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Larval fish composition and spatio-temporal variation in the estuary of Pendas River, southwestern Johor, Peninsular Malaysia

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Abstract—The temporal and spatial patterns of family composition and abundance of fish larvae in the Pendas River mangrove estuary (Southwestern Johor) of Peninsular Malaysia was studied monthly using bongo net in daylight sampling. Environmental factors viz., water temperature, salinity, dissolved oxygen, pH and conductivity were also monitored during sampling. In total 2687 individuals representing 19 families were collected during 12 months study period (October 2007 to September 2008). The larval fish community was dominated numerically by a few families. Clupeidae was the most abundant making up 41.07% of the total catch, followed by Blenniidae (24.45%), Terapontidae (8.80%), Gobiidae (5.40%) and Sillaginidae (3.22%). These five families constituted 82.94% of the total catch; the remaining 17.06% consisted of another 14 families. The family composition of fish larvae varied with season and location in the estuary. Several of the families showed maximum numbers during the monsoon. The diversity of the ichthyoplankton assemblage in the Pendas River mangrove estuary (19 families) is lower than in most other tropical estuaries.

Key words: Fish larvae, diversity, Pendas River, Malaysia

Introduction

Studies on 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 space and time, determination of habitats used by fish during their larval phase and discovery of new fisheries. Three general categories of fish are found in estuaries: marine fishes that use estuaries seasonally (temporary estuarine residents), those that complete their entire life history within the estuarine system (residents), and those that enter the estuary on rare occasions or are occasionally found in low numbers near inlets (Lenanton and potter 1987). Many marine fishes, including those are not resident species; spawn in or near productive coastal bays and estuaries (Chute and Turner 2001). The larval fish assemblages in near shore coastal waters are complex both in terms of species composition and distribution patterns (Harris et al. 1999, Sponaugle et al. 2002).

Mangroves in the estuaries are to absorb inorganic compounds from freshwater runoff for photosynthesis and thus play an important role as primary producers. Estuary play a role in energy transfer between a river and the sea, which is especially important for many commercial fishes whose larvae and juveniles are dependent on the estuary as a nursery and feeding ground (Tzeng and Wang 1992). Fishes play an important part in estuaries as they constitute permanent and temporary community components, with marine species visiting these habitats for feeding, reproduction, growth and protection (Rez-Guzaman and Huidobro 2002). The highly productive nature of estuarine habitats (Nixon et al. 1986, Day et al. 1989) and their role as nursery areas to fish in early many life history stages are well documented for temperate (Blabber 2000, Drake and Arias 1991, Shackell and Frank 2000) and tropical estuarine habitats (Franco-Gordo et al. 2003, Harris et al. 2001). Since early life stages are a particularly vulnerable phase, it is hypothesizes that marine fish larvae and juveniles migrate into estuaries to make use of high food abundance and refuge against predators, in order to maximize survival (Frank and Legget 1983, Kennish 1990, Van der Veer et al. 2001). Therefore, a greater understanding of ichthyoplankton dynamics in estuaries would facilitate the further development of hypotheses about estuarine nursery function (Rakocinski et al. 1996). Estuarine larval fish assemblages are variable both in terms of species composition and distribution patterns (Harris et al. 1999). These assemblages change continually in time and space, according to reproductive seasons of the species and also due to the environmental fluctuations (Garcia et al. 2003, Harris and Cyrus 1995, Hettler and Hare 1998). However, there seem to be a general tendency for estuarine fish larvae to peak in abundance during spring and summer (Cowan and Birdsong 1985, Harris et al. 1999, Talbot and Able 1984, Young and Potter 2003).

Ecologically, larvae and adult are often entirely different and can be considered different ecospecies (Leis and Carson-Ewart 2003). Ichthyoplankton surveys help to detect spatial and temporal variations in the abundance and composition of larvae over wide areas, thus indicating production and management option (Gullstrom and Dahlberg 2004). Establishment of larval fish identification is also essential not only to fisheries management, but to the monitoring of the aquatic environment through inventory of the fish fauna or ichthyoplankton fauna in the target waters. As fish are exposed to the highest mortality during egg and larval stages, study on survival success (survival rate) of commercially important fishes is one of the main subjects of fisheries sciences (Kawaguchi 2002). Therefore, the present study was undertaken to investigate the composition and distribution of fish larvae in the estuary of Pendas River, Southwestern Johor, Peninsular Malaysia.

