STUDIES ON SOME ASPECTS OF THE BIOLOGY OF THE COMMON ANCHOVY, *THRISSOCLES MYSTAX* (BLOCH & SCHNEIDER)

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Introduction

The anchovies form an important fishery along the Malabar Coast and contribute considerably to the fish catches during certain seasons of the year and especially during the lean years for sardines. Of the 7 species of anchovies recorded along the west coast, *Thrissocles mystax* is the most common and is caught abundantly in the commercial hauls. It has a wide distribution and is known to occur in the seas of India, Malay Archipelago and China. It attains a maximum length of 205 mm.

The present knowledge of the biology of *Thrissocles mystax* is very meagre. Chidambaram and Venkataraman (1946) have, in their account of the natural history of certain marine food-fishes of Madras Presidency, given brief notes on the size, food, spawning season, fishery and economic importance of the anchovies in general, along with a tabular statement showing their total landings along the west coast during the years 1937–42. Some aspects of their bionomics, methods of capture and economic importance have been dealt with by Devanesen and Chidambaram (1948). Bhimachar and Venkataraman (1952), in their studies on the fish populations along the Malabar Coast, have briefly indicated the seasonal fluctuation in the occurrence of *Thrissocles mystax*, along with that of four other species of *Thrissocles*, in the inshore waters off Calicut during 1949–50.

Material and Methods

The present study is based on the specimens caught in the routine departmental biweekly fish collections from the sea off West Hill, Calicut, and also of samples obtained from the commercial catches, during the years 1950–52. The specimens were analysed for their total length, weight, sex, food and gonadal condition. The majority of them were obtained from catches made with the boat-seine and gill-net, locally known as *paithu vala* and *chala vala* respectively, which form the two important nets used along this coast for capturing pelagic shoaling fish. Details of these two nets and their mode of operation have been described by Bhimachar and Venkataraman (*op. cit.*). For the length-frequency studies the total length of fish (from the tip of the snout to the end of the ventral fluke of the caudal fin) was taken into consideration and the specimens

were analysed for their size-frequencies irrespective of the gear employed. They were grouped at 10 mm. intervals and the frequencies occurring in each size-group were converted into percentages in order to facilitate comparison.

For the study of food habits, the stomach contents were analysed in detail, both qualitatively and quantitatively. They were examined either fresh or after preservation in 4% formalin. The various food constituents were identified, as far as possible, up to the species but in most cases up to the genera. Two methods were adopted for the quantitative estimation of food, Pearse's method (Pearse, 1915—cited by Breder and Crawford, 1922) and Points method (Swynnerton and Worthington, 1940—as reviewed by Hynes, 1950). There was close similarity between the values obtained by these two methods in respect of the seasonal variations in the abundance of the different groups of food elements. The specimens were also analysed for their sex, and, in regard to females, the gonadal stages were determined on the basis of the maturity scales fixed by the International Council for the Exploration of the Sea. In the case of males, they were noted as either mature or immature, from the size and general colour of the testes, and this was confirmed by microscopic examination.

Length-Frequency Studies

The length-frequency analyses, for those months in 1950–51 for which data are available, are given in Table I wherein the figures given within brackets are the frequencies converted into percentages which are shown graphically in Fig. 1. In the length-frequency histogram for January 1950, a distinct mode at 155 mm. and another one at 35 mm. are seen, of which the latter, though not conspicuous, could be followed clearly during the subsequent months. The fish measuring 35 mm. belong to group A and evidently are fish of the year, while the fish measuring 155 mm. represent group B and belong to the stock recruited during the previous spawning season, *i.e.*, from September 1948 to May 1949. In the histogram for February 1950, two modes are seen in group A, one at 25 mm. and another at 45 mm. While the former mode represents a newly recruited stock, the latter, which is the same stock observed in January, indicates a growth of 10 mm. This modal length has further advanced to 55 mm. in March 1950. During the subsequent months of April and May 1950, growth of this group was not discernible, as the mode remained constant at 55 mm. The entry of large numbers of post-larval and juvenile anchovies into the fishery during the peak spawning period extending from November 1949 to March 1950, has apparently tended to mask the progression of this mode. This modal length increased to 75 mm. by June 1950 and it further advanced to 95 mm. in August 1950. After this, these juvenile specimens were not represented in the subsequent samples taken in October and November 1950, indicating their absence from the fishing grounds during

