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Food and feeding habits of the greenback grey mullet *Liza subviridis* (Valenciennes, 1836) from Parangipettai waters, south-east coast of India

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ABSTRACT

The feeding ecology and prey preference of greenback grey mullet *Liza subviridis* (Valenciennes, 1836) were investigated in Parangipettai waters (11°29'25.55"N; 79°45'38.62"E) from May 2011 to April 2012. A total of 328 male and 360 female specimens of *L. subviridis* were analysed. Detritus and sand particles formed the major food item of *L. subviridis* in both sexes besides, diatoms, dinoflagellates, algae, zooplankton, foraminiferans, polychaetes and larval forms were also noticed and ranked respectively based on the quantities. Feeding intensity showed that the percentage of 'empty' stomachs varied from 7.2% (November 2011) to 19.3% (August 2011) and from 7.1% (March 2012) to 19.2% (August 2011) in males and females respectively whereas the 'gorged' stomach in males and females was in the ranges of 4.6% (March 2012) - 14.5% (December 2011) and 4.6% (September 2011) - 14.5% (April 2012). The gastrosomatic index of males and females ranged between 5.9% (October 2011) - 8.2% (May 2011) and 6.1% (March 2012) - 8.1% (May 2011) respectively. The results agree with the previous reports and extend the understanding on its well-being, reproductive seasons and stock of *L. subviridis* in Parangipettai waters.

Keywords: Feeding biology, *Liza subviridis*, Parangipettai waters, Prey preference

Food and feeding biology of fish is ever relevant in the determination of their habitat, distribution and other associated factors (Bal and Rao, 1984). Parangipettai waters (11°29'25.55"N; 79°45'38.62"E) along the south-east coast of India are abound with mullets which are available throughout the year (Reddy, 1977; Rahman *et al.*, 2013; Rahman *et al.*, 2015). Mulletts (Teleostei: Mugilidae) primarily consume tiny living and dead plant material or any other organic matter. Ecologically, they play an important role in the energy flow of food web in the estuarine communities. Mulletts generally imbibe the surface sediment, which is full of detritus and microalgae, particularly diatoms and also forage into seagrasses and other substrates for epiphytes and epifauna (Collins, 1985).

The study of food and feeding behaviours of an organism is one of the foremost features in the study of its biology (Qasim, 1972) and stomach content analysis has become a regular practice as opined by Hyslop (1980). Knowledge of fish feeding pattern and quantitative assessment of food habits can be obtained from stomach content analysis. Investigation on the diet helps in understanding suitably the production, habits, intensity of feeding and the ecological role of fish population, which are useful in describing the trophic status and the pattern

of growth rate of fish (Mohanraj, 2000). Such analyses unravel the trends in the seasonal, geographical and spatial differences in the nutritional composition of fish (Lear, 1972; Vinogradov, 1972; Frost, 1977).

Biological aspects of Mugilidae have not gained much importance (except *Mugil cephalus*) since the other members are difficult to identify (Thomson, 1966). Therefore the biological aspects such as age, growth, length-weight relationship, feeding habits, reproduction and stock assessment of other species of mugilids remains uncertain in Parangipettai waters. *Liza subviridis* (Valenciennes, 1836) is abundant in Parangipettai waters (Rahman *et al.*, 2013) and studies on its feeding behaviours have not been attempted so far in Indian waters and therefore the present study was undertaken.

L. subviridis samples were collected from the fish landing centre at Annankoil, Parangipettai during May 2011 to April 2012. Cast net, seine net, drag net and gillnet of varying mesh sizes were also operated for catching mullets from Vellar Estuary, Parangipettai (11°29'25.55"N; 79°45'38.62"E) to retain the sample size on the greater side. As many as 328 male specimens of *L. subviridis* (85 to 254 mm in total length, TL) and 360 female specimens (85 to 265 mm TL) were collected and analysed. The male and female fishes were identified

by examining the gonad. After recording the size and sex, total weight of each specimen was taken; its gut was dissected out, weighed and subjected to analysis for food composition and feeding intensity.

The feeding intensity was assessed by visual estimation based on the swelling of the gut and the quantity of food present inside. The different stomach conditions based on the amount of richness were expressed as gorged, full, $\frac{3}{4}$ full, $\frac{1}{2}$ full, $\frac{1}{4}$ full, trace and empty as suggested by Pillay (1952). The gut was then excised and contents were analysed under binocular microscope for the food composition, preference and relative importance of various diet contents following the “points (volumetric) method” (Pillay, 1952).

The gastrosomatic index (GaSI) was calculated for each specimen to estimate the feeding intensity by making use of the following formula:

$$\text{GaSI} = \frac{\text{Weight of the gut}}{\text{Weight of the animal}} \times 100$$

Composition of gut contents: Composition of diet contents for males and females in relation to month is given in Tables 1 and 2. Based on the overall percentage of occurrence in the gut, the food items were ranked.

