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FEEDING HABITS OF DIFFERENT FISH SPECIES IN NEGOMBO LAGOON

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Abstract

To investigate the feeding habits of different fish species in Negombo lagoon, fish species were collected from Kadolkele and Liyanagemulla sites during February 2015 to July 2015 using a drag net. Collected specimens were preserved in 5% formalin. Later, the fish specimens were dissected, and stomach contents were mixed with water to make a suspension. One ml of suspension was added to the Sedgewick Rafter cell, and examined under the light microscope. The occurrence %, volume %, numbers %, and the Relative Importance Values (RIV) were calculated. The gut contents of 62 samples from 12 fish species were analyzed; 11 species were found to feed on mangroves, 10 on seagrasses, and 8 on filamentous algae. 13 food items were identified. Most of the analysed fish were categorized as omnivores and opportunistic feeders. The juvenile fish mainly feed on a combination of mangroves, seagrasses and filamentous algae. Apart from plant matter, the juvenile fish were found to feed upon *Cyclops* sp. and mysids. Although *Hemirhamphus marginatus* is an omnivore, it specially fed on mangroves, seagrasses and filamentous algae. Furthermore, *H. marginatus* consumed common food items in both habitats except mangroves and molluscs, and the shifting of its diet was depended on the availability of food. The broadest niche breadth was recorded by *H. marginatus* and the shortest niche breadth by the herbivorous fish species, *Siganus vermiculatus* and *Liza macrolepis*. *Caranx sexfasciatus* exhibited an ontogenetic shift in their diet. The smaller *C. sexfasciatus* was a carnivore and the larger individuals of the same species were herbivores.

Key words: Feeding habits, Juvenile fish, Mangroves, Seagrasses, Negombo lagoon.

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Introduction

Estuaries and lagoons are among the most productive ecosystems in the world. Negombo lagoon is a highly productive ecosystem in Sri Lanka. Mangroves are the main vegetation type bordering the Negombo lagoon and seagrasses are submerged in it. These ecosystems provide diverse habitats for commercially important fish and crustaceans. Many species of fish utilize mangrove and seagrass areas as feeding or nursery sites (Sasekumar, 1984; Pinto and Punchihewa, 1996) and this vegetation constantly supplies the coastal waters with nutrients. However, estuaries and lagoon are highly dynamic ecosystems that are very vulnerable both to natural and anthropogenic disturbances.

The food and feeding habits of fish species are closely associated with their ecological environment. Stomach content analysis of fish provides important details about their feeding patterns and this allows us to understand their feeding strategy (Lagler, 1949). However, it is difficult to identify all the contents in the stomach and clearly separate the organisms into prey categories for quantification due to the presence of unidentifiable and inseparable partially digested material (Baker, 2014).

Generalized food preferences were often associated with early growth stages but as the fish matured, various populations were more specialized in their feeding habits (Livingston, 1982). A study of Cross River Estuary, Nigeria showed that feeding habits of fish species vary with age and the stage of development (Ajah, 2012). Both juvenile and sub adult stages of *Citharinus latus* fed on phytoplankton with the diet of the adult stage being planktonic. *Ethmalosa fimbriata* was omnivorous at the juvenile stage, monophagus (phytoplanktonic) at the sub-adult stage and planktonic at adult stage (Ajah, 2012). However, *Hepsetus odoe* was found to be carnivorous at both the juvenile and adult stages but tilted towards omnivory at sub adult stage. *Trichiurus lepturus* was carnivorous at all three stages (Ajah, 2012).

Morphologically similar closely related species in a fish community utilize the same food resources and habitats for their co-existence (Costa and Fernando, 1967). The gut content of mullet species *Valamugil buchanani* and *Liza subviridis* from Merbok estuary in Malaysia, showed that both species fed on plant and animal materials (Kaniz, et al, 2013). However, plant materials were the most abundant food items of both fish species.

