

Evaluation of some feeding habits of *Rastrelliger kanagurta* (Cuvier, 1817) in the Persian Gulf (Hormozgan Province)

Daghooghi B.^{1*}; Kaymaram F.²; Vosoughi A.¹; Valinassab T.²; Moradi M.³

Received: December 2015

Accepted: August 2018

Abstract

The Indian mackerel (*Rastrelliger kanagurta*, Cuvier, 1817) is one of the commercial small pelagic fish in the Persian Gulf and Oman Sea. In the current research, feed preference index (FP), fullness index (FI), and stomach contents of *Rastrelliger kanagurta* were evaluated to assess the quantity and type of feed habits. A total of 573 specimens were collected randomly from Bandar - Abbas and Qeshm Island fishing sites from November 2011 to October 2012. The minimum and maximum total lengths were 13.9 and 35.5cm, respectively with the highest frequency in length group of 24-26cm. Results showed that 21.3% of stomachs were full, 44.5% were semi-full and 34.2% were empty. Planktons and fish were the main and random feed items of this species respectively. Fullness index and Vacuity index for this species were calculated 21.3 and 34.2, respectively. Stomach contents analysis revealed that phytoplankton (66%) and zooplankton (34%) form the main feed of *Rastrelliger kanagurta*. Among the phytoplankton, Bacillariophyceae (86%) was the dominant feed followed by Cyanophyceae (8%) and Dynophyceae (6%). Copepods (88%) were dominant zooplanktonic feed items. *Encrasicholina punctifer* was the only bony fish observed. Maximum and minimum of GaSI index were estimated 2.57 and 1.12 in October and February, respectively. Condition factor and relative guts length were calculated 1.76 and 2.38, respectively. The results indicated that this fish is a relatively frugal species which consumes plankton as the main feed.

Keywords: *Rastrelliger kanagurta*, Indian mackerel, Feeding Habits, Persian Gulf, Hormozgan Province.

1-Islamic Azad University. Sciences and Research Branch. Tehran, Iran.

2-Iranian Fisheries Research Institute, Agricultural Research, Education and Extension Organization (AREEO), Bandar Abbas, Iran.

3-Iranian National Oceanography Center. Tehran, Iran.

*Corresponding author's Email: b.daghooghi@gmail.com

Introduction

The Scombridae family is distributed in Indian and Pacific Ocean, as well as Red Sea, Arab Sea and Persian Gulf. This family includes 15 genera and 49 marine epipelagic and oceanic species (Collette and Nauen, 1983). The Indian mackerel *Rastrelliger kanagurta* (Cuvier, 1817) is one of the most important pelagic species of scombridae family that is widely distributed in the tropical Indo-West Pacific region, from South Africa, Seychelles, Red Sea, Indonesia, north of Australia to Malaysia, Sea of China and Ryukyu Island, as well as Persian Gulf and Oman Sea. This species has entered from Suez channel into Mediterranean Sea (FAO, 1983). A dense shoal of the Indian mackerel appears regularly in certain months of the year along the coast which has high catch more often and constitutes one of the most important marine fishery resources along Iranian coasts (FAO, 1983). Annual catch of the Indian mackerel have been reported 1912 tons from Persian Gulf and Oman Sea (Iranian waters) in 2013 (IFO, 2014). Among four coastal provinces, Hormozgan Province has the most catch of this species with 1757 tons (IFO, 2014). 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). Young mackerel feed on plankton but in adult individuals, carnivorous habits and feeding on macro plankton such as fish and shrimp

larvae were observed (Rao and Rao, 1957). Minimum life span of *R. kanagurta* was estimated 4 years and maximum fork length recorded for this species was 35 cm but it is normally 25 cm (FAO, 1983). Spawning season of Indian mackerel was reported in India from September to March, the eggs hatched immediately (Luther, 1973). The studies on the feed and feeding of the Indian mackerel *R. kanagurta* by various authors till the year 1960 have been reviewed by Chidambaram *et al.* (1952). The studies made thereafter are those of Rao (1962), Noble (1965), Rao (1965), Venkataraman and Mukundan (1971) and Luther (1973). It could also be seen that there is no published information on the feeding habits of Indian mackerel from Calicut in India after the study by Venkataraman (1961), Pradhan (1956), Bhimachar and George (1952), Kutty (1962), Rao (1965), Nobel (1965), Luther (1973), Sivadas and Bhaskaran (2009). This study conducted qualitative and quantitative analysis of stomach contents to determine the monthly prey composition and feeding intensity of *R. kanagurta* in the Persian Gulf.

