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Food and feeding habits of *Omobranchus* sp. (Blenniidae: Omobranchini) larvae in the Seagrass-Mangrove ecosystem of Johor Strait, Malaysia

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Abstract

The stomach contents of *Omobranchus* sp. (family Blenniidae) larvae were investigated in a seagrass-mangrove based ecosystem in Johor Strait, Malaysia from October 2007 to September 2008. Specimens of larval fish were collected through subsurface towing of a Bongo net from five different stations. The stomach sacs of 267 *Omobranchus* sp. larvae were separated and observed, which comprised of 24 significant food stuffs belonging to 6 main groups *viz.* phytoplankton (62.45%), zooplankton (18.24%), algae (5.56%), plant-like particles (5.75%), debris (4.22%) and unidentified particles (2.03%). *In situ* water parameters were also measured throughout the sampling cruises. There was a strong and significant positive correlation between stomach phytoplankton and salinity ($r = 0.658$, $p < 0.05$). Canonical correlation analysis indicated a weak relationship (29.8%) between stomach contents and physico-chemical parameters. Only salinity appeared to be the controlling factor for the stomach contents of *Omobranchus* sp. larvae in the investigated area. Based on the stomach content analysis, it could be concluded that *Omobranchus* sp. were mainly herbivorous during the larval stages.

Key words

Larvae, Mangrove-seagrass ecosystem, *Omobranchus* sp., Stomach contents

Introduction

Blennies (Teleostei: Blenniidae) are known as a diverse group of marine fish which includes 20 described species under nine genera in the western central North Atlantic area (Ditty *et al.,* 2005). Blenniids are small in size, sexually dimorphic and scaleless fish with jugular pelvic fins with 2-4 soft rays each. A total of 19 blenniid *Omobranchus* fish have been reported so far from all over the world (Springer and Gomon, 1975) and six species among these were reported in Japanese water (Aizawa, 1993).

The distribution range of blennies is wide, occurring in the Indian, Pacific and Atlantic oceans, in subtropical, tropical and temperate water all over the world (Froese, *et al.,* 2003; Helfman, *et al.*, 1997; Nelson, 1994). The importance of seagrass beds as 'nursery' habitats for commercially important species has reached almost a paradigm status, despite few studies mentioning the proportion of fish from seagrass habitats that were in the early juvenile stage. Moreover, seagrass beds are important feeding habitats for juvenile and adult fish since dense seagrass cover produces a great quantity of organic material and can offer good substrate for smaller algae, diatoms and sessile fauna. Organisms usually found in seagrass beds also include hydroids, copepods, amphipods, gastropods, isopods, carid shrimps and fish (McRoy and Helfferich, 1977).

Blenniids are not food fish, but some genera are gathered for aquarium use (Wheeler, 1985). Several studies were conducted in terms of food and feeding habits of the adult fish (Chrisafi *et al*., 2007; Dadzie *et al*., 2000, Jardas *et al*., 2007, Ibrahim *et al*., 2003). It is reported that polychaets, amphipods and algae were the dominant food contents in the stomach (Gold-schmid *et al.,* 1980), whereas Jardas (1996) found that algae, benthic invertebrate groups and detritus were the main components of their diet. Meanwhile, the diet composition of the adult peacock blenny from the Mediterranean Sea was mostly fish eggs, algae, benthic molluscs, crustaceans and polychaets (Zander, 1986).

However, there is limited information on the feeding habits of larval fish of *Omobranchus,* although some published reports are available on food and feeding habits of other families of larval fish (Grabowsha and Grabowski, 2005; Kakareko *et al*., 2005; Ara *et al*., 2009, 2010 and 2011; Arshad *et al*., 2013). Therefore, studies on food and feeding habits of *Omobranchus* sp. larvae were undertaken to assess the diet composition and temporal variation of their natural diets from a seagrass-mangrove based ecosystem in Johor Strait, Malaysia.

Materials and Methods

Study area : The study was carried out in the coast of Gelang Patah, Johor Strait, Malaysia, which is dominated by seagrass and mangroves (Fig.1). Five sampling stations were selected along the axis of river estuary and Johor Strait. The specific locations of the sampling stations were: S1 upper estuary (01^{0} 23.345 N; 103^{0} 36.741 E); S2 middle estuary (01^{0} 22.79 N; 103^{0} 38.140 E); S3 lower estuary (01^{0} 21.597N; 103^{0} 37.491E); S4 Merambong seagrass beds (01^{0} 19.414N; 103^{0} 35.628E) and S5 outside the seagrass area (open sea) (01^{0} 18.799N; 103^{0} 35.246E).

Sampling procedure and identification : Sampling was done every month during the full moon/new moon period in daylight and at high tide from October 2007 to September 2008. Samples of larval fish were collected using a Bongo net (mesh size 500 µm, mouth diameter 0.3 m and length 1.3 m) through 30 min subsurface tows from each station. Samples were immediately fixed in 5% formalin and were carried to laboratory and kept in dark place until analysis. At each sampling station, the following water parameters were obtained by YSI multi parameter recorder: dissolved oxygen