The gut analysis of 34 fish species collected from mangrove and seagrass areas in the Negombo lagoon, revealed that feeding habits vary among them, with the ratio of herbivore: carnivore: omnivore being 4:9:21 (Pinto and Punchihewa, 1996). Most of the cohabitating fish species in the Negombo lagoon feed on different food items, resulting in ecological segregation (Shirantha and Wijeyaratne, 2002). However, the food items of 10 species of fish showed that amongst them a high dietary overlap was evident.

The study on the food and feeding habits of *Scatophagus argus* in Cochin Estuary, India (Sivan and Radhakrishnan, 2011), revealed that algae and detritus dominated the diet. Furthermore, it was evident that the flexibility in their feeding ecology and food selection was based on the relative abundance of prey and also an ontogenetic shift in diet.

The high ecological productivity of mangroves provides facilities for the continuation of food chains throughout brackish water ecosystems (Saenger et al., 1983). Furthermore, it is estimated that up to 80 % of the global fish catch is directly or indirectly dependent on mangroves. In Negombo lagoon, mangroves are fast disappearing due to human population expansion, development projects and industrial pressure.

The purpose of this study is to provide detailed information on the feeding relationships of fish species living in two different areas, a mangrove area and an area cleared of mangrove. Therefore, considering the economic and ecological significance of fish in brackish waters, present investigation would further advance the understanding of their feeding relationships with respect to their habitats. The main objective of this study is to determine the type of food consumed by different fish species and their corresponding habitat relationships. The study further aims to determine whether diet variations occur within the same species with different age groups or fish lengths.

Methodology

Fish specimens were collected from two different sites Kadolkele and Liyanagemulla, in Negombo lagoon (Fig. 1). The Kadolkele site is a mangrove area located in the upper part of the lagoon and the other site, Liyanagemulla is without mangrove vegetation and is located in the mid lagoon area close to Katunayake highway.

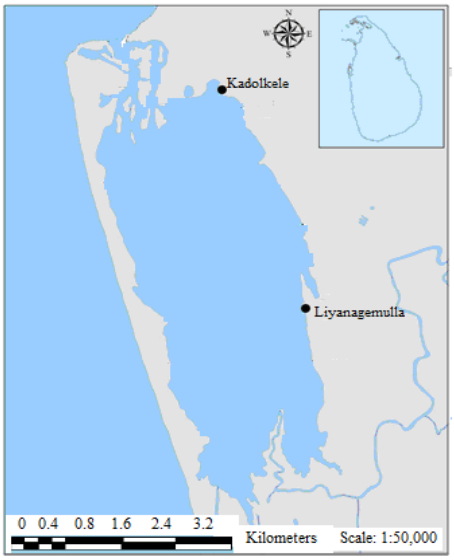

Figure 1: Study sites, Negombo lagoon

Fish samples were collected using a drag net of mesh size 0.9 cm, in each month, starting from February to July 2015. The net was dragged along 100 m length. Samples were preserved immediately in 5 % formalin to inhibit the enzymatic activities of the gut contents to prevent any further digestion.

The length of each individual of fish specimen was measured using a standard measuring tape. By dissecting each fish specimen, the gut contents were taken out carefully and mixed with 10 ml water to prepare a suspension. 1 ml of suspension was added to the Sedgewick Rafter cell and examined under the light microscope using the eyepiece micrometer. The sample of the gut contents were observed in 20 squares. Three replicates were

trialed up to sixty squares per specimen. Percentage occurrence (F %), percentage volume (V %), percentage of numbers (N %), and finally Relative Importance Values (RIV) (Hyslop, 1980) were calculated for each fish species where more than two individuals were captured.

