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Feeding Strategies and Diet Composition of Oil Sardine *Sardinella longiceps* Valenciennes 1847 in the Trawl Bycatches off Parangipettai, Southeast Coast of India

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Abstract

The feeding strategies and diet composition of oil sardine, *Sardinella longiceps* caught during January to December 2010 by trawl net off the Parangipettai southeast coast of India was studied in detail. There was a preponderance of empty stomachs in all the months. Diatoms (66.5%) and zooplankton (18.5%) were the major components of the food items. Dinoflagellates (15%) also formed a major part of the stomach content throughout the year. The preferences for diatoms were found to be higher in male fish (40.04%) than in female (38.46%). Copepods were more abundant in male (11.08%) than in female (10.35%). But dinoflagellates were less abundant in male (9.44%) than in female (10.35%). The semi digested matter (41.46%) was higher in male than in female (43.32%). The monthly gastro somatic index ranged from 0.85 to 2.40 in male and 0.89 to 2.42 in female and values were generally higher prior to premonsoon months. It is obvious that composition and preference of food are the same in both sexes.

Introduction

Food forms the basis for all the functional needs of an individual fish as well as the population but it differs considerably based on their food preference. Feeding is one of the main concerns of daily life in fishes and they devote large portion of its energy to searching for food. Feeding and searching for food are factors, which regulate or at least influence the distribution, migration and growth of fish (Papaconstantinou and Caragitsou 1992). Studies on food and feeding habits of fishes help in understanding various aspects of their biology like migration, growth, maturation, spawning and seasonal variation in biochemical composition. Accurate description of the diets and feeding habits provides the basis for understanding the trophic interactions in aquatic food webs (Vander Zanden et al. 2000) and also helps to determine the niche in ecosystem, the

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preferred food items and food spectrum overlapping with that of co-existing fishes (Basudha and Vishwanath 1999).

In the group-wise contribution of world marine fish production, Clupeids occupy top position at an average of approximately 32% of the annual marine fish production. Among the clupeids, the Indian oil sardine, *Sardinella longiceps* Valenciennes 1847 is the most predominant species that forms the mainstay of the pelagic fishes of India and its stock is probably widespread in the Indo-Pacific region (Selvin Pitchaikani and Lipton 2012). Presently, the west coast of India indicates a declining trend compared to an ascending pattern along the east coast of India. The Indian oil sardine, supports a pelagic fishery contributing 2 to 33% of the annual marine fish production in India. The oil sardine fishery is the single largest fishery along the east coast as well as west coast. On the southeast coast, the fishing season is from April to December with peak catches during April-June in the Tamil Nadu coast and July-October along the Andhra coast (Pillai et al. 2003).

Information on the diet composition of *S. longiceps* is fragmentary. As stated by Hornell (1910) the food of the oil sardine from the fish curing yards of the Madras State was reported to be 'mud' but, he described for the first time some of the food constituents of the species. Information about the nature of the food of this fish is available from the works of John and Menon (1942), Chidambaram (1950), Devanesan and Chidambaram (1953) and Dhulkhed (1962). Nair and Subrahmanyam (1955) and Nair (1960) are of the opinion that the diatom, *Fragilaria oceanica* Cleve 1873 is an indicator of the abundance of the Indian oil sardine. Kumar and Balasubrahmanyan (1989) stated that *F. oceanica* was less in the gut of fishes from Parangipettai waters. Recently (Remya et al. 2013) studied seasonal variations in the diet of the Indian oil sardine, *S. longiceps* off Cochin, Kerala. In the present study, an attempt was made to investigate the seasonal fluctuations in the diet composition of the *S. longiceps* from the inshore waters off Parangipettai.

