THE FOOD AND FEEDING HABITS OF THE INDIAN OIL SARDINE *SARDINELLA LONGICEPS* VALENCIENNES

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Introduction

Information on the food of the Indian oil sardine, *Sardinella longiceps*, known as *Mathi* in Malayalam, forming one of the foremost commercially important fisheries of the west coast of India, is fragmentary. As stated by Hornell (1910) the food of the oil sardine from the fish curing yards of the Madras State was reported to be 'mud' but, he described for the first time some of the food constituents of the species. Further, in 1924 he along with Nayudu gave a detailed account of the food composition and its seasonal fluctuations. Information about the nature of the food of this fish is available from the works of John and Menon (1942), Chidambaram (1950), Devanesan and Chidambaram (1953) and Dhulkhed (1962). Nair and Subrahmanyam (1955) and Nair (1960) are of the opinion that the diatom, *Fragilaria oceanica* is an indicator of the abundance of the Indian oil sardine.

In the present paper an attempt is made to describe the seasonal fluctuations in the food components found in the stomach contents of the oil sardine from the inshore waters off Calicut and to correlate the same with the feeding intensities in different age groups.

Material and Method

Specimens of *S. longiceps* for this study were collected from the fish landings at Calicut. They were caught by the boat seines (*Paithuvala, Mathikollivala, Pattankollivala, Thattaumvala* and *Nethalvala*) and gill nets (Mathichalavala). Occasionally they were caught by the cast net (*Veesuvala*). Fishing was carried out at the depth range of 2-27 metres.

Attempts were made to collect weekly samples of *S. longiceps*, each sample consisting of 12 specimens, during the period of three years from November 1959 to October 1962, but due to the seasonal nature of the fishery and the unsteadiness of the catches the number of samples and number of fish in some of the samples varied in certain months. Samples obtained from different types of gear were combined for the purpose of the study.

During these three years of study 82 samples of 905 specimens were analysed. The fish were measured for total length and their weight, sex and

stage of maturity were noted. The stomachs were removed and after wiping off the moisture, they were weighed in a chemical balance. The stomachs were cut open and the food was removed. Great care was taken to separate the food from the epithelial layer of the stomach wall to which the former was found closely adhering. The weight of the empty stomach with the epithelial tissue was also taken. The difference between these two weights gave the weight of the food. By mixing up with 5% formalin the food content was raised to a volume of 10 cc., out of which 1 cc. was taken on a counting chamber and the various food items were counted. To obtain quantitative estimates for different items, these counts were computed for a total of 10 cc. Side by side, the occurrence method was also followed.

Depending on the percentage of the months when particular food items occurred in the stomach of the fish, the different items were grouped into 'very common' (76-100%), 'common' (51-75%), 'frequent' (26-50%) and 'rare' (1-25%) Further, the monthly percentage frequency of occurrence of the different food items appearing in the stomachs of the fish examined in a month, was also studied.

Each one of these methods has its own limitations, particularly in determining the food and feeding habits of the oil sardine which is mostly a phytoplankton feeder. The occurrence method, while showing relative importance of different items, does not indicate the quantitative abundance of each item. The number method helps to assess only the numerical quantity of each item present in the stomach, but it does not indicate the importance of one item as compared with any other item. For instance the diatoms are small, the dinoflagellates slightly bigger and the zooplankton members are very much bigger; further they are bound to vary in their nutritive values. Hence the number alone of a particular item may not have much significance in its importance as an item of food. Very often the quantity of food in the stomach being too small to estimate its total volume, the weight method was preferred in spite of the difficulties involved in separating the epithelial layer closely adhering to the food as explained earlier. A combination of the above cited three methods was tried to overcome the disadvantages of adopting exclusively any one of them.

As indicated by Nair (1952) fish up to the sizes of 9.9 cm., 14.9 cm., and 18.9 cm., were considered to be one, two and three year old respectively and those above them to be four year old.

STOMACH

Irrespective of the size of the fish and the amount of food, the stomachs of the oil sardine were found bulged. The posterior end of the cardiac stomach was translucent while the entire pyloric stomach was highly opaque. When a stomach was opened, it was noticed invariably, that there was some

quantity of food left in the pyloric end even though the cardiac stomach was empty. Hence, in very rare cases, fully empty stomachs in *S. longiceps* were met with. From Table I it is noticed that during the first two years of observation the empty stomachs were rare, appearing only in November 1959, July and September 1960 and September and October 1961. In the third year empty stomachs were met with in good percentages in most of the months. The percentages varied from 4.2 to 64.6.

In absolutely fresh fish, the food was separated very easily from the stomach epithelium but in those examined a few hours after landing, it was found extremely difficult to separate the same as the epithelium was breaking into bits and getting mixed up with the food. Hence as many fish as possible were examined in fresh condition.

Food

Sardines are well known for their pelagic habits, feeding on planktonic elements. Unlike other species of sardines, the Indian oil sardine, *S. longiceps*