Materials and Methods

Study area

Larval fishes were sampled from the estuary of Pendas River (Fig. 1), southwest of Johor (N 01°23.345′; E 103°36.741′ and N 01°18.799′; E 103°35.246′), Peninsular Malaysia. Three sampling stations were selected along the axis of Pendas River estuary and Johor Straits; these were upper estuary (S1), middle estuary (S2) and lower estuary (S3). The sampling stations were approximately 1 km apart from each other (Fig. 1).

Habitat characteristics

Environmental variables (Table 1) were tested for normality assumptions. Parametric tests were applied to all the variables and found normally distribution. After testing the homogeneity of variance, an analysis of variance (ANOVA) stated that there were significant differences between sites except in temperature ($p>0.05$).

Field sampling

Monthly sampling was conducted between October 2007 and September 2008. Specimens of larval fishes were collected by a bongo net (0.3 m mouth diameter, 1.3 m long, 500 μm mesh at the body and cod end) from each stations through 30 min surface tows in day light. A flow meter (Hydro-Bios) was attached to the net in order to determine the volume of the water filtered. At each sampling station, temperature (°C), dissolved oxygen (mg/L), salinity (ppt), pH, total dissolved solid (mg/L) and conductivity (mS/cm)

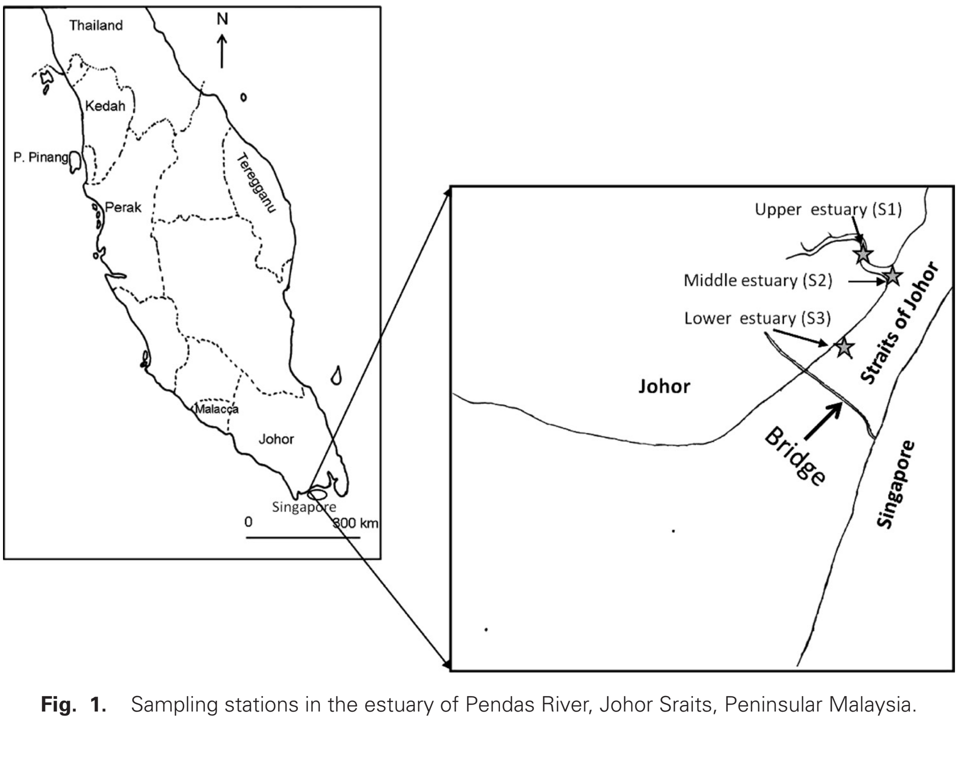

Fig. 1. Sampling stations in the estuary of Pendas River, Johor Sraits, Peninsular Malaysia.

