BIOLOGY OF THE SILVER BELLY, *LEIOGNATHUS BINDUS* (VAL). OF THE CALICUT COAST

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INTRODUCTION

The silver bellies constitute one of the important inshore fisheries of India. From All-India fish landings* it is evident that there have been wide fluctuations in the magnitude of *Leiognathus* fisheries from 1950 to 1963. Of the 7 species of *Leiognathus* known to occur in the inshore regions, only 6 species are of commercial importance ; even amongst these, *L. bindus* (Val.) locally called *Nalla Mullen* is the most abundant in the Malabar coast. A perusal of previous work Chidambaram and Venkataraman (1946), Devanesan and Chidambaram (1948), Bhimachar and Venkataraman (1952), Nayar (1958), Venkataraman (1960) and Anon (1962) revealed that very little information is available on the biology and fishery of *L. bindus* (Val.) a commercially important species. Therefore, it was felt desirable to investgate in detail the biology and fishery of this species at Calicut from 1956 to 1958.

General investigations on other species of *Leiognathus* and *Gazza* were made by Chacko (1949), Arora (1951), Chidmabaram and Venkataraman (*op. cit.*), Devanesan and Chidambaram (*op. cit.*) Bhimachar and Venkataraman (*op. cit.*) Krishnamurthi (1957) Kuthalingam (1958), Bapat and Bal (1952) and Venkataraman (*op. cit.*) ; many of these authors have paid attention to studying mainly the feeding habits and fisheries of these silver bellies.

MATERIAL AND METHODS

The material for the present work was collected during the years 1956-58 at the Calicut fish landing centre and from December 1958 to May 1959 from trawler Catches off Calicut. Random samples of commercial catches were obtained mostly from the boat-seine catches. The samples were analysed for their total length, body height weight, food, sex, and gonadic maturation.

The total-length of the fish (measured from the tip of mandible, when mouth is closed to the tip of caudal fin) was taken into consideration for length frequency studies, and were grouped at 5 mm. interval and the frequencies converted into percentages.

Quantitative and qualitative analyses of food of the fish were made. The different items of food found in the stomach were examined either in fresh condition or after preservation in 5% formalin. The various constitutents of food were identified into main groups and general since the different items of food taken in are found to be of varying size, this study is based on

*Figures referred from the Annual Reports of Central Marine Fisheries Research Institute, Mandapam Camp.

the 'points method' of analysis of food. Due consideration is given to the size of the food organisms. The points that are carefully allotted to each item of the food consumed are converted to percentage composition, to facilitate comparison.

Sex was determined by careful examination of the gonads. The different stages of maturation of the female fish were recognised into five categories as : I-II immature, III-IV maturing, V mature, VI spawning and VII spent. The fecundity of the ovaries (preserved in 5% formalin) was estimated by counting the ripe ova in stage V of maturation in a certain weighed portion and therefrom estimating the total number contained in the entire ovary of the fish.

FISHERY

L. bindus yields a fairly good fishery all along the Malabar Coast, especially in Calicut. The season of its fishery in Calicut area is from April to December excepting in June every year, the abundant landings being from August to November. From January to March there is practically no silver belly fishery. Most of the catches in the Malabar area are made from the inshore waters with the boat-seines *Paithu vala, Odam vala, Nethal vala* and the cast net *Veechu vala.* Occasionally, small catches of the fish are obtained in the gill nets *Ayila chala vala* and *Mathi chala vala* also. Of the above mentioned nets the boat-seines *Paithu vala* and *Odam vala* are the most efficacious ones for their capture, especially when dense shoals are encountered rippling in the surface waters.

Fishing operations are carried out both during day and night. Very good catches are reported to be procured during foggy nights and also during the dark phase of moon when the shoals reveal their presence by luminescence in the surface and sub-surface waters.

Field observations have shown that the shoals of this fish move towards the surface film of water and a few individuals resort to leaping behaviour.

The fishery for the young fish generally occurs in April and May in the 20-25 mm. area and the catches are made therefrom by *Odam vala.* It may be emphasized here that the catches of *L. bindus* obtained by the indigenous gear are supported largely by the medium size group (fish measuring 55-95 mm. in total length).

The minimum recorded size during the present work is 30 mm. and the largest being 114·0 mm. (in total-length).

Other species of *Leiognathids* of lesser economic importance occurring in the catches with *L. bindus* in the Calicut coast are *L. splendens* (Cuv.), *L. insidiator* (Bl.), *L. ruconius* (H.B.) *L. blochi* (C.V.), *L. equulus* (Forsk.) *L. daura* (Cuv.) and *Gazza minuta.*

In the field and in the laboratory, the adult as well as the young fish are distinguishable by the presence of an orange pigment spot on the upper enterior portion of spinous dorsal fin the fin having a black pigment at its edge, and also by the horizontally protrusible nature of the mouth.

Distribution : The distribution of *L. bindus* (Val.) according to Weber and de Beaufort (1931) extends to "China, Formosa, Philippines, Celebes, Java, Borneo, Sumatra, Singapore, sea of Penang, British India and Ceylon". Munro (1955) has mentioned "Gulf of Manaar and trawling grounds" as the region of its distribution.