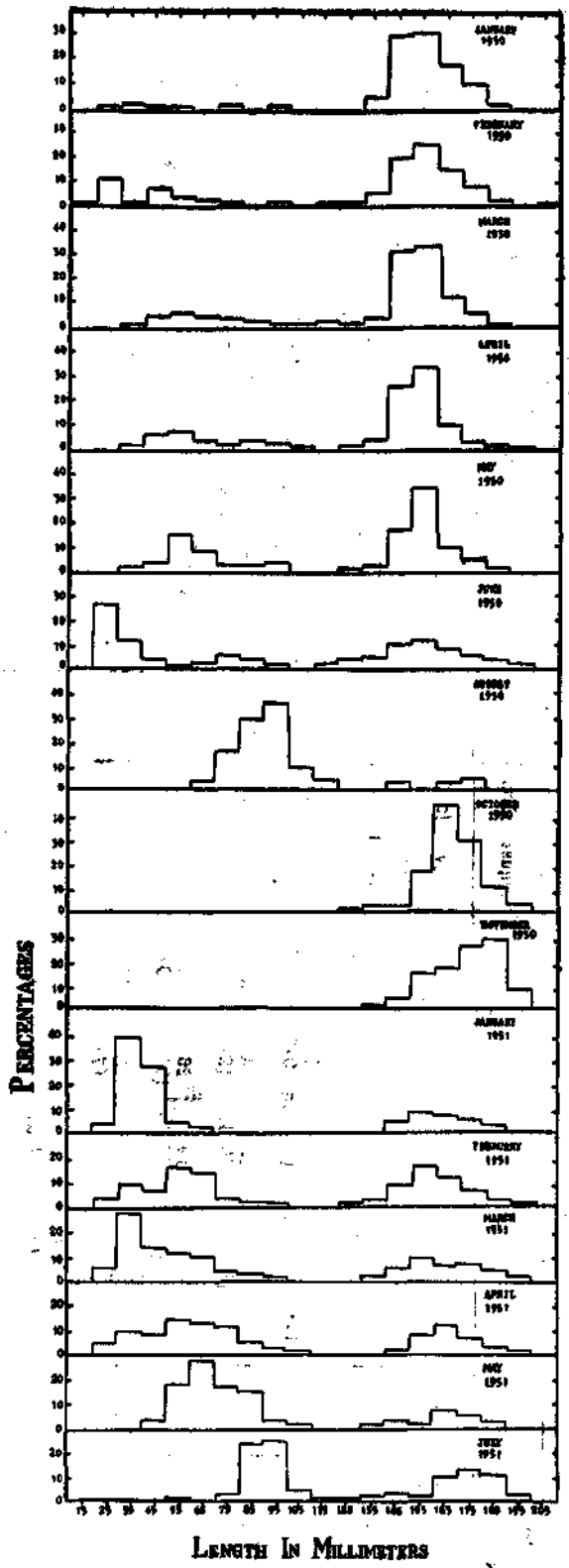

FIG. 1. Histograms showing the length-frequency distribution of *Thrissocles mystax* during 1950–51.

TABLE I

Length-frequency analyses of Thrissocles mystax *for different months during* 1950 and 1951

Size groups in mm.	1950									1951					
	Jan.	Feb.	March	April	May	June	August	Oct.	Nov.	January	Feb.	March	April	May	July
10-20	..	2 (0·5)	..	..	..	..	..	..	..	..	..	..	..	..	..
20-30	2 (0·3)	58 (11·9)	..	..	..	177 (25·5)	..	..	..	5 (3·3)	5 (2·7)	16 (4·2)	15 (5·2)	..	..
30-40	6 (0·8)	8 (1·7)	1 (0·1)	1 (0·3)	1 (0·5)	78 (11·2)	..	..	..	60 (39·2)	16 (8·8)	102 (26·9)	27 (9·2)	..	..
40-50	2 (0·3)	39 (8·0)	33 (4·8)	16 (5·4)	4 (2·2)	21 (3·0)	..	..	..	41 (26·8)	12 (6·6)	47 (12·5)	25 (8·6)	7 (3·0)	..
50-60	1 (0·2)	11 (2·2)	37 (5·4)	19 (6·4)	26 (14·8)	1 (0·1)	..	..	..	6 (3·9)	28 (15·4)	40 (10·6)	42 (14·4)	41 (17·4)	1 (0·4)
60-70	..	9 (1·8)	16 (2·3)	7 (2·3)	13 (7·4)	11 (1·7)	1 (2·5)	..	..	2 (1·3)	25 (13·7)	38 (10·1)	36 (12·3)	65 (27·6)	..
70-80	1 (0·1)	1 (0·2)	8 (1·2)	3 (1·0)	3 (1·7)	36 (5·2)	6 (15·0)	..	..	..	5 (2·7)	11 (2·9)	36 (12·3)	39 (16·5)	8 (3·0)
80-90	..	..	4 (0·6)	8 (2·7)	3 (1·7)	25 (3·6)	11 (27·5)	..	..	..	2 (1·1)	7 (1·9)	15 (5·2)	35 (14·8)	63 (23·5)
90-100	1 (0·1)	2 (0·4)	1 (0·2)	3 (1·0)	4 (2·3)	11 (1·7)	14 (35·0)	..	..	..	2 (1·1)	2 (0·5)	4 (1·4)	6 (2·6)	65 (24·3)
100-110	..	..	1 (0·2)	2 (0·7)	..	..	3 (7·5)	..	..	..	..	..	2 (0·7)	2 (0·8)	14 (5·2)

110–120	..	1 (0·2)	2 (0·3)	..	..	10 (1·4)	1 (2·5)	..	..	..	..	..	..	..	2 (0·7)
120–130	..	1 (0·2)	1 (0·1)	5 (1·7)	2 (1·1)	25 (3·6)	..	2 (0·6)	..	..	1 (0·6)	..	..	..	2 (0·7)
130–140	34 (4·7)	23 (4·7)	22 (3·2)	11 (3·7)	3 (1·7)	34 (4·9)	..	5 (1·4)	2 (0·5)	..	2 (1·1)	2 (0·5)	..	2 (0·8)	6 (2·2)
140–150	223 (30·5)	96 (19·6)	214 (31·1)	79 (26·5)	29 (16·5)	70 (10·1)	1 (2·5)	5 (1·4)	20 (4·9)	6 (3·9)	16 (8·8)	17 (4·5)	6 (2·0)	5 (2·1)	7 (2·6)
150–160	233 (31·9)	122 (24·9)	226 (32·9)	101 (33·9)	60 (34·1)	79 (11·4)	..	53 (15·6)	62 (15·2)	11 (7·2)	31 (17·0)	34 (9·0)	22 (7·5)	2 (0·8)	6 (2·2)
160–170	134 (18·4)	72 (14·7)	78 (11·4)	30 (10·1)	18 (10·2)	55 (7·9)	1 (2·5)	145 (42·9)	69 (16·9)	10 (6·6)	21 (11·5)	23 (6·1)	34 (11·6)	16 (6·8)	27 (10·1)
170–180	81 (11·1)	38 (7·8)	37 (5·4)	10 (3·3)	8 (4·5)	33 (4·8)	2 (5·0)	96 (28·4)	105 (25·7)	8 (5·2)	12 (6·6)	24 (6·4)	18 (6·2)	11 (4·7)	34 (12·7)
180–190	12 (1·6)	5 (1·0)	4 (0·6)	2 (0·7)	2 (1·3)	20 (2·9)	..	28 (8·5)	118 (28·9)	4 (2·6)	3 (1·7)	13 (3·4)	7 (2·4)	5 (2·1)	28 (10·5)
190–200	..	..	1 (0·1)	1 (0·3)	..	7 (1·0)	..	4 (1·2)	32 (7·[illegible])	..	1 (0·6)	2 (0·5)	3 (1·0)	..	5 (1·[illegible])
200–210	..	1 (0·2)	1 (0·1)	..	..	..		..	..	..	..	..	..	..	..
Total ..	730	489	687	298	176	693	40	338	408	153	182	378	292	236	268

this period. The mode seen at 25 mm. in the histogram for June 1950 was due to the recruitment of new stock (born in April-May 1950) by the late spawners of the same season.

