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Feeding habits of larval fishes of the family Gobiidae (Actinopterygii: Perciformes) in seagrass beds of Sungai Pulai estuary, Johor Strait, Malaysia

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Abstract — Diet composition and feeding habits of fish larvae from the family Gobiidae were investigated in seagrass beds of Sungai Pulai estuary, Johor Strait, Malaysia. Samples were collected monthly from December 2007 to May 2008. Stomach contents were analyzed in 88 larval specimens with size range between 2.0 to 4.0 mm in total length. Prey analyses of stomach contents identified 24 important items belonging to seven major diet groups: phytoplankton, zooplankton, algae, insects, plant-like matter, debris and unidentified matters. In term of percentage, dominant preys were phytoplankton (56.33%) and this was followed by plant matters (15.13), zooplankton (9.84%), algae (9.73%), debris (4.85%), decapods appendages (3.19%), unidentified matters (2.39%) and insects (1.73%). The *in situ* temperatures were recorded in the range of 26.92 to 30.83°C (Mean±SD, 28.60±1.38); dissolved oxygen ranged from 4.73 to 6.24 mg L^{-1} (5.56±0.53) and the salinity fluctuation was between 29.37 and 33.68 ppt (31.31±1.68). Among the series of food items, phytoplankton was the first rank by Simple Resultant Index (56.33%) and followed by plant-like matter (15.13%). The results of the study could be used to conclude that gobiid larvae are mainly herbivorous.

Key words: Diet composition, fish larvae, seagrass bed

Introduction

The family Gobiidae constitutes the largest family of fishes in many ecologically important habitat such as mangroves and seagrass beds and often been highlighted because of prolonged taxonomic difficulties and interrelationships of its component taxa (Winterbottom 1993, Hoese and Gill 1993, Hoese 1984). Gobiids are abundant in a wide variety of shallow marine and estuarine habitats and most species are closely associated with the bottom habitat with many living in burrows. In the Indo-Pacific, gobies are frequently the most abundant larvae in coastal plankton towing results. About 160 genera with about 1200 species occur in the Indo-Pacific (Hoese 1984, Birdsong et al. 1988). Currently 212 genera and 1,875 species are recognized, making gobies the largest marine fish family and the most species-rich family of vertebrates (Nelson 2006).

The importance of seagrass beds as 'nursery' habitat for commercially important species has reached almost paradigm status, despite few studying mentioning the proportion of fish from seagrass habitats that were early juveniles. For example, in a study of a Guatemalan seagrass beds, 83% of fishes were early juvenile's stages (Arrivilaga and Baltz 1999). Therefore, seagrass beds are important feeding habitats for juvenile and adult fishes. A dense vegetation of seagrass produces a great quantity of organic material. This may offer a good substrate for smaller algae, diatoms and sessile fauna. Organisms that usually can be found in the seagrass beds include diatoms, hydroids, copepods, amphipods, gastropods, isopods, caridean shrimps, and fishes (McRoy and Helfferich 1977).

Studies of larval fishes are often the best way to provide information of great value to fishery biologists and managers of fisheries. These include location of spawning grounds in term of space and time, determination of habitats used by fish during their larval phase, fishery independent estimates of stock size and stock boundaries, discovery of new fisheries, feeding habits of larvae, condition of larvae, insight into recruitment fluctuations, and historical changes in all of the above. Fish larvae must optimize their food intake by being effective prey searchers and predators in order to maintain a high growth rate and survive to recruitment (Ostergaard et al. 2005).

Different fishes consume different types of food and feeding habit of fishes varies from season to season. Defining dietary preferences for the early stages is therefore an important element in the assessment of feeding conditions and larval chances of meeting food requirement (Robichaud-LeBlanc et al. 1997). Observations on larval prey preferences are mainly based on analyses of gut contents. A lack of empirical data on the diets of fish larvae in the wild, however, again leads to a reliance on results from aquaculture study (Humphries et al. 1999). The knowledge about the specification of food items both qualitatively and quantitatively from the present study can be applied in aquaculture development. In terms of management, such studies are essential for evaluation of the ecological role of the fish larvae as well as the understanding of its position in the food web structure in the seagrass ecosystem. Various studies have been carried out in terms of food and feeding habits of the adult fishes (Chrisafi et al. 2007, Dadzie et al. 2000, Jardas et al. 2007), but there is limited information about the feeding habits of larval gobiids (Grabowsha and Grabowski, 2005 and Kakareko et al. 2005). Therefore, the present study was undertaken to assess the feeding habits and diet composition of larval fishes of most common family Gobiidae in the seagrass beds of Sungai Pulai estuary, Johor Strait, Malaysia.

