

# Feeding biology of the Indian mackerel, *Rastrelliger kanagurta* (Cuvier, 1817) off Ratnagiri coast, Maharashtra, India

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(Received : 27 February, 2014; accepted 29 March, 2014)

## ABSTRACT

Both qualitative and quantitative analyses were carried out to study the feeding habits of *R. kanagurta*. The analysis indicated that this species feeds mainly on zooplankton (43.56%), phytoplankton (39.93%) and algae (2.89%). The present study therefore shows that *R. kanagurta* is planktivorous feeder. Detailed studies on the seasonal and ontogenetic changes in the diet composition, qualitative aspects of the diets and feeding dynamics in relation to size groups starting from 10 - 12 cm to 28 - 30 cm, the food items namely phytoplankton, zooplankton, algae, miscellaneous items and semi-digested matter were in different proportions.

**Key words :** Feeding biology, Indian mackerel, *Rastrelliger kanagurta*, Maharashtra

## Introduction

The Indian mackerel, *Rastrelliger kanagurta* (Cuvier, 1817) is one of the important pelagic, shoaling marine fish that is widely distributed in the Indo West Pacific region. India contributes 90% of the world mackerel production, out of which 77% is from west coast and 23% is from east coast of India. Along the Indian coast its fishery is only second in importance to the oil sardine *Sardinella longiceps*. Indian mackerel being a much esteemed table-fish which is greatly in demand, its fishery is an important source of livelihood to those engaged in fishing and dependent industries.

The Indian mackerel has been variously classified as a planktonivore/ omnivore with varied diet composition (diatoms, dinoflagellates, copepods, crustaceans and occasionally fish and sand particles) recorded by researchers in various fishery centres

along the Indian coast (Vivekanandan *et al.*, 2009). Except a few reports based on stray landings of mackerel from deep sea trawlers conducting exploratory surveys from the northwest coast observations on diet composition of mackerel are mostly from inshore waters of < 20 m depths (Kutty, 1965; Rao, 1965).

Investigation on the food and feeding habits will throw more light on the migratory and shoaling habits of pelagic species of fish, and it is particularly important for a species of high commercial value such as the mackerel. There are many references on the food and feeding habits of the mackerel and a list on the main contributions on this subject from the Indian and other coasts of the Indo-Pacific area is available in the recent review, "Our current knowledge on the food and feeding habits of the Indian mackerel at Maharashtra coast.

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## Material and Methods

The present study is based on the freshly caught fish samples were transported to the lab in ice and individual fish were evaluated to study the variations in food intake individual fish were cut open and depending on the state of distension of the stomach were assigned as poorly fed (empty to 1/4 full), moderate (1/2 full) and actively fed (3/4 to full). The samples were collected from Mirkarwada fish landing of Ratnagiri, at weekly intervals from March 2011 to February 2012.

Both qualitative and quantitative analysis was carried out to study the feeding of *R. kanagurta*. The identification of different organisms was done upto the generic level and whenever possible upto the species level, depending on the state of digestion. The quantitative analysis was carried out by using volumetric method. The stomach contents were emptied into a petridish. The volume of individual food item was measured and later converted into percentage. From the volume obtained for individual fish, monthly averages and percentages were worked out. The volume index which is the percentage volume of each food item was calculated from the volumes displaced by all the food items over the whole period.

## Results

### Food Composition

The details of qualitative and quantitative analyses of stomach contents of *R. kanagurta* during different months are presented in Table 1 and percentage composition of food items during different months from March 2011 to February 2012 are shown in Fig. 1.

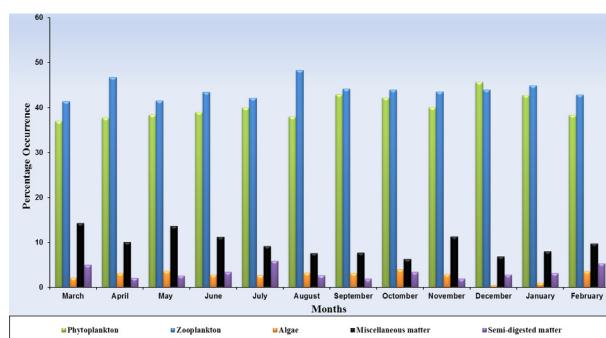


Fig. 1. Percentage composition of food items of *R. kanagurta* during different months

The analysis of gut content showed that zooplankton and phytoplankton formed the main food. In all the months, algae and miscellaneous animal remains also occurred forming a secondary diet. The average proportions of the gut contents for the whole period of study were approximately 43.56 % zooplankton, 39.93% phytoplankton, 2.89% algae, 10.08% miscellaneous items and 3.54% semi-digested matter respectively Fig.2.

