Food and feeding Biology of Fish *Epinephelus malabaricus* of Palk Bay and Gulf of Mannar coastal waters

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Abstract:
The present study was distribution, growth; migration and behavior of fishes are all largely dependent on the availability of preferred prey organism. Groupers are one of the most important carnivorous fishes of coral reefs, feeding mainly on the crustaceans and fishes. The present study revealed the feeding biology of Epinephelus malabaricus collected from the mixing zone of Gulf of Mannar and Palk bay coastal waters. The percentage of dietary concentration and feeding intensity was investigated from July 2013 up to June 2015. The results were promising and revealed the information on the food consumption of fishes in the study area and helped to understand the fish's feeding biology, its survival, abundance, migration and reproduction.

Keywords: *Epinephelus malabaricus, feeding, intensity, diet, survival, migration.*

Introduction

The application of scientific knowledge for the development of fishing industry lies in an intimate knowledge on the biology of fishes. Without the information on the life history, habits and behavior of fishes, it is not possible to plan, control and manage the fishery resources in a satisfied manner. The food and feeding habits of fishes is in higher concern for the fishery biologists. The stomach content analyses are said to be an important parameter in the studies on fish biology. Such studies help to gain information on the main prey organisms and the preference or dietary overlap between year classes or different species living in the same or comparable habitats. Such studies allow determining the seasonal and geographical variations in dietary composition to discern the diet rhythm in feeding behavior and to estimate the energy resources and to help in modeling energy flow in marine ecosystem. In addition, the quality and quantity of food is one of the critical determinants, influencing the timing of reproduction, fecundity, age at first maturity and the survival of the larval fish.

Sample collection

The Fishes were collected from the two stations (station 1- Mandapam North Sea [Palk Bay] and stations 2 - Mandapam South Sea (Gulf of Mannar). The Stomachs of grouper *E.malabaricus* was collected from the commercial fishing catches at the Mandapam landing centre. The analysis was done during July 2013- august 2015. A total of 909 specimens (males-201, females-299, juveniles-409) were collected and analyzed. The nature of the stomach content during sampling was observed either as empty or loaded and data was recorded. Samples were preserved in 5% neutral formalin for further analysis. The stomach contents were emptied and examined under microscope. The food items were identified up to the species level wherever possible. The following methods were applied for food and feeding biology.

Feeding Methods

Feeding is one of the important attributes of an organism since the energy needed for other activities. Hence, knowledge on the food consumption of fishes is vital and it generally helps to understand the fish's survival, abundance, migration and reproduction. The feeding habit of fishes forms one of the main investigations in any study on the biology of fishes [1]. Investigations on the food and feeding habits will contribute to the intensive research on the migratory and shoaling habits of pelagic fishes and it is particularly important for a species of high commercial value such as the grouper. Groupers are one of the most important carnivorous fishes of coral reefs, feeding mainly on the crustaceans and fishes (Smith, 1961; Thompson and Munro, 1978). The present observation is based on the analysis of gut contents of grouper collected from Mandapam (Palk Bay) and Gulf of Mannar coastal waters. Tessy (1992) have reported that a juvenile of *E.diacanthus* is a carnivores. James *et al* (1996) have stated that *E. areolatus* is a typical carnivorus macro plankton feeder. Different aspects of the feeding ecology and nutrition have been studied for the different *Palinurus* spiny lobsters, e.g. *P. interruptus* (Castaneda-Fernandez de Lara et al., 2005; Briones-Fourzan et al., 2003), *P. elephas* (Goni et al., 2001), *P. echinatus* (Goes and Lins-Oliviera, 2009) and *P. homarus* (Radhakrishnan and Vivekanandan, 2004). Several researchers and scientists have studied these species for over a decade and a half (Koenig et al. 2007, Felix-Hackradt and Hackradt 2008, Brusher and Schull 2009, Craig et al. 2009, Gerhardinger et al.

2009, Mann et al. 2009, McLeanachan 2009, Murie et al. 2009, Graham et al. 2009, Evers et al. 2009, Cass-Calay and Schmidt 2009). The reports have described the biology, behavior, and population status of groupers.