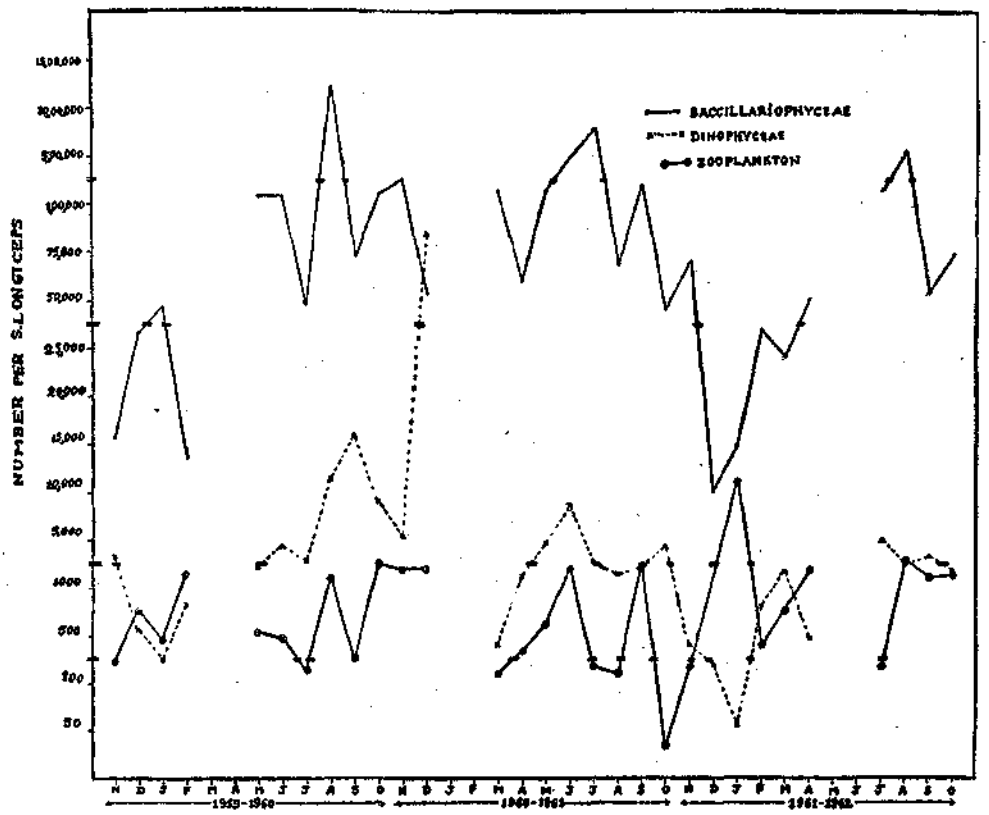

Fig. 1—Monthly averages of Baccillariophyceae, Dinophyceae and Zooplankton per *S. longiceps* during 1959-1962.

is predominantly a phytoplankton feeder and this is indicated by the presence of extremely fine straining mechanism provided by the well developed gill rakers in this fish.

As shown in Fig. 1, Baccillariophyceae and Dinophyceae formed the two major components among the phytoplanktonic organisms along with the Myxophyceae which appeared only occasionally. The zooplanktonic forms were poorly represented and among them the copepods were more common.

No distinct periods of abundance of a particular group or groups of food items were observed. In general, all planktonic forms appeared in the food of this fish in abundance during May to November.

(a) *Diatoms*

The following 18 genera were noticed in the stomach of *S. longiceps*: 1. *Sceletonema costatum* (Grev.), Cleve. 2. *Thalassiosira* spp., 3. *Coscinodiscus* spp., 4. *Planktoniella sol* (Wallich) Schutt, 5. *Aulacodiscus orbiculatus* Subrahmanyan, 6. *Rhizosolenia* spp., 7. *Bacteriastrum* spp., 8. *Chaetoceros* spp., 9. *Dityhum sol* Grun, 10. *Triceratium* spp., 11. *Biddulphia* spp., 12. *Fragilaria oceanica* Cleve, 13. *Thalassionema nitzschioides* Grun, 14. *Thalassiothrix* spp., 15. *Pleurosigma* spp., 16. *Nitzschia* spp., 17. *Surirella fluminensis* Grun and 18. *Asterionella japonica*. The last named species appeared only once in the food of this fish during December 1959.

Five members, namely, *Coscinodiscus* spp., (except in January 1962), *Biddulphia* spp., *Fragilaria oceanica*, *Pleurosigma* spp., and *Nitzschia* spp., (Table II) appeared in the food throughout and were considered to be 'very common' *Thalassiosira* spp., *Aulacodiscus orbiculatus* and *Thalassiothrix* spp., which appeared in more than 50% of the months of observation were treated as 'common' members. *Sceletonema costatum*, *Planktoniella sol*, *Rhizosolenia* spp., *Triceratium* spp., *Thalassionema nitzschioides* and *Surirella fluminensis* occurring in more than 25% but less than 50% of the months were considered as 'frequent' members. The remaining forms which appeared occasionally were treated as 'rare'.

From Table II it is noticed that the monthly percentage frequency of the stomachs in which *Coscinodiscus* spp., occurred, varied from 7.6 to 100. In all the months excepting February 1962, when it was 7.6, the percentage was above 54.1. From May to November, its percentage occurrence was very high.

The monthly percentage frequency of *Biddulphia* spp., ranged from 2.7 to 100. During the second year of observation, its occurrence was maximum during the period March to November.

TABLE I

Number of fish examined and their percentage with food in stomachs.

Month	1959-60			1960-61			1961-62		
	No. of fish examined	Fish with empty stomach (%)	Fish with food (%)	No. of fish examined	Fish with empty stomach (%)	Fish with food (%)	No. of fish examined	Fish with empty stomach (%)	Fish with food (%)
November . .	30	3.4	96.6	36	..	100.0	48	64.6	35.4
December . .	29	..	100.0	36	..	100.0	48	14.6	85.4
January . .	30	..	100.0	..	..	..	35	28.6	71.4
February . .	20	..	100.0	..	..	..	36	27.8	72.2
March . . .	..	..	..	24	..	100.0	24	4.2	95.8
April . . .	..	..	..	36	..	100.0	36	5.6	94.4
May . . .	24	..	100.0	24	..	100.0	..	..	..
June . . .	12	..	100.0	12	..	100.0	..	..	..
July . . .	30	16.7	83.3	12	..	100.0	36	..	100.0
August . .	36	..	100.0	35	..	100.0	36	..	100.0
September . .	36	2.8	97.2	36	33.4	66.6	12	..	100.0
October . .	36	..	100.0	24	41.7	58.3	36	16.7	83.3
TOTAL .	283	2.5	97.5	275	8.0	92.0	347	19.4	80.6

TABLE II

Monthly percentage frequency of occurrence of diatoms in the food of S. longiceps.

Month	Year	*Sceleto-nema costatum*	*Thalassio-sira* spp.	*Coscino-discus* spp.	*Plankto-niella sol*	*Alacodis-cus orbi-culatus*	*Rhizoso-lenia* spp.	*Bacteria-strum* spp.	*Chaeto-ceros* spp.	*Ditylum sol.*
November	1959	..	17.2	58.6	10.3	..	6.8	3.4	..	..
	1960	5.4	2.7	91.6	..	2.7	..	16.6	..	..
	1961	..	100.0	64.7	..	..	..	..	..	..
December	1959	..	10.3	100.0	3.4	..	3.4	3.4	6.8	..
	1960	5.4	2.7	52.7	..	10.8	..	..	..	..
	1961	41.4	2.4	19.4	..	12.1	..	..	..	..
January	1960	3.3	..	76.6	..	23.3	10.0	..	6.6	3.3
	1961	..	..	..	..	..	..	..	..	..
	1962	40.0	4.0	..	..	12.0	..	..	..	..
February	1960	..	..	85.0	5.0	30.0	55.0	..	10.0	..
	1961	..	..	..	..	..	..	..	..	..
	1962	42.3	53.8	7.6	..	7.6	..	..	..	..
March	1960	..	..	..	..	..	..	..	..	..
	1961	..	..	54.1	4.1	33.3	4.1	..	..	..
	1962	..	91.3	69.5	21.7	30.4	4.3	..	..	..
April	1960	..	..	..	..	..	..	..	..	..
	1961	..	2.7	80.5	..	8.3	..	..	..	..
	1962	..	82.3	94.1	14.7	2.9	..	..	..	2.9
May	1960	4.1	50.0	95.8	50.0	62.5	29.1	..	..	..
	1961	..	..	100.0	8.3	20.8	..	..	..	..
	1962	..	..	..	..	..	..	..	..	..