Curing :

As described by Nayar (*op. cit.*) for Vizhingam area, there are two types of curing, *i.e.* salt curing and beach-drying, prevalent in Malabar also, the former being more commonly practised. Huge quantities are cured by salt-curing process. In this method, one part of salt is added to six parts of wet weight of the fish.

As the fish are inexpensive they are also utilized for the preparation of fish meal which used for poultry feeding.

LENGTH FREQUENCY STUDIES

The percentage length-frequency distribution curves of *L. bindus* at Calicut obtained from boat seine samples for the period, July 1956-October 1958 are presented in Fig. I. Table I indicates the length frequency distributions of the different sizes in each month.

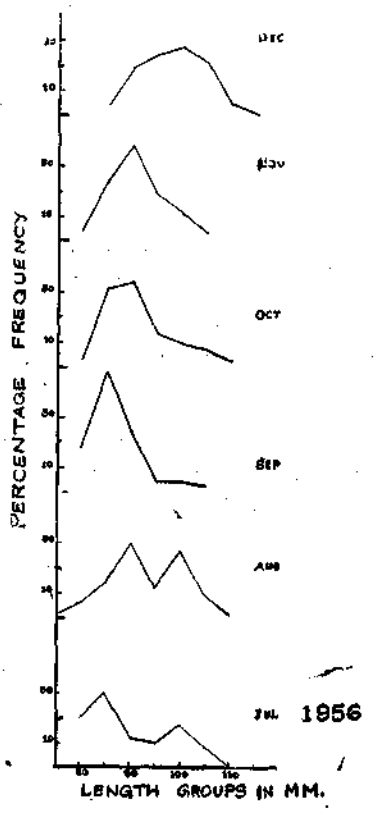

Fig. 1. Percentage size-group distribution curves for *L. aindus* at Calicut for 1956.

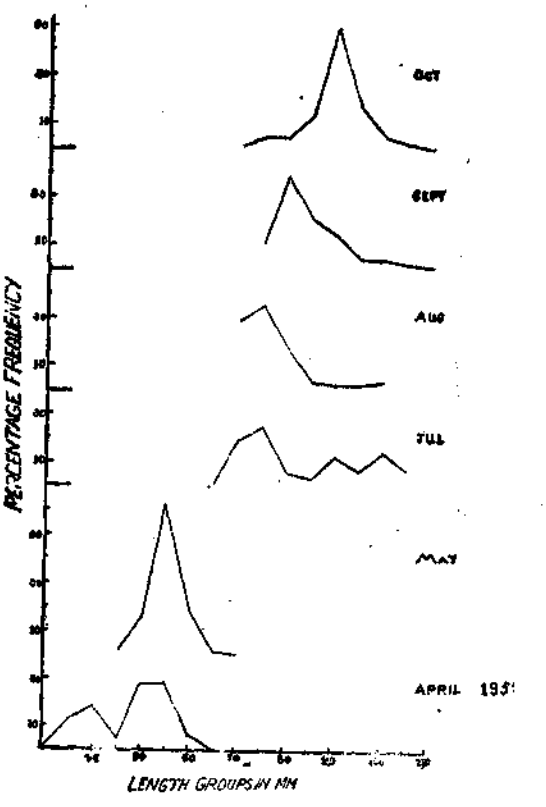

Fig. 2. Percentage size-group distribution curves for *L. bindus* at Calicut for 1957.

It is evident from the curve (Fig. 1) that in 1956 *L. bindus* having a modal size of 85 mm entered the commercial fishery in July. By the end of the season i.e., in December, this progressed to 100 mm. The fluctuations in the modal sizes noticed during the intervening month (especially in September) may be attributed to the entry of separate broods or population having different sizes into the fishery.

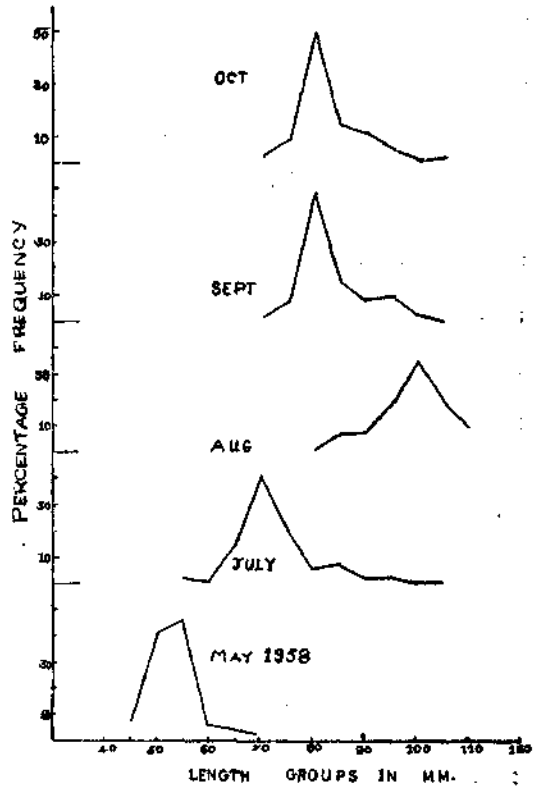

Fig. 3. Percentage size-group distribution curves for *L. bindus* at Calicut for 1958.