3.1. Point's method

In the present investigation the points method of Swynnerton and Worthington (1940) were used as reviewed and modified by Kalaiselvam (1990). The points such as 100, 80,60,40,20 and 10 were allotted among the gut contents with due consideration to the size of the organisms as well as their abundance. The points gained by each food item from all the stomach examined were summed up and expressed as percentage of total number of points. This method is essentially a volumetric one and is preferred by many authors since it has the advantage of giving roughly both quantitative and qualitative data without the need for very detailed counts. The stomachs were considered 'gorged' when the stomach expanded fully with packed food, with its wall thin and transparent., 'full' when the stomach was filled with food normally its wall being thick and in tack., '3/4 full' when it was partly in collapsed condition and its wall was thick., the stomach was designated as '1/2 full', 1/4 full' and 'trace' according to the relative condition of the stomach as indicated. The empty stomachs were either found in contracted state or loosely expanded to appear full but empty. The later was considered ' regurgitated stomachs'. In the present study, not only regurgitated stomachs (Daan, 1973) but also the empty stomachs were eliminated while calculating the percentage frequency of occurrence of food items.

The feeding intensity based on the degree of fullness of the stomach of fish was determined. The stomach was allotted points. From 0 to 100 in accordance with its fullness (0=for empty, 10=for trace, 20= for 1/4 full, 40=for 1/2 full, 60=for 3/4 full, 80=for full and 100 = for gorged). The percentage frequency of 'empty' 'trace' '1/4 full', 1/2 full', '3/4 full', 'full' and 'gorged' stomachs were calculated from the total number of fishes examined in each month, and for the sake of convenience, 'gorged', 'full' and '3/4 full' stomachs were clubbed together and designated as actively fed. On the other hand, under moderately fed and poorly fed heading, were included '1/2 full' and '1/4 full' and 'trace' stomachs respectively.

3.2. Preponderance method

Earlier studies followed different methods to study the feeding phenomenon of fishes. The method to be employed for food analysis in fishes must be based on the diet of the fish as suggested by Pillay (1953). The index preponderance method of Natarajan and Jhingran (1961) used by James (1967) for ribbon fishes by Vasudev Pai (1968) for percoid fishes by Ramanathan (1977) for flat fishes, by Venketaramani (1979) for carangids, by Sreenivasan (1979) for *D. dayi* by Sivakumar (1981) for *Thyrassa* spp., Sivakumaran (1991) for Mackerel fishes, by Srinivasan (1992) for Scad fishes was followed in the present study and the formula is:

$$I = vioi / \Sigma vioi \times 100$$

Where, 'vi' - percentage of volume of each food item, 'oi' - percentage of occurrence of each item of food and 'I' - the index

Results

4.1. Food composition

The percentage index of various food items of juveniles, males and females of *E.malabaricus* are given in Table.1and 2. The percentage index for juveniles and adults showed that the Sepia, Squilla, and Gastropods as the preference feed by the animals. Veliger, Copepods and Lucifers were found in fewer amounts. Sixteen types of feed matter were found and after identification they were listed out (Table.3). In both, adults and juveniles, fish crab and prawns were found to be more abundant than other animals.

4.2. Food composition in various months

Index of preponderance was calculated month wise for knowing the feeding behavior of *E.malabaricus* from July 2013 to June 2015 (Table 4&5). The fishes crab, prawn and sepia were found in the gut of the study animal in all the months. The squilla sp was absent in the months of Aug to Oct (2013) and in Nov to Jan (2014/2015). The other food items that were present in the gut region were octopus, gastropods, bivalves' copepods, zoea, veliger, lucifer spp., alima larva fish eggs, fish scales, sand grain and unidentifiable material. Crabs were the dominant food item. Similarly prawn and sepia constituted the other important feeds. Few of the feeding organisms were absent in certain months and few food items were found in trace amounts. Thus results ensure that *E.malabaricus* is a carnivorous macro plankton feeder, feeding generally on squilla and octopus except in some months in which they feed on fishes crab, prawn and sepia.