June .	1960	50.0	50.0	83.3	8.3	41.6	75.0	25.0	41.6	..
	1961	8.3	..	100.0	..	16.6	..	..	..	16.6
	1962	..	..	..	..	..	..	..	..	..
July .	1960	4.0	92.0	92.0	44.0	64.0	4.0	..	..	..
	1961	8.3	100.0	100.0	..	50.0	..	..	..	..
	1962	..	91.6	88.8	..	22.2	..	..	..	..
August .	1960	..	25.0	66.6	2.7	5.4	5.4	..	..	..
	1961	8.5	100.0	97.1	..	25.7	2.8	..	..	11.4
	1962	..	63.9	97.3	2.7	2.7	..	..	..	..
September	1960	..	..	100.0	..	..	..	..	..	..
	1961	..	100.0	95.8	8.4	16.6	..	..	..	..
	1962	..	58.3	100.0	..	..	..	..	..	..
October .	1960	..	2.7	100.0	..	5.4	2.7	..	..	..
	1961	28.5	71.4	92.8	..	..	..	..	..	..
	1962	..	36.3	80.0	3.3	..	..	..	..	..

TABLE II—*Contd.*

Month	Year	*Triceratium* spp.	*Biddulphia* spp.	*Fragillaria ocenica*	*Thalassionema nitzschoioides*	*Thalassiothrix* spp.	*Pleurosigma* spp.	*Nitzschia* spp.	*Surirela fluminensis*
November	1959	..	48.2	86.2	..	13.7	44.8	17.2	..
	1960	..	85.0	86.1	2.7	..	41.6	91.6	..
	1961	11.7	90.8	94.1	..	..	82.3	11.7	..
December	1959	..	48.1	100.0	3.4	10.3	55.1	37.9	3.4
	1960	..	80.0	91.6	..	..	63.9	55.4	..
	1961	..	48.6	75.5	..	..	73.1	26.8	..
January	1960	..	26.6	90.0	13.3	69.9	76.6	100.0	26.6
	1961	..	..	..	..	..	..	..	..
	1962	4.0	36.0	56.0	..	..	28.0	28.0	..
February	1960	..	50.0	100.0	35.0	40.0	75.0	95.0	15.0
	1961	..	..	..	..	..	..	..	..
	1962	3.8	95.5	96.1	..	19.2	57.6	76.9	..
March	1960	..	..	..	..	..	..	..	..
	1961	..	100.0	95.8	..	..	100.0	41.6	..
	1962	4.3	47.7	60.8	..	34.8	73.9	65.2	4.3
April	1960	..	..	..	..	..	..	..	..
	1961	8.3	98.0	91.6	..	11.1	91.6	16.6	2.7
	1962	2.9	98.2	64.6	..	5.8	91.1	55.8	8.8
May	1960	8.3	100.0	100.0	..	83.3	79.1	45.8	12.5
	1961	8.3	96.0	95.8	..	29.1	62.5	4.1	..
	1962	..	..	..	..	..	..	..	..

June . . .	1960	..	66.6	100.0	..	100.0	66.6	75.0	..
	1961	58.3	100.0	100.0	..	83.3	100.0	41.6	..
	1962	..	..	..	..	..	..	..	..
July . . .	1960	..	20.0	96.0	32.0	40.0	36.0	20.0	..
	1961	..	100.0	100.0	25.0	58.3	100.0	33.3	8.3
	1962	..	27.7	80.4	13.8	44.4	44.4	8.3	..
August . .	1960	..	2.7	88.8	..	..	11.1	11.1	..
	1961	14.2	95.0	94.2	22.8	68.5	62.8	17.1	..
	1962	..	2.7	100.0	..	5.4	91.6	25.0	..
September . .	1960	..	20.0	94.2	..	..	62.8	34.2	..
	1961	..	12.6	91.6	4.2	..	29.1	37.5	..
	1962	..	8.3	100.0	..	..	8.3	25.0	..
October . .	1960	..	36.0	77.7	..	..	55.5	33.3	..
	1961	7.1	64.2	100.0	..	..	35.7	7.1	..
	1962	3.3	80.0	90.0	..	..	40.0	56.6	..

The monthly frequency of occurrence of *F. oceanica* in the food of the fish was seen to range between 56 and 100 percent. Excepting in December 1961, January, March and April, 1962, the percentage was always above 80.4.

Pleurosigma spp., appeared in the stomachs with the percentage frequency ranging between 8.3 and 100. There appeared to be no seasonal sequence in its occurrence in the food of this fish.

Thalassiosira spp., occurred in the stomachs with the percentage frequency ranging between 2.4 and 100. In general, it can be stated that during the monsoon months of May to September this item of food was present to a greater extent.

A. orbiculatous had a frequency range of 2.7-64.0 per cent. It did not show any seasonal fluctuation in the food of this fish.

The percentage frequency of occurrence of *Thalassiothrix* spp., ranged from 5.4 to 83.3. In this case also no seasonal sequence in its abundance was noticed.

The monthly percentage frequency of occurrence of *P. sol* varied between 2.7 and 50.0, *Rhizosolenia* spp., between 2.7 and 75.0, *Triceratium* spp., between 2.9 and 58.3, *T. nitzschioides* between 2.7 and 35.0 and *S. fluminensis* between 2.7 and 26.6. All these forms appeared irregularly in the food of *S. longiceps*.

The percentage frequency of 'rare' diatoms found in the stomachs of *S. longiceps viz., Bacteriastrum* spp., *Chaetoceros* spp., and *D. sol* in general, varied between 2.7 and 41.6.

(b) *Blue green algae*

The blue green algae or Myxophyceae was represented in the food of *S. longiceps* by a single member, *Trichodesmium thiebautii* Gomont which appeared (Table III) in 13 months, forming 43% of the months under observation. Its percentage frequency of occurrence varied from 2.8 to 50.0 and hence it was considered as a 'frequent' item in the food of this fish.

(c) *Dinoflagellates*

The dinoflagellates found in the food of *S. longiceps*, are 1. *Prorocentron micans* Ehrenb, 2. *Dinophysis* spp., 3. *Ornithocercus* spp., 4. *Glenodinium lenticulata* Schiller, 5. *Peridinium* spp., and 6. *Ceratium* spp.

