Gut content analysis and Feeding Habits of the Indian Mackerel, *Rastrelliger kanagurta* (Cuvier) at Ratnagiri

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Abstract— In the current research, some feeding habits and diet composition of Indian Mackerel, *Rastrelliger kanagurta* were investigated by regular monthly collection over the period of 13 months from April 2014 to April 2015. A total of 350 specimens of *Rastrelliger kanagurta* were evaluated. The highest and lowest fork length and body weight were 25cm -16.7 cm and 141.23 g - 60.94 g respectively. Studies have shown that this fish having the relative length of Gut RLG = 0.78± 0.004, is mainly carnivorous (meat-eater) since zooplankton (21.4%) and fish body parts in the form of Semi digested matter (3.54%) were observed in the gut. *Coscinodiscus* sp. was found to be the most preferable food of plant origin constituting 32.43% by number followed by *Dinophysis miles* which constituted 11.97% by number repectively. Among zooplankton, Tintinnids (7.89%) were the most dominant items followed by *Calanus* copepod (5.65%).contributing The CV = 53% indicates the middle alimentary of this fish. The feeding intensity was higher during October to January and during April to July which coincided with the period of gonadal maturation. The fullness index (FI) increased in January and July before spawning and decreased in March and September during spawning.

Index Terms— copepod, GaSI, gut content, Indian mackerel, *Rastrelliger kanagurta*, Ratnagiri, stomach emptiness index,

1 Introduction

As food intake is the major factor controlling fish production, studies of food intake and growth of the various species is expected to yield valuable information for assessing the role of the particular species in the marine food web[1-2]. Diets of fish correspond to a combination of many important ecological components that include behavior, condition, habitat use, energy intake and inter/intraspecific interactions. An accurate description of diets and feeding habits provides the basis for understanding the trophic interactions in aquatic food webs[3]. The diet of fishes changes with a number of factors which are extrinsic (biotope, region) or intrinsic (species, size, behaviour) and thus information on the diet of fishes is important to know the basic functioning of fish assemblages which are important for developing Ecosystem-Based Fisheries Management (EBFM) models[4-5].

The Indian mackerel, *Rastrelliger kanagurta* is an important fishery resource in the Indian EEZ especially along the southwest coast of India as well as an important forage item for the highly prized food fishes such as seer fishes and tunas occupy higher trophic levels[6]. The Indian mackerel, *Rastrelliger kanagurta*[7] is a pelagic shoaling fish that form commercial fisheries along the coasts of the countries bordering the Red Sea, Oman Sea, Arabian Gulf, Pakistan, India, Sri Lanka, Bangladesh, Myanmar, Thailand and Malaysia [8]. Studying the feeding habit of fishes does have great importance both in Fisheries and Aquaculture. In Fisheries, it provides information on distribu-

tion pattern and therefore the feeding ground of both local and regional level and also has direct implications for a tackle like long line and fish trap which is used as bait. In Aquaculture, the knowledge of food items requires the larvae so as to supply different live food at different life stages. The studies on the food and feeding of the Indian Mackerel *R. kanagurta* by various workers have been reviewed. It could also be seen that there is no published information on the feeding habits of Indian Mackerel from Ratnagiri. The present study was undertaken with a view to providing food and feeding habits of *R. kanagurta* in the present context of the fishery scenario.

2. Materials and Methods:

The study area was restricted to the Ratnagiri coast, located on the west coast of India. Fish samples were collected from fishing centers around three different stations *i.e*. Mirkarwada, Dabhol and Burundi. In this area, Mackerels are usually caught by the cast net, the gill-net and the shore-seine (Rampan) and trawl net. Monthly sampling was done from April 2014 to April 2015. During 13 months study, a total of 350 specimens of *Rastrelliger kanagurata* were completely assessed biometrically. The specimens were preserved in ice until it reaches the laboratory. The morphometric measurements of each individual samples were taken before dissection: Total Length (TL), Fork Length (FL), Standard Length (SL), and Intestinal Length (IL). Total length and fork length were measured with the accuracy of 0.5 cm, total weights and the stomach weights of the sample fishes were measured with the accuracy of 0.1g through the use of digital balance.