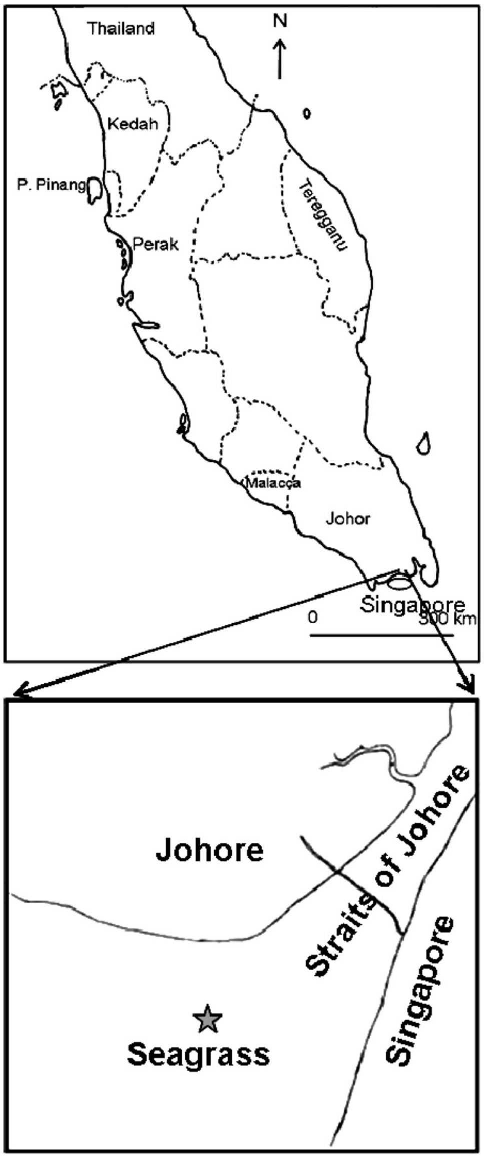

Fig. 1. Geographical local of sampling station (*) in the seagrass beds of Sungai Pulai estuary, Johor Strait, Malaysia.

Materials and Methods

Samples collection

Samples of larval fishes were collected monthly between December 2007 and May 2008 from seagrass beds of Sungai Pulai estuary (01°19.414″N 103°35.628″E), Johor Strait, Malaysia (Fig. 1). Depths of the collection sites were between 3.0 to 4.0 m. Fish larvae were collected by 30 min subsurface towing of a bongo net (0.3 m mouth diameter, 1.3 m long, 500 μm mesh at the body and cod end). The collected samples were preserved in 5% formalin and transported to the laboratory for further analysis. *In situ* hydrological parameters such as water temperature, salinity, dissolved oxygen, pH and conductivity were recorded by YSI (556 MPS, USA) during the sampling cruises.

Stomach examination

In the laboratory, the larval fishes were separated from the other zooplankton. In total 88 larvae of Gobiidae were sorted and identified using OLYMPUS dissecting microscope (SZ 51) and Leis and Carson-Ewart (2000). Total length of each individual of gobiid larvae was measured using KEYENCE digital microscope (VHX 500) before the specimens were dissected. Stomach portion was carefully removed from the body by an incision made to the abdominal region under a dissecting microscope. The stomach's membrane layer was dissected using a fine needle. Stomach contents were then identified to the possible lowest systematic level and counted under a compound microscope.