In both the sexes, detritus was found maximum during all the months and contributed up to 60.4% during April 2012 in males and 62.7% during March 2012 in females. Minimum proportions of detritus were found during September 2011 in males (37.4%) and November 2011 in females (38.7%). Mean percentage contribution of detritus during the study period was 44.4% in males and 46.6% in females. The average sand content in the gut was found to be 12.45% in males and 11.5% in females. Sand was found maximum during the month of January 2012 (18.9%) and minimum during March 2012 (8.6%) in males. In females maximum sand content was found to be 18.3% (June 2011) and minimum (8.6%) during July 2011.

Average contribution of diatoms in males and females was 10.36 and 10.2% respectively. Diatoms were found maximum during September 2011 (14.3%) and

Table 1. Dietary composition (%) during May 2011 - April 2012 in male *Liza subviridis*

Months	Detritus	Sand	Diatoms	Dinoflagellates	Algae	Zooplankton	Foraminiferans	Polychaetes	Larval forms	Miscellaneous
May-2011	45.2	10.7	11.4	8.9	6.3	7.9	2.3	2.5	2	2.8
June	40.8	13.6	10.3	10.9	4.4	7.9	3.7	2.9	2.3	3.2
July	41.7	12.4	10.9	12.5	5.2	6.3	3.1	3.6	2.2	2.1
August	39.1	15.3	12.7	10.3	4.1	6.5	2.2	4.7	2.9	2.2
September	37.4	12.9	14.3	8.9	4.8	9.9	3.6	4.1	2.1	2
October	51.7	9.1	10.8	9.2	3.1	5.1	2.7	2.4	3.1	2.8
November	45.5	13.1	8.7	8.3	4.1	3.6	4.2	6.3	3.8	2.4
December	38.1	16.6	10.2	6.8	7.1	6.6	3.9	3.1	2.9	4.7
January-2012	39.9	18.9	7.8	10.1	6.5	3.1	2.7	4.1	2.6	4.3
February	40.6	9.1	12.7	7.8	7.3	5.1	5.9	2.2	3.8	5.5
March	52.8	8.6	7.7	5.1	5.8	2.9	4.6	3.9	2.5	6.1
April	60.4	9.2	6.9	4.1	3.6	2.3	2.8	3.1	2.7	4.9
Average	44.4	12.5	10.4	8.6	5.2	5.6	3.5	3.6	2.7	3.6

Table 2. Dietary composition (%) during May 2011 - April 2012 in female *Liza subviridis*

Months	Detritus	Sand	Diatoms	Dinoflagellates	Algae	Zooplankton	Foraminiferans	Polychaetes	Larval forms	Miscellaneous
May-2011	44.2	9.1	10.6	9.9	7.1	6.5	2.8	3.7	2.5	3.6
June	41.5	18.3	7.9	9.7	6.4	3.1	2.3	4.1	2.6	4.1
July	56.2	8.6	6.7	4.5	5.1	2.3	4.9	3.4	2.7	5.6
August	43.8	13.3	12.7	9.3	4.1	5.5	2.2	3.7	2.5	2.9
September	45.2	10.7	12.8	9.7	3.3	5	3.1	2.4	3.1	4.7
October	42.8	11.1	11.7	7.8	6.3	4.1	4.5	2.3	3.9	5.5
November	38.7	11.6	12.3	10.9	4.8	7.9	3.7	4.9	2	3.2
December	46.4	12.6	8.9	11.3	3.2	3.3	2.1	5.6	3.9	2.7
January-2012	39.1	12.9	13.1	8.7	4.8	9.7	3.6	4	2.1	2
February	51.2	10.1	9.7	8.7	4	3.5	4.2	3.2	3.1	2.3
March	62.7	9	6.9	4.3	3.2	2.3	2.5	3.1	2.7	3.3
April	48.2	11.2	9.2	6.8	5.1	6.6	3.4	3.1	2.2	4.2
Average	46.7	11.5	10.2	8.5	4.8	4.9	3.3	3.6	2.8	3.7

January 2012 (13.1%) in males and females respectively and minimum proportions were found during April 2012 (6.9%) in males and July 2011 in females (6.7%). Dinoflagellates formed 8.6% of gut contents in males and 8.4% in females. Dinoflagellates were found maximum during July 2011 (12.5%) and minimum during April 2012 (4.1%) in males and in females it was during December 2011 (11.3%) and March 2012 (4.3%) respectively. Zooplankton were found maximum during September 2011 (9.9%) in males and January 2012 (9.7%) in females and minimum (2.3%) was observed in both males (April 2012) and females during July 2011 and March 2012. Zooplankton contributed 5.6% in males and 4.9% in females. Maximum proportions of algae in males and females were found during February 2012 (7.3%) and May 2011 (7.1%) and minimum proportions in males and females were found during October 2011 (3.1%) and December 2011 and March 2012 (3.2%) with an average of 5.2% in males and 4.8% in females.