Excepting *Ornithocercus* spp., (Table III) which appeared only in 8 months forming 26.6% of the months under observation, all the remaining 5 items appeared in more than 83.3% of the months and can be regarded as 'very common', forms. *Ornithocercus* spp., can be considered as a 'frequent' item. The monthly percentage frequency of this item varied from 6.6 to 28.5.

TABLE III

Monthly percentage frequency of occurrence of Trichodesmium thiebauti *and dinoflagellates in the food of* S. longiceps

Month	Year	*Trichodesmium thiebauti*	*Prorocentron micans*	*Dinophysis* spp.	*Ornithocercus* spp.	*Glenodinium lenticulata*	*Peridinium* spp.	*Ceratium* spp.
November . .	1959	..	54.8	58.5	20.6	37.9	30.9	34.3
	1960	..	75.0	75.0	..	36.1	19.4	69.3
	1961	..	11.7	5.8	..	5.8	29.4	11.7
December . .	1959	..	62.0	54.8	6.8	10.3	30.9	13.7
	1960	..	66.6	5.4	..	..	8.3	16.5
	1961	4.8	17.0	..	..	..	17.0	2.4
January . .	1960	3.3	30.0	6.6	..	20.0	26.6	16.6
	1961	..	..	..	..	..	..	..
	1962	..	8.0	..	..	..	8.0	4.0
February . .	1960	30.0	...	55.0	..	25.0	30.0	100.0
	1961	..	..	..	..	..	..	..
	1962	3.8	23.0	3.8	..	..	..	..
March . . .	1960	..	..	..	..	..	..	..
	1961	4.1	..	..	..	12.5	12.5	12.4
	1962	8.6	8.6	30.4	8.6	12.9	47.8	65.1
April . . .	1960	..	..	..	..	..	..	..
	1961	11.1	..	5.4	..	19.4	11.1	..
	1962	..	2.9	5.8	..	23.4	20.5	26.4

TABLE III—*Contd.*

Month	Year	*Trichodesmium thiebauti*	*Prorocentron micans*	*Dinophysis* spp.	*Ornithocercus* spp.	*Glenodinium lenticulata*	*Peridinium* spp.	*Ceratium* spp.
May . . .	1960	37.5	8.3	62.5	..	45.8	37.5	50.0
	1961	12.5	8.3	12.5	..	12.5	58.3	8.2
	1962	..	..	..	..	..	..	..
June . . .	1960	50.0	..	50.0	8.3	25.0	8.3	91.6
	1961	..	75.0	25.0	..	25.0	83.3	100.0
	1962	..	..	..	..	..	..	..
July . . .	1960	..	12.0	92.0	16.0	40.0	56.0	76.0
	1961	8.3	8.3	83.3	..	8.3	66.7	50.0
	1962	..	..	38.8	..	..	55.4	100.0
August . .	1960	..	47.2	80.5	..	47.2	27.7	8.1
	1961	2.8	31.4	42.8	..	20.0	54.2	42.6
	1962	..	8.3	30.5	..	30.5	25.0	..
September . .	1960	..	2.8	94.2	..	28.5	8.5	16.8
	1961	12.5	71.4	50.0	25.0	29.1	8.3	12.5
	1962	..	50.0	58.3	..	66.6	..	..
October . .	1960	..	2.7	97.2	..	2.7	11.1	54.8
	1961	..	64.2	85.7	28.5	7.1	21.3	7.1
	1962	..	16.6	46.6	6.6	3.3	3.3	16.6

Peridinium spp., appeared in 28 out of 30 months of observation. Its frequency of occurrence varied from 3.3 to 66.7 per cent; during September and October it appeared less frequently.

Dinophysis spp., and *Ceratium* spp., occurred almost equally *i.e.*, in 27 and 26 months respectively out of 30 months of observation. The percentage frequency of occurrence in the former varied from 5.4 to 97.2 and in the latter from 2.4 to 100. No distinct period of maximum occurrence of these two forms was noticed.

P. micans and *G. lenticulata* appeared in 25 out of 30 months of observation. The percentage frequency of occurrence in the former varied between 2.7 and 75.0 and in the latter, it varied between 2.7 and 66.6.

(d) *Zooplankton*

Zooplankton occupied a secondary place in the food of *S. longiceps*. In all ten items were found *viz.*, 1. Tintinnids, 2. Copepods, 3. *Evadne* spp., 4. *Lucifer* spp., 5. Crustacean eggs, 6. Nauplii, 7. Zoeae, 8. Bivalve larvae, 9. Cypris stage of *Lepas* and 10. Fish eggs.

Of these, the tintinnids and copepods (Table IV) which appeared in 90% and 93% respectively of the months, were regarded as very 'common' forms. Crustacean eggs and nauplii which occurred in 50% and 56% of the months were considered as 'common' forms. All the rest which appeared in less than 25% of the months were considered as 'rare' forms.

Tintinnids were not found in the food of *S. longiceps* during March and July 1961 and September 1962. The percentage frequency of occurrence varied between 2.8 and 85.0 in the various months under study. They were met with in abundance in the food during the period from November to June.

The monthly percentage frequency of occurrence of copepods varied from 8.3 to 80.0 except in October and November 1961 when they were totally absent in the food. There was no distinct period in which they could be considered as occurring abundantly.

The monthly percentage frequency of occurrence of crustacean eggs varied between 2.9 and 72.0. Its period of maximum occurrence in the food appeared to be from September to January or February.

Nauplii had the monthly percentage frequency of occurrence varying between 2.7 and 41.6.

Of the zooplanktonic organisms the monthly percentage frequency of *Evadne* spp., *Lucifer* spp., zoeae, bivalve larvae, cypris stage of *Lepas* and fish eggs in the food of the fish varied between 2.7 and 27.2 per cent and they were considered 'rare'.

TABLE IV

Monthly percentage frequency of occurrence of zooplankters in the food of S. longiceps

Month	Year	Tintinnids	Copepods	*Evadne* spp.	*Lucifer* spp.	Crustacean eggs	Nauplii	Zoeae	Bivalve larvae	Cypris stage of *Lepas*	Fish eggs
November	1959	44.7	24.1	..	..	30.9	6.8	..	..	6.8	13.7
	1960	72.1	33.3	..	..	21.6	5.4	..	..	..	..
	1961	28.3	..	..	..	..	..	..	..	..	..
December	1959	82.5	51.7	..	3.4	17.2	30.9	3.4	13.7	..	3.4
	1960	35.3	16.6	..	..	41.6	..	..	..	..	..
	1961	16.8	19.5	..	..	65.8	7.3	..	..	..	2.4
January	1960	63.2	40.0	..	..	10.0	23.3	3.3	6.6	..	..
	1961	..	..	..	..	..	..	..	..	..	..
	1962	28.0	12.0	..	..	72.0	4.0	..	..	..	..
February	1960	85.0	80.0	10.0	10.0	15.0	25.0	10.0	15.0	..	..
	1961	..	..	..	..	..	..	..	..	..	..
	1962	7.6	23.0	..	..	3.8	..	..	..	..	..
March	1960	..	..	..	..	..	..	..	..	..	..
	1961	..	16.6	..	..	..	..	..	..	..	..
	1962	21.7	60.8	4.3	..	12.9	..	..	..	..	..
April	1960	..	..	..	..	..	..	..	..	..	..
	1961	5.4	25.0	..	..	..	2.7	..	..	..	..
	1962	64.5	55.8	..	..	2.9	2.9	..	..	..	..