Materials and methods

The study area was restricted to the strait of Hormuz located in the Persian Gulf consisted of Hormuz Island, Bandar-Abbas, and Qeshm Island fishing grounds (Fig. 1). The fishery of Indian mackerel was operated by drift-net and small trawlers, the fishing season starting from every September to June annually (Pradhan, 1956).

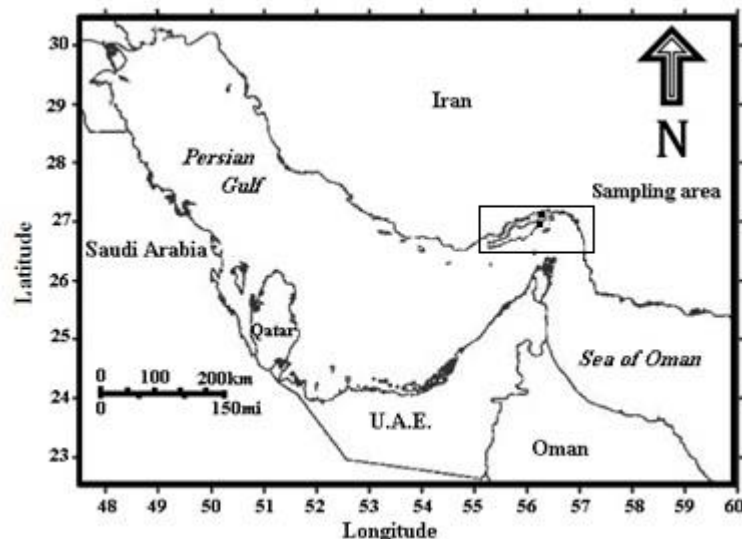


Figure 1: The study area for sampling of *Rastrelliger kanagurta* in the Persian Gulf (Hormozgan Province) (2011-2012).

It was arranged to have at least 45 specimens monthly, all samples were obtained from Bandar-Abbas and Qeshm Island fishing site and were transported in icebox to the laboratory for further measurements and studies. The intact specimens were measured for total and fork length (cm) and body weight (g). Before removing the stomach from the each individual specimen, its weight, sex, and stage of maturity were recorded. Later the stomachs were carefully removed and preserved in 90 % alcohol solution (Biswas, 1993) for subsequent analysis. The volume of the stomach contents was determined by displacement method. Then the stomach contents were made to one ml. All the macro-planktonic organisms, when present, were first separated and counted. After stirring well, a subsample of 1 ml was taken with a graduated pipette and evenly spread over Bazarove counting slide. It was examined under a binocular microscope (Nikon Invert Model TS100) and analyzed by

Numerical Method (Pillay, 1952). 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 (Tomas *et al.*, 1997; Hoppenrath *et al.*, 2009).

The various calculated feed indices comprised of the CV Stomach condition were categorized to full, semi full and empty. The Fullness Index (FI) = $(N_{sf}/N_t) \times 100$ calculated as follows: N_{sf} =the number of stomachs with same fullness. N_t =Total number of studied stomachs (Dadzie *et al.*, 2000). Condition factor was calculated as follows:

$CF = (w/FL^3) \times 10^5$ Whereas w = fish weight (g) and FL = Fork length (cm) (King, 1995). Relative guts length was estimated as follows: $RLG = IL/TL$, whereas IL = intestine length (cm) and TL = total length (cm). If $RLG < 1$, fish is carnivore and if $RLG > 1$, fish is herbivore and if RLG is mean, fish tend to omnivore (Biswas, 1993).

The Vacuity Index (VI) was calculated as follows:

$VI(\%) = \frac{\text{Number of empty stomachs}}{\text{Number of total stomachs}} \times 100$ (Biswas, 1993). Index intended to be interpreted If $40 \leq VI < 60$, aquatic is moderately fed. If $60 \leq VI < 80$, aquatic is relatively low fed. If $80 \leq VI < 100$, aquatic is low fed (Biswas, 1993). The Gastro-Somatic Index calculated as follows:

$GaSI(\%) = \frac{\text{Stomach weight (g)}}{\text{Body weight (g)}} \times 100$ (Biswas, 1993).

The feed Preference Index (FP) was calculated as follows: $FP(\%) = \frac{\text{Number of stomachs which contain a specific prey}}{\text{Number of stomachs which contain food}} \times 100$ (Biswas, 1993). According to this formula if $FP < 10$, eaten prey is considered to be negligible in the diet. If $10 \leq FP < 50$, eaten food is considered as minor food and if $FP \geq 50$, eaten food is considered as the main

food of fish (Euzen, 1987). All tests were undertaken using SPSS Version 16.

