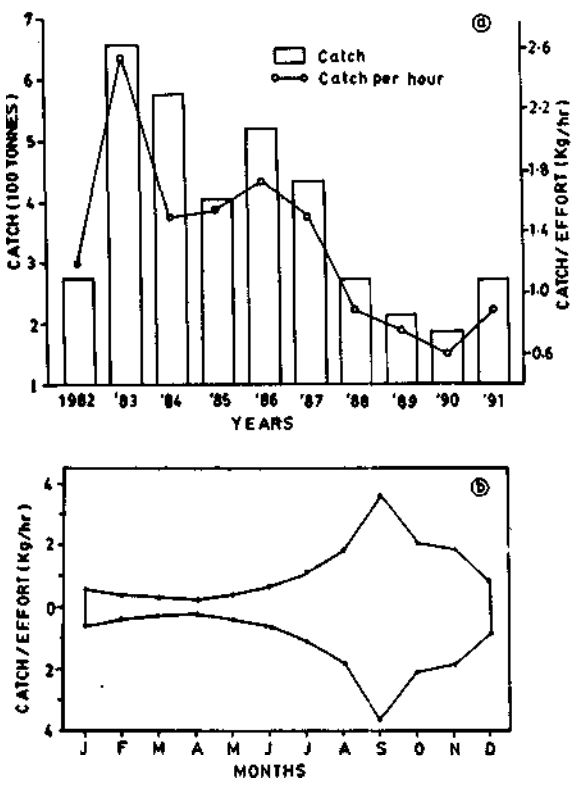

Fig. 1. (a) Annual catch and abundance and (b) Seasonal abundance of *T. lepturus* in the small trawler landings at Visakhapatnam during the period 1982-'91.

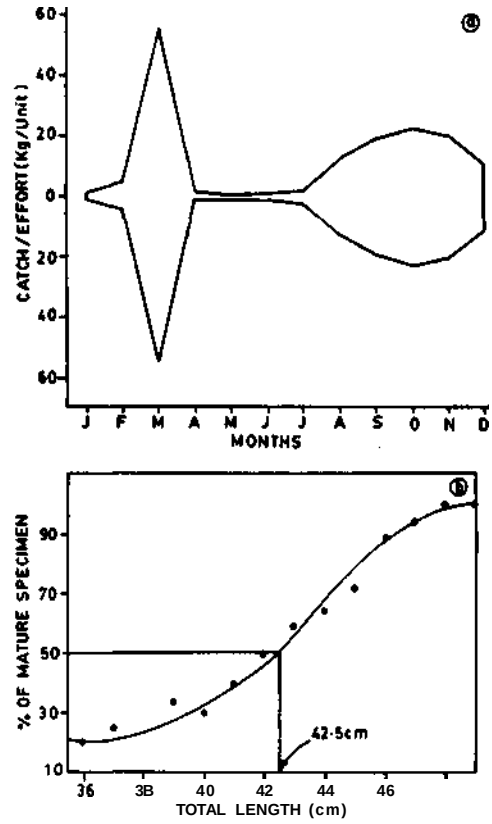

Fig. 2. (a) Seasonal abundance of *T. lepturus* in boat seine landings at Visakhapatnam and (b) size at maturity of *T. lepturus* from Visakhapatnam waters.

same. However, while the trawl net is dragged along the bottom, the boat seine is operated in the column water. The abundance of ribbonfish during July-December period in both the gear could be taken as an indication of the availability of the group of fishes both at the bottom as well as column waters in the ground.

However, the abundance of ribbonfish in boat seine during March can be explained only in the context of coastal upwelling which is reported to occur off Visakhapatnam during March-May (La Fond, 1954; Narasimha Rao *et al.,* 1986 Vijayakumaran *et al.,* 1996). Unpublished data collected by one of the authors (K. Vijayakumaran) indicate that during 1990-'92, the period for which data from boat seine are available, peak upwelling occurred during March-April. It could be presumed that during intense upwelling, when the deeper cold water moves shorewards, the ribbonfish moves into the upper column, thereby becoming vulnerable to boat seine, rather than in the trawl net.