The modal length of group B, which was observed at 155 mm. in January 1950, remained constant during the subsequent months, February to June, which may probably be due to the predominance of that particular size-group in the population and also due to the non-availability of larger-sized groups in sufficient numbers on the fishing grounds. The histogram for October 1950, when the next large collection (the sample of this group obtained in August 1950 being not representative, as the numbers were too poor) was obtained, showed its mode at 165 mm. The collection obtained in November showed a modal length of 185 mm. Judging from the wide variation in the respective modal sizes of the two foregoing collections, and a growth of 20 mm. over a period of one month being not likely, it can be inferred that the latter collection, though of group B, belonged to an earlier stock than the preceding one.

The juvenile specimens of group A, observed last in August 1950, entered into the fishery as adults in January 1951, forming group B. The length-frequency histograms for the months, January to March 1951, show the mode of this group at 155 mm. and the mode shifted to 165 mm. by April-May 1951. The histogram for July 1951 shows a further advancement of this mode to 175 mm. After this, the growth could not be followed as the samples which were obtained in the subsequent months were not large enough for the length-frequency analysis.

The histogram for January 1951, as in the previous year, shows the presence of a new generation of post-larval and juvenile specimens (born in November-December 1950) in the samples, which during the subsequent months shows an increase in size, with some fluctuations, attaining a modal length of 95 mm. by July 1951.

From the foregoing account, it is seen that group A, recruited presumably during the months of November-December 1949, entered the fishery as post-larval and juvenile forms in January 1950 and attained a modal length of 95 mm. by August 1950, in about 8–9 months. Subsequently, this stock left the fishing grounds and reappeared in the fishery in January-February 1951 with a modal length of 155 mm., indicating a growth of 60 mm. in the course of 5–6 months. This modal length advanced further to 175 mm. by July 1951, after which its increase could not be followed since the samples in the subsequent months were not large enough to justify any conclusions. Judging from the growth-rate during the second year, it is evident that the

highest mode of 185 mm., observed in November 1950, was reached towards the end of the second year of its life.

Based on the observations given above, it could be deduced that the fish attains an average length of 95 mm. during the first year of its life (in the course of 8–9 months) and of 155 mm. during the earlier part and 185 mm. at the end of its second year of life, the growth-rate during the second year being thus comparatively very slow. It is also seen that the fishery is mainly constituted by the first- and second-year classes. It is probable that the maximum size of 205 mm. is reached by the fish during the third year of its life.

It would be interesting to compare the age of this species of the anchovy with that of species occurring elsewhere. Clark and Phillips (1952), in their studies on the biology of the Northern anchovy, *Engraulis mordax mordax* Girard, have stated that the oldest anchovy in the fishery had completed seven years of life. The European anchovy, *E. encrasicholus* (L.), has been observed to attain a total length of 12–15 cm., 15–18 cm. and 18–21 cm. in 1, 2 and 3 years respectively (Fage, 1911, 1935, 1937; Arne, 1931; Meek, 1916; and De Buen, 1931). Blackburn (1950), comparing the growth-rate of the European species with that of *E. australis* (White) obtained from Victorian waters, Australia, observed that the growth of the former is almost double that of the latter which attains a length of only 7–8 cm., 9 cm. and 10–11 cm. in 1, 2 and 3 years respectively. The findings as regards the age and growth of *Thrissocles mystax* are more comparable with that of *E. encrasicholus* than with that of *E. australis* or *E. mordax mordax*.

Food and Feeding Habits

In the course of this investigation, 1,067 specimens were examined for their stomach contents, of which 132 specimens had empty stomachs. Tables II, III and IV show the variations in the percentage composition of the different food components taken by the fish during the years 1950, 1951 and 1952 respectively and these are represented graphically in Fig. 2 for the years 1950 and 1952 only. A brief account of the different food items and their occurrence during different periods of the year in the stomach of fish examined, is given below.

Decapods:

Prawns constituted the most dominant food of this anchovy, the average percentage for the entire period being 34·7. In 1950, they were most abundant in the stomach contents during the months, January to June. But, from the latter half of June till October, they were practically absent, except for small numbers recorded during August. They were again noticed in appreciable quantities in the stomach contents from October to December, the maximum being in December. More or less the same trend of occurrence was noticed during 1951 and 1952 also, the prawns being dominant during the post-monsoon and summer months, which

TABLE II

Percentage composition of different food items taken by Thrissocles mystax *during* 1950

Months	No. of specimens examined	No. of specimens with empty stomachs	Percentage of fish with empty stomachs	Range in length in mm.	Stomach contents										
					Prawns	*Acetes*	*Lucifer*	Copepods	Amphipods	Stomatopods	Other crustaceans	Fish	Polychætes	Molluscs	Miscellaneous
January ..	75	..	..	135–183	64·0	..	2·7	1·8	..	..	0·8	3·0	23·3	..	4·4
February ..	100	14	14	106–192	40·7	2·0	2·3	0·8	0·4	15·5	2·7	1·5	33·0	..	1·1
March ..	110	4	3·6	64–201	41·0	44·4	2·4	0·4	0·2	0·4	1·4	5·4	4·4	..	..
April ..	50	..	..	135–175	18·5	62·4	0·9	..	0·5	..	0·1	15·0	2·6	..	..
May ..	24	..	..	97–184	35·9	40·4	1·8	2·2	0·6	..	..	14·4	..	4·7	..
June ..	48	14	29·2	75–193	23·1	31·7	2·9	0·6	..	1·6	0·2	36·4	1·8	1·7	..
July ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
August ..	14	6	42·9	86–173	7·5	..	25·5	2·5	5·5	..	6·2	24·8	24·5	..	3·5
September ..	7	1	14·3	85–191	..	12·5	3·7	2·8	..	..	..	49·7	26·7	..	4·6
October ..	20	3	15	121–186	21·6	...	0·7	17·5	1·3	6·2	4·1	15·7	31·7	1·2	..
November ..	31	6	19·4	151–200	30·1	17·4	..	0·5	..	..	0·5	25·5	20·0	..	6·0
December ..	20	..	..	136–195	63·5	..	3·0	6·0	..	..	2·5	25·0	..	..	..
Average percentage					31·4	19·2	4·2	3·2	0·9	2·0	1·7	19·7	15·3	0·5	1·9

