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Food habit and diet composition of *Karalla dussumieri* (Valenciennes, 1835) and *Gazza minuta* (Bloch, 1795) from Mandapam vicinity of Gulf of Mannar, Tamil Nadu

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Original Article

Abstract

The diet composition and food habits of two species of Silverbellies, *Karalla dussumieri* (Valenciennes, 1835) and *Gazza minuta* (Bloch, 1795) from Mandapam vicinity of Gulf of Mannar was analysed. The diet composition was studied from December 2016 to April 2018. *K. dussumieri* with full stomachs appeared in very high percentages (100%) in December followed by empty stomachs (100%) in January and February. Empty stomachs were prevalent in most of the months for *G. minuta* with a peak in January (100%). The vacuity index (VI) of *K. dussumieri* was highest during January (100%) and minimum from September to December (11-21%). Correspondingly the highest fullness index (FI) was recorded during December (4.69). The monthly mean FI of *G. minuta* has shown a single maximum value during August (4.81), whereas the highest VI was noticed in most of the months with a peak in January (100%). Fishes of higher length group 105-110 mm and above had the highest FI in both species. The diet analysis of *K. dussumieri* revealed that a planktivorous feeding habit as copepods became the principal diet with an average %IRI of 32%, followed by foraminifera (26.12%). The monthly average %IRI values showed that *G. minuta* is a carnivorous fish with teleost fishes (50%) as the main food followed by shrimps (15%) and copepods (9%). The gut content of smaller fishes showed diatoms, polychaetes and amphipods as the main components and as they grew, more of nekton appeared in the stomach.

Keywords: *Diet analysis, feeding index, Gazza minuta, Karalla dussumieri, Gulf of Mannar*

Introduction

Silverbellies occupy a key niche in the inshore marine ecosystem as they have a protractile mouth, which opens either upward, downward or horizontal. Species of the genera *Karalla*, *Eubleekeria*, *Leiognathus* and *Photopectoralis* have either straight or downward pointing protractile mouths bare of teeth; tend to prefer plankton or benthos as their diet. The extensible teeth less mouth pointing upward in fishes of genus *Deveximentum* assists feeding of pelagic plankton. The mouth of *Gazza* spp. pointing forward or horizontal when protracted, with distinct caniniform teeth in both jaws assist in carnivory. Thus the silverbellies exhibit a multidimensional food guild in the ecosystem. Presence of circumesophageal light organ aid ventral counter illumination for avoiding predation and also ensures species-specific sexual dimorphism (Sparks *et al.*, 2005; Chakrabarty *et al.*, 2011). Unlike juveniles, some of the adult silverbellies inhabiting the Palk Bay exhibit diurnal vertical migration, staying at the bottom during daytime and moving upward during night hours for grazing plankton (Venkataraman and Badrudeen, 1974).

All India landing of silverbellies during 2017 was 89,901t. Tamil Nadu accounts for more than 84% (76,221t) of the silverbellies landed along the Indian coast, followed by Kerala (8.14%) and Andhra Pradesh (6.23%). The contribution of silverbellies to the total marine fish landing in Tamil Nadu during 2016 and 2017 was 17.75% and 11.7% respectively (CMFRI, 2017 and 2018

a, b). Within Tamil Nadu, the south-east coast comprising Palk Bay and Gulf of Mannar regions yields the highest catches of silverbellies as the fishery in these regions is almost continuous throughout the year.