Food and feeding

A qualitative analysis of the food of *T. lepturus* indicated that the fish is a voracious carnivore with a strong cannibalistic tendency. The food items consisted mainly of finfishes and prawns. The items identified include *Acetes* spp. ribbonfish, *Stolephorus* spp., *Sardinella* spp. *Loligo* spp., *Harpodon nehereus, Upeneus* spp., *Fistularia* spp., *Saurida* spp. and prawns. Among these items, prawns, *Acetes* spp. and ribbonfish were encountered along with digested fish remains during most of the months. This finding is in agreement with those of earlier workers (Prabhu, 1955; Srinivasa Rao, 1967; Narasimham, 1972; James *et al.,* 1983). Specimens with empty guts outnumbered those with food in the gut during all months except December. April-June and December were noticed to be comparatively good feeding months.

Sex ratio, maturity and spawning

Chi square test on sex ratio for different months showed that adult males were significantly more (5 %) during March-May. But during August - November, females were dominant in the catch. Among the pre-adults, females outnumbered males in general and significantly (5 %) during April-May and July-September periods. Though the differences in sex ratios indicate a differential fishing due to the changes in the pattern of migration of sexes to and from the fishing grounds, the actual pattern of the spawning migration with regard to the spatial and temporal aspects and its effect on the fishery can be understood only by further studies. A significant dominance of females over males was observed in most of the months by James *et al.* (1983).

The size at which 50 % of the fish attain maturity for *T. lepturus* was estimated to be 42.5 cm (Fig. 2 b). This size is attained by the fish in nine months. The size at which 100 % of the fish mature was estimated as 48 cm which the fish attains in 11 months. Prabhu (1955) and Narasimham (unpublished) estimated the size at maturity as 51 and 52.5 cm respectively. These values are little higher than the present value. However, James *et al.* (1983) found it to be 43.1 cm, which is much closer to the present value.

Although gravid and running specimens are rarely met with, partially spent fish were observed from February

to July in the fishery. Fully spent and resting fish were observed in the fishery in almost all the months except February, March and May. During October-December period resting fish were predominant. The abundance of pre-adults was pronounced during August-September. Based on the temporal distribution of maturity stages as well as young fish, it could be deduced that *T. lepturus* spawns from January to September with peak activity during February to June. Narasimham (1972) also reported from Kakinada that this species spawns from January to September with a peak during February-June.

The examination of size frequencies of ova in fishes of different stages of maturity showed the progression of only one major batch of ova developing from immature to mature stages. The occurrence of different spent stages in the fishery with the same sized dominant ova indicates that mature ova are not released at one time but in spurts over a period. James and Baragi (1990) stated that two major lots of ova mature and succeed one another, each lot being released at least in three batches.

The near absence of spawning fish in the commercial catches and the scarcity of eggs and larvae in the routine plankton collections led the earlier workers (Narasimham, 1972, Prabhu, 1950 and James *et ah,* 1986) to presume that *T. lepturus* moves away from the usual fishing grounds for breeding. The presence of specimens in various degrees of partial spawning in the fishery during breeding season could be an indication that the fishing ground is not far away from the breeding ground. Narasimham (1972) from Kakinada suggested the breeding ground of this species to be in offshore waters beyond 30 m depth. In the light of the above statement one must expect a certain degree of overlap between the breeding and fishing grounds since the mechanised trawlers operate even upto 70 m depth with a usual range between 20 and 50 m depth.

Length-weight relationship

Length-weight relationship for male and female *T. lepturus* was obtained as:

Male : $W = 0.00273\ L^{3245862}$ ($r = 0.9961$)

Female : $W = 0.000223\ L^{3*98627}$ ($r = 0.9950$)

ANCOVA (Table 1) showed that the two regression lines have significantly (5 %) different slopes but elevations were not significantly (5 %) different. The t test on correlation coefficients through Z conversion showed the r values representing a common population correlation. The regression coefficients for both male and female showed significant departure (5 %) from the isometric value three. Narasimham (1972), investigating from Kakinada, which is adjacent to Visakhapatnam coast, has also found the exponent to be significantly different from three.

