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A SNAPSHOT STUDY ON LARVAL FISH DIVERSITY IN SELECTED MANGROVE AREAS OF PENINSULAR MALAYSIA, MALAYSIA

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Abstract

The study on composition, abundance and diversity of larval fish was conducted with the aim to attain information on larval fish breeding ground and made easy for fishery management. Larval fish were collected during September 2015 from mangrove areas of Pekan Pahang, Pendas Johor, Matang Perak and Setiu Terengganu using a bongo net, towed at a depth of about 0.5 m from the surface for 5 min against the tidal flow. A total of 354 larval fish were collected, representing 21 families and 51 species. The top 3 families were Gobiidae (39.26%), Engraulidae (14.97%) and Clupeidae (14.40%), occurred in all sampling areas except in Setiu. The most abundant 11 species formed about 50% of all collected larval fish. Gobiidae spp. were the most abundant, making up 17.8% of the total catch, followed by Clupeidae spp. (12.7%), Engraulidae spp. (8.2%), *Ambassis dusumieri* (6.5%), *Thryssa kammalensis* (4.8%), *Pseudogobius masago* (both 4.8%), Sillaginidae spp. (4.2%), Ambassidae spp. (3.4%), *Pseudogobius* sp. (3.4%), Blenniidae spp. (2.8%), and *Hemigobius hoevenii* (2.5%). The highest diversity of larval fish was recorded for Pendas, Johor with Shannon Wiener index H_s = 2.699, and the lowest was Setiu, Terengganu (H_s = 0.832). The highest evenness index of larval fish species was recorded for Pekan, Pahang with E_s = 0.815 and the lowest for Setiu Terengganu with E_s = 0.465, indicating high single-species dominance. Species overlapping was the highest between Pendas and Setiu at 14.3%, and zero similarity of fish composition was recorded between Matang and Setiu according to Jaccard coefficient. Findings from surveillance of larval fish species provide valuable information for future biodiversity studies and allow better management of biodiversity resources in the mangrove ecosystem of Malaysia.

Keywords: Larval fish, species composition, diversity, mangrove area, Peninsular Malaysia

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Introduction

Malaysia supports a sizeable area of mangrove forest, which covers 505,382 ha, and is automatically ranked as the second largest surface area covered with mangrove forest among Asian countries (Sandilyan and Kathiresan, 2014). About 99,180 ha of mangrove area was distributed in Peninsular Malaysia (Tan, 2007), and the rest of them were in Sabah and Sarawak. Mangrove is a productive area used by aquatic animals, especially fish. Three hypotheses have been proposed to explain the high abundance of fish in mangrove areas (Laegdsgaard and Johnson, 2001; Wang *et al.*, 2009): (1) the predator refuge hypothesis, which stresses that the structural complexity of mangrove pneumatophores and prop roots provide excellent shelter from predators for juvenile and small fish by migrating into vegetated areas of mangroves particularly when the trees are inundated by water; (2) the feeding hypothesis, where there is a greater abundance of food within mangrove due to high productivity and abundance of benthic fauna (Laegdsgaard and Johnson, 2001); and (3) cover of extensive areas (Hajisamae *et al.*, 2006).

Mangrove ecosystems have enormous ecological value. They protect and stabilize coastlines, enrich coastal waters, and yield commercial forest products (Kathiresan and Bingham, 2001). Not only aquatic animals but also humans benefited from mangroves as they provide protection by acting as coastal buffering against negative impacts of wave action as a result of rising sea levels due to climate change (Alexandris *et al.,* 2013). Mangrove forests along West Malaysia's coastline had greatly buffered the tsunami that hit Malaysia in 2004 (Siti-Nurazlinee, 2011). Despite this, mangrove forests along the coastline of Malaysia are increasingly being threatened by rapid development and urbanization (Ong, 1995) as well as pollution and over-cropping of timber (Farnsworth and Ellison, 1997). Thus, the reduction in mangrove forests could have a significant impact on the levels of diversity of mangrove fish residents.

