J. mar. biol. Ass. India, 1978, **290** (1 & 2): 120-137

SOME ASPECTS OF THE BIOLOGY OF THE RIBBONFISH *TRICHIURUS LEPTURUS* LINNAEUS

P. S. B. R. JAMES, T. R. CHANDRASEKHARA GUPTA AND S. L. SHANBHOGUE

Fisheries College, University of Agricultural Sciences, Mangalore

ABSTRACT

The paper presents the results of studies carried on the age and growth, maturation, spawning, fecundity, sex-ratio and food of *Trichiurus lepturus* obtained from the trawl net catches landed at Mangalore, southwest coast of India. The relationship between the snout-vent length (SV length) and standard length (SL) was found to be $Y = 146.94 + 2.0359 \times$ where 'Y' is the snout-vent length and 'X' is the standard length. The life span of the species was estimated to be at least six years, attaining S.V. length of 120 mm at the end of first year, 216 mm at the end of second year, 276 mm at the end of third year and 336 mm at the end of fourth year. The minimum size at first maturity for females was found to be 140 mm S.V. length and for males 130 mm. The species spawns throughout the year with a protracted spawning period and the individual spawning more than once. The number of mature ova is found to vary between 1,000 and 1,34,000 in the fishes of size from 136 to 381 mm S.V. length. The relationship between fecundity and S.V. length, fish weight and ovary weight were calculated. Studies on sex-ratio distribution indicated highly significant dominance of females. Teleosts, prawns and shrimps formed the important food of the species. The salient features of the present observation with those of earlier studies which were mainly based on the fishes obtained from the inshore area were compared and discussed.

INTRODUCTION

THE RIBBON-FISHES of the family Trichiuridae are represented in the seas around India by four well recognised species, namely, *Trichiurus lepturus* Linnaeus, *Lepturacanthus savala* (Cuvier), *Eupleurogrammus muticus* (Gray) and *E. intermedius* (Gray) which contribute to the commercial fishery at a number of places along the coast (James, 1967). Four other new species recently described (Gupta, 1967; Dutt and Thankam, 1967) were considered by the senior author (James, 1967) to represent, if at all, two more species *T. pantului* Gupta and *L. gangeticus* (Gupta) (James, 1969). Silas and Rajagopalan (1975) while reporting *T. auriga* Klunzinger from the south-west coast of India considered it a valid species.

It was earlier thought that the ribbonfish catches are always obtained from inshore waters and that it is essentially a pelagic resources obtained through gears such as shore-seines, boat seines and drift nets. But with recent developments in fishing methods and extension of fishing activities to deeper areas of the sea, the resources are now better exploited. In the light of the works carried out at Mangalore during 1970 and 1971 and from observations reported from elsewhere, it is indicated that trawl nets contribute to fairly good catches of the ribbon-fishes especially of the dominant species *T. lepturus* in the seas around India. This observation suggests that this important resource is exploitable in deeper areas by trawl nets because of a possible demersal phase.

Vijayaraghavan (1951) and Prabhu (1955) studied certain aspects of biology of *Trichiurus haumela* (= *T. lepturus*), while Tampi *et al.* (1968) and Narasimham (1972 a, b; 1976) investigated the spawning periodicity, rate of growth and the length-weight relationship, relative condition, occurrence of juveniles and

the age and growth respectively of *T. lepturus*. With a view to compare and contrast with the earlier findings on the species based on material obtained from inshore areas, a detailed study of the length-frequency distribution, maturity, spawning, fecundity, sex-ratio and the food of *T. lepturus* was made by examining the material obtained from the trawl catches landed at Mangalore and the results are presented in this paper.

Material and Methods

Material for the study was obtained from the trawl catches landed at Mangalore during the period January 1970 to May 1971. Random samples of *T. lepturus* were obtained from the commercial catches. Measurements (snout-vent length and standard length) and weights of the fish were taken fresh condition. The sex and stage of maturity were also recorded in fresh condition. The ovaries and stomach contents were preserved in 5% formaldehyde for future detailed examination.

For length frequency analysis, the fish were grouped according to a size interval of 10 mm snout-vent length and length frequency curves were drawn. The modes in the length frequency curves were traced to the extent possibles in successive months for determining the rate of growth and age of the fish. The maturity of the species has been studied by classifying the maturity stages according to their macroscopic and microscopic appearance and microscopic structure of the ova. The frequency of spawning was determined by taking ova-diameter measurements according to the method of Clark (1934). The fecundity of the species was estimated by the gravimetric method and standard statistical methods were employed to find the relationship between fecundity and length, and weight of fish and weight of ovary. The food of the species was studied qualitatively and quantitatively. Quantitative analyses were made both by the volumetric (displacement) and occurrence methods and the results thus obtained were combined to indicate the relative importance of items of food by the Index of Preponderance as employed by James (1967). The intensity of feeding was studied by classifying the stomachs according to their degree of fullness into full, 3/4 full, 1/2 full, 1/4 full, little and empty.

Observations

Relationship between the snout-vent length and the standard length

In ribbonfishes, the tip of the tail is very fragile and liable to break easily. Hence snout-vent length (SV length) should be more reliable than standard length (SL). Therefore, the relationship between SV/SL was worked out by analysing a total of 100 fishes ranging in size between 98 and 394 mm. The regression equation was calculated by the method of least squares using the formula, $Y = a + bX$ where 'X' and 'Y' denote snout-vent length and standard length of the fish respectively and 'a' and 'b' are two constants. The relationship was found to be $Y = 146.94\,X\ 2.0359\ X$ (Fig. 1).

Age and Growth

Length frequency distribution

In November 1969 (Fig. 2 a), the size range of the fish was 141 to 340 mm S.V. length, with modes at 151-160 mm, 191-200/201-210 mm and 271-280 mm. In December, the size range was 141 to 310 mm, four modes being found at 151-160 mm, 201-210 mm, 241-250 mm and 301-310 mm. In January 1970, the fishes measuring 81 to 310 mm were available. A number of modes were seen at 101-110 mm, 121-130 mm, 201-210 mm, 221-230 mm, 241-250 mm, 271-280 mm and 291-300 mm. In this month, smaller fishes appeared in the commercial catches and larger fish also became prominent. In February, the size range of the