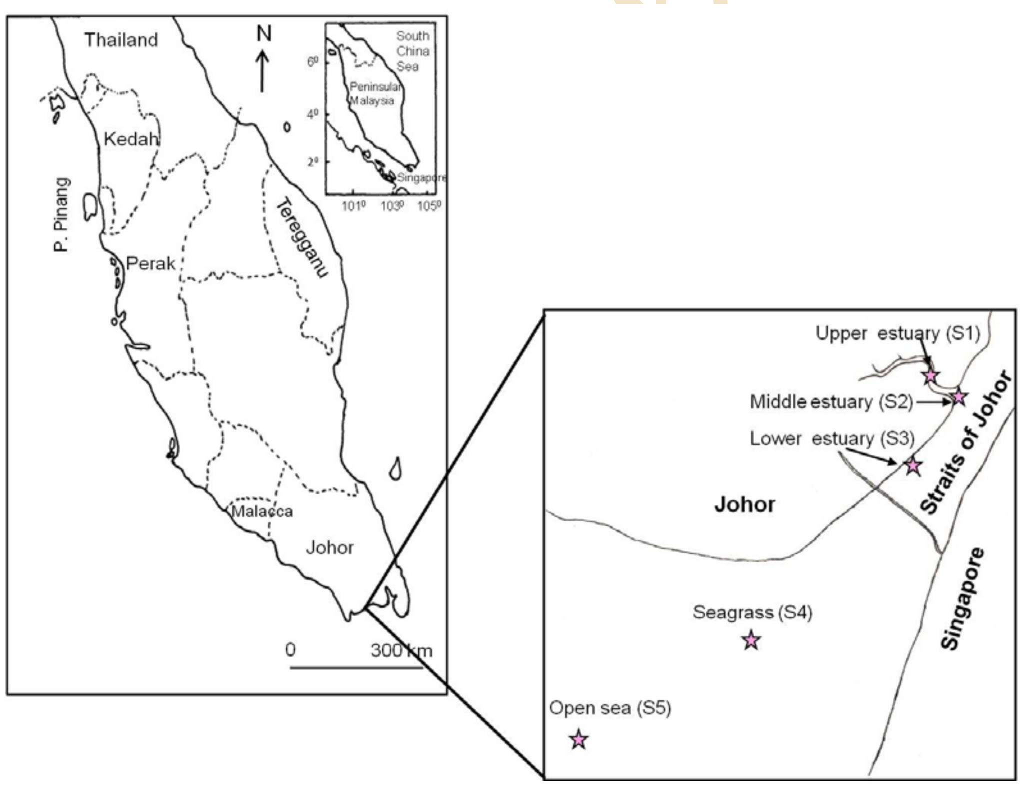

Fig. 1 : Geographical location of the sampling sites in the seagrass-mangrove ecosystem of Gelang Patah, Johor Strait, Malaysia

(mg l^{-1}), salinity (ppt), temperature (^{o}C), pH and conductivity (mS cm^{-1}). Total suspended solids (TSS) were analyzed following the APHA (2012) procedure. In the laboratory, the larval fish were sorted from the rest of the zooplankton and were preserved in 75% ethanol. Individual *Omobranchus* sp. was identified using relevant literature (Ghaffar *et al*., 2010; Leis and Carson-Ewart, 2000; Okiyama, 1988; Russell, 1976).

Stomach examination : In total, 267 specimens of *Omobranchus* sp. were taken for stomach examination. The total length for each species was measured prior to dissection using a Keyence digital microscope (VHX-500). The mean length of *Omobranchus* sp larvae varied from 1.59 to 5.20 mm. Each larval fish was laid on a counter slide and a drop of water was laid onto it. The stomach was detached from the larvae using a probe under a stereomicroscope. Then the stomach contents were shattered using a fine needle. A drop of distilled water was dripped onto the stomach contents and a cover glass was laid on the slide to keep the thickness of each food items as equivalent as possible. The number of food items were counted and identified to the possible lowest taxonomy with an inverted microscope.

Data analysis : To analyze the composition of stomach contents, the percentage frequency of occurrence and percentage of numerical abundance were calculated as follows:

Percentage frequency of occurrence (Fpi) = (N_{li} / Np) X 100

Where, N_{li} = number of the stomachs in which food item *i* was found and N*p* = number of non-empty stomachs (Chrisfi *et al.,* 2007).

Percentage of numerical abundance (Ci) = $ni / \sum_{i=1}^{m} ni$ X 100

Where *ni* = number of i^{th} food items and m = number of food items (Chrisfi *et al.,* 2007).

Simple resultant index (%Rs) was used to assess the relative importance of food items (Mohan and Sankaran, 1988):

$$\text{Simple Resultant Index (\%Rs)} = \frac{\sqrt{C_i^2 + F_{pi}^2}}{\sum_{i=1}^{m}\sqrt{C_i^2 + F_{pi}^2}} \times 100$$

where, C*i is the* percentage numerical abundance and F*pi is the* percentage frequency of occurrence.

Canonical correspondence analysis was conducted using the software CANOCO (Canonical Community Ordination) vers. 4.5 (ter Braak and Šmilauer, 2002) to examine the association between stomach contents of *Omobranchus* sp. and environmental variables. Dissimilarities in DO, temperature, salinity, pH, conductivity, TSS among the months were analyzed by one way analysis of variance (ANOVA).

Results and Discussion

Environmental variables : The mean value of temperature recorded in the seagrass mangrove ecosystem of Johor Strait was 28.76 ± 0.32°C (mean ± SD). The lowest temperature was recorded at 26.61°C in March; while highest temperature was recorded at 30.97°C in May (Table 1). Dissolved oxygen was lowest (4.47 mg L^{-1}) in April and highest (6.05 mg l^{-1}) in September. Salinity varied between 25.76 and 32.48 ppt (28.56 ± 0.57 ppt) (Table 1). The pH concentration was relatively constant from 7.56 (November) to 7.99 (September). The mean conductivity was found to be

Table 1 : Monthly variation of different water parameters in the seagrass mangrove ecosystem, Johor, Malaysia

