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Seasonal variations in the diet of the Indian oilsardine, *Sardinella longiceps* Valenciennes off Cochin, Kerala

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ABSTRACT

Seasonal fluctuations in the food of the oilsardine *Sardinella longiceps* landed by ring seines from the inshore waters off Cochin were studied during 2010. *S. longiceps* is chiefly a plankton feeder with diatoms, dinoflagellates and zooplankton appearing in the diet in decreasing order of abundance. During pre-monsoon (February-May), *Pleurosigma* was present in 70% of the stomachs analysed followed by *Thalassiosira, Biddulphia* and *Coscinodiscus*. During monsoon season (June-September), 87.5% of the stomachs contained *Coscinodiscus* followed by *Thalassiosira* and *Pyrophacus.* During post-monsoon (October- January) again, the frequency of occurrence of *Pleurosigma* (74.2%) was higher followed by *Biddulphia* and *Thalassiosira.* Zooplankton, represented by tintinnids and copepods, were present in the diet throughout the year, but in relatively less number of stomachs. Higher feeding activity was observed during monsoon (June-September), which coincided with maximum spawning activity.

Keywords: Diatoms, Phytoplankton, *Sardinella longiceps*, Zooplankton

Introduction

The Indian oilsardine, *Sardinella longiceps*, is a tropical coastal and pelagic schooling fish, which attains a maximum length of 22 cm and has quick population doubling time of less than 15 months. It forms the largest stock in the Indian Ocean and plays a crucial role in the ecosystem as a plankton feeder as well as food for large predators (www.fishbase.org). It forms the largest fishery in the Malabar upwelling region along the south-west coast of India. The fishery is known for annual fluctuations and for a cyclic pattern of abundance (Jayaprakash and Pillai, 2000). The oilsardine fishery is the single largest fishery along the Cochin coast as well. The fishing season off Cochin usually commences towards the end of south-west monsoon, *i.e.*, end of August or early September, generally with the recruitment of juveniles. Peak landing is from October to January and the fishery continues beyond March. Climate change has been recognised as one of the drivers of oilsardine distribution and abundance (Vivekanandan *et al*., 2009). An increase in the strength of the monsoon is considered favourable for an increase in the catch. The south-west monsoon and the resultant biological, oceanographic and meteorological conditions seem to be responsible for the catch fluctuations to a large extent. In addition to inter and intra annual variability, another reason for fluctuation in oilsardine abundance may be the availability of suitable food.

Hornell (1910) first published an account of the food of oilsardine and also emphasised the importance of undertaking the study in greater detail. Since then, several papers have been published on the food of oilsardine especially from the south-west coast of India (Nair, 1952; Kagwade, 1964; Noble, 1965; Dhulkhed, 1970). These studies show that oilsardine is a planktivore and one of the few clupeoids in which diatoms form a significant part of the adult diet. Dinoflagellates and copepods were also reported in the diet of oilsardine.

Food contents in the stomach of fish during different seasons in a year provide direct information on seasonal fluctuations in the feeding habit as well as indirect information on the availability of types of food in the environment. A perusal of literature shows that most of the works pertaining to the food and feeding behaviour of oilsardine off Cochin and Cochin backwaters are mostly confined to the 1960s and 1970s. As a result, very little information is available on the feeding of this dominant fishery resource off Cochin for the past three decades. Considering this, a study was carried out on the seasonal variation and relative abundance of plankton present in the gut of oilsardine. A comparison with earlier studies on the diet of oilsardine has also been made.