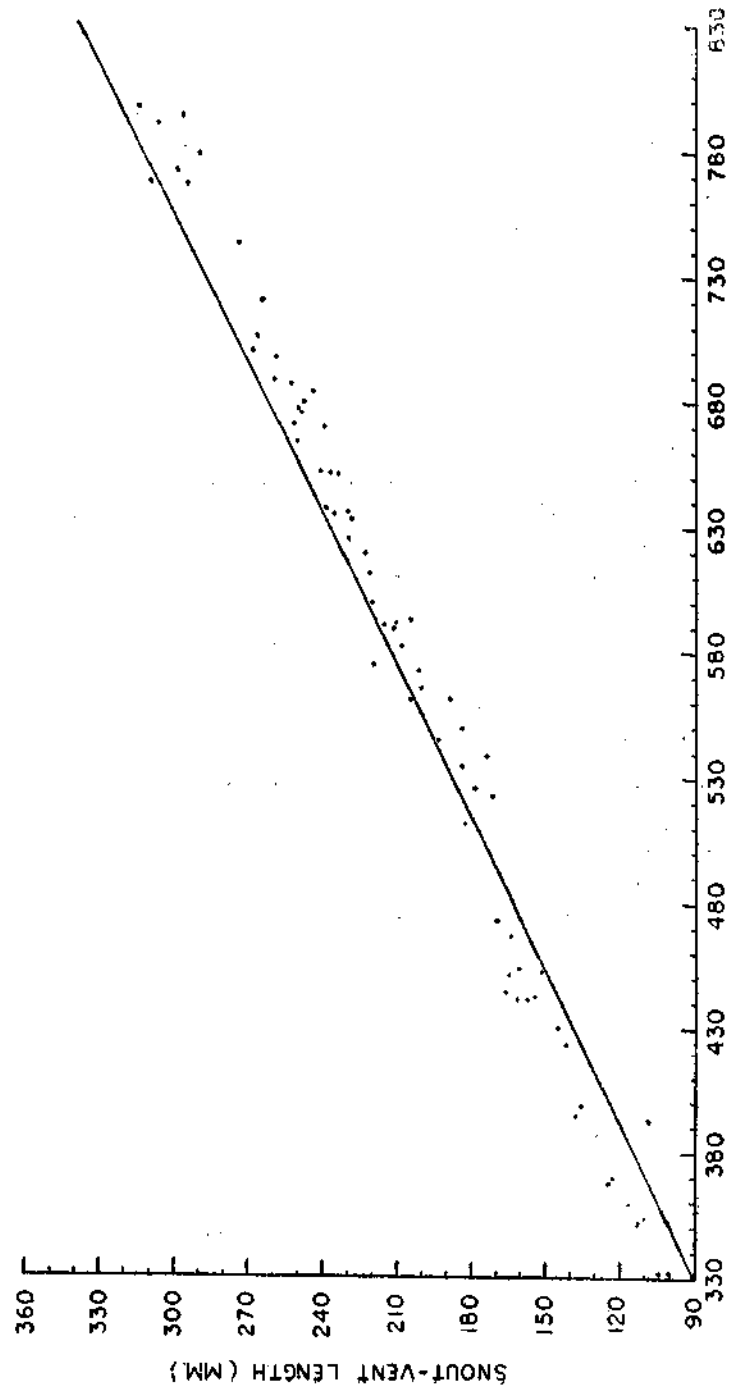

Fig. 1. Relation between standard length and snout-vent length in *T. lepturus*.

fish was very wide, from 81 to 400 mm. But modes were formed only at 131-140 mm, 271-280/281-290 mm. The proportion of the recruits considerably increased from the previous month and very large fish were present in the catches. In March, fish varied in size from 81 to 350 mm with modes at 121-130 mm, 221-230 mm, 281-290 mm, 301-310 mm, 321-330 mm/331-340 mm. The newly recruited fish and older fish existed together, the former dominating. In April, the size range of fish in commercial catches was 81 to 390 mm. Modes were found at 131-140 mm, 241-250 mm, 281-290 mm, 351-360 mm and 411-420 mm. In May, the total size range of fish was 91 to 370 mm with only a single mode at 131-140 mm. The older fish are almost negligible in number. This indicated that after April the older fish were not available in the normal fishing zone upto about 24 metres depth. Due to onset of southwest monsoon samples of fish were not available from June to August. In September, the total size range of fish was limited from 111 to 190 mm, with modes at 111-120 and 141-150 mm. Large fish were not represented in the catches. In October, fish varied in size range 121 to 240 mm. Modes were present at 121-130 mm 171-180 mm and 231-240 mm. In November, the size range varied from 101 to 300 mm with modes at 101-110 mm, 131-140 mm, 201-210 mm, 261-270 mm and 291-300 mm. There was some representation

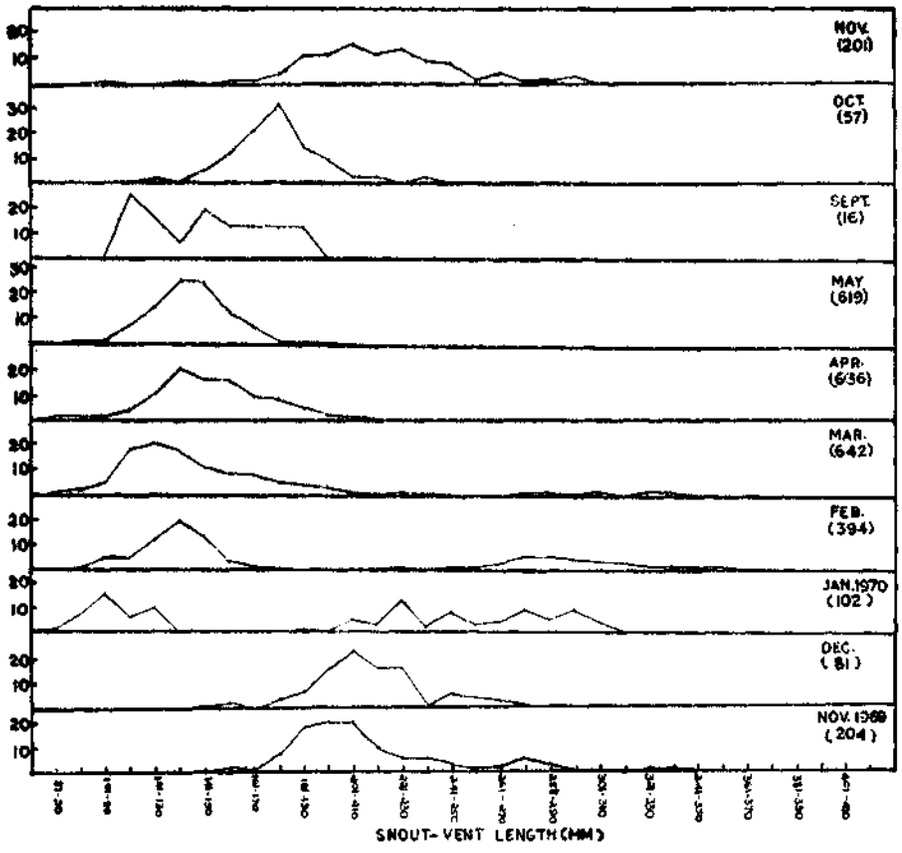

Fig. 2 a. Length frequency curves for *T. lepturus* for the period November 1969 to November 1970.

of large fish in October and November. In December, the size range was 151 to 310 mm with a single mode at 221-230 mm.

In January 1971 (Fig. 2 b) the total size range was 121 to 360 mm. Modes were present at 121-130 mm, 231-240 mm and 351-360 mm. In February, the size range was 141-320 mm. Modes were present at 151-160 mm, 221-230 mm, 281-290 mm and 311-320 mm. In March, the size range varied from 101 to 340 mm with modes at 131-140 mm, 241-250 mm, 271-280 mm and 321-330 mm. In April, the size range varied from 111 to 380 mm. Modes were found at 131-140 mm, 241-250 mm, 281-290 mm, 311-320 mm, 331-340 mm, 351-360 mm and 371-380 mm. In May, the size range was 81 to 380 mm, with modes at 131-140 mm, 241-250 mm and 371-380 mm. Large fish which encountered in small numbers in October and November occurred in larger numbers upto May. As in 1970, in 1971 also, the new recruits appeared from about January. The proportion of the new recruits increased towards May, when they co-existed with older fish.