Results

A total of 573 Indian mackerel were sampled, among which 34.2 %, 44.5% and 21.3% of stomachs were identified empty, semi full and full respectively. The maximum and minimum numbers of full stomachs were observed on October and January, respectively (Fig. 2). Vacuity Index (VI) was calculated 34.2 and it shows that Indian mackerel is a severe appetite fish. FI was calculated 21.3 and the maximum and minimum of FI were estimated 58.9 and 0 in January and July, respectively. The peak of Gastro-Somatic Index was found from October to November (Fig. 3).

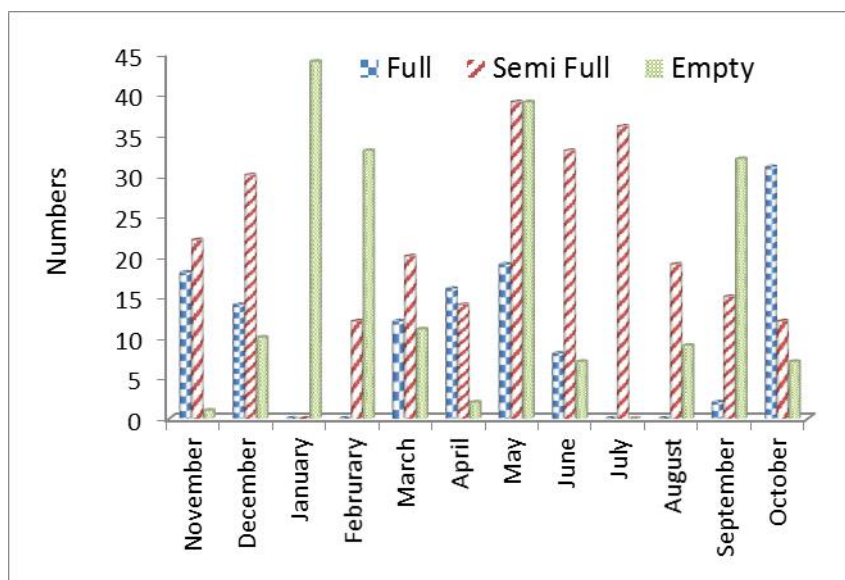


Figure 2: Stomach condition of *Rastrelliger kanagurta* of the Persian Gulf (Hormozgan Province) (2011-2012).

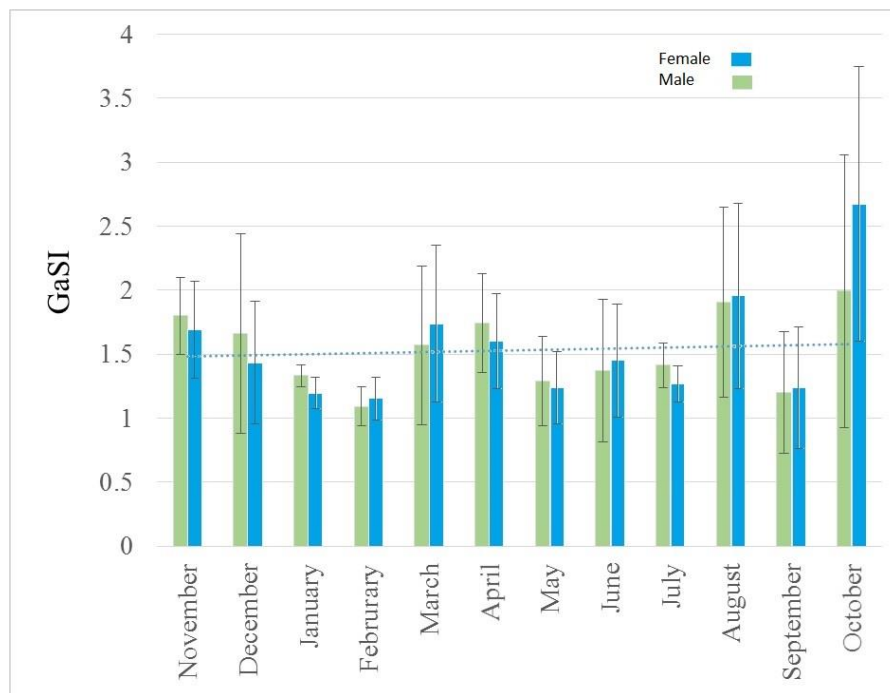


Figure 3: GaSI of Indian mackerel in both male and female from Hormozgan Province (2011-2012).