May	1960	50 0	79.1	..	..	4.2	12.5	..	..	..	.
	1961	20.8	8.3	..	..	..	..	..	16.6	..	..
	1962	..	..	..	..	..	..	..	..	..	..
June	1960	66.6	33.3	..	..	..	41.6	..	..	..	..
	1961	75.0	41.6	..	..	..	..	..	..	..	..
	1962	..	..	..	..	..	..	..	..	..	..
July	1960	8.0	52.0	..	..	..	16.0	..	..	..	..
	1961	..	33.3	..	..	..	..	..	..	..	..
	1962	8.1	13.5	..	..	..	2.7	..	..	..	..
August	1960	5.4	61.2	27.7	..	..	..	..	..	..	..
	1961	2.8	22.8	..	..	..	..	2.8	..	..	..
	1962	5.4	30.5	..	..	..	..	..	..	..	..
September	1960	2.8	20.0	2.8	..	..	2.8	..	..	..	..
	1961	35.7	54.1	..	..	12.5	12.5	8.3	..	..	12.5
	1962	..	25.0	..	..	..	25.0	..	..	..	..
October	1960	16.6	33.2	2.7	..	36.1	2.7	..	2.7	2.7	2.7
	1961	7.1	..	..	..	..	..	..	..	..	..
	1962	26.6	23.3	..	..	30.0	..	..	..	..	..

Feeding

While the relative importance of the different items of food is judged by the occurrence method as described earlier, the intensity of feeding was evaluated by the number method. The number of each food item in a fish varied in the sample. Hence the average number of an item in the samples of a month was taken to represent the feeding intensity on the particular item in respect of all fish and those in different age groups.

Table V shows that I year group rarely occurred in the samples. It appeared during July 1960 and November 1961, forming 24.0 and 5.9 per cent respectively. The catch comprised mainly of the II and III year classes consisting of the immature and the mature ones respectively.

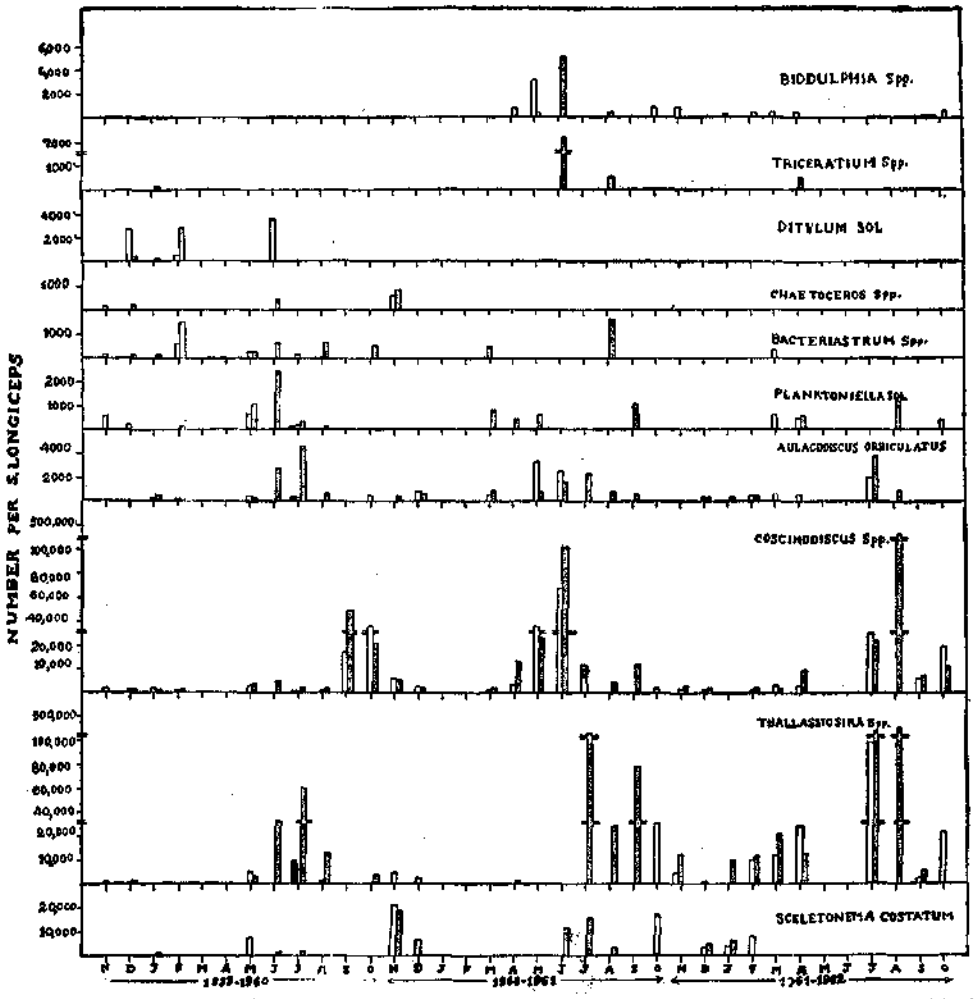

FIG. 2A Food of *S. longiceps*. Monthly averages of diatoms per *S. longiceps* in the I (black bars) II (Blank bars) and III (dotted bars) year classes during 1959-1962.