The vast majority of marine teleost fish have a pelagic larval phase that differs greatly in morphology from the adult. The pelagic stage may last as briefly as 1 week in some damselfish (Pomacentridae) or more than 64 weeks in some porcupine fish (Diodontidae) (Leis and McCormick, 2002). The larval fish of epipelagic species share the same habitat with their adults. By contrast, larval fish of meso- and benthypelagic species are typically found in the epipelagic zone, which is much closer to the surface than their adults, and undergo an ontogenetic descent as they grow and develop (Leis, 2015).
Larval fish frequently bear little resemblance to the adults for two reasons: 1) the larval fish are, at least initially, incompletely developed and lack structures found in adults (e.g., scale of fins); and 2) the larval fish frequently have specializations to pelagic existence that result in some of the most spectacular marine creatures known, but the specialization will be lost as development proceeds (Leis, 2015). The identification of larval fish has been an important morphological issue in marine ecology due to the dramatic transformations that most species undergo from early larval stages to adulthood (Bernal *et al.,* 2014).

Studies on species composition of larval fish assemblages and distribution in mangrove estuaries have been documented in a few occasions (Blaber *et al.,* 1997a; Tzeng *et al.,* 1997; Ooi and Chong, 2011; Ara *et al.,* 2013; Abu El-Regal and Ibrahim, 2014; Rezagholinejad *et al.,* 2016). Larval fish studies in the mangrove ecosystem were challenged by a few aspects such as the requirement of extensive sampling work, tedious and time-consuming identification process on larval fish samples, and the greatest challenge—the lack of larval fish identification keys.

Information on larval fish in mangrove estuary of Malaysia is still lacking and requires more surveys to be conducted. Most recent records on larval fish study in Malaysia were done in Marudu Bay, Sabah (Rezagholinejad *et al.,* 2016); Pendas, Johor (Ara *et al.,* 2011); and Matang, Perak (Ooi and Chong, 2011). Larval fish communities in different habitats of mangroves were compared on the basis of species richness, abundance, and diversity. For example, 19 families represented by 92,934 larval fish specimens were identified in the Matang estuaries (Ooi and Chong, 2011), 24 families (2801 larval fish specimens) in Gelang Patah Johor with moderate abundance of larval fish captured during September (Ara *et al.,* 2013), and 20 families (3879 larval fish specimens) in Marudu Bay Sabah (Rezagholinejad *et al.,* 2016). Matang Perak manifests the highest abundance of larval fish collections among all, as the huge mangrove forest area of 41,711 ha and 8653 ha of estuarine waterways (Ooi and Chong, 2011) allows Matang to house a large number of larval fishes. This study was intended to add more larval fish data, which will benefit management and conservation efforts to protect both the fish and their habitat from drastic changes.

Materials and Methods

Data Collection

Larval fish samples were collected from 10 September to 17 September 2015. Four mangrove areas surveyed, namely, Pendas in Johor, Pekan in Pahang, Matang in Perak, and Setiu in Terengganu (Fig. 1). Both Pendas and Matang were located on the west side of Peninsular Malaysia; Pekan and Setiu were on the east of Peninsular Malaysia. The position of sampling sites and physical features are given in Table 1. The sampling was conducted during a full moon as the moon phases influence the distribution of larval fish species by changing their abundance and composition in the mangrove creeks

(Lima *et al.*, 2015). Sampling work was focused during the highest tide by referring to tide tables (National Hydrographic Malaysia, 2015).

Larval fish were sampled with bongo net with 500 µm mesh size of the body and cod end, equipped with a flow meter in the net opening to measure the water flow rate. The net was towed at a depth of about 0.5 m from the surface for 5 min against the tidal flow at a speed of 2 knots. Weights of 2 kg were loaded when the bongo nets had difficulties to submerge or when the tide was large. Sampling activities were focused around 50 m^2 of the mangrove area. Whole samples were preserved in 95% ethanol during sampling and later transported to the laboratory where the larval fish were sorted out from the rest of the zooplankton.

Morphological identifications of larval fish

Identification of individual larval fish to the family level and if possible, to genus level was carried out based on appropriate literature (Russell, 1976; Okiyama, 1988; Jayaseelan, 1998; Leis and Carson-Ewat, 2000; Ghaffar *et al.*, 2010). Morphological identifications were usually successful up to the family level and, for some individuals, up to the genus and species level. All individuals were measured to the nearest 0.1 mm total length, except for certain individuals lacking tailfins and tightly coiled or folded body shape. Voucher specimens were kept in the Aquatic Laboratory, Aquaculture Department, Faculty of Agriculture, Universiti Putra Malaysia, Serdang.