Table 1. Physico-chemical water characteristics of different sampling site in the estuary of Pendas River (Mean±SD).

Parameters	Upper estuary	Middle estuary	Lower estuary	P
Temperature (°C)	$26.65^{a} \pm 3.68$	$28.3^{a} \pm 1.79$	$28.64^{a} \pm 1.89$	0.083NS
*DO (mg L^{-1})	$3.93^{a} \pm 0.40$	$4.79^{b} \pm 0.85$	$5.18^{bc} \pm 0.86$	0.000*
*Salinity (ppt)	$24.72^{a} \pm 4.81$	$27.52^{a} \pm 3.22$	$28.89^{b} \pm 1.73$	0.019*
*pH	$7.39^{a} \pm 0.31$	$7.58^{a} \pm 0.37$	$7.88^{b} \pm 0.12$	0.001*
Conductivity (mS cm^{-1})	$39241.32^{a} \pm 7209.16$	$42819.52^{a} \pm 5397.04$	$45074.38^{c} \pm 5819.74$	0.042*

For each environmental variable, means with the same letter superscript are not significantly different. * The mean difference is significant at 5% level; NS, not significant at 5% level.

were recorded on board during each cruise by means of YSI meter (556 MPS, USA).

Sample processing

After each tow, samples were immediately fixed in 5% formalin and transported to the laboratory. Fish larvae were sorted from the rest of the zooplankton and they are preserved in 75% alcohol. Individuals of fish larvae were identified to the family level using the appropriate literature (Leis and Carson-Ewart 2000, Okiyama 1988, Russell 1976). Numbers of individuals per family were counted and then standardized to number of fish larvae per 100 m^3 from the entire sample.

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 (Pielou 1966). Family richness was calculated following Margalef (1958). Between-station variations in temperature, salinity, DO, pH, conductivity, fish density and diversity indices were analyzed by one way analysis of variance (ANOVA). All analyses were done using SPSS version 11.5 and PRIMER (Plymouth Routines Multivariate Ecological Research) (Clarke and Warwick 1994).

Table 2. Composition and abundance (expressed as the mean no. of larvae/100 m^3) of larval fishes in the estuary of Pendas River.

Family	Mean Density (Larvae/100 m^3)			Mean total (%)
	Upper estuary	Middle estuary	Lower estuary	
1 Ambassidae	—	—	0.24	0.24
2 Belonidae	0.05	0.03	—	0.11
3 Blenniidae	8.94	5.25	5.86	24.45
4 Carangidae	0.05	0.51	0.13	0.83
5 Clupeidae	3.30	13.34	20.04	41.07
6 Engraulidae	0.10	0.55	0.16	0.98
7 Gobiidae	2.34	1.71	0.11	5.40
8 Hemiramphidae	—	0.03	—	0.11
9 Leiognathidae	—	—	0.03	0.03
10 Monacanthidae	0.03	0.11	—	0.17
11 Monodactylidae	—	0.15	0.08	0.27
12 Mullidae	0.24	0.21	0.70	1.28
13 Nemipteridae	0.33	0.41	0.77	1.72
14 Sillaginidae	1.87	0.52	0.05	3.22
15 Syngnathidae	0.10	0.20	0.03	0.60
16 Teraponidae	2.30	1.36	4.02	8.80
17 Toxotidae	0.05	0.06	0.05	0.26
18 Triacanthidae	0.05	0.06	0.16	0.30
19 Uranoscopidae	—	0.09	0.03	0.15
20 Unidentified	4.78	2.12	0.99	10.08
Total number	**522**	**909**	**1256**	
Total family	**14**	**17**	**16**	
Total density/100 m^3	**24.72**	**26.71**	**33.45**	

Results

Fish larval composition and abundance

A total of 2687 larvae were collected from the study areas, with a mean abundance of 28.29 per 100 m^3. The larval fish assemblage included 19 families, where 14 found in upper estuary, 17 in middle estuary and 16 in lower estuary (Table 2). Clupeidae was the most abundant family which contributed 41.07% of total fish abundant which was followed by Blenniidae (24.45%), Teraponidae (8.80%), Gobiidae (5.40%), Sillaginidae (3.22%), Nemipteridae (1.72%) and Mullidae (1.28%). The majority of unidentified individuals (10.08% of the total catch) were yolk-sac larvae (Table 2). Five dominant families (Blenniidae, Clupeidae, Gobiidae, Teraponidae and Sillaginidae) were observed consistently in the study areas (Fig. 2). Temporal abundance of total larval fishes in the upper, middle and lower estuary is presented in Fig. 3.