The Relative Length of Gut (RLG) was calculated through the equation [9]:

RLG = Length of gut / Total length

Calculation of Gastro-somatic Index (GaSI) is a useful and efficient way for comparing the food consumption during various months and for determining the environmental and physiological effects on feeding habits. The GaSI for each month was obtained through the equation [10] :

GaSI = [Weight of gut (gm) / Bodyweight (gm)] X 100

Based upon the stretch of the muscles of the stomach and the volume of the food within it, the degree of Fullness Index (FI) was divided into three categories: full, semi-full and empty and Fi was calculated through the following equation [11]:

$$FI = \frac{\text{No. of stomachs with the same degree of fullness}}{\text{Total No. of the stomachs examined}} X\ 100$$

The stomach emptiness index (CV) determines the amount of the fish's appetite for the feeder (food). The stomach emptiness index (CV) was obtained through the following equation[12] :

$$CV = (Es/Ts)\ X\ 100$$

Where CV = Stomach emptiness index
Es = Empty stomachs
Ts = Total stomachs examined

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 maturity stage of each fish was noted and the gut inclusions were carefully washed into a petri-dish. The stomach contents were preserved in 4% formalin solution for further analysis. The total volume of the stomach contents was determined by the displacement method. Then the stomach contents were diluted to 10 ml and out of this 1 ml were taken by means of a graduated pipette and examined in detail over a counting chamber. It was examined under a binocular microscope and analyzed by Numerical Method[13]. Each food item is counted in an aliquot sample and its relative abundance is expressed as a percentage of the total number of items in the gut contents. The number of each macro-plankton species was recorded for determining the relative importance of various feed elements. Feed items were identified up to each level wherever possible by various references [14, 15].

The stomach contents were identified into broad but exclusive categories like copepods, diatoms, dinoflagellates, crustaceans (excluding copepods), foraminifera, tintinnids, fish eggs, chaetognaths, sand and detritus. Fine greenish or brownish coloured organic matter

that could not be attributed to any category was classified "detritus" as differentiated from "sand" which had a grainy texture. Digested tissue remains probably of fish/shrimps occurring as a whitish pasty mass which couldn't be identified were classified as "digested".

3 Results:

In this study, 350 *R. kanagurta* were examined. The minimum and maximum FL was 16.7 and 25cm, respectively and the lowest and highest body weight was 60.94 and 141.23 g. The average RLG value of *R. kanagurta* for immature and mature categories in both males and females was 0.78 ± 0.004. Al-Husaainy (1949) stated that if RLG is < 1, the fish is a carnivore. Therefore, based on this theory, since the measurement of *R. kanagurta* is found as RLG = 0.78 therefore, it is categorized as a carnivorous fish. A significant variation in the RLG was noticed between immature and mature categories irrespective of sex. RLG values of immature category ranged from 0.69 to 0.82 for males and 0.71 to 0.83 for females. The RLG values of mature fishes were higher compared to that of immature fishes *i.e*. 0.67-0.843 for males and 0.73-0.85 for females. RLG values showed normal distribution and no significant difference ($p>0.05$) was observed between sexes. However, a significant difference ($p<0.05$) was observed between the RLG values of immature and mature groups.

The stomach emptiness index (CV) in this fish was found to be 53% and since this value is more than 40 and less than 60 (40 < CV=53% < 60), therefore, this fish is middle alimentary. Also, the stomach Fullness Index (FI) for both males and females increased in January and July before spawning and decreased in March and September during spawning. The average Fullness Index (FI) during 13 months was 47%. (Fig.1)

The details of qualitative and quantitative analyses of stomach contents and percentage composition of food items during different months from April 2014 to April 2015 are shown in Fig. 2. From the gut content analysis, it was observed that the food of mackerel consisted of zooplankton, phytoplankton fishes, etc. The average proportions of the gut contents for the whole period of study were approximately 21.4 % zooplankton, 68.93% phytoplankton, 6.02% miscellaneous items, and 3.65% semi-digested matter respectively. Among the phytoplankton, several genera of phytoplankton were identified. Of these, *Coscinodiscus sp.* (32.43%) were most dominant followed by *Dinophysis miles* (11.97%), *Biddulphia sp.* (4.89%), Fragilaria (4.43%), *Chaetoceros sp.* (3.94%), *Skeletonema sp*. (3.44%), *Ceratium furca (*2.95%), *Noctiluca sp.* (2.43%), *Navicula sp*. (1.47%) and *Pleurostigma sp*. (0.98%). Zooplankton (21.4%) formed an important food item next to phytoplankton. Among the zooplankton, the *Tintinnids* (7.89%) were the most dominant item followed by *Calanus* copepod (5.65%). Among zooplankton, copepod was the most dominant item and among phytoplankton noticed was *Coscinodiscus sp.* and *Dinophysis miles*. A miscellaneous item formed (6.02%) the food items in the gut in which, Scales (0.48%), Fish eggs (0.87%), and Sand grains (4.67%). Semi digested matter (3.54%) mainly consists of fish body parts. A study on the relationship between feeding habits and spawning habits has shown that the amount of stomach contents increased during the initial steps until the maturity of the spawned eggs and decreased when they reached the maturity, that is, at hatching time.

