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Note

Insights on diet dynamics of Indian mackerel *Rastrelliger kanagurta* (Cuvier, 1816)

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ABSTRACT

The diet of Indian mackerel *Rastrelliger kanagurta* (Cuvier, 1816) is reported based on the gut content analysis of specimens collected along the central Kerala coast, India. The study indicated ontogenetic variations in diet with diet breadth being highest in the largest size class of >231 mm total length (TL). Copepods followed by diatoms were the preferred food items. Detritus was an important diet component, especially during the pre-monsoon season and in the larger (>231 mm TL) size groups. The Preponderal Index (Ip) indicated seasonal differences in proportions of the various prey consumed. Spearman Rank Correlation Coefficient indicated similar diet quality during monsoon (June-September) and post-monsoon (October-January) seasons; but significant differences as compared to pre-monsoon season (February-May). Based on the results of the study, Indian mackerel was classified as an opportunistic feeder with a diet component that broadly reflects its seasonal-spatial habitats and local food availability.

Keywords: Diet breadth, Diet seasonality, Indian mackerel, Ontogeny, *Rastrelliger kanagurta*

Food intake is the major factor controlling fish production and a study of food and feeding of fishes can shed light on the behaviour, habitat use, energy intake of the various fish species and inter/intraspecific interactions that occur in the aquatic ecosystem (Walters *et al.,* 1997). The Indian mackerel *Rastrelliger kanagurta* (Cuvier, 1816) is an important fishery resource in the Indian EEZ especially along the south-west coast of India as well as form an important forage item for the highly valued food fishes such as seerfishes and tunas occupying the higher trophic level (Vivekanandan *et al*., 2009). Earlier studies on food and feeding of mackerel have indicated a planktonic diet with dominance of copepods and presence of diatoms, dinophysids, crustaceans, molluscan larvae, benthic algae, amphipods and miscellaneous items while piscivory was reported only from the studies on the west coast of India (Bhimachar and George, 1952; Noble, 1962; Rao, 1965; James and Joseph, 1976; Sivadas and Bhaskaran, 2009; Supraba *et al*., 2014). Climate change induced impacts on the mackerel fishery in India are manifested as extension of its distribution range to deeper waters resulting in higher volumes in trawl landings and increasing availability in pelagic fishing gears along the north-west coast of India (Vivekanandan, 2011). The impacts of adverse feeding conditions on growth, maturation and reproduction besides distribution and abundance patterns, in fish stocks, implies that quantitative and qualitative aspects of fish diets in their natural environment have to be periodically evaluated.

Monthly samples of Indian mackerel were collected from ring seine and trawl net landings along central Kerala coast from January 2005 to June 2006. These were individually evaluated (N=1469) for the following parameters: total length (mm), total weight (g) and stage of maturity (indeterminate, immature, maturing, ripe and spent following Pradhan and Palekar, 1956). Stomachs were assigned as poorly fed (empty to 1/4 full), moderate (1/2 full) and actively fed (3/4 to full), depending on their state of distension (Hyslop, 1980). Qualitative analysis of guts was done only in 'actively fed' category comprising 411 individual mackerels. The stomach contents were identified into 12 broad but exclusive categories namely, copepods, diatoms, dinoflagellates, crustaceans (excluding copepods), foraminifera, tintinnids, fish eggs, chaetognaths, semi-digested matter, algae, sand and detritus. Fine greenish or brownish-coloured organic matter that could not be attributed to any category was classified as "detritus" and was differentiated from "sand" which had grainy texture. Semi-digested tissue, probably of fish/shrimps occurring as a whitish pasty mass, which could not be identified were classified as "semi-digested matter". Seasonal food preferences were studied using the frequency of occurrence (% FO) of each food item (Hynes, 1950) and Index of Preponderance (Ip) as given by Marshall and Elliott (1997). The seasons classified by Menon *et al*. (2000) as Pre-monsoon (February to May), Monsoon (June to September) and Post-monsoon (October to January) was adopted for comparing the results.

Diet similarities among seasons were compared using Spearman Rank Correlation Coefficient (Rs) as given in Fritz (1974). Ontogenetic diet variations for 5 size groups namely, <140, 141-170, 171-200, 201-230 and >231 mm TL, taking into consideration its life history milestones such as maturation and growth phases (Yohannan, 1979) were recorded. Diet breadth (B) for each size group was calculated as $B = 1/(\sum pi^2)$ where p_i is the proportion of the i^{th} item of the N items in the diet (Krebs, 1999). Graphical method of Costello (1990) was used to depict relative importance of each food item.

Empty stomachs were observed in all seasons while active feeding was highest during monsoon. Copepods and diatoms were the most commonly observed food items in the mackerel stomachs examined in all the seasons. Based on the frequency of occurrence, crustaceans were highest in monsoon and post-monsoon seasons while foraminifera, algae and detritus ranked high during the pre-monsoon season (Table 1). The Preponderance Index (Ip) on a seasonal scale indicated that during the pre-monsoon period, detritus and macroalgae dominated the diet components while copepods and 'semi-digested matter' dominated during the monsoon and post-monsoon period (Table 2). Spearman Rank Correlation Coefficient indicated significant correlation among the monsoon and post-monsoon seasons as compared to the pre-monsoon season (Table 3).