In 1957, juveniles having modal size of 50-55 mm. mainly entered the fishery in April. In addition to it , a secondary mode at 40 mm. was noticed in the catches, this modal group may be a separate brood from the late spawning. It may be mentioned here that in the earlier months *i.e.*, from January to March, there was no catch of the fish in the indigenous gear. The mode was at 55 mm. in May. There was no fishery in June. In July and August the modal size of the fish further increased to 75 mm. In September, the modal size of this group advanced to 80 mm. The maximum mode of 90 mm. was reached in October which may be attributed to the occurrence of heterogeneous populations in the fishery. The fishery met with an abrupt end by the close of that month.

In 1958, there were no landings of this fish up to April. In May, the juveniles whose modal size was 55 mm, entered the catches. As in the previous two years, there was no fishery in June on account of monsoon. In July, the modal size progressed to 70 mm. In August, however, a sharp increase in the modal size (100 mm) was noticed which obviously shows that those fish belonged to an entirely separate population or brood. A further increase in growth, compared to 70 mm size in July, was noticed during September-October, reaching a maximum modal size of 80 mm by the end of October.

The examination of the fish from the trawler catches off Calicut showed that in February and March 1959, their modal sizes were at 45 and 55 mm respectively. These modes are

TABLE I

Length frequency distribution of L. bindus *(boat-seine catches) collected from Calicut*

(Nos. in brackets indicate frequency percentages)

Size groups (mm.)	Mid Point (mm.)	1956							1957									1958					
		June	July	Aug.	Sep.	Oct.	Nov.	Dec.	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	May	June	July	Aug.	Sep.	Oct.
30—34	2	..	..	..	..	..	..	..	6 (1·8)	..	..	..	..	..	..	..	..	..	..	..	..	..	..
35—39	37	..	..	..	..	..	..	..	42 (12·4)	..	..	..	..	..	..	..	..	..	..	..	..	..	..
40—44	42	..	..	..	..	..	..	..	62 (18·2)	..	..	..	..	..	..	..	..	..	..	..	..	..	..
45—49	47	..	..	..	..	..	..	..	19 (5·6)	7 (1·7)	..	..	..	..	..	..	..	7 (7)	..	..	..	..	..
50—54	52	..	..	..	..	..	..	..	93 (27·4)	60 (15)	..	..	..	..	..	..	..	41 (41)	..	..	..	..	..
55—59	57	..	..	..	..	..	..	..	94 (27·6)	252 (62·8)	..	..	..	..	..	..	..	46 (46)	..	3 (1·7)	..	..	..
60—64	62	..	..	..	..	..	..	..	23 (6·8)	76 (19·0)	..	..	..	..	..	..	..	6 (6)	..	2 (1·1)	..	..	..
65—69	67	..	..	..	..	..	..	..	1 (·3)	4 (1)	..	3 (1·5)	..	..	..	..	..	..	..	29 (16·6)	..	..	..
70—74	72	..	..	..	..	..	..	..	..	2 (·5)	..	40 (20)	29 (29)	..	2 (2)	..	..	..	..	71 (40·8)	..	2 (2)	3 (3)
75—79	77	..	..	1 (1)	..	2 (·6)	..	..	..	..	..	50 (25)	40 (40)	12 (12)	5 (5)	..	..	..	..	37 (21·3)	..	8 (8)	9 (9)
80—84	82	..	22 (20)	6 (6)	34 (18·2)	8 (2·5)	4 (4)	..	..	..	..	13 (6·5)	18 (18)	39 (39)	5 (5)	..	..	..	..	10 (5·7)	1 (1)	50 (50)	50 (50)
85—89	87	..	33 (30)	14 (14)	90 (48·1)	98 (31)	24 (24)	4 (4)	..	..	..	8 (4)	4 (4)	21 (21)	15 (15)	..	..	..	..	13 (7·5)	7 (7)	16 (16)	15 (15)
90—94	92	..	14 (12·7)	30 (30)	45 (24)	108 (34·2)	38 (38)	19 (19)	..	..	..	25 (12·5)	2 (2)	14 (14)	50 (50)	..	..	..	..	3 (1·7)	8 (8)	9 (9)	12 (12)
95—99	97	..	11 (10)	12 (12)	8 4·22	42 (13·3)	19 (19)	24 (24)	..	..	..	15 (7·5)	2 (2)	5 (5)	17 (17)	..	..	..	..	4 (2·3)	19 (19)	10 (10)	6 (6)
100—104	102	..	20 (18·2)	27 (27)	8 4·3	29 (9·2)	12 (12)	27 (27)	..	..	..	30 (15)	4 (4)	4 (4)	5 (5)	..	..	..	..	1 (·6)	35 (35)	4 (4)	2 (2)
105—109	107	..	9 (8·2)	9 (9)	2 (1.1)	21 (6·6)	3 (3.0)	21 (21)	.. ..	.. ..	..	14 (7)	1 (1)	3 (3)	1 (1)	..	..	..	..	1 (·6)	20 (20)	1 (1)	3 (3)
110—114	112	..	1 (·9)	1 (1)	..	8 (2·5)	..	5 (5)	..	..	..	2 (1)	..	1 (1)	..	..	..	..	..	..	10 (10)	..	..
TOTAL		..	110	100	187	316	100	100	340	401	..	200	100	100	100	..	..	100	..	174	100	100	100