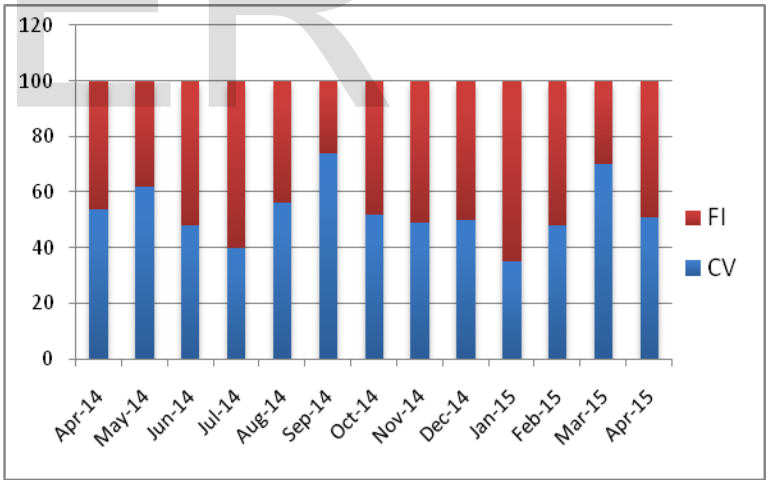

Fig. 1 The process of variation in (CV) and (FI) in *R. Kanagurta* at Ratnagiri

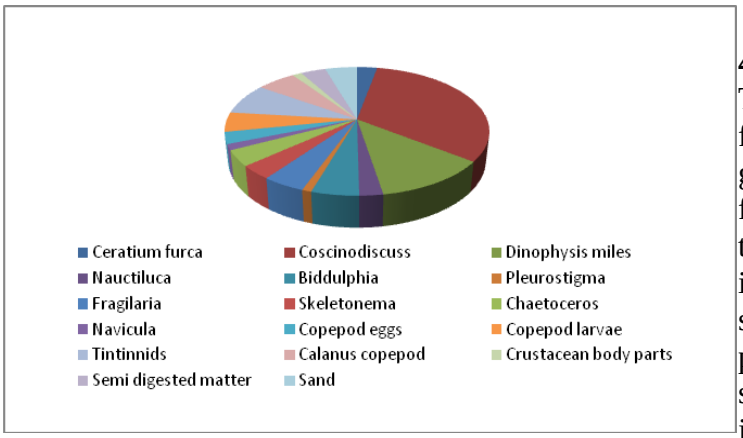

Fig. 2 Gut content analysis of *R. kanagurta* at Ratnagiri.

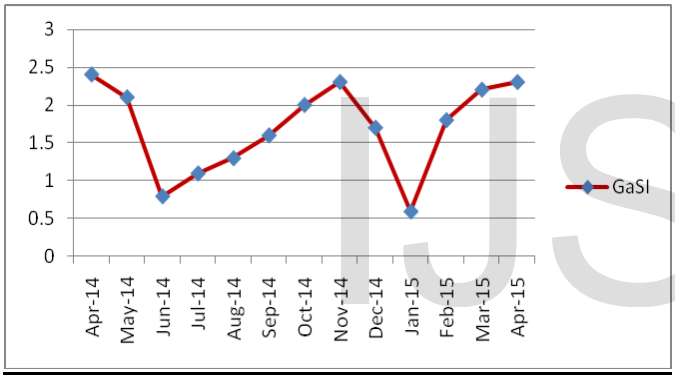

Fig. 3 Monthly Changes in Gastro-Somatic index (GaSI) of *R. kanagurta* at Ratnagiri

Monthly fluctuations in gastro-somatic index of *R. kanagurta* during April, 2014 to April, 2015 are shown in fig. 3. The Gastro-Somatic Index (GaSI) varied during the study period, as it had the highest level from March to May and the lowest from June to August again highest level from September to November and lowest from December to February. That means the highest level of Gastro-somatic index (GaSI) observed before and after spawning. It was observed that during these 2 peaks, the fish had the highest feeding (food consumption). This fact notes that its feeding habit has a close correlation with its reproduction. The GaSI suggests that fish reflecting less desire for feeding during its reproduction period, might be related to the abdominal cavity being occupied by the ripe gonads.