Percentage of occurrence (F %) = $\frac{\text{The number of stomachs which a given food item is found}}{\text{The number of stomachs examined}} \times 100\ \%$

Percentage of number (N %) = $\frac{\text{The number of stomachs which a given food item is found}}{\text{The number of total food item in all specimens}} \times 100\ \%$

Percentage of volume (V %) = $\frac{\text{The volume of one food item found in all specimens}}{\text{The volume of all food items in all specimens}} \times 100\ \%$

Relative Importance value (RIV) = (N% + V %) x F%

The niche breadth of each species was calculated based on Levins measure of niche breadth, Levins Index (B), where p_i is the proportion of food items. The counts of the number of food items used by each individual of fish species was considered.

$$B = 1 / \sum p_i^2$$

Results

Among the 12 different species of fish, Liza *dussumier*, *Leiognathos brevirostis* and *Eleotris fusca* were recorded with only one individual from the mangrove site. Due to a fewer number of individuals, their gut content analyses were calculated as percentage volume of food items present in the gut (Table 1). Accordingly, *L. brevirostis* and *E. fusca* mainly fed on *Cyclops* sp. (42 % & 48 % respectively), while *L. dussumier* fed mainly on animal matter. All of them fed on mangroves and seagrass with the exception of *E. fusca* which fed on mangroves but not seagrass. All three species seem to be omnivorous.

Table 1: The percentage volume of food items contained in the stomachs of some fish species.

	Length (cm)	Percentage volume of food items							
Species		Sg	Mg	Fa	Cy	Uap	Dt	My	Dp
Liza dussumier	4.25	13	-	4	18	45	-	11	9
Leiognathos brevirostis	4.80	38	8	-	42	4	8	-	-
Eleotris fusca	4.30	-	15	-	48	11	11	15	-

Sg = Sea grass, Mg = Mangroves, Fa = Filamentous algae, Cy = *Cyclops*, Uap = Unidentified animal parts, Dt = Detritus, MY = Mysids, Dp = *Daphnia* sp.

Atherinomorus duodecimalis and *Oryzias melastigma* were captured only from a mangrove area, and were found to feed upon seven different food types (Table 2). They commonly feed on plant matter (mangroves, sea grasses and filamentous algae), *Cyclops* sp. and detritus. All individuals (F %) of *A. duodecimalis*, depend

mainly on *Cyclops* sp., mangroves and mysids. *Cyclops* sp. had the highest importance value (RIV), followed by mangroves and mysids. All ten individuals of *O. melastigma* fed on detritus and eight fed on *Cyclops* sp. and seagrasses (F %). However, *Cyclops* sp. was the most important (RI value) food item, followed by seagrasses and detritus. Both species showed omnivorous feeding habits.

Table 2: Gut content analysis of *A. duodecimalis* and *O. melastigma*

	Atherinomorus duodecimalis (N=10, Length 1.2-1.7cm)				*Oryzias melastigma* (N=10, Length 2.25-3.05cm)			
Food type	F %	N %	V %	RIV	F %	N %	V %	RIV
Seagrasses	40	42.85	8.64	2060	80	50	41.56	7325
Mangroves	100	71.42	36.65	10807	20	12.5	6.48	380
Cyclops sp.	100	71.42	52.29	12371	80	50	23.33	5866
Filamentous algae	20	14.28	1.16	309	40	25	2.93	1117
Detritus	40	42.85	6.64	1980	100	2.5	45.50	4800
Diatoms	-	-	-	-	60	37.5	18	3330
Molluscs	-	-	-	-	20	12.5	0.002	250
unidentified animal parts	40	57.14	3.59	2429	-	-	-	-
Mysid	100	71.42	6.34	7776	-	-	-	-

F%-Percentage occurrence, N%-Percentage number, V%-Percentage volume, RIV-Index of relative importance, N-Number of individuals

Parambassis dayi and *Ambassis urotaenia* were captured only from the mangrove area and fed on both plant and animal matter (Table 3), therefore appearing to be omnivores. However, the most important food items of *A. urotaenia* (RI value) were mangroves, filamentous algae and seagrasses, and only one individual recorded animal matter. Therefore, their diet showed preference towards herbivory while *P. dayi* showed a greater dietary emphasis towards animal matter.

Table 3: Gut content analysis of *P. dayi* and *A. urotaenia*.