Relative condition

The relative condition of males and females (Fig. 3 a and b) showed more or less the same trend during different months." The relative condition of females showed high values during May-November and low values during January-April and July-October. Narasimham (1972) reported low values of K_n in females during February - July and an improvement thereafter. The K_n values for males oscillated in the same pattern as that for females, however, the amplitude was less. The majority of the fishes examined for length-

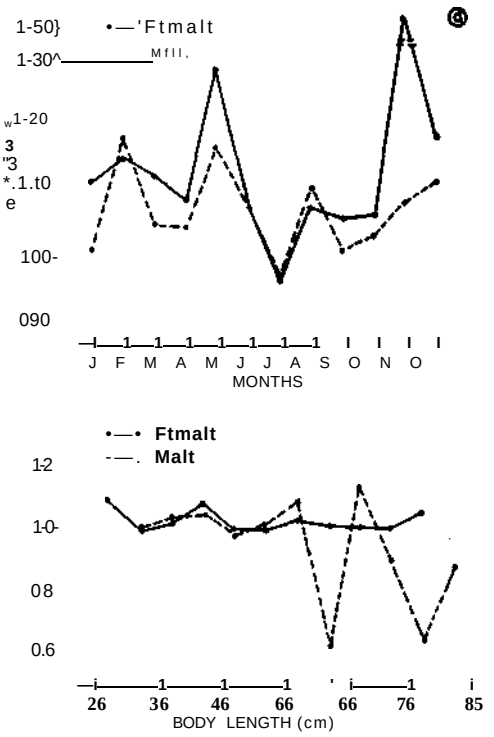

Fig. 3. Relative condition factor, K_n of male and females, (a) during different months and (b) at different lengths of *T. lepturus* from Visakhapatnam waters.

frequency in May and November were young which might possibly have influenced the improved condition. The lowest condition seen in July could be due to the influence of spent and resting fishes as a result of intense spawning activity during February-June.

The condition in females was the highest at a length of 27.5 cm which came down at 32.5 cm, but slightly improved upto 42.5 cm, to decline once again at 47.5 cm and remained more or less steady upto 75 cm. The K_n for males showed a similar trend as that of females upto 57.5 cm but oscillated widely thereafter. The first decline of K_n in females after 27.5 cm could be attributed to the changes related to the onset of maturity and the second decline after 47.5 cm, to the first spawning of majority of the fish. These observations more or less agree with the estimated size at maturity for this fish (Fig. 2 b).

Growth, mortality and exploitation

The maximum size of *T. lepturus* encountered in the present study was 102 cm. The parameters of von Bertalanffy's growth function obtained (Figs. 4 a, b and 5 a) were : L_m =

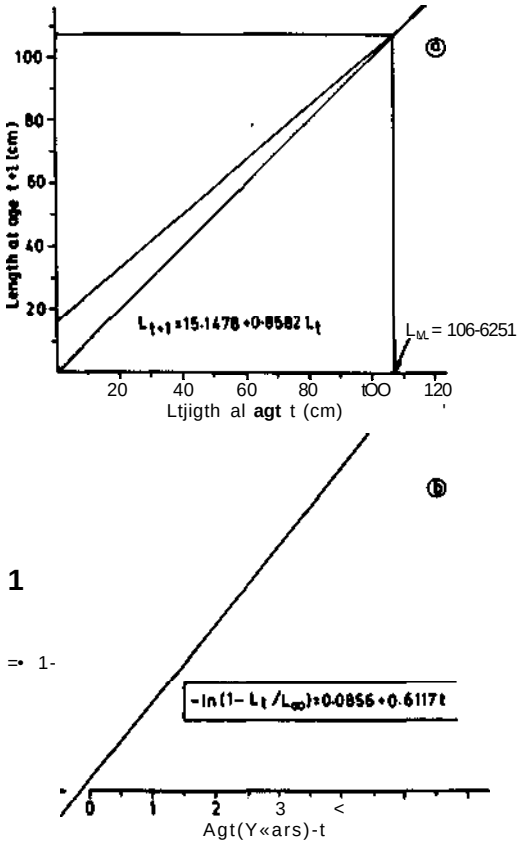

Fig. 4. (a) Ford-Walford plot for estimating L_ and K and (b) plot for estimating t_o and K given L_M, of *T. lepturus* from Visakhapatnam waters.