TABLE V

Monthly percentage occurrence of different age groups of S. longiceps *in the samples*

Month	1959-60				1960-61				1961-62			
	No. of fish	I	II	III	No. of fish	I	II	III	No. of fish	I	II	III
November	29	..	93.1	6.9	36	..	41.6	58.4	17	5.9	94.1	..
December	29	..	51.7	48.3	36	..	75.0	25.0	41	..	48.8	51.2
January	30	..	46.6	53.4	..	..	..	..	25	..	40.0	60.0
February	20	..	70.0	30.0	..	..	..	..	26	..	84.6	15.4
March	..	..	..	..	24	..	58.3	41.7	23	..	95.6	4.4
April	..	..	..	..	36	..	16.6	83.4	34	..	38.2	61.8
May	24	..	50.0	50.0	24	..	12.5	87.5	..	..	..	..
June	12	..	..	100.0	12	..	8.3	91.7	..	..	..	..
July	25	24.0	52.0	24.0	12	..	..	100.0	36	..	33.4	66.6
August	36	..	16.6	83.4	35	..	..	100.0	36	..	..	100.0
September	35	..	45.7	54.3	24	..	..	100.0	12	..	8.3	91.7
October	36	..	52.7	47.3	14	..	100.0	..	30	..	73.3	26.7

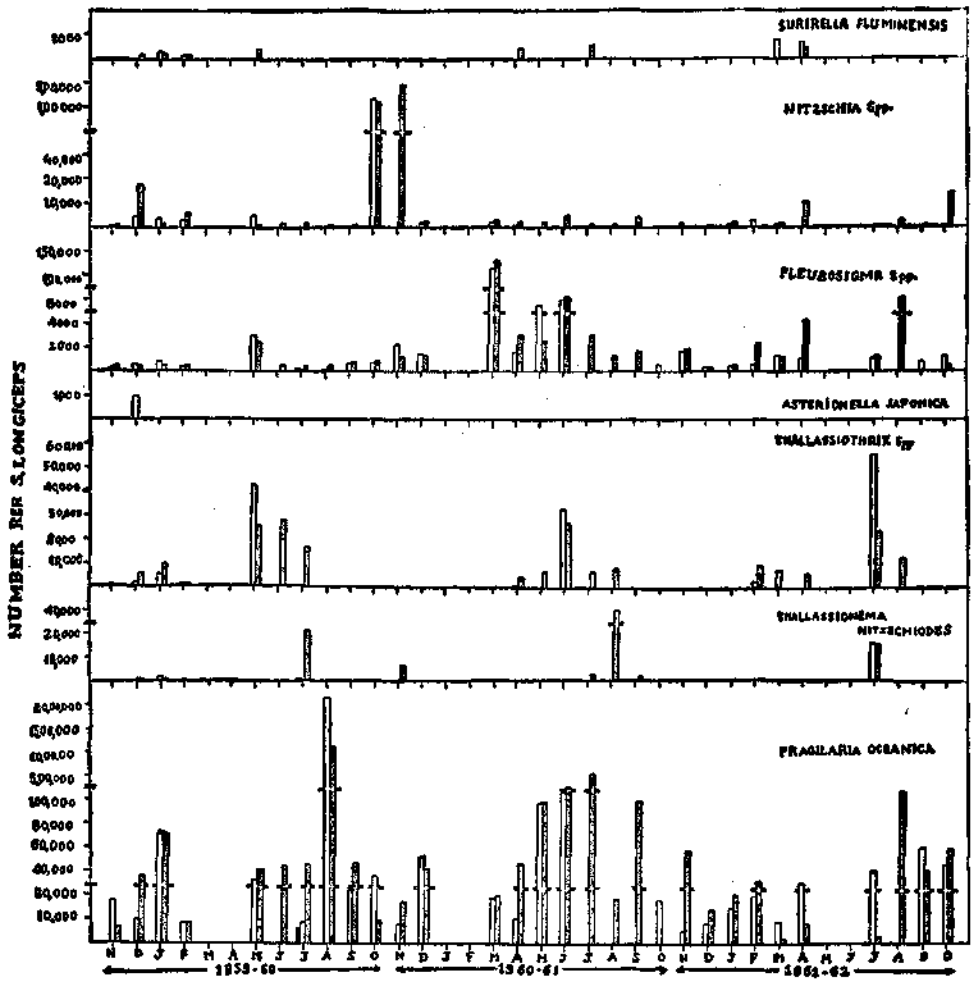

FIG. 2B Food of *S. longiceps*. Monthly averages of diatoms per *S. longiceps* in the I (black bars) II (Blank bars) and III (Dotted bars) year classes during 1959-1962.

Among the 'very common' diatoms (Fig. 2 A & B), *S. longiceps* fed actively on *F. oceanica* throughout the year. The highest count (average) of this item was, 1,389,562 cells in general per fish in August 1960 and these were distributed between the II and III year classes with the counts of 2,207,333 and 1,200,846 cells per fish respectively. The lowest count of this item was in February 1960 when it was only 8,425 and 8,533 cells per fish in the II and III year classes respectively. May to September can be considered as the period of maximum consumption of this item.

The intensity of *Coscinodiscus* spp., found in the food of *S. longiceps* was not the same throughout the year. The period of maximum intensity was

from May to October. Its highest count of 252,570 cells per fish in general, was found in August 1962, when only the III year class was present. The lowest of 310 cells was found in December 1961 with 256 for the II and 400 for the III year classes.

Nitzschia spp., occurred almost uniformly except during 2-3 months in a year. Normally the count of this item per fish did not exceed more than 10,000. The period of high feeding on this item may be said to be roughly from September to December. The highest count of 273,115 cells per fish was noticed in November 1960, of which 6,123 cells were found in the II year class and 446,660 in the III year class.

There was no uniform feeding on *Pleurosigma* spp., and there were also no definite periods when the intensities in feeding were particularly high or low. The maximum number of 121,433 cells per fish was found in March 1961 and these were distributed at the rate of 113,400 and 132,680 cells per fish in the II and III year classes respectively.

Biddulphia spp., though very common in most months, appeared only in small numbers. The highest of 23,421 cells per fish was found in June 1961. These occurred in II year class 9,600 cells and III year class 29,282 cells per fish.

A. orbiculatus was encountered from May to July but in very small numbers. The highest of 2,980 cells per fish was observed in July 1962. The II year class had 1,920 cells and the III year class 3,616 cells on an average per fish.

Whenever *Thalassiothrix* spp., occurred in the food of *S. longiceps* it appeared in comparatively good numbers. The highest of 35,240 cells per fish was noticed in July 1962. The II and III year classes had an average of 55,173 and 23,280 cells per fish respectively. Feeding on this item appeared to be intensive during the period May-July.

Amongst the 'frequent' forms, *T. nitzschioides* had the highest of 41,275 cells per fish in August 1961 when the fish examined were all in the III year class. It occurred during the period may to August.

The highest of 19,800 cells of *S. costatum* per fish was encountered in November 1960 with 20,800 cells in the II year and 18,800 cells in the III year classes.

Triceratium spp., had the highest of 5,028 cells per fish in June 1961 when the fish were in the III year class.

P. sol appeared in the food in very small number. The highest of 2,400 cells per fish were noticed in June 1960 when the fish were in III year class.

