

BIOLOGY AND FISHERY OF SILVERBELLY *LEIOGNATHUS DUSSUMIERI* (VALENCIENNES) FROM GULF OF MANNAR

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ABSTRACT

Length-weight relationship of male and female *L. dussumieri* was found to be different. Within females, the immature, maturing, mature and spent-recovering females differ from one another in the length-weight relationship. Males weigh comparatively less than females. Among the females, immature, maturing and spent-recovering females weigh more than mature females. This species mainly spawns during April-May and November-December. Minimum size of maturity for males were found to be 78 mm and for females 83 mm. Generally, females predominate over males in the commercial catches. The counts of mature ova ranged from 805 to 41683 per female. The fecundity-length relationship has been studied by three different formulae and it was found that fecundity is better related to direct cube of length.

The most important items of food of the species included polychaetes, copepods, amphipods, bivalves, gastropods and foraminiferans. No significant variations in the food of fish from different places in different seasons; have been found. The feeding habits of this fish also do not change with age. The fish was found to feed more actively in the month of January, February, April and November at Kilakarai. The fish attains the length of 99 mm at the end of first year, 114 mm at the end of second year, 128 mm at the end of third year, 138 mm at the end of fourth year and 145 mm. at the end of fifth year. The life span of the species was found to be five years, the maximum length recorded in the present study was 161 mm.

Good catches are obtained from deeper waters (20 to 40 metre) of Gulf of Mannar. The species is mainly landed by drift gillnets and trawl nets, zero, one year and two year old fish contribute the bulk of the commercial catches. More intensive fishing in deeper waters of Gulf of Mannar would augment the catches of this species.

INTRODUCTION

The fishes of the family LeAognathidae, popularly called silverbellies contribute to an important fishery in the states of Tamil Nadu, Kerala, Andhra Pradesh and Karnataka. Of these states, Tamil Nadu accounts for the bulk of the catches of silverbellies. Within Tamil Nadu, the southeast coast comprising Palk Bay and Gulf of Mannar regions yield very high catches of silverbellies. In

these regions, the fishery is almost continuous throughout, generally from April to October along the Palk Bay and November to March along the Gulf of Mannar coast.

In this area, of the 19 species of silverbellies known to occur in the seas around India, except *Leiognathus blochii*, *L. elongatus* and *L. indicus*, all the other 16 species occur in varying proportions throughout the year. Of the 16 species occurring in this area, *L. jonesi* is the most dominant in Palk Bay followed by *L. brevisrostris* and *S. ruconius*. In the Gulf of Mannar, the relative abundance of various species varies considerably, *L. dussumieri* being one of the dominant species. Other species commonly found in the Gulf of Mannar are *L. bindus*, *Secutor insidiator*, *S. ruconius* and *Gazza minuta*.

Published information on various aspects of the systematics, biology and fishery of the silverbellies in Palk Bay and the Gulf of Mannar region includes the works of James (1968, 1969, 1975) on the systematics; Chacko (1949) Arora (1951) James and Badrudeen (1975) on the biology; Chacko (1944 a, b) Krishnamurthy (1957), Mahadevan (1958), James and Clement Adolf (1965) James (1973), Venkataraman and Badrudeen (1974) on the fishery. In addition, James (1971) reported the occurrence of the blue green algae on silverbellies and James and Badrudeen (1968) dealt with certain abnormalities in the family Leiognathidae. Published information on Leiognathidae from elsewhere along the Indian coast includes the works of Venkataraman (1960), Balan (1963), Satyanarayana Rao (1968) Mahadevan Pillai (1972) on biology; Rani Singh and Talwar (1978a, 1978b) on systematics and Jayabalan et al (1978) on the occurrence of a symbiotic bioluminescent bacteria in Leiognathids.

Since no detailed information is available on the biology and fishery of *L. dussumieri*, a detailed study is made during 1963-67 and results are given in this paper.

MATERIAL AND METHODS

Material for this study was collected from the commercial fish catches landed at Kilakarai (drift gill nets—*mayavalai*—55 to 60 mm mesh size), Mandapam (trawlnets) and Vedalai (drift gillnets—*Choodavalai*—25 mm mesh size). These gears are operated at depths ranged from 7 to 40 m. All the samples were preserved in formalin for detailed analyses. Standard method employed by various authors for length-weight relationship (Kesteven 1947, Leoren 1951); age and growth (Petersen 1892, Graham 1929, Menon 1950, 1952), food and feeding habits (Hynes 1950, Pillay 1953), maturity and spawning (Clark 1934, Hickling and Ruterberg 1936, Dejong 1940, Prabhu 1956) were followed. Details of the methods used are given under the respective sections.

LENGTH-WEIGHT RELATIONSHIP

A total of 213 females ranging in size from 75 to 149 mm and 105 males ranging in size from 75 to 129 mm were analysed for length-weight relationship

according to different stages of maturity., immature (Stage I), maturing (Stage II), mature (Stage III) and spent (Stage IV). The relevant date are given in Table 1.

TABLE 1. *Statistics of length-weight relationship of L. dussumieri.*

	Female				Male		
	Immature	Maturing	Mature	Spent recovering	Immature	Maturing	Mature
N	24	146	20	15	17	78	10
ΣX	47.0766	293.9454	57.5594	3&7603	33.0534	154.1132	20.2322
SX ²	92.3650	592.1101	118.3672	63.0945	64.2857	304.6712	40.9520
ΣY	24.7336	175.4515	36J8745	20.0411	16.5058	82.6247	12.1534
SXY	48.5979	3'54.1846	75.9480	41,1370	32.1615	163.7471	24.6399
ΣY ²	25.8039	213.9486	49.0920	26.9009	16.2834	89.0836	14.9227
a	-5.9633	-5.0776	-5.6675	-4.0611	-5.9549	-4.6170	-4.5657
b	3.5655	3.IIIS9	3.3976	2.6319	3.5621	2.8729	2.8573
b +	0.1974	0.0608	0.1SH5	0.3394	0.1988	0.0102	0.0474
r	0.9662	0.9737	0.9645	0.9066	0.9777	0.9561	0.9776

N = Number of specimens. a, b = regression coefficients.
 2ΣX, ΣY = Sums of Log. length (X) and Log. weight (Y) b + = Standard error of estimate 'b'
 2ΣX².ΣY², ΣXY = Sum of squares and products. r = correlation coefficient.

Details of the analyses of covariance for data on males and females are shown below:

Source of variation	Degrees of freedom	Sum of squares	Mean square	F
Deviation from average regression	315	0.4646		
Deviation from individual regressions within samples	314	0.4282	0.0014	
Difference	1	0.0364	0.0364	26.02

The analyses indicated that differences between the regression coefficients were significant at 1% level.

The test of heterogeneity was performed for data on the three groups of males viz., Stage I, Stage II and Stage III. The details are:

Source of variation	D.F.	S.S.	M.S.	F
Deviation from average regression	101	0.1633		
Deviation from individual regressions within samples	99	0.1524	0.0015	
Difference	2	0.0109	0.0055	3.57

It was found that the difference between the regression coefficients was not significant at 1% level. Hence data for all the stages of males were pooled (Fig. 1) and a pooled regression estimate was made for males. The logarithmic and parabolic equations for males were found to be:

$$\text{Log } W - 2.9591 \text{ Log } L - 4.7850$$

$$W - 0.000016406 L$$

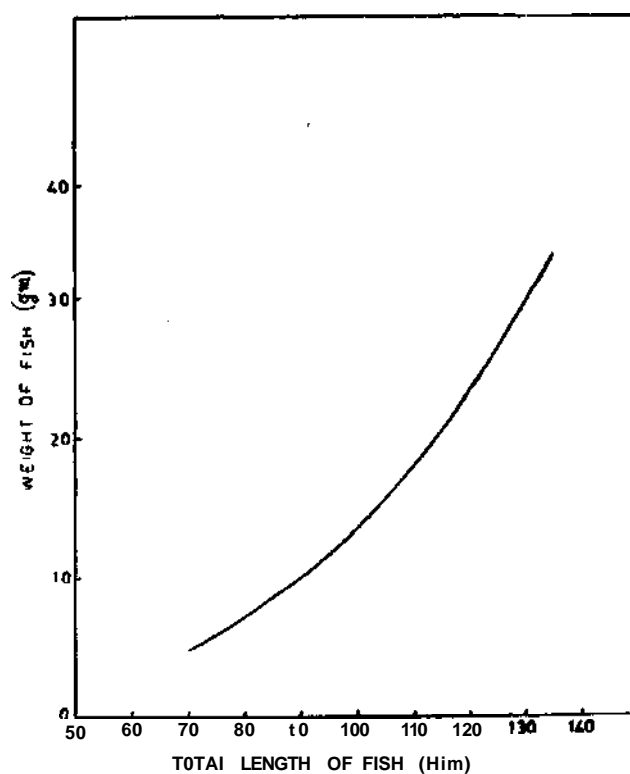


FIG. 1. Length-weight relationship of males of *L. dussumieri*.