Detailed information on the food habits of fishes is considered an essential prerequisite to understanding community ecology, structure and stability of food webs, trophodynamics, growth, spawning, migration and fishery. Silverbellies have also been the focus of many studies in Indian waters and several reports have been made on the food and feeding of different species from various regions of the Indian coast. The diet composition of *Leiognathus brevirostris, Gazza minuta* and *Secutor insidiator* from the south-east coast of India was given by James and Badrudeen (1975), Kuthalingam *et al.* (1958) and Jayabalan and Ramamoorthi (1985). Comprehensive studies on food and feeding of silverbellies from both east and west coast of India were conducted *viz.* Six species of leiognathids off Madras coast *viz.*, *Leiognathus insidiator, L. ruconius, L. fasciatus, L. equulus, L. splendes* and *G. miuta* (Basheeruddin and Nayar, 1961), *Leiognathus bindus, L. dussumieri, L. daura* and *Secutor ruconius* off Waltair (Rao, 1964), *L. ruconius* off Bombay (Bapat and Bal, 1952) and Calicut (Venkataraman, 1960); *L. blochii* off Trivandrum (Gopinath, 1946) and Calicut (Venkataraman, 1960); *L. bindus* off Gulf of Mannar (Chacko, 1949), Calicut (Venkataraman, 1960; Balan, 1963), off Visakhapatnam (Rao *et al.,* 2015) and Ratnagiri coast (Borah *et al*., 2016); *L. brevirostris* off Kerala (Sebastian and Inasu, 2011), *L. splendens* off Calicut (Venkataraman, 1960) and Ratnagiri coast (Acharya and Naik, 2016); *L. dussumieri* off Mandapam waters (James and Badrudeen, 1981) and Tuticorin (Nagarajan, 2014); *L. jonesi* of Palk Bay and Gulf of Mannar by James 1986.

Material and methods

Samples of *K. dussumieri* and *G. minuta* caught by trawlers were collected biweekly from Pamban Therkuvadi fish landing centre (FLC) from December 2016 to April 2018. The locations of fishing ground of silverbellies in the Gulf of Mannar is given in Fig. 1. Length and weight of individual fish were taken to an accuracy of 1 mm using a graduated scale and 0.01 mg respectively using an electronic balance. Each fish was then cut open to record the sex and stage of maturity following the ICES scale (Lovern and Wood, 1937). A total of 924 specimens of *K. dussumieri* ranging in size from 80 to 135 mm and 941 fish of *G. minuta* ranging in size from 80 to 166 mm were analysed for food and feeding studies. Each gut was removed and preserved in 5% buffered formalin for further studies. Diet composition was analysed following the method of 'Index of Relative Importance (IRI %)' established by Pinkas *et al.* (1971) through suitable modification to estimate the volume index.

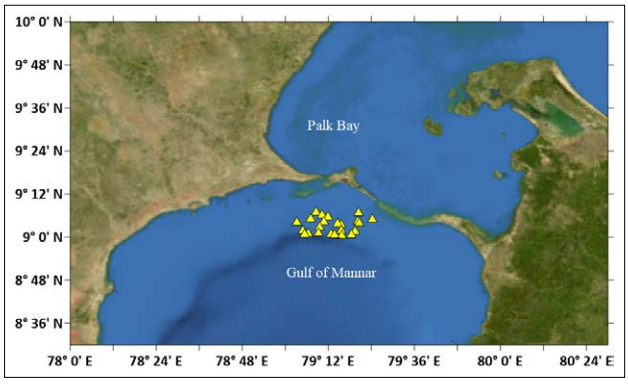

Fig. 1. Locations of silverbelly fishing grounds off Mandapam, Gulf of Mannar

$$IRI = (\%N + \%V)\ \%O$$

Where, %N, %V and %O are percentages of the number, volume and frequency of occurrence of prey

The gut of each fish was emptied into a petri dish and examined under a binocular microscope (Nikon SMZ1270) at 8x magnification. If the food items were in the advanced state of digestion, they were treated as 'digested matter'. The phytoplankton (Subrahmanyan, 1946; Verlencar and Desai, 1971), zooplankton (Kasturirangan, 1963; Santhanam and Srinivasan, 1994) and benthos (Gosner, 1971) were identified and allotted points according to their volume in the stomachs. In this way, one large organism counted as many as several small ones. These points were multiplied by the number counted. All the products were added up and converted into percentages (volume) for all items in different months.

The feeding intensity was determined by eye examination based on the distension of the stomach and the amount of food contained in the stomach. The various stomach conditions were gorged, full, ¾ full, ½ full, ¼ full and empty in which gorged and full were considered as an indication of 'actively fed', ¾ full and ½ full as 'moderately fed' and ¼ full and empty as 'poorly fed' (Sebastian and Inasu, 2011).

Two feeding indices, vacuity index (VI) and fullness index (FI) were calculated for each month and the size group of both species. Vacuity index (VI) is the percentage ratio of the empty stomachs to the total number of stomachs analysed (Preciado *et al.*, 2014) and FI is the ratio of the weight of stomach contents to the total body weight of fish (Hyslop, 1980).