4.4. Feeding intensity

From the results it can be observed that there was not much variation in the food habits between males and females of *E.malabaricus*. Fishes showed higher index followed by crab, prawn, sepia and squilla in the order of abundance. Other food items like gastropods, bivalves, octopus, copepods, zoea, veliger; lucifer spp, alima larva, fish eggs, fish scales and sand grain were present and showed less index values. Major food of juveniles was fishes and showed an index value

whereas in adults, fishes constituted second important food while crab formed the major food item in *E.malabaricus* Prawn, sepia was found as food in juveniles while other items like squilla gastropods, bivalves, octopus copepods, zoea, veliger, lucifer spp., alima larva, fish egg fish scales and sand grain occurred less. The degree of fullness in stomach for the period, July 2013 to June 2015 is listed in tables 6&7. *E.malabaricus* showed varied feeding intensity from month to month. Fish showed moderately fed stomachs in other months. Difference in the feeding intensity may be due to the environmental factors and also due to the availability of food. It was observed that the feeding intensity was higher in mature fishes than immature fishes.

4.5. Food composition in various size groups

The Index of preponderance of food items in various size groups of *E.malabaricus* are given in Table.8 It was observed that fishes and prawn showed higher percentage of index value in specimens ranging from 50 to 150mm and the value decreased in specimens ranging from 150 to 250mm. It was noted that from the size 250 to 350mm prawn spp was found. Sepia spp were found in all the size groups. The octopus and squilla spp was found is only from 150mm onwards. Gastropods and bivalves were found in some months copepods and veliger were found in all size groups except 650 to 750mm and 850 -950mm only fish scales and sand grain were found in all groups. Zoea, Lucifer spp, Alima larver, and fish eggs were found in some groups. Fishes and crabs showed higher index in different higher size groups (250-350 mm; 650-750 mm).From the results it is explained that smaller size groups of *E.malabaricus* prefer mainly copepods and veliger and large size groups prefer bigger forms like fishes, crab, prawn and sepia. Thus it is evident that smaller size group prefer zooplankton while large size groups fed on macro plankton.

Discussion

The present study revealed that *E.malabaricus* is a carnivorous and macro plankton feeder. The food of *E.malabaricus* was dominated by fishes than crab, prawn and sepia. It indicated that those species were available abundantly throughout the season. It was also found that juveniles preferred microplankton copepods, zoea, lucifer and alima larvae and other crustaceans, while adults fed on mainly fin and shell fishes only. In size groups above 150mm, lucifer spp was also found as food. *E. diacanthus* is a demersel fish in the South West Coast of India, which prefers to life on rocky habitats and as such they are abundant in the Wadge Bank, Quilon Bank and Gulf of Mannar. Here the sea bottom is mostly rocky without crops of rocks farming ideal habitats for grouper.

The qualitative and quantitative analyses of gut contents have shown that crustaceans and fishes were the most preferred food items of *E.malabaricus*. From the information obtained from the fisher folks, the trawl net operation and hook and line operation were in the daytime only and thus the samples collected belonged to the day catch. The different food items obtained from the stomach indicated that the fishes are a bottom feeder, feeding mainly on the active mobile crustaceans like crabs, prawns, squilla and fishes. There was an increase in weight gain and the amount of food taken with an increase in temperature and this indicates faster growth among the Caribbean population compared with those of Florida and Bermuda. Investigation on the food and feeding of large size group fishes of *E.malabaricus* obtained by hook and line was not successful, as the stomach, in most of the fishes brought up from the depths were damaged, or the contents of the stomach were spewed out when the fishes were removed from the hooks. Regurgitating the food and everything of stomachs during hauling up is common phenomenon in demersal fishes. According to Fair Bridge (1951) a large proportion of flat head disgorge their stomach contents when they are brought to surface.

As Smith (1961) observed in other groupers, *E.diacanthus* also swallows its food without chewing it and so it was fairly easy to identify the organisms present in the fish feeds by Sight Job (1940) observed that even the disposition of the mouth of perches like *E.tauvina* is more suited for browsing and pecking off food from the ground. The fish opens its month and dilates the gill covers rapidly draw in a current of water and literally in hales the food (Smith, 1961). Randall (1967) mentioned the food of *E.striatus* as crustaceans. Premalatha (1989) studied the food habits of *E.aereolatus, E.chlorostigma, E.bleekeri* and *E.diacanthus* and reported that the diet composition of *E.aereolatus* was mainly small crustaceans; fish scales and cuttle bones were also met with in them.