	Parambassis dayi (N=6)				*Ambassis urotaenia* (N=3)			
Food Type	F%	N%	V%	RIV	F%	N%	V%	RIV
Cyclops sp.	100.00	85.71	99.00	18471.00	33.33	20	0.056	668.46
Diaptomus sp.	83.33	71.42	2.27	6140.58	-	-	-	-
Daphnia sp.	50.00	42.85	0.09	2174.00	-	-	-	-
Diaphanosoma sp.	16.66	14.28	14.28	475.80	-	-	-	-
Seagrasses	33.33	28.75	0.03	959.23	66.66	40	29.42	4627.53
Mangroves	33.33	28.75	0.05	959.90	66.66	40	99.37	9290.40
Detritus	33.33	28.75	0.49	959.87				
Filamentous algae	-	-	-	-	100.00	60	0.14	6004.00
Unidentified animal parts	-	-	-	-	33.33	20	0.12	666.99

F%-Percentage occurrence, N%-Percentage number, V%-Percentage volume, RIV-Index of relative importance, N-Number of individuals

Siganus vermiculatus and *L. macrolepis* fed on plant matter (seagrasses, filamentous algae and mangroves) and detritus, therefore appearing to be herbivores. All individuals of both species fed on seagrasses and detritus (F %). The most important food items (RIV) of *S. vermiculatus* were seagrasses, detritus and mangroves while *L. macrolepis* showed a

similar importance but instead of mangroves, the filamentous algae showed more importance (Table 4). Both species were captured only from the mangrove area.

Table 4: Gut content analysis of *S. vermiculatus* and *L. macrolepis*.

	Siganus vermiculatus 2.1-2.7(N=4)				*Liza macrolepis* 3.4-5.3 (N=3)			
Food type	F %	N %	V %	RIV	F %	N %	V %	RIV
Seagrasses	100	100	98.63	19863	100	75	74.73	14974
Filamentous algae	25	25	0.02	626	66.66	50	1.66	3444
Detritus	100	100	0.6	10060	100	75	20.97	9599
Mangroves	25	25	0.75	2518	33.33	25	2.26	909

F%-Percentage occurrence, N%-Percentage number, V%-Percentage volume , RIV - relative importance value, N-Number of individuals

Analysis of individuals captured from different areas

Hemirhamphus marginatus was the only fish species captured from both areas. The individuals collected from the mangrove site fed on a variety of food items; seagrasses, mangroves, molluscs, *Cyclops* sp., *Daphnia* sp., *Diaphanosoma* sp., filamentous algae, diatoms (*T. nitzschioides* & *C. pelagica*) and mysids (Table 5). All individuals from the mangrove site fed on filamentous algae, mangroves, and *Cyclops* (F %) and the most important (RIV) food items were seagrasses, mangroves and *Cyclops*. The individuals collected from the mangrove cleared site fed on same food items (as the mangrove site) except on mangroves and molluscs. Among the 10 individuals, nine fed on diatoms and detritus, eight fed on *Cyclops* sp., diatoms and mysids; revealing the most important food items (IRI) to be *Cyclops* sp., seagrasses and detritus. The results of both sites showed that *H. marginatus* is an omnivore (Table 5).

Table 5: Gut content analysis of *H. marginatus* collected from mangrove site, and mangroves cleared site.

	Mangrove site (N=5)				Mangrove cleared site (N=10)			
Food type	F%	N%	V %	RIV	F%	N%	V %	RIV
Seagrasses	80	40	88.59	10287.25	70	77.77	98.95	12370.49
Mangroves	100	100	0.79	10079.48	-	-	-	-
Filamentous algae	100	50	1.59	5159.66	70	77.77	.0009	5443.95
Cyclops sp.	100	50	0.99	5099.23	80	88.88	0.02	7112.00
Daphnia sp.	80	40	3.57	3486.26	30	33.33	0.05	1001.64
Diaphanosoma sp.	80	40	3.77	3501.66	20	22.22	0.01	444.63
Diatom(*T. nitzschioides*)	80	40	0.19	3215.87	80	88.88	0.05	7114.40
Diatom (*C. pelagica*)	40	20	0.47	818.85	90	100	0.10	9009.13
Molluscs	20	10	0.49	209.92				
Mysids	20	10	0.01	200.24	80	88.88	0.06	7115.11
Detritus	-	-	-	-	90	100.00	0.76	9060.86