Month	Tem(°C)	DO(mg l^{-1})	Sal(ppt)	pH	Cond(mS cm^{-1})	TSS
Oct,07	29.07	5.14	28.38	7.58	42104.15	8.20
Nov,07	28.91	5.61	25.76	7.56	40278.48	12.07
Dec,07	28.09	5.05	26.85	7.90	40779.78	11.13
Jan, 08	27.84	4.97	30.99	7.72	50197.03	15.80
Feb,08	28.04	5.38	32.48	7.75	49632.65	32.20
Mar,08	26.61	4.68	28.61	7.64	44274.50	33.33
Apr,08	28.53	4.47	28.27	7.97	44262.10	27.67
May, 08	30.97	4.83	28.83	7.94	44835.60	25.20
Jun,08	28.99	5.72	25.91	7.73	38578.80	27.40
Jul,08	28.93	5.18	27.50	7.93	45563.60	37.10
Aug, 08	29.02	5.51	30.05	7.87	46649	39.40
Sep,08	30.11	6.05	29.11	7.99	44764.06	29.44
Mean	28.76	5.22	28.56	7.80	44326.64	24.91
SD	0.32	0.13	0.57	0.44	1018.54	3.06
Range	26.61-30.97	4.47-6.05	25.76-32.48	7.56-7.99	38578.80-50197.03	8.20-39.40

44326.64 ± 1018.54 (mS cm^{-1}) and ranged between 38578.80 and 50197.031 (mS cm^{-1}) (Table 1). The highest total suspended solid (TSS) was recorded at 39.4 mg l^{-1} in August and the lowest value was 8.2 mg l^{-1} in the month of October (Table 1). Significant ($p < 0.05$) variations were observed in water temperature, dissolved oxygen, salinity, pH, conductivity and TSS amongst the different months during the study period.

Diet composition : A total of 267 stomachs from *Omobranchus* sp. larvae were examined and no empty stomachs were observed (Table 2). The overall diet composition of *Omobranchus* sp., ranked by Simple Resultant Index (%Rs) are presented in Table 3. Analysis of food items in the gut showed that the most important prey, according to the %Rs, were phytoplankton (63%) followed by zooplankton (18%), algae (6%), plant-like matter (6%), debris (4%) and unidentified materials (3%).

Monthly variation of diets : Monthly percentage frequency of occurrence (Fpi) and numerical abundances (C*i*) of food items in 267 stomachs of *Omobranchus* sp. are presented in Table 4 and 5. Phytoplankton was the most dominant food item found in each month during the study period. The highest frequency of occurrence (87.50%) of phytoplankton

Table 2 : Total numbers of larval fish of *Omobranchus* sp. studied for feeding habits from the seagrass-mangrove ecosystem of Gelang Patah, Johor

Month	S1	S2	S3	S4	S5	Total	Length size (mm)
Oct, 07	2	1	5	10	2	20	2.25-4.74
Nov, 07	-	1	3	-	5	8	3.90-4.72
Dec, 07	-	-	3	10	4	17	2.60-3.36
Jan, 08	10	-	5	-	3	20	1.99-3.07
Feb, 08	5	2	10	5	2	29	1.59-4.96
Mac, 08	-	7	10	5	-	20	2.65-4.32
Apr, 08	10	5	3	10	-	33	2.40-5.20
May, 08	10	10	4	6	1	25	2.45-4.80
Jun, 08	-	4	6	5	3	16	2.40-4.21
Jul, 08	6	2	3	7	5	27	1.65-4-67
Aug, 08	10	6	10	10	2	42	2.62-4.66
Sep, 08	3	-	5	2	-	10	2.89-4.29
Total	56	47	67	70	27	267	1.59-5.20

Table 3 : Overall stomach composition in the fish larvae of *Omobranchus* sp. ranked by Simple Resultant Index (%Rs)

Food items		C*i*	F*pi*	% Rs
1.	Phytoplankton	53.08	73.41	62.45
	Dacytyloccopsis fasicicularis	18.30	32.26	26.31
	Coscinodiscus sp.	3.51	1.35	2.32
	Chromophyta	2.46	1.17	1.89
	Nitzschia baccata	18.13	33.46	23.38
	Gonyaulax sp.	1.89	0.63	1.38
	Ceratium sp.	0.14	0.18	0.16
	Peridium sp.	1.58	0.43	1.14
	Lyngbya limnetica	1.85	1.17	1.52
	Paramecium sp.	0.69	0.23	0.51
	Other spp	4.44	2.53	3.54
2.	Zooplankton	22.43	15.20	18.79
	Copepod	13.69	10.88	12.12
	Cladocerans	1.67	0.60	1.23
	Rotifer	0.77	0.26	0.56
	Larval stage (nauplii)	4.80	2.72	3.82
	Ostracods	0.07	0.02	0.05
	Amphipods	0.42	0.13	0.30
	Thaliacians (tunucates)	0.49	0.23	0.37
	Larvaceans (appendicularians)	0.75	0.36	0.56
3.	Algae	7.22	3.50	5.56
4.	Plant-like matter	7.38	3.79	5.75
5.	Debris	5.68	2.19	4.22
6.	Unidentified materials	4.02	1.72	3.03

Table 4 : Monthly percentage frequency of occurrence (F *pi*) of food items in the guts of *Omobranchus* sp.