TABLE III

Percentage composition of different food items taken by Thrissocles mystax *during* 1951

Months	No. of specimens examined	No. of specimens with empty stomachs	Percentage of fish with empty stomachs	Range in length in mm.	Stomach contents										
					Prawns	*Acetes*	*Lucifer*	Copepods	Amphipods	Stomatopods	Other crustaceans	Fish	Polychætes	Molluscs	Miscellaneous
April ..	28	..	..	154–194	60·1	20·4	0·2	..	..	..	5·7	13·4	0·2	..	..
May ..	23	..	..	71–183	34·9	41·4	6·1	1·1	5·1	..	1·5	3·5	..	..	6·4
July ..	18	8	44·4	91–184	8·9	..	1·9	0·3	0·6	..	55·7	32·6	..	..	..
August ..	16	6	37·5	134–199	..	..	..	0·9	..	..	0·8	60·8	13·3	..	24·2
September ..	2	..	..	169–187	..	..	..	..	..	..	..	..	100·0	..	..
November ..	7	1	14·3	148–193	32·7	..	..	..	..	0·7	16·6	0·6	32·7	16·7	..
December ..	2	..	..	149–182	100·0	..	..	..	..	..	..	..	..	..	..
Average percentage					33·8	8·8	1·2	0·3	0·8	0·1	11·5	15·8	20·9	2·4	4·4

TABLE IV

Showing the percentage composition of different food items taken by Thrissocles mystax *during* 1952

Months	No. of specimens examined	No. with empty stomachs	Percentage of fish with empty stomachs	Range in length in mm.	Stomach contents										
					Prawns	*Acetes*	*Lucifer*	Copepods	Amphipods	Stomatopods	Other crustaceans	Fish	Polychaetes	Molluscs	Miscellaneous
January ..	15	2	13·3	146–188	53·8	..	..	..	..	46·2	..	..	..	..	..
February ..	17	1	5·9	110–201	71·1	..	13·7	0·8	7·6	..	..	4·0	2·8	..	..
March ..	45	..	..	55–173	30·5	38·4	5·3	0·9	4·5	16·2	0·4	1·3	1·3	..	1·2
April ..	64	..	..	52–185	55·5	20·5	9·3	4·9	2·0	..	..	5·4	1·9	..	0·5
May ..	54	..	..	52–192	50·6	13·8	6·8	6·3	16·4	..	..	..	1·8	3·5	0·8
June ..	6	6	100	134–168	..	..	..	..	..	..	..	..	..	..	..
July ..	36	24	66·7	142–200	25·3	..	2·5	5·7	7·2	..	3·6	41·0	9·8	..	4·9
August ..	9	1	11·1	185–200	..	..	23·1	2·9	..	..	8·6	62·5	2·9	..	..
September ..	76	15	19·7	135–199	..	..	2·3	23·1	6·1	10·0	10·6	8·0	38·4	..	1·5
October ..	58	7	12·1	135–191	31·8	6·6	..	2·0	4·8	3·3	6·4	6·2	28·9	..	..
November ..	41	5	12·2	135–185	41·3	..	4·9	1·9	0·7	3·3	..	9·4	33·6	..	4·9
December ..	51	11	21·6	129–187	64·8	..	2·2	..	..	..	10·8	22·2	..	..	..
Average percentage					38·6	7·2	6·4	4·4	4·5	7·2	3·7	14·5	11·9	0·3	1·3