TABLE 1. *Comparison of regression lines of male and female* Trichiurus lepturus *by ANCOVA*

	df	Regression coefficient	Deviation from regression		
			df	SS	MSS
Males	362	3.245862	361	0.621212	0.001721
Females	405	3.298627	404	1.261541	0.003123
Pooled			765	1.882753	0.002461
Common	767	3.277984	766	1.895395	0.002474
Reg. coeff.			I	0.012642	0.012642
Total	768		767	1.895576	0.002471
Adj. means			1	0.000181	0.000181

Comparison of slope : F = (0.012642) / (0.002461) = 5.136936* (df 1,765).
Comparison of elevation : F = (0.000181) / (0.002474) = 0.073161 @(df 1,766).
* = Significant at 5 % level, @ = not significant at 5 % level.

106.8251 cm, K = 0.6117 per year and t_o = -0.1399 years. Thus the VBGF for *T. lepturus* can be written as:

L_t = **106.8251** (l-e-CBHTft + 0.1399))

A comparison of the present values of the von Bertalanffy's growth parameters with those of earlier workers (Table 2) shows that the present values are closer to those estimated by Somvanshi and Antony (1989) from northwest coast of India. The values reported by Narasimham (1976) from Kakinada differ very much from the present values. Considering the maximum size of *T. lepturus* sporadically reported in the past at 109 cm (Somvanshi and Antony, 1989), 121 cm (Chakraborty, 1990), 112 cm (Tampi *et al*, 1971), 115 cm (Narasimham, 1976) and 102 cm (present study), it is felt that the L_M value of 145.2 cm arrived at by Narasimham (1976) may be on the higher side. Usually it is expected that the L_M value be closer to the average length of large fish normally occurring in the fishery.

The ⌖ values calculated based on parameters given by different authors (Table 2) yielded an average of 3.8598 ± 0.0951 for Indian waters. It is inter-

TABLE 2. *Growth parameters given by different authors and growth performance index* 0' *for* Trichiurus lepturus

Source	Locality	***K***	K	t_o	0
Narasimham (1976)	Kakinada waters	145.2	0.29	-0.20	3.7863
Ingles & Pauly (1984)	Philippine waters	78	0.70	-	3.6293
Somvanshi & Antony (1989)	Northwest coast of India	109	0.64	-	3.8810
Chakraborty (1990)	Bombay waters	129.7	0.50335	0.0011125	3.9278
Present study	Visakhapatnam waters	106.8251	0.6117	-0.1399	3.8439

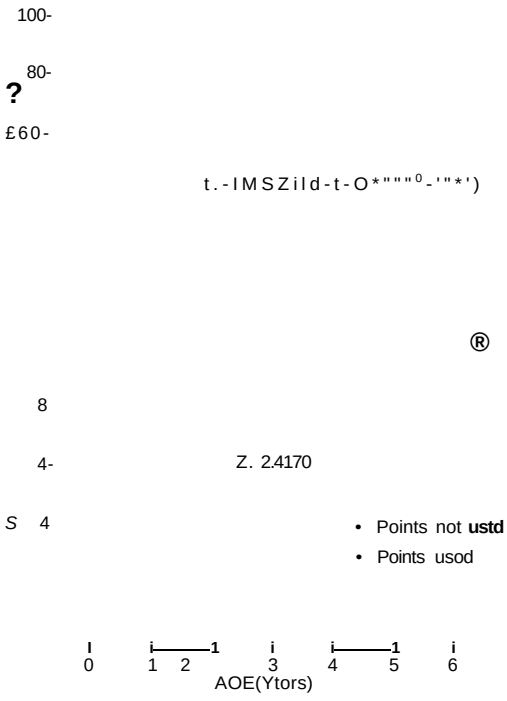

Fig. 5. (a) Estimated growth curve and (b) age structured catch curve of *T. lepturus* from Visakhapatnam waters.

