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Temporal and Spatial Distribution of Larval Fish Assemblage in Different Ecological Habitat in Johor Strait, Peninsular Malaysia

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ABSTRACT

Fish larval diversity is very important for management of the fisheries resources. Fish larval density, family richness, Shannon Wiener index and evenness were determined by analyzing samples collected from the seagrass-mangrove ecosystem of Gelang Patah, Johor Strait, Peninsular Malaysia between October 2007 and September 2008. Five stations were selected namely upper estuary (S1), middle estuary (S2), lower estuary (S3), seagrass beds (S4) and outside seagrass beds (S5). In total, 24 fish larval families were identified from the investigated area. Among them, 14 occurred in upper estuary, 17 in middle estuary, 16 in lower estuary, 20 in seagrass beds and 16 in outside seagrass beds. Overall five (Clupeidae, Blenniidae, Terapontidae, Gobiidae and Sillaginidae) were the most dominant in study areas. Shannon-Wiener index varied significantly within monsoon and intermonsoon seasons peaking in the months October-January and May-August. The highest density of larval fishes was recorded at seagrass station (S4) and the spatial variations in larval density were significant ($p<0.05$) between seagrass and other four sampling sides. None of the diversity indices showed significant among-stations except only family richness was significantly ($p<0.05$) higher in seagrass beds than upper estuary.

Key words: Fish larvae, assemblages, diversity, seagrass-mangrove ecosystem, estuary

INTRODUCTION

Fish larval composition, spatiotemporal patterns of diversity and distribution are helpful to examine factors influencing the structure of the larval fish community (Galactos *et al.*, 2004). Surveys of ichthyoplankton are helpful to detect spatial and temporal variations in abundance and composition of fish larvae over large areas, therefore, representing production and management option (Gullstrom and Dahlberg, 2004). Identification of fish larvae is important not only for fisheries management purposes; it also helps to monitor of the aquatic environment through inventory of the fish fauna or ichthyoplankton fauna in the target waters. As fishes are exposed to potentially high mortality during egg and larval stages, study on larval diversity and survival rate of commercially important fishes is one of the main researches in fisheries science (Kawaguchi, 2003).

Marine research in the seagrass-mangrove ecosystem in Peninsular Malaysia is limited and the use of this habitat by larval fishes is poorly understood. Ecologically, larvae and adult are often entirely different and can be considered different ecospecies (Leis and Carson-Ewart, 2003). Seagrass beds and mangrove are place, where species are known to use as habitats during their larval and juvenile life stage (Nagelkerken *et al.*, 2000). They stay there for at least a few months. This is because these habitats provide high abundance of food and low predation pressure (Huijibers *et al.*, 2008). Even though the importance of seagrass bed as nursery areas for fish is well documented but most studies have focused on adult and juveniles rather than on larval stages (Sanchez-Velascoa *et al.*, 1996).

A lot of fish species especially larval and juvenile stages inhabit in the seagrass beds around the year throughout their entire life history for their survival and feeding (Edgar and Shaw, 1995). There are 60 described seagrass species worldwide and the majority of species are found in the Indo-Pacific region (Leis and Carson-Ewart, 2000). Merambong Shoal seagrass beds are among the most dense seagrass ecosystem in Peninsular Malaysia. Adult fish study was conducted in the Merambong seagrass beds by Jimmy (2007) but no specific study on the larval diversity and ecology has been conducted so far except the studies carried out by Arshad *et al.* (2011) and Ara *et al.* (2010, 2011). The objectives of the present study were to compare the fish larval density and composition among the river, estuary, mangrove, seagrass and outside seagrass beds of the southwestern coastal waters of Johor, Peninsular Malaysia.