Rate of growth and life span

Since the fish spawns over a prolonged period and also since individual fish spawns more than once, there is a possibility of overlap of different size modes resulting from broods recruited at different periods. However, in the absence of other suitable methods to determine the age and rate of growth, some of the modes in length frequency curves were traced with caution over short periods to study these aspects. In January 1970, the newly recruited fish was at a model size at 101-110 mm. This was not represented in February but in March and April, it could be identified at 121-130 mm and 131-140 mm respectively. In May it was not seen. This progression suggested an increment of 10 mm per month. Another size mode observed in January 1970 at 121-130 mm progressed to 131-140 mm in February

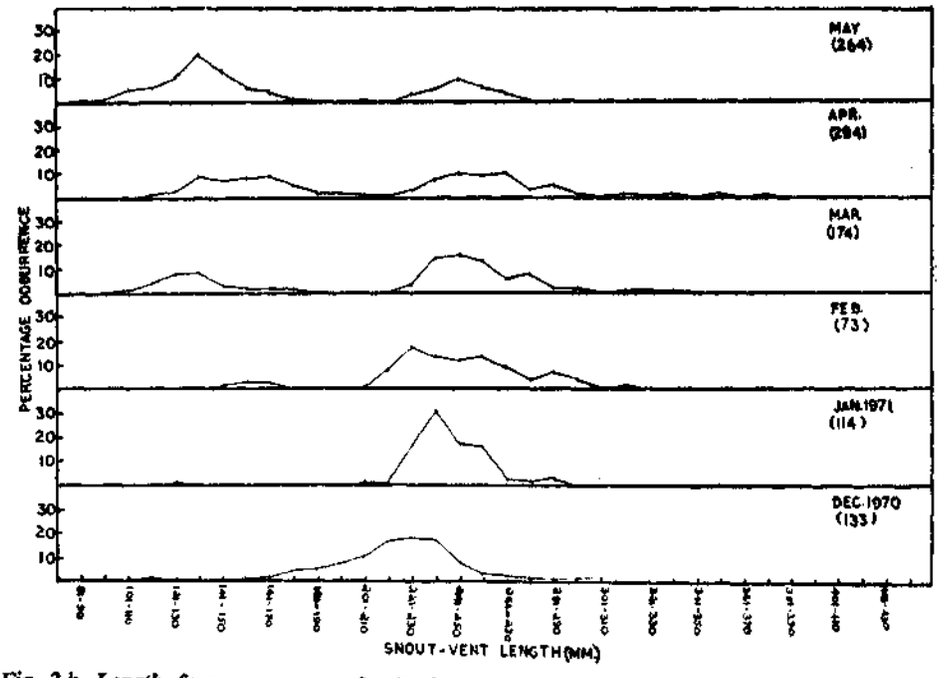

Fig. 2 b. Length frequency curves for *T. lepturus* for the period December 1970 to May 1971.

indicating the same rate of growth. The mode in September 1970 at 111-120 mm could be traced to 121-130 mm in October and 131-140 mm in November, showing a growth rate of 10 mm per month. The size present at 101-110 mm in November 1970 was traced to 111-120 mm in December and 121-130 mm in January confirming a growth rate of 10 mm per month. It could therefore be concluded that the fish after recruitment to the fishery grow at a rate of 10 mm per month. At the end of first year, on this basis, it is expected to attain at least 120 mm S-V length (391 mm SL). However, in the months before recruitment, a still faster growth rate is possible.

Tracing the 131-140 mm size mode in February 1970 through November to 201-210 mm, a growth of 70 mm in 9 months was recorded. This indicated a growth rate of 7.7 mm or 8 mm per month during the second year of life. The size mode at 131-140 mm in November 1970 was traced to 151-160 mm in February 1971 accounting for an increment of 20 mm in three months or 6.6 mm (or 7 mm) in a month. On this basis, the fish showed growth of 8 mm per month in the second year, as the total growth being 96 mm. Hence, the size of the fish at the end of second year would be 216 mm S.V. length (587 mm SL).

The 231-240 mm mode length group observed in January 1971 was traced to 241-250 mm in March. This indicated a growth of 10 mm in 2 months or 5 mm in a month. On this basis, the total growth in the third year was estimated to be 60 mm. Hence, the probable size of the fish at the end of third year would be 276 mm S.V. length (708 mm SL).

A similar growth rate was recorded for the fish belonging to next year group, as the size mode at 291-300 mm in January 1970 was found to progress to 301-310 mm in March 1970, indicating 10 mm growth in 2 months. Based on this, the size of the fish at the end of fourth year was assessed to be 336 mm S.V. length (828 mm SL).

The length frequency curves indicating that the commercial catches included a few fishes above 374 mm. S.V. length (850 mm SL), which from the above conclusions should be in the fifth year of life. Since the fish above this size was limited in the samples, growth in the fifth year of life was not estimated. As few larger fishes measuring above 347 mm S.V. length was encountered in the commercial catches, the life span of the species would be at least six years.

Reproduction

Maturity

The maturation process was studied by tracing the development of ova in different maturity stages which were distinguished by macroscopic and microscopic observation of the ovary (Table 1). The size distribution of ova in various stages of maturity is shown in Fig. 3. Except in stage I, ova smaller than 6 oc.m.d. were not measured as these were the transparent, immature ova present in all the ovaries.

From the ova diameter frequency curves, it is seen that from stage III onwards two groups of ova are present. The first groups of ova develop faster and gets distinctly separated from the second group. The wide size range indicates the protracted breeding pattern of the fish. This contention is supported by actual observation of the presence of large transparent ova in the ovaries of fish collected at different times. It is further interpreted that the ripe ova are shed in a fairly long period, with some interval between the successive spawnings because of the presence of a second group of ova in all the nature ovaries. The occurrence of mature, partially spent and spent ovaries in a number of months supports the view that the spawning period is a prolonged one and that individual fish spawns more than once. However, a sample of fish collected on a particular day contained fish in at least

TABLE 1. *Classification of maturity stages of female* T. lepturus

Stage of maturity	Macroscopic appearance of the ovaries	Microscopic characteristics of the ova	Total size range of ova (mm)	Size range of largest group of ova (mm)	Mode of largest group of ova (mm)
I	Ovaries thin, transparent occupying about 1/3 of the body cavity.	Ova irregular in shape, fully transparent, with a clear nucleus. Ova invisible to naked eye.	0.02-0.40	0.02-0.40	0.12-0.20
II	Ovaries slightly thicker than previous stage, flat, transparent, occupying about ½ of body cavity.	Ova somewhat spherical, with commencement of deposition of yolk granules nucleus faintly visible. Ova still invisible to naked eye.	0.02-0.70	0.40-0.70	0.42-0.50
III	Ovaries yellowish, turgid, occupying more than ½ the body cavity.	Largest group of Ova spherical, opaque with full deposition of yolk, visible to naked eye. Nucleus invisible.	0.02-1.00	0.72-1.00	0.82-0.90
IV	Ovaries yellowish, with prominent blood vessels, cylindrical in shape, occupying about 3/4 of the body cavity.	Ova spherical semi-opaque, with commencement of vacuolation of yolk.	0.02-1.20	0.80-1.20	1.02-1.10
V	Ovaries lose yellow colour, dull brick red in colour, ovarian wall thin, occupying more than 3/4 of the body cavity.	Ova spherical semi-transparent, with narrow perivitelline space.	0.02-1.60	0.80-1.60	1.32-1.40
VI	Ovaries very light brick red in colour, ovarian wall very thin and papery, ovaries fully occupy the body cavity pushing aside the rest of the viscera.	Ova fully transparent with clear perivitelline space.	0.02-2.20	1.50-2.20	0.82-1.90
VIIA	Ovaries yellowish, partially glabby, occupying more than ½ the body cavity, resembling stage III.	Ova spherical, opaque, with full deposition of yolk, few compressed irregularly shaped residual eggs or their remains.	0.02-0.90	0.60-0.90	0.72-0.80
VIIB	Ovaries of irregular shape, blood shot, pale yellow in colour, very flabby and almost empty, occupying about ½ the body cavity, resembling stage II.	Ova irregular in shape, mostly transparent, few granular white ova.	0.02-0.30	0.02-0.30	0.12-0.20

two different stages of maturity and in many months, advanced stages of maturity coupled with partially spent and spent stages were recorded, indicating the absence of periodicity in spawning.