esting to note that all the *§* values derived by us from the published data of Indian authors, except that from Narasimham (1983), were well within the limits (5 %) of the mean value. The (j)' value obtained from Ingles and Pauly (1984) did not come within the limits (5 %) of the mean (3.8137 ± 0.1434) calculated using all the five *§'* values including that of Ingles and Pauly (1984).

The fishery is represented mostly by fishes of one to three years of age. The longevity, t_{mm} was estimated as 4.9 years. The instantaneous total mortality coefficient, Z calculated by Beverton and Holt's (1956) formula as well as catch curve method for the 4 years shows a general increase (Table 3) during the first three years and a decline in the 4th year. The Z value calculated from pooled data for 4 years was 3.4706 from Beverton and Holt's (1956) formula and 2.4170 by catch curve method (Fig. 5 b). The latter value was used for further calculations. Natural mortality coefficient obtained from Pauly's empirical formula was 0.8934 using which the fishing mortality rate was estimated as F (2.417-0.8934) = 1.5236. The total mortality coefficient of Z = 2.4170 obtained in the present investigation is nearer to the values of Z of 1.79 and 1.96 computed by Somvanshi and Antony (1989) and

TABLE 3. *Mortality and exploitation of* T. lepturus *from Visakhapatnam waters for different years*

Parameter	1989	1990	1991	1992	Pooled
1. Z (Beverton & Holt)	4.3736	4.8800	5.5682	4.2102	3.4706
2. Z (Catch curve)	3.2002	3.0315	5.6712	2.3152	2.4170
3. Natural mortality - M (Pauly)	0.8934	0.8934	0.8934	0.8934	0.8934
4. Fishing mortality - F (2-3)	2.3068	2.1381	4.7778	1.4218	1.5236
5. Effort (hours)	2,84,349	3,16,046	3,13,440	2,20,867	2,83,676*
6. Exploitation ratio - E	0.7208	0.7053	0.8425	0.6141	0.6304
7. Exploitation rate - U	0.6915	0.6713	0.8396	0.5535	0.5741

* Average effort for 4 years.

Chakraborty (1990) respectively, as compared to the much less Z value of 1.2 estimated by Narasimham (1983). The present exploitation ratio of 0.6304 and exploitation rate 0.5741 indicate slight overexploitation as compared to the underexploited or moderately exploited status of the fisheries investigated by other authors. The declining trend of catch and catch per hour in recent years (Fig. 1 a) also indicate that the fishing pressure on this species is above optimum along Visakhapatnam coast.

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References

Anon. 1994. *Annual Report.* Cent. Mar. Fish. Res. Inst. 1992-'93, 92 pp.

Beverton, R. J. H. and S.J. Holt 1956. A review of methods for estimating mortality rates in fish population, with special reference to sources of bias in catch sampling. *Rapp. et process-Verbaux desReunions, Conseil Inter, pour I Exploitation de la mer.,* **140** (1) : 67-83.

Chakraborty, S. K. 1990. Fishery, age, growth and mortality estimates of *Trichiurus lepturus* Linnaeus from Bombay waters. *Indian J. Fish.,* 37 (1) : 1-7.

Ingles, J. and D. Pauly 1984. An atlas of the growth, mortality and recruitment of Philippine fishes. *ICLARM Tech. Rep.,* 13 : 127pp.

James, P. S. B. R. and V. M. Baragi 1990. Ovary as an indicator of frequency of spawning in fishes. *Proc. Indian Nat. Sci. Acad.,* B 46 (4) : 479-489.