MATERIALS AND METHODS

Study area: The present study was carried out in the coastal waters of Gelang Patah, Johor Strait, Peninsular Malaysia (Fig. 1). Five sampling sides were selected for this study. The location of the sampling stations were as S1 (N 01°23.345′; E 103°36.741′), upper estuary; S2 (N 01°22.79′; E 103°38.140′), middle estuary; S3 (N 01°21.597′; E 103°37.491′), lower estuary; S4 (N 01°19.414′; E 103°35.628′), Merambong seagrass beds and S5 (N 01°18.799′; E 103°35.246′), outside seagrass areas (open sea). Sampling stations were approximately 1 km apart from each other (Fig. 1).

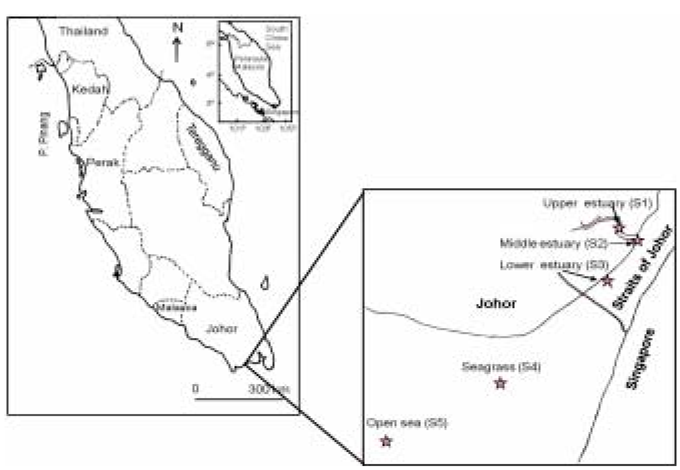

Fig. 1: Sampling area (stars) in the seagrass-mangrove ecosystem of Gelang Patah, Johor Strait, Peninsular Malaysia

Fig. 2: Bongo net (Mesh size: 500 μm, mouth diameter: 0.3 m and length: 1.3 m) was used to catch fish larvae in the seagrass-mangrove ecosystem of Gelang Patah, Johor

Field sampling: Monthly sampling were conducted during full moon/new moon period in daylight, at high tide between October 2007 to September 2008. Samples of fish larvae were collected by using Bongo net (Fig. 2) through 30 min subsurface tow from each station. A flowmeter (Hydro-Bios) was attached to the net in order to determine the volume of the water filtered. After each tow, samples were immediately fixed in 5% formalin and transported to the laboratory.

Sample processing and identification: At the end of sampling program, the fish larvae were sorted from the rest of the zooplankton and they were preserved in 75% alcohol. Individuals of fish larvae were identified to the family level using the appropriate literature (Leis and Carson-Ewart, 2000; Russell, 1976; Okiyama, 1988; Ghaffar *et al.*, 2010). Numbers of individuals per family were counted from the entire sample and then standardized to number of fish larvae per 100 m^3 based on flow meter readings. Body Length (BL) of each individual was measured to the nearest 0.1 mm.

Data analysis: Diversity of the larval fish assemblage was expressed by the Shannon-Wiener Index (Shannon and Weaver, 1963) and equitability or evenness was measured by Pielou's evenness index (J) (Pielou, 1966). Richness was calculated following Margalef (1958). Between station variations in fish density and diversity indices were analyzed by one way Analysis of Variance (ANOVA). All analyzes were done using SPSS version 15.0 and PRIMER (Plymouth Routines Multivariate Ecological Research) (Clarke and Warwick, 1994).

RESULTS

Fish larval composition and temporal abundance: Overall the larval fish assemblage included 24 families, where 14 found in upper estuary, 17 in middle estuary and 16 in lower