Food items	Frequency of occurrence (%)												Average
	O	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	
1. Phytoplankton	82.82	68.17	63.13	82.04	74.43	78.00	65.96	76.46	58.13	71.58	**87.50**	77.57	**73.81**
Dacytyloccopsis fasicicularis	34.35	16.14	31.15	36.07	34.85	38.75	28.94	34.34	32.5	35.42	39.55	37.07	**33.26**
Coscinodiscus sp.	1.91	0.45	0.82	2.05	2.68	-	-	1.06	0.31	2.46	1.31	1.46	**1.45**
Chromophyta	2.29	0.45	0.82	1.76	1.03	1	4.26	0.53	0.31	0.19	1.45	-	**1.28**
Nitzschia baccata	40.08	45.29	24.60	39.88	27.63	35	20.43	37.88	22.5	30.68	41.39	36.10	**33.45**
Gonyaulax sp.	0.38	-	0.82	1.76	1.03	0.75	1.70	0.18	-	-	0.39	0.49	**0.83**
Ceratium sp.	-	1.35	-	-	-	-	0.85	-	-	-	-	-	**1.1**
Peridium sp.	0.38	-	0.82	0.29	0.82	0.75	-	0.71	0.63	-	0.26	0.49	**0.57**
Lyngbya limnetica	0.76	0.45	0.82	0.59	2.68	-	6.38	0.35	-	-	1.05	0.98	**1.5**
Paramecium sp.	-	-	0.82	-	0.21	0.75	0.85	0.18	-	-	-	-	**0.56**
Other species	2.29	4.04	2.46	-	2.06	0.75	2.55	0.88	1.88	2.27	1.97	0.98	**2.01**
2. Zooplankton	4.96	17.04	17.22	8.49	8.04	9.75	16.60	19.11	35.01	24.81	6.04	12.20	**14.94**
Copepod	4.20	8.52	11.48	7.33	7.01	6.5	9.36	11.15	30.94	18.56	5.78	9.76	**10.88**
Cladocerans	-	1.79	1.64	0.29	-	0.25	0.85	0.35	0.63	0.38	-	0.98	**0.79**
Rotifer.	0.38	-	-	-	1.44	0.25	-	0.35	-	0.57	0.13	-	**0.52**
Larval stage (nauplii)	0.76	5.83	0.82	0.29	1.03	2.75	4.68	7.43	1.88	5.49	0.26	1.46	**2.72**
Ostracods	-	-	-	-	-	-	-	-	-	0.19	-	-	**0.19**
Amphipods	-	-	-	0.29	-	-	-	-	1.25	-	-	-	**0.77**
Thaliacians (tunucates)	-	-	1.64	-	-	-	0.43	0.18	0.31	0.19	-	-	**0.55**
Larvaceans (appendicularians)	-	0.90	1.64	0.29	-	0.25	1.28	-	-	-	-	-	**0.87**
3. Algae	6.49	5.83	4.10	2.93	8.04	3.5	6.38	0.35	0.63	0.57	0.79	2.44	**3.50**
4. Plant like matter	1.91	4.48	8.20	3.52	4.95	5.75	4.48	1.77	2.5	0.76	2.76	4.39	**3.78**
5. Debris	2.67	-	5.71	2.05	3.30	1.5	2.55	1.77	2.19	1.33	1.18	1.95	**2.35**
6. Unidentified materials	1.15	4.48	1.64	0.59	1.24	1.5	3.83	0.53	1.51	0.95	1.71	1.46	**1.71**

Table 5 : Monthly percentage of numerical abundance (Ci) of food items in the guts of *Omobranchus* sp.

Food items	Numerical abundance (%)												Average
	O	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	
1. Phytoplankton	55.88	45.81	48.23	56.97	59.19	48.44	60.66	49.98	48.05	57.60	65.33	50.03	**53.84**
Dacytyloccopsis fasicicularis	17.65	14.58	17.64	19.33	16.57	17.53	22.95	15.83	18.18	20.80	21.39	16.07	18.21
Coscinodiscus sp.	5.88	2.08	1.18	5.37	5.92	-	-	3.33	1.30	6.40	5.21	5.36	4.20
Chromophyta	2.94	2.08	1.18	2.15	2.96	4.12	4.92	2.50	1.30	0.80	4.62	-	2.68
Nitzschia baccata	16.18	14.58	18.82	21.51	17.16	14.43	16.39	17.5	19.48	21.60	21.97	17.88	18.12
Gonyaulax sp.	1.47	2.08	-	6.45	2.96	2.06	3.28	0.83	-	-	1.73	1.79	2.51
Ceratium sp.	-	-	2.35	-	-	-	1.64	-	-	-	-	-	1.99
Peridium sp.	1.47	2.08	-	1.08	2.37	3.09	-	3.33	2.60	-	1.16	1.79	2.11
Lyngbya limnetica	2.94	2.08	1.18	1.08	3.55	-	4.92	1.67	-	-	1.16	3.57	2.46
Paramecium sp.	-	2.08	-	-	0.60	3.09	1.64	0.83	-	-	-	-	1.64
Other species	5.88	4.17	5.88	-	4.14	3.09	4.92	3.33	5.19	5.60	7.51	3.57	4.83
2. Zooplankton	8.82	24.99	27.05	18.30	11.84	16.49	20.50	35.83	31.17	28.00	16.18	23.22	**21.85**
Copepod	7.35	14.58	11.76	13.98	8.88	10.31	9.84	20.83	18.18	19.20	15.02	14.29	13.68
Cladocerans	-	4.17	3.53	1.08	-	1.03	1.64	1.67	2.60	0.80	-	3.57	2.23
Rotifer	1.47	-	-	-	2.96	1.03	-	0.83	-	2.40	0.58	-	1.54
Larval stage (nauplii)	1.47	2.08	9.41	1.08	2.96	4.12	5.74	12.5	5.19	6.40	1.16	5.36	4.78
Ostracods	-	-	-	-	-	-	-	-	-	0.80	-	-	0.80
Amphipods	-	-	-	1.08	-	-	-	-	3.90	-	-	-	2.49
Thaliacians (tunucates)	-	2.08	-	-	-	-	0.82	0.83	1.30	0.80	-	-	1.16
Larvaceans (appendicularians)	-	2.08	2.35	1.08	-	1.03	2.46	-	-	-	-	-	**1.80**
3. Algae	14.71	10.42	10.59	8.60	10.65	11.34	6.56	1.67	2.60	2.40	3.46	3.57	**7.20**
4. Plant like matter	7.35	6.25	9.41	8.60	8.82	11.34	4.92	5.00	6.49	3.20	6.36	10.74	**7.36**
5. Debris	8.82	8.33	-	5.38	5.92	6.19	3.26	5.83	7.79	4.80	4.62	7.14	**6.16**
6. Unidentified materials	4.41	4.17	4.71	2.15	3.55	6.19	4.10	1.67	3.90	4	4.05	5.30	**4.01**

Table 6 : Correlation coefficient (r) between water parameters and gut contents of *Omobranchus* sp.