Materials and Methods

A total of 330 samples of oil sardines were obtained from the trawl catches in Parangipettai (Lat. 11^0 24' N; Long. 79^0 46' E) during January to December 2010. Sampling was carried out at monthly intervals during 6.00 to 10.00 am, except during the off-season (from 15^{th} April to 30^{th} May). The samples were brought to the laboratory in ice boxes and preserved in 5% formaldehyde for further analysis. The total length (mm), total weight (g), sex and degree of stomach fullness were recorded. The stomachs were visually classified as full, ¾ full, ½ full, ¼ full, trace and empty depending upon the degree of fullness and the amount of food contained in them. The guts were cut open and the food components were analysed and categorised as diatoms, dinoflagellates, copepods, crustaceans (excluding copepods), tintinnids, fish eggs and detritus. The frequency of occurrence of each food item was calculated following Hynes (1950) as $F_i = 100 * N_i / N$, where F_i is the frequency of occurrence of the i^{th} food item in the sample; N_i = number of stomach in which the i^{th} item was found and N= total number of stomachs (with food) examined. The average intensity of

feeding was evaluated by the points method. Points were assigned as 1.0, 0.75, 0.5, 0.25, 0.10 and 0 for full, ¾ full, ½ full, ¼ full, trace and empty stomachs, respectively (Bapal and Bal 1958). Fishes with stomachs full and ¾ full were considered as active feeders, ½ full as moderate feeders and ¼ full and trace full stomachs as poor feeders following the method used by Rao and Rao (2002).

Gastro somatic index (Ga.S.I.) was calculated using the method adopted by Desai (1970). For this purpose, the following formula was employed:

$$\text{Ga.S.I.} = \frac{\text{Weight of the stomach contents}}{\text{Weight of the fish}} \times 100$$

Results

Sardinella longiceps forms the major part of sardine catches landed by the trawlers along Parangipettai coast, and available throughout the year. The total lengths of the specimens ranged from 141 to 180 mm. Diatoms, dinoflagellates and copepods were commonly observed in the stomach content collected in almost all the seasons in the order of abundance.

Variation in the diet composition in male and female oil sardine

The results of the present study revealed that the food preferences of male and female fishes were similar with variations in the magnitude of different food items consumed. The preferences for diatoms were found to be higher in male fish (40.04%) than in female (38.46%). Copepods were more abundant in male 11.08% than 10.35% in female. But dinoflagellates were less abundant in male 9.44% than in female (10.35%). The semi digested matter constitutes higher 41.46% in male and 43.32% in female (Fig. 1)**.**

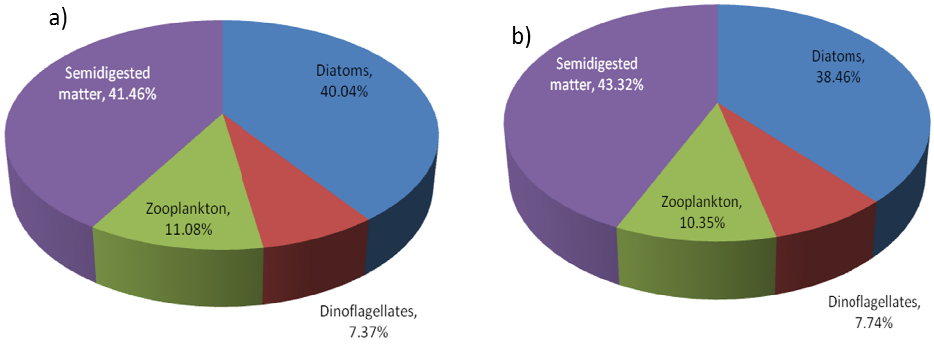

Fig. 1. Percentage composition of (a) male and (b) female fish of *S. longiceps*.

Monthly variation in the diet of male and female oil sardine

Frequency of occurrence of different food items varied in different months according to their availability and preference of fish (Table 1). Diatoms were present in the stomach throughout the year and formed the bulk of the diet in male oil sardine. The highest percentage (48.87%) was recorded in November (monsoon) followed by 48.25% in October (monsoon) and the lowest percentage (33.36%) were recorded in April (summer) in the male. But in the female the highest percentage (43.31%) was recorded in summer (June) followed by 42.89% in postmonsoon (February) and the lowest percentage was 28.21% in premonsoon (September). Among diatoms, *Coscinodiscus* spp. were found throughout the year in the diet of male and female species, with the abundance ranging from 11.4%, in October to 5.36% in April. *Pleurosigma* spp., *Thalassiosira* spp., *Triceratium* spp., *Gyrosigma* sp. and *Chaetoceros* spp. were irregularly found in the diet of male and female *S. longiceps* throughout the year. But *Skeletonema* spp., *Rhizosolenia* sp., *Odontella* spp., *Nitzschia* spp., *Navicula* sp., *Fragilaria* spp., *Eucampia* sp., *Cyclotella* sp., *Bellerochea* sp., *Bacteriastrum* spp. and *Asterionella* sp., were found to be very low.