Rhizosolenia spp., had the highest of 1,600 cells in August, 1961 in fish of III year class.

S. fluminensis appeared in very small numbers, the highest of 800 cells per fish being in March 1962 in fish of II year class.

Excepting *T. nitzschioides*, none of the remaining 'frequent' forms showed any particular period of high utilisation by the fish.

The 'rare' forms of diatoms were sporadic in their occurrence.

Myxophyceae represented by *T. thiebautii* (Fig. 3) had the highest of 24,000 cells in May 1961 among III year class.

P. micans the 'very common' form of dinoflagellates (Fig. 4) had the highest of 107,985 cells per fish in December 1960 with 121,335 and 14,533 cells per fish in the II and III year classes respectively. No distinct season of high feeding on this food item was noticed.

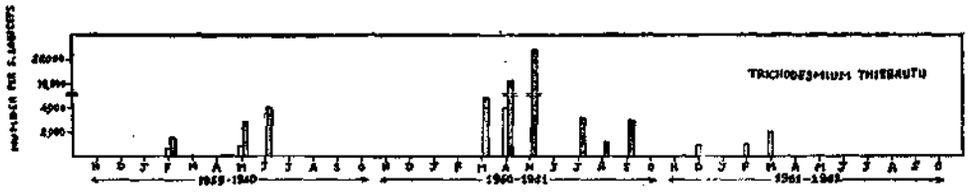

FIG. 3 Monthly average of *T. thiebautii* per *S. longiceps* in II (Black bars) and III (dotted bars) year classes during 1959-1962.

Dinophysis spp., had the highest number of 16,785 cells per fish in September 1960 when the II year class had 9,940 and the IV year class 22,489 cells per fish. The fish was found to feed more on this food item during the period July-December.

G. lenticulata had the maximum of 6,593 cells per fish in March 1962 when the fish were in the II year class. It was found more in the food during the period March-November.

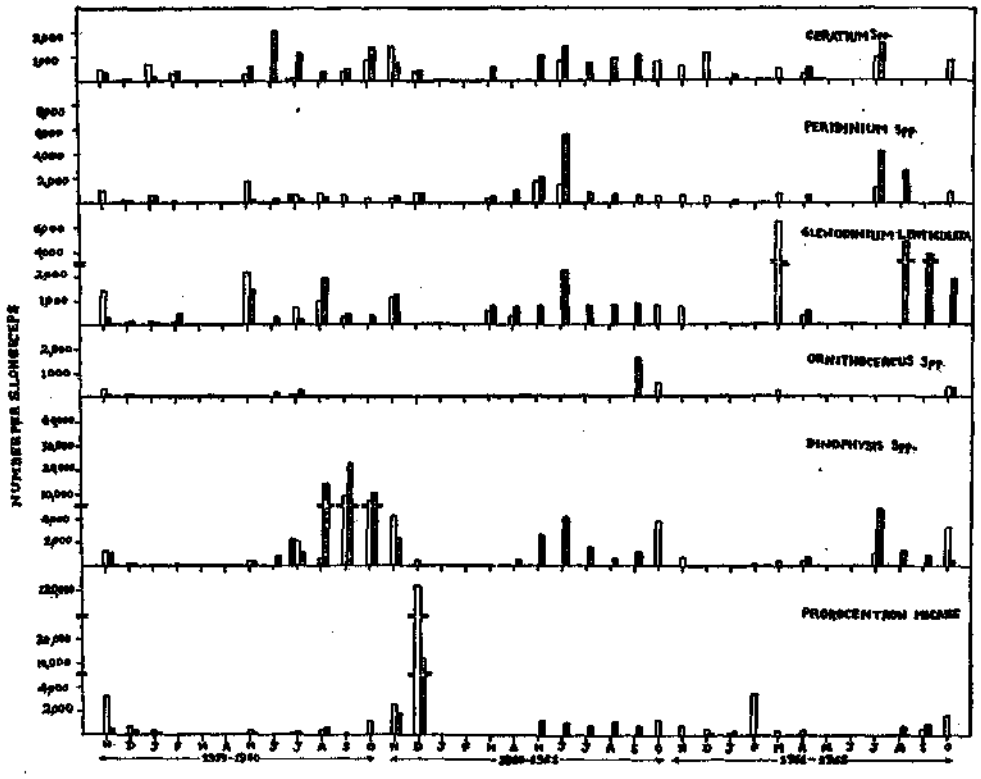

FIG. 4 Monthly average of dinoflagillates per *S. longiceps* in the I (black bars) II (Blank bars) and III (dotted bars) year classes during 1959-1962.

Peridinium spp., had the highest of 5,280 cells per fish in June 1961 when 1,690 and 5,689 cells per fish were observed among the II and III year classes respectively. The fish was found to feed on this item more or less uniformly throughout the year.

Ceratium spp., had the highest of 2,127 cells per fish in June 1960 when all the fish examined were in the III year class. There was no well marked period of high feeding on this food item by the fish.

Ornithocercus spp., 1,666 cells per fish, was found in September 1961 in fish of III year class.

Among the zooplanktonic organisms (Fig. 5), tintinnids had the highest of 1,555 per fish (all fish) in June 1961, with a distribution of 1,333 and 1,667 per fish in II and III year classes respectively.