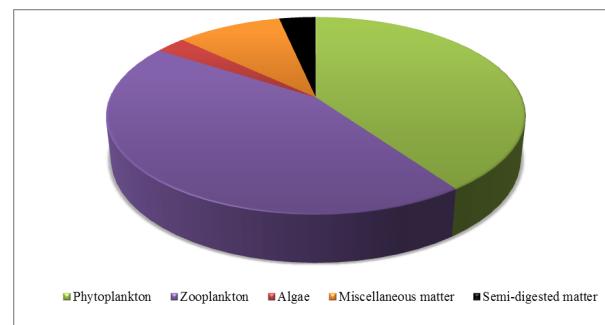


Fig. 2. Percentage composition of food items of *R. kanagurta*

Among the zooplankton the *Eucalanus* (12.58%) were the most dominant item followed by *Calanus* (11.12%). The *Eucalanus* formed the major food content, maximum in the month of March (24.00%) and minimum in the month of January (6.0%). Phytoplankton (39.93%) formed an important food item next to zooplankton. Several genera of phytoplankton were identified. Of these, *Coscinodiscus* (15.17%), *Biddulphia* (13.99%), *Nitzschia* (10.48%), *Skeletonema* (7.44%), *Pleurosigma* (7.27%), *Rhizosolenia* (7.11%), *Chaetoceros* (6.96%), *Peridinium* (6.56%) and *Ceratium* (6.30%) were dominant. Higher percentage of phytoplankton were recorded in December (43.75%), and lower percentage in the months of May (37.43%).

Algae (2.89 %) also formed the most important food item. Considerable quantities were found in the months of October (4.46%). The lowest quantity was observed during the month of December (0.63%).

Miscellaneous item formed (10.08%) the food items in the gut in which, Scales (35.84%), broken appendages (21.81%), Fish eggs (19.51%) and Sand grains (22.84%).

Semi digested matter (3.54%) was recorded in all the months with peak abundance in July (6.47%). The lowest quantity was noticed during September (2.00%).