Table 1. Frequency of occurrence of various food items in males (M) and females (F) of the *S. longiceps*.

	Postmonsoon		**Summer**		**Premonsoon**		**Monsoon**	
Diatoms	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**
Asterionella sp.	1.7	1.3	2.5	1.9	1.9	2.2	0.8	0.7
Bacteriastrum sp	1.5	1.2	0.8	1.5	2.4	2.0	2.2	0.5
Bellerochea malleus	1.8	2.0	2.5	1.7	1.5	1.9	1.6	1.3
Chaetoceros sp	3.3	1.8	0.0	1.3	1.4	1.2	3.0	2.0
Coscinodiscus sp	7.6	7.9	7.5	7.8	6.8	14.1	8.3	5.4
Cyclotella sp	2.1	2.0	1.2	1.6	2.2	0.9	1.5	1.0
Eucampia sp	1.6	1.6	2.0	1.9	2.2	2.6	1.0	1.3
Fragilaria sp	2.2	3.2	1.6	1.9	0.9	1.4	2.7	3.0
Gyrosigma balticum	2.6	1.5	2.2	1.6	2.0	1.0	2.0	2.2
Navicula sp	0.9	2.2	2.9	2.3	1.0	0.6	2.7	1.1
Nitzschia sp	2.9	4.4	0.0	2.4	1.6	3.6	2.0	1.2
Odentella sp		1.7		0.4		1.7		2.6
Pleurosigma sp	3.0	3.6	2.7	5.6	0.8	1.8	2.3	3.8
Rhizosolenia ***sp***	1.5	1.6	1.8	3.4	1.4	0.0	2.8	2.0
Skeletonema sp	1.0	1.9	1.0	1.2	2.5	1.5	2.3	0.8
Thalassiosira sp	2.3	2.4	3.9	3.8	2.2	1.8	1.3	0.9
Triceratium sp	2.5	1.8	2.9	2.2	0.6	1.9	3.3	1.1

Dinoflagellates								
Ceratium sp	2.1	1.6	0.6	2.8	1.8	1.1	1.6	2.5
Dinophysis sp	2.5	1.5	2.1	1.1	1.3	2.3	2.5	1.9
Protoperidinium sp	2.1	0.7	2.6	0.7	2.6	1.8	2.8	2.3
Pyrophagus sp	1.2	1.4	1.2	0.0	2.3	0.6	2.1	1.0
Prorocentrum micans	2.4	1.9	2.6	3.0	0.5	1.9	0.9	1.1
Copepods								
Copepods nauplii	2.5	2.6	2.6	2.1	2.4	1.5	1.9	2.3
Acartia sp	0.3	1.4	1.2	2.0	2.3	2.1	1.6	2.6
Oithona sp	2.6	0.7	0.0	1.0	0.0	0.8	1.0	1.4
Tintinnopsis sp	0.9	1.8	2.4	2.5	1.9	1.3	2.6	1.0
Microsetella sp	2.0	0.8	1.2	0.8	1.2	1.4	1.8	0.6
Euterpina acutiforns	1.9	1.5	1.2	0.9	0.9	0.6	1.8	1.9
Mysis larvae	1.8	0.4	0.7	2.7	1.1	1.9	1.7	1.7
Digested matter	41.9	41.6	47.6	37.9	52.0	46.9	40.1	45.1

Dinoflagellates were also present in the stomach throughout the year in male and female fish. *Protoperidinium* sp., was the most dominant species of dinoflagellates and ranged from 0.29% in February (postmonsoon) to 3.73% in January (postmonsoon). *Dinophysis* sp., *Ceratium* spp., *Dinophysis* sp., *Protoperidinium* spp., *Pyrophagus* sp. and *Prorocentrum micans* were also found in the gut of *S. longiceps*.

