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Food and feeding habits of Indian mackerel (*Rastrelliger kanagurta)* in the southern part of Qeshm Island, Persian Gulf

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Abstract

The study investigated the stomach contents of Indian mackerel (*Rastrelliger kanagurta*) from the southern part of Qeshm Island in the Persian Gulf from April 2016 through March 2017. The food and feeding behavior of *R. kanagurta* with a fork length of 17.8 to 22.5 cm was assessed from the analysis of gut contents. The frequency of occurrence and numeric methods were used for stomach content analysis. *R. kanagurta* fed on diatoms, dinoflagellates, crustaceans, molluscs, forams and ciliates. Organisms of plant origin including diatoms (Bacillariophyceae) and dinoflagellates (Dinophyceae) were the main prey constituting about 72% of food items by number and 66.67% by the occurrence. *Coscinodiscus* sp. were found to be the most preferable food of plant origin constituting 46.92% by number and 12.88% by occurrence, followed by *Guinardia* sp. which constituted 9.74% and 7.58% by number and occurrence, respectively. Among zooplankton, crustaceans were the dominant prey contributing to 19.58% of the food items by number and 24.61% by occurrence. Copepoda was the most preferable crustacean constituting 7.57% by occurrence and 5.72% by number. Gastro-Somatic Index (*GaSI*) was found to be the highest in autumn and the least in winter that is before and after the spawning season. The stomach emptiness index was 36.15% indicating the comparatively gluttonous behavior of the fish. Overall *R. kanagurta* in the southern part of Qeshm Island in the Persian Gulf is planktonivorous and feeds on a wide range of planktonic organisms.

Keywords: Indian mackerel, Feeding habit, Stomach contents, Frequency of occurrence, Numerical method, Persian Gulf.

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Introduction

Fish like any other organisms rely on the energy received from food to perform biological processes such as growth, reproduction and other metabolic activities. Hence, food is the basis for all functions performed by individual taxa as well as populations (Bal and Rao, 1990). Feeding is one of the leading concerns of daily living in fishes, in which the fish devotes a significant portion of its energy searching for food (Hajisamae *et al*., 2003). Detailed data on the diet, feeding ecology and trophic inter-relationship is fundamental for better understanding of the life history including growth, breeding and migration (Bal and Rao, 1984) and the functional role of the different fishes within aquatic ecosystems (Blaber, 1997; Wootton, 1998). On the other hand, it has great importance in fisheries providing information on distribution pattern and the nursery and feeding grounds of target fish species (Selvam *et al*., 2015). Indian mackerel (*Rastrelliger kanagurta*) is an inhabitant of shallow waters (Moazzam *et al*., 2005), which is distributed throughout the coastal waters of the Persian Gulf (Taghavimotlagh *et al*., 2014). Murray (1880) has reported this species from Sindh in Pakistan as *Scomber microlepidotus* and *S. kanagurta,* whereas Zugmayer (1913) reported this species from the Makran coast as *S. microlepidotus*. Several studies have targeted different aspects of the biology of *R. kanagurta*. This species has been subjected to different biological investigations including reproduction (e.g. Collette and Nauen,, 1983; Moazzam *et al*., 2005); and length-weight relationships (e.g. Edwards and Shaher, 1991; Abdurahiman *et al*., 2004). Similarly several studies have focused on the feeding ecology of Indian mackerel (*R. kanagurta*) in different regions including Asia (Nayak, 2003; Moazzam *et al*., 2005; Bagheri *et al*., 2013; Supraba *et al*., 2016).

The present study dealt with food and feeding behavior of *R. kanagurta* to provide basic data on the feeding habits of the species in the Persian Gulf. The results will be utilized for the description of ecological processes and for the sustainable management of fisheries resources.

Materials and methods

Fish samples (n=260) for food analysis were collected from purse seine, beach nets and gill nets operating in the southern part of Qeshm Island in the Persian Gulf on a seasonal basis from April 2016 through March 2017 (Fig. 1).