Size at first maturity

For this study, the fish were grouped according to a size interval of 10 mm and the percentage occurrence of different maturity stages in the various size groups. The data for 1970 indi-

cated that the females measuring from 91 to 220 mm were in stage I, from 111 to 370 mm S.V. length in stage II, from 131 to 390 mm in stage III, from 131 to 370 mm in stage IV, from 131 to 390 in stage V, from 271 to 340 mm in stage VI, from 151 to 420 mm in stage VII. In 1971 females of size 80 to 260 mm were in stage I, of 151 to 320 mm in stage II, of 161 to 440 mm in stage III, of 231 to 360 mm in stage IV, of 231 to 360 mm in stage V, and of 141 to 290 mm in stage VII. The smallest size group of 131 to 140 mm. Therefore, the size at first maturity for male was about 130 mm S.V. length (412 mm SL). Mature males (stage III and above) also occur from about this size. It was found that both sexes attain maturity at about the same size, the males possibly a little earlier than females.

Spawning season

A total of 797 females and 601 males in 1970 and 453 females and 346 males in 1971

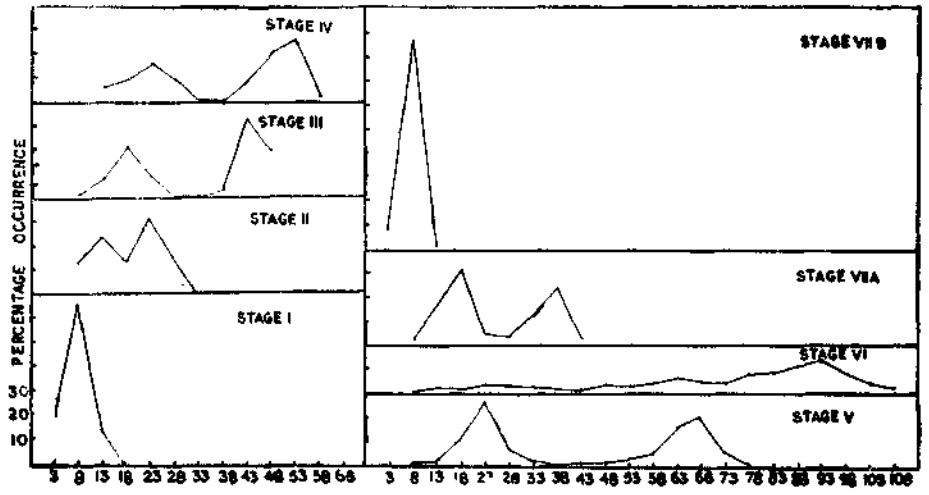

Fig. 3. Ova diameter frequency polygons of the ovaries of *T. lepturus* in various stages of maturity.

female fish in spent condition was found in the size range of 141 to 151 mm S.V. length. Mature females also appear at about this size range. Therefore, the minimum size at first maturity for the female was found to be about 140 mm S.V. length (431 mm SL).

In 1970 the males in stage I measured from 80 to 230 mm ; stage II from 111 to 270 mm ; stage III from 131 to 370 mm ; stage VII from 131 to 290 mm S.V. length. In 1971 males in stage I had the size range from 91 to 260 mm ; stage II from 121 to 280 mm ; stage III from 211 to 300 mm ; stage IV to stage VI no males ; stage VII from 201 to 300 mm S.V. length. The data for both the years together indicated that the smallest spent male was found in the were examined for the determination of the spawning season. The distribution of maturity stages of female, month-wise during the year 1970 is shown in Fig. 4 a. The mature female fish (stage III and above) and spent fish occurred in almost all the months of the year. This indicated that the species spawns almost throughout the year. This confirms the observation made earlier on the basis of the development of ova in different maturity stages.

In the case of male (Fig. 4 b) mature (stage III and above) and spent fish occurred in almost all months indicating that spawning period is a prolonged one.

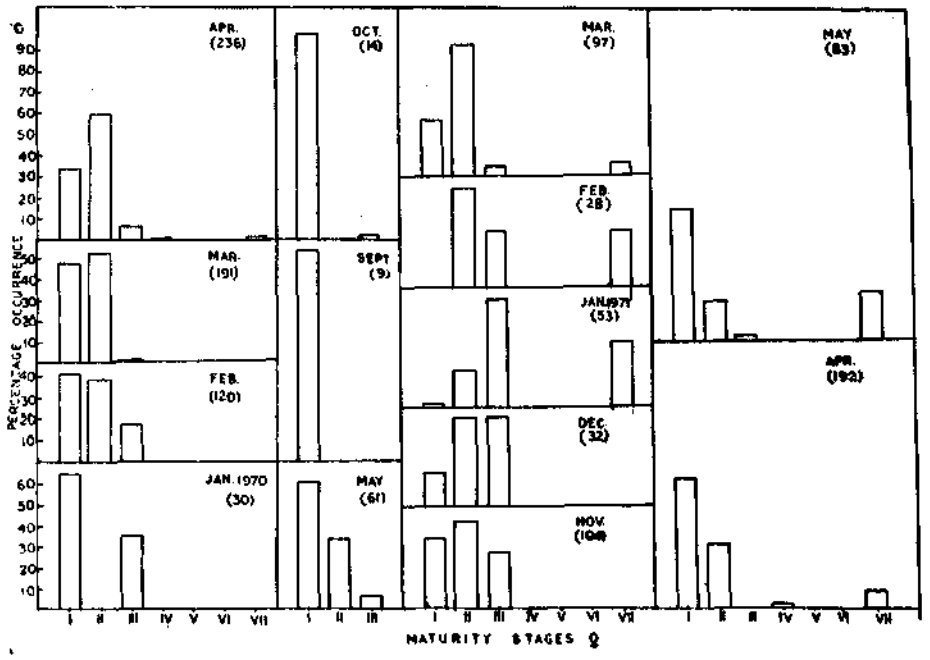

Fig. 4 a. Percentage occurrence of females of *T. lepturus* in different stages of maturity during the period January 1970 to May 1971.