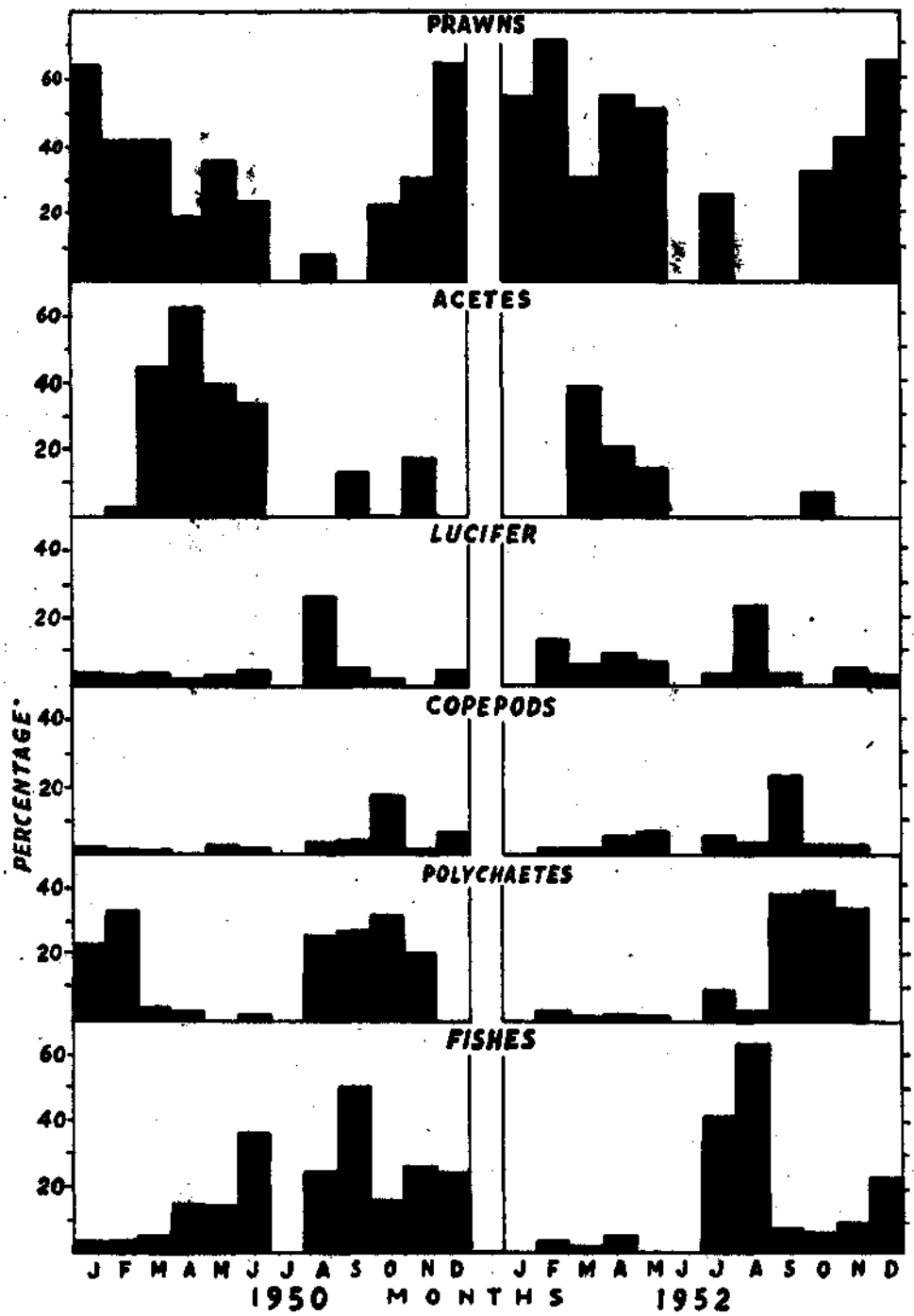

FIG. 2. Histogram showing the variation in the occurrence of different food organisms in the stomach of *Thrissocles mystax* during different months in 1950–51.

extend from September to February and from March to May respectively. The three most common species of prawns forming the food of this fish were *Penæus indicus*, *Parapenæopsis stylifera* and *Metapenæus dobsoni*. Another common decapod, that formed an important constituent of the food, was the small shrimp, *Acetes dispar*. It was abundantly consumed during the summer months of March–May 1950 and during the first half of June, after which it was totally absent in the stomach contents till the end of the year, except for brief periods in September and November. Its abundant occurrence in the stomach contents was again noticed during the summer months of 1951 and 1952. *Lucifer* was a common form present in the stomach contents almost all through the year, both in 1950 and 1952, and its maximum occurrence was in August during both the years, while in 1951 it was in May.

Copepods.—Copepods constituted an important item of diet and were in evidence during both the pre-monsoon and post-monsoon periods, with occasional occurrence during the monsoon months. The peak of their occurrence in the stomachs was noticed in October 1950 and in September 1952. The most common copepods observed were *Pseudodiaptomus mertoni*, *Temora turbinata*, *Centropages alcocki*, *Paracalanus* sp., *Euterpina* sp., *Caligus* sp. and *Acartia* sp.

Amphipods.—Amphipods, the most common form being *Cheiriphotis megacheles*, constituted good proportions of its diet during some months in 1952, while during the two earlier years their presence in the stomach contents was very poor.

Stomatopods.—The stomatopod, *Squilla*, was occasionally present in large numbers in the stomach contents during the post-monsoon period, as was noticed in January 1952.

Other crustaceans.—Among other crustaceans the cladoceran, *Evadne*, formed the main food with which the stomachs on some occasions were practically gorged, especially during the rainy months of July and August. Penæid larvæ, zœa and megalopa stages of crabs, small crabs and mysids were also observed commonly in the stomach contents, mainly during the post-monsoon months. Larvæ of *Hippa* and Cirripede also formed part of its food.

Fish.—Both adult and post-larval fish constituted a major food item during the months, June–September. As most of the fish noticed in the stomach contents were in a digested condition or only fragments of it were present, it was not possible to determine their identity.

Polychætes.—Polychætes (mainly *Prionospio pinnata*) were one of the dominant food items of this fish, mainly occurring during the post-monsoon period. They were abundantly present during January and February and from August–November 1950. They were again noticed during August–December 1951, the maximum being in September. More or less the same trend of occurrence in the stomach contents was noticed in 1952 also, the largest number recorded being in October,

Molluscs.—Larval bivalves were rare in the stomach contents and were present in appreciable numbers only on one occasion in November 1951.

Miscellaneous.—The diatoms were placed under the miscellaneous group, as they were poorly present in the stomachs of this fish and formed an insignificant part of its diet. The common diatoms observed in its stomach were *Coscinodiscus* and *Pleurosigma*. Included under the miscellaneous is also the chætognath, *Sagitta*, some numbers of which were present in the stomach contents on very few occasions. Under this section are also included a few unrecognizable and unidentified organisms.

A close correlation between the stomach contents of *Thrissocles mystax* and the organisms available in its environment could be made out. The three species of prawns, *Penæus indicus*, *Metapenæus dobsoni* and *Parapenæopsis stylifera*, which form the main food of this anchovy during the post-monsoon and summer months, also occur abundantly during the same period in the inshore area off West Hill, Calicut, from where most of the specimens examined for food were obtained. Again, the small shrimp, *Acetes dispar*, which is plentiful in the inshore area off West Hill during the summer months of March, April and May, showed a corresponding dominance in the stomach contents also. The decline in the occurrence of prawns and *Acetes* noticed in the stomach contents during the monsoon months coincided with their poor fishery during the same period in the inshore area. Instead, the fish fed mostly on adult and post-larval fishes, as shown by a steep rise in their occurrence in the stomach contents during this period. As already stated, polychætes (mainly *Prionospio pinnata*) form one of the chief items of its food. Seshappa (1953), in the course of his studies on the inshore sea bottom fauna off West Hill, stresses the importance of this polychæte as fish food and states "*Prionospio pinnata* is about the most important member of the bottom infauna of the West Hill sea, both from the point of view of abundance and from the point of value as fish food." The recolonisation of this species in the inshore area after a temporary absence during the monsoon months due to adverse conditions, takes place in September. The polychæte occurs abundantly till May of the following year, and it is during this period, especially during the earlier part, that it was noted in large numbers in the stomach contents. Among the minor items of food, the cladoceran, *Evadne*, showed a distinct dominance in the stomach contents during the rainy season, which also forms the abundant season for the cladocerans in the plankton as observed by George (1953). Copepods, which occurred abundantly in the stomachs of this fish during September and October, have also been noticed in appreciable numbers in the plankton during the same period.