The differences between the regression coefficients for the various groups of females viz., immature, maturing, mature and spent were tested and the 'F' values are given below:

	F	F1%	Degrees of freedom
Between stages I, II, III & IV	6.72	3.78	3:205
Between stages I, II & III	6.58	4.61	2:192
Between stages I, II & IV	5.54	4.61	2:179
Between stages II & III	7.82	6.63	1:170
Between stages III & IV	11.49	7.31	1: 39
Between stages I & II	4.19	6.63	1:166

The above covariance analyses showed that the regression coefficients of the immature and maturing groups alone were not significant at 1% level. Hence, logarithmic and parabolic equations for lengthweight relationship for the various groups of females are given below. The curves are shown in Fig. 2.

Immature and maturing females:

$$\begin{aligned} \text{Log } W &= 3.1732 \text{ Log } L - 5.1878 \\ W &= 0.0000064893 L^{3.1732} \end{aligned}$$

Mature females:

$$\begin{aligned} \text{Log } W &= 3.3976 \text{ Log } L - 5.6675 \\ W &= 0.0000021503 L^{3.3976} \end{aligned}$$

Spent females:

$$\begin{aligned} \text{Log } W &= 2.6319 \text{ Log } L - 4.0611 \\ W &= 0.000086876 L^{2.6319} \end{aligned}$$

Applying 't' test, it was found that the regression coefficients of the males and females of Stage I and II were significantly different from 3 at 1% level and the regression coefficients of mature females (Stage III) and spent females (Stage IV) were not significant at 1% level. The results are given below.

Groups	Regression coefficient b	Standard error of b +	to b-3	t	D.F.	t 1 %
Male	2.9591	0.0064	-0.0409	6.39	103	2.62
Female Stages I & II	3.1732	0.0029	0.1732	59.72	168	2.60
Female Stage III	3.3976	0.1815	0.3976	2.19	26	2.78
Female Stage IV	2.6319	0.3394	-0.3681	1.08	13	3.01

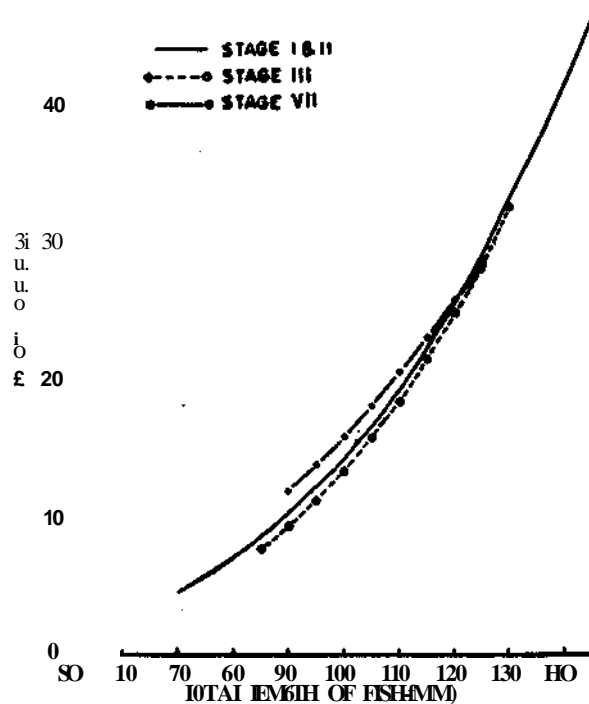


FIG. 2. Length-weight* relationship of females, of *L. dmsumieri*.

The results of the analyses of data on lengths-weight (Figs 1&2) show that the males weigh comparatively less than the females. Among the females, the immature, maturing and spent females weigh more than the mature females. This may be due to the accumulation of fat in fish other than the mature fish.

REPRODUCTION /

Maturity. Maturity of the species was studied by classifying the gonads into various stages of maturity based on macroscopic and microscopic structure. The following maturity stages were recognised.

Stage I : Ovaries small, transparent, occupying a very small portion of the body cavity. Ova not visible to the naked eye, measure a maximum of 6 oc. m.d. (one ocular micrometer division = 0.021 mm). Testes similar in appearance as the ovaries.

Stage II : Ovaries occupy about 1/3 of body cavity, semitransparent. Granular ova visible to naked eye, measure a maximum of 15 oc.m.d. and the mode of the largest group of eggs falls at 11 oc.m.d. Testes semitransparent, occupy about 1/3 of body cavity. •

Stage III : Ovaries occupy about i the body cavity, yellow in colour, ova measure a maximum of 18 oc.m.d. the mode of the largest group of eggs falls at 14 ocm.d. Ova opaque with full deposition of yolk. Testes occupy about i the body cavity, creamy-white in colour.

Stage IV : Ovaries occupy about $\frac{1}{3}$ of the body cavity, pale yellow in colour, ova measure a maximum of 24 oc.m.d. The mode of the largest group of ova lies at 20 oc.m.d. ova semitransparent. Testes creamy-white and occupy nearly $\frac{1}{3}$ of the body cavity.

Stage V : Not recorded in this study.

Stage VI : Not recorded in present study.

Stage VII : Ovaries small, blood-shot, occupy less than $\frac{1}{3}$ of the body cavity, maximum size of ova 18 ocm.d. the mode of the largest group of ova falls at 14 oc.m.d. Testes small and occupy less than $\frac{1}{3}$ of the body cavity.

Development of ova to maturity: Size distribution, of ova in different stages of maturity is shown in Fig. 3. Except in stages I and VII, ova smaller than 4 ocm.d. were not measured, as they are present in all the ovaries, representing the immature stock. In stage I, the ova measure a maximum of 6 oc.m.d. In stage II, a small group of ova with a mode at 11 oc.m.d. gets separated from the general

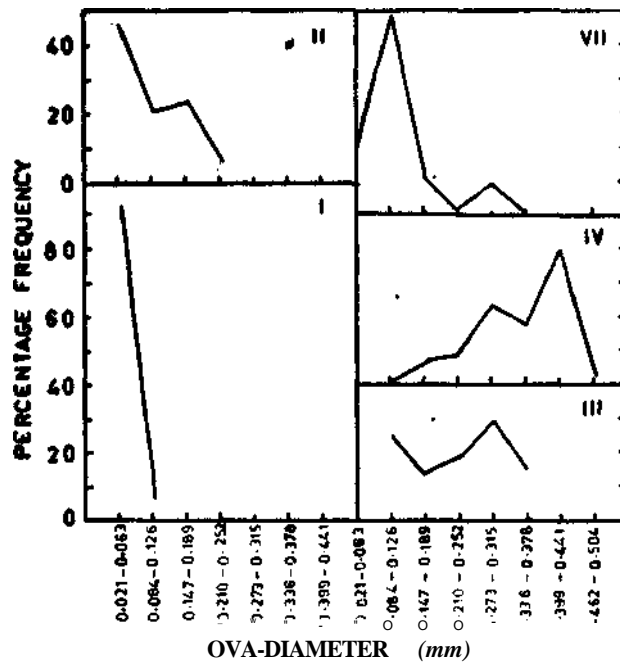


FIG. 3. Ova-diameter frequency polygons for various stages of maturity in *L. dussumwri*

stock. In this stage, the ova measure a maximum of 15 oc.m.d. In stage III, the group of ova which got separated from the general stock shows a progress with a mode at 14 oc.m.d. The maximum-size ova in this stage reaches 16 oc. m.d. In stage IV, two distinct modes may be seen, the first one at 20 and second one at 14 oc.m.d. But the two modes are not well separated from each other or from the general stock. Stage V and VI were not encountered in the present study. In stage VII (spent), in addition to the general stock of ova, two modes are seen, one at 14 and another at 5 oc.m.d, The mode in stage IV at 14 oc.m.d. corresponds to the second mode in stage IV at 14 ocm.d. Therefore, it appears that release of ova may be at short intervals.