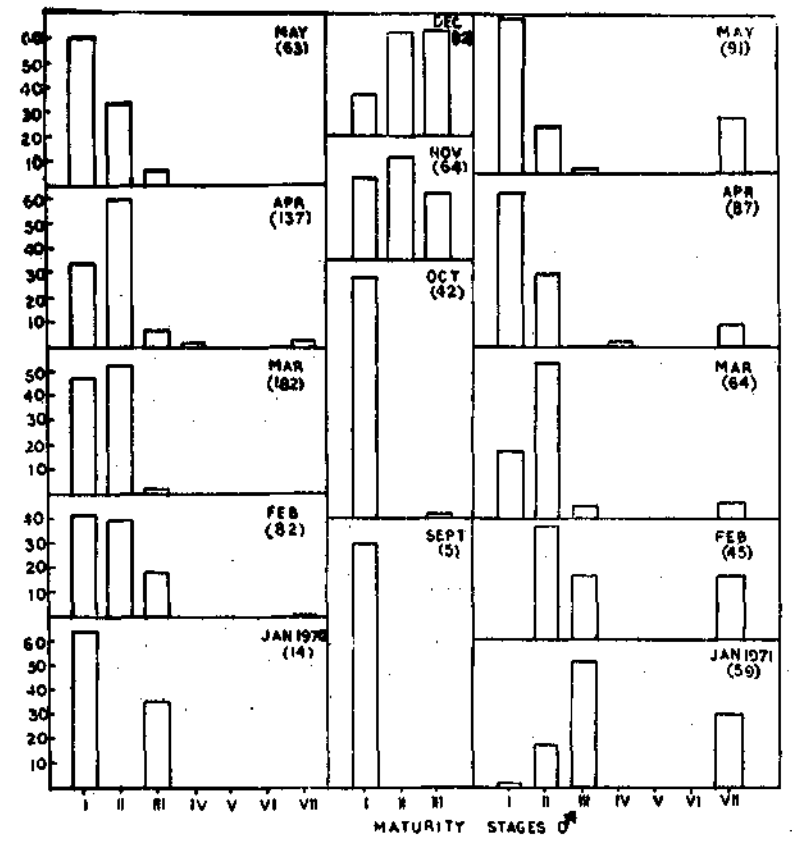

Fig. 4 b. Percentage occurrence of males of *T. lepturus* in different stages of maturity during the period January 1970 to May 1971.

Fecundity

Fecundity was estimated by the gravimetric method for 54 fishes in the size range of 136 to 381 mm S-V length (398 to 910 mm SL) and weighing 52 to 847 gms. The number of mature ova was found to vary between 1000 and 1,34,000.

Relation between fecundity and snout-vent length

The data on fecundity and snout-vent length for 54 fishes were plotted in a scatter diagram (Fig. 5). The formulae $Y = a + bX^3$ and $Y = aX^b$ were fitted to the data. The curve-linear relationships were found to be

$$Y = 0.001569\ X^3 - 3217$$

$$Y = 0.002038\ X^{2.9201}$$

Where X = snout to vent length and Y = number of mature ova (fecundity). These two formulae are equally correlated and the respective correlation co-efficients were 0.78 and 0.80 and the ' b ' value (2.92) of the second formula indicates almost a cubic relationship.

Relation between fecundity and fish weight

The data on fecundity and fish weight were plotted in Fig. 6 for different stages of maturity. In the straight line relationship, the ' b ' values were found to be in the increasing order of 82/gm of fish weight in stage III, 110 in stage IV and 133 in stage V and VI. The numbers of mature ova calculated per gram of fish weight were 82, 98 and 96 in stages III, IV and V-VI respectively. Covariance analysis indicated that there was no significant difference between the slopes of all stages. A pooled regression was found as follows :

Y (fecundity) = 102.47 X (wt. of fish) — 4865

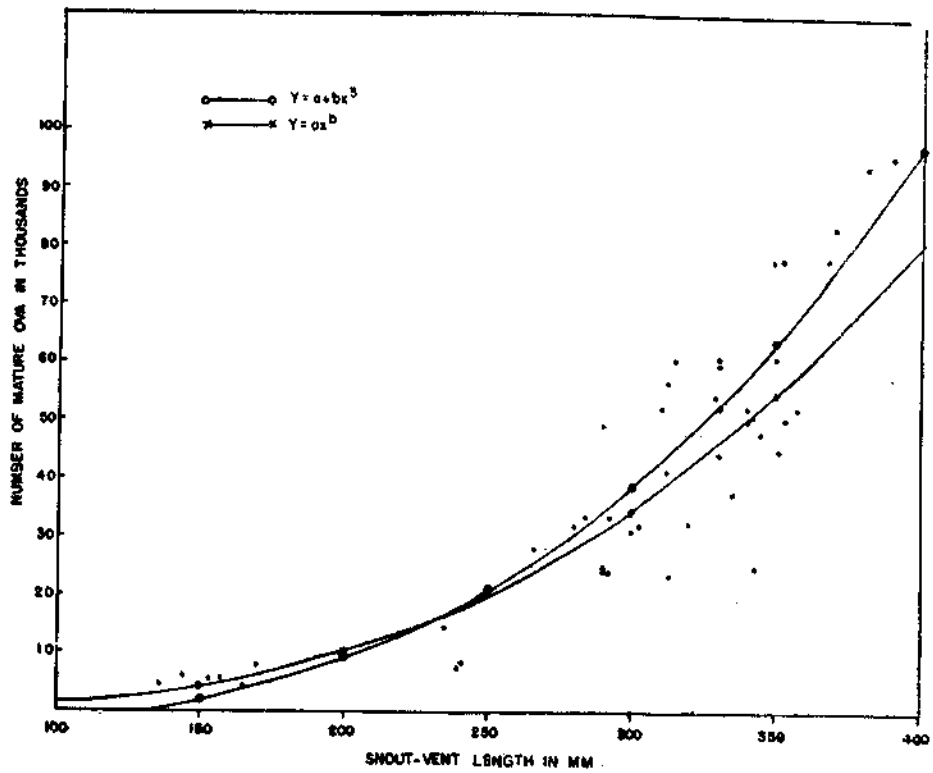

Fig. 5. Relation between fecundity and snout-vent length in *T. lepturus*.

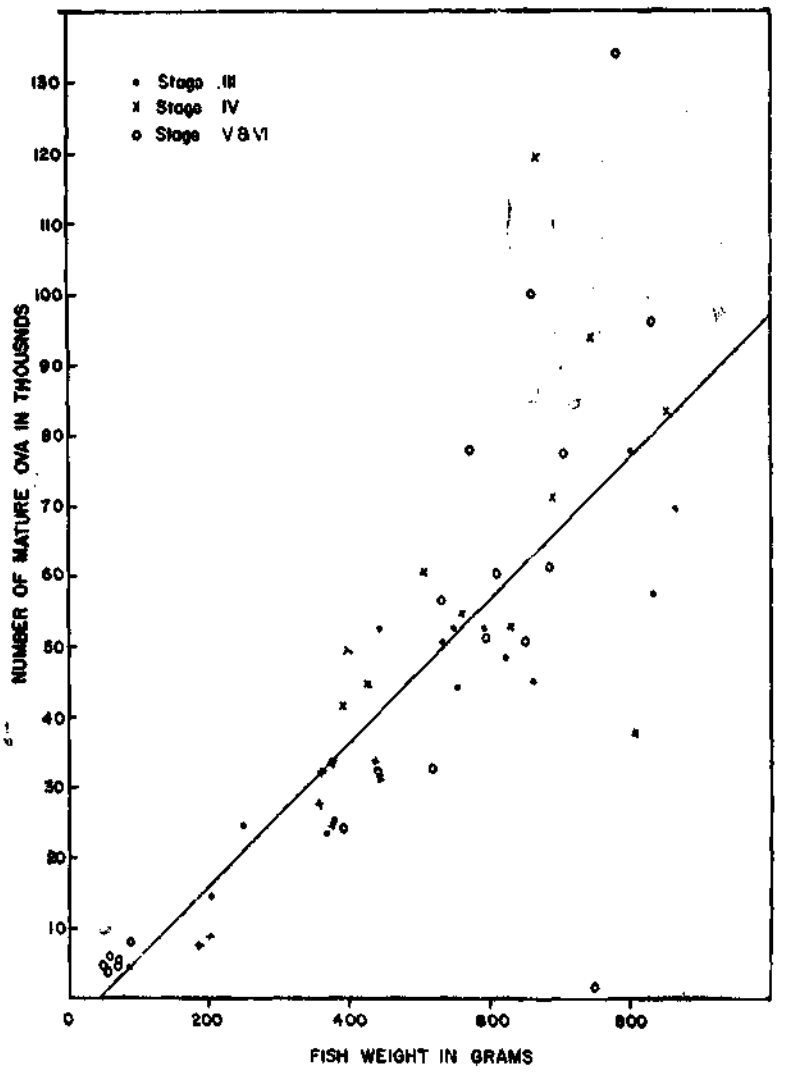

Fig. 6. Relation between fecundity and fish weight in *T. lepturus*.