Results and discussion

Actively fed stomachs in *K. dussumieri* were prevalent from July to December with peak in December 2016 (100%) and December 2017 (96.55%) (Fig. 2). The highest percentages of moderately fed fish were observed in March 2017 (71.21%)

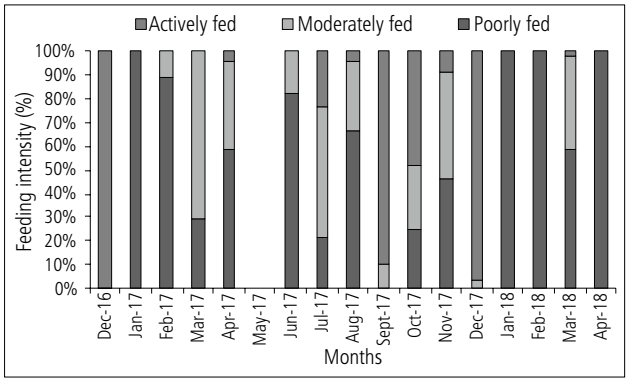

Fig. 2. Monthly feeding intensity of *K. dussumieri*

and the range was 10 to 60% from February to August 2017. Poorly fed fish was recorded in all months except September and December 2017. The percentage of poorly fed stomachs was highest (100%) in January and February 2018. The monthly feeding intensity of *G. minuta* is given in Fig. 3. The incidence of the actively fed stomach was less than 25% and was noticed only in 8 out of 16 months. The percentage was the highest in February (23.73%) followed by 2-15% from July to December 2017. The highest percentage of moderately fed stomachs was noticed in August (65.77%) and November (49.44%). Poorly fed stomach condition was prevalent in most of the months with the highest percentages in January to July (>70%) except in February 2017 (54.24%).

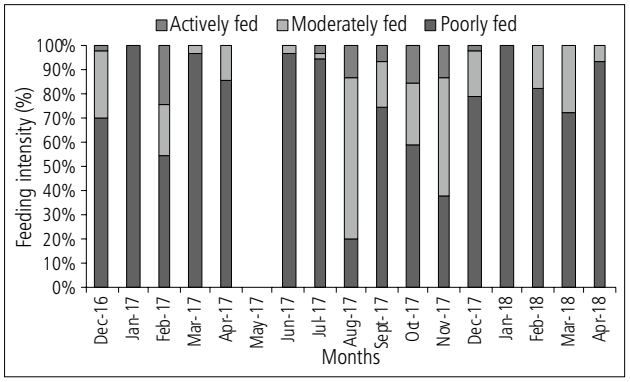

Fig. 3. Monthly feeding intensity of *G. minuta*

The percentage of feeding intensity of *K. dussumieri* concerning length class is presented in Fig. 4. Fish with actively fed stomachs were absent up to 85-90 mm length class. Thereafter it has slowly increased to 28.57% in the 130-135 mm size group. The highest percentage of moderately fed stomachs also was noticed in the largest fish (57.14%). However, the incidence of poorly fed stomachs was prominent in all the sizes of 70-75 mm, except in the largest size class (130-135 mm), where the percentage of moderately and actively fed stomachs dominated. Length-wise feeding intensity in *G. minuta* also showed a similar trend (Fig. 5). The occurrence of actively fed stomachs

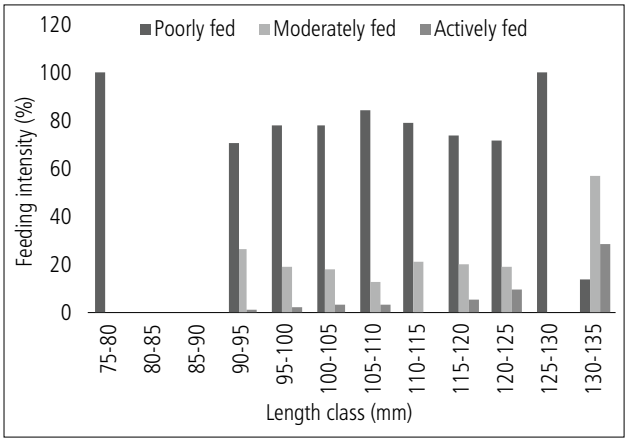

Fig. 4. Length-wise feeding intensity of *K. dussumieri*

was minimum in the smaller sizes and as the fish grows the percentage increased up to 28.57% in 130-135 mm size. The percentage of moderately fed stomachs was between 20 and 27% in the size class from 90-95 to 130-135 mm. The smaller fish had fed poorly and as they grow the percentage of empty and quarter full stomachs decreased to 45.71% (130-135 mm) from 100% (75-80 mm).