Table 1: Comparison of fish larval density among the different sampling stations

	Mean density (larvae/100 m^3)					
Family	S1	S2	S3	S4	S5	Mean total (%)
Ambassidae	-	-	0.24	1.9	0.81	0.93
Belonidae	0.05	0.03	-	-	-	0.06
Blenniidae	8.94	5.25	5.86	3.98	1.14	16.35
Carangidae	0.05	0.51	0.13	0.06	0.08	0.56
Clupeidae	3.30	13.34	20.04	37.91	14.15	42.63
Cynoglossidae	-	-	-	0.03	0.04	0.03
Engraulidae	0.10	0.55	0.16	1.67	0.92	1.56
Gobiidae	2.34	1.71	0.11	7.48	2.21	6.44
Hemiramphidae	-	0.03	-	0.03	-	0.03
Leiognathidae	-	-	0.03	0.57	0.08	0.21
Monacanthidae	0.03	0.11	-	0.17	-	0.15
Monodactylidae	-	0.15	0.08	0.06	0.04	0.20
Mullidae	0.24	0.21	0.70	0.79	2.14	2.06
Nemipteridae	0.33	0.41	0.77	3.19	0.10	1.90
Rachycentridae	-	-	-	0.11	-	0.03
Samaridae	-	-	-	0.06	-	0.02
Scatophagidae	-	-	-	0.08	0.19	0.13
Sillaginidae	1.87	0.52	0.05	4.23	1.84	4.09
Sphyraenidae	-	-	-	-	0.04	0.02
Syngnathidae	0.10	0.20	0.03	-	-	0.36
Terapontidae	2.30	1.36	4.02	13.75	8.04	13.54
Toxotidae	0.05	0.06	0.05	0.03	-	0.16
Triacanthidae	0.05	0.06	0.16	0.28	0.11	0.32
Uranoscopidae	-	0.09	0.03	-	-	0.09
Unidentified	4.78	2.12	0.99	3.41	1.74	7.94
Total number	522.00	909.00	1256.00	2801.00	937.00	
Total family	14.00	17.00	16.00	20.00	16.00	
Total density/100 m^3	24.72	26.71	33.45	79.08	33.67	

S1: Upper estuary; S2: Middle estuary; S3: Lower estuary; S4: Seagrass beds, S5: Outside seagrass area

estuary; 20 in seagrass beds and 16 in the outside of seagrass beds (Table 1). Overall Clupeidae was the most abundant family in the study areas which contributed (42.63%) of total fish larval abundant which was followed by Blenniidae (16.35%), Terapontidae (13.54%), Gobiidae (6.44%) and Sillaginidae (4.09%). The majority of unidentified individuals (7.94% of the total catch) were yolk-sac larvae (Table 1).

Five dominant families (Blenniidae, Clupeidae, Gobiidae Terapontidae and Sillaginidae) were observed consistently around the year in the different study areas (Fig. 3, 4). Clupeid larvae were the most dominant family appeared every month with maximum numbers in February-March (Fig. 4) which were the period of northeast monsoon season. Major peak of clupeid occurred in monsoon (February-March), which indicated seasonal spawning.

Diversity index of fish larvae in five sampling sites: The highest fish larval density was in seagrass beds and the lowest was found in upper estuary in Pendus River (Fig. 5a). The highest

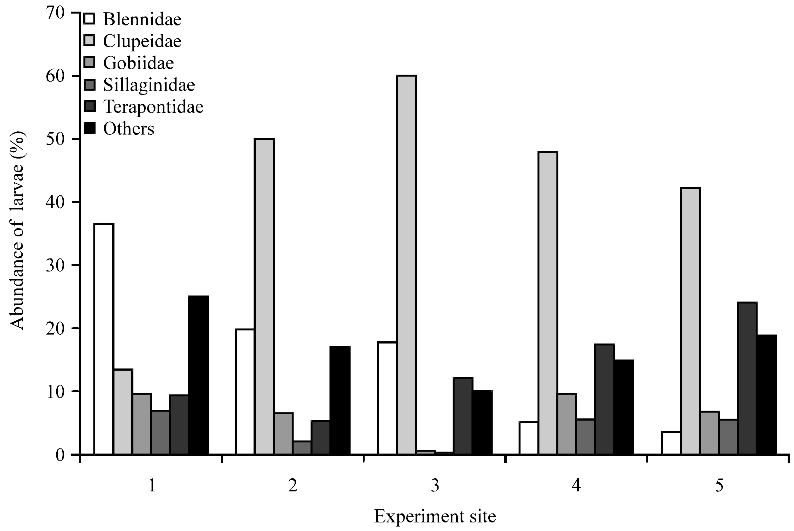

Fig. 3: Spatial variation of top five families in the study areas of Johor Strait