Zooplankton occupied second place in the diet of male *S. longiceps.* The monthly percentage composition of the occurrence of copepods varied from 1.11% in postmonsoon (February) and 3.96% in summer (March) in male, but in female, 1.23% in monsoon (November) and 3.12% in postmonsoon (January). *Acartia* spp., varied between 1.11% (July) and 4.03% (April), *Tintinopsis* spp., between 1.23% (January) and 3.21% (June), *Oithona* spp., between 0.29% (December) and 2.36% (July), *Microsetella* sp between 1.14% (July) and 1.78% (October), and *Euterpina* sp., between 1.13% (December) and 2.96% (November).The monthly percentage occurrence of *Mysis* larvae varied between 1.02% in summer (March) and 2.34% in premonsoon (July) in male and female.

Semi-digested matter was also found throughout the year of male fishes. It fluctuated between 31.08% in monsoon (November) and 51.35% in premonsoon (August) with an average value of 41.46% of total food composition. Similarly, the semi-digested matter fluctuated between 37.77% in summer (March) and 52.52% in premonsoon (September) with an average value of 43.32% of total food composition in female.

Feeding intensity in relation to male and female

A high percentage of males have 'active' stomachs during October. Fish with '¾ full' stomach were not found during January and November, but in December 39.34% had '¾ full' stomachs. Predominance of 'moderate' stomachs was observed throughout the year with dominance in June-September with a high percentage in September (57.23%). 'Poor' stomachs were encountered throughout the year with dominance in January (64.83%). Empty stomachs were lacking in January, February, June and September and with raised percentage in April (16.47%) (Fig.2).

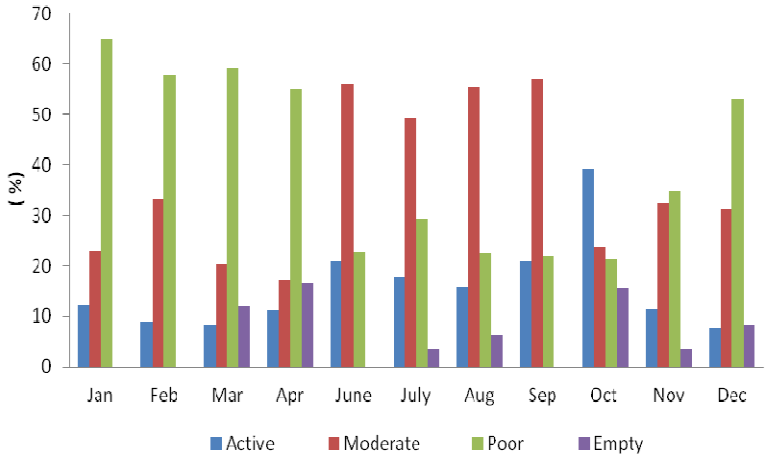

Fig. 2. Monthly variation of feeding intensity (% in Numbers) in male *S. longiceps*

Female fish with lowest percentage of 'active' stomachs was observed in October and highest percentage (23%) was observed in June. Prevalence of '¾ full' stomachs was recorded during February to August, November and December with the maximum percentage in June (20.27%). Fish with 'moderate' stomachs were observed during all the months with dominance in September (66.94%) and low in April (15.21%). Highest percentage occurrences of 'poor' stomachs were noticed in October (67.74%) while it was slight in December (16. 63%). Fishes with empty guts were observed in the month of January to September and December with the maximum percentage in March (16.43%) (Fig. 3).

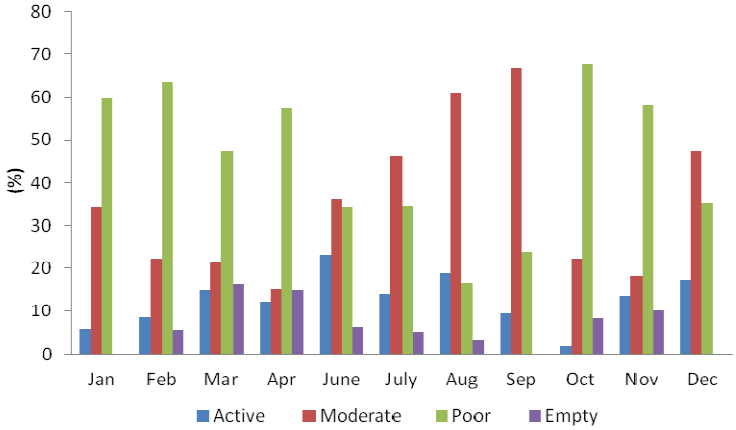

Fig. 3. Monthly variation of feeding intensity (% in Numbers) in female *S. longiceps*.