Stomach content analysis

To analyze the composition of the stomach, percentage frequency of occurrence and percentage numerical abundance was adopted:

$$\text{Percentage frequency of occurrence } (F_{pi}) = (N_{1i}/N_p) \times 100$$

Where N_{1i}, the number of the stomachs in which food item $_i$

Table 1. Monthly variation of different water parameters in the seagrass beds of Sungai Pulai estuary, Johor, Malaysia

Month	Temp. (°C)	DO (mg L^{-1})	Sal (ppt)	pH	Cond. (mS cm^{-1})
Dec. 07	28.38	5.63	29.92	7.99	45848.25
Jan. 08	27.83	5.95	32.26	8.01	51612.50
Feb. 08	28.12	6.24	33.68	7.99	51385.25
Mar. 08	26.92	5.00	32.88	7.61	50250.25
Apr. 08	29.54	4.73	29.37	8.14	45546.00
May. 08	30.82	5.80	29.78	8.06	46167.50
Mean	28.60	5.56	31.31	7.97	48468.29
SD	1.38	0.53	1.68	0.17	2654.183
Range	26.92–30.82	4.73–6.24	29.37–33.68	7.61–8.14	45848.25–51612.50

was found and N_p, the number of non-empty stomachs (Chrisafi et al. 2007).

Percentage numerical abundance

$$(C_i) = ni \Big/ \sum_{i=1}^{m} ni \times 100$$

Where n_i; the number of ith food item, m; the number of food items (Chrisafi et al. 2007).

The relative importance of food item on the diet of larva was assessed by Simple Resultant Index (%Rs) of the i th food item proposed by Mohan and Sankaran (1988).

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; refers to the percentage numerical abundance and F_{pi}; is the percentage frequency of occurrence.

Results

Environmental variables

The mean value of salinity recorded in the seagrass beds of Sungai Pulai estuary, Johor Strait was 31.31±1.68 ppt (mean±SD). The lowest value of salinity was recorded at 29.37 ppt in April; while the highest salinity was recorded at 33.68 ppt in February (Table 1). Water temperature was relatively constant between 26.92 and 30.82°C (mean±SD, 28.60±1.38°C) and dissolved oxygen was lowest (4.73 mg O_2 L^{-1}) in April and highest (6.24 mg O_2 L^{-1}) in February (Table 1). Hydrogen ion concentration varied from 7.61 (March) to 8.14 (April). The mean conductivity was found 48468.29±2654.18 mS cm^{-1} and ranged between 45848.25 and 51612.50 mS cm^{-1} (Table 1).

Diet composition

A total of 88 stomachs of larval gobiids were examined and there was no empty stomach. Analyses of prey in the stomachs identified 24 important items belonging to seven major diet groups: phytoplankton, zooplankton, insects, algae, plant-like matter, debris and unidentified materials (Table 2). The monthly percentage frequency of occurrence (F_{pi}) of food items in the guts of fish larvae are presented in Table 3. The average most important preys in the stomachs were phytoplankton (49.81%), followed by plant-like matter (16.07%), zooplankton (13.29%), algae (11.14%), debris (4.92%), unidentified matters (3.22%) and insects (2.39%). Monthly percentage of numerical abundance (C_i) of food items in the stomachs of fish larvae are presented in Table 4. The predominant item here was also phytoplankton (63.47%) and this was followed by plant-like matter (15.26%), algae (8.88%), debris (5.12%), zooplankton (5.03%), unidentified matters (1.37%) and insects (0.87%). Overall diet compositions of larval Gobiidae ranked by Simple Resultant Index (Rs) are presented in Table 5. The most important prey confirmed by Simple Resultant Index (Rs) was also phytoplankton (56.33%). Of the recorded crustaceans, ostracods represented the major food item, followed by copepods. Of the phytoplankton, Chromophyta registered the highest percent-

Table 2. Major food items found in the stomach of fish larvae in seagrass beds of Sungai Pulai estuary, Johor Strait, Malaysia

Major group	Food items
1. Phytoplankton	Chromophyta, Dinoflagellate, Diatoms, Centric Diatoms, *Chlamydomonas*, *Coscinodiscus* sp., *Euglena* sp., *Gonyaulax* sp. and other species
2. Zooplankton:	Ostracod, Copepod, Amphipod, Isopod, *Paramecium* sp., Larvaceans, Larval stage, Thaliacians (Tunicates), Decapod Appendages and Mysid
3. Insects	
4. Algae	
5. Plant like matter	Dried roots, stems, grass leaves and parts of unidentified plants
6. Debris	
7. Unidentified materials	

Table 3. Percentage frequency of occurrence (F_{pi}) of food items in the guts of Gobiidae in seagrass beds of Sungai Pulai estuary, Johor Straits, Malaysia