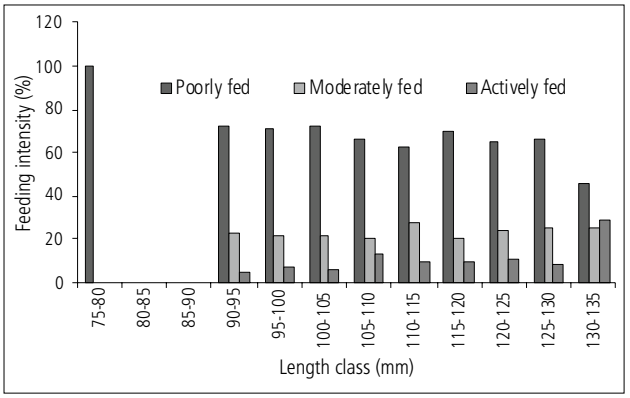

Fig. 5. Length-wise feeding intensity of *G. minuta*

The more incidence of poorly fed stomachs from January to July and moderately and actively fed stomachs from August to December in both species indicate seasonality in feeding. Restricted food intake was observed during peak spawning months followed by more occurrences of actively fed fish. However, Jayabalan and Ramamoorthi (1985) found no relation between growth/maturity stages and feeding intensity in *G. minuta*. Nagarajan (2000) also reported the absence of seasonal and sexual variation in feeding intensity in *S. insidiator* and *G. minuta* from the Tuticorin coast. He also reported that active feeding intensity increases with increasing size groups in *G. minuta*, and in both sexes, larger fish (> 101-110 mm) were found to be active feeders. As the fish grows the size of their mouth increases proportionately, their swimming

capacity is modified, and their energy requirements may also vary (Qasim, 1971).

The monthly mean VI and FI of *K. dussumieri* and *G. minuta* is depicted in Table 1. The fullness index in *K. dussumieri* was highest (4.69%) with the lowest VI (2.71%) in December and highest vacuity index (100%) with minimum FI (0.02) was observed in January 2017 and 2018. In *G. minuta* highest FI (4.81%) was in August and a higher VI (100%) was recorded in January 2017 and 2018. The highest VI and lowest FI noticed from January to July indicate a peak spawning and hence meagre feeding.

Table 1. Monthly distribution of Vacuity Index (VI) and Fullness Index (FI) in *K. dussumieri* and *G. minuta*

Months	*K. dussumieri*		*G. minuta*	
	VI (%)	FI	VI (%)	FI
Dec-16	2.71	4.69	52.34	1.13
Jan-17	100.00	0.02	100.00	0.05
Feb-17	31.91	0.24	48.89	0.16
Mar-17	83.67	0.14	88.89	0.29
Apr-17	78.26	0.17	73.81	0.23
Jun-17	93.02	0.03	95.30	0.03
Jul-17	79.35	0.30	73.03	0.30
Aug-17	39.01	1.81	9.77	4.81
Sep-17	15.09	2.35	44.23	2.05
Oct-17	21.31	2.12	55.85	2.12
Nov-17	11.69	2.01	21.45	2.35
Dec-17	12.20	3.80	40.62	1.80
Jan-18	100.00	0.02	100.00	0.05
Feb-18	95.00	0.05	80.00	0.24
Mar-18	71.64	1.24	74.81	0.41
Apr-18	58.18	1.99	89.57	0.99

Table 2. Length-wise distribution of VI and FI in *K. dussumieri* and *G. minuta*

Length class (mm)	*K. dussumieri*		*G. minuta*	
	VI (%)	FI	VI (%)	FI
75-80	53.5	0.52	45.32	0.14
80-85	0.00	0.00	0.00	0.00
85-90	0.00	0.00	0.00	0.00
90-95	38.46	1.59	53.95	0.86
95-100	21.57	1.81	42.02	1.36
100-105	34.43	1.03	42.14	1.24
105-110	27.37	2.14	38.24	1.57
110-115	33.33	1.83	38.46	1.92
115-120	50.00	1.46	35.85	1.90
120-125	43.87	2.04	37.14	2.71
125-130	53.49	2.56	50.00	1.62
130-135	40.00	3.56	10.31	2.79