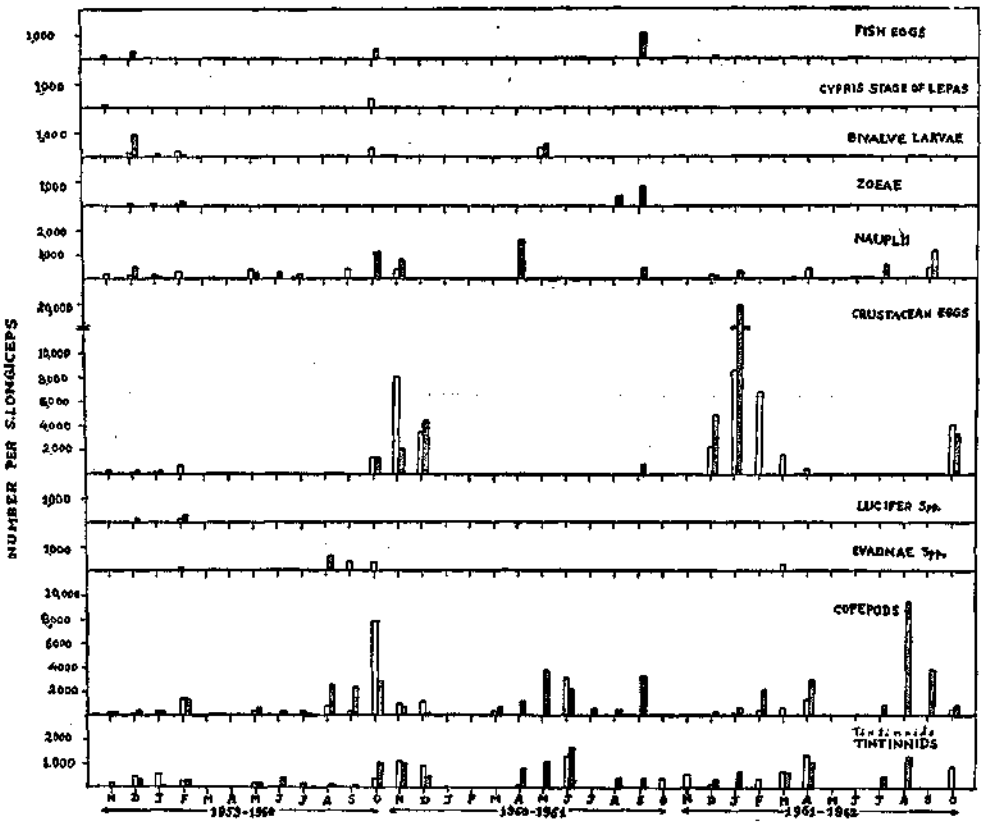

FIG. 5 Monthly average of Zooplaniters per *S. longiceps* in the I (Black bars), II (blank bars) and III (dotted bars) year classes during 1959-1962.

The copepods had the maximum of 9,550 members per fish in III year class in August 1962. Neither the tintinnids nor the copepods show any period of high feeding on them by the fish.

Crustacean eggs, were 15,315 per fish on an average in January 1962, the II year class having 8,594 and the III year class 19,593 eggs per fish. In general, the fish fed more on this from October to March or April.

The highest of 1,600 nauplii per fish were observed in April 1961 when the fish examined were in the III year class.

Regarding the 'rare' forms of zooplankton, it can only be said that whenever they appeared in the food of *S. longiceps*, their number hardly exceeded 1,000 per fish.

FIG. 6 Monthly average weight of food *S. longiceps* during 1959-1962.

FEEDING INTENSITY

From the monthly averages in weight of food of *S. longiceps*, shown in Fig. 6 the feeding intensities appear to be highly irregular. However, in the month of December of all the years, the food intake was the lowest. In the occurrence of peak values of food intake in different months in different years there is no uniformity. February, May and September of 1960, July of '61 and April and August of '62 had shown high values of feeding intensity. In general it may be stated that during February to September the feeding intensities were high and in the rest of the months low.

DISCUSSION

The earlier workers had observed diatoms and dinoflagellates mainly forming the food of the oil sardine along with tintinnids, copepods etc. In the present findings also three organisms have been found to comprise the food of the species. According to Hornell and Nayudu (*loc. cit.*) unrecognisable detritus was found to form a fairly good bulk of the stomach contents. Such unrecognisable matter was always found in the present findings also but, there was no suitable way of estimating its quantitative abundance. From the point of view of meeting the nutritional requirements of the fish, probably the detritus is as important an item as the planktonic forms. The application of weight method in this connection may be stated to be more suitable as it takes even the detritus into consideration.

Hornell and Nayudu (*loc. cit.*) also observed three periods in accordance with the nature of the food intake, they being a period from May to August or September a diatomaecious one, another from September to November or December a dinoflagellate one and a third from December to April a miscellaneous one. The present study did not show distinct periodicity marked by greater abundance exclusively of any group or groups of organisms forming the food of oil sardine. In general all the planktonic forms appeared comparatively to be in greater abundance during the period May to November.

Nair and Subrahmanyan (*loc. cit.*) have stated that the oil sardine shows a special preference to phytoplankton with *F. oceanica* forming the major

component of its food, more especially in the case of the juveniles which form the bulk of the commercial landings. In the present study this formed an important item and round the year in the food of the species. Like most other 'very common' forms of diatoms mentioned in the paper, *F. oceanica* also was met with in the period of May to November. Numerically this species ranks higher than any other species of 'very common' diatoms. Considering the extreme smallness of the cells in the above species it is doubtful whether it should be regarded more important than other 'very common' forms of larger size like, *Pleurosigma* spp., *Coscinodiscus* spp., etc. It may also be pointed out that not only in respect of *F. oceanica,* but also in regard to other food components, no difference in the rate of feeding was noticed in different age group.

It may not be out of place to discuss here whether the oil sardine is strictly a selective feeder. Among the numerous planktonic organisms, preference was shown for phytoplanktonic forms as diatoms and dinoflagellates, some of the members of which were found to be 'very common' in the food; the quantitative abundance of the zooplanktonic forms was very much less, with tintinnids and copepods alone occurring 'very common'. The non-edible forms like *Noctiluca* were not met with and Myxophyceae, zoeae, fish eggs etc., were rare among the stomach contents. Subrahmanyan (1958) has recorded numerous diatoms and dinoflagellates occurring in the plankton on the west coast of India, but out of these, members of only 24 genera were met with in the present study. The total absence of numerous phytoplanktonic and zooplanktonic elements other than those specified in the present work which has also been noted by earlier authors indicates a certain amount of selectivity in the nature of the food of the species.

SUMMARY

The stomach contents of a large number of samples of *S. longiceps* collected during the period November 1959 to October 1962 at Calicut from the catches by different nets, *viz., Paithuvala, Mathikollivada, Thattumvala, Nethalvala, Mathichalavala* and *Veesuvala* operated at depth ranges of 2-27 meters, were analysed.

The occurrence method, number method and weight method were followed to assess the relative importance of different food items. The feeding intensity was studied separately for different year classes.

S. longiceps is chiefly a phytoplankton feeder with diatoms, dinoflagellates and zooplankton appearing in the order of abundance in its food throughout the year. Myxophyceae group was represented by one species of *Trichodesmium.* Very often, bulk of the stomach contents was formed by unrecognisable detritus. Possibly it may have some nutritional value.

Amongst the vast number of diatoms and dinoflagellates occurring in the sea off the west coast of India, members of only 24 genera and similarly a few of the zooplankton forms were observed in the food of *S. longiceps.*

Fragilaria oceanica formed an important item of food, like any of the other 'very common' items, such as *Coscinodiscus* spp., *Biddulphia* spp., *P. micans* and *Peridinium* spp., all of which appeared all round the year, generally in greater abundance during May to November.

Feeding intensity was not found to differ with any particular item or group of items in different age groups.

The question whether *S. longiceps* is a selective feeder has been briefly discussed.

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