FIGURE. 1. Map of Peninsular Malaysia showing mangrove area where larval fish were collected.

TABLE 1. Sampling sites at mangrove area in Peninsular Malaysia with its locality and habitat description.

Sites	Station	Description of Site
1	Pendas, Johor (1°22'07.3"N; 103°38'11.3"E)	Minimal disturbance of mangrove forest due to road works. Depth ≤8 m. Water: clear and bluish black in color. Flow velocity: steady. (3250–4370 sm^3/s).
2	Pekan, Pahang (3°27.047"N; 103°26.687"E)	Minimal amount of mangrove vegetation. Depth ≤6 m. Water: muddy and brown in color. Flow velocity: medium tide with minimal wave. (1390–6250 sm^3/s)
3	Matang, Perak (4°47'41.10"N; 100°37'32.70"E)	Mangrove forest intact. Depth ≥8 m. Water: clear and greenish in color. Flow velocity: steady. (2540–3420 sm^3/s)

4	Setiu,Terengganu (5°40.504"N; 102°43.147"E)	Mangrove forest intact. Depth ≤2 m. Water: very clear and greenish in color. Abundant of fish farming activities. Flow velocity: steady. (1490–2760 sm^3/s)

Biodiversity analysis

Indices of diversity and evenness were calculated to indicate patterns of diversity, abundances, and equitability within and among stations (Ayala *et al.*, 2016). Species diversity relates to the number of different species and the number of individuals of each species within any one community. Shannon–Wiener diversity index (H) is a measure of diversity, which takes into account both species richness and an evenness of abundance among the species present (Shannon and Weaver, 1949). In essence, it measures the probability that two individuals randomly selected from an area will belong to the same species. The formula explained by calculating *p*, the proportion (n/N) of individuals of one particular species found (n) divided by the total number of individuals found (N), ln is the natural log, Σ is the sum of the calculations, and *s* is the number of species. The formula for calculating H is presented as;

$$H = -\sum_{i=1}^{S}(p_i \ln p_i)$$

The evenness of distribution was presented by Evenness Index (Magurran, 1988) whereby *Es* = *Ds/ Dmax*, where *Dmax* is the value *Ds* would take if the abundances in the samples are all equal. The *Ds* value was calculated from the Simpson index as follows:

$$D = \frac{\sum ni(ni-1)}{N(N-1)}$$

where n_i is the number of individuals in the *i*-th species and *N* is the total number of individuals. The *Ds* value is set between 0 to 1; a better tool to explain results obtained from single snapshot samplings, where a temporal element was not involved.

The similarity in the species composition of larval fish among stations was determined by the Jaccard coefficient and clustered with unweighted pair-group using arithmetic averages (UPGMA). The Jaccard coefficient were calculated using the index below:

Jaccard Index = (the number in both sets) / (the number in either set) * 100

The Catch index was used to express the number of individuals per species caught; thus, dominant species can be determined. The value of this index is calculated as *Ci* = n_i / *N*, where n_i is the number of individuals in the *i*-th species and *N* is the total number of individuals caught. One-way analysis of variance (ANOVA) was done in XLSTAT 2016 to determine differences in the number of individuals and number of species between sampling stations.

Results and Discussion

Composition of larval fish

The investigation on larval fish diversity and distribution have received a lot of attention for the past decades but mostly have been focusing on mangrove areas located on the west side of Peninsular Malaysia (Ara *et al.*, 2011; Ooi and Chong, 2011). Larval fish studies from the east side of Peninsular Malaysia such as in Setiu and Pekan have yet to be done. One reason why studies on larval fish living in mangrove have been focused in the area of Matang and Pendas was mainly due to the fact that the mangrove forests in Peninsular Malaysia were predominantly distributed on the west side of the region with an area of 90,041 ha or 92% of the total mangroves in Malaysia. Only a small portion (8% of mangrove areas of Peninsular Malaysia) of mangrove forest was found on the east side of the region (7739 ha) where Setiu and Pekan were situated (Chong, 2007a). Despite this, information on the status of larval fish composition and abundance in those areas is important for fisheries management and as an indicator for predicting fishing stocks. According to Teh and Teh (2014), the east coast of Malaysia was responsible for 24% of fish landing in Malaysia.