Spatial density and diversity

Total mean density of fish larvae was found to be 24.72, 26.71 and 33.45 individuals/100 m^3 in the upper, middle and lower estuary, respectively (Fig. 4a). The spatial variations in density of fish larvae were not significant ($p>0.05$) among the stations. The highest mean Shannon Winner diversity index (1.48) was recorded at middle estuary while the lowest (1.18) was found at upper estuary (Fig. 4b). The highest evenness (0.77) was calculated at middle estuary and there was no variation in evenness between upper and lower estuary (Fig. 4c). The highest family richness was also found at middle estuary (1.72) and the lowest richness (1.34) was recorded at upper estuary (Fig. 4d). None of the diversity indices showed significant variation ($p>0.05$) among the stations.

Temporal density and diversity

The highest mean total density of fish larvae (113.12 individuals/100 m^3) was recorded in February (Fig. 5a). 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. 5b). Family richness also clearly indicated two peaks in a year. One peak was in January–March and another in May–August (Fig. 5d).

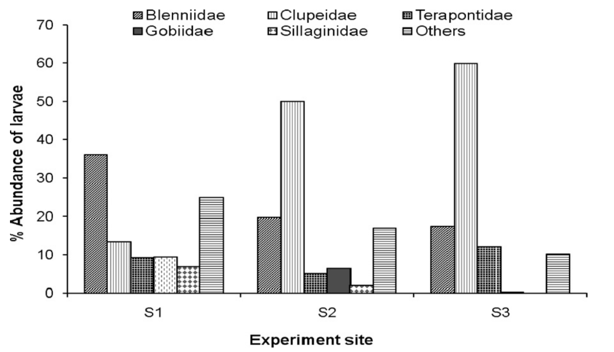

Fig. 2. Abundance of top five families in upper (S1), middle (S2) and lower (S3) estuary of the Pendas River.

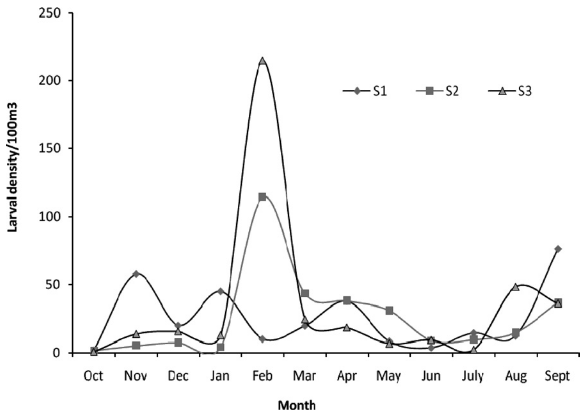

Fig. 3. Temporal abundance of larval fishes in upper (S1), middle (S2) and lower (S3) estuary of the Pendas River.