F%-Percentage occurrence, N%-Percentage number, V%-Percentage volume, RIV -Index of relative importance, N-Number of individuals

Analysis of different size (length) of fish

Hemirhamphus marginatus individuals that were captured from the mangrove cleared site were categorized under different length ranges; 5.5-6.9 cm (as small) and 12.05-16.05 cm (as large). Analysis revealed that small fish depend on seven different food types while large fish depend on nine food types (Table 6). Among

them, the common food types are seagrasses, *Cyclops* sp., diatoms, mysids, filamentous algae and detritus. The large fish fed on *Daphnia* sp. and *Diaphanosoma* sp. but the small fish did not consume these food items, which are the main difference in food items between them. The majority of small fish consumed the diatom *Cerataulina pelagica* and detritus, while all large fish fed on *Thalassionema nitzschioides, Cyclops* sp., filamentous algae and detritus. The most important food item (RIV) for small fish was *C. pelagica* while for large fish, it was seagrasses. All individuals showed a common omnivorous food habit.

Table 6: Gut content analysis of *H. marginatus* with different length ranges captured from mangrove cleared area.

Food type	Small size (5.50-6.10cm), (N=4)				Large size (16.70-14.90cm), (N=6)			
	F %	N %	V %	RIV	F %	N %	V %	RIV
Seagrasses	50	28.57	7.12	1784.84	83.33	55.55	96.86	12700.1
Cyclops sp.	50	28.57	3.70	1598.90	100	66.66	0.07	6672.95
Diatom (*T. nitzschioides*)	50	28.27	0.02	1414.61	100	66.66	0.004	6666.40
Diatom (*C. pelagica*)	100	57.14	5.29	6243.51	50	33.33	0.089	1670.94
Mysids	25	14.28	4.60	472.03	16.66	11.11	0.003	185.13
Filamentous algae	25	14.28	0.14	360.70	100	66.66	0.004	6666.44
Detritus	100	57.14	9.15	6629.00	100	66.66	0.759	6741.92
Daphnia sp.	-	-	-	-	50	33.33	0.012	1667.10
Diphasoma	-	-	-	-	50	33.33	0.017	1667.36

F%-Percentage occurrence, N%-Percentage number, V%-Percentage volume, RIV-Index of relative importance, N-Number of individuals

Zenarchopterus dispar was collected only from the mangrove site with differing sizes of individuals being clearly observed. The smaller *Z. dispar* depends on a variety of food items; mainly all fed on detritus, seagrasses, mangroves, *Cyclops* sp., *Daphnia* sp. and filamentous algae. Detritus had the highest importance value (IRI) followed by seagrasses. The adult individuals mainly consumed detritus and seagrass (Table 7). Both the adult and smaller fishes commonly fed on plant matter (filamentous algae & seagrass), animal matter (*Cyclops* sp. & *Daphnia* sp.) and detritus. Therefore, both the adult and juvenile *Z. dispar* are omnivores.

Table 7: Gut content analysis of juvenile and adult *Z. dispar*

Length of small fish 3.45 cm, 4.25 cm, 4.95 cm (N = 3),					Adult fish length 16.15 cm (N = 1)
Food Type	F%	N%	V%	RIV	Percentage volume of food item
Seagrasses	100.00	33.33	11.67	4500.00	18.85
Mangroves	100.00	33.33	6.50	3983.00	-
Cyclops sp.	100.00	33.33	8.81	4221.00	4.59
Daphnia sp.	100.00	33.33	10.44	4377.00	1.47
Diaptomus sp.	33.33	11.11	2.25	445,28	-
Mysids	66.66	22.22	11.04	2217.11	-
Detritus	100.00	33.33	49.55	8288.00	63.28
Filamentous algae	100.00	33.33	5.79	3912.00	7.75
Unidentified animal parts	100.00	33.33	8.53	4186.00	4.56