**Table 1.** Qualitative and quantitative composition of the gut content of *Rastrelliger kanagurta*

| Months/<br>Gut content          | March<br>2011 | April | May   | June  | July  | Aug   | Sept  | Oct   | Nov   | Dec   | Jan<br>2012 | Feb   |
|---------------------------------|---------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------------|-------|
| Total no fish observed          | 52            | 53    | 54    | 40    | 49    | 45    | 54    | 51    | 56    | 52    | 50          | 55    |
| <b>I. Phytoplankton</b>         | 37.43         | 39.01 | 39.46 | 38.98 | 37.65 | 38.89 | 42.00 | 40.13 | 40.91 | 43.75 | 41.86       | 39.09 |
| <i>Asterionella</i>             | 7.5           | 5.6   | 4.1   | 7.2   | 12.2  | 4.3   | 0.0   | 6.8   | 7.4   | 5.0   | 2.5         | 5.8   |
| <i>Biddulphia</i>               | 13.4          | 11.3  | 13.7  | 13.0  | 17.6  | 15.7  | 11.9  | 8.2   | 9.9   | 11.3  | 16.3        | 17.4  |
| <i>Coscinodiscus</i>            | 19.4          | 16.9  | 13.7  | 10.1  | 8.1   | 7.1   | 19.4  | 19.2  | 18.5  | 13.8  | 15.0        | 11.6  |
| <i>Chaetoceros</i>              | 7.5           | 8.5   | 11.0  | 8.7   | 6.8   | 0.0   | 7.5   | 8.2   | 6.2   | 7.5   | 5.0         | 2.3   |
| <i>Dinophysis</i>               | 11.9          | 7.0   | 8.2   | 7.2   | 4.1   | 11.4  | 6.0   | 0.0   | 3.7   | 6.3   | 6.3         | 0.0   |
| <i>Nitzschia</i>                | 13.4          | 11.3  | 9.6   | 13.0  | 9.5   | 8.6   | 11.9  | 12.3  | 13.6  | 10.0  | 5.0         | 7.0   |
| <i>Pleurosigma</i>              | 0.0           | 8.5   | 6.8   | 8.7   | 0.0   | 7.1   | 9.0   | 11.0  | 8.6   | 5.0   | 11.3        | 7.0   |
| <i>Rhizosolenia</i>             | 4.5           | 8.5   | 11.0  | 8.7   | 6.8   | 11.4  | 0.0   | 8.2   | 0.0   | 10.0  | 5.0         | 7.0   |
| <i>Skeletonema</i>              | 7.5           | 2.8   | 6.8   | 2.9   | 12.2  | 7.1   | 10.4  | 1.4   | 7.4   | 10.0  | 7.5         | 8.1   |
| <i>Ceratium</i>                 | 6.0           | 8.5   | 0.0   | 8.7   | 4.1   | 8.6   | 6.0   | 0.0   | 2.5   | 7.5   | 11.3        | 9.3   |
| <i>Peridinium</i>               | 3.0           | 11.3  | 8.2   | 0.0   | 1.4   | 5.7   | 9.0   | 11.0  | 4.9   | 1.3   | 10.0        | 9.3   |
| <i>Thalassionema</i>            | 4.5           | 0.0   | 4.1   | 7.2   | 10.8  | 8.6   | 3.0   | 5.5   | 7.4   | 10.0  | 0.0         | 8.1   |
| <i>Thalassiothrix</i>           | 1.5           | 0.0   | 2.7   | 4.3   | 6.8   | 4.3   | 6.0   | 8.2   | 9.9   | 2.5   | 5.0         | 7.0   |
| <b>II. Zooplankton</b>          | 40.78         | 45.05 | 40.00 | 43.50 | 42.94 | 47.22 | 44.67 | 44.59 | 42.42 | 45.00 | 44.77       | 41.82 |
| <i>Oithona</i>                  | 8.0           | 5.7   | 5.1   | 6.5   | 7.7   | 9.0   | 8.7   | 5.3   | 9.1   | 3.9   | 0.0         | 5.2   |
| <i>Eucalanus</i>                | 24.0          | 10.2  | 10.1  | 11.7  | 10.3  | 12.4  | 17.4  | 11.8  | 9.1   | 6.5   | 6.0         | 14.6  |
| <i>Pseudodiaptomus</i>          | 0.0           | 6.8   | 6.3   | 5.2   | 5.1   | 0.0   | 7.2   | 7.9   | 4.5   | 10.4  | 2.4         | 2.1   |
| <i>Temora</i>                   | 12.0          | 6.8   | 11.4  | 11.7  | 10.3  | 10.1  | 0.0   | 0.0   | 9.1   | 7.8   | 0.0         | 8.3   |
| <i>Calanus</i>                  | 12.3          | 9.8   | 12.2  | 6.5   | 11.0  | 14.1  | 16.4  | 7.1   | 9.5   | 8.3   | 14.3        | 12.0  |
| <i>Acartia</i>                  | 0.0           | 3.7   | 0.0   | 10.4  | 9.6   | 5.9   | 3.0   | 7.1   | 2.4   | 4.2   | 5.2         | 5.4   |
| <i>Cladocerans</i>              | 4.1           | 4.9   | 6.8   | 6.5   | 0.0   | 5.9   | 0.0   | 8.6   | 10.7  | 15.3  | 15.6        | 13.0  |
| <i>Cirripede larvae</i>         | 2.7           | 0.0   | 4.1   | 6.5   | 0.0   | 0.0   | 3.0   | 4.3   | 6.0   | 4.2   | 6.5         | 0.0   |
| <i>Mysids</i>                   | 6.8           | 3.7   | 2.7   | 5.2   | 4.1   | 2.4   | 1.5   | 0.0   | 0.0   | 2.8   | 5.2         | 4.3   |
| <i>Sergestids</i>               | 2.7           | 6.1   | 5.4   | 2.6   | 0.0   | 4.7   | 7.5   | 2.9   | 3.6   | 2.8   | 2.6         | 3.3   |
| <i>Amphipods</i>                | 2.7           | 3.7   | 4.1   | 5.2   | 6.8   | 7.1   | 0.0   | 4.3   | 7.1   | 8.3   | 6.5         | 4.3   |
| <i>Nauplius larvae</i>          | 8.2           | 7.3   | 5.4   | 7.8   | 12.3  | 5.9   | 9.0   | 12.9  | 13.1  | 0.0   | 6.5         | 7.6   |
| <i>Tintinnids</i>               | 0.0           | 6.1   | 5.4   | 2.6   | 6.8   | 2.4   | 11.9  | 5.7   | 0.0   | 6.9   | 10.4        | 4.3   |
| <i>Zoea</i>                     | 4.1           | 2.4   | 5.4   | 2.6   | 1.4   | 5.9   | 3.0   | 4.3   | 4.8   | 2.8   | 3.9         | 2.2   |
| <i>Mysis</i>                    | 2.7           | 7.3   | 4.1   | 3.9   | 2.7   | 2.4   | 1.5   | 4.3   | 2.4   | 1.4   | 1.3         | 3.3   |
| <i>Polychaete larvae</i>        | 2.7           | 6.1   | 4.1   | 2.6   | 2.7   | 3.5   | 3.0   | 1.4   | 0.0   | 2.8   | 2.6         | 0.0   |
| <i>Molluscan larvae</i>         | 5.5           | 7.3   | 5.4   | 2.6   | 6.8   | 7.1   | 6.0   | 10.0  | 7.1   | 9.7   | 10.4        | 8.7   |
| <b>III. Algae</b>               | 2.23          | 3.30  | 3.78  | 2.82  | 2.94  | 3.33  | 3.33  | 4.46  | 3.03  | 0.63  | 1.16        | 3.64  |
| <b>IV. Miscellaneous matter</b> | 14.53         | 10.44 | 14.05 | 11.30 | 10.0  | 7.78  | 8.00  | 7.01  | 11.62 | 7.50  | 8.72        | 10.0  |
| Broken appendages               | 30.8          | 15.8  | 15.4  | 25.0  | 29.4  | 28.6  | 16.7  | 27.3  | 21.7  | 8.3   | 20.0        | 22.7  |
| Fish eggs                       | 23.1          | 26.3  | 23.1  | 25.0  | 17.6  | 14.3  | 8.3   | 18.2  | 21.7  | 25.0  | 13.3        | 18.2  |
| Sand grains                     | 11.5          | 31.6  | 26.9  | 30.0  | 5.9   | 35.7  | 33.3  | 18.2  | 26.1  | 16.7  | 20.0        | 18.2  |
| Scales                          | 34.6          | 26.3  | 34.6  | 20.0  | 47.1  | 21.4  | 41.7  | 36.4  | 30.4  | 50.0  | 46.7        | 40.9  |
| <b>V. Semidigested matter</b>   | 5.03          | 2.20  | 2.70  | 3.39  | 6.47  | 2.78  | 2.00  | 3.82  | 2.02  | 3.13  | 3.49        | 5.45  |