Percentage of polychaetes in males was found maximum (6.3%) during November 2011 and minimum (2.2%) during February 2012 whereas in females, it was in the range of 2.3% (October 2011) - 5.6% (December 2011) with an average of 3.57% in males and 3.62% in females. Average foraminiferans observed was found to be 3.5% for males and 3.3% for females respectively. Foraminiferans were found maximum during February 2012 (5.9%) in males and during July 2011 in females (4.9%) and were minimum during August 2011 (2.2%) and December 2011 (2.1%) in males and females respectively. Larval forms (2.7% in males and 2.8% in females) were found maximum (3.8%) during November 2011 and February 2012. The minimum (2%) was found during May 2011 in males. In females, larval forms were in the range of 2% (November 2011) - 3.9% (October and December 2011). Food contents which could not be recognised due to the digestive process were

considered as miscellaneous. Miscellaneous item was found maximum (6.1%) during March 2012 and minimum (2%) during September 2011 in males and females and ranged from 2% (January 2012) to 5.6% (July 2011) with an average of 3.6% in males and 3.7% in females.

Feeding intensity: The intensity of feeding for both sexes during different months of the study period is given separately in Tables 3 and 4. The proportion of 'empty' stomachs varied from 7.2% (November 2011) to 19.3% (August 2011) in males and 7.1% (March 2012) to 19.2% (August 2011) in females respectively. The 'trace' condition was in the ranges of 9.2% (December 2011) - 23.2% (January 2012) and 10% (April 2012) - 21.9% (December 2011) in males and females respectively. The '1/4 full' condition in males and in females varied from 9.4% (March 2012) to 23.3% (May 2011) and from 11.5% (November 2011) to 17% (July 2011). The '1/2 full' condition in males and females was in the ranges of 9.5% (January 2012) - 17.5% (June 2011) and 9.4% (September 2011) - 18% (June 2011) respectively. The '3/4 full' condition in males and females respectively ranged from 8.5% (July 2011) to 18.7% (December 2011) and from 12% (October 2011) to 18.7% (April 2012). An average of 18% of the stomach samples in males and 19% in females were full. The incidence of 'full' stomachs was found to be more than 12.6% during all the months with minimum of 12.6% (May 2011) in males and 14% (August 2011) in females. Maximum values were witnessed during November 2011 (22.3%) in males and May 2011 (23%) in females. 'Gorged' stomach in males and females was in the ranges of 4.6% (March 2012) - 14.5% (December 2011) and 4.6% (September 2011) - 14.5% (April 2012) respectively.

Gastrosomatic index (GaSI): GaSI of males and females obtained for each month is given in Tables 5. The index of males was found maximum during May 2011 (8.2%)

Table 3. Percentage of fullness of stomach (feeding intensity) in male *Liza subviridis* during May 2011 - April 2012

Months	Empty	Trace	1/4 full	1/2 full	3/4 full	Full	Gorged
May-2011	12.4	13	23.3	15	12.2	12.6	11.5
June	15.2	16.8	19.2	17.5	9.5	15.6	6.2
July	17.5	17.5	15	16.5	8.5	15.5	9.5
August	19.3	16	13.2	20	9.5	14.5	7.5
September	12.5	18.5	11.2	16.5	13.5	19.5	8.3
October	8.2	11.2	16.5	15.7	14.5	21.5	12.4
November	7.2	11	14.8	14.2	18	22.3	12.5
December	8.4	9.2	18	16.2	18.7	15	14.5
January-2012	12.8	23.2	11.5	9.5	16.5	19.8	6.7
February	13.6	21.9	10.2	13.5	15.4	17.2	7.9
March	13.2	20.3	9.4	16.5	14.5	21.5	4.6
April	14.6	21.5	10.2	14.2	12	21.2	6.4
Average	12.9	16.6	14.4	15.4	13.5	18	9.2

Table 4. Percentage of fullness of stomach (feeding intensity) in female *Liza subviridis* during May 2011 - April 2012

Months	Empty	Trace	¼ full	½ full	¾ full	Full	Gorged
May-2011	12.4	10.2	13.1	16	15.3	23	10
June	13.2	16.2	15.6	18	12.6	15.6	8.8
July	17.5	17.5	17	11.3	13.5	17.2	6
August	19.2	15.5	16.5	13	12.8	14	9
September	13.5	20	16.5	9.4	14.5	21.5	4.6
October	14.7	21.5	14.2	10	12	21.1	6.5
November	13	21	11.5	11.5	16.5	19.8	6.7
December	13.6	21.9	15	10.5	14.1	17	7.9
January-2012	12.5	14.5	16.5	11.5	13.5	19.5	10
February	8	11.3	15.8	16.5	14.5	21.5	12.4
March	7.1	11	14.6	16.8	16	22	12.5
April	8	10	14.6	17.8	18.7	16.4	14.5
Average	12.7	16.1	15.1	13.5	14.5	19.1	9.1