Spawning season: The distribution of maturity stages month-wise is shown in Figs 4 and 5. The data indicate that at Kilakarai, Mandapam and Vedalai fish were predominantly in stages I, II, III and VII. Stages IV occurred very rarely and hence not included in the tables. In view of the rare occurrence of stage IV and non-occurrence of stages V and VI, the occurrence of stage III is considered as an index of spawning activity, correlated with the occurrence of spent fish. The mature fish (stage III), occurred in fairly high percentage during the months of February, March at Kilakarai and January to March at Mandapam.

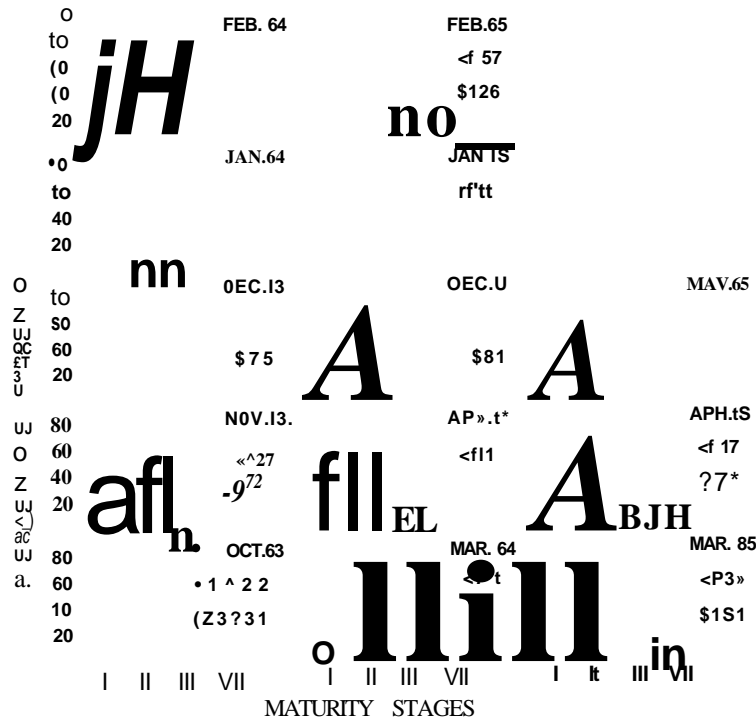


FIG. 4. Month-wise occurrence of males and females of *L. dussumieri* in various of maturity, at Kilakarai' (October 1963 to May 1965).

Spent fish were in greater percentage in April, May, November and December at Kilakarai and November at Mandapam. Since the mature fish was available from January to March and spent fish in April, May and November, December,

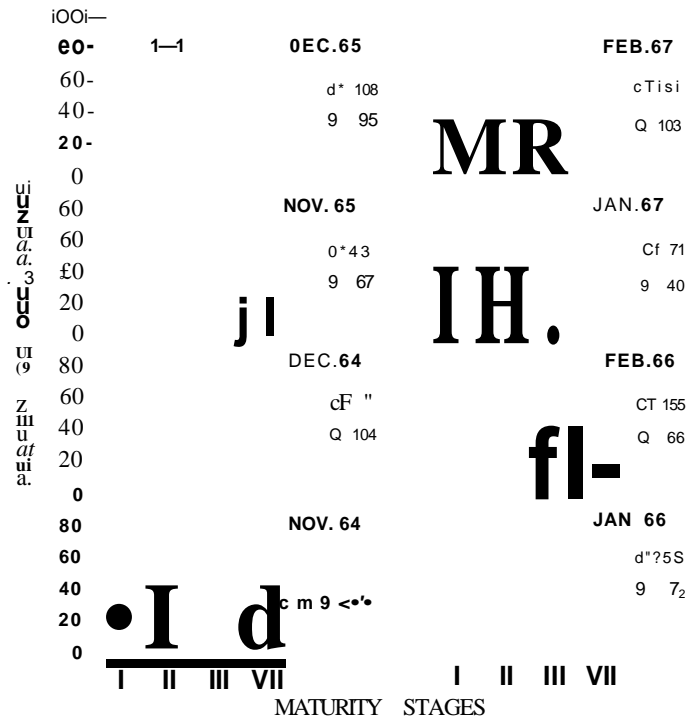


FIG. 5. Monthly occurrence of males and females of *L. dussumieri* in various stages of maturity at Mandapam (March 1964 to February 1967).

it appears that the fish may spawn in April, May and November, December. Since data on the occurrence of mature and spent fish are not continuously available for all the months, it has not been possible to precisely fix the total spawning period.

Size at first maturity: For the determination of size at first maturity, frequency of occurrence of different stages of maturity in various size groups was studied. Results for males and females from Kilakarai and Mandapam are given in Table 2 & 3.

Owing to very rare occurrence of fish in stage IV and complete absence of stages V and VI, fish in stage III were considered as mature for this purpose. In the case of males from Kilakarai, the smallest mature fish was found in the size group 88-92 mm, and the spent fish in the size group 98-102 mm. In the case of males from Mandapam, the smallest mature fish was found in the size group 78-82 mm and smallest spent fish in 83-87 mm group. Therefore, it is possible to conclude that males might be maturing at any size between 78-87 mm.

TABLE 2. *Percentage occurrence of females and males of L. dussumieri in different stages of maturity during the period from 1963 to 1965 Kilakarai (Gulf of Mannar).*

Stage of maturity	Females		Males	
	Size range (mm)	Occurrence (%)	Size range (mm)	Occurrence (%)
I	58-127	2.94-100.0	58-122	3.23-100.0
II	78-147	14.29-100.0	78-132	12.50-100.0
III	88-137	4.35-100.0	88-127	5.00-100.0
VII	88-132	5.26- 50.0	98-117	3.23-100.0

In the case of female fish from Kilakarai, the smallest mature fish was found in the size group 88-92 mm and the spent fish also in the same group. In the case of female from Mandapaim, the smallest mature fish was found in the size group 83-87 mm and smallest spent fish in the size group 93-97 mm. From this data it is possible to conclude that females must be maturing at any size from 83 to 92 mm. Therefore, the minimum size of maturity for male may be stated to be 78 mm and for female 83 mm.

TABLE 3. *Percentage occurrence of females and males of L. dussumieri in different stages of maturity during the period from 1964 to 1967 from Mandapam (Gulf of Mannar).*

Stage of maturity	Female		Male	
	Size range (mm)	Occurrence (%)	Size range (mm)	Occurrence (%)
II	68-142	3.13-100.0	68-107	1.03-100.0
II	73-142	13.33-100.0	73-132	22.22-100.0
III	83-137	3.23-100.0	83-127	0.85-100.0
VII	93-132	4.55-100.0	83-117	0.85-35.29

Fecundity: Fecundity estimations were made for 114 fish by the gravimetric method. The linear relationship between ovary weight and fecundity was found to be:

$$\text{Fecundity (in thousands)} = 1.462 + 0.0131 \times \text{Ovary weight (mg)}$$

The correlation coefficient 'r' has been found to be 0.86. The means and standard deviations of ovary weight and fecundity were found to be 617 mg, 9.45 thousands and 484 mg, 7.4 thousands. The scatter diagram and the fitted line for ovary weight and fecundity are presented in the Fig. 6.