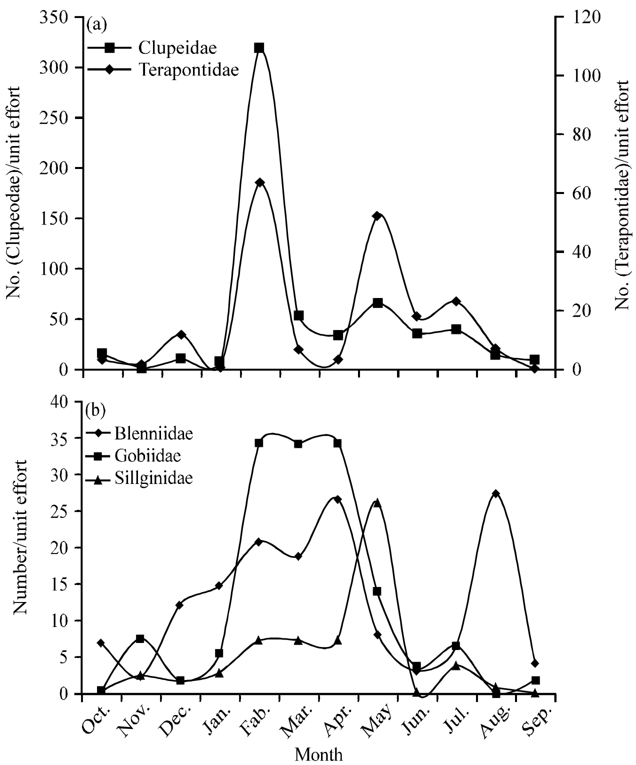

Fig. 4(a-b): Temporal variation of top five families in the study areas of Johor Strait

mean evenness (0.77) was observed at middle estuary and the lowest (0.69) was at seagrass (Fig. 5c). The highest mean family richness was observed at seagrass beds (1.82) and lowest richness (1.34) was found at upper estuary (Fig. 5d). None of the diversity indices showed significant among-stations except only family richness was significantly higher ($p<0.05$) in seagrass beds than upper estuary (Fig. 5b-d).