Relation between fecundity and ovary weight

The data of ovary weight were plotted against the number of mature ova in respect of different maturity stages in Fig. 7 and straight line regressions were found for the respective stages. The number of mature ova per gram of ovary weight are found to be 2184, 1509 and 1079 in stages III, IV and V-VI respectively. As in the relationship of ovary weight and fish weight, here again stages IV and V-VI were not significantly different and whereas stage III was found to be significantly different at 1% level. The equations may be represented as follows :

for stage III, Y (=fecundity = 13420 + 1542 X (= ovary wt.)

for stage IV-VI, Y = 132 + 1252 X

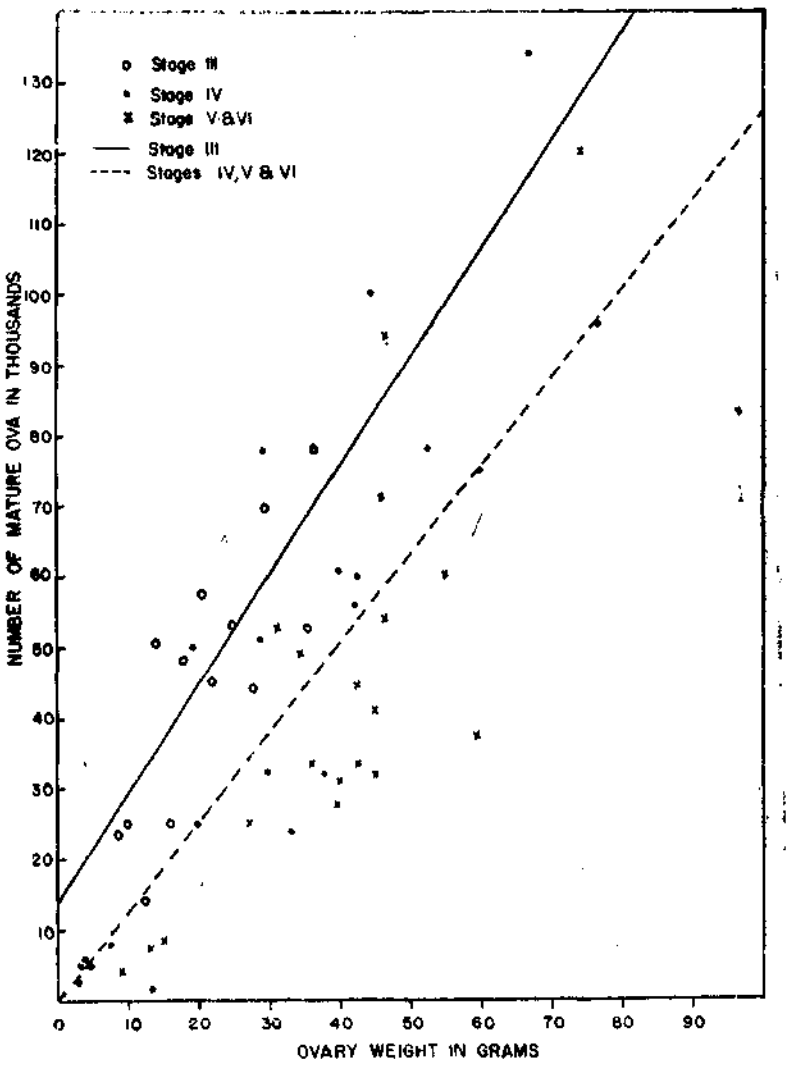

Fig. 7. Relation between fecundity and ovary weight in *T. lepturus*.

Relation between ovary weight and fish weight

The scatter points were plotted in Fig. 8 for different stages of maturity and straight line regressions were found. The 'b' values 0.0302, 0.0653 and 0.0795 were found to be in increasing order as expected in respect of stages III, IV and V-VI. The percentage of ovary weight was found to be 3.76 in stage III, 6.48 in stage IV and 6.55 in stage V-VI. The percentage of ovary weight in stages IV and V-VI were found to be close. Analysis of covariance indicated that stage IV and V-VI were not significantly different and hence they were pooled. However, stage III was found to differ significantly at 5% level from stages IV and V-VI. The following equations were found better fitted :

for stage III, Y(=ovary wt) = 4.1336 + 0.0302 X(=fish wt) and for stages IV-VI Y = 2.729 + 0.0713

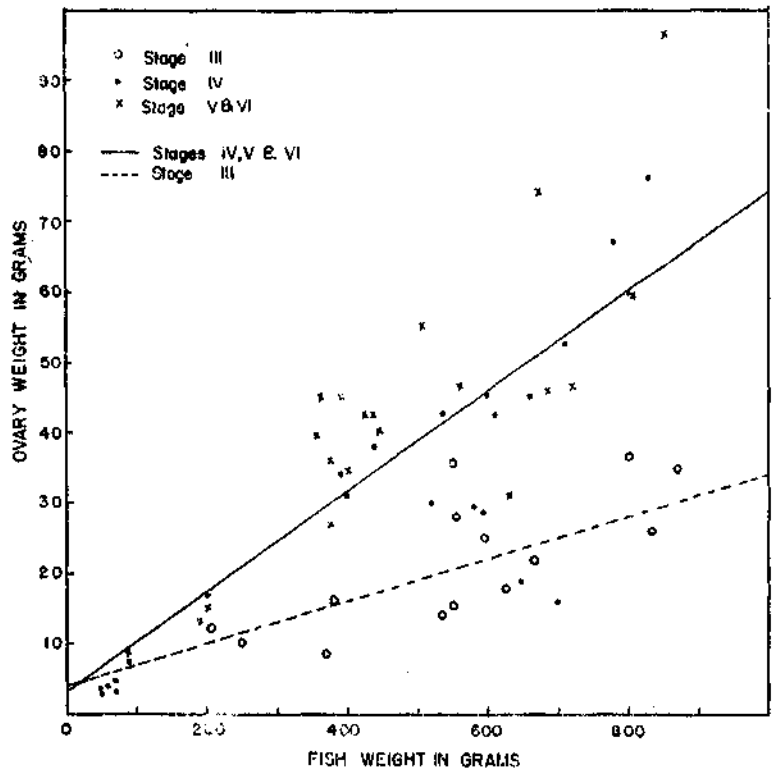

Fig. 8. Relation between ovary weight and fish weight in *T. lepturus*.

Sex ratio

The details of sex-ratio in the commercial catches from January 1970 to May 1971 are given in Table 2. The sex ratios obtained for February and April, November-December 1970 and March-April 1971 were found to show highly significant dominance of females and a lesser degree of significance in January 1970. This dominance of females in most of the months observed was reflected in the pooled data of sex-ratio in favour of females with high degree of significance. Only the months October 1970 and February 1971 were found to show different degrees of significance in favour of males.