Table 5. Gastrosomatic index of *Liza subviridis* during May 2011 - April 2012

Months	GaSI (%)	
	Male	Female
May-2011	8.2	8.1
June	7.2	7.3
July	7.1	7.9
August	7.6	6.8
September	6.1	6.2
October	5.9	6.3
November	7.6	8.0
December	7.4	7.4
January-2012	6.5	6.5
February	6.3	6.2
March	6.5	6.1
April	8.1	7.7

and minimum in October 2011 (5.9%). Maximum index in females was observed during May 2011 (8.1%) and minimum during March 2012 (6.1%).

Studies on food and feeding habits of *L. subviridis* showed its preference for detritus and sand particles. Detritus and sand dominated the food items during all the months. Next to them *L. subviridis* preferred diatoms, dinoflagellates, algae, zooplankton, polychaetes, foraminiferans, larval forms and miscellaneous items. The diatoms and dinoflagellates identified were *Coscinodiscus* sp., *Navicula* sp., *Nitzschia* sp., *Belleriochea* sp., *Planktonella* sp., *Odontella* sp., *Thalassiothrix* sp., *Skeletonema* sp., *Chaetoceros* sp., *Pleurosigma* sp. and *Ceratium* sp. Zooplankton comprised species such as *Favella*, *Acrocalanus*, *Paracalanus*, *Euterpina* and *Oithona*. Algae such as *Enteromorpha* sp., *Ulva* sp. and *Gracilaria* sp. were commonly observed in the stomach.

It is evident from the present results that both sexes of *L. subviridis* have a proclivity to feed on diatoms, dinoflagellates, zooplankton and algae than any other food item encountered. Like *M. cephalus* (Odum, 1970), *L. subviridis* was also found to be a day time and smart feeder which suckles constantly all over the day. This is clearly evident in the present study as it prefers a wide range of organisms. The grey mullets were reported to be plankton feeders and omnivorous (Das, 1977; Zismann *et al.*, 1975).

Results similar to the present study have been reported by Chan and Chua (1979), Prapaporn *et al.* (1998) in Thachin Estuary, Thailand and Fatema *et al.* (2013) in Merbok Estuary of Peninsular Malaysia. Studies in *Mugil cephalus* also observed preference for diatoms (Tandel *et al.*, 1986; Khan and Fathima, 1994; Rao and Sivani, 1996; Bekova *et al.*, 2013; Rao and Babu, 2013; Modou *et al.*, 2014; Mondal *et al.*, 2015). Blaber (1976) as well as Wijeyratnae and Costa (1990) noticed high proportion of sand in the stomachs of grey mullets. Foraminiferans were also observed in the gut of *L. subviridis* along with the other food items. Brusle (1981) observed the presence of foraminiferans in the gut of mullets besides other organisms. Bapat and Bal (1952) found copepods to constitute the main food of *L. parsia* in Mumbai waters. Foraminiferans, polychaetes, crustaceans, molluscan and miscellaneous items were also recorded by them.

Grey mullets are typically bottom feeders subsisting on decayed organic matter, fresh and decaying algae and diatoms (Jacob and Krishnamurthy, 1948; Pillay, 1953; Bond, 1979; El-Marakby *et al.*, 2006; Mondal *et al.*, 2015). From the results obtained presently it is clear that the food of different size groups of *L. subviridis* largely comprise of decaying matter, sand, diatoms, dinoflagellates and zooplankton.

The occurrence of huge extent of fine sand grains in the gut contents throughout the year indicated that this species browses on the bottom mud ingesting tiny particles of silt along with detritus and other food materials. Wood (1964) proved that tiny particles are extremely wealthier in phosphate and nitrogen than the larger particles rejected by grey mullets. The presence of fine sand particles in the gut of grey mullets has been reported by Odum (1970) who observed that fine particles have significantly higher organic value than the coarser particles. The results of the gut analysis of the present study make it clear that the grey mullets have their stomach gorged with detritus indicating detritus as their favourite food. Evidence on the principal prey organism and the fondness or nutritional overlay between years, classes or varied species dwelling in the similar or comparable environments can be gained through food and feeding studies (Clarke, 1980). The present study expanded the knowledge on relationship between the species and its food items which will be helpful for forecasting the abundance, breeding seasons and exploitation of the stock of *L. subviridis* in Parangipettai waters. The results of the present study provides vital information on the food and feeding biology of *L. subviridis* and forms the benchmark data that will be helpful for future studies on the biology of Indian mullets.

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