Among the adults the feeding intensity was high during maturing stages, but low in mature and spawning individuals and again high in the spent and spent recovering ones. Similar results were also made by Venkatasan (1969). Higher percentage of empty stomach was noticed in mature fisher, suggesting that well developed goods hinder feeding and thus empty stomach occurred during breeding season. Similar observation was also made by Venkataramani (1979) in *Carangoides malabaricus* and *Alepes kalla*. In the present study of *E.malabaricus* consumed size groups the fishes were found in sizes which ranged from 850 to 950 mm size groups. Crabs ranged from 350 to 450mm size groups. Prawns were about 250 to 350mm size groups, sepia and squilla were found in 150 to 650mm size groups respectively.

Conclusion

Although results of this study present some ecological information on the feeding habits of the natural habitat in the study area, more research is needed to draw a more comprehensive pattern of their feeding characteristics based on population dynamics of macro-invertebrates, hydrobiology of the area with similar studies on feeding and habitats *s* in the neighboring areas. Investigations on the food and feeding habits will throw more light on the migratory and shoaling habits of pelagic species of fish and it is particularly important for a species of high commercial value such as the grouper.

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Table: 1. Percentage of feeding intensities of immature and mature fishes in *E.malabaricus*

S.No	Number of specimen	Immature	Mature

	Examined				
		409		500	
1	Actively fed	32.16	-	37.15	-
2	Gorged	-	50.60	-	11.15
3	Full	-	10.38	-	6.50
4	3/4 Full	-	13.02	-	21.23
5	Moderately fed	14.62	-	24.10	-
6	1/4 Full	46.92	20.57	29.37	14.32
7	Trace	-	26.35	-	15.05
8	Empty	6.30	-	10.00	-

Table: 2. Percentage of feeding intensities in relation to intermediates, females and males of *E.malabaricus*

S.No	Sex No.of specimens examined	Intermediates		Females		Males	
		409		299		201	
1	Actively fed	39.99	-	37.29	-	34.24	-
2	3/4 Full	-	14.99	-	18.10	-	16.12
3	Full	-	12.00	-	16.18	-	12.12
4	Gorged	-	13.00	-	3.01	-	6.00
5	Moderately fed	14.23	-	17.15	-	29.28	-
6	1/2 Full	-	14.23	-	17.25	-	29.28
7	Poorly fed	23.55		27.19	-	21.14	-
8	1/4 Full	-	16.30	-	16.10	-	22.12
9	Trace	-	14.75	-	11.04	-	10.02
10	Empty	22.23	-	18.37	-	15.34	-

Table: 3. Percentage of index of various food items in *E.malabaricus*

S.No	Food items	Males	Females	Juveniles
1	Fish	28.02	30.99	28.07
2	Crab	23.27	20.23	17.27
3	Prawn	12.99	11.07	17.07
4	Sepia	9.07	10.27	8.99
5	Squilla	6.21	5.00	4.27
6	Gastropods	6.11	6.41	3.24
7	Bivalves	3.33	3.33	3.99
8	Octopus	4.00	2.11	1.04
9	Copepods	0.14	1.51	3.14
10	Zoea	0.04	0.27	1.30
11	Veliger	0.67	1.05	2.30
12	Lucifer spp.	0.11	0.16	0.99
13	Alima laroa	0.02	0.14	1.24

14	Fish eggs	1.02	1.50	2.54
15	Fish scales	1.54	1.99	2.00
16	Sand grain	0.99	1.30	1.44
17	Unidentified	1.64	2.58	1.21

Table: 4. Percentage of dietary composition of various food items in relation to different months *E.malabaricus* as assessed by point's method (Hynes 1950) in the year of 2013-2014.