Materials and methods

Oilsardine samples (n = 348) were collected once a week from ring seine landings at Kalamukku and Cochin Fisheries Harbour during January-December, 2010. Samples were transported to the laboratory in ice and individual fish were evaluated for the following: total length (mm), total weight (g), maturity stage (immature, maturing, ripe and spent) and stomach fullness. In order to determine stomach fullness, each fish was dissected and based on the state of distension, the stomach was classified as poorly fed (empty to 1/4 full), moderate (1/2 full) and actively fed (3/4 to full). Quantitative analysis was done for 127 specimens with half-full to full stomachs. These samples were preserved in 5% formalin with labels indicating length, weight, sex, maturity stage and date of capture of individual fish. The guts were cut open, the stomach contents were analysed and categorised as diatoms, dinoflagellates, copepods, crustaceans (excluding copepods), tintinnids, fish eggs and detritus. The frequency of occurrence of each food item was calculated following Hynes (1950) as $F = 100 * N_i / N$, where F is the frequency of occurrence of the i^{th} food item in the sample; N_i = number of stomach in which the i^{th} item was found and N= total number of stomachs (with food) examined. In order to obtain information on the seasonal diet variations, monthly data were grouped as pre-monsoon (February to May), monsoon (June to September) and post- monsoon (October to January) (Menon *et al*., 2000). The stage of maturity was noted to see whether there is any correlation between feeding intensity and maturity stage of the fish.

Results and discussion

Total length of sampled fishes ranged between 122-183 mm, 110-210 mm and 112-119 mm during pre-monsoon, monsoon and post-monsoon seasons, respectively with males dominating females in all seasons. Immature fishes with half-filled stomach were dominant during pre-monsoon and immature fishes with empty stomach were dominant during post-monsoon season (Table 1).

The present observations support that of Dhulkhed (1968), that the oilsardine fishery in the Mangalore zone was mainly supported by immature fish (stages I and II) during October to February. During monsoon, mature fishes (stages V and V1) were dominant. June-September period indicates the spawning season of oilsardine coinciding with the south-west monsoon when the hydrological conditions *viz*., temperature and salinity of the inshore waters are low due to the influx of flood waters (Dhulkhed, 1964). In the present study, empty, one-fourth and three-fourth full stomachs were observed during monsoon, contributing to about 24.0, 24.5 and 23.5% respectively. Three-fourth and full stomachs contributed 28.49% during monsoon, indicating increased feeding activity (Fig. 1). This shows active pre-spawning feeding activity as indicated by large volume of food present in the stomach of females in stage V. But, during active spawning, the stomachs were always found to be empty indicating cessation of feeding activity. Active feeding was again noticed in the spent individuals, as reported by Nair (1952).

Table 1. Biological characteristics of oilsardine off Cochin, during January-December 2010

Biological parameters	Pre- monsoon	Monsoon	Post- monsoon	Annual average
Length range (mm)	122-183	110-201	112-193	
Sex ratio (%)				
Male	51.88	51.76	47.61	50.42
Female	48.12	48.24	52.39	49.58
Maturity stages (% in total number of samples)				
Immature	81.88	36.92	89.92	69.57
Developing	10.83	0.00	10.08	6.97
Mature	7.29	46.53	0.00	17.94
Spent	0.00	16.56	0.00	5.52
Stomach content (% in total number of samples)				
Empty	2.08	24.00	39.09	21.72
Trace	3.33	2.95	20.69	8.99
One-fourth	17.29	24.51	19.67	20.49
Half	60.63	20.05	17.97	32.88
Three-fourth	11.46	23.49	0.50	11.82
Full	5.21	5.00	2.08	4.10

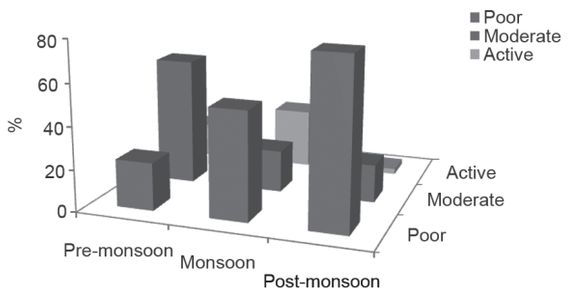

Fig. 1. Feeding intensity (% in numbers) in relation to seasons

Diatoms, dinoflagellates, tintinnids and copepods were most commonly observed in the stomachs examined in all the seasons in the order of abundance. Twenty nine species of plankton were observed, of which 19 were diatoms, six were dinoflagellates and four were zooplankton. Among phytoplankton, species of *Pleurosigma, Coscinodiscus, Nitzschia, Biddulphia, Thalassiosira, Fragilaria, Gyrosigma, Peridinium, Navicula, Chaetoceros, Dinophysis, Cyclotella* and *Thalassionema* were present in the stomach during all the seasons. Species of *Skeletonema, Ornithoceros, Pyrophacus, Globigerina, Asterionella, Rhizosolenia, Radiolarian, Ceratium, Triceratium, Prorocentrum, Melosira,* and *Eucampia,* though observed in the stomach contents, were not present in all the seasons.