### Food in relation to size

The details of percentage composition of various food items in the stomach contents of *R. kanagurta* in various size groups are given in the Table 2. Analysis of data revealed that in all the size groups start-

ing from 10 - 12 cm to 28 - 30 cm, food items such as phytoplankton, zooplankton, algae, and miscellaneous matter were found in different proportions. Zooplankton were the most dominant of all size groups ranging from 42.92 to 53.15 % and no signifi-

cant difference was noticed between size groups. Phytoplankton was dominant in the size groups 16 - 18 cm (40.64%) and 14-16 cm (40.25%). In the remaining size groups, no significant difference was noticed. Data revealed that the small size group preferred plant origin food and when size increases they mostly preferred animal origin food.

### Feeding intensity

The percentage occurrence of stomach in various degrees of fullness during the study period is presented in Table 3. Greater percentage of fishes had stomachs with considerable quantity of food indicating active feeding during month of November, May, August and February. Moderate feeding was noticed during July, September, October and December. Poor feeding was observed during March and June. There was no fish with empty stomach observed during study.

### Discussion

It is reported that fish metabolism has an influence on feeding behavior and feed intake by fish is such that it meets their energy requirements (Bowen *et al.*, 1995). Thus if a diet has low energy value, fish will compensate by eating more within the limits of its stomach capacity (Mittelbach, 2002).

The qualitative analysis of food of *R. kanagurta* indicated that this species feeds mainly on zooplankton (43.56%), phytoplankton (39.93%) and algae (2.89%). The present study therefore shows that *R. kanagurta* is planktivorous feeder. The main food items indicate that its pelagic habitat. This is in agreement with the observations of earlier reports of Devanesan and John (1940); John and Menon (1942); Chidambaram (1944); Bhimachar and George (1952); Pradhan (1956); Chacko (1949); Kuthalingam (1956); Rao (1962a & b); Noble (1965); Ishihara *et al.*(1996);