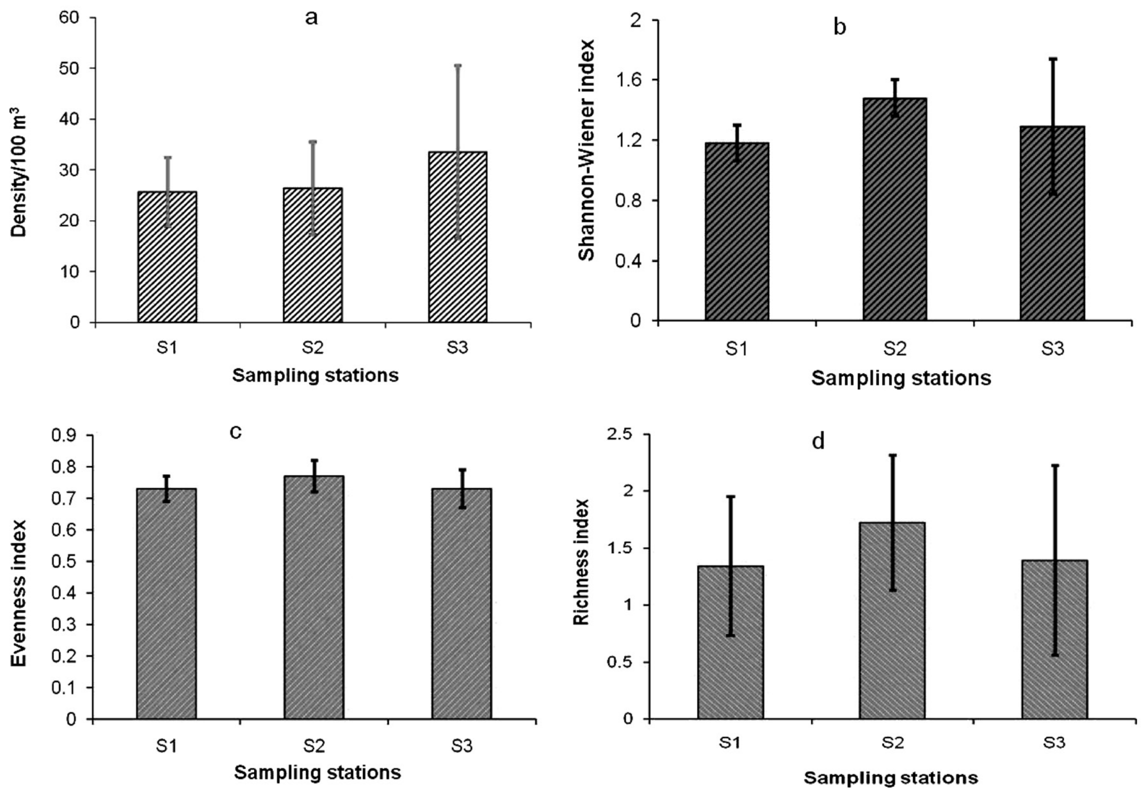

Fig. 4(a–d). Spatial variations in fish larval diversify (density/100 m^3), Shannon-Wiener index of diversity, family richness and evenness index for the fish larval community in the estuary of Pendas River; values are mean±SE derived from 12 sampling cruises.