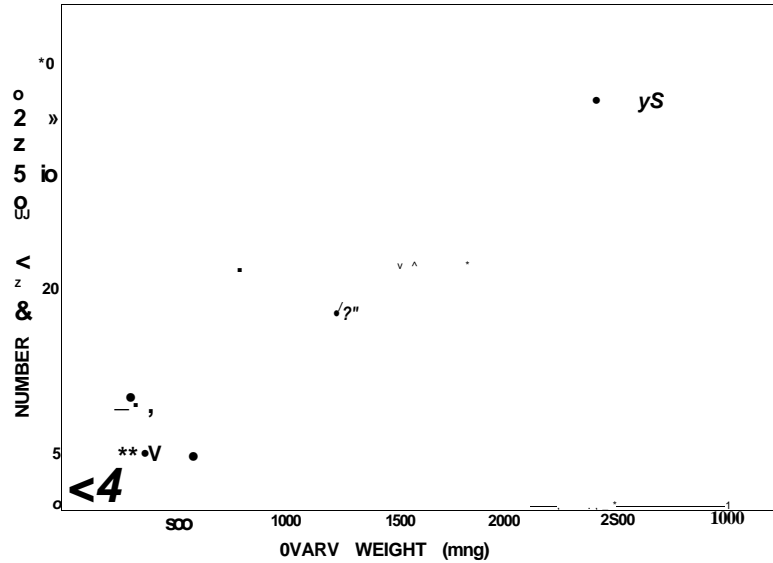


FIG. 6. Relationship between weight of ovary and number of mature ova for samples of *L. dussuneri* at Maodiapam and KiakairaJ.

The scatter diagram of fecundity-length data is presented in Fig. 7. The relationship was studied by using the formulas $Y = aX^D$, $Y = a + bX^3$ and $Y = bX^3$. The details are given below:

Formulae	Constants		Std. error of b +	correlation coefficient r
	a	b		
$Y = aX^b$	0.000183	3.8749	0.5753	0.55
$Y = a + bX^3$	-2081	0.01412	0.0024	0.50
$Y = bX^3$	—————	0.01193	0.0066	0.87

The sums, sum of squares and products for the equation $\text{Log } X = a + b \text{Log } Y$ ($Y = aX^b$) were: $\sum X = 205.4515$; $\sum X^2 = 406.0728$; $\sum Y = 407.4241$; $\sum Y^2 = 1606.0655$ and $\sum XY = 805.6561$.

For the equation, $Y = a + bX^3$, the sums of squares etc. were as follows; $\sum X^3 = 91644684$; $\sum (X^3)^2 = 87358651000000$; $\sum Y = 1077253$; $\sum Y^2 = 16368371000$ and $\sum X^3 Y = 104266500000$.

For the formulae $Y = bX^3$ the sums of squares and products are same as for the formulae $Y = a + bX^3$ but the 'Y' intercept 'a' is forced to be zero and the slope 'b' is obtained by using the formula,

$$b = \frac{\sum (X^3 Y)}{2 \sum (X^3 P)}$$

Among the three curves fitted, it is found that fecundity is better related to direct cube of length.

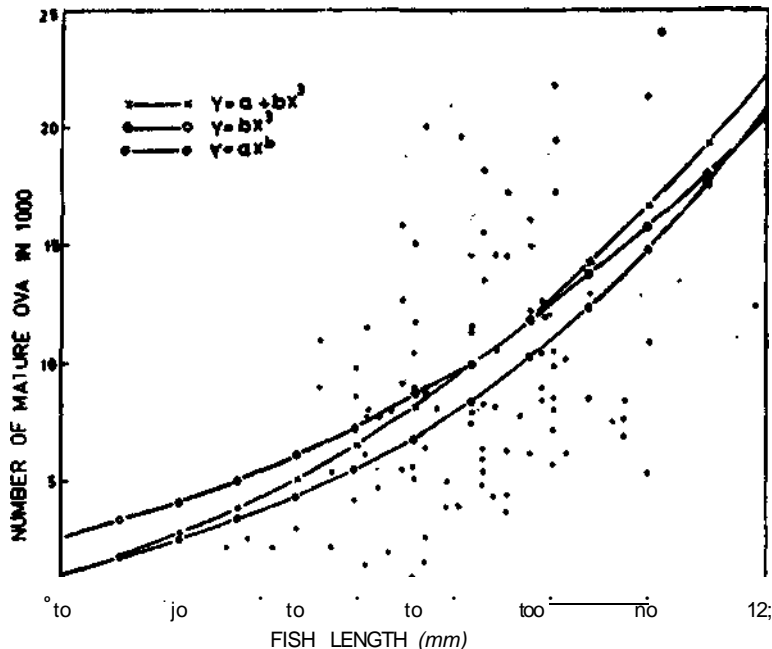


FIG. 7. Comparison of fecundity-length regression according to different formula for samples of *L. dussumieri* from Mandapam and Kilakarai.

Sex ratio: For this study, samples of *L. dussumieri* collected from trawl catches at Mandapam, drift gillnet catches at Kilakarai and Vedalai and shore seine catches at Vedalai were analysed. In the month-wise data presented in Table 4, females dominated only in the catches obtained from gillnets and shore seines. Males showed significant dominance during the months January and February 1966 & 1967. The gear-wise pooled data showed significant dominance of males in trawl catches at Mandapam and females in gill net catches at Kilakarai and shore seine catches at Vedalai.

Season-wise data with chi-square values are presented in Table 5. The highly significant dominance of males in trawl catches from January to March resulted in the dominance of males for the season 1965-'66. The pooled data for the period January-March revealed the high significant dominance of males in trawl catches and females in other gear.

TABLE 4. Sex-ratio of *L. dussumieri* collected from different gears and centres along Gulf of Mannar.

Month	Observed ¹ Males	No. of Females	Ratio of female (male = 1)	Chi-square value
I Mandopam (Trawl net)				
March 64	34	39	1.14	0.34
November	18	49	2.72	14.34 **
December	41	104	2.54	27.37 **
November 65	43	67	1.56	5.24 **
December	108	95	0.88	0.83
January 66	256	72	0.28 ¹	103.22 ***
February	155	87	0.56	19.11 **
January 67	71	40	0.56	8.66 **
February	181	103	0.57	21.42 **
Total	907	656	0.72	40.31 **
II. Kilakkarai (gillnet)				
October 63	22	31	1.41	1.33
November	27	72	2.67	20.45 **
December	49	75	1.53	5.45 **
January 64	1	6	6.00	3.57
February	15	19	1.27	0.47 **
March	6	39	6.50	24.20 **
April	11	61	5.55	34.72 **
December	6	82	13.67	65.64 **
January 65	16	22	1.38	0.95
February	57	126	2.21	26.02 **
March	35	151	4.31	72.34 **
April	17	74	4.35	35.70 **
May	7	14	2.00	2.33
Total	269	774	2.88	244.51, **
III. Vedalai-gillnet				
April 66	36	44	1.22	0.80
May	13	15	1.15	0.14
June	8	14	1.75	1.64
Total	57	73	1.28	1.97
IV. Vedalai - shore seine				
May 66	29	53	1.82	7.02 **
November	6	17	2.83	5.26 *
February 67	75	120	1.60	10.38 **
April	39	56	1.44	3.04
Total	149	246	1.65	23.82 **

* Significant at 5%

¹* Significant at 1%

TABLE 5. *Season-wise sex-ratio (Male : Female) of L. dussumieri for the years 1963-64 to 1966-67 from the near shore catches (gillnets & shore seines) and off shore catches (Trawl nets) from Gulf of Mannar with Chi-square values (M = Males; F = Females).*

	1963-64			1964-65			1965-66			1966-67			Total		Chi-square
	M	F	Chi-square	M	F	Chi-square	M	F	Chi-square	M	F	Chi-square	M	F	
Oct. Near shore catches	98	180	24.19	6	82	65.64	•-	—	—	6	17	5.26	110	279	73.42
Dec. Off shore catches	—	—	—	59	153	41.68	(151	: 162)	0.39	—	—	—	(210	: 315)	21.00
last. Near shore catches	22	64	20.51	108	299	89.63	--	—	—	75	120	10.38	205	483	112.33
Mar. Off shore catches	34	39	0.34	—	—	—	(411	: 159)	111.41	(252	: 143)	30.08	(697	: 341)	122.10
Apr. Near shore catches	11	61	34.72	24	88	36.57	86	: 126	7.55	39	56	3.04	160	351	71.39
Jun. Off shore catches	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	165	344	62.95	197	622	220.54	648	: 447	36.90	372	: 336	1.83	1382	: 1769	47.53

In Tables 6 and 7 data on the ratio of males to females for each 5 mm group, for trawl net catches and gillnet catches are presented. The data indicate that in the size groups 75-95 mm males significantly dominated in trawl catches alone. The females dominated in the size groups 95-125 mm in gillnet catches and in 110-120 and 130 mm groups in trawl catches.