Among zooplankton, copepods and tinntinids were found in the stomach during all the seasons (Fig. 2, 3 and 4). As observed by earlier authors, phytoplankton formed the major portion of the diet of oilsardine followed by zooplankton. Among the phytoplankton, diatoms like *Coscinodiscus, Biddulphia, Thalassiosira, Nitzschia* and *Pleurosigma* were found to be the favourite food items of oilsardine in the present study based on the frequency of occurrence. One important observation of the analysis is that *Fragilaria oceanica,* which was reported as the major component in the diet and was considered as an indicator species of abundance of oilsardine (Nair and Subrahmanyan, 1955) was found to occur only in 30% of the stomachs in the pre-monsoon (Fig. 2), 18% in the monsoon (Fig. 3) and 6% in the post-monsoon seasons (Fig. 4). It is not apparent whether the abundance of *F. oceanica* has declined in the environment or the fish has shifted the food preference. Seasonal variations were observed in the diet, for example, *Pleurosigma* was found to be dominant during pre-monsoon and post-monsoon seasons occurring in 70% and 74% of the stomachs analysed, respectively. During monsoon, *Coscinodiscus* was found to be dominant being recorded in 87.5% of the stomachs examined. followed by *Thalassiosira* (81.3%). *Biddulphia* and *Thalassiosira* (42.5% each) were encountered in high frequency during pre-monsoon.

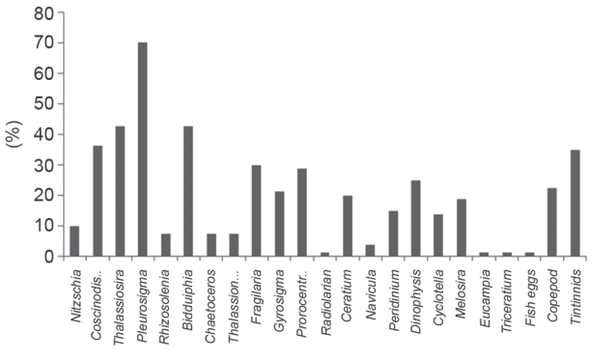

Fig. 2. Frequency of occurrence of plankton in the stomach of oilsardine during pre-monsoon

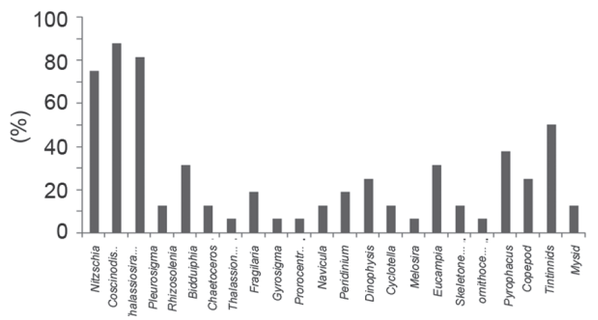

Fig. 3. Frequency of occurrence of plankton in the stomach of oilsardine during monsoon

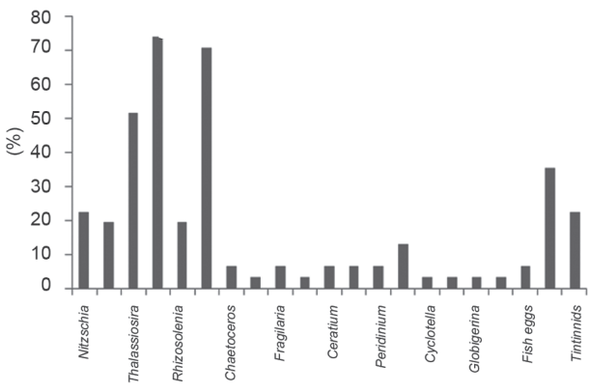

Fig. 4. Frequency of occurrence of plankton in the stomach of oilsardine during post-monsoon