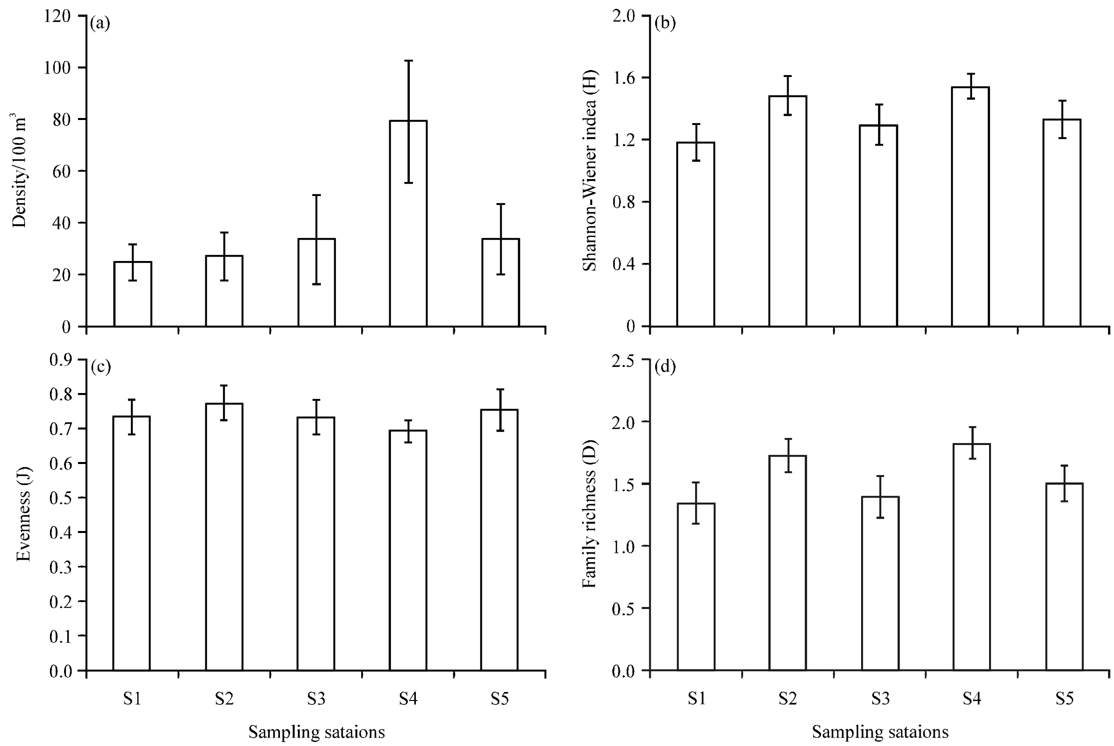

Fig. 5(a-d): Spatial variations in (a) Fish larval diversity, (b) Shannon-Wiener index (H) of diversity, (c) Evenness (J) and (d) Family richness (D) for the fish larval community in Johor Strait, Values are Mean±SE derived from 12 sampling cruises

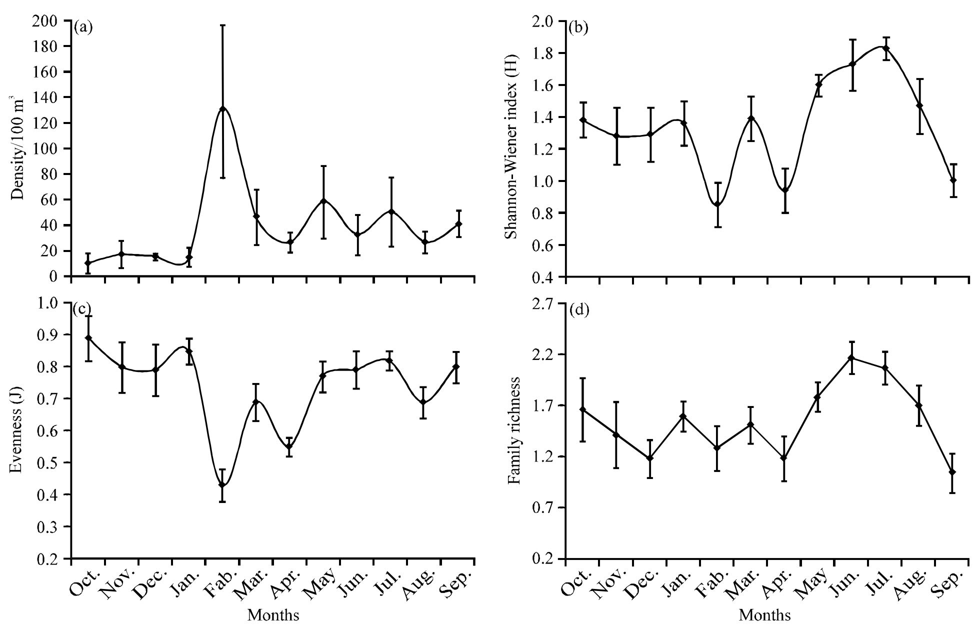

Fig. 6(a-d): Temporal variations in (a) Fish larval diversity, (b) Shannon-Wiener index (H) of diversity, (c) Evenness (J) and (d) Family richness (D) for the fish larval community in Johor Strait, Values are Mean±SE derived from 5 sampling stations

The highest mean density (130 individuals/100 m^3) of fish larvae was recorded in February (Fig. 6a). The density of total larval fishes varied significantly ($p<0.05$) among the different months. Shannon wiener index showed significant variation within monsoon and intermonsoon seasons peaking in the months of December-January and May-August (Fig. 6b-c). Family richness also clearly indicated two peaks in a year; one peak was in January-March and another May-August (Fig. 6d).