Gut content	Temp	Salinity	DO	pH	Cond.	TSS
Phytoplankton	0.041	0.658*	-0.026	0.039	0.635*	0.160
Zooplankton	0.254	-0.68*	0.147	0.194	-0.568	0.107
Algae	-0.392	0.215	-0.182	-0.444	0.063	-0.416
Plant	-0.522	-0.052	-0.125	-0.289	-0.150	-0.278
Debris	-0.205	0.103	-0.210	-0.043	-0.062	-0.310
Unidentified	-0.102	-0.453	0.008	-0.162	-0.414	-0.183

Note: * Significant at 0.05 levels

Table 7 : Results of the canonical correspondence analysis (CCA) for stomach contents of *Omobranchus* sp. and environmental variables

Axes	1	2	3	4	Total
Eigenvalues	0.053	0.041	0.019	0.015	0.250
Species-environment correlations	0.929	0.870	0.950	0.602	
Cumulative percentage variance of species data	21.300	37.800	45.500	51.600	
Cumulative percentage variance of species-environment relation	39.200	69.600	83.90	95	
Sum of all eigenvalues					0.250
Sum of all canonical eigenvalues					0.298

in the gut was observed in August and lowest (63.13%) in December (Fig.2). The second most important food item zooplankton was also observed in each month of the year. Highest occurrence (34.01%) of zooplankton was found in June, whereas lowest (4.96%) was in October (Fig. 2). Highest occurrence (8.04%) of algae was observed in February and lowest (0.35%) was in May. Highest plant like matters (8.20%) was in December and lowest (0.76%) was in July. Similarly, debris was also highest (5.74%) in December and, furthermore, the highest occurrence of unidentified materials was in November (4.48%).

In terms of numerical abundance, the largest quantity (65.33%) of phytoplankton was observed in the gut in August and lowest (45.81%) in November (Table 5). Highest numeric abundance (35.83%) of zooplankton was found in May, whereas lowest (8.82%) occured in October. Algal components were consistently observed throughout the year and varied from 0.35% (May) to 8.04% (February).

Relationship between abundance of food items and environmental variables : Correlation was studied between the measured environmental variables on food item abundance in the gut contents. It was found that all the four food items (algae, plant-like matter, debris and unidentified) were negatively correlated with temperature. However, none of the food items were significantly correlated with temperature. There was a strong and significant correlation between phytoplankton contents and salinity ($r = 0.658$, $P < 0.05$). However, there was a negative significant correlation ($r = -0.681$, $P < 0.05$) between salinity and zooplankton (Table 6). Phytoplankton, algae, plant-like matter and debris were negatively correlated with dissolved oxygen, whereas zooplankton was positively correlated (Table 6). There was no significant relationship between pH and food items.

Canonical correspondence analysis : Eigenvalues of CCA were calculated as 0.053(CCA1), 0.041(CCA2), 0.019(CCA3) and 0.015(CCA4) for the first four multivariate axes. Correlation coefficients between the larvae and environment for the first four axes were found as 0.929, 0.870, 0.950 and 0.602, respectively (Table 7). The cumulative percentage variance of larval fish-environmental relation for the first four axes was represented as 51.6% whereas 21.3% and 37.8% modeled by the first and second axes. The first CCA axis (Eigenvalue = 0.053) alone modeled 39.2% of the explained variance, demonstrating the second highest species-environment correlation (0.929) (Table 7). The second axis represented 30.4% of the

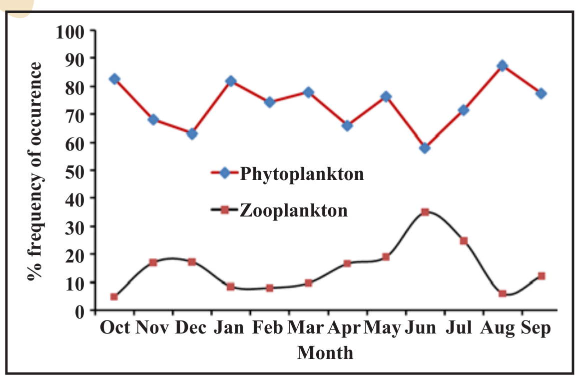

Fig. 2: Monthly variation of phytoplankton and zooplonkton abundance in the stomach contents of *Omobrabchini* sp.