Results of stomach contents study showed that Indian mackerel fed on Phytoplankton, Zooplankton and fish. The food preference (FP) were calculated for *Copepods* (FP=75.45) and then *bivalve* (FP=37.81), *Coscinodiscus* (FP=35.55), *Tintinnids* (FP=29.59), *Peridinium* (FP=25.46), *Ceratium* (FP=23.39), *Pyrophacus* (FP=20.87), *Dinophysis* (FP=16.97), *Pleurosigma* (FP=16.28), *Noctiluca* (FP=15.82) and *Oscillatoria* (FP=11.47) were second hand feed items and *Encrasicholina punctifer* (FP=8.02), *thalassiothrix* (FP=8.02), *Naupli* (FP=6.65) and also other feed items with FP lower than 10 were random foods identified for this species. The identified numbers of fish, zooplankton and phytoplankton species were 1, 10 and 24, respectively (Table

1). Fish scale was found only in the stomach of one specimen.

Copepods were dominant zooplankton and Bacillariophyceae were dominant phytoplankton observed in Indian mackerel stomach contents. Copepods formed the major elements in the feed regime of Indian mackerel. They were present in the gut practically throughout the year (except January) and the maximum feeding of them was from March-May. Other zooplankton elements such as foraminifera, shrimp larvae, ostracods, naupli, lamellibranchia larvae, fish egg, were found periodically in specific months in the year.

Encrasicholina punctifer was the only fish that Indian mackerel fed on, just observed in April, may, June, September and November (Fig. 4).

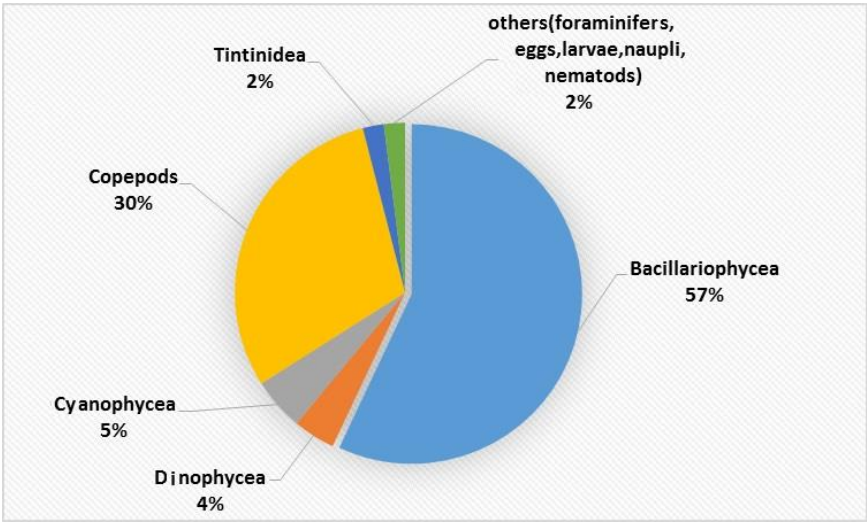


Figure 4: Total stomach contents of *Rastrelliger kanagurta* from Hormozgan Province (2011-2012).

Relative gut length (RLG) was calculated 2.38. Condition factor of Indian mackerel were estimated monthly with mean of 1.76, and peak of CF= 1.94 in April and less CF=1.65 in October (Fig. 5).

Table 1: Food items of *Rastrelliger kanagurta* stomach contents from Hormozgan Province (2011-2012).

Fish	Bony fishes	Engraulidae	<i>Encrasicholina punctifer</i>
		Crustacea	<i>Copepod , Ostracod, Shrimp larvae, Naupli</i>
		Mollusca	<i>Gastropods, Bivalve, Lamellibranchia larvae</i>
	Zooplankton	Others	<i>Tintinnids , Foraminifera, Fish egg , Nematod, Fish scale</i>
Plankton	Phytoplankton	Bacillariophyceae	<i>Rhizosolenia, Coscinodiscus, Pyrophacus, Pleurosigma, Amphora, Thallassiothrix, Navicula, Gyrosigma, Astrionella, Bellerochea, Chaetoceros, Thallasionema, Eucampia, Planktoniella, Stephanopyxis, Biddulphia</i>
		Dinophyceae	<i>Ceratium, Peridinium, Dinophisis, Noctiluca, Prorocentrum, Gymnodinium, Ornithocercus</i>
		Cyanophyceae	<i>Oscillatoria</i>