Gastro-Somatic Index (Ga.S.I)

Monthly fluctuations in gastro-somatic index of male and female *S. longiceps* during January-December 2010 are shown in Fig 4. The pattern of variation was significantly different in males and females during the months. The Ga.S.I values gradually increased from April to September. In male maximum Ga.S.I was observed in September (premonsoon) at 2.34% and minimum in January (postmonsoon) at 0.85%. In female the maximum Ga.S.I value of 2.42% was observed during September (premonsoon) and minimum was 0.89% recorded during January (postmonsoon).

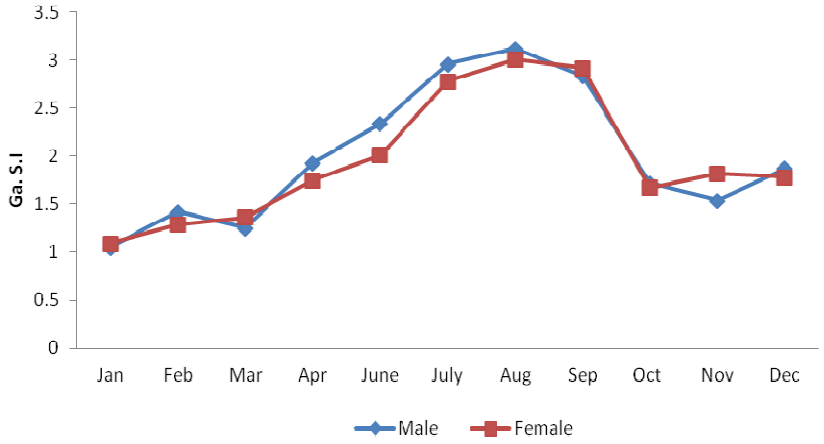

Fig. 4. Monthly variation of gastro-somatic index in male and female *S. longiceps*.

Discussion

Knowledge on the feeding regimes of fish species is of great importance in understanding their ecological interaction (Alberto et al. 2003). The length of the intestine of the fish depends upon the feeding habits. Carnivorous fishes normally have short and more or less straight intestine. This is because meat gets digested more easily (Pandey and Shukla 2005; Serajuddin and Ali 2005), whereas in herbivorous fishes, the intestine is long and highly coiled because plant food items take more time to get digested. The intermediate condition is found in omnivores. Since, *S. longiceps* possesses a long and highly coiled intestine it can be classified as a herbivorous fish.

In the present study, *S. longiceps* shows preference of feeding exclusively on planktonic diatoms in the pelagic regions. This observation is similar to the findings reported in Trivandrum (John and Menon 1942), Calicut (Venkataraman 1961), Mangalore (Dhulkhed 1964), Karwar (Noble 1969) and Parangipettai (Kumar and Balasubrahmanyan 1989). The analysis of stomach content of *S. longiceps* from Parangipettai coast revealed that this species consumed a variety of food items in this region. Diatoms including *Coscinodiscus* spp, *Biddulphia* spp, *Thalassiosira* spp, *Nitzschia* spp and *Pleurosigma* spp were found to be the favorite food items of oil sardine based on

the frequency of occurrence in the present study. Dinoflagellates formed the second most important food of *S. longiceps.* This is in agreement with the findings of Dhulkhed (1962) and Kagwade (1964).

Among the different species of diatoms found in the diet of the oil sardine, *F. oceanica* formed the most important constituent and they found the existence of a significant correlation between the occurrence of this diatom and the oil-sardine. However, in the present study the annual average abundance of *F. oceanica* was 1.88% in male and 2.4% in female gut contents of *S. longiceps* at Parangipettai waters. But Kumar and Balasubrahmanyan (1989) reported previously *F. oceanica* were less in the gut contents of *S. longiceps* at Parangipettai waters.

Oil sardines near Parangipettai were seldom found to abstain from feeding. Digested foods were present in almost all the guts examined. The presence of considerable quantities of semi digested matter might be due to the rapid digestion that takes place in the tropical waters and the metabolic rate is high (Kalita and Jayabalan 2000). Usually they feed at the surface as evidenced by their planktonic stomach contents. Occasionally they appear to feed at the bottom, in which case their guts were almost filled with silt and sand. However, occurrence of sand alone need not necessarily imply bottom feeding as concluded by Devanesan (1943).