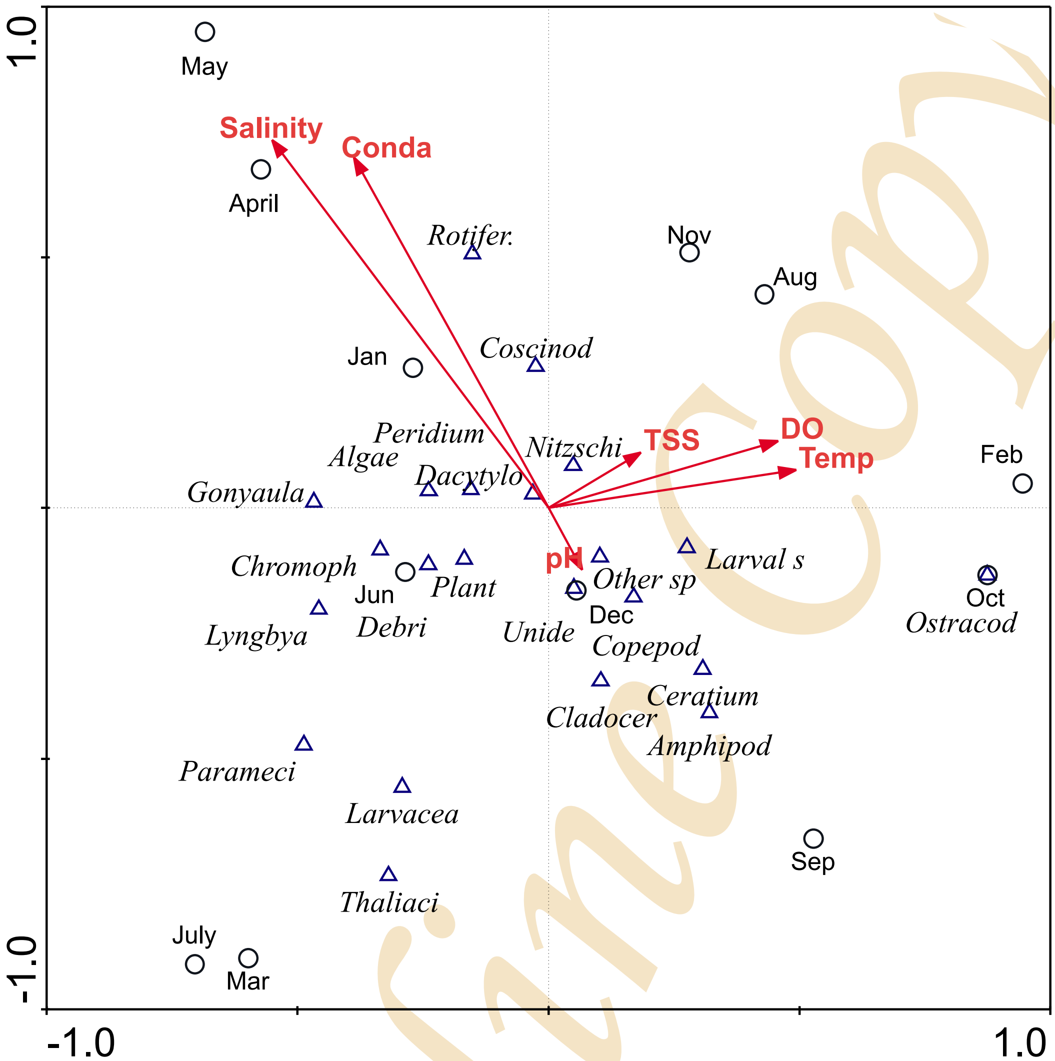

Fig. 3 : Canonical correspondence analysis ordination of monthly (dots) temporal variations in stomach contents (indicated by solid arrows) of *Omobranchus* sp. and environmental variables (physico-chemical conditions)

explained variance of the larval fish-environment relationship (Table 7), while the third and fourth axis explained 14.30% and 11.10% of the variance of species-environment relationship, respectively. Since 69.6% of the cumulative percentage variance of larval fish-environment relation were explained by the first two CCA axes (Table 7), the results found from the first two axes are presented (Fig. 3). It could be concluded that the CCA test indicated a weak correlation (29.8%) between the stomach contents and physico-chemical parameters (Table 7). This revealed that stomach contents might be slightly influenced by the different tested water quality parameters (*i.e.* temperature, salinity, dissolved oxygen, pH and TSS).

The major prey item found in the stomachs of *Omobranchus* sp. was phytoplankton and represented 63.01% of simple resultant index (%Rs) in *Omobranchus* sp. (Table 3). Most phytoplankton in the stomachs comprised of *Dacytyloccopsis fasicularis* followed by *Nitzschia baccata* (23.38%) and *Coscinodiscus* sp. (2.32%). Mendiola (1970) stated that phytoplankton does not contribute significantly to food of fish larvae, as it is supposedly present in the gut content of larvae only when they are ≤ 9.0 mm. According to Dadzie *et al.* (1998) the highest frequency of occurrence of phytoplankton in the fish larvae was *Coscinodiscus* sp. and *Rhizosolenia* sp. This is in contrast to Hunter and Thomas

(1972) where they found that the main phytoplankton in the stomach content of larval fish was dinoflagellate, *Gymnodium splendens*.

Among zooplankton, copepods (12.12%) were the most common food items of *Omobranchus* sp. and was followed by nauplii stages of different shrimp larvae (3.82%) and cladocerans (1.23%). It is stated that marine fish larvae that hatch and grow in the wild typically feed on zooplankton. The distribution pattern and dietary habits of larval fish are associated with distribution and abundance of copepod prey (Islam *et al.,* 2006). Total length (TL) of the larvae examined in the present study was 1.59 to 5.20 mm. It is reported that adult copepods are approximately 0.7 to 3.5 mm in size (Marak, 1974). Therefore, it could be accepted that copepods are one of the food items of *Omobranchus* sp. larvae. Different stages of copepods are the main components of the diet during the ontogenetic development of most pelagic fish (Last, 1980). Other zooplankton present in the stomach included ostracods, amphipods, thaliacians (tunucates) and larvaceans. Ryland (1964) and Shelbournes (1962) reported that larvae feed on larvaceans during the early part of their life. Cladocerans (1.23%) were also observed in the gut content of *Omobranchus* sp. Zooplanktons are positive indicators of future fisheries health as they are a food source for organisms at higher tropic levels.