F%-Percentage occurrence, N%-Percentage number, V%-Percentage volume, IRI-Index of relative importance, N-Number of individuals

Two individuals of *Caranx sexfasciatus* were captured from mangrove area and showed two different lengths (4.95 cm & 10.05 cm). Due to fewer numbers of individuals, their gut content analysis was performed according to percentage volume of the food items. Both commonly fed on detritus (Table 8). Other than that, the small fish fed on *Cyclops* sp. and mysids, and the larger fish fed on mangroves and seagrasses. The smaller fish highly depend on mysids while larger fish highly depend on detritus. According to the analysis smaller *C. sexfasciatus* is a carnivore and the larger individual is a herbivore.

Table 8: The percentage volume of food items contained in the guts of *Caranx sexfasciatus*

Food Type	Percentage volume of food items	
	Small individual (4.95 cm)	Large individual (10 .05 cm)
Seagrasses	-	9.63
Mangroves	-	10.53
Filamentous algae		20.24
Detritus	11.41	59.59
Cyclops sp.	11.96	-
Mysids	76.63	-

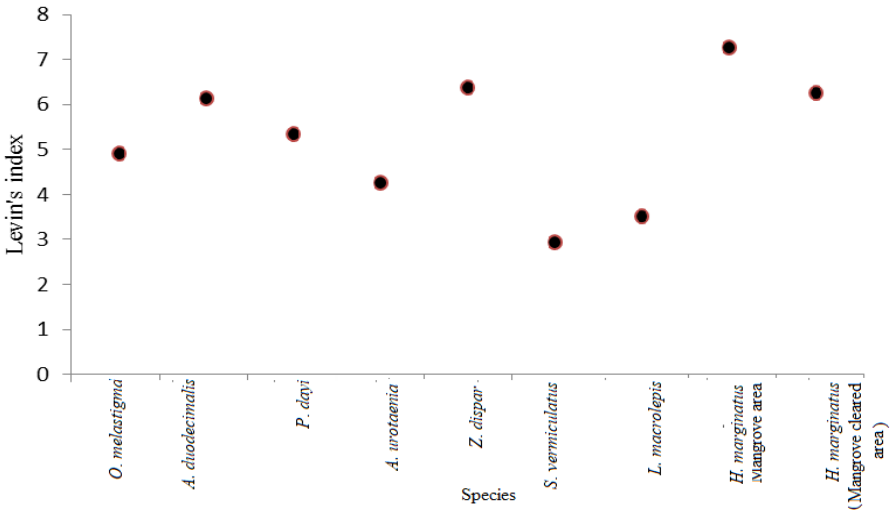

Figure 2: Niche Breadth of fish species (Levins Index)

According to niche breadth of fish species (Fig. 2), the broadest niche breadth was achieved by *H. marginatus* that were captured from mangroves and fed on ten food items; *Z. dispar* and *A. duodecimalis* fed on nine food items and achieved the second broadest niche breadth. The herbivorous fishes, *S. vermiculatus* and *L. macrolepis* were recorded to have the shortest niche breadth.

Discussion

The gut contents of 60 samples from 12 different fish species were analyzed with 13 food items being identified: plant materials (detritus, mangroves and seagrasses), phytoplankton (filamentous algae, diatom), molluscs and crustaceans (*Cyclops* sp., *Daphnia* sp., *Daptomus* sp., *Diphanosoma* sp. and mysids). Most of the species depend on plant matter: mangroves (11 species), seagrasses (10 species), and filamentous algae (9 species). Among the 12 species recorded from the mangrove areas, *E. fusca* and *A. urotaenia* did not feed on seagrasses while *L. dussumieri* did not feed on mangroves. *Eleotris fusca, L. brevirostis* and *P. dayi* did not feed on filamentous algae. *Hemirhamphus marginatus* is the only fish species that fed on diatoms (*T. nitzschioides* and *C. pelagica*). Ten fish species fed on detritus with the exception of *L. dussumieri* and *A. urotaenia*. Results indicated that mangroves, seagrasses and filamentous algae have a higher importance as food items in numerous fish species. Similarly, *V. buchanani* and *L. subviridis* in Malaysia fed on plant and animal matter (Kaniz et al., 2013), and their most abundant food items were recorded to be plant matter.