DISCUSSION

In a large-scale study in Thailand, Janekarn and Boonruang (1986) found that clupeid larval density was highest in February. Second highest family Terapontidae was found year round with the highest peak abundance in February (Fig. 4a), in a period in which this family may have their peak of spawning. Even in the other months these larvae occurred much more than the others.

The family of Gobiidae was dominant and lives in the seagrass areas. Aziz *et al.* (2006) reported two species of gobioid fish from the seagrass bed of Merchang Lagoon, Peninsular Malaysia. Larval gobiids were observed around the year with highest peaks in February-April (Fig. 4b) during northeast monsoon.

Several studies show that Gobiidae are distributed widely in the coastal areas regardless of climate and factors such as seagrass composition, temperature and biological variables (Kwak and Klumpp, 2003; Blaber *et al.,* 1997). Schooling species showed clump, highly variable recruitment that presumably resulted from aggregative settlement and this can be related to the high occurrence of family Gobiidae (Anand and Pillai, 2005).

Mean total fish larval densities were found to be 24.72, 26.71, 33.45, 79.08 and 33.67 individuals/100 m^3 in the upper, middle and lower estuary; seagrass and open sea, respectively (Fig. 5a). The highest mean density (79.08 individuals/100 m^3) of larval fishes was recorded at seagrass site (S4). The spatial variations in density of fish larvae were significant ($p<0.05$) between seagrass and other four sampling sites. The highest mean diversity index (1.54) was also observed in seagrass site while the lowest (1.18) was found at lower estuary (Fig. 5b).

Seasonal patterns of abundance of fish larvae linked to reproductive strategies of adult populations and their life cycles, which in turn are often associated with oceanographic and meteorological features (Hernandez-Miranda *et al.*, 2003). Biotic factors are related to food availability and zooplankton abundance is sometimes related to larval fish abundance, namely the seasonality of abundance of larval fish can be strongly correlated with densities of copepod nauplii (Mateo *et al.*, 2006). Prey availability may also be an important factor influencing faunal abundance in tropical seagrass beds. High seagrass standing crop provides good shelter and food resources for small organisms such as epiphytic epifauna like Amphipods, Isopods and Tanaids (Kwak and Klumpp, 2003).

Temporal diversity in species composition and abundance appear to be considerable for fish larvae communities utilizing tropical seagrass beds. Other factors that can contributes the abundance of fish larvae in seagrass beds are food and shelter availability, predator abundance, larval behaviour and physical conditions (Leis, 1991). Zaleha *et al.* (2006) reported that harpacticoid copepods are known as small size copepods and distributed along coastal areas of Terengganu, Pahang, Johor and this zooplankton are very suitable for the mouth size of larval fishes. Habitat complexity is a strong determinant of fish assemblage structure. Enhanced food resources and protection from predators are generally considered the main benefits of vegetated areas (Chavanich *et al.*, 2004). The high primary productivity of the seagrass beds and associated epiphytic and benthic algae ensure that an abundant supply of organic matter is available as the basic energy source for more or less complicated food webs. Moreover, the three dimensional structure of the vegetation, with its network of roots and rhizomes and often dense leaf canopy, offers hiding places that protect against predation (Guidetti and Bussoti, 2002). The vegetation structure also confers physical and chemical qualities to the environment that may attract fauna. These characteristics make them a suitable recruitment area for fishes (Hemminga and Duarte, 2000).

CONCLUSION

Fish larvae known to exist in the coastal waters of Gelang Patah, Johor Strait were identified. In total, 24 fish larval different families were found in the study areas. Among 24 families, five famihes occurred consistently around the year. The highest number (293 individuals/100 m^3) of fish larvae was found in the month of February in seagrass beds. Family richness was significantly higher ($p<0.05$) in seagrass region than upper estuary. Shannon Wiener index and Margalef richness were higher during the monsoon months (December-January and May-August).

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