Furthermore, instead of phytoplankton and zooplankton, the other important food item consumed by *Omobranchus* sp. larvae was plant-like matter since this was ranked third by Simple Resultant Index (%Rs) at 5.75%. Plant-like matter consisted of dried roots, stems, grass leaves and unidentified plant parts. Zooplankton also feed on other particulates such as plant matter and bacteria (Reshetiloff, 2004) and therefore this could explain, at least in part, the presence of these in the stomach. Recent research on the food habits of *Acetes indicus* from the coastal water of Malacca indicates that the species was omnivorous where the main food items were plant-like matter (Amin *et al.,* 2007).

It was revealed that there was a higher occurrence of phytoplankton in the stomach of *Omobranchus* sp. larvae during the inter-monsoon months (January-March and August-October) in the investigated area when salinity was slightly higher than during the monsoon season. In contrast, the peak occurrence of zooplankton was found in monsoon seasons (November-December and May-July) during the study period. Salinity showed a positive significant correlation with phytoplankton content ($p < 0.05$), but was negatively correlated with zooplankton ($p < 0.05$). In the CCA test, larval fish were plotted nearer to the vector, indicating a stronger relationship with them. It has been reported that species situated close to the origin either do not show a strong relationship with any of the variables or are found at average values of environmental variables (Marshall and Elliott, 1998). In the study, salinity was found to be a significant variable affecting the stomach content composition in the investigated estuary. On the other hand, temperature, DO, pH and TSS were not found to be significant with diet composition. Therefore, it may be concluded that salinity is the controlling factor for the stomach contents of *Omobranchus* sp. larvae in the investigated area.

Primarily bottom-dwellers, blennies tend to feed on other benthic organisms that include both algae and invertebrates. Some are planktivores, some carnivores while others scrape algae off corals and rocks, and in the process, may be feeding on small organisms that live in association with the algae. Some blennies nip pieces of skin, scales, or fins from larger fish (Froese *et al.,* 2003; Helfman *et al.,* 1997). Blennies are largely herbivorous and as such play an important role in grazing reef algae, keeping these from smothering corals. Blennies are a predominant group in intertidal and inshore zones and are specialized to occupy holes and crevices (Wheeler, 1985).

A total of 24 important items (%Rs > 0.05) belonging to six major groups (phytoplanktons, zooplanktons, algae, plant matters, debris and unidentified materials) were identified in the stomachs of *Omobranchus* larvae. According to simple resultant index (Rs), the predominant food items found in their stomach were phytoplankton (> 60%) and therefore, *Omobranchus* sp larvae may be recognized as a herbivore. The CCA test indicated a weak correlation (29.8%) between the stomach contents and physico-chemical parameters. Only salinity might be the controlling factor for the stomach contents of *Omobranchus* sp. larvae in the investigated area. This information could be useful in determining the role *Omobranchus* sp. in the food web of the community.

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References

Aizawa, M. : Fishes of Japan with pictorial keys to the species. Tokai Univ. Press, Tokyo. Blennidae. pp. 952-980 (1993).

Amin, S.M.N., A. Arshad., S.S. Siraj and S. B. Japar : The biology and life history of sergestid shrimp Acetes indicus (Decapoda: Sergestidae) in the coastal waters of Malacca, Peninsular Malaysia. *Biost.,* **5**, 9-17 (2007).

APHA : Standard methods for the examination of water and waste water. American Public Health Association (22nd Edn.). Washington DC, p. 1496 (2012).

Ara, R., A. Arshad., L. Musa., S.M.N. Amin and P. Kuppan : Feeding Habits of Larval Fishes of the Family of Clupeidae (*Actinopterygii: Clupeiformes*) in the Estuary of River Pendas, Johor, Malaysia. *J. Fish. Aqua. Sci*., **6,** 816-81(2011).

Ara, R., A. Arshad., N. Amrullah., S.M.N. Amin., S.K. Daud., A.A. Nor. Azwady and A.G. Mazlan : Feeding habits and temporal variation of diet composition of fish larvae (Osteichthyes: Sparidae) in the sungai Pulai seagrass bed, Johor, Peninsular Malaysia. *J. Biol. Sci.,* **9**, 445-451(2009).

Ara, R., A. Arshad., S.M.N. Amin., S.K. Daud., J.S. Bujang and M.A. Ghaffar : Feeding habits of larval fishes of the family Gobiidae (Actinopterygii: Perciformes) in seagrass beds of Sungai Pulai estuary, Johor Strait, Malaysia. *Coas. Mar. Sci.,* **34**, 123-128 (2010).

Arshad, A., R. Ara, S.M.N. Amin and A.G. Mazlan : Diet composition in larval fishes of the family terapontidae (Actinopterygii: Perciformes in the Seagrass-bed of Johor Strait, Malaysia. *Asian J. Anim. Vet. Adv*., **8**, 325-332 (2013).

Chrisfi, P., P. Kaspiris., G. Katselis : Feeding habits of sand smelt (*Atherina boyeri*, Risso 1810) in Tichonis Lake (western Greece). *J. Appl. Ichth*., **23**, 209-214 (2007).

Dadzie, D., F. Abou-Seedo and E. Ai-Qattar : The food and feeding habits of the silver pomfret, *Pampus argenteus* (Euphrasen), in Kuwait waters. *J. Appl. Ichth*., **16**, 61-67 (2000).

Dadzie, S., F. Abou-Seedo and T. Ai-Shallal : The onset of spawning in *Pampus* argenteus (Euphrasen) in Kuwait waters and its implications for management. *Fish. Manag. Eco*., **5**, 1-5 (1998).

Ditty, J. G., R.F. Shaw and L.A. Fuiman : Larval development of five species of blenny (Teleostei: Blenniidae) from the western central North Atlantic, with a synopsis of blennioid family characters. *J. Fish. Biolo*., **66**, 1261–1284 (2005).