From the present findings it is noted that the food and feeding habits of *S. longiceps* is the same in both the sexes, but there was conspicuous variance in the percentage of occurrence of different food items. Monthly variation in the gut contents confirmed that both the sexes have identical feeding habits, consuming the same food items, but with slight variation in the magnitude. It could be inferred that the major portion of the diet comprised of diatoms, dinoflagellates and copepods almost throughout the period of investigation. There was slight variation in the diet of *S. longiceps* in relation to season.

Fishes with heavily fed (full and ¾ full), moderately fed (1/2 full), poorly fed (1/4 full and trace) and empty stomachs were observed during most of the months. The empty stomach and stomach fullness indices are very important to assess the feeding intensity (Shanti Prabha and Manjulatha 2008). Feeding intensity is negatively related to the percentage of empty stomachs (Bowman and Bowman 1980). Feeding intensity is more in female when compared to male, which are indicative of poor feeding. The feeding intensity of a fish is related to its stage of maturity, reproductive state and the availability of food items in its environment (Maddock and Burton 1999; Sivakami 1996; Kiran and Puttaiah 2004). Breeding periodicity was found to have profound influence on the feeding rate in *S. longicceps.* Most active feeding period was found in the gonad maturing and ripening stages, which is the second and the third stage of the cycle. This suggests that, at this stage, the fish feeds more voraciously because of higher energy demand associated with gonad development (Roja Sebastian 2011). Feeding intensity was found to be less during the pre spawning and spawning periods in female as indicated by the low degrees of fullness. Low feeding activity was observed during October to March. Just after spawning, from April onwards, when the

largest number of spent individuals was encountered and the feeding intensity increased considerably. High feeding intensity observed during June – September might be attributed to increased feeding activity to meet the demand for more energy in spawning season. Observations based on high feeding intensity in spent fish may be suggestive of high food requirements for building up of the gonads. In male, feeding activity pattern followed almost similar to that of female. Feeding activity was very low in January and high during July-September. High feeding activity pointed to the extra requirements of energy and low feeding to the exhaustion caused by spawning. The low pre-spawning feeding intensity seen might be ascribed to the matured gonads, permitting limited space in the abdominal cavity for intake of food. The occurrence of poor feeding coincident with peak breeding in other fishes has been reported by Bhuiyan et al. (2006). According to Kiran and Puttaiah (2004), other reasons for empty stomachs are regurgitation, periodicities in feeding, availability of food, digestibility, physiological reasons, health factor and low metabolic activity.

The stomach fullness, was high in the active feeder and low in the poor feeder, this result was in agreement with Ebtisam Faisal (2008). The feeding activity of *S. longiceps* was found to fluctuate with season as well as maturity stages. The intensity of feeding was high during the pre-monsoon (July - September). It may be related to food abundance during this season and to the predominance of immature and maturing fishes which feed actively.

Gastro-somatic index indicated higher feeding intensity in immature and juvenile fishes than the mature ones. This may be attributed to the very high food requirements in the young and fast growing fish (Armstrong et al. 1992; Sivakami 1996). Small-sized fish feed actively and more frequently than larger ones. This phenomenon has been recorded in majority of fish species (Nikolsky 1963). The variations in the feeding intensity of both sexes of the fish were observed to be the same. However, male consumed more food than female. Higher feeding intensity in male compared to female has been reported by Khumar and Sddiqui (1989) in *Labeo calbasu* (Hamilton 1822) and Rao and Rao (1991) in *Nemipterus japonicus* (Bloch 1791). This might be due to the fact that female fish experienced more physiological stress than male fish during the spawning period. Maximum feeding intensity was observed in both sexes in maturing stage (III), as they approached the size at first maturity. Similar result was reported by Serajuddin and Ali (2005) in *Macrognathus pancalus* Hamilton 1822.

Conclusion

The present study indicated that *S. longiceps* exhibited stenophagism by selecting a few types of food in their diet despite the presence of a large number of prey types in the habitat. The results revealed that the fish is a “herbivorous-stenophagic-surface feeder”. It is obvious that composition and preference of food are the same in both sexes. But observations on the average amount of feeding in both sexes showed that the male fish exhibit a little higher feeding intensity than female.

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