Food and Feeding Habits

The stomach contents of 569 fishes in the size range 87 to 412 mm S-V. length (270 to

TABLE 2. *Sex ratio of* T. lepturus

Months	Total No. of fish	Males	Females	Ratio-males to females	X^2
Jan. '70	44	14	30	1 : 2.14	5.82*
Feb.	202	82	120	1 : 1.46	7.15**
Mar.	373	182	191	1 : 1.04	0.22
Apr.	373	137	236	1 : 1.72	26.28**
May	124	63	61	1 : 0.96	0.03
June to August	No data				
Sep.	14	5	9	1 : 5.80	1.14
Oct.	56	42	14	1 : 0.33	14.00**
Nov.	168	64	104	1 : 1.62	9.52**
Dec.	44	12	32	1 : 2.66	9.09**
Jan. 71	112	59	53	1 : 0.88	0.32
Feb.	73	45	28	1 : 0.62	3.96*
Mar.	161	64	97	1 : 1.51	6.76**
Apr.	279	87	192	1 : 2.20	39.52**
May	174	91	83	1 : 0.91	0.37
Total	2197	947	1250	1 : 1.32	41.79**

* 5% significance level.
** 1% significance level.

838 mm SL) were examined during the period January 1970 to May 1971. Quantitative analyses were done both by the volumetric (displacement) method and occurrence method and the results thus obtained were combined to indicate the relative importance of items of food by the Index of Preponderance as employed by James (1967). The details are shown in Table 3. Intensity of feeding was studied by classifying the stomachs according to the degree of fullness. Details of the percentage occurrence of various food organisms in the stomach contents in different size groups during the above period were also studied.

The qualitative analyses of food of the species indicated that the food consisted of a variety of teleostean fishes, prawns, shrimps, cephalopods and stomatopods. Though the fishes in the stomach contents were found in various degrees of digestion rendering them difficult to identify at least over a dozen different species were found as shown in Table 3. All the unidentifiable species however, were grouped into one category, 'fishes'. The trawl fish catches in the area composed of about 50 different species of fishes but the stomach contents of *T. lepturus* included only a few of them as mentioned above. Some of the fishes occurred in the stomach contents only occasionally, though they were abundant in the catch. This indicated that compared to all other items of food, teleosts form the dominant item of the species and that it exercised a certain amount of selectivity in food. It was noteworthy, that the oil-sardine and the mackerel were also important items of food of *T. lepturus* off Mangalore.

Next to teleosts, prawns and shrimps formed the important food of the ribbonfish. The prawns often found were *Metapenaeus dobsoni* and *Parapenaeopsis stylifera* which were also the common species in the trawl catches off Mangalore.

TABLE 3. *Relative importance* of food items in the stomach contents of* T. lepturus (*January* 1970 *to May* 1971)

Items of food	1970						1971						
	Jan. (44)	Feb. (86)	Mar. (85)	Apr. (81)	May (34)	Oct. (11)	Nov. (31)	Dec. (12)	Jan. (30)	Feb. (31)	Mar. (42)	Apr. (51)	May (31)
Fishes ..	98.49	37.54	98.66	89.99	83.52	100.00	60.30	89.01	47.83	91.98	85.10	80.02	65.91
Leiognathus bindus ..	4.09	—	—	—	4.84	—	—	—	—	—	—	—	—
Leiognythus sp. ..	—	—	0.20	—	—	—	8.43	10.20	—	—	—	1.43	11.89
Sardinella sp. ..	—	—	0.34	6.60	—	—	—	—	—	—	—	—	—
S. longiceps ..	—	—	—	—	10.49	—	7.87	—	35.17	—	4.25	—	5.94
Eel (young one) ..	—	—	—	—	0.80	—	—	—	—	—	—	—	—
Stolephorus sp. ..	—	—	—	—	—	—	15.30	—	—	—	—	—	14.87
Thrissocles sp. ..	—	—	—	—	—	—	0.46	—	—	—	—	6.87	0.68
Osteogeneosus militaris ..	—	—	—	—	—	—	3.70	—	—	—	—	—	—
Saurida sp. ..	—	—	0.02	—	—	—	—	—	—	1.50	—	—	—
Selar kalla ..	—	—	—	5.11	—	—	—	—	—	0.37	2.13	—	—
Nemipterus japonicus ..	—	—	—	—	—	—	—	—	—	—	2.13	—	—
Rastrelliger kanagurta ..	—	62.23	0.72	2.38	—	—	—	—	—	—	11.45	—	—
Prawns ..	1.40	—	0.04	—	—	—	0.92	—	8.61	1.24	—	0.57	0.68
Metapenaeus sp. ..	—	—	0.20	—	—	—	—	—	—	—	—	—	—
M. dobsoni ..	—	—	—	1.63	—	—	—	—	—	—	—	—	—
Parapenaeopsis stylifera ..	—	—	—	0.48	—	—	—	—	—	—	—	—	—
Penaeus merguiensis ..	—	—	—	—	—	—	—	—	—	—	6.38	—	—
Acetes sp. ..	—	22.09	0.03	0.67	0.32	—	—	—	—	—	—	—	—
Sepia ..	—	—	0.08	—	—	—	—	—	—	—	—	—	—
Cephalopod ..	—	—	0.05	—	—	—	—	—	—	—	—	—	—
Loligo ..	—	—	—	—	—	—	—	—	7.65	4.88	—	—	—
Squilla (*Oratosquilla nepa*) ..	—	—	—	—	—	—	0.22	0.78	0.71	—	—	—	—

* Number of fish examined in each month given in parenthesis. Other figures indicate percentage.

Cephalopods, represented by *Sepia* and *Loligo* were only of limited occurrence. Stomatopods, represented by *Oratosquilla nepa* though abundant in the area were consumed only in negligible quantities. As to the seasonal differences in the food of *T. lepturus*, the data indicated that fishes and prawns formed the regular food in almost all months but cephalopods were found between January and March and stomatopods between November and January.

The observations on intensity of feeding indicated that active and reduced rates of feeding were found interspersed in all the months and this appeared to be correlated with prolonged spawning of the species. However, the percentage occurrence of empty stomachs was very high in almost all the months.

Details of the percentage occurrence of various food items in the stomach contents of *T. lepturus* in different size groups indicated that fishes as food were preferred by fish of all sizes. Larger species of fishes like mackerel and oil sardine and prawns were found in the stomachs of large ribbon fish. Small fish preferred juveniles of fishes, small fishes such as *Stolephorus* and *Thrissocles* and shrimps (*Acetes*). Thus, there seemed to be no striking change in the food of the fish from the young to adult stage. The diet appeared to be depended on the availability of particular organisms. Bigger fish have a wider variety of organisms as food compared to smaller fish.

Discussion

The age and growth of *T. haumela* (=*T. lepturus*) from the seas around India was studied by Prabhu (1955). According to him, it attains a length of 18 cm in the first year, 30 cm in the second, 46 cm in the third and 54 cm in the fourth year of life. However, his data do not include size groups above 56 cm. It has been observed by the senior author that both on the east and west coasts of India sizes nearly double those studied by Prabhu occur in the commercial catches. Hence, the samples obtained by him do not appear to be truly representative of the population and consequently the rates of growth and life span of the species as given by him are open to doubt as already pointed out by James (1967). Similar remarks were made by Narasimham (1978). In the present study, the sizes at the end of first, second, third and fourth year have been deduced to be 120 mm S-V length (391 mm SL), 216 (587), 276 (708) and 336 (828) respectively. Comparison of these values with those of Prabhu essentially indicates (1) a much faster growth rate during all the years, especially in first year with resultant higher sizes at the end of each year of life and (2) a higher life span of at least six years. These results satisfactorily explain the larger sizes available in the commercial catches.