Furthermore, the ten fish species in the present study depend on animal matter. Most of them depend on *Cylops* sp. (ten species) and mysids (six species). Only four species fed on *Daphnia* sp. and *Daptomus* sp. while two species fed on *Diphanosoma* sp. and molluscs. This suggest that apart from plant matter, the next most important food items for juvenile fish are *Cyclops* and mysids.

Most of the fish analyzed (*L. dussumieri, L. brevirostis, E. fusca, H. marginatus, Z. dispar, O. melastigma,* and *A. duodecimalis*) are omnivores and a high dietary overlap was evident among them. These results agree with previous similar studies from the Negombo lagoon (Pinto and Punchihewa, 1996; Shirantha and Wijeyaratne, 2002). Accordingly, more omnivorous fish are seem to inhabit this lagoon. The omnivorous fish found in this lagoon might be opportunistic feeders, who feed on different food items, depending on their availability.

The present study found that, *S. vermiculatus* and *L. macrolepis* are strict herbivores. Although, *A. urotaenia* and *P. dayi* feed on both animal and plant matter, the main food items for *A. urotaenia* skewed towards herbivory and *P. dayi* showed more importance towards carnivory. Similarly, Pinto and Punchihewa (1996) recorded *S. vermiculatus* as a herbivore and *P. dayi* as a carnivore in a study from the same lagoon.

According to present findings that younger (4.95 cm) *C. sexfasciatus* is a carnivore and the older (10.05 cm) one is a herbivore. Pinto and Punchihewa (1996), also recorded *C. sexfasciatus* (length range 3.8-6.3cm) as a carnivore. Considering the size of fish in both studies, it is obvious that the younger ones are carnivores and the larger ones are herbivores. It is evident that the feeding habits of *C. sexfasciatus* vary with its age.

Feeding habits of *H. marginatus* do not vary with age, both young and elderly were found to be omnivores. However, when considering the food types, there is a difference in diatom species they consumed. Small individuals consumed mainly the diatom *C. pelagica* while larger fish fed on the diatom *T. nitzschioides*. This showed that the food items and feeding habits of some fish species vary with their age and stage of their

development. This is supported by Ajah (2012), in which both the juvenile and sub adult stages of *Cithcarinus latus* were phytoplankton and the adult stage was planktonic and *Trichiurus lepturus* was carnivorous at all three stages.

Fish species analysed from the mangrove area (*L. dussumieri, L. brevirostis, E. fusca, A. uroteenia, H. marginatus, Z. dispar, O. melastigma, A. duodecimalis, S. vermiculatus*. *Parambassis dayi* and *L. macrolepis*) were directly dependent on mangroves as a source of food.

Hemirhamphus marginatus found from both areas mainly fed on common food items. However, *H. marginatus* captured from the mangrove area fed specially on mangroves, filamentous algae and seagrasses whereas *H. marginatus* from mangrove cleared area fed specially on seagrasses and filamentous algae and did not consume mangroves or molluscs. According to these findings, *H. marginatus* is a selective feeder, however the shifting of diet may occur depending on the habitat.

Among the 12 species, the broadest niche breadth was achieved by *H. marginatus* and the second broadest niche breadth was evidenced in *Z. dispar* and *A. duodecimalis*. Shorter niche bread was recorded by herbivorous fish. Although most of the analyzed fish are omnivores, the juvenile fish mainly feed on mangroves and seagrasses.

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