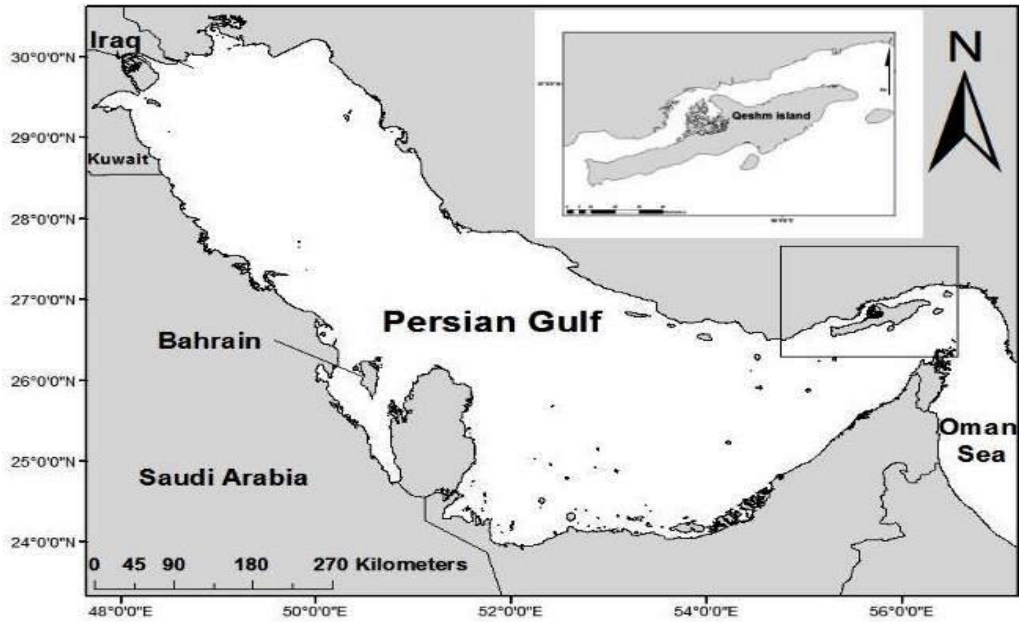

Figure 1: Location of the sampling area in the southern part of Qeshm Island (Persian Gulf).

Samples were immediately iced and transported to the laboratory for further analysis. In the laboratory, the specimens were cleaned, and total lengths (L to the nearest mm), total weights (W to the nearest g), weight of gut (W to the nearest g) and degree of stomach fullness were recorded.

In each season 65 specimens were dissected, their stomach removed and preserved in 10% formalin solution and later on examined under the Zeiss Axiovert S100 Inverted Microscope for content identification. In the first stage, the zooplankton and phytoplankton were identified, and the number of the individuals was counted (Newell and Newell, 1977).

The analysis was continued using frequency of occurrence and numerical methods as described by Hyslop (1980). Using the numerical method, the number of each food item was expressed as the percentage of the total number of items found in the stomach. The frequency occurrence of each prey item in the stomach contents was expressed as the percentage of the total number of stomachs containing food (Hyslop, 1980).

The stomachs were visually classified into three categories, i.e., full and empty depending upon the amount of food contained in them and degree of fullness and the Stomach fullness index (*SFI*) was estimated using the following equation (Dadzie *et al*., 2000):

SFI (%)=Number of stomachs with the degree of fullness/total number of the stomachs examined * 100

The weight method was utilized to analyze the stomach contents (Biswas, 1993). Mean relative weight of food content was calculated as described by Hyslop (1980) as follows:

$$\text{Mean weight of content} = \frac{\text{Total stomach contents weight}}{\text{Total fish weight}} \times 100$$

Gastro Somatic Index (*GaSI*) was calculated for all seasons, proposed by Desai (1970) to estimate the feeding intensity of fish using the following equation:

GaSI (%) = Weight of gut (g) / Weight of fish (g) * 100

Additionally, we calculated the Stomach Emptiness Index (*SEI*) proposed by Euzen (1987) to estimate fish appetite using the following equation:

SEI (%) = Empty stomachs / Total stomachs examined * 100

The logical conclusion in this formula is that if $0\leq SEI<20$, the fish is gluttonous; $20\leq SEI<40$, the fish is comparatively gluttonous; $40\leq SEI<60$, the fish is middle alimentary; $60\leq SEI<80$, the fish is comparatively hypoalimentative and $80\leq SEI<100$, the fish is hypoalimentative.