A total of 354 individuals of larval fish were collected from the 4 stations of mangrove areas in this study. Morphological analyses identified 51 species belonging to 21 families (Table 2). Among the 21 families, the top 3 families, namely, Gobiidae (39.26%), Engraulidae (14.97%), and Clupeidae (14.40%), occurred in all sampling areas except in Setiu. The most abundant 11 species formed about 50% of all collected larval fish. The Catch index showed that *Gobiidae* spp. was the most abundant species (17.8%) followed by *Clupeidae* spp. (12.7%), *Engraulidae* spp. (8.2%), *Ambassis dusumieri* (6.5%), *Thryssa kammalensis* (4.8%), *Pseudogobius masago* (4.8%), *Sillaginidae* spp. (4.2%), *Ambassidae* spp. (3.4%), *Pseudogobius* sp. (3.4%), *Blenniidae* spp. (2.8%), and *Hemigobius hoevenii* (2.5%) (i.e., >2% of the total catch) (Table 2).

All larval fish families were represented by more than one species (n ≥ 2), with the only exceptions being the families of Callionymidae, Pomacentridae, Apogonidae, Mugilidae, Sciaenidae, and Mullidae, where they were represented by only one species.

TABLE. 2. Occurrence of larval fishes from the four mangrove areas surveyed in Peninsular Malaysia.

Family	Species	Occurrence				Catch index
		Pendas in Johor	Pekan in Pahang	Matang in Perak	Setiu in Terengganu	
Sillaginidae	*Sillago sihama*		1			0.003
	Sillago spp.	15				0.042
Blenniidae	*Cirripectes stigmaticus*	1				0.003
	Blenniidae spp.	8			2	0.028
Tetraodontidae	Tetraodontidae sp.	1				0.003
	Terapontidae sp.		1		1	0.006
Apogonidae	Apogonidae sp.	1		1		0.006
Mullidae	Mullidae sp.				1	0.003
Eleotridae	*Eleotris* sp.			2		0.006
	Eleotris oxycephala		1			0.003
Leiognathidae	*Leiognathus* sp.	2				0.006
Gerreidae	*Gerres* sp.	2				0.006
	Gerres shima	2				0.006
Clupeidae	*Hilsa kelee*	2				0.006
	Sardinella sp. A	2				0.006
	Sardinella sp. B	2				0.006
	Clupeidae spp.	14		31		0.127
Scatophagidae	*Scatophagus argus*	4	1			0.014
	Scatophagus sp.				1	0.003
Monacanthidae	*Monacanthus* sp.	1				0.003
	Paramonacanthus sp.	1				0.003
Sparidae	*Sparus* spp.	7				0.020
Lutjanidae	*Lutjanus apodus*			3		0.008
Sciaenidae	Sciaenidae sp.			1		0.003
Sygnathidae	*Hippichthys penicillus*	2				0.006
Mugilidae	*Paramugil parmatus*		1			0.003
	Mugilidae sp.			1		0.003
Ambassidae	*Pseudamia* sp.	2	1			0.008
	Ambassis marianus	4	3			0.020
	Ambassis dusumieri				23	0.065
	Ambassis sp.				1	0.003
	Ambassidae spp.	1		11		0.034
Engraulidae	*Thryssa kammalensis*		17			0.048
	Thryssa hamiltonii	1	5	1		0.020
	Engraulidae spp.	5	13	11		0.082
Gobiidae	*Boleophthalmus pectinirostris*		3			0.008
	Periopthalamus modestus		2	3		0.014
	Pseudogobiopsis sp. 'A'		2			0.006
	Pseudogobiopsis sp. 'B'		2	1		0.008
	Pseudogobius masago	3	9	5		0.048
	Pseudogobius sp.	3	2	7		0.034
	Acentrogobius sp.	2	2	2		0.017
	Hemigobius sp.			1		0.003
	Mugilogobius sp.		1	1		0.006

	Gobiopterus sp. 'A'			4		0.011
	Gobiopterus sp. 'B'			7		0.020
	Glossogobius aureus	3				0.008
	Hemigobius hoevenii	1		8		0.025
	Gobiidae spp.		11	52		0.178
Callionymidae	Callionymidae sp.	1				0.003
Pomacentridae	Pomacentridae sp.	1				0.003
Total number of fish larvae		94	78	153	29	
Total no. of species		29	19	20	6	

Diversity of larval fish

The analysis of the diversity indices showed that Pendas had the highest diversity index (H=2.699), whereas Setiu had the lowest value of diversity index (H=0.832) (Table 3). The number of species was also much higher in Pendas than the rest of the sampling stations as indicated by their richness values (Table 3). The evenness values were almost the same between Pendas and Pekan (E=0.801 and E=0.815, respectively), whereas Matang was slightly lower (E=0.737) compared with Pendas and Pekan. However, Setiu recorded the lowest evenness value, indicating high single-species dominance (Table 3).