The fish shows intense feeding during the period immediately following the monsoon, which is also its maturing period. The peak of its feeding is reached during the months, December to May, when the stomachs of all the specimens were generally gorged with prawns and *Acetes*. But a decline in the feeding intensity is noticed during the monsoon months, as judged from the relatively higher percentage of fish showing empty stomachs.

From an analysis of its food, it is seen that the fish is mainly a carnivore. It may be mentioned that a similar carnivorous food habit, with crustaceans forming the major food item, has been observed in the allied species of anchovy *Thrissocles hamiltonii* (Grey), *T. purava* (Ham.) and *Setipinna phasa* (Ham.) by Mookerjee and Mookerjee (1950), Bal and Bapat (1950) and Jones and Menon (1951). *Thrissocles mystax* feeds at all levels as shown by the presence of pelagic crustaceans, fish and fish larvæ and bottom-living polychætes. Zooplanktonic elements were more common in the stomach contents than phytoplanktonic elements. Some differences in the feeding habits of juvenile and adult specimens were noticed. Juvenile specimens showed a marked preference for *Lucifer*, *Acetes*, larval penæids and fish post-larvæ, while larger specimens preferred prawns, fish and polychætes. The presence of small numbers of *Sagitta* in the stomachs on a few occasions could only be regarded as a rare inclusion.

Spawning Period

The accompanying table (Table V) shows the percentage of mature and immature females (graphically represented in Fig. 3) observed in each month during the years 1950 and 1951. Those females which showed ovaries in stage IV and above were included under the category of mature specimens while the rest were counted as immature specimens.

It is seen that this fish has a prolonged spawning season extending over a period of 8 months from September to May of the following year. But its maximum spawning activity is limited to the November–March period, judging from the largest percentage of mature specimens recorded during this period. During the subsequent months of April and May, there was a decline in the percentage of mature specimens, the immature ones predominating the collections. During the months June–August, specimens of all sizes, including adult ones, were immature with an appreciable increase in their fat contents.

As ripe and oozing specimens, fertilized eggs or early larvæ were not obtained from the inshore area during the period of the investigation, it is probable that the spawning takes place elsewhere. But, in the case of

TABLE V

Percentage of mature and immature fish during 1950–51

Months		No. of females	Percentage of mature fish	Percentage of immature fish	Months		No. of females	Percentage of mature fish	Percentage of immature fish
January	1950 ..	28	92·9	7·1	January	1951 ..	20	75·0	25·0
February	1950 ..	35	92·1	7·9	February	1951 ..	14	78·6	21·4
March	1950 ..	49	73·1	26·9	March	1951 ..	68	72·1	27·9
April	1950 ..	26	26·9	73·1	April	1951 ..	67	47·8	52·2
May	1950 ..	12	16·7	83·3	May	1951 ..	32	6·3	93·7
June	1950 ..	27	..	100·0	June	1951 ..	5	..	100·0
July	1950 ..	4	..	100·0	July	1951 ..	82	..	100·0
August	1950 ..	11	..	100·0	August	1951 ..	3	..	100·0
September	1950 ..	6	33·3	66·7	September	1951 ..	42	59·5	40·5
October	1950 ..	41	48·8	51·2	October	1951 ..	13	63·8	46·2
November	1950 ..	181	95·6	4·4	November	1951 ..	20	85·0	15·0
December	1950 ..	9	66·7	33·3	December	1951 ..	4	75·0	25·0