Results

The major food items found in the stomach of *R. kanagurta* are shown in Table 1. The stomach contents were grouped into molluscs, crustaceans, diatoms, dinoflagellates, forams, and ciliates. We observed that food items of plant origin were the most important items occurring in all stomachs. Diatoms (Bacillariophyceae) and dinoflagellates (Dinophyceae) made up the major items, constituting about 71.99% of food by number and 66.67% by occurrence. *Coscinodiscus* sp. constituted the most preferable food item of plant origin where it occurred in 46.92% food items by number and 12.88% by occurrence followed by *Guinardia* sp., which occurred in 9.74% of food items by number and 7.58% by occurrence. *Nitzschia* sp., *Leptocylindrus* sp., and *Bacteriastrum* sp. were the least important food items of plant origin which constituted <1% by number and by occurrence of food items. Crustaceans constituted the second largest constituents of the stomach, accounting for 19.58% by number and 24.61% by occurrence. The third food item was molluscs, which constituted 5.85% by number and 4.43% by occurrence. Ciliates and forams were the least important items contributing to 2.53% and 0.05% by number and 2.86% and 1.43% by occurrence, respectively. In total, based on the numerical method, crustaceans and diatoms formed the most important food items in the diet for this species (53.28 and 35.16%, respectively).

Table 1: Stomach contents of *Rastrelliger kanagurta* collected from the southern part of Qeshm Island (Persian Gulf).

Food items	***Numerical method***		***Occurrence method***	
	N	***%***	***N***	***%***
Ciliate				
Tintinnidae	910	2.53	20	2.86
Crustacean				
Copepoda	2724	7.57	40	5.72
Egg	1551	4.31	45	6.44
Alpheus sp.	1300	3.72	12	1.72
Harpacticoida	124	0.34	18	2.58
Ostracoda	794	2.21	26	3.72
Pieces of crustacea	515	1.43	31	4.43

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Table 1 continued:

Diatom				
Amphora sp.	105	0.29	30	4.29
Ørataulina sp.	19	0.05	1	0.29
Nitzschia sp.	3	0.01	2	0.14
Leptocylindrus sp.	3	0.01	1	0.14
Melosira sp.	25	0.07	1	0.14
Proboscia sp.	130	0.36	1	0.14
Helicotheca sp.	30	0.08	1	0.14
Pinnularia sp.	19	0.05	7	1.00
Bellerochea sp.	78	0.21	4	0.57
Bacteriastrum sp.	1	0.01	1	0.14
Pinnularia sp.	14	0.04	4	0.57
Coscinodiscus sp.	16890	46.92	90	12.88
Guinardia sp.	3507	9.74	53	7.58
Gyrosigma sp.	361	1.00	34	4.86
Navicula sp.	183	0.51	16	2.29
Pleurosigma sp.	370	1.03	55	7.87
Rhizosolenia sp.	828	2.30	9	1.29
Surirella sp.	70	0.19	21	3.00
Dinoflagellate				
Ceratium sp.	229	0.64	28	4.01
Dinophysis sp.	1327	3.69	31	4.43
Noctiluca sp.	760	2.11	12	1.72
Polykrikos sp.	90	0.25	3	0.43
Prorocentrum sp.	41	0.11	3	0.43
Peridinium sp.	673	1.87	48	6.87
Pyrocystis sp.	161	0.45	9	1.29
Forams				
Foraminifera	18	0.05	10	1.43
Molluscs				
Bivalve	2057	5.71	24	3.43
Gastropoda	49	0.14	7	1.00

Regarding the seasonal occurrence of different food items in the gut of *R. kanagurta*, we observed the high percentage of occurrence by diatoms during both autumn and summer (53.3 and 48.1%, respectively; Fig. 2), while the high percentage of dinoflagellates occurred in winter (40.0%). The highest percentage of occurrence of crustaceans was detected during autumn (36.26%). Molluscs occurred at a high percentage during winter constituting 5.83% of the examined guts. Finally, the high percentage of occurrences of forams and ciliates were recorded during autumn (4.95%) and spring (7.14%), respectively.

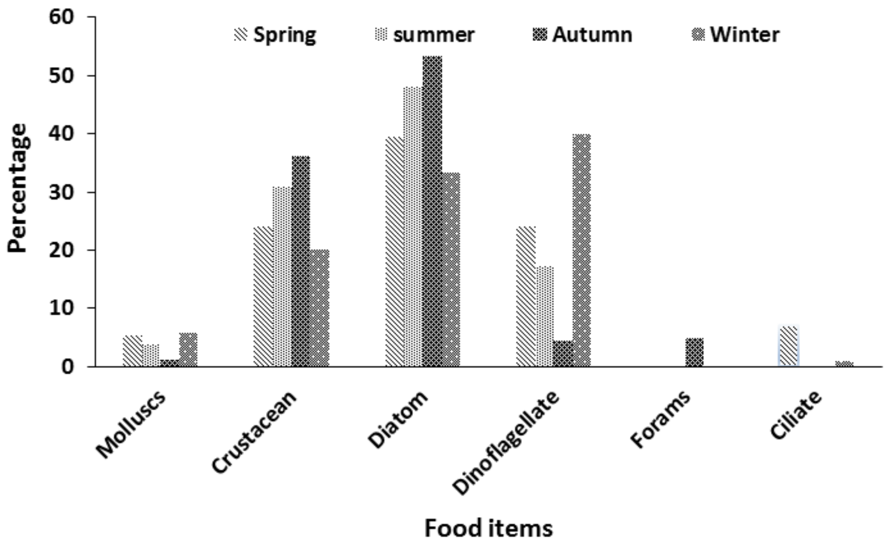

Figure 2: Seasonal occurrence of food items of *Rastrelliger kanagurta* in southern part of the Qeshm Island (Persian Gulf).