TABLE II

Percentage occurrence of different food items in the fish examined during different months

	1956						1957								1958					
	July	Aug.	Sep.	Oct.	Nov.	Dec.	Apr.	May	July	Aug.	Sep.	Oct.	Nov.	Dec.	April	May	July	Aug.	Sep.	Oct.
Total No. of fish examined	22	22	20	24	22	24	18	42	32	32	20	12	..	..	..	30	30	30	30	40
Copepods	18	10	..	10	26	50	66	64	50	15	20	32	..	..	..	50	55	30	38	40
Polychaetes	..	..	..	30	..	..	..	5	..	..	..	25	..	..	..	..	..	..	10	9
Evadne	3	2	..	2	1	4	..	..	..	..	..	10	..	..	..	..	..	..	..	2
Penilia	..	1	..	..	..	..	2	..	7	..	..	..	..	..	..	..	..	..	..	..
Larval bivalves	..	..	..	..	1	..	3	2	..	..	..	4	..	..	..	9	..	..	2	2
Larval crustaceans	..	..	..	..	2	..	..	..	5	..	..	..	..	..	..	..	..	..	..	..
Fish scales	4	5	..	3	15	6	2	..	3	4	40	4	..	..	..	..	8	6	8	5
Diatoms	5	..	..	2	4	5	1	5	10	11	10	..	..	..	..	5	3	2	5	0
Mucus and digested matter	70	82	100	53	51	35	26	24	25	70	30	25	..	..	..	36	34	62	37	22

significant since they represent broods from the deeper area (32 mm.) off Calicut, resulting from the early spawning, and also since the fish were not present in the local boat-seine catches during those two months.

From the analysis of length frequency data, it may be stated that there is an overall increase in the size of the fish from 50 mm. in April to 90 mm. in November *i.e.*, showing a growth of 40 mm. in the course of seven months, each year (in 1957 and 1958), in general.

The juveniles tend to show a faster rate of growth as observed from the progression of their modal size from 50 to 75 mm. during the April-July period.

FOOD AND FEEDING HABITS

A total of 450 fish were examined during the course of this investigation. The stomach of the fish is small, restricting the size and quantity of the food consumed by them.

TABLE III

Percentage of empty stomachs in the total number of stomachs of L. bindus *examined during different months, from July* 1956 *to October* 1958.

Month	1956	1957	1958
January		Material unavailable	
February		Do.	..
March		Do.	..
April	..	10·0	..
May	..	12·5	..
June		Material unavailable	
July	10·0	10·0	5·0
August	10·0	15·0	10·0
September	50·0	10·0	5·0
October	50·0	5·0	4·0
November	2·5	..	..
December	10·0	..	..

Copepods formed the most important food item encountered in the stomach of the fish (vide table II) agreeing essentially with the observations of Kuthalingam (*op. cit.*) on *L. insidiator*, *L. daura* and *L. splendens*. The phytoplankton formed only a minor portion of their food and constituted less than 10% of the total volume. During the monsoon months, however, there was an occasional increase in the occurrence of phytoplankton in the stomach which as pointed out by George (1953) can be correlated with their abundance in the environment during this period.

Other food items such as cladocerans (*Evadne* and *Penilia*), larval bivalves and larval crustaceans were also present in the stomachs, though in small quantities. On a few occasions in October, unidentified polychaetes (small sized ones) also occurred in appreciable numbers in the stomach contents, coming next in importance to copepods.

TABLE IV

Sex distribution of monthly totals of samples of L. bindus *from July* 1956 *to October* 1958

Months sexes	1956						1957			1958			1956-58		
	Boat seine		Catches	Gill net		catches	Boat seine		catches	Boat seine		catches	Boat seine		Total fish examined Boat seine & Gill net catches (all sexes)
	F	M	Indeterminate	F	M	I	F	M	I	F	M	I	F	M	
January	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
February	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
March	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
April	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
May	..	..	..	..	..	..	..	..	..	0	0	100	..	..	100
June	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
July	28	35	12	..	..	..	40	37	0	24	25	25	92	97	226
August	52	48	0	16	12	7	32	35	33	51	49	0	135	132	335
September	43	54	3	..	..	..	48	38	14	48	52	0	139	144	300
October	108	92	0	..	..	..	49	51	0	53	47	0	210	190	400
November	44	56	0	22	75	0	..	..	..	..	..	..	44	56	197
December	13	12	0	25	75	0	..	..	..	..	..	..	13	12	125
Yearly total	288	297	15	63	162	7	169	161	47	176	173	125	633	631	1,683

Fish scales were observed in the stomachs in most of the months; it is in conformity with the observations of Venkataraman (*op. cit.*) in regard to this species. But the total absence of any other solid parts of fish tends to suggest that the scales might be accidental ingestions.