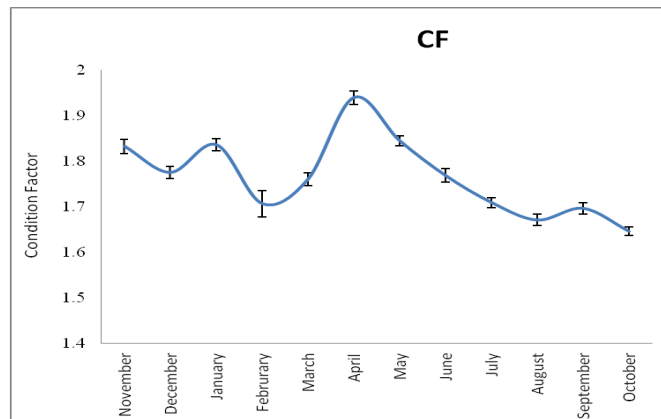


Figure 5: The fluctuation of condition factor of *Rastrelliger kanagurta* from Hormozgan Province (2011-2012).

Discussion

Analysis of gut content is widely used to ascertain the feed and feeding habit of a fish species. Accurate description of diets and feeding habits provides the basis for understanding the trophic interactions in aquatic feed webs (Zanden and Rasmunssen, 2000). Understanding fish nutrition habits requires extensive field and laboratory studies to inter the main sources of nutrition for a species. Even then, feeding studies can identify the prevalence of food items but it is not possible to assess the diet preferences of fish without detailed complementary studies to estimate the range and abundance of potential feed items available in their natural environment (Biswas, 1993). It is clear that feed habits such as frequency of feeding or size and species of prey, are constrained by the evolutionary history leading to the species, body shape and digestive system (Nikolsky, 1963). In this study, copepod (75.45%) was the dominant feed items of Indian mackerel. Copepods were the most frequent zooplankton in Persian Gulf area (Saraji, 2001) and high density of

copepods were observed in spring and autumn (Saraji and Naderi, 1996). The presence of an aquatic diet depends on the availability of its choosing. The critical factor in determining the reliability and availability of prey fish is feeding (Dorner *et al.*, 2003). Studies on feed and feeding of Indian mackerel have been done through periodical examination of stomach contents and indicated a planktonic diet with dominance of copepods and presence of diatoms, dinophysisids, crustaceans, molluscan larvae, algae, amphipods and miscellaneous items (Bhimachar and George, 1952; Pradhan, 1956; Rao and Rao, 1957; Noble, 1962; Venkataraman and Mukundan, 1971; Sivadas and Bhaskaran, 2009).

In this study, *R. kanagurta* was shown to be a relatively plankton feeder from the overall estimate of vacuity index of 34.2 %. Analysis of feed and feeding of mackerel by previous researchers showed that mackerel is a plankton feeder (Noble, 1962; Venketaraman, 1961; George, 1952; Kutty, 1962; Rao, 1965)

The peak of GaSI occurred in autumn, so, this might coincides with

saving energy for spawning season (Dadzie *et al.*, 2000). The peak of GSI was reported from April to July (Daghooghi, 2009). Naturally, feeding intensity of fish will be decreased in spawning season and be increased afterwards (Bhimachar and George, 1952; Chidambaram *et al.*, 1952; Noble, 1962; Rao, 1965).

As for *R. kanagurta*, a broad range of matters including *Diatoms*, *Dianophyceae*, *Crustacea*, molluscs larva, *Algae* and *Amphipoda* were reported (Bhimachar and George, 1952; Pradhan, 1956; Rao and Rao, 1957; Noble, 1962).

Copepods are the most abundant plankton in coastal water in the Bandar - Abbas (Saraji, 2001) and the presence of a tight coat causes them to be digested less than other groups in the stomach (Saraji *et al.*, 2005) and clearly this is the main reason for a planktivorous fish specially *R. kanagurta* to have crustacean group in their planktonic feed habitat. Bhimachar *et al.* (1952) and Chidambaram *et al.* (1952) reported that in inshore waters the diet of mackerel was dominated by copepods (50%), followed by cladocerans, larval/adult decapods, phytoplankton, lamellibranch larvae and fish eggs/larvae.

The results of survey by Salarpouri (2006) also showed that crustaceans (*Copepods*) are the main feed of Sandy Sardine in Qeshm area that 44% stomach content was crustaceans. Another survey by Daghooghi (2009) in Oman Sea showed that copepods forms 58% of stomach content of Sandy Sardine. Feed digestion and feeding in

the previous studies also confirm that copepods are the main fraction of feed for *R. kanagurta* most often (Bhimachar and George, 1952; Venketaraman, 1961; Noble, 1965; Rao, 1965). In the present work, molluscs including Bivalves and their larva and Gastropods formed 10% of feeding habitat. In a survey by Narayana (1958) main percent of food in stomach of *R. kanagurta* was fed on larval stage of Bivalves, Gastropods, and fairy Dentalium and Cavolina during whole year except November. Bivalves' larvae were the most abundant in December and April.