**Table 2.** Percentage occurrence of food items in different size groups of *Rastrelliger kanagurta*

| Size group (cm) | No. of fish | Food items    |             |       |                      |                      |
|-----------------|-------------|---------------|-------------|-------|----------------------|----------------------|
|                 |             | Phytoplankton | Zooplankton | Algae | Miscellaneous matter | Semi-digested matter |
| 10-12           | 21          | 34.37         | 50.83       | 8.85  | 4.60                 | 1.35                 |
| 12-14           | 15          | 37.95         | 49.16       | 8.67  | 2.13                 | 2.09                 |
| 14-16           | 30          | 40.25         | 42.92       | 12.00 | 2.51                 | 2.32                 |
| 16-18           | 40          | 40.64         | 44.52       | 6.21  | 5.28                 | 3.35                 |
| 18-20           | 70          | 36.20         | 48.38       | 6.37  | 7.01                 | 2.04                 |
| 20-22           | 183         | 32.48         | 49.10       | 8.09  | 6.43                 | 3.90                 |
| 22-24           | 174         | 31.54         | 49.45       | 7.26  | 9.86                 | 1.89                 |
| 24-26           | 58          | 30.26         | 53.12       | 6.05  | 7.74                 | 2.83                 |
| 26-28           | 15          | 31.54         | 50.45       | 6.26  | 9.86                 | 1.89                 |
| 28-30           | 4           | 30.26         | 53.15       | 6.10  | 7.74                 | 2.79                 |

**Table 3.** Percentage occurrence of *Rastrelliger kanagurta* in various degrees of fullness of stomach

| Months       | No. of Fish examined | Feeding Intensity |        |        |        |        |
|--------------|----------------------|-------------------|--------|--------|--------|--------|
|              |                      | Full              | ¾ full | ½ full | ¼ full | Little |
| March- 2011  | 52                   | 14                | 16     | 16.2   | 50     | 3.22   |
| April        | 53                   | 5                 | 9      | 17.68  | 59     | 10     |
| May          | 54                   | 34.02             | 38.14  | 14.43  | 13.4   | -      |
| June         | 40                   | 21.96             | 34.69  | 17.9   | 25.44  | -      |
| July         | 49                   | 22.35             | 26.69  | 28.84  | 22.13  | -      |
| August       | 45                   | 36.28             | 24     | 22     | 17.89  | -      |
| September    | 54                   | 27                | 30     | 21.76  | 11.99  | 9      |
| October      | 51                   | 30                | 24.86  | 19.89  | 26     | -      |
| November     | 56                   | 15                | 64.28  | 11.44  | 5.35   | 4      |
| December     | 52                   | 22.1              | 26.08  | 38     | 13.81  | 0      |
| January-2012 | 50                   | 21.92             | 35.78  | 36.86  | 5.44   | 0      |
| February     | 55                   | 30.2              | 33.05  | 34.63  | 2.12   | -      |

Yohannan and Sivadas (2003) and Hulkoti (2005). Whereas Chidambaram (1944) and Devanesan and Chidambaram (1948) observed young mackerel feeding on fish, especially *Stolephorus spp.* indicating the carnivorous habit of the young fish. Venketaraman and Mukundan (1971) also supported this view based on their observations. Sivadas and Bhaskaran (2009) reported first time occurrence of *Bregmaceros spp.* in the mackerel stomach.

Although intensity of feeding in mackerel has been reported to vary with maturity and spawning conditions, being minimal during spawning, high in the maturing group, and maximum during post-spawning period (Bhimachar and George, 1952; Chidambaram *et al.*, 1952; Noble, 1962; Rao, 1965) no such decline in feeding activity of maturing or ripe fishes was observed in the present study. This agrees with the observations recorded by Kuthalingam (1956) and Krishnamoorthi (1971) in the Indian mackerel and threadfin bream respectively.

In the present study the feeding habits of the different size groups indicated differences in their prey preferences agreeing with the observations made by some earlier workers (Chidambaram, 1944; Rao and Rao, 1957; Rao, 1962). Kuthalingam (1956) based on his investigations on the food of mackerel from Madras coast categorized the nature of feeding in relation to size of the fish. He also noted that the post-larval forms to be herbivorous feeding on diatoms and other algae and juveniles omnivorous feeding on all surface forms available in the area. Thus the preference to zooplankton by all size groups indicated in the present study may be due to availability as they are the most abundant item in the Arabian Sea along the southwest coast of India (Madhupratap, 1999; Mohamed *et al.*, 2008; Smith and Madhupratap, 2005).

Because of its varied diet that includes plant and animal matter the Indian mackerel may be considered as an omnivore. Omnivory is a feeding strategy that enables fish to complement protein from invertebrate prey like copepods with energy from the more abundant primary foods such as detritus and algae, especially when their favored food items are scarce (Bowen *et al.*, 1995).

The feeding intensity was higher during November followed by May. But poor feeding was recorded during April to July. It can also be seen from the results that the poor feeding was noticed during

spawning season. The poor feeding during March & April, could be due to less availability of food or occurrence of low density of flavored food in the habitat. The present study was confined to studying the food items available in the guts at the time of analysis which revealed that there are seasonal variations in diet and physiological factor like maturation are also influencing feeding patterns.

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