TABLE. 3. Larval fish abundances, indices of diversity, and evenness at stations sampled on September 2015 in mangrove areas of Peninsular Malaysia.

Sites	Sampling date	Fish larval collected (total number)	Species present (total number)	Shannon Wiener Index (H)	Evenness Measures (E)
Pendas, Johor	September 14, 2015	94	29	2.699	0.801
Pekan, Pahang	September 12, 2015	78	19	2.443	0.815
Matang, Perak	September 17, 2015	153	20	2.21	0.737
Setiu, Terengganu	September 10, 2015	29	6	0.832	0.465

The ANOVA showed that a significant difference exists between the four mangroves areas (F=1.365, $P< 0.05$). Regarding the spatial distribution of larval fish (Table 2), Matang harbored the highest number of larval fish collected (43.22%) and was represented by 20 families. Specimens from family Clupeidae, Engraulidae, and Gobiidae were the most abundant in Matang. The mangrove in Matang recorded the highest number of total larval fish caught, reflecting sufficient food resources (i.e., zooplankton) in mangroves (Chong, 2007b). Combined with the high value of diversity index, this result indicates that this area is more suitable for larval fish compared with the other stations. This was in contrast to the situation in Setiu whereby the number of individuals caught was the lowest even though the sampling area had recently been gazetted as a protected area (2015), called the Setiu Wetland, Terengganu. In addition, Setiu was observed as an extensive fish farming or aquaculture area which according to Abroguena *et al.* (2012), the aquaculture pond operation usually affects mangrove function and lead to increase in stress level of ecosystem health.

Pendas mangrove had a slightly higher number of specimens (26.55%), represented by 29 families, compared with Pekan mangrove area (22.03%), which was represented by 19 species. Specimens from family Clupeidae and Sillaginidae were found in highest number at Pendas, whereas Gobiidae was the most dominant in Pekan's collection of larval fish. However, Setiu recorded the lowest specimens caught (n = 29) and the lowest species occurrence (6 species), with Ambassidae as the most caught (Fig. 2). Pendas had a diverse mangrove forest and exhibited the most extensive seagrass bed ecosystem in Peninsular Malaysia (Ara *et al.,* 2013), where species are known to inhabit during their juvenile life stage (Nagelkerken *et al.,* 2002). Despite the second highest capture of larval fish (n = 94), Pendas was found to possess the highest number of species diversity. Even though this area had experienced a significant anthropogenic disturbance: the Johor Port at Pasir Gudang in Malaysia was constructed in 1972–77 (Fong, 1984); in addition to extensive damming and land reclamation works being carried out, the finding from this sampling did not show any adverse effect from those activities.

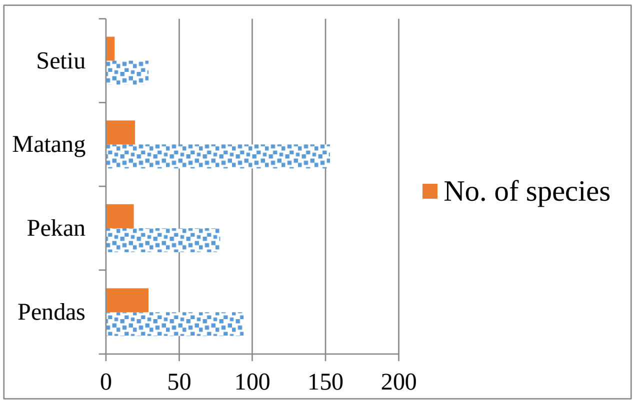

Figure 2. Number of larval fish species and individuals caught at different mangrove stations.