Mucus and digested material were invariably present in the stomach contents, almost in all the months, throughout this investigation. Though the observations of Venkataraman (*op. cit.*) on the food of this species support the present findings to a considerable extent, it may be added that no penaeid prawn was met with in the stomach of the specimens examined in detail, during the course of this work. The present study shows that the fish is mostly a zooplankton feeder. The percentages of empty stomachs occurring in the various months are also given (Table III). Their feeding proclivities further reveal that they are not highly voracious. There is no evidence from the data to show that there is a reduction or temporary suspension of feeding activity during the period of spawning.

MATURATION AND FECUNDITY

As the gonads are small, they are classified broadly under five categories : immature (I—II), maturing (III—IV), mature (V), spawning (VI) and spent (VII).

Minimum size at first maturity :

For determining the size at first maturity, a total of 825 fish collected from July 1956 to December 1956 were examined. The percentages of the mature fish were calculated (stage V fish were used) for each 5 mm. size group. It may be mentioned that no mature fish was found with a length less than 70 mm. 2·9 per cent were mature at 75 mm., 7·2 per cent at 80 mm., 53·0 per cent at 85 mm, 56·7 per cent at 90 mm, 75·8 per cent at 95 mm, and 100 per cent at 100 mm. group and above. Thus it may be reasonably stated that in *L. bindus* the minimum size (total-length) at first sexual maturity is 87·0 mm. (mid point of 85—89 mm. group). It may be mentioned that the average standard length at first maturity of *L. splendens* (Arora, *op. cit.*) is 60·0 mm. Since Arora's observations were based on standard length measurements, it is not possible to compare the data for the two species.

TABLE V

Percentage of mature fish (stages III-V) in each 5 mm. of length of L. bindus.

Length in mm.	Mid Point	Total fish observed	Number mature	Percent mature
30—34	32	6	0	0
35—59	37	42	0	0
40—44	42	52	0	0
45—49	47	19	0	0
50—54	52	83	0	0
55—59	57	100	0	0
60—64	62	23	0	0
65—69	67	40	0	0

TABLE V—*contd.*

Length in mm.	Mid Point	Total fish observed	Number mature	Percent mature
70—74	72	75	0	0
75—79	77	103	3	2·9
80—84	82	180	13	7·2
85—89	87	245	130	53·0
90—94	92	370	210	56·7
95—99	97	165	125	75·8
100—104	102	165	165	100·0
105—109	107	90	90	100·0
110—114	112	24	24	100·0

TABLE VI

Percentage of mature fish (stage III and above) recorded by months

Months	Percentage mature
January	Material unavailable
February	0
March	0
April	0
May	0
June	Material unavailable
July	18·2
August	33·0
September	42·7
October	88·7
November	92·4
December	96·0

The numbers of ova occurring in each ovary of fish in stage V of maturation are estimated. For this purpose, a portion of ovary is taken and weighed out separately. The number of big-sized (ripe) ova that is contained in that portion is counted and from this the total number estimated. The various sizes of the individual fish and the corresponding figures of ova (based on examination of sixteen specimens) are given in the table VII. From this table, it may be concluded that an ovary of *L. bindus* contains an average of 6,162 ripe eggs; the larger fish may contain even upto 7,735 eggs. The present investigation shows that the fecundity of this species is nearly the same as that of *L. splendens* reported by Arora (*op. cit.*).

TABLE VII

Fecundity of L. bindus

Size of fish (mm)	Maturation stage	Weight of ovary (gm.)	Weight of sampled portion of ovary (gm.)	No. of ova in sampled portion	Estimated No. of ova	Average No.
98·0	V	0·180	0·020	550	4950	..
99·0	Do.	0·200	0·050	1250	5000	..
100·0	Do.	0·205	Do.	1300	5330	..
101·0	Do.	0·215	Do.	1370	5890	..
103·0	Do.	0·210	Do.	1450	6090	..
104·0	Do.	0·200	Do.	1600	6400	..
105·0	Do.	0·210	Do.	1550	6510	..
106·0	Do.	0·225	Do.	1400	6300	..
108·0	Do.	0·230	Do.	1425	6555	..
109·0	Do.	0·230	Do.	1500	6900	..
104·0	Do.	0·390	Do.	725	5655	..
106·0	Do.	0·365	Do.	700	5110	..
109·0	Do.	0·325	Do.	800	5200	..
104·0	Do.	0·355	Do.	970	6885	..
112·0	Do.	0·521	0·108	1600	7735	..
114·0	Do.	0·385	0·055	915	6405	6162

The fish in oozing condition (stage VI) have not been encountered in the indigenous country craft catches. In the trawl catches, obtained from deeper waters *i.e.*, beyond the 30 mm. depth area, however, the fish in advanced stage V condition are encountered from December to February. From this evidence, it can be inferred that these adult fish while nearing the phase of spawning, perhaps, move back into the undisturbed deeper waters which may impart necessary ecological stimuli for their successful spawning. Further, it has also been observed that small-sized juveniles (post-larvae) of *L. bindus* (35—50 mm. in total-length) occur earlier (during February-March) in the deeper waters (trawling areas) only from where the spawners are met with. And subsequently only, do the new recruits (juveniles) migrate in huge quantities into the inshore (8—15 m.) fishing areas which are normally rich in plankton production, mainly for purposes of feeding. This cycle (as revealed from the nature of their fishery) was found repeated during this investigation. In this shallow region they are used up heavily by various predators such as ribbon fishes, seer fishes, *Arius* spp., sharks, dolphins and sea birds, in addition to man.