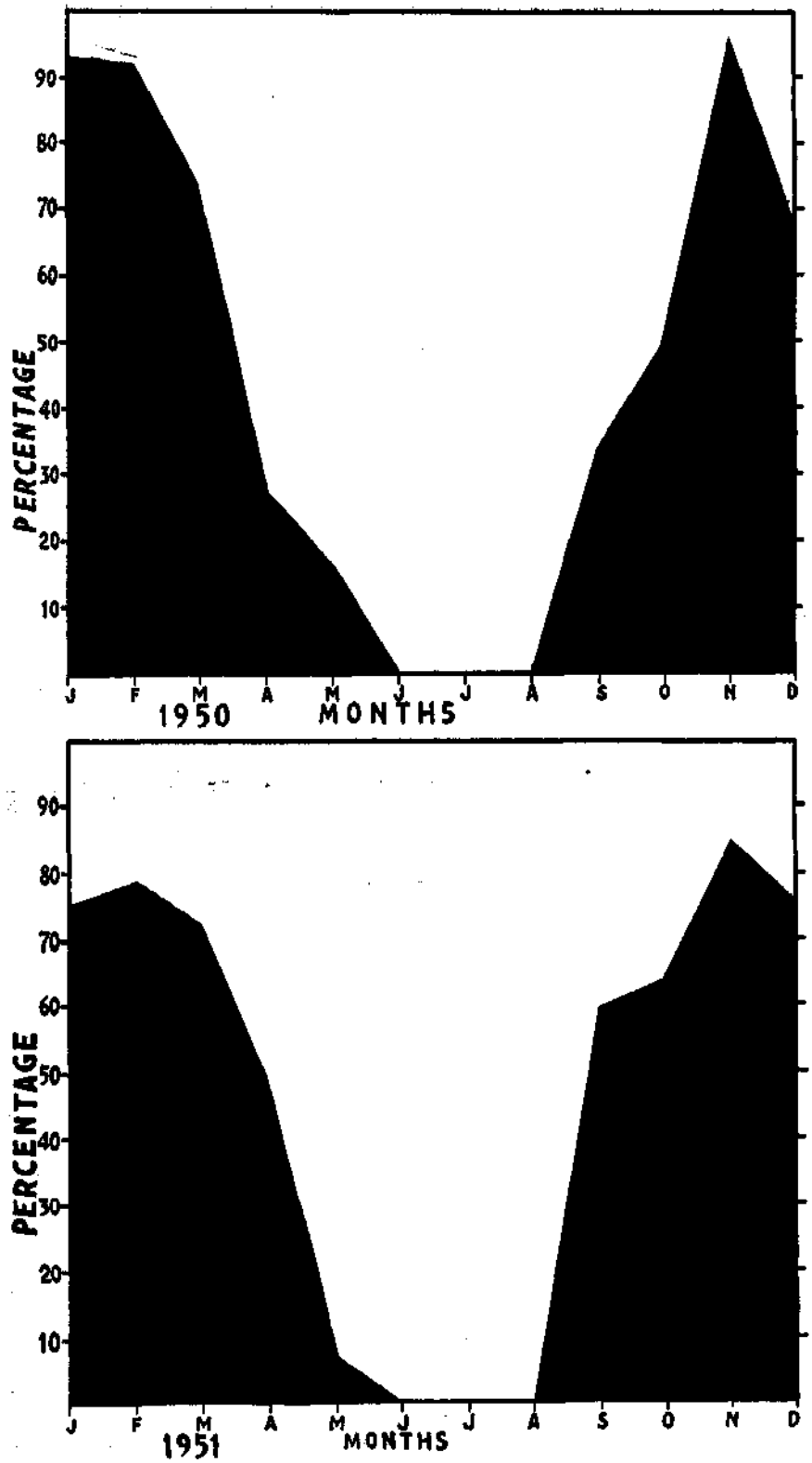

FIG. 3. Histograms showing the percentage of mature and immature females for each month in 1950 and 1951. Black represents stages IV and above, while blank represents stages I to III.

Thrissocles purava, Palekar and Karandikar (1952) state that "the species visits Bombay shores mainly for spawning" twice a year.

Size at First Maturity

The table shown below gives the numbers of mature and immature females and also the percentage of mature females in each 10 mm. size-group from the samples taken during the peak of their spawning season.

Table VI

The number of mature and immature females and percentage of mature fish in each 10 mm. of length

Length in mm.	Total fish observed	Number mature	Number immature	Percentage mature
20– 30	21	0	21	0·0
30– 40	24	0	24	0·0
40– 50	32	0	32	0·0
50– 60	40	0	40	0·0
60– 70	35	0	35	0·0
70– 80	45	0	45	0·0
80– 90	23	0	23	0·0
90–100	15	0	15	0·0
100–110	11	0	11	0·0
110–120	12	0	12	0·0
120–130	2	0	2	0·0
130–140	20	5	15	25·0
140–150	28	17	11	60·7
150–160	52	49	3	94·2
160–170	40	39	1	97·5
170–180	62	62	..	100·0
180–190	101	101	..	100·0
190–200	37	37	..	100·0
200–210	1	1	..	100·0

The results show that 25·0% of the specimens were mature at 130–140 mm., 60·7% at 140–150 mm., 94·2% at 150–160 mm. and 97·5% at 160–170 mm., and practically all the specimens over 170 mm. were mature. No mature specimens were noticed among the size-groups below 130 mm. Since 60·7% of the specimens were mature at 140–50 mm. it can be stated that first maturity is attained at a length of 140–50 mm. by the end of the first year of its life or beginning of the second year.

LENGTH-WEIGHT RELATIONSHIP

In order to find out the length-weight relationship, the individual weights and measurements of 175 specimens, ranging in size from 50 mm. to 200 mm., were recorded. The entire size-range was divided into eight size-groups, each at 20 mm. interval. The average length and weight of all the observations in each group were recorded. The length-weight relationship was determined through the use of the general formula $W = AL^k$, where W and L represent the weight and length of the fish respectively and A and k are the constants. The formula worked out to be

$$W = \cdot 0000003776\ L^{2.912}$$

where the value of k is very near three. From the above formula the calculated value of W was derived for the given value of L. It is seen from Table VII (and Fig. 4) that both calculated weights and the corresponding observed weights agree closely with one another and the weight of the fish varies almost as the cube of the length, the length-weight relationship thus showing a normal pattern.

TABLE VII

Average observed and calculated weights of Thrissocles mystax

Size-group in mm.	Number of observations	Length (average)	Weight in g. (average)	Calculated weight in g.
50– 70	4	62·25	2·27	1·985
70– 90	10	81·00	3·4	3·969
90–100	9	101·77	7·94	7·655
110–130	3	120·66	11·91	12·474
130–150	60	141·77	20·13	20·696
150–170	46	156·00	25·23	25·799
170–190	38	176·18	36·00	36·855
190–210	4	192·25	46·21	47·628

STUDIES ON OTOLITHS AND SCALES

Detailed examination of the otoliths and scales of the fish of different sizes for the presence of growth rings was carried out. No growth rings were

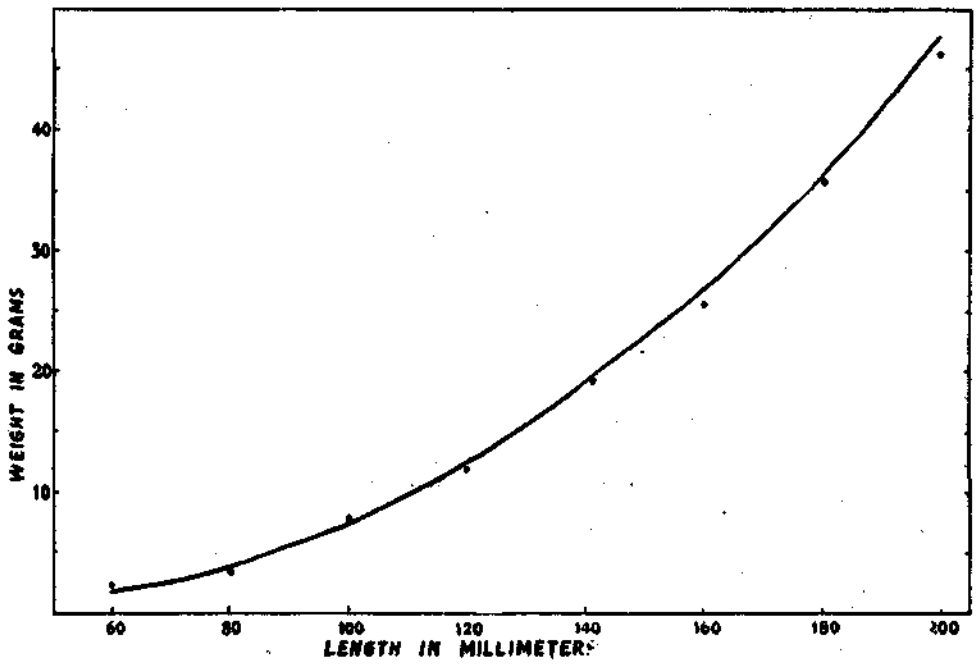

FIG. 4. Calculated length-weight curve (solid line) fitted to the average observed length-weight values (black dots).

noticed in otoliths even after careful scrutiny following the method adopted for the study of the otolith of the oil sardine (Nair, 1949). But a detailed examination of the scales indicated the presence of distinct growth rings along with a number of false ones. Growth rings were not observed in specimens measuring less than 14 cm., while in specimens measuring 14–20 cm. the number of rings varied generally from 1 to 3, though any definite relationship with the size of the fish could not be established. From the observations so far made, it has not yet been possible to draw any positive correlation between the size of fish and the number of rings.