Seasonal variations of different food items showed that diatoms formed the main food items of plant origin during different seasons (Fig. 3). However, crustaceans were the preferable food of animal origin during all the seasons. Overall, the results of the two methods emphasized the importance of plants as a major food resource for the *R. kanagurta* in the Persian Gulf.

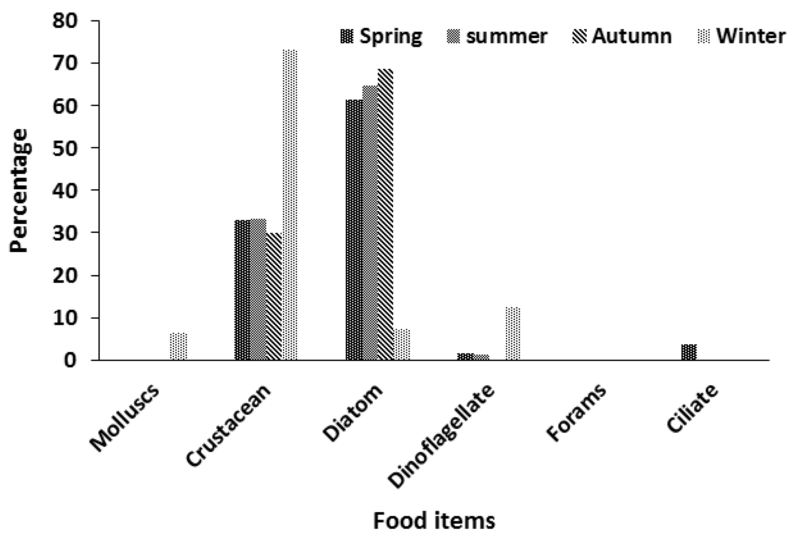

Figure 3: Seasonal percentage of food items of *Rastrelliger kanagurta* in the southern part of Qeshm Island (Persian Gulf) by numerical method.

Regarding the seasonal variation of feeding intensity as an index of the stomach fullness, the maximum number of empty stomachs was observed during winter (67.6%; Table 2). The stomach emptiness index (*SEI*) was 36.15%. The value is in the range of 20-40, reflecting that the *R. kanagurta* is comparatively gluttonous.

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Table 2: Percentages of seasonal variation in gut fullness of *Rastrelliger kanagurta* in the southern part of Qeshm Island (Persian Gulf).

State of gut	Spring	Summer	Autumn	Winter
Full	16.3	54.3	43.9	-
Half	43.8	42.4	47.8	32.4
Empty	39.9	3.3	8.3	67.6

The seasonal variations in the mean weight of stomach contents in the collected fish samples showed that the highest mean weight of stomach contents was attained during autumn, whereas the lowest was recorded during winter (Table 3).

Table 3: Seasonal variation in mean weight of stomach content ±SD of *Rastrelliger kanagurta* in the southern part of Qeshm Island (Persian Gulf).

Season	Mean weight of stomach contents
Spring	0.61± 0.22
Summer	0.90± 0.40
Autumn	1.20± 0.58
Winter	0.54± 0.32

The Gastro-Somatic Index (*GaSI*) varied during the seasons studied, as it demonstrated the highest level in autumn and the lowest in winter. In fact, the highest level was observed before and after the spawning season (Fig. 4).