Table 1. Percentage occurrence of various food items in Indian mackerel gut during different seasons

Item/Season	Pre-monsoon	Monsoon	Post-monsoon
Copepods	64.3	89.9	95.3
Diatoms	64.3	69.6	72.1
Dinoflagellates	13.1	30.4	32.6
Fish eggs	10.7	5.1	2.3
Crustaceans	15.5	69.6	44.2
Foraminifera	67.9	25.3	7.0
Tintinnids	16.7	5.1	9.3
Algae	54.8	26.6	34.9
Detritus	78.6	36.7	11.6
Sand	63.1	7.6	9.3
Semi-digested matter	66.7	100.0	86.0
Molluscs	0.0	7.6	0.0
Chaetognaths	0.0	0.0	11.6
Total	100	100	100

Table 2. Preponderance Index (Ip) and ranking (in parenthesis) of various food items during different seasons for Indian mackerel

Prey items	Pre-monsoon	Monsoon	Post-monsoon	Annual (All seasons combined)
Copepods	16.89 (2)	43.86 (1)	39.29 (2)	33.3 (1)
Semi-digested matter	15.13 (3)	28.70 (2)	41.48 (1)	28.4 (2)
Detritus	28.48 (1)	1.91 (5)	0.82 (6)	10.4 (3)
Diatoms	8.58 (6)	9.47 (4)	5.78 (4)	7.9 (4)
Crustaceans	0.67 (8)	12.67 (3)	10.45 (3)	7.9 (5)
Foraminifera	11.87 (4)	0.13 (9)	0.13 (8)	4.0 (6)
Algae	8.12 (7)	1.54 (6)	1.19 (5)	3.6 (7)
Sand	9.31 (5)	0.14 (8)	0.02 (9)	3.2 (8)
Dinoflagellates	0.29 (10)	1.46 (7)	0.80 (7)	0.9 (9)
Tintinnids	0.53 (9)	0.03 (11)	0.02 (10)	0.2 (10)
Fish eggs	0.14 (11)	0.01(11)	0.01 (11)	0.1 (11)
Molluscs	-	0.10 (10)	-	-

Table 3. Correlation in seasonal diet composition

Seasons	Pre-monsoon	Monsoon	Post-monsoon
Pre-monsoon	1.0	0.482	0.181
Monsoon		1.0	0.778***
Post-monsoon			1.0***

*** significant at 0.01 level (2 tailed)

The dominance of copepods followed by diatoms, irrespective of seasons was obtained using Costello analysis (Fig. 1). Similar observations were made by the earlier workers (Bhimachar and George, 1952; Pradhan,1956; Noble, 1962; Sivadas and Bhaskaran, 2009).

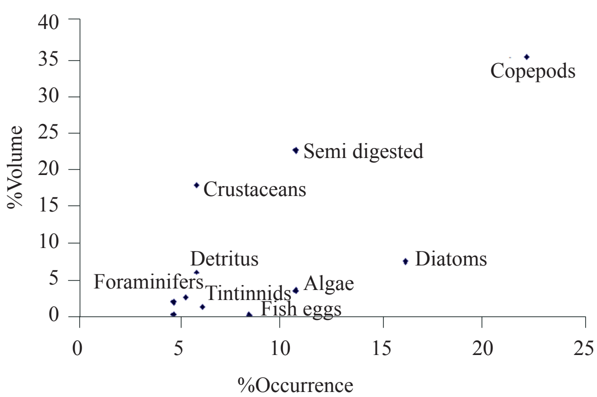

Fig. 1. Costello analysis indicating the dominant prey items in the diet of Indian mackerel