TABLE 6. *Chi-square test for L. dussumeri of different size groups from trawl net catches at Mandapam.*

Size group (mm)	Males	Females	Chi-square value
70	2	1	0.33
75	17	3	9.80 **
80	68	25	19.88 **
85	202	62	74.24 **
90	179	82	36.05 **
95	193	116	19.19 **
100	114	123	0.34
105	76	86	0.62
110	26	73	22.31 **
115	17	40	9.28 **
120	6	24	10.80 **
125	5	12	2.88
130	—	7	7.00 **
135	—	1	1.00
Total	905	655	40.06

* Significant at 5%

** . Significant at 1%

The percentage length-frequency distribution in trawl net catches and gillnet catches (Fig. 8) showed that there was no selection of sex within the size ranges obtained in respective gears. The modal positions of the curve for males are similar to those in the curve for combined sexes in the respective gears. This indicates that there is no growth variation between sexes. The percentage of males in each length group in trawl net and gillnet catches indicated that the males decline from 95 mm and 110 mm group in gillnet catches and trawl net catches respectively (Fig. 9).

The foregoing analyses shows that generally females predominate over males in the commercial catches -and during the period January-March males were significantly in higher numbers than females. In *L. brevirostris* also, females were found to dominate in the trawl catches obtained from Gulf of Mannar except during February and March (James and Badrudeen 1975).

TABLE 7. Chi-square test for *L. dUssumienii* of different size groups from gillnet catches at Kilakkarai.

Size group (mm)	Males	Females	Chi-square values
60	3	1	1.00
65	4	4	0.00
70	5	5	0.00
75	5	4	0.11
80	7	7	0.00
85	11	14	0.36
90	32	45	2.19
95	40	97	23.72 **
100	49	155	55.08 **
105	58	162	49.16 **
110	30	126	59.08 **
115	13	83	51.04 **
120	9	44	23.11 **
125	2	13	8.07 **
130	2	3	0.20
135	—	1	1.0
140	—	—	—
145	—	1	1.0
Total	270	765	236.74 **

* Significant at 5%

** Significant at 1%

FOOD AND FEEDING HABITS

A total of 478 fish from KMcarai, M'andiapam were examined for the analyses of gut contents. The gut contents were examined qualitatively and quantitatively. For qualitative estimation, points (Volumetric) method as given by Hynes (1950) was adopted. Each food item in the gut was allotted certain number of points based on its volume and taking into consideration both the size of the fish and the fullness of the gut. The results are given in Tables 8 and 9. The data indicate that copepods, polychaetes, amphipods, bivalves, gastropods and foraminiferian were the dominant items of food. Other items were present only in minor quantities. *Coscinodiscus* was recorded only on two occasions. Sand grains were occasionally present. At all the places the guts contained high percentage of semi-digested matter which could not be separately identified and attributed to individual groups.

Variation in the food of the fish during different years: For this purpose, data from Kilakkarai during the years 1963 to 1965 (Table 8) were available for comparison. From the table it may be seen that copepods were more abundant in 1965 compared to 1964. Amphipods were recorded in 1964 only. Gastropods,

bivalves and polydaietes were more abundant in 1965 than in 1964. There were no significant differences in the relative quantities of other items in both the years.

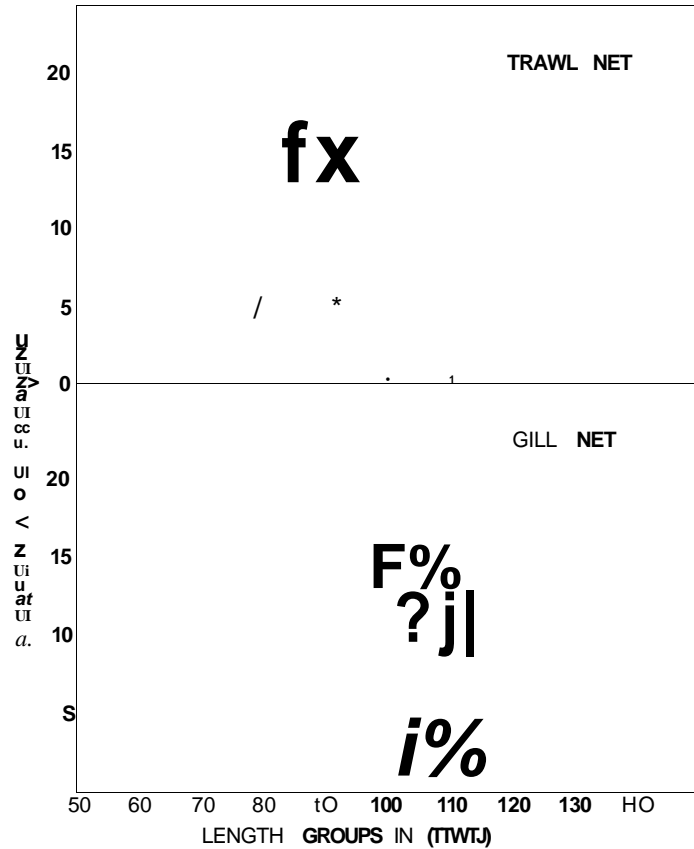


FIG. 8. Petrwmtaige Jenigth^frequeincy distililbutdoin of males and females of *L. dussumieri* in trawlnt and gilneit caliches.

Seasoned occurrences of food items: No significant difference were found between the months with regard to the major items in gut contents.

Variations in food of fish from different places: The data on gut contents for different places during the years 1963 to 1967 are given in Tables 8 and 9. The results indicate that the fish has fed upon fee same items at different places. At Vedalai, amphipods and crustacean remains were absent in the gut contents. This may perhaps be due to the bigger sizes of fish obtained from the drift gill nets at this place.

Intensity of feeding: For the study of intensity of feeding, the guts of fishes were classified into various catgories designated as full, J full, 1 full, *i* full, little and

empty depending on the degrees of their fullness. The results of the study on the intensity of feeding of fish from Kilakarai (October to Deoemiber 1963, January to April 1964 and January to May 1965) and from Mandapam (November 1965 to February 1966) are given in Tables 10 and 11 respectively. Majority of the fish from Kilakarai from; October to December 1963 had the guts *i* full and *i* full. During the period January to April 1964 majority of the fish had the

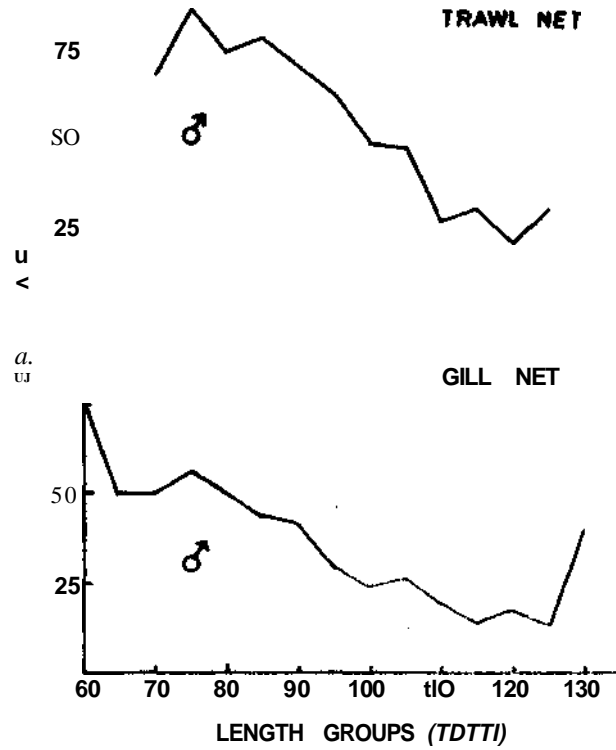


FIG 9. The percentage of males of *L. dussumieri* in each length group in trawl net and gill net catches.

guts *i* full and *i* full and from January to May 1965 majority of the fish had the guts *f* full, *i* full and *i* full. During the period October to December 1963, intensive feeding was found in November; during the period January to April 1964, fish fed intensively in February and during the period January to May 1965, they fed intensively in January and April. In general, the fish was found to feed more actively in the months of January, February, April and November (Table 10). Fishes from Mandapam were found to have the guts *i* full and *i* full from November 1965 to February 1966. No significant differences were found between the months (Table 11).