The fish in stages IV and V of maturation were very common from September to November. Generally, the spent fish were noticed in the catches in May, July and August every year. On the evidences from the occurrence of the fish in stage V, the fish in spent condition, the young ones, and also on the basis of frequency distribution of ova-diameters of intra-ovarian eggs, it is reasonable to infer that the spawning of *L. bindus* commences from December and terminates by end of February and it takes place in the deeper areas.

Studies on the sex composition based on 1683 individuals of the fish have shown that in the boat-seine catches in 1956, the female to male ratio was 288 : 297; in 1957, the corresponding ratio was 169 : 161; in 1958, the corresponding figures were 176 : 173 respectively, showing that there was no considerable preponderance of either sex. The sex (female to male) ratio computed for the three years was found to be 633 : 631.

In the gill net catches in 1956, the female to male ratio was found to be 63:162. This reduction in the number of females may probably be due to the females moving down to deeper waters and getting more scattered in distribution unlike the males which may move compactly in shoals at the surface areas yielding themselves to passive and bigger captures. Remarks of Larraneta (1959) are of interest here : "In captures, the sex ratio becomes significantly heterogeneous, pointing to a separation of sexes. According to Andreu and Rodriguez Roda (1952) there is a horizontal separation as purse seines fishing from the surface to bottom make captures with significant sex predominances. Muzinic (1954) notes a vertical separation, with males found in deeper waters, trawler catches containing more males than females."

Text Fig. 7 represents frequency distribution of diameters of intra-ovarian eggs, measured from five mature specimens obtained at the approach of the spawning season. It can be inferred from the single sharp mode seen in the fig. 7 (based on ova-diameter measurements of about 1,000 eggs from each fish) that the eggs are released only in a single batch in the season of spawning and that they spawn only once in a year and that the season of spawning is not prolonged. The ova-diameter measurements based on the study of five ovaries showed a range from 0·145 to 0·465 mm., of which the 0·306—0·385 mm. mode was conspicuous.

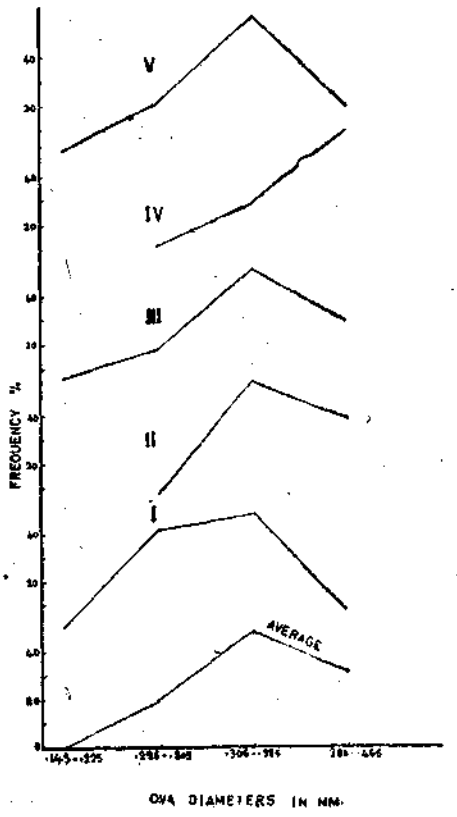

Fig. 7. Ova-dimeter frequency curves for *L. bindus*.

LENGTH-WEIGHT RELATIONSHIP

650 specimens ranging in total-length from 30·0 mm. to 114·0 mm. were weighed individually for this purpose. The average observed values for weight and length of each 5 mm. length groups were found from this and utilized to derive the length-weight relationship applying the general fromula $W=AL^B$ (where W is the weight, A a constant, L the total-length and B the power expressing the relation between the increases in weight and length. The formula worked out in the present case is $W=0\cdot00002452\ L^{2\cdot8041}$ where W is in gm. and L in mm. Weights are calculated substituting the average lengths for the 5 mm. length groups and plotted to draw a curve which shows close agreement with the observed values represented by dots (Text fig. 4).