No. of guts	Dec.	Jan.	Feb.	Mar.	Apr.	May	
	10	10	30	5	5	28	
Food items	Frequency of occurrence (%)						Average
1. Phytoplankton	50	70	37.49	33.33	45.83	62.20	49.81
Chromophyta	30	35	18.27	23.81	20.83	31.71	26.60
Dinoflagelate	—	—	2.88	—	—	—	0.48
Centric diatom	—	—	—	—	8.33	3.66	2.00
Chlamydomonas	3.33	—	0.96	—	—	—	0.72
Euglena sp.	—	10	—	—	4.17	—	2.36
Cosconodiscus sp.	—	—	—	4.76	—	—	0.79
Gonyaulax sp.	—	—	—	—	—	1.22	0.20
Other species	16.67	25	15.38	4.76	12.50	25.61	16.65
2. Zooplankton	13.33	—	19.22	28.57	12.51	6.10	13.29
Ostracod	—	—	0.96	4.76	4.17	—	1.65
Copepod	6.67	—	2.88	4.76	—	2.44	2.79
Amphipod	3.33	—	3.85	—	—	—	1.20
Isopod	—	—	1.92	—	—	2.44	0.73
Paramecium sp.	—	—	—	—	4.17	—	0.70
Larvaceans	3.33	—	4.81	—	—	—	1.36
Larval stage (crab)	—	—	—	—	—	1.22	0.20
Thaliacians (Tunicates)	—	—	0.96	—	—	—	0.16
Decapod appendages	—	—	2.88	19.05	4.17	—	4.35
Mysid	—	—	0.96	—	—	—	0.16
3. Insects	—	—	4.81	9.52	—	—	2.39
4. Algae	13.33	—	9.62	14.29	12.50	17.07	11.14
5. Plant-like matter	23.33	25	11.54	4.76	20.83	10.98	16.07
6. Debris	—	10	10.58	4.76	4.17	—	4.92
7. Unidentified species	—	—	6.73	4.76	4.17	3.66	3.22

Table 4. Percentage of numerical abundance (C_i) of food items in the guts of Gobiidae in seagrass beds of Sungai Pulai estuary, Johor Strait, Malaysia

No. of guts	Dec.	Jan.	Feb.	Mar.	Apr.	May	
	10	10	30	5	5	28	
Food items	Numerical abundance (%)						Average
1. Phytoplankton	88.08	83.16	45.41	47.92	45.98	70.25	63.47
Chromophyta	55.05	73.68	29.66	33.33	35.06	34.92	43.62
Dinoflagelate	—	—	1.84	—	—	—	0.31
Centric diatom	—	—	—	—	3.45	0.62	0.68
Chlamydomonas	0.46	—	0.26	—	—	—	0.12
Euglena sp.	—	2.11	—	—	0.57	—	0.45
Cosconodiscus sp.	—	—	—	11.46	—	—	1.91
Gonyaulax sp.	—	—	—	—	—	0.41	0.07
Other species	32.57	7.37	13.65	3.13	6.90	34.30	16.32
2. Zooplankton	1.84	—	8.40	10.41	7.47	2.07	5.03
Ostracod	—	—	1.05	1.04	1.72	—	0.64
Copepod	0.92	—	0.79	1.04	—	0.41	0.53
Amphipod	0.46	—	2.10	—	—	—	0.43
Isopod	—	—	1.05	—	—	1.45	0.42
Paramecium sp.	—	—	—	—	4.60	—	0.77
Larvaceans	0.46	—	1.31	—	—	—	0.30
Larval stage (crab)	—	—	—	—	—	0.21	0.04
Thaliacians (Tunicates)	—	—	0.52	—	—	—	0.09
Decapod appendages	—	—	0.79	8.33	1.15	—	1.70
Mysid	—	—	0.79	—	—	—	0.13
3. Insects	—	—	3.15	2.08	—	—	0.87
4. Algae	5.50	—	7.61	26.04	4.60	9.50	8.88
5. Plant like matter	4.59	12.63	14.96	8.33	33.91	17.15	15.26
6. Debris	—	4.21	17.06	3.13	6.32	—	5.12
7. Unidentified species	—	—	3.41	2.08	1.72	1.03	1.37

age rank.