TABLE 9. *Relative importance of food items in the gut contents of L. dussumieri from Mandapam (Gulf of Mannar) during the period 1964 to 1966. (Values expressed in percent. Figures in parantheses indicate number of fish examined. Samples obtained from trawl net only).*

	1964			1965		1966	
	Miair. (42)	Nov. (10)	Dec. (20)	Nov. (10)	Dec. (20)	Jan, (30)	Feb. (36)
semii-digested matter	49.05	46.00	51.04	47.33.	46.95	48.30	51.89
Copapodies	15.51	20.00	3.12	10.72	8.96	13.96	8.29
Folyohaetes	12.34	—	2.08	8.93	10.03	7.55	6.40
Crustacean remains	1.90	8.00	14.5*	8.93	5.01	3.02	5.69
Amphjpodes	7.91	—	—	• —	—	0.3S	—
Nemait-odes	1.58	—	5.21'	—	—	—	—
G:lstirapods	0.63	8.00	2.08	8.93	12.90	9.06	12.80
Biwailves	9.17	10.00	6.25	5.36	7.08	8.30	8.53
Fish scales	—	—	5.21	—	1.79	0.3i8	—
Foramiiiiifecans	1.90	6.00	—	9.83	6.45	8.63	6.40
Sand grains	—	2.00	5.21l	—	—	—	—
<i>Coscinodiscus</i>	—	—	5.21	—	—	0.38	—

Feeding habits in relation to age: In order to study the relation between the feeding habits and age of fish, data collected from Kilakarai (1963 to 1965) and Mandapam (1964 to 1966) were analysed. Data for all the years from each place were pooled together and tabulated (Tables 12 and 13).

Kilakarai: At this place, semidigested remains, copepods, polychaetes, crustacean remains and amphipods have been found to be the most common. They were found in the gut contents of all the fish ranging in size from 53-132 mm. The other items, the nematodes, gastropods, bivalves, fish scales, foraminiferans and *Coscinodiscus* were mainly restricted to fish of the size range 73 to 117 mm. Of these items, *Coscinodiscus* were present in a restricted size range of 93 to 107 mm. From this it appears that while certain items were fed upon by fish of all sizes certain others appear to be limited to restricted size ranges.

Mandapam: The data from Mandapam show that except *Coscinodiscus*, all the other items of food were present in the entire size range of 63 to 132 mm. *Coscinodiscus* were present in fish ranging in size from 68 to 97 mm.

Although some differences were found in the data from Kilakarai and Mandapam in the presence of certain items of food in particular size ranges, pooled data for both the places indicate that there is no significant change in the feeding habits of the fish in relation to increase in size (age).

AGE AND GROWTH

i) *Length-frequency distribution:* For this study samples of fishes were collected from Kilakarai (December 1963 to 1965), Mandapam (November 1964 to

TABLE 10. *Percentage occurrence of the guts of L. dussumieri in various degree of fullness from Kilakarai (Gulf of Mannar) October 1963 to April 1964 and January to May 1965).*

Condition of food	1963			1964				1965				
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Jan	Feb	Mar	Apr	May
No. of fishes	20	34	30	10	20	17	40	10	40	42	20	11
MI	—	1.76	13.33	—	—	23.53	5.00	—	10.00	2.38	5.00	9.09
i Full	5.00	23.53	3.33	20.00	65.00	29.41	17.50	40.00	22.50	21.43	50.00	18.18
i Full	20.00	23.53	43.33	20.00	35.00	41.18	35.00	30.00	25.00	21.43	—	18.18
i Fuji	15.00	17.65	16.67	50.00	—	5.88	12.50	—	22.50	26.19	10.00	36.36
Untie	60.00	23.53	23.33	10.00	—	—	40.00	30.00	20.00	28.57	35.00	18.18
Empty												

1967) and from Vedalai (February 1966 to June 1966). Fish were grouped into 5 mm length groups and the percentage of each group in the total for each month has been calculated. The length-frequency curves for the 'three' places are shown in Figs. 10 to 12.

Kilakarai: During December 1963 (Fig. 10) four modes were observed at 70, 90, 105 and 120 mm. In January 1964, no distinct mode was found, whereas in February, three modes were found at 100, 110 and 120 mm. In March only one distinct mode was found at 100 mm. In April a single mode was present at 95 mm. The length-frequency curves indicate that fish of a wide size range were available in December when compared to other months.

In December 1964, two modes were seen at 100 and 110 mm. In January, February and March 1965 only a single mode was present at 150 mm. In April, a single mode was present at 110 mm. In May, a single mode was found at 100 mm.

TABLE 11. *Percentage occurrence of the guts of L. dussumieri in various degrees of fullness from Mandapam (Gulf of Mannar) (November 1965 to February 1966).*

No. of fish	1965		1966	
	Nov. 10	Dec. 20	Jan. 36	Feb. 30
Full	10.00	15.00	2.78	20.00
i Full	50.00	60.00	33.33	46.67
i Full	10.00	15.00	27.78	26.67
i Full	10.00	10.00	22.22	3.33
little	20.00		13.89	3.33
Empty				

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TABLE 13. *Percentage occurrence of food items in the guts of L. dussumieri in various size groups during the period 1964 to 1966 from Mandapatn (Gulf of Mannar).*

Size group in mm	No. of fish examined	Semi-digested matter	Copepods	Polychaetes	Crustacean remains	Amphipods	Nematodes	Gastropod;	Bivalves	F&h sc.les	Foraminiferans	Sand grains	Coscinodiscus
63-67	2	1.10	1.53	1.18	--	—	—	—	1.89	—	1.16	—	—
68-72	12	6.59	8.40	4.70	5.48	4.17	—	4.25	6.61	—	6.98	—	—
73-77	15	8.79	9.16	4.70	10.96	8.33	17.66	10.64	10.38	9.38	11.63	—	—
78-82	22	12.09	16.03	12.94	10.96	12.50	17.66	12.77	14.15	12.50	16.28	—	—
83-87	29	15.93	19.85	20.00	24.66	12.50	11.76	22.35	17.92	28.13	25.58	33.33	—
88-92	31	15.93	18.32	22.35	15.07	20.84	11.76	19.15	21.70	12.50	19.77	—	—
93-97	16	8.24	8.40	8.23	9.59	8.33	11.76	15.96	9.43	21.88	8.14	50.00	—
98-102	9	6.39	4.58	7.06	8.21	8.33	—	6.38	4.72	3.12	3.49	—	—
103-107	6	3.30	4.58	3.53	2.74	8.33	—	1.06	3.77	3.12	—	—	—
108-112	9	4.94	5.34	9.41	8.22	8.33	11.76	4.25	6.61	6.25	4.65	16.67	—
113-117	2	1.10	1.53	2.36	1.37	4.17	11.76	1.06	0.94	3.12	1.16	—	—
118-122	2	1.10	1.53	2.36	2.74	—	—	2.13	0.94	—	1.16	—	—
123-127	—	—	—	—	—	—	—	—	—	—	—	—	—
128-132	1	0.55	0.75	1.18	—	4.17	5.88	—	0.94	—	—	—	—

The length-frequency data indicate that only fish of restricted length range occurred during the period, with modes at 70, 90, 95, 100, 105, 110 and 120 mm.