FISHERY

Table VIII (as also Fig. 5) given below shows the annual estimated landings of the anchovies from the data maintained in the fish-curing yards in the South Kanara and Malabar Coasts for a period of 28 years, from 1925 to 1953. Of the few species of anchovies included in these landings, *Thrissocles mystax* was the most common form constituting the largest portion of the catches and as such a general picture of the fluctuations seen in the fishery of this species could be made out.

TABLE VIII

The estimated landings of anchovies along the West Coast (South Kanara and Malabar) from 1925–53

Seasons	Landings in maunds	Seasons	Landings in maunds
1925–26	8,852	1939–40	9,336
1926–27	13,050	1940–41	10,384
1927–28	10,782	1941–42	8,737
1928–29	11,281	1942–43	1,633
1929–30	2,642	1943–44	5,026
1930–31	2,040	1944–45	20,251
1931–32	5,660	1945–46	15,951
1932–33	4,929	1946–47	9,759
1933–34	4,992	1947–48	52,854
1934–35	5,105	1948–49	4,634
1935–36	11,240	1949–50	3,380
1936–37	11,305	1950–51	1,020
1937–38	16,039	1951–52	2,088
1938–39	15,807	1952–53	3,819

It is seen that there was an irregular fluctuation in the abundance of the fishery at intervals ranging from 2 to 6 years. Only during 11 seasons did the annual landings along the Malabar and South Kanara coasts exceed 10,000 maunds, while during other years the landings were considerably less. The highest landing was in 1947–48 when 52,854 maunds were obtained and the lowest was in 1950–51 when only 1,020 maunds were recorded. The average annual landings for the entire period is about 9,736 maunds. It is significant to note that during the years 1944–48, there was a marked increase in the landings of the anchovies, when the oil-sardine fishery was poor.

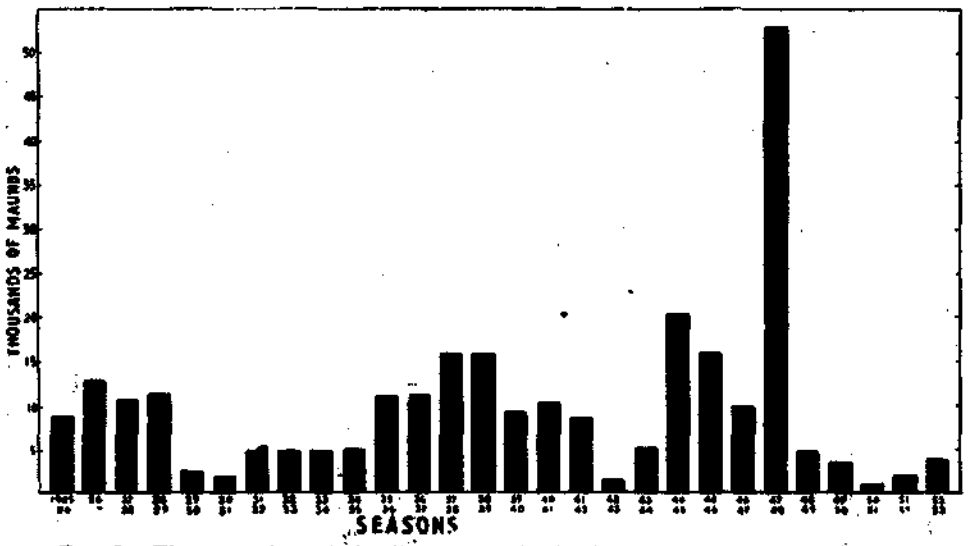

FIG. 5. The annual total landings of anchovies in the South Kanara and Malabar Coasts for the years 1925–26 to 1952–53.

SUMMARY

The results reported here on the biology of the anchovy, *Thrissocles mystax*, are based on a study of the specimens occurring in experimental hauls from the inshore area off West Hill, Calicut, and also of material obtained from the commercial catches during the years 1950–52.

The length-frequency studies show that the fish attains an average length of 95 mm. during the first year of its life (in the course of 8–9 months), and 155 mm. during the earlier part and 185 mm. at the end of the second year of its life, the growth during the second year being comparatively slow. The fishery is mainly constituted by the first and second-year classes. It is probable that the maximum size of 205 mm. is reached by the fish during the third year of its life.

A detailed study of the food and feeding habits shows that it is mainly a carnivore, prawns, *Acetes*, polychætes, and fish forming the major items of its food. A close correlation between the seasonal abundance of the different food items taken by the fish and their corresponding dominance in the foreshore waters could be made out. It shows intensive feeding during the post-monsoon and summer months with the peak during December–May. A decline in the feeding intensity is noticed during the monsoon months.

The species has a prolonged spawning season extending over a period of months from September to May, though the maximum spawning activity is

limited from November to March. It attains first maturity at a length of 140–150 mm. by the end of first year or beginning of the second year of its life.

Growth rings could not be made out in otoliths. A careful examination of the scales of specimens measuring 14–20 cm. indicated the presence of distinct growth rings which generally varied from 1 to 3. From the observations so far made on the scales, it has not yet been possible to draw any positive correlation between the size of fish and the number of rings.

The estimated annual landings of the anchovies along the West Coast (South Kanara and Malabar) for the years 1925–53 show irregular fluctuations. A marked increase in the landings of anchovies was noticed during some years when the oil-sardine fishery was poor.

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