The change in VI concerning the size of *K. dussumieri* is presented in Table 2. Highest index (53.2%) was observed in 75-80 mm size. Thereafter the mean VI was reduced to 27.37% at 105-110 mm size. The highest (3.56) and lowest (0.52) FI value was observed in the largest and smallest size classes. A similar trend was found in *G. minuta* that largest size class had minimum VI (10.31%) and highest FI (2.79). Combinations of the highest gonadosomatic index and VI with the least FI in April indicate spawning and less feeding of *E. jonesi* from off Mandapam (Remya *et al.,* 2019).

Diet analysis of K. dussumieri

According to the meteorological factors and other hydrographical features of the study area, the year could be divided into four seasons. Pre-monsoon period (July to September), Monsoon period (October to December), Post-monsoon period (January to March) and Summer period (April to June). Season wise diet analysis of *K. dussumieri* through calculating %IRI of different food items is given in Table 3. Among different diets encountered copepods dominated with 32%, followed by foraminifera (26.12%) (Fig. 6). The digested matter was observed up to 13% in the guts. Other food items were of lesser importance.

Table 3. Season wise Index of Relative Importance (%IRI) of food items in *K. dussumieri*

Food items	Seasons			
	Post-monsoon	Summer	Pre-monsoon	Monsoon
Diatoms	1.82	0.00	0.00	2.03
Foraminiferans	20.92	33.33	22.00	28.25
Amphipods	1.83	2.67	3.50	0.93
Copepods	21.60	39.67	41.00	25.50
Ostracodes	2.83	2.67	5.67	0.75
Crustacean remains	9.60	7.33	14.33	3.00
Nematodes	1.33	0.67	1.67	0.63
Bivalves	10.17	5.00	6.69	11.25
Gastropods	8.67	1.33	1.57	4.50
Eggs	1.50	0.00	0.25	1.25
Digested matter	19.73	7.33	3.33	21.93

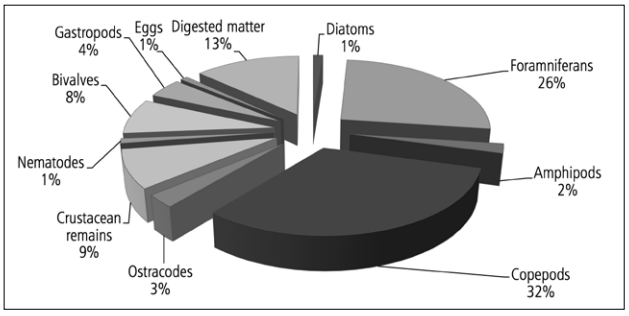

Fig. 6. Percentage composition of different diets in the guts of *K. dussumieri*

Crustaceans and foraminiferans together contributed 72%. Among crustaceans, copepods were consumed the highest and the fraction was nearly 40% in summer and pre-monsoon. Calanoids (41%) and cyclopoids (32%) were the major copepods followed by harpacticoids (11%). Foraminiferans dominated the diet during summer (33.33%) and monsoon (28.25%). A significant quantum of the digested matter was also noticed in diet during monsoon (22%) and post-monsoon (20%) and hence it can be treated as the third most important gut content. Bivalves were detected in all seasons with the highest fraction of 11.25% during monsoon. The %IRI of planktonic gastropod was between 4 and 10% during monsoon and post-monsoon. Phytoplankton content, especially diatoms such as *Coscinodiscus* and *Asterionella* spp. was nearly 2% during monsoon and post-monsoon and no diatoms were observed in the remaining seasons. Nematodes and eggs were observed in all seasons with a %IRI of less than 2%.

