Species composition and diversity of fishes from the seagrass habitat of Lawas, Sarawak, Malaysia

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Abstract

Aim: To investigate the species composition and diversity of fishes from the seagrass habitat in Lawas, Sarawak, Malaysia.

Methodology: Fishes were collected with an encircling gillnet net during the dry, wet and intermediate season of the year. Water characteristics were analyzed *in-situ* through analytical methods.

Results: A total of 60 fish species from 37 families were recorded in the seagrass ecosystem. Dominant species with highest total abundance observed were *Lethrinus lentjan* (12.83%), *Hyporhamphus limbatus* (8.50%) and *Leiognathus equulus* (8.33%). Cluster analysis revealed three fish species assemblages; *Lethrinus lentjan* and *Lutjanus fulviflamma* (dry season), *Nibea soldadu*, *Platycephalus indicus* and *L. equulus* (intermediate season), while *Hyporhamphus limbatus*, *Gerres erythrouus*, *Thryssa hamiltonii*, *Gerres oyena*, *Sphyraena jello* and *Gnathanodon speciosus* (wet-intermediate season). All indices (no. of species, diversity and evenness) showed an increasing trend from dry, wet to intermediate season.

Interpretation: The seagrass ecosystem of Lawas harbours a rich and diverse group of fish communities indicating an important fishery resource habitat. The findings of this study provide baseline information on fish resources from this seagrass ecosystem, which will be useful for the conservation and management of its fish resources in the future.

Key words: Fish diversity, Important species indices, Seagrass ecosystem, Species composition

To investigate the species composition and diversity of fishes from the seagrass habitat in Lawas, Sarawak, Malaysia

FISH
60 species
37 families

Dominant and important fish species

Lethrinus lentjan
Hyporhamphus limbatus
Leiognathus equulus
Gerres erythrouus
Thryssa hamiltonii

To seagrass ecosystem of Lawas harbours a rich and diverse group of fish communities including juvenile and adult stages, especially for the commercially important fishes.

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Introduction

Seagrass beds have extremely high primary and secondary productivity, which support a great abundance and diversity of fishery resources. In seagrass ecosystem, many local coastal communities catch fish and other biological resources for their livelihood. It is well established that seagrass beds are excellent feeding and nursery habitats of many fishes and invertebrates during their juvenile stages, due to high abundance of food and low predation pressure (Huijbers *et al.*, 2008). Many fish species, especially juveniles and those at larval stage inhabit seagrass beds throughout their entire life history (Browyn, 2006). The distribution and abundance of fish larvae of different size range throughout a year confirmed the continuous spawning activity of larvae in seagrass beds (Ara *et al.*, 2011). Seagrass beds can support a great abundance and diversity of marine invertebrates because of higher organic content in the area (Zaleha *et al.*, 2015). Furthermore, seagrass form the food and habitats for the vulnerable dugongs, seahorses and endangered green and hawksbill turtles, as well as other fishes. The seagrass ecosystem also acts as a feeding ground for seasonal migratory birds (Japar *et al.*, 2006; Juanita *et al.*, 2017; Mazlan *et al.*, 2017).

In Malaysia, the studies on seagrass ecosystems and functions are mainly based on seagrass beds found in Peninsular Malaysia. The seagrass beds have been documented to harbor diverse fish species and important commercial fishes (Arshad *et al.*, 2001; Arshad *et al.*, 2006), diverse and abundant ichthyoplankton (Ara *et al.*, 2013), post-larval shrimps (Arshad *et al.*, 2011), diverse microbenthic communities (Wong *et al.*, 2014), and abundance of zooplankton (Mathias and Yusoff, 2015). Among the commercial fish species inhabiting these seagrass habitats are *Ilisha* spp., *Stolephorus indicus*, *Thryssa hamiltoni*, *Hippocampus* spp., *Lates calcarifer*, *Lutjanus chrysotaenia*, *Plotosus canius*, *Apolyne mussextarius*, *Rastrelliger kanaqurta*, *Siganus guttatus*, *S. javus*, *Siganus* sp., *Epinephalus* sp. and *Therapon* spp. (Arshad *et al.*, 2001). Major families of ichthyoplankton that occur consistently in the seagrass habitats around the year are Clupeidae, Terapontidae, Nemipteridae, Sillaginidae, Blenniidae and Gobiidae (Ara *et al.*, 2013), while the major post larval shrimp recorded in the habitats are *Lucifer*, *Acetes*, *Peneaus* and *Mysis* (Arshad *et al.*, 2011).

There are 78 recorded sites of seagrass beds, scattered in the west and east coasts of Peninsular Malaysia and, Sabah and Sarawak in East Malaysia. The largest seagrass bed is in Sarawak (240 ha), followed by Johor (112 ha), Terengganu (105 ha), Kelantan (87 ha) and Negeri Sembilan (11 ha) (Japar and Muta Harah, 2011). The seagrass bed in Sarawak occurs only at a single location in Lawas making it the single largest seagrass bed in Malaysia, and still considered in pristine condition. Eight seagrass species has been recorded in Lawas (Abu Hena *et al.*, 2016; Japar *et al.*, 2006; Ahmad Kamil *et al.*, 2013). Information on other ecosystem components from the Lawas seagrass beds

such as fish resources are not well documented. Keeping in view the above this study was conducted with the aim to determine the seasonal diversity and abundance of fish communities in the seagrass ecosystem of Lawas, Sarawak and its relation to physico-chemical parameters.

Materials and Methods

The seagrass bed in Lawas (4°55'26.6"N, 115°23'30.0"E) is located on the south eastern corner of South China Sea, within the Brunei Bay (Fig. 1). The seagrass bed is approximately 15 km to the small town of Lawas, North Sarawak, bordering Sabah (33 km) and Brunei (25 km). The coastal communities comprise small-scale fisherman in Lawas established in Kampung Punang, Kampung Kuala Lawas and Kampung Awat-awat. Eight species of seagrass have been recorded in the study area, i.e. *Halodule pinifolia*, *Halodule uninervis*, *Halophila ovalis*, *Halophila minor*, *Halophila beccarii*, *Cymodocearo tundata*, *Enhalus acroides* and *Thalassia hemprichii* (Japar *et al.*, 2006; Ahmad Kamil *et al.*, 2013). The seagrass bed in Lawas is adjacent to a mangrove forest reserve dominated by mangrove species such as *Avicennia* sp., *Bruguiera parviflora*, *B. sexangula*, *Lumnitzera racemosa*, *L. littorea*, *Nypa fruticans*, *Rhizophora apiculata*, *R. mucronata*, *Sonneratia alba*, *S. caseolaris* and *Xylocarpus granatum* (Gandaseca *et al.*, 2014).

The study area experience three seasonal monsoon patterns: intermediate (January till April), dry (May till August) and wet (September till December). The average total monthly rainfall in the area is 244.17 mm. The highest average total monthly rainfall recorded during the intermediate season (250.40 mm), followed by wet season (235.75 mm) and dry season (206.30 mm). Batang Lawas, Sungai Punang, Sungai Sangkurum, Sungai Siang-Siang and Sungai Bangat are the major rivers

Fig. 1 : Geographical location of sampling area (shaded) at seagrass beds in Lawas, Sarawak.

flowing in the study area