Monthly variations of diets

Highest frequency of occurrence of phytoplankton (70%) was found in January, zooplankton (28.57%) and algae (14.29%) in March. Meanwhile, the highest occurrence of debris (10.58%) was observed in February and plant-like matter (23.23%) was seen in December (Table 3). Highest numerical abundance of phytoplankton was recorded in December (88.08%), zooplankton (10.41%) and algae (26.04%) was in March, plant matter (33.91%) and debris (17.06%) in February and March respectively (Table 4).

Discussion

Our study indicates that the gobiid larvae are exclusively herbivore. According to the overall data, their main preys are the phytoplankton. This prey group represents more than 55% of total Rs (Table 5). The fish larvae appeared to select food of a certain size range varying with the size of the larvae. It is observed that the total length of fish larvae was between 2.0 and 4.0 mm and width of mouth of the larvae was ranged from 225.0 μM to 414.44 μM. Marak (1973) reported that the size range (~100 μM nauplii to ~1000 μM adult) fit into the mouth of many larval fish. Thus, copepods could be accepted as one of the diets for Gobiidae fish larvae. Based on numerical abundance, phytoplankton (Chromophyta) is the most dominant item ingested by the larvae. Similar results are also found in the diets composition of anchovy larvae which are also phytoplankton, dominated by dinoflagellates *Gymnodium splendens* (Hunter and Thomas 1972). The choice of specific group of diets could be attributed to the opportunistic behavior of the larvae. Chromophyta is naturally dominant in the seagrass ecosystem of Sungai Pulai estuary and because of their abundance; Gobiidae larvae instantly prefer this phytoplankton. Selective feeding strategy and preference could only be confirmed in laboratory trials. No other available data on gobiid larvae are available yet for confirmation. Instead of phytoplankton, the other important food items consumed by the larvae are algae and plant-like matter. For example, larvae of plaice and sand eel feed on appendicularians (larvacean) during the early stage of their life (Ryland 1964, Shelbourne 1962). Basically, plant matter consists of roots, stems, grass leaves and part of unidentifiable plants. This was also frequently (17.15%) been found in the stomachs of the gobiid larvae. Recent study on food and feeding habits of *Acetes indicus* in the coastal waters of Malacca indicated that the species was omnivorous where the main food items was plant-like matter (Amin et al. 2007). Less frequent food items found in the stomach of larvae were unidentified species (1.37%) and insects (0.87%). Debris (5.12%) was also one of the food items found in stomachs of larvae. However, debris could not be considered as important food items for fish larvae.

Table 5. Overall diet composition of Gobiidae ranked by Simple Resultant Index (%Rs) in seagrass beds of Sungai Pulai estuary, Johor Strait, Malaysia

Food items	C_i	F_{pi}	%Rs
1. Phytoplankton	63.47	49.81	56.33
Chromophyta	43.62	26.60	34.89
Dinoflagelate	0.31	0.48	0.39
Centric diatom	0.68	2.00	1.44
Chlamydomonas	0.12	0.72	0.50
Euglena sp.	0.45	2.36	1.64
Cosconodiscus sp.	1.91	0.79	1.41
Gonyaulax sp.	0.07	0.20	0.14
Other species	16.32	16.65	15.92
2. Zooplankton	5.03	13.29	9.84
Ostracod	0.64	1.65	1.21
Copepod	0.53	2.79	1.94
Amphipod	0.43	1.20	0.87
Isopod	0.42	0.73	0.57
Paramecium sp.	0.77	0.70	0.71
Larvaceans	0.30	1.36	0.95
Larval stage (crab)	0.04	0.20	0.14
Thaliacians (Tunicates)	0.09	0.16	0.12
Decapod appendages	1.70	4.35	3.19
Mysid	0.13	0.16	0.14
3. Insects	0.87	2.39	1.73
4. Algae	8.88	11.14	9.73
5. Plant like matter	15.26	16.07	15.13
6. Debris	5.12	4.92	4.85
7. Unidentified species	1.37	3.22	2.39

Conclusions

The variety of food consumed by fish larvae of Gobiidae though phytoplankton was most frequent indicates that they are mainly herbivorous. Since the availability of suitable food is one of the important factors influencing the survival of larval fish, the knowledge from this study is hope will provide information for the development of fisheries and aquaculture. Also, the knowledge can be used for further study from any other areas instead of seagrass beds.

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