The results of the present study indicate that *K. dussumieri* is more of a planktivorous fish feeding mainly on planktonic crustaceans, foraminiferans, bivalves etc. No significant change was noticed in the diet with an increase in the size of the fish. The downward protruding mouths with slender and minute teeth on jaws (FAO, 1983) enable this fish to eat zooplankton and invertebrates associated with the sea bottom. Further, Venkataraman and Badrudeen (1974) studied the diurnal vertical migration of *L. jonesi* (the present name is *Eubleekeria jonesi),* one of the dominant silverbellies in the Palk Bay. It states that vertical migration enables ingestion of phytoplankton in pelagic water during the night and during the day time they rely on zoobenthos and zooplankton at the bottom. James and Badrudeen (1975, 1981) also found out similar type of food items in the guts of *L. brevirostris* (present name is *Nuchequula gerreoides*) another chief silverbelly inhabiting the Palk Bay. The food and feeding habits of *L. dussumieri* (the present name is *Karalla dussumieri*) off Mandapam waters (James and Badrudeen, 1981) and off Tuticorin (Nagarajan, 2014) of the Gulf of Mannar show polychaetes, copepods, amphipods, bivalves, gastropods, foraminiferans and crustacean remnants as the major diets. These three silverbellies viz., *L. jonesi, L. brevirostris* and *L. dussumieri* exist in adjacent ecosystems and have a mouth when protracted forms a tube directed downwards with small, numerous teeth, hence may prefer similar diets. Further James and Badrudeen (1981) also reported no changes in diet preferences across different seasons and age groups of *K. dussumieri*. The present study shows copepods and foraminiferans remained as the major diet constituents in all seasons and moderate variation in %IRI of other gut contents across seasons.

Diet analysis of G. minuta

Among different diets encountered in *G. minuta*, finfish especially *Stolephorus* spp. dominated with 50%, followed by shrimps (15%). The third and fourth position was occupied by copepods (9%) and stomatopods (5%) respectively. An equal fraction (4%) of polychaete worms, crabs and cuttlefishes were noticed as favourable diet next to stomatopods. The incidence of remaining food items was found <3% in the diet (Fig. 7). The season wise %IRI of different food items in the gut of *G. minuta* is given in Table 4.

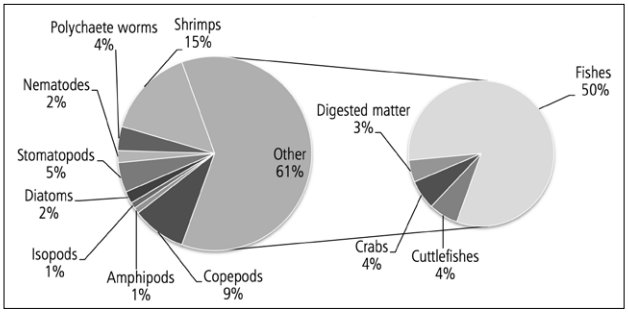

Fig. 7. Percentage composition of different diets in the guts of *G. minuta*

Table 4. Season wise %IRI of food items in *G. minuta*

Food items	Seasons			
	Post-monsoon	Summer	Pre-monsoon	Monsoon
Diatoms	2.17	3.50	2.00	1.26
Isopods	1.19	0.50	3.13	0.79
Amphipods	1.30	0.25	2.15	1.51
Copepods	4.35	18.00	6.73	5.71
Stomatopods	2.08	8.50	8.07	2.50
Nematodes	2.23	0.50	5.34	1.50
Polychaete worms	3.35	9.00	3.72	0.88
Shrimps	11.21	18.00	13.50	16.15
Crabs	5.30	4.00	3.54	2.41
Cuttlefishes	2.49	1.50	8.50	2.50
Fishes	61.28	31.00	43.32	62.95
Digested matter	3.06	5.25	0.00	1.86

Finfishes dominated the diet with the highest %IRI of 63% during monsoon and the fraction never dropped below 30% in the remaining seasons. An equal composition of shrimps and copepods (18%) was detected in summer and %IRI of shrimps never dropped below 10%. The highest incidence of stomatopods and polychaete worms was also noticed during summer (8.5 and 9% respectively). The highest index of crab was seen in post-monsoon (5.3%) followed by summer (4%). The fraction of cuttlefishes was 8.5% during pre-monsoon and <3% in the remaining seasons. The digested matter was observed in all seasons except pre-monsoon and %IRI was between 2 and 5%. The incidence of diatom was 3.5% during summer and the