Meanwhile, although Pekan was not heavily covered by mangrove forests and turbid water, it was found to house a number of larval fishes from a minimal diversity of larval fish (H = 2.443). According to Negelkerken *et al.* (2008), some species respond positively to the turbidity of the water and also lessen the predation rate by reducing the effectiveness of large visual fish predators. Turbid water also holds great potential to benefit larval fish as it is rich in nutrient and enhance zooplankton availability (Carreon-Martinez *et al.*, 2015). However, the findings on the diversity of larval fish in this study could be different once the identification of specimen to family level (spp) managed to be grouped according to genera or species level. Even so, in most cases of larval fish identification, they are best identified to family level due to the lack of identification keys (Ooi and Chong, 2011). Similarity analyses through Jaccard's coefficient showed that Pendas and Setiu have the highest similarity of species (0.143) which is Blennidae spp. The similarity of species composition was the least between Matang and the rest of the stations. Only 2.1% of species were found to be overlapped between them. More interestingly, there were zero similarities of fish composition between Matang and Setiu as one was located on the west of Peninsular Malaysia, facing the Malacca strait, and the other was located on the east of Peninsular Malaysia, which was influenced by the South China Sea (Fig. 3).

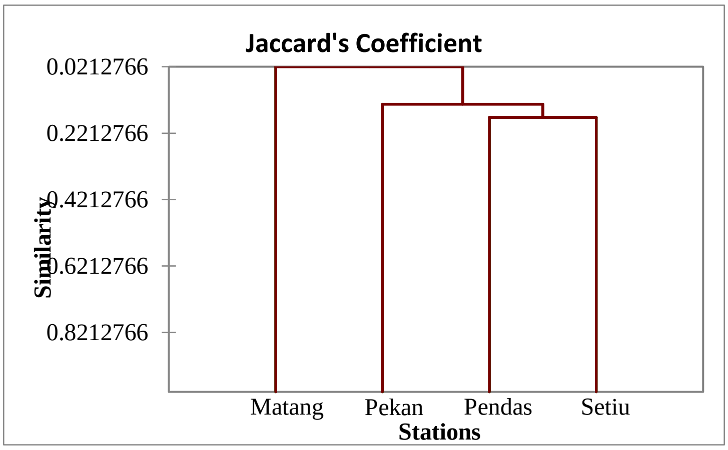

FIGURE 3. A dendogram showing a cluster of the larval fish species occurrence among the mangrove areas studied.

Overall, the larval fish catch was numerically dominated by the family Gobiidae (38.7% of the total catch), particularly in Matang and was also found in Pendas and Pekan. The result was similar to the findings by Chong (2007b), in which Gobiidae family populated the highest number of catch among other families in the Matang mangrove area. Huang *et al.* (2013) claimed to capture 23 genera and 27 species of gobioid fish, including *Hemigobuis hoevenii* and *Acentrogobius sp*. in the Matang mangrove. The abundance of Gobiidae in 3 sampling sites was not surprising as Gobiidae was known to be a resident fish in mangrove area where their occurrence is relative to brackish water habitat and estuary (Huang *et al.*, 2013) with soft substratum with little debris cover (Negelkerken *et al.*, 2008). The larval fish phase of Gobiidae took approximately 40 days according to Thresher (1984), and the likely reason for them to dominate the mangrove area was due to the long larval phase. Ooi *et al.* (2011) claimed to find all ontogentic stages throughout the mangrove estuary in Matang, thus indicating their use of the mangrove estuary as feeding, spawning, and nursery grounds.

Engraulidae was found as the most abundant family (n = 35) in Pekan, whereas Clupeidae (n = 31) was the most abundant family in Matang. Both families came from the order Clupeiformes where they primarily live in oceans. Some species inhabit coastal margins and fresh water for at least a portion of their lives (Grzimek's Animal Life Encyclopedia, 2004). They were known as seasonally estuarine spawners (Blaber *et al.*, 1997b) where their larval fish assemblages are variable both in terms of species composition and distribution patterns. This situation categorizes them as marine migrants who enter the estuary at predominantly the postflexion and post larval stages (Ooi *et al.*, 2011). *Thryssa kammalensis* and *Thryssa hamiltonii* from the *Engraulidae* family were successfully identified in the mangrove habitat in Pekan, whereas *Clupeidae* had not been identified to the lowest level in Matang. Both families have been documented in the mangrove area in Taiwan (Tzeng *et al.,* 1997), Oman Sea (Rabbaniha *et al.,* 2014), Greece (Koutrakis *et al.*, 2004), and Lima Estuary, Portugal (Ramos *et al.,* 2011).