Mean condition factor (CF) for *R. kanagurta* during this survey was 1.76 and the maximum index was obtained in April (1.94) and the minimum in October (1.65). The feeding activity of the mackerel appeared to have distinct correlation with its spawning phase. During the period April-July, when the spawning activity of the mackerel was at its peak, the feeding intensity was low. The feeding activity was found to reach its maximal level during September, October and November when most of the fish were in spent and recovering condition.

Investigation by Daghooghi (2009) showed that the peak of sex maturation is starting from July in the Persian Gulf, so, reduced amount of condition factor might be due to spawning in the summer and feeding intensity in mackerel is low during the pre spawning and spawning periods, while in maturing specimens, it is high (Bhimachar and George 1952; Chidambaram *et al.*, 1952; Noble,

1965). It has also been noted that in spent condition, feeding is comparatively more than in mature specimens.

Vacuity index investigation (34.2) also showed that this species is a fairly voracious fish. The fairly high percentage of empty stomach, in spite of voracious in the present study, can be due to fishing method, time and high speed on enzymatic digestion in tuna fish so that this fish possess a high level of metabolism rate and feed digestion in their stomach very fast (Daghooghi, 2009).

Planktons and Bucaneer anchovy were recognized as feed diet preference and random feed for *R. kanagurta* respectively. Although some genera (*Copepods*, *Peridinium*, *Coscinodiscus*, ...) of planktons have very high abundance as compared to others, it is not possible to clearly determine the preferred feed for the filter feeders fish. The presence of one organism in feed habit depends on the availability and selection of aquatic organism (Dorner *et al.*, 2003). Feed composition of fish sometimes relates to permanent fluctuation in the amount of zooplankton in the environment (Mostardo *et al.*, 2007) or existence of every kind of other catch (Persson and Bronmark, 2002; Galarowicz *et al.*, 2006) and abundance and existence of copepods are the reason that copepods are the preferred feed for all-size fish groups (Raymont, 1983; Gopinathan *et al.*, 1984; Madhupratap, 1999; Mohamed *et al.*, 2008; Smith and Madhupratap, 2005). Evidence of copepod as an important item of feed

has achieved without considering the catch season and size of *R. kanagurta* in previous research works (Bhimachar and George, 1952; Pradhan, 1956; Noble, 1962; Rao and Rao, 1957; Sivadas and Bhaskaran, 2009) .

Indian mackerel consumed more phytoplankton in November, January, August and September and zooplankton was dominated during other months in the regime. Bhimachar and George (1952) observed a close similarity between the feed constituents and the planktonic elements during different seasons of the year. But as Pradhan (1956) has already indicated, at Karwar in India, the order of abundance of various planktonic organisms is not always the same in the corresponding analyses of gut contents. The quantity and quality of the feed of mackerel vary with the variations in planktonic elements in the inshore area. The intensity of feeding differs in various times of the year.

The feeding selectivity of mackerel and other pelagic fish depends, among other things, on the spacing of gill rakers and other physical limitations and adaptations; hence, it is not difficult to explain certain inclusions as deviations from the normal food (George, 1964).

In our study, few fish eggs were observed only in the content of five Indian mackerel stomachs in November, December, and March. The occurrence of fish eggs in the stomachs of mackerel has been observed by most of the researchers, but it is doubtful whether this habit would have any adverse effect on the fish groups that

they feed from their eggs (a view put forwarded by some researchers) as these eggs are taken in stray numbers and are too random.

In the present study, the absence of sand grains in the stomachs shows that the fish feeds either at the surface or below surface and not at the bottom, but few fish scales without any digested parts of fish were found in two stomachs. The presence of sand grains and fish scales in the stomach contents, recorded by some workers suggests that mackerel, though essentially a plankton feeder, at times resorts to bottom feeding (Chidambaram, 1944; Deveanesan and Chidambaram, 1948; Bhimachar and George, 1952; Pradhan, 1956; Noble, 1965; Kutty, 1965). These scales might have been taken in, as they fell off from the moving shoals and might not necessarily be due to carnivorous habits (George, 1964).

Devanesan and Chidambaram (1948) suggested that the Indian mackerel occasionally supplements its planktonic diet by feeding at the bottom on the dead and decaying fish; since they sometimes found fish scales and sand particles in the mackerel stomach.