Froese, R., D. Pauly. and D. Woodland : Fish Base (On-line). FishBase World Wide Web electronic publication. Accessed July 28, 2003 at http://www.fishbase.org, (2003).

Ghaffar, M.A., L.W. Teck and Z. Talib : A field guide for sampling and identification of larval fish from coastal waters of southeastern peninsular Malaysia. Universiti Kebangsaan Malaysia, pp.55 (2010).

Goldschmida, A., K. Kotrschal., W.D. Krautgartner and H. Adam : Morphologie des gebisses und Nahrungspraferenzen von dreizehn adriatischen Blenniiden (Teleostei, Perciformes). *Zool.Scripta.,* **9**, 67-78 (1980).

Grabowska, J. and M. Grabowski : Diel-feeding activity in early summer of racer goby *Neogobius gymnotrachelus* (Gobiidae): a new invader in the Baltic basin. *J. Appl. Ichth*., **21**, 282-286 (2005).

Helfman, G., B. Collete and D. Facey : The Diversity of Fishes. Malden, MA : Blackwell (1997)

Hunter, J.R. and G.L. Thomas : Effect of prey distribution and density on the searching and feeding behaviour of larval anchovy *Engraulis mordax* Girard. In: The Early Life History of Fish, (Ed.: J.H.S. Blaxter), New York: Springer-Verlag Berlin Heidelberg, pp. 559-574 (1972).

Ibrahim, S., M. Muhammad., M.A. Ambak., M.Z. Zakaria., A.S. Mamat., M.M. Isa and S. Hajisamae : Stomach contents of six commercially important demersal fishes in the South China Sea. *Turk. J. Fish. Aquat. Sci*., **3**, 11-16 (2003).

Islam, M.S., M. Hibino and M. Tanaka : Distribution and the diet of larval and juvenile fishes: Influences of salinity fradient and the turbidity maximum in a temperate estuary in upper Ariake Bay, Japan. *Estu. Cost. Shelf. Sci.,* **68**, 62-74 (2006).

Jardas, I., M. Santic., V. Nerlovic and A. Pallaoro : Diet composition of blackspotted smoot-hound, *Mustelus punctulatus* (Risso, 1826) in the eastern Adriatic Sea. *J. Appl. Ichth*., **23**, 279-281(2007).

Jardas, I.: Adriatic ichthyofauna. Skolska knjiga d. d., Zagreb. (1996).

Kakareko, T., J. Zbikowski and J. Zytkowicz : Diet partitioningin summer of two syntopic neogobiids from two differenthabitats of the lower Vistula River, Poland. *J. Appl. Ichth*., **21,** 292–295 (2005).

Last, J.M. : The food of 25 species of fish larvae in the west-central North Sea. MAFF lowestoft. *Fisheries Technical Report*., **60**, 1-44 (1980).

Leis, J.M. and B.M. Carson-Ewart : The larvae of Indo-Pacific coastal fishes. Fauna Malesiana Handbook 2, Brill, Leiden, pp. 850 (2000).

Marak, R.R. : Food and feeding of larval redfish in the Gulf of Maine. *In*:The Early Life History of Fish (Ed.: J.H.S. Blaxter). Springer-Verlag, Berlin, pp. 267–275 (1974).

Marshall, S. and M. Elliott : Environmental influences on thefish assemblages of the Humber Estuary, U.K. *Estua. Coast. Shelf. Sci*., **46**, 175-84 (1998).

McRoy, C.P. and C. Helfferich : Seagrass ecosystems. Marcel Dekker, Inc, New York, p. 314 (1977).

Mendiola, B.R. : Food of the larval anchoveta *Engraulis ringens. In:* The early life history of fish. (Ed.: J. H. S. Blaxter) Springer-Verlag, N.Y., pp. 277-285 (1970).

Mohan, M.V. and T.M. Sankaran : Two new indices for stomach content analysis of fishes. *J. Fish Bio*., **33**, 289-292 (1988).

Nelson, J. : Fishes of the World – third edition. New York, NY: John Wiley and Sons (1994).

Okiyama, M. : An atlas of the early stage fishes in Japan. Tokai University press, Japan. Tokyo, xiii+1154 pp (1988).

Reshetiloff, K. : Chesapeake Bay: Introduction to an Ecosystem. Page 20, U.S. Environmental Protection Agency for the Chesapeake Bay Program. EPA 903-R-04-003, CBP/TRS 232/00 (2004).

Russell, F.S. : The eggs and planktonic stages of British Marine Fish. London-New York-San Francisco: Academic Press, p. 677 (1976).

Ryland, J.S. : The feeding of plaice and sand-eel larvae in the southern North Sea. *J. Mar. Bio. Assoc. U.K*., **44**, 343-364 (1964).

Shelbourne, J.E. : Predatory prey size relationship for plaice larvae feeding on Oikopleura. *J. Mar. Bio. Assoc. U.K*., **42**, 243-252 (1962).

Springer, V.G. and M.F. Gomon : Revision of the blenniid fish genus *Omobranchus* with descriptions of three new species and notes on the others species of the tribe Omobranchini. *Smithsonian Contrib. Zoo.,* **177**, 1–135 (1975).

ter Braak, C.J.F. and P. Šmilauer : CANOCO reference manual and CanoDraw for Windows user's guide: software for canonical community ordination (vers. 4.5). New York: Microcomputer Power, (2002).

Wheeler, A. : The World Encyclopedia of Fishes. London, Macdonald. (1985).

Zander, C.D. : Blenniidae. In: Fishes of the North-eastern Atlantic and the Mediterranean, (Eds.: P.J.P. Whitehead, M.L. Bauchot, J.C. Hureau, J. Nilsen & E. Tortonese), Paris:Unesco, Vol. **III**, pp. 1096-1112 (1986).