A comparison of the stomach contents of oilsardine with earlier studies (Dhulkhed, 1962; Kagwade, 1964; Noble, 1965) indicated that, adult oilsardine prefer phytoplankton followed by zooplankton, as food. Diatoms, such as Radiolarians, *Cyclotella, Melosira, Eucampia, Globigerina* and *Asterionella* were found only during the present study. Dinoflagellates like species of *Trichodesmium*, *Glenodinium* and *Surirella* observed in previous studies, were not recorded in the present study. Zooplankton species were found to be less in the present study as compared with the previous studies.

Since simultaneous plankton collection from the environment was not done along with fish sampling, it is difficult to conclude whether oilsardine is an opportunistic feeder. However, it can be reaffirmed that *S. longiceps* is chiefly a phytoplankton consumer, feeding on diatoms and dinoflagellates. There are seasonal variations observed in diet, and physiological factors related to maturation may influence feeding patterns.

Table. 2. Comparison of stomach contents of *Sardinella longiceps* observed in the present study with that of earlier studies

Items	Present study	Earlier references
Phytoplankton		
Diatoms		
Coscinodiscus	✓	Dhulkhed, 1962; Kagwade, 1964; Noble, 1965
Fragilaria oceanica	✓	-do-
Pleurosigma	✓	-do-
Biddulphia	✓	-do-
Triceratium	✓	-do-
Rhizosolenia	✓	Dhulkhed, 1962; Kagwade, 1964
Skeletonema	✓	Dhulkhed, 1962
Thalassiosira	✓	-do-
Planktoniella sol	Nil	-do-
Bacteriastrum sp.	Nil	-do-
Chaetoceros sp.	✓	Dhulkhed, 1962; Noble, 1965
Ditylum sol.	Nil	Dhulkhed, 1962
Triceratium	✓	Dhulkhed, 1962 Kagwade, 1964; Noble 1965
Thalassionema	✓	Dhulkhed, 1962
Thalassiothrix	Nil	-do-
Navicula	✓	Noble, 1965
Diplones	Nil	Khagwade, 1964
Aulacodiscus orbiculatus	Nil	Dhulkhed, 1962
Tropedoneis	Nil	Dhulkhed, 1962 Noble, 1965
Radiolarian	✓	Nil
Cyclotella	✓	Nil
Melosira	✓	Nil
Eucampia	✓	Nil
Coccosphere	✓	Nil
Globigerina	✓	Nil
Asterionella	✓	Nil
Nitzschia	✓	Kagwade, 1964
Dinoflagellates		
Dinophysis	✓	Dhulkhed, 1962; Kagwade, 1964; Noble, 1965
Prorocentrum	✓	Dhulkhed, 1962; Kagwade, 1964
Pyrophacus	✓	Dhulkhed, 1962; Kagwade, 1964
Peridinium	✓	-do-
Ceratium	✓	Dhulkhed, 1962; Kagwade, 1964; Noble, 1965
Ornithoceros	✓	Kagwade 1964
Trichodesmium	Nil	Dhulkhed, 1962
Glenodinium lenticulata	Nil	-do-
Surirella ftuminensis	Nil	-do-
Zooplankton		
Copepods	✓	Dhulkhed, 1962; Kagwade, 1964; Noble, 1965
Bivalves (young)	Nil	Kagwade, 1964
Cirripedes (young)	Nil	Dhulkhed, 1962; Kagwade, 1964; Noble, 1965
Tintinnids	✓	Kagwade, 1964
Foraminiferans	Nil	Dhulkhed, 1962; Noble, 1965
Evadne sp.	Nil	Dhulkhed, 1962
Lucifer sp.	Nil	-do-
Crustacean eggs	Nil	Dhulkhed, 1962; Noble, 1965
Nauplii	Nil	-do-
Zoea	Nil	-do-
Fish eggs	✓	-do-
Mysids	✓	Nil

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