The larval fish of families Blenniidae and Sillaginidae were found in Pendas and was also recorded by Ara *et al.* (2013) in the same locality. *Sillago sihama* from *Sillaginidae* family was identified in Pekan, and this species is known to be a resident of the mangrove habitat. In this study, larval fish from the family Sparidae was found only in Pendas and was also recorded by Ara *et al.* (2009) and Ng *et al.* (2015) at the same locality. Identified larval fish in this study such as *Gerres filamentosus*, *Hippichthys penicillus*, *Scatophagus argus*, *Glossogobius aureus*, and *Monacanthus* sp. (family *Monachantidae*) were recorded in Pendas by Ng *et al.* (2015).

The larval fish assemblages found in this study were composed of a few species with high abundance and a portion of single species occurrence, which is a common feature of estuarine populations (Ramos *et al.,* 2006 and Ayala *et al.,* 2016). A single occurrence of larval fish species was found in the family Pomacentridae, Callionymidae, Mugilidae, Sciaenidae, Apogonidae, and Mullidae. From all the six families, only Mugilidae was found to be resident fish, whereas the rest were non-resident (seasonally found or found only on rare occasions). Specimen from the family Sciaenidae was also found by Ooi *et al.* (2011) from the same locality, and larval fish from the Mugilidae family was claimed to be one of the most difficult taxonomic group for species identification due to its morphologic conservity (Prasanna-Kumar *et al.*, 2011).

Many fish species found in mangrove estuaries are commonly known to be euryhaline and represent only one phase of their life history pattern, where the adult occurs in marine waters (Chong, 2007b). For some species, these nursery habitats are the same for both larval fish and adult, but for most species, these nursery habitats are distinct. The different usage of mangrove estuaries by larval fish enabled them to be separated into three general categories: marine fish that use estuaries seasonally (temporary estuarine residents); those that complete their entire life history within estuarine system (residents); and those that enter the estuary on rare occasions or are found in low numbers near inlets (occasional) (Lennaton and Potter, 1987). Nevertheless, the majority of larval fish surveyed during this study were resident.

Surveillance of fish species composition and diversity provides useful information for management and conservation of marine ecosystems. It helps determine adult fish population dynamics, plus their dispersal and settlement events are imperative in ensuring consistent stock recruitment (Baran, 2002). The same attention was given by many researches in Malaysia as they see the same importance as why this study was conducted. Among the studies reporting on larval fish abundance and distribution were for example on Malaysia as a whole (Rosdi et al., 1998), and more specific areas like Johor (Ara *et al.,* 2014; Arshad *et al.,* 2012; Ara *et al.,* 2011a) Marudu, Sabah (Rezagholinejad *et al.,* 2016b), Matang Perak, Perak (Ooi and Chong, 2011), Sarawak (Muhamad and Rahim, 2014), East Coast of Peninsular

Malaysia (Zulkifli *et al.*, 2001), Pulau Layang-Layang (Zulkifli *et al.*, 2002), West Coast Peninsular Malaysia (Abdul Haris Hilmi and Muhammad Faisal, 2006), and Pulau Payar (Meii and Ali, 2000).

Conclusion

Overall, the study was able to increase data collection on larval fish composition and diversity in mangrove areas of Peninsular Malaysia, especially in mangrove areas on the east side of Peninsular Malaysia as studies on larval fish was very limited. The finding shows potential of each sampling areas as larval fish recruitment habitats and nursery grounds where Pendas harbor has the highest number of families while Setiu was the least. From this snapshot study, Matang have shown to house highest collection of larval fish followed by Pendas, Pekan and Setiu. However, shortcomings of our results were clearly recognized, and data should be treated with great caution since it was based on a limited number of samples for certain families. Indeed, further studies on their taxonomy with higher number of samples per sampling areas are required as larval fish are high in commercial value especially as the main diet to most predator fish. This further indicates the importance of mangrove ecosystem as nursery areas for the economically important fishes. On the other hand, further assessments of species identification are needed by adopting the DNA barcoding method as morphological identification of some larval fish to species level is challenging.

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