James, P. S. B. R., T. R. Chandrasekhara Gupta and S. L. Shanbhogue 1983. Some aspects of the biology of the ribbonfish *Trichiurus lepturus* Linnaeus. *J. mar. biol. Ass. India,* 20 (1&2) : 120-137.

James, P. S. B. R., K. A. Narasimham, P. T. Meenakshisundaram and Y. Appanna Sastry 1986. Present status of ribbonfish fishery in India. *Cent. Mar. Fish. Res. Inst., Spl. Pub.* No. 24, 49pp.

La Fond, E. C. 1954. On upwelling and sinking off the east coast of India. *Andhra University Mem. in Oceanogr.,* No. 1, p. 117-121.

Le Cren, E. D. 1951. The length-weight relationship and seasonal cycle in the gonad weight and condition in the perch *(Perca fluviatilis). J. Anim. Ecol,* 20 : 201-219.

Narasimham, K. A. 1970. On the length-weight relationship and relative condition factor in *Trichiurus lepturus* Linnaeus. *Indian J. Fish.,* 17Q&2) : 90-96.

Narasimham, K. A. 1972. Occurrence of early juveniles of ribbonfish, *Trichiurus lepturus* Linnaeus in the Kakinada area with notes on their food. *Indian J. Fish.,* **19Q&2)** : 210-214.

Narasimham, K. A. 1976. Age and growth of the ribbonfish *Trichiurus lepturus* Linnaeus. *Indian J. Fish.,* 23(1&2) : 174-183.

Narasimham, K. A. 1983. On the fishery, mortality and yield per recruit of the ribbonfish, *Trichiurus lepturus* Linnaeus. *Indian. J. Fish.,* **30(1)**: 90-109.

Narasimha Rao, T. V., D. Panakala Rao, B. Prabhakara Rao and V. S. Ramaraju 1986. Upwelling and sinking along Visakhapatnam coast. *Indian. J. Mar. Sci.,* 15 : 84-87.

Pauly, D. 1983. Some simple methods for the assessment of tropical fish stocks. *FAO Fish. Tech. Pap.*, No. 243, 52 pp.

Pauly, D. and J. L. Munro 1984. Once more on the comparison of growth in fish and invertebrates. *ICLARM, Fishbyte,* 2(1) : 21.

Prabhu, M. S. 1950. On the breeding habits of ribbonfish, *Trichiurus haumela* (F). *Curr. Sci.,* 19(7) : 213-214.

Prabhu, M. S. 1955. Some aspects of the biology of ribbonfish *Trichiurus haumela* (F). *Indian J. Fish.,* 2(1) : 132-163.

Snedecor, G. W. 1961. *Statistical Methods.* Allied Pacific Private Limited, Bombay, 534 pp.

Somvanshi, V. S. and Antony Joseph 1989. Population dynamics and assessment of *Trichiurus lepturus* Linnaeus stock in north-west coast of India. *FSI, Spl. Pub.,* No. 2, p. 1-32.

Sparre, P., E. Ursin and S. S. Venema 1989. Introduction to tropical fish stock assessment. Part I. Manual. *FAO Fish. Tech. Pap.,* No. 306 (I), 337 pp.

Srinivasa Rao, K. 1967. Food and feeding habits of fishes from trawl catches in the Bay of Bengal with observation on diurnal variation in the nature of feed. *Indian J. Fish.,* 11(1) : 277-314.

Tampi, P. R. S., P. T. Meenakshisundaram, S. Basheeruddin and J. C. Gnanamuthu 1971. Spawning periodicity of ribbonfish *Trichiurus haumela* (F) with a note on its rate of growth. *Indian J. Fish.,* 15(1&2): 56-60.

Thomas, P. A. 1969. The goat fishes (Family Mullidae) of the Indian seas. *Memoirs III, Mar. Biol. Ass. India, 11A* pp.

Vijayakumaran, K., B. Narayana Rao and K. Radhakrishna 1996. Surface productivity and related hydrography off Visakhapatnam coast during premonsoon and winter months of 1987-'89. *Indian J. Mar. Sci.,* 25 : 29-34.