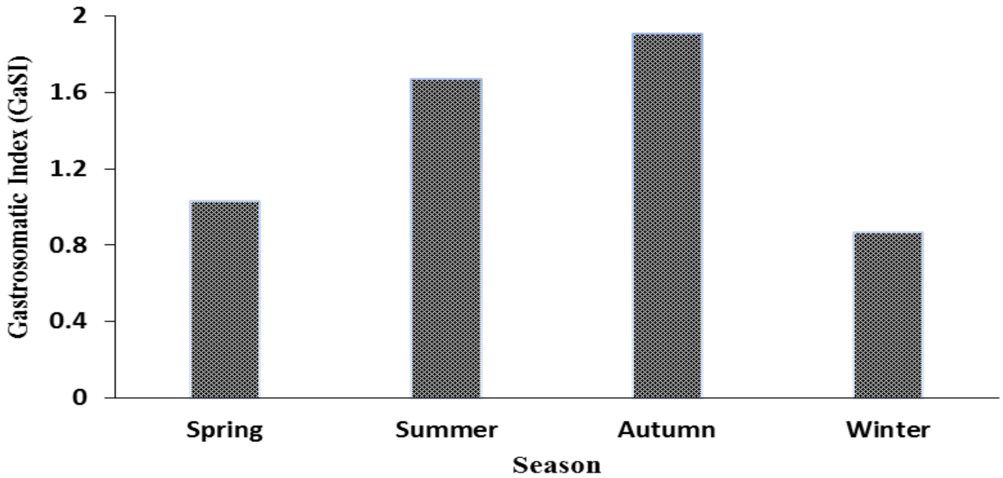

Figure 4: Seasonal variations of Gastro-Somatic index (*GaSI*) of *Rastrelliger kanagurta* in the southern part of Qeshm Island (Persian Gulf).

Discussion

The study of the feeding ecology of fish species is useful to assess trophic relationships and their implications for ecosystem functioning (Brey, 2012). 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 (Vander Zanden and Rasmunssen, 2001; Taghavimotlagh *et al*., 2014). Generally speaking the Indian mackerel juveniles feed on different food items including

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phytoplankton, small zooplankton, and polychaete larvae (Collette and Nauen, 1983). However, as fish grow, they gradually change their dietary habits, a process that is reflected in the relative shortening of the intestine (Collette and Nauen, 1983).

For example, Sree Renjima *et al*. (2016) have pointed out that in the coast of the southeastern Arabian Sea the *R. kanagurta* larvae feed predominantly on microzooplankton and then switch over to a diet dominated by Calanoid copepods as they grow further.

The results of the current study showed that diatoms and dinoflagellates were the preferable food items of plant origin where they occurred in more than 46.28% of the sampled fish. In agreement with the results of the current study, Bagheri *et al*. (2013) reported that phytoplankton (45%) is the essential food item of the *R. kanagurta* in the study region.

The current study revealed that, crustaceans including copepods, eggs and larval forms comprised the maximum part of the food of animal origin in *R. kanagurta*. The highest percentage of occurrence of crustaceans was detected in the stomach contents of this fish during autumn (36.26%) which might be the indication of high density of crustaceans in the study area. In contrast, Bagheri *et al*. (2013) mentioned that copepods (71%) were the predominant zooplankton group in the Persian Gulf. The effect of seasonality should always be taken into account in studies on food and feeding habits of fish because the temporal changes of biotic and abiotic factors alter the structure of the food web during the year (Wootton, 1998; Kariman *et al*., 2009). Accordingly, the composition of food varied from season to season depending upon the fluctuations in the occurrence of various planktonic elements (Kariman *et al*., 2009; Taghavimotlagh *et al*., 2012; Supraba *et al*., 2016).

In the present study, the maximum number of empty stomachs was during winter (67.6%). However, the maximum *GaSI* value was recorded during autumn (1.90%). These results show that both maximum values are recorded before and after the spawning season in the study area (Arrafi *et al*., 2016). The results may be expounded in light of the abdominal cavity which is entirely occupied by the ripe gonads, and so stomachs were always empty during this season (Kariman *et al*., 2009). During the warm months, there seemed to be a decrease in the feeding activity, probably due to an increased spawning activity by these fish. Moazzam *et al*. (2005) and Sivadas and Bhaskaran, (2009) reported a similar pattern in the spawning and feeding activity of *R. kanagurata* in the Arabian Sea.

In the present study, *R. kanagurta* is found to be a planktonivorous species feeding on a wide range of planktonic organisms, which is in agreement with the findings of previous studies on *R. kanagurta* in the region (Sivadas and Bhaskaran, 2009; Bagheri *et al*., 2013). Similar observations in the stomach contents of *R. kanagurta* were also

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reported by Supraba *et al*. (2016) from the Arabian Sea.

In conclusion, the results highlight the fact that food items of plant origin including diatoms (Bacillariophyceae) and dinoflagellates (Dinophyceae) form the most important food items constituting about 71.99% of food items by number and 66.67% by occurrence in *R. kanagurta*. The *GaSI* and percentage of empty stomach 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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