Mean length of intestine in Indian mackerel during this investigation was calculated 2.38. According to Biswas's definition *R. kanagurta* is planktivour but considering planktivorous habitat of *R. kanagurta* in the early stage of life and changing this way of feeding to predation and carnivorous in large size fish, definition of this species as a planktivorous fish with respect to ecology and feeding way of *R. kanagurta* is a challenge and needs to be more

investigated unless planktivorous habitat is accounted for fish with relative length of 1.

References

- Bhimachar, B.S. and George, P.C., 1952.** Observations on the food and feeding of the Indian mackerel *Rastrelliger kanagurta* (Cuvier). *Proceedings of the Indian Academy of Science*, 36B(3), 105-117.
- Biswas, S.P. 1993.** Manual of methods in fish biology, South Asian Publishers. PVR.LTD., India, 157 P.
- Chidambaram, K. 1944.** Food of the Indian mackerel *Rastrelliger kanagurta* (Russell) of the west coast of Madras Presidency. *Curr.Sci.*, 13(8) 214 -215.
- Chidambaram, K., Krishnamurthy, C.G., Venkataraman, R. and Chari, S.T., 1952.** Studies on mackerel: Fat variation and certain biological aspects. *Proceedings of the Indian Academy of Science*, 35B(2), 43 –68.
- Collette, B.B. and Nauen, C.E., 1983.** FAO species catalogue. Vol. 2. Scombrids of the world. An annotated and illustrated catalogue of tunas, mackerels, bonitos and related species known todate. *FAO Fisheries Synopsis*, 125(2), 137.
- Dadzie, S.F., Abou-Seedo and Al-Qatton, 2000.** The food and feeding habits of the silver pomfret, *Pampus argenteus* (Eupharsen), in Kuwait waters and its implications for management. *Fisheries Management and Ecology*, 5, 501-510.

- Daghooghi, B., 2009.** A survey on feeding habit of dominant Tuna fishes and Sardine in west of Oman Sea (Jask area). The final report project. Iranian Fisheries Research Organization. 117 P.
- Devanesan, D. W. and chidambararn, 1948.** The Common Food fishes of the Madras Presidency_Government Press, Madras: 79 P.
- Dorner, H., Berg, S., Jacobsen, L., Hulsmann, S., Brojerg, M. and Wagner, A., 2003.** The feeding behavior of large perch *Perca fluviatilis* (L.) in relation to food availability: A comparative study. *Hydrobiologia*, 506(1), 427 – 434.
- Euzen, E., 1987.** Food habits and diet composition of some fish of Kuwait. *Kuwait Bulletin of Marine Science*, 9, 65-85.
- FAO., 1983.** FAO speices catalogue. Vol.2. Scombridae of the word. 137 P.
- Galarowicz, T.L., Adams, J.A. and Wahl, D.H., 2006.** The influence of prey availability on ontogenetic diet shifts of a juvenile piscivore. *Canadian Journal of Fisheries and Aquatic Sciences*, 63(8), 1722–1733.
- George, P.C., 1952.** Studies on mackerel: Fat variations—and certain biological aspects. *Proceedings of the Indian Academy of Sciences*, 35 B, 43-68.
- George, P.C., 1964.** Our current knowledge on the food and feeding habits of the Indian Mackerel, *Rastrelliger kanagurta*. Central Marine Fisheries Research Institute, Mandapan Camp, India.
- Gopinathan, C.P., Nair, P.V.R. and Nair, A.K.V., 1984.** Quantitative ecology of phytoplankton in the Cochin backwater. *Indian Journal of Fisheries*, 31(3), 325–336.
- Hoppenrath, M., Elbrachter, M. and Gerhard, D., 2009. Marine phytoplankton. Germany, Senckenberg. 264 P.
- IFO, 2014.** Annual Report of Catch Statistics. Iranian Fisheries Organization. Tehran. Iran.
- King, M., 1995.** Fisheries biology, assessment and management. Fishing News Books. Oxford. 341 P.
- Kutty, M.N., 1962.** Observations on the Indian mackerel *Rastrelliger kanagurta* (Cuvier) from the trawl catches along the Bombay Coast. *Indian Journal of Fisheries*, 9(2), 590-603.
- Luther, G., 1973.** Observations on the fishery and biology of the Indian mackerel *Rastrelliger kanagurta*, Malabar coast. *Indian Journal of Fisheries*, 7(2), 275-306.
- Madhupratap, M., 1999.** Free –living copepods of the Arabian Sea: Distribution and research perspectives. *Indian Journal of Marine Sciences*, 28, 138 – 145.
- Mohamed, K.S., Zacharia, P.U., Muthiah, C., Abdurahiman, K.P. and Nayak, T.H., 2008.** Trophic modeling of the Arabian Sea ecosystem off Karnataka and simulation of fishery yields. Central Inland Fisheries Research Institute. 140 P.
- Mostardo, E., Campo, D., Castirola, L., Esposito, V., Scarabello, M.P. and Andaloro, F., 2007.** Feeding