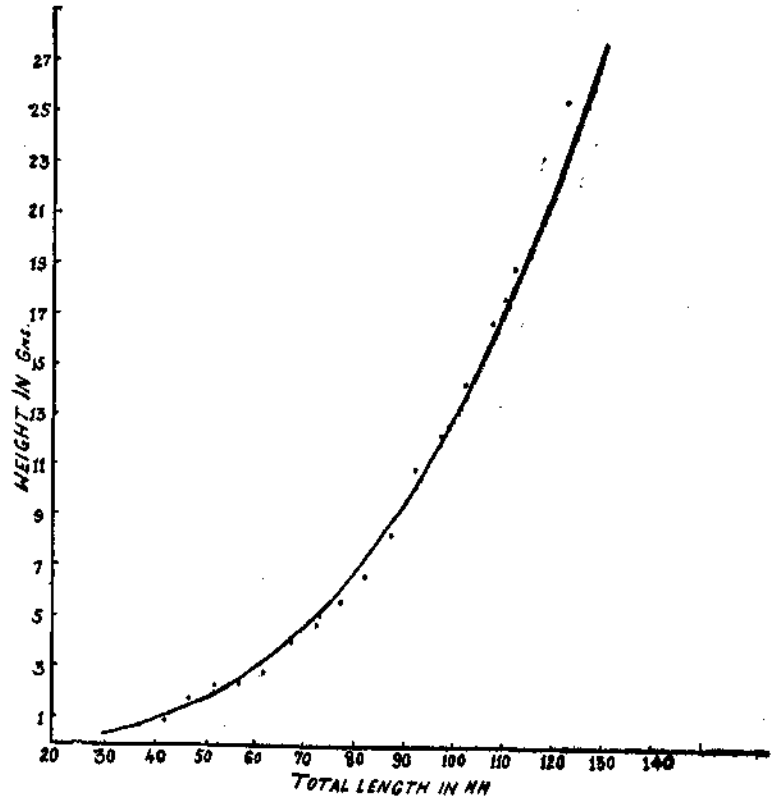

Fig. 4. Showing Length-Weight Relationship of *L. bindus*.

PONDERAL INDEX

Hickling (1930), Menon (1950) and several other investigators have correlated fluctuations in ponderal index with the attainment of maturity and spawning in different species of fishes. The length-weight data of *L. bindus* are analysed for the various length-groups. "K" is calculated by using the formula (as used by Hickling, *op. cit.*) : $K=\frac{W}{L^3}\times 100$, where W is the weight of the fish in grams, L the length of the fish in cm. and K the ponderal index.

All the available size groups occurring in different months, up to 110 mm. in total-length are taken into account for this calculation. It may be added that the fish representing all size groups were not available at the same time in the catches during the period of this investigation. The graph indicating the average K values for each size group is given in Text Fig. 5.

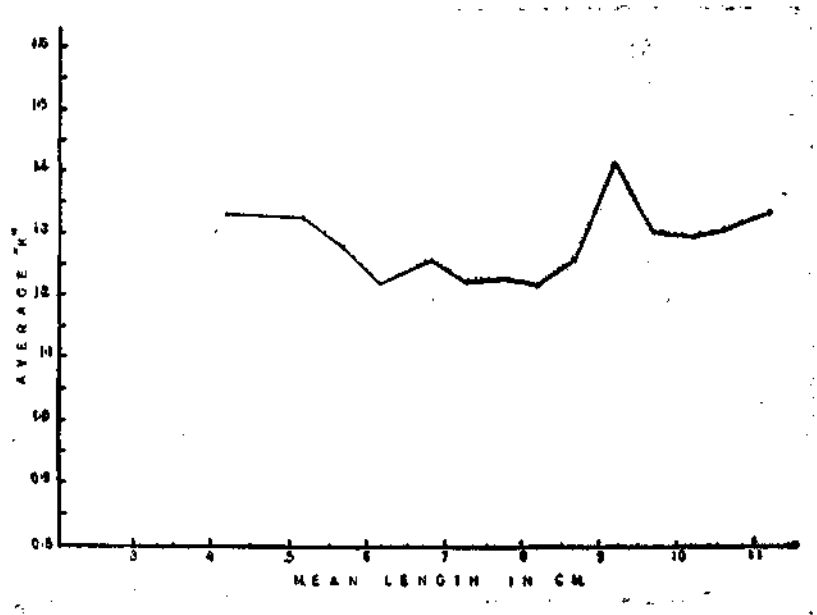

Fig. 5. The average '*K*' ponderal index at the different lengths of *L. Bindus*

From the pattern of the curve obtained in this case, it may be pointed out that the fish mature at an average length of 92.2 mm. This inference is supported by the data on maturation studies, which have indicated that the fish attain their first maturity at the size of 87.0 mm.

LENGTH-BODY HEIGHT RELATIONSHIP

A total of 796 fish ranging in size from 30-114 mm. are taken into consideration. Average observed values of length and body height for each 5 mm. group are found out from individual measurements. They are given in table VIII. Utilizing these values, the relation between the total-length and the body height of the fish has been expressed by the formula, $H = 0{\cdot}25908 + 0{\cdot}38944\ L.$, where H is the height in mm. and L the total-length in mm. The observed values are represented by dots ; the line represents the calculated values (Text fig. 6).