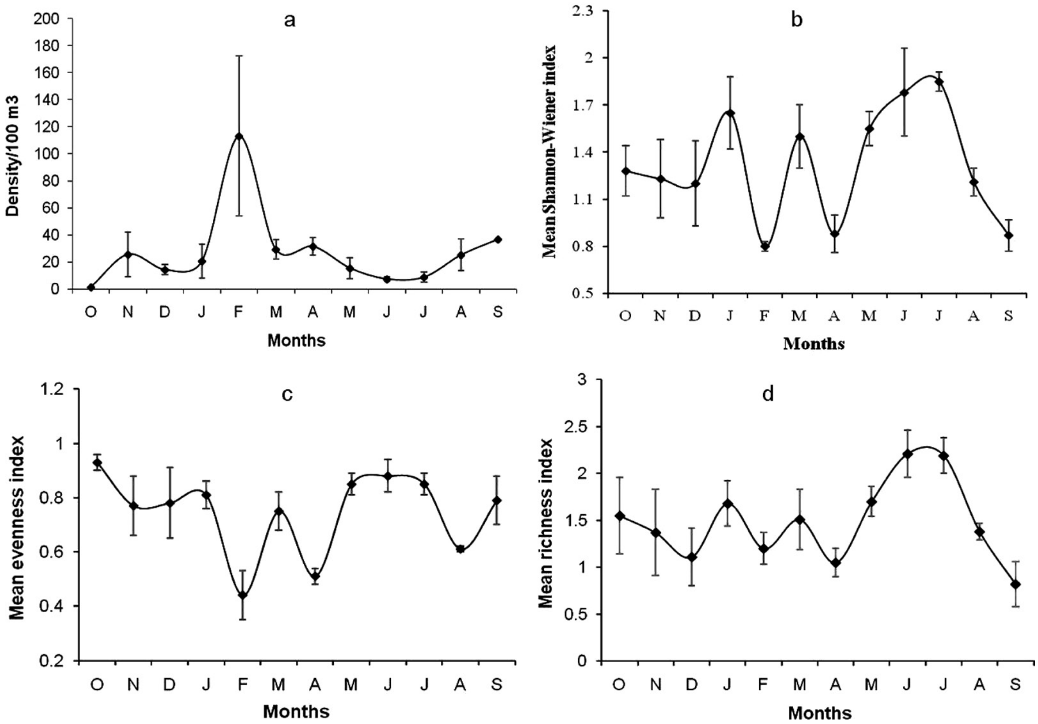

Fig. 5(a–d). Temporal variations in fish larval diversity (density/100 m^3), Shannon-Wiener index of diversity, family rishness and evenness index for the fish larval community in the estuary of Pendas River; values are mean±SE derived from 5 sampling stations.

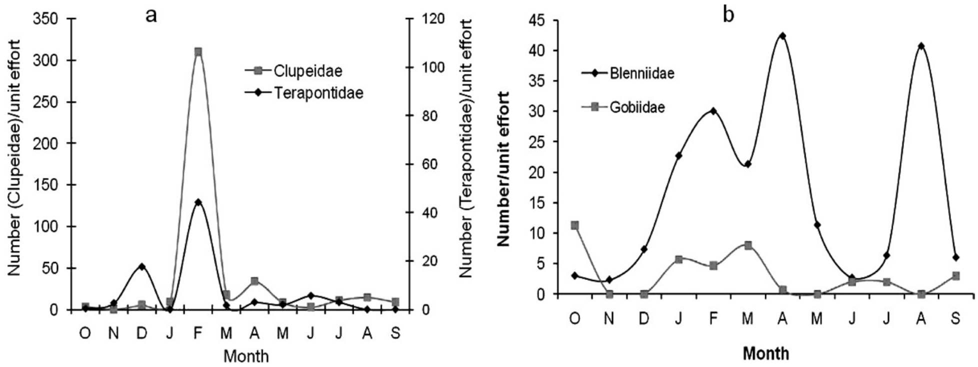

Fig. 6. Temporal variation of top four families in the study areas.

Discussion

The larval fish assemblage included 19 families, where 14 found in upper estuary, 17 in middle estuary and 16 in lower estuary. Clupeidae was the most abundant family which contributed 41.07% of total fish abundant which was followed by Blenniidae (24.45%), Teraponidae (8.80%), Gobiidae (5.40%) and Sillaginidae (3.22%). The majority of unidentified individuals (10.08% of the total catch) were yolk-sac larvae (Table 2). The highest mean density (113.12 individuals/100 m^3) of fish larvae was recorded in February (Fig. 5a). 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. 5b). Family richness also clearly indicated two peaks in a year; one peak was in January–March and another in May–August (Fig. 5d). 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).

Clupeid larvae were the most dominant family appeared every month with maximum numbers in February–March which were the period of northeast monsoon season in Peninsular Malaysia. Major peak of clupeid occurred in monsoon (February–March), which indicated seasonal spawning (Fig. 6a). In a large-scale study in Thailand, Janekarn and Boonruang (1986) found that clupeid larval density was highest in February. Second highest family Teraponidae, was found in year round with the highest peak abundance in February (Fig. 6a), possibly reflecting spawning period of this family. Even in other months these larvae occurred much more than the others. Larval gobiids were observed in around the year with highest peaks in January–March (Fig. 6b) during northeast monsoon. Aziz et al. (2006) reported two species of gobiid fish from the seagrass bed of Merchang Lagoon, Peninsular Malaysia. 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 David 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). Distribution pattern of total fish larvae revealed that the total number of families and densities in the estuary clearly decreased from the lower estuary to upper estuary (Table 2). This indicates that fish larvae in the estuary originated from the open sea. Recruitment of dominant families (Clupeidae, Blenniidae, Gobiidae and Teraponidae) to the estuary occurred around in January–March (Northeast monsoon) and June-August (Southwest monsoon). The unique feature of fish larval assemblage in the Pendas River estuary is the monsoonal influence on their abundance.

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