S.No.	Food items	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
1.	Fish	24.20	20.23	20.41	25.10	20.21	35.55	20.23	20.41	26.53	26.29	14.22	20.15
2.	Crab	24.51	22.52	20.23	25.22	25.51	25.12	37.10	42.52	18.53	15.00	19.22	25.22
3.	Prawn	15.10	14.22	20.55	18.53	15.52	25.41	19.00	12.52	21.21	32.51	28.21	15.20
4.	Sepia	12.15	15.5	20.61	15.15	16.10	-	12.24	14.07	10.31	-	8.25	18.12
5.	Squilla	2.31	-	-	-	3.33	-	2.00	-	8.20	5.00	8.08	2.99
6.	Gastropods	5.23	1.23	5.53	2.53	4.00	-	5.00	5.00	10.00	8.27	7.50	3.13
7.	Bivalves	5.23	4.22	4.21	5.53	8.15	3.50	-	0.24	0.11	5.11	-	-
8.	Octopus	2.00	10.00	-	-	-	2.07	0.12	0.12	3.03	2.23	-	-
9.	Copepods	4.51	2.10	2.52	3.0	2.65	-	2.10	0.27	0.13	0.30	4.44	2.50
10.	Zoea	-	2.5	-	-	-	1.89	-	-	-	-	-	2.95
11.	Veliger	1.5	0.51	1.86	0.26	0.26	-	-	0.62	-	-	1.24	-
12.	Lucifer spp.	1.35	1.76	-	0.59	-	0.59	-	-	0.96	1.55	-	-
13.	Alima larva	-	1.57	-	1.21	-	0.82	-	-	-	1.22	-	-
14.	Fish eggs	0.59	1.92	-	-	-	2.70	-	0.11	0.28	-	-	-
15.	Fish scales	0.97	0.19	0.79	1.02	-	1.85	-	0.97	2.04	-	2.04	-
16.	Sand grain	0.94	0.24	-	-	0.92	1.89	0.17	-	-	0.63	0.50	1.09
17.	Unidentified	1.41	1.29	3.89	1.87	3.35	1.66	2.20	3.15	4.68	7.89	6.30	8.29

Table: 5. Percentage of dietary composition of various food items in relation to different months *E.malabaricus* as assessed by point's method (Hynes 1950) in the year of 2014-2015.

S.No.	Food items	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
1.	Fish	27.18	22.21	12.53	14.21	26.10	28.20	22.20	24.53	20.41	25.20	37.61	30.62
2.	Crab	36.22	30.00	38.52	25.53	32.60	28.21	30.53	24.61	20.54	15.32	29.99	20.24
3.	Prawn	20.24	15.53	8.22	10.54	5.82	10.54	13.52	11.21	15.99	20.89	10.53	13.99
4.	Sepia	-	13.25	14.23	15.25	15.25	11.25	16.52	18.20	19.20	26.44	9.23	6.49
5.	Squilla	2.27	5.97	2.99	15.09	-	-	-	1.99	5.52-	-	2.23	5.50
6.	Gastropods	-	-	2.25	2.80	-	3.20	2.50	15.21	5.21	-	9.23	6.49
7.	Bivalves	2.52	-	2.25	5.28	5.42	5.23	3.52	7.25	5.52	2.24	-	3.24
8.	Octopus	2.52	-	3.20	-	4.52	3.21	-	2.23	3.21	-	-	2.23
9.	Copepods	1.51	2.99	-	-	2.10	1.99	0.96	-	0.27	-	-	0.11
10.	Zoea	0.31	-	1.21	-	-	-	0.82	-	-	1.22	-	-
11.	Veliger	-	2.12	0.99	0.27	1.99	1.24	-	-	1.48	-	1.15	0.99
12.	Lucifer spp.	-	2.51	1.20	-	1.15	1.15	1.00	-	-	-	1.52	0.27
13.	Alimalarva	1.99	-	-	-	8.9	0.27	0.12	0.15	0.48	1.48	1.29	1.08
14.	Fish eggs	-	2.51	2.12	-	2.15	2.15	1.52	-	1.52	1.53	0.36	1.83
15.	Fish scales	0.63	1.42	1.46	-	-	0.63	1.43	-	-	0.26	-	-
16.	Sand grain	0.31	0.21	0.65	-	0.68	-	1.16	-	1.99	-	0.75	1.26
17.	Unidentified	4.30	2.28	7.90	11.05	1.23	1.49	0.68	4.62	4.18	2.67	4.11	6.95

Table: 6. Percentage of feeding intensities of *E.malabaricus* during different months of the year 2013-2014.