Prabhu (1955) remarked that the occurrence of juveniles between 7 and 9 cm towards the end of July indicates the growth rate of about this size in one and half month's duration. He has compared this with the statement of Tang and Wu (1936) that *T. japonicus* (=*T. lepturus*) attains a size of 5.4 to 9.5 cm in a period of a month and a half from the time of spawning. However, this does not favourably agree with his estimation of 18 cm at the end of first year. On the other hand, such fast growth rate of about 45 mm per month in the early stage appears to be in agreement with at least 10 mm per month on the average during first year to attain about 120 mm S-V length (or 391 mm SL).

From length frequency study, Narasimham (1976) estimated the average lengths to be 41.6 69.0 and 88.5 cm at the end of first, second and third years respectively. By the Von Bertalanffy growth equation, be obtained the lengths of 42.7, 68.6, 87.9, 102.4 and 113.2 cm at the end of first, second, third, fourth and fifth years respectively. He also found that these results are in agreement with those

of Dawson (1967), Misu (1964) and Hamada (1971) except for the one year old fish as given by Misu (1964). The body-length (snout-vent length) data of Misu (1964) as converted by Narasimham (1978) to total length by Von Bertalanffy equation given by Misu gave corresponding lengths of 24.9, 69.6, 90.8, 103.4, 110.7 cm for the first to the fifth years respectively. Similarly, the data of Hamada (1971) were converted by Narasimham (1978) and arrived at total lengths of 40.1, 67.6, 86.6, 102.0 and 113.2 cm for the first to fifth years respectively. Comparison of these results with the results of the present study indicate that the latter are slightly on the lower side.

Though Prabhu (1955) indicated a short, definite spawning, once a year in June for the species, the present observations indicate a prolonged spawning of the species in almost all the months of the year. The occurrence of several maturity stages including ripe and spent individuals in many months of the year at Mangalore (Figs. 4 a, b) coupled with ova-diameter studies support this contention.

Tampi *et al.* (1971) observed that off Madras, the fish spawns more than once in a year and the two seasons given are roughly around May-June and November-December. Off Kakinada, Narasimham (1972 b) observed that the spawning period in *T. lepturus* is prolonged with peak activity in February-June. In the East China and Yellow Seas, the species was found to spawn from May to July (Misu, 1958 ; 1964). Yamada (1971) stated that *T. lepturus* spawns from April to August in the East China Sea.

The minimum size at maturity, according to Prabhu (1955) is 47.48 cm. In the present study, female fish was found to be mature at 140 mm S-V length (431 mm SL) and male fish at 130 mm S-V length (412 mm SL). Narasimham (1972 a) indicated that 90% of fish attained sexual maturity at 625 mm total length. The upper limit of 16,000 ova given by Prabhu (1955) for the fecundity of the species appears to be an under-estimate since upto 1,34,000 ova were estimated in the present study.

Regarding the food of this species, there has been great agreement between several authors who worked on this species (James, 1967). Narasimham (1972 b) found that in the smaller juveniles of calanoid copepods predominated while the larger juveniles preferred fish, prawn larvae and a variety of crustaceans. Similar observations were made by Vijayaraghavan (1951) and Basheeruddin and Nayar (1962). The present observations also substantiate earlier findings that the species is a voracious carnivore and predominantly piscivorous. The occurrence of other commercially important species like the mackerel and the oil-sardine in the stomachs of large individuals of *T. lepturus* is note-worthy.

References

BASHEERUDDIN, S. AND K. N. NAYAR 1962. A preliminary study of the juvenile fishes of coastal waters off Madras City. *Indian J. Fish.*, **8** : 167-188.

CLARK, F. N. 1934. Maturity of the California sardine (*Sardina caerulea*) determined by ova diameter measurements. *Fish. Bull. Scaramento*, **42** : 7-49.

DAWSON, C. E. 1967. Contributions to the biology of the cutlass fish (*Trichiurus lepturus*) in the Northern Gulf of Mexico. *Trans. Amer. Fish. Soc.*, **96** ; 117-121.

DUTT, S. AND V. THANKAM 1967. Two new species of trichiurid fish from Waltair. *J. Bombay nat. Hist. Soc.*, **63** (3) : 755-758.

GUPTA, M. V. 1967. Two new species of ribbonfishes of the genus *Trichiurus* Linnaeus (Pisces : Trichiuridae) from the Hooghly estuarine system. *Proc. Zool. Soc.* Calcutta, **19** : 169-170.

HAMADA, R. 1971. Age and growth of the ribbonfish *Trichiurus lepturus* Linnaeus based on the transverse

section of the otolith. *Bull. Seikal. Reg. Fish.* Lab., **41** : 53-62.

JAMES, P. S. B. R. 1967. The ribbonfishes of the family *Trichturidae* of India. Mem. 1, *Mar. biol. Ass. India*, pp. 226.

——— 1969. Comments on the four new species of ribbonfishes (Family : Trichiuridae) recently reported from India. *J. mar. biol. Ass. India*, **9** (2) : 327-338.

MISU, H. 1958. Studies on the fisheries biology of the ribbonfish (*Trichiurus lepturus* Linnaeus) in the East China and Yellow Seas. 1. On the age and growth. *Bull. Seikai Reg. Fish. Res. Lab.*, **15** : 1-16.

——— 1958. Studies on the fisheries biology of the ribbonfish (*Trichiurus lepturus* Linnaeus.) in the East China and Yellow Seas. 2. On the maturity and the spawning. *Ibid.*, **16** : 21-33.

——— 1964. Fisheries biology on the ribbon fish (*Trichiurus lepturus* Linnaeus) in the East China and Yellow Seas. *Ibid.*, **32** : 5-58.

NARASIMHAN, K. A. 1972 a. On the length-weight relationship and relative condition in *Trichiurus lepturus* Linnaeus. *Indian J. Fish.*, **16** : 90-96.

——— 1972 b. Occurrence of early juveniles of the ribbonfish *Trichiurus lepturus* Linnaeus in the Kakinada area with notes on their food. *Ibid.*, **19** : 210-214.

——— 1976. Age and growth of ribbonfish *Trichiurus lepturus* Linnaeus. *Ibid*,, **23** : 174-182.

PRABHU, M. S. 1955. Some aspects of the biology of the ribbonfish. *Trichiurus haumela* (Forsskal) *Ibid.*, **2** : 132-163.

SILAS, E. G. AND M. RAJAGOPALAN 1975. Studies on demersal fishes of the deep neritic waters and the continental slope. 2. On *Trichiurus auriga* Klunzinger with notes on its biology. *J. mar. biol. Ass. India*, **16** (1) : 253-274.

TAMPI, P. R. S., P. T. MEENAKSHISUNDARAM, S. BASHEERUDDIN AND J. C. GNANAMUTHU 1971. Spawning periodicity of the ribbonfish *Trichiurus lepturus* Linnaeus with a note on its rate of growth. *Indian J. Fish.*, **15** : 53-60.

TANG, S. F. AND H. W. WU 1936. A preliminary note on the spawning ground of *Trichiurus japonicus* (Schlegal) in Poi-hai *Ling. Sci. Jour.*, **15** (4) : 651.

VIJAYARAGHAVAN, P. 1951. Food of the ribbonfishes of Madras. *J. Madras Univ.*, B **21** : 81-95.