Table 5. Length-wise %IRI of G. *minuta*

Food items	Length class (mm)											
	80-85	85-90	90-95	95-100	100-105	105-110	110-115	115-120	120-125	125-130	130-135	135-140
Diatom	13.72	5.38	4.98	9.81	0.31	0	0	0	0	0	0	0
Isopod	11.09	2.34	0.68	7.32	0	0	0	1.34	0	0	0	0
Amphipods	13.53	11.02	5.61	1.48	0	0	0	0	1.82	0	0	0
Copepods	34.41	38.94	27.73	7.32	2.19	2.51	1.63	0.64	0	0	0	0
Stomatopod	0	0	0	0	0.8	1	3	13.02	12.5	21	25.77	18
Nematodes	0.64	0	0	10	11.54	7	12	14	6.32	11	18.23	2
Polychaete worm	0	0	0	6	16.84	18.23	25	20.67	14.31	17.86	20	21
Shrimp	0	11	7	8	21	21.68	15.37	4.41	0.84			
Crab	0	0	0	0	0	0	0	0.54	0	8	2	8
Cuttlefish	0	0	0	0	7.32	0	0	0	3.21			
Fish	0	0	12.7	30.43	25	38	30	28.54	41	23.14	20	37
Digested matter	14.61	10.32	12	19.64	15	11.58	13	16.84	20	19	14	14

fraction was below 2.5% in the remaining seasons. Whereas the %IRI of nematodes was minimum during summer (0.5%) followed by the highest fraction of 5.34% in pre-monsoon. The highest %IRI of both isopods and amphipods was 3.13 and 2.15% respectively and encountered during pre-monsoon.

Size wise %IRI of different gut contents of *G. minuta* is presented in Table 5. Major food items in length classes 80-85 mm and 95-100 mm were diatom (0.31 to 13.72%), isopod (0.68 to 11.09%), amphipod (1.48 to 13.53%) and copepod (2.19 to 38.94%). Stomatopods appeared in the diet of fish with a length above 100 mm and %IRI varied from 0.8% in 100-105 mm to 25.77% in 130-135 mm. An %IRI above 2% was noticed for nematodes from 95-100mm size and above. Fish with $<$100 mm size had $>$12% polychaete worms in their diet. The occurrence of shrimp in the gut was detected in fish with sizes between 85-90 mm and 120-120 mm. %IRI of crab was in between 2 and 8% in fish above 125 mm. Cuttlefishes were also noticed in 100-105 mm and 120-125 mm sizes. Fishes started to appear as the chief food in fishes of 90-95 mm and above sizes with %IRI between 12.7 and 41%.

The present study indicates that *G. minuta* is an omnivorous column feeder, preying more upon fishes and crustaceans and the feeding intensity increases with size. There was a noticeable shift (from omnivory to carnivory) in the food preferences of *G. minuta* with age. The chief components in the diet of *G. minuta* were found to be fish, especially *Stolephorus* spp., followed by shrimp, crab, cephalopods, polychaetes, stomatopods, copepods etc. Kuthalingam (1958) reported that *G. minuta* is a surface feeder during its early life, and its dietary habits and preferences change from that of a plankton-feeding habit to a bottom-feeding habit with the approach of adulthood. Jayabalan and Ramamoorthi (1985) found differential feeding preferences with age in *G. minuta*, with a transition from omnivory to carnivory with advancing age. They reported the dominant food items in *G. minuta* were fishes, mainly *Stolephorus* spp., *Thryssa* spp., *Pseudorhombus* spp., *Cynoglossus* spp. and. *Apogon* spp. Prawns ranked next to finfishes. Nagarajan (2000) reported that the food items of *G. minuta* from the Tuticorin coast included semi-digested matter, fish, prawns, copepods, filamentous algae, polychaetes, diatoms etc. and active feeding intensity increases with increasing size groups. He also reported the absence of seasonal variation in feeding intensity in *G. minuta.* The present study shows finfish as the major diet in all seasons and a fairly high %IRI of copepod and shrimps were noticed during summer. *G. minuta* have its mouth pointing forward when protracted, with distinct caniniform teeth in both jaws (FAO, 1983). These particular characteristics enable this species to become carnivorous, unlike other silverbellies that co-exist in Gulf of Mannar. Kuthalingam (1958) reported diet composition of *G. minuta* from Madras waters consists of nearly 84% animal matter.

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