TABLE VIII

Total length-Body Height Relationship

Size groups (mm.)	Mid point (mm.)	No. of fish examined	Average Length (mm.)	Average height of body (mm.)
30—34	32	26	32·5	14·2
35—39	37	30	37·0	15·0
40—44	42	65	41·9	16·0
45—49	47	54	46·9	18·0
50—54	52	44	52·4	21·1
55—59	57	43	56·5	21·9
60—64	62	75	61·1	22·8
65—69	67	30	66·8	26·2
70—74	72	69	72·7	29·0
75—79	77	61	77·0	30·9
80—84	82	48	82·4	32·4
85—89	87	50	87·0	33·6
90—94	92	25	91·4	35·3
95—99	97	53	96·2	36·7
100—104	102	35	102·0	40·6
105—109	107	38	107·2	42·4
110—114	112	50	111·0	44·2

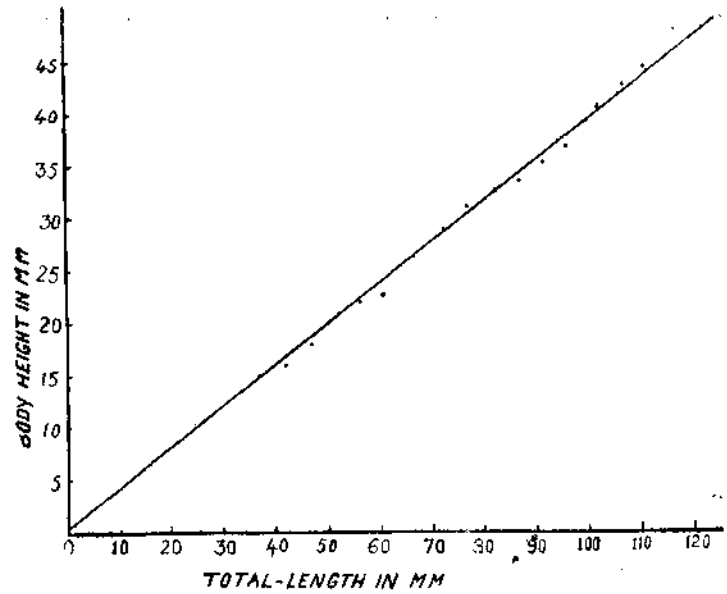

Fig. 6. Showing Total length-body height relationship of *L. bindus*.

GENERAL REMARKS

During the season of good silver belly fishery, the bulk of the catches is from the medium size groups.

L. bindus, on the whole, formed about 65-85% in number in the catches of Leiognathids. In April and May of each year, the percentage in the catches composed by the juveniles ranged from 75to 85. This rise in percentage may be attributed to the probable non-association of other species of *Leiognathus* with the shoals of this species, before entering the inshore areas. The scarcity of occurrence of juveniles of other species of *Leiognathus* in the inshore catches of Calicut during that time lends further support to this view.

The species that are found commonly associated with *L. bindus* are *Arius thalassinus* (young ones), *Teuthis* sp., *Dussumieria hasselti*, *Caranx kalla*, *Opisthopterus tardoore*, *Lactarius lactarius*, *Gazza minuta*, other spp. of *Leiognathus*, *Kowala coval*, *Ambassis gymnocephalus*, *Trichiurus* sp., *Metapenaeus dobsoni* and certain jelly fishes.

The luminescence of silver belly according to Harvey (Brown, 1957) is "due to definite luminous organs consisting of a flattened ring of luminous tissue radially arranged around the oesophagus where it joins the stomach; there is a sort of reflector, represented by a thick layer of tissue next to oesophagus, and so-called lens and the light organ is supplied with blood vessels". This characteristic glow in *L. bindus* persists for a couple of hours even after death ; but the glow is visible at night only. According to Haneda (1950) the greenish glow in the 15 species of Leiognathidae which he examined is due to luminous bacteria. It is this luminescence of the shoals of *L. bindus* which normally enables their easy detection and subsequent capture in huge quantities by boat-seines, during dark nights.

It may be mentioned that unlike *L. splendens* which spawns more than once in a season extending from March to August (Arora, *op. cit.*), *L. bindus* spawns only once in a year and its spawning period is shorter (from December to the end of February), even though both of them are more or less equally fecund.

Discharge of mucus over the body is a remarkable feature of this species which renders the fishing nets slimy and difficult to handle during fishing operations.

SUMMARY

Observations on the biology of *L. bindus* from 1956 to 1958 are presented.

L. bindus yields a fairly good fishery along the Calicut coast from April to December, August to November being the peak season. Boat-seines are mainly employed for the fishery.

The length-frequency distributions of the fish for three years are presented and discussed. The medium size groups (55-95 mm.) mainly support the fishery. The fish are essentially zoo-plankton feeders, copepods being the dominant food item. The length-weight relationship of the species has been expressed by the formula $W=0\cdot00002452\ L^{2\cdot8641}$. The total length-body height relation has been found out as $H=0\cdot25908+0\cdot38944\ L$. The size at first maturity has been found to be 87·0 mm. An ovary contains, on an average, 6,162 ripe eggs. The fish spawn once a year from December to end of February, in the deeper waters.

Its dense shoals are often characterized by their rippling movements in the surface waters. Normally, luminescent shoals yield heavy catches during foggy, dark nights.

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