Mandapam: The length-frequency curve for November 64 (Fig. 11) shows three modes at 105, 115 and 125 mm. In December, only one mode was observed at 100 mm. In November '65 two modes were observed at 100 and 110 mm,

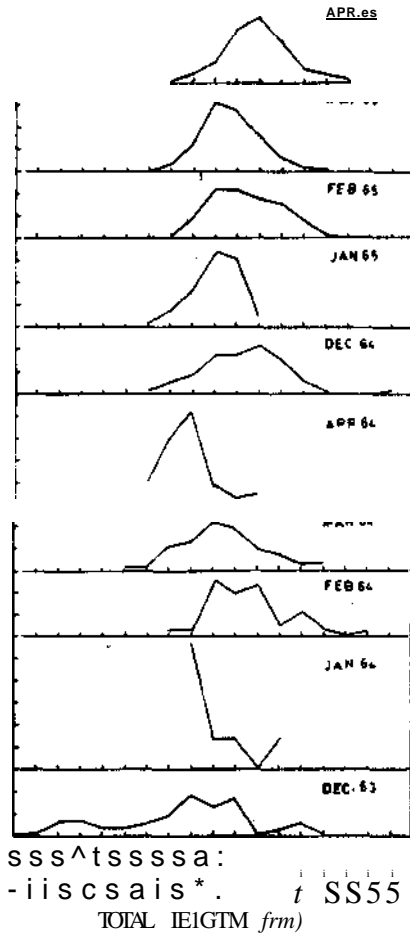
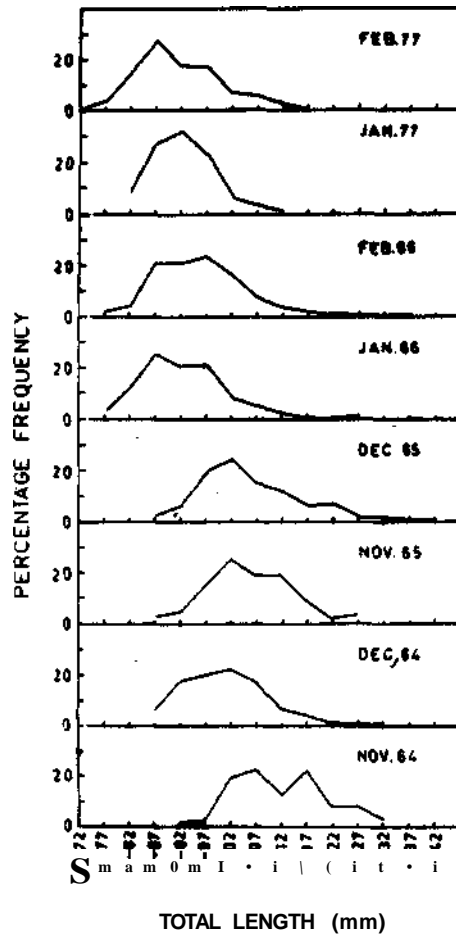


FIG. 10. Length-frequency curves for *L. dussumieri* from Kiiakanai (drift gnet catches) from December 1963 to April 1964, and December 1964 to May 1965 and January-February 1966).



RIG. 11. Length-frequency curves for *L. dussumieri* from Mandapaim (trawl catches) during the period November-December 1964, November 1965 to February 1966 and January-February 1967).

whereas in December, three modes were seen at 100, 110 and 130 mm. In January '66 the modes were present at 85 and 95 mm. In February only a single distinct mode was observed at 95 mm. Similarly, in January '67 a single mode was present at 90 mm and in February at 85 mm. Since continuous data were not available, it has not been possible to trace the progression of modes. However, the length frequency curves indicate that prominent modes were found at 80, 90, 95, 100, 105, 115 and 125 mm. Addition of small sized fishes mainly takes place during the period January-February. Fishes captured in November-December period are usually larger than those captured in January-February period.

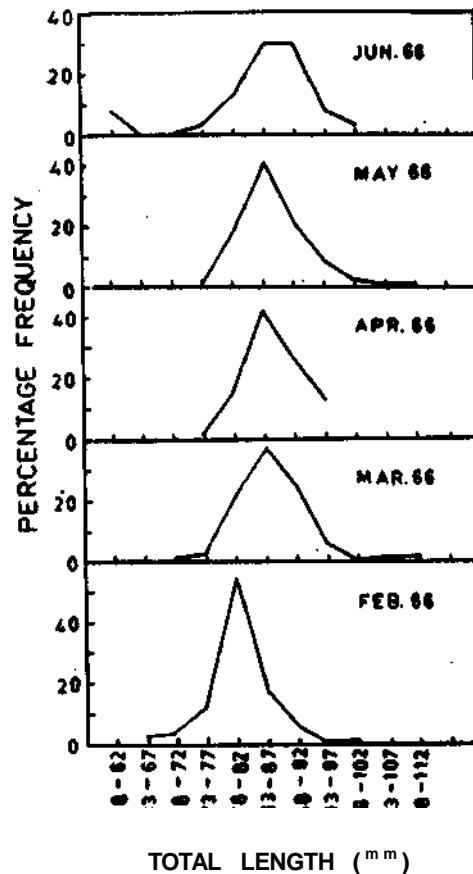


FIG. 12. Length-frequency curves for *L. dussumieri* from VedataM (draft gillnet catches) from February 1966 to June 1966).

Vedalai: In February '66 (Fig. 12) a single prominent mode was present at 80 mm. Whereas in March, April and May the mode was stationary at 85 mm and in June the mode was present between 85 and 90 mm.

The length-frequency curves indicate that only fish of restricted length range were available during the period, with modes at 80 and 85 mm.

Study of bones: A total of 265 of fishes in size range from 66 to 161 mm were examined for this purpose. Fishes were cooked in water and the cleithrum and supraoccipital bones were separated. Seasonal marks in the form of transparent lines interspersed with opaque broad areas or bands have been observed on the supraoccipital crest and cleithrum. The number of transparent lines alternating with opaque bands was found to be related to the size of the fish. Invariably, the number of transparent lines on the supraoccipital crest and the cleithrum was found to be identical. Occasionally, false marks were also noticed. Sometimes when seasonal marks were clear on one bone the same were not clear on the other bone of the same fish.

Interpretation of seasonal marks on the bones: The cleithrum and supraoccipital crest of the 0-year group fishes were fully transparent. Growth of the bones is indicated by an opaque edge. Completion of growth of a season is indicated by the formation of a transparent line enclosing an opaque area. In larger fishes the transparent central area of the bone is therefore followed by a series of broad opaque areas alternating with narrow transparent lines, the former representing the period of active growth and the latter slow growth or cessation of growth. Therefore, a set of these areas i.e. one opaque and one transparent area should present an year's growth. On this basis, in this study, the first transparent area surrounding the first opaque area has been recognised as the first annulus. Thus a fish which has completed one year would have a central transparent area followed by a broad opaque band and a narrow transparent line. The number of annuli, therefore indicate the age of fish in years. In fish the age determination from otolith reading were based on the assumption that growth rings on the otolith are laid down annually. There is no absolute proof available that this is true (Graham 1929). In the present case, the formation of transparent lines at the edge of the bones has not been found to be restricted to any particular time of the year. This may also be related to the fact that the fish has been found to spawn in April-May and in November-December which periods may also be extended on either side. The range in length and mean length of fish at each age group arrived at by the study of seasonal marks on a cleithrum and on supraoccipital crest are given in Table 14. Fish in the 0-year group ranged in size from 66 to 103 mm, one year group from 78-120 mm, second year group from 88-145 mm, the third year group from 100-149 mm, fourth year group from 119-158 mm; and fifth year from 143-148 mm. The mean length at the end of first year has been found to be 99 mm, at the end of second year 114 mm, at the end of third year 128 mm, at the end of fourth year 138 mm and at the end of fifth year 145 mm.

Growth rate and life span: While it has not been possible to trace the progress of modes in length-frequency curves for the determination of growth rate in

view of the discontinuity of the data, some conclusions on the rate of growth can be drawn from the study of seasonal marks formed on the supraoccipital crest and cleithrum. From table 14 it is evident that growth rate in first year is quite rapid, decreasing gradually on the following years. It should be mentioned here that adequate number of fish were not available to fix the mean size of fourth year classes precisely.

The maximum size of the fish recorded in the present study was 161 mm. Since average length of five year old fish has been found to be 145 mm (Table 14), such fish, according to the study of the seasonal marks formed on the bones should be five years old. Therefore, the life span of the species may be fixed at five years.