4. Discussion:

The relation between food and feeding habits of any fish species is generally determined by the method of gut content analysis. An exact description of diets and feeding habits provides the basis for understanding the trophic interactions in aquatic feed webs [3]. Trophic interaction, on the other hand, is essential to understand the functional role of the fish and their impact on population dynamics and biodiversity within their ecosystems[3,16]. Generally speaking, the Indian mackerel juveniles feed on different food items including phytoplankton, small zooplankton, and polychaete larvae [8]. However, as fish grow, they gradually change their dietary habits, a process that is reflected in the relative shortening of the intestine [8].

Because of its varied diet that has plant and animal matter, the Indian mackerel could also be considered as an omnivore. Omnivory may be a feeding strategy that permits fish to enrich protein from invertebrate prey like copepods with energy from the more abundant primary foods like detritus and algae, especially when their favored food items are scarce [17]. In the present study, *R. kanagurta* is found to be a planktivorous species feeding on a wide range of planktonic organisms like Coscinodiscus and Dinophysis miles which is in agreement with the findings of previous studies on *R. kanagurta* in the region[18, 19]. Similar observations in the stomach contents of *R. kanagurta* were also reported from the Arabian Sea [20].

The presence of sand grains and fish scales within the mackerel stomach has been reported[21-23]. According to one study mackerel impounded in the 'rampan'net had 80-90% of sand grains in their stomach [24]. According to Kutty (1965)[23], the presence of sand grains, foraminiferans, fish scales and molluscan shell bits noticed within the stomachs of mackerel from Bombay waters suggested that the fish altogether probability ate up rock bottom ooze within the sea. Devanesan and Chidambaram (1948)[21] suggested that the Indian mackerel occasionally supplements its planktonic diet by feeding at rock bottom on the dead and decaying fish; since they often found fish scales and sand particles within the mackerel stomach. In the present study also, miscellaneous food items, semi-digested matter consisting of fish scales, eggs, and sand grains were observed in

the stomachs of mackerel caught not only in the trawl net but also in the ring net. Moreover, the stomach contents were dark greenish in colour when sand grain was present. Devanesan and Chidambaram (1948) [21] observed young mackerel feeding on fish, especially *Stolephorus sp*. indicating the carnivorous habit of the young fish. This view is also supported by some researchers based on their observation of fish, parts of fish, and fish scale in the stomachs of young mackerel of size 64-113 mm[25]. Kutty (1965)[23] observed *Trypauchen vagina*, *Acetes indices*, *etc*. in the stomach and opined that this might be selected by sight. This supports the fact that *R. kanagurta* which found on the Ratnagiri coast is a carnivore fish.

The peak of GaSI occurred from March to May and from September to November, so, this might coincides with saving energy for the spawning season[11]. So these results are similar to the results *i.e*. The peak of GSI was reported from April to July[26] and Naturally, feeding intensity of fish are going to be decreased in spawning season and be increased afterwards[22, 27-29]. The feeding intensity was higher during February and July before spawning. But poor feeding was recorded during March and August *i.e.* after spawning season and that might be due to less availability of food or occurrence of the low density of flavored food in the habitat. High feeding intensity was observed during February and July might be attributed to meet the demand for more energy in the spawning season. Observations based on high feeding intensity in spent fish may be suggestive of high food requirements for building up of the gonads.

5. Conclusion:

In conclusion, the results highlight the fact that food items of plant origin including diatoms (Coscinodiscaceae) and dinoflagellates (Dinophyceae) form the most important food items constituting about 68.93% of food items by number in *R. kanagurta*. The average relative length of gut (RLG) of *R. kanagurta* was 0.78 indicating that this species is highly carnivorous in its feeding behaviour. This fish has a medium feeding habit. The highest level of the Gastro-Somatic Index (GaSI) observed before and after spawning. The GaSI suggests that fish reflecting less desire for feeding during its reproduction period might be related to the abdominal cavity being occupied by the ripe gonads.

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