- abits of the bullet tuna *Auxis rochei* in the southern Tyrrhenian Sea. *Journal of the Marine Biological Association of the United Kingdom*, 87(4), 1007 -1012.
- Nikolsky, C.V., 1963.** The ecology of fishes. Academic Press, London. 352 P.
- Noble, A., 1962.** The food and feeding habits of the Indian mackerel *Rastrelliger kanagurta* (Cuvier) at Karwar. *Indian Journal of Fisheries*, 9A(2), 701 – 713
- Noble, A., 1965.** The food and feeding habit of the Indian mackerel *Rastrelliger kanagurta* (Cuvier) at Karwar. *Indian Journal of Fisheries*, 9A(2), 701-713.
- Persson, A. and Bronmark, C., 2002.** Foraging capacity and resource synchronization in an ontogenetic diet switcher, Pike perch (*Stizostedion lucioperca*). *Ecology*, 83(11), 3014 – 3022.
- Pillay, T.V.R. 1952.** A critique of the methods of study of food of fishes. *J. Zool. Soc. India.*, 4: 185 – 200.
- Pradhan, L.B., 1956** Mackerel fishery of Karwar. *Indian Journal of Fisheries*, 3(1), 141-85.
- Rao, K.V.N., 1962.** Observations on the bionomics of the Indian mackerel, *Rastrelliger kanagurta* (Cuvier), caught in the Lawson's Bay, near Waltair, Andhra coast. Proceedings of the Symposium on Scombroid fishes, Part2, pp. 586-590.
- Rao, K.V.N., 1965.** Food of the Indian mackerel *Rastrelliger kanagurta* (Cuvier) taken by drift nets in the Arabian Sea off Vizhinjam, south Kerala. *Indian Journal of Fisheries*, 9(2) A, 530-541.
- Rao, K. V. N. and K. P. Rao. 1957.** Differences in the food of the young and the adult Indian mackerel, *Rastrelliger kanagurta* (Cuv.). *Nature*, 180, 711 – 712.
- Raymont, J.E.G., 1983.** The major taxa of the marine zooplankton. *In*: Raymont, J.E.G. (Ed.) Plankton and Productivity in the Oceans. Vol. 2. Pergamon Press, NY, pp. 52 – 332.
- Salarpouri, A., 2006.** Study on some biological aspects of dominant smal pelagic fishes in coastal waters of Qeshm Island. MScThesis. Bandar Abbas Branch. Islamic Azad University. 85 P.
- Saraji, F., 2001.** Density and Biodiversity of plankton community in eastern, center and western of Bandar Abbas. *Fisheries Iranian Science Bulletin*, 4, 15-26.
- Saraji, F., Dehghani, R. and Zarshenas, Gh., 2005.** A survey on food habit of silver pomfret (*Pampus argenteus*) in Hormozgan Province. Oman Sea Fisheries Research Center. 47 P.
- Saraji, F. and Naderi, H., 1996.** A survey on plankton of Bandar Abbas coastal waters. Oman SEA Fisheries Research Center. pp. 15– 26.
- Sivadas, M. and Bhaskaran, M.M., 2009.** Stomach content analysis of the Indian mackerel *Rastrelliger kanagurta* (Cuvier) from Calicut, Kerala. *Indian Journal of Fisheries*, 56(2), 143–146.
- Smith, S.L. and Madhupratap, M., 2005.** Mesozooplankton of the Arabian Sea: Patterns influenced by

seasons, upwelling and oxygen concentrations. *Progress in Oceanography*, 65, 214–239.

Tomas, C.R., Hasle, R.G., Syveresten, E.E., Steidinger, K.A., Tangen, K., Throndsen, J. and Heimdal, B.R., 1997. Identifying marine phytoplankton. USA, Academic Press. 858 P.

Venketaraman, G., 1961. Studies on the food and feeding relationships of the inshore fishes off Calicut on the Malabar coast. *Indian Journal of Fisheries*, 7(2), 275-306

Venketaraman, G. and Mukundan, C., 1971. A note on the food of young mackerel. *Journal of the Marine Biological Association of India*, 12(1&2), 230-232.

Zanden, V.M.J. and Rasmussen, J.B., 2000. Variation in N and C trophic fractionation: Implications for aquatic food web studies. *Limnology and Oceanography*, 46(8), 2061 - 2066.