TABLE 14. *Length range and mean length of L. dussumieri at each age group*

Age group	No. of fish	Range in length (mm)	Mean length (mm)	Growth increment per year (mm)
0	45	66-103	85	—
1	90	78-120	99	—
2	78	88-145	114	15
3	43	100-149	128	14
4	6	119-158	138	10
5	2	143-148	145	7

FISHERY

Of the 16 species of silverbellies occurring in Palk Bay and the Gulf of Mannar, *L. jonesi* contributes to the bulk of the catches. Other species common in this area are *L. brevisrostris*, *L. dussumieri*, *Gazza minuta* and *Secutor ruconius*. Generally, *L. dussumieri* has been found to be the dominant in the Gulf of Mannar, compared to its occurrence in Palk Bay. Within the Gulf of Mannar, the catches of *L. dussumieri* are more important from deeper water (20-40 metres) than shallow waters. Larger fishes (120 to 145 mm) are obtained from deeper waters.

The size range of *L. dussumieri* from commercial catches was found to be from 57 to 145 mm with the 93-117 mm size group dominant. Since the drift gillnets have large mesh (25.60 mm), juveniles of his species were not recorded from this gear. The trawl catches from deeper waters do not include the juveniles indicating their absence in that region.

This species is captured in the area both by drift gillnet and trawl-nets. Bulk of the catches are landed by trawl nets during the period November-March. This fish is also known to move in schools occasionally, but it is usually captured with other silverbellies. The data on food and feeding habits of this species indicate that this species prefers a sandy, coral-sandy area rather than muddy areas.

The life span of the species is estimated to be five years, the maximum size recorded in the present study being length 161 mm. Since the commercial catches are dominated by fish 93-117 mm size, the 0-year, one year and two year old fish mainly support the fishery. Since the species is short lived and breeds by the time it is one year old and since the present method of exploitation leaves enough brood to replenish the future stocks, it is advisable to catch the fish of all sizes for the best utilization of the resource, Since the larger fishes are known to be found in deeper water, exploitation of this fish in deeper water in the Gulf of Mannar is likely to increase the catch of this species.

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REFERENCES

- ARORA, H. L. 1951. A contribution to the biology of Sivair-bellies. *Leiognathus splendens* (Cuv) Scot It Proc. Indo Pacific Fish coun. 1-6.
- BALAN, V. 1963. Biology of the Silverbelly *Leiognathus bindus* (Vail) of the Client coast. *Indian. J. Fish.* 10: MO-134.
- CHACKO, P. I. 1944a. The Silverbellies of Pamban Proc. 31st Indian Sci. Congr. 86
- CHACKO, P. I. 1944b. On the Bionomics of the Leioognatidae *Curr. Sci.* 13(8).
- CHACKO, P. I. 1949. Food and feeding habits of the Mies, of the Gulf of Mannar Proc. Indian Acad. Sci. 29(3): 83-97.
- CLARK, P. N. 1924. Maturity of the Caffifamfe sardine (*Sardine caerulea*) determined by ova-diameter measurements *Fish. Bull. Sacramento* 42: 7-49.
- DE JONG, J. K. 1940. A preliminary investigation of the spawning habits of the fishes of the Java sea. *Treubia* 17: 307-330.
- GRAHAM, M. 1929. Studies of age determination in fish Part II. A survey of literature *Fish. Invest. London Ser.*, 11(2): 1-50.
- HYNES, H. B. N. 1950. The food of fresh water strickle backs (*Casterosteus aculeatus* and *Pygosteus pungitius*) with a review of methods used in studies of the food of fishes /. *Arim Ecol.* 19: 36-58.
- HICKLING, C. F. AND E. RUTENBERG. 1936. The ovary as an indicator of spawning period of fishes, /. *Mar. Biol. Ass. U.K.* 21: 311-317.
- JAMES, P. S. B. R. AND CLEMENT ADOLF. 1965. Observat'on on trawl fishing in the Palk Bay and Gulf of Mannar in varinity of Maintapani *Indian J. Fish.*, 12(2). 350-545.
- JAMES, P. S. B. R. 1968. *Leiognathus leuciscus* (Gumther) and *L. smithursti* (Ramsay and Ogilly) Family: Leioognatidae; Pisces - Two new records from Indian Sea. *J. Mar. Biol. Ass. India* 9(2): 300-302.
- JAMES, P. S. B. R. AND M. BADRUDEEN. 1968. On certain anomalies in the fishes of the family Leioognathidae /. *mar. biol. Ass. India.*, 10(1): 107-113.
- JAMES, P. S. B. R. 1969. A new species of Silverbelly *Leiognathidae jonesi* sp. nov. (Family: Leioognathidae Pisces) from the Indian seas. /. *mar. biol. Ass. India*, 11(1 and 2): 316-319.

- JAMES, P. S. B. R. 1971. On the occurrence of blue-green algae of fishes of the family Leionathidae. *J. mar. biol. Ass. India*, 13(1): 133-135.
- JAMES, P. S. B. R. 1973. The fishery potential of Silverbellies *Proc. Sym. living Resources of the Sea around India* pp. 439-444 Spl. Publ. Central Marine Fisheries Research Institute, Cochin.
- JAMES, P. S. B. R. AND M. BADRUDEEN. 1975. Biology and fishery of *Leiognathus hrevirostris* (val) from the Palk Bay and the Gulf of Mannar. *Indian J. Mar. Sci.*, 4(1): 50-59.
- JAMES, P. S. B. R. 1975. A systematic review of the fishes of the family Leionathidae. *J. mar. biol. Ass. India* 17(1): 131-172.
- JAYABALAN, N. K., DHEVENDRAN AND K. RAMAMURTHY. 1978. Occurrence of symbiotic Bioluminescent bacteria in Indian Leionathidae. *Ciirr. Sci.* 17(47) 648-649.
- KESTEVAN, G. L. 1947. On the ponderal index or condition factor as employed in fisheries biology *Ecology* 17: 78-80.
- KRISHNAMURTHY, B. 1957. Fishery resources of the Rameswaram Island. *Indian J. Fish* 4: 229-223.
- LE CREN, C. D. 1951. The length-weight relationship and seasonal cycle in gonad weights and condition of the perch *Perca fluviatilis*. *J. Anim. Ecol.* 20: 20-219.
- MAHADEVAN, S. 1958. Report on the Kaairia *Leiognathus* spp. and *Gazza minuta* fishery of Rameswaram Island to the Gulf of Mannar and Palk Bay. *Proc. 4th Indian Sci. Cong.* Part III abstract No. 91.
- MAHADEVAN PILLAI, P. K. 1972. Fecundity and spawning habit of some Silver bellies *Indian. Fish* 19: 196-199.
- MENON, M. D. 1950. The use of bones other than otoliths in determining the age and growth rate of fishes. *J. Cons. Int. Explor. Mer.* 16: 311-335.
- MENON, M. D. 1952. The determination of age and growth of fishes of tropical and subtropical waters. *Journ. Bombay. Nat. Hist. Soc.*, 51: 625-635.
- * PETERSEN, C. G. J. 1892. Fiskebiologiske forhold i Hoibonk Fjord, 1890-91. *Beret. Dan. Biol. St.* 1*90(91), 1: 12-83.
- PRABHU, M. S. 1956. Maturity of intraovarian eggs and spawning periodicities in some fishes. *Indian J. Fish.*, 3: 59-90.
- PILLAY, T. V. R. 1952. A critique of the method of study of food of fishes. *J. Tool. Soc. India*, 4: 185-200.
- RIANISINOH AND P. K. TALWAR. 1978a. On the little known pony fish, *Gazza achlamys* Jordan and Starks (Pisces: Leionathidae) in the Indian waters. *Curr. Sci.*, 23 (47): 930-931.
- RANISING AND TALWAK, P. K. 1978b. On a new species of silver belly, *Leiognathus indicus* (Pisces: Leionathidae) from the Bay of Bengal. *Bull. Zool. Stir. India.* 1(3) 275-277.
- SATYANARAYANA RAO, K. 1968. Reproductive and lipid levels of *Leiognathus splendens* (Cuv) *J. Mar. Biol. Ass. India* 9(2): 302-322.
- VENKATARAMAN, G. AND M. BADRUDEEN. 1974. On the diurnal variation in the catches of silver bellies in the Palk Bay. *Indian. J. Fish.*, 2(1): 254-265.
- VENKATARAMAN, G. 1960. Studies on the food and feeding relationship of the inshore fishes off Calicut on the Malabar Coast *Indian J. Fish.*, 7: 275-306.

* Original not referred.