The preference for copepods can be attributed to them being the most abundant item in the zooplankton community along the south-west coast of India (Pillai *et al.,* 1973; Madhupratap, 1999; Madhupratap *et al.,* 2001). Marine phytoplankton (diatoms, dinoflagellates) and other algae are rich in polyunsaturated fatty acids such as docosahexaenoic acid (DHA), eicosapentaenoic acid (EPA) and arachidonic acid (AA) as reported by Tocher (2003). Phytoplankton being a significant diet item for mackerel, the fatty acids in the plankton are also passed on through the marine food chain. Bhimachar and George (1952) had reported that mackerel avoided feeding on chaetognaths but it occurred as part of diet (11.6% occurrence and 6 ranking in Ip) of the fishes sampled during post-monsoon season. Anchovy, sardines and Indian cod (*Bregmaceros* spp.) have been reported in the diet (Devanesan and Chidambaram, 1948; Kutty, 1965; Venkataraman and Mukundan, 1970; Sivadas and Bhaskaran, 2009; Supraba *et al.,* 2014) but were not observed in the present study. The occurrence of macroalgae was significantly higher in the diet of relatively large sized mackerel especially during the pre-monsoon period when it reportedly moves to deeper waters (Yohannan and Abdurahiman, 1998) and resort to bottom feeding. According to Qasim (1972), detritus in food webs are of significant importance in several marine fishes which may otherwise be planktivores or carnivores. A possible reason for this is that in comparison to seasonal phytoplankton production trends, detrital particles with its nutritive value in terms of C:N ratio ranging from 5-10.5:1, are available round the year (Qasim and Sankarnarayanan, 1972). Bacteria associated with aggregated particulate material that can be retained by the filtration structures of the fishes is considered as a potential food resource for higher trophic levels in the marine pelagic systems (Newell, 1984) which indicates that detritus forms an important supplementary food source of Indian mackerel. Rajan (1968) reported that certain known carnivorous fishes in the Chilka Lake fed on detritus even while other food organisms were readily available. Madhupratap *et al.* (1994) hypothesised the detritus food chain as a significant influence in determining the success of mackerel fisheries *vis-a-vis* oilsardine which feeds on plankton alone. In other words, planktivorous fishes are more vulnerable during periods of adverse environmental conditions when there is less than optimum plankton production either quantitatively or qualitatively thereby affecting its dietary energy requirement adversely. Fish metabolism influences feeding behaviour with intake synced to meet the energy requirements and a diet with a low energy value, is compensated by eating more within the limits of its stomach capacity (Mittelbach, 2002). This was indicated by the diet composition trends during the pre-monsoon season when %FO of guts with detritus content was 79% *versus* <37% and Ip was 28.5 *versus* <2%, compared to the monsoon and post-monsoon seasons. Evidently, the Indian mackerel has a non-selective feeding habit and diet composition reflects local fluctuations in prey availability with strategies to maximally exploit available food resources seasonally.

Diet breadth was highest in the size class of >231 mm indicating more generalised feeding habits compared to <140 mm size groups (Fig. 2) as the fish becomes more tuned for utilisation of energy from all possible sources. Ontogenetic variations based on Ip indicated dominance of detritus (37.59) followed by copepods (19.3) in the largest size group (>231 mm). Copepods, diatoms and dinoflagellates dominated in 171-230 mm size range while in the <140 mm size group, copepods (62.24) were dominant followed by semi-digested matter (24.90) (Table 4). The seasonal variations in the availability of the prey types and the natural habitat shifts by mackerel over its life cycle are obviously the reasons for this. Hunter and Leong (1981) had reported that anchovy *Engraulis mordax* required a daily ration of copepods equivalent to 4-5% of female wet weight per day to support annual cost of growth and reproduction. Similarly, copepods were the major diet component of mackerel in all the seasons. The fatty acid profile of mackerel when compared to sardine occupying the same ecological niche, indicated higher DHA component which was attributed to the rich wax esters found in copepods, its preferred food item as compared to sardines with preference for diatoms (Ganga *et al*., 2010).

Table 4. Preponderance Index (Ip) for the various size groups of mackerel

Prey/Size group (mm)	<140	141 -170	171- 200	201 - 230	>231
Copepods	62.24	47.29	70.35	72.28	19.30
Diatoms	12.86	0.64	25.06	10.36	4.22
Dinoflagellates	0.00	0.01	2.88	6.38	0.00
Fish eggs	0.00	0.01	0.08	0.00	0.42
Crustaceans	0.00	17.24	0.00	0.80	0.20
Foraminifera	0.00	0.00	0.00	0.09	14.59
Tintinnids	0.00	0.00	0.00	0.44	0.54
Algae	0.00	0.07	1.20	0.84	16.23
Detritus	0.00	0.00	0.43	0.09	37.59
Sand	0.00	0.00	0.00	3.90	4.36
Semi-digested matter	24.90	34.74	0.00	4.83	2.55

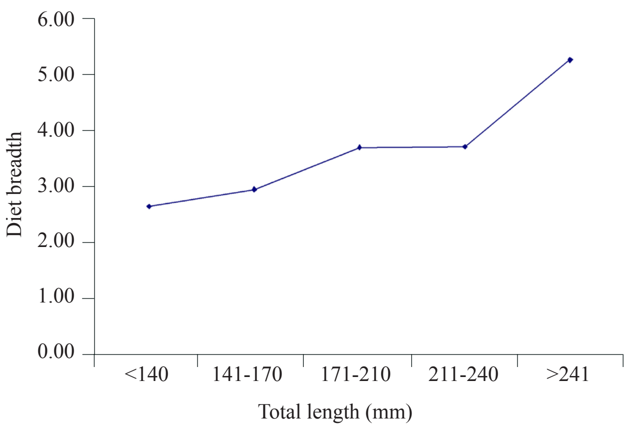

Fig. 2. Diet breadth (B) of Indian mackerel showing diversity of prey consumed among size groups

Ecosystem based fisheries management with its emphasis on prey-predator interactions is gaining traction as a management tool for multi-species complex of fishery resources that are being targeted. The trophic interactions and energy flow in the marine ecosystem based on diet composition data of major fished and non-fished groups therefore emerge as important data inputs in such models (Mohamed *et al.,* 2008). Most of the studies on diet habits of Indian mackerel indicate it to feed on plankton (Noble and Geetha, 1992). However, the detrital pathway also obviously plays a major role in this species and should be considered for assigning trophic values, especially at different life history stages.

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