	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
No.of specimen Examined	39	32	32	20	44	23	33	38	30	41	31	39
Gorged	8.23	4.25	7.42	6.52	5.29	5.25	9.99	9.28	7.25	5.52	7.52	8.25
Full	12.25	9.28	7.25	7.23	9.52	6.42	8.27	12.31	10.23	6.23	8.23	7.99
3/4 Full	12.58	12.31	-	5.25	5.28	7.28	10.21	4.25	-	7.23	10.99	12.31
1/2 Full	12.51	15.21	15.21	15.42	8.25	12.73	18.52	15.21	7.52	20.54	10.12	15.29
1/4 Full	15.28	21.25	20.22	20.52	-	18.21	11.00	21.25	18.58	15.44	18.23	12.51
Trace	25.25	28.21	12.52	18.28	32.21	30.31	25.21	28.21	38.00	20.29	20.25	20.25
Empty	15.28	12.52	15.52	20.24	38.25	10.52	28.15	12.52	35.23	18.29	27.55	32.29

Table: 7. Percentage of feeding intensities of *E.malabaricus* during different months of the year 2014-2015.

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
No.of specimen Examined	40	38	44	41	51	40	48	43	34	32	54	42
Gorged	4.52	6.23	-	10.48	6.54	9.48	3.48	12.12	8.15	6.54	5.28	5.29
Full	17.48	-	5.75	12.42	-	8.12	8.25	14.28	15.15	6.12	8.23	5.28
3/4 Full	6.28	5.28	7.54	15.53	5.28	5.28	14.21	7.58	9.41	16.14	10.23	9.52
1/2 Full	5.25	7.51	8.12	10.53	7.94	8.28	12.48	-	8.15	14.42	12.42	8.25
1/4 Full	10.59	10.28	12.23	7.12	10.21	8.50	16.32	10.13	15.12	17.48	16.42	10.99
Trace	25.25	15.25	22.25	25.28	15.18	17.12	27.48	16.32	18.14	28.41	25.20	32.21
Empty	25.24	30.28	22.55	12.24	30.16	22.23	10.52	28.41	2.48	12.41	15.25	28.29

Table: 8. Percentage of dietary composition of various food items in relation to different size (mm) groups of *E.malabaricus* as assessed by point method (Hynes 1950)

Size groups	50-150	150-250	250-350	350-450	450-550	550-650	650-750	750-850	850-950	950-1050
Fish	19.52	16.21	28.15	20.15	20.15	27.27	20.50	22.25	42.25	38.15
Crab	8.15	12.99	20.19	38.20	22.99	32.99	38.20	32.99	22.20	33.99
Prawn	18.15	20.99	28.99	10.20	18.12	10.53	10.50	19.38	10.53	10.53
Sepia	8.23	10.15	15.45	11.12	10.12	16.99	12.23	16.99	15.27	16.20
Squilla	-	14.52	2.27	2.60	1.19	3.00	5.22	-	-	2.21
Gastropods	2.12	3.00	5.99	-	4.20	4.21	3.27	-	-	-
Bivalves	2.14	6.14	4.99	2.15	4.52	2.15	-	-	-	1.27
Octopus	-	1.21	3.27	3.21	3.52	1.27	-	-	-	-
Copepods	6.28	3.25	2.53	1.99	0.27	0.27	0.40	0.34	-	0.64
Zoea	3.52	2.99	-	-	0.41	-	-	-	0.27	-
Veliger	8.99	2.79	1.27	0.27	1.89	0.99	-	0.20	0.54	0.27
Luafer spp.	2.29	2.23	-	-	0.20	-	0.50	-	-	-
Alima larva	5.12	2.53	-	0.66	0.12	-	-	-	-	-
Fish eggs	8.23	4.23	3.21	1.41	3.68	0.44	0.89	-	1.99	-
Fish scales	3.21	3.23	2.23	2.99	2.21	2.04	1.27	0.68	0.99	4.21
Sand grain	5.68	2.33	3.42	3.49	1.99	2.99	2.22	2.21	1.22	2.29
Un identified	2.00	1.20	2.54	1.61	4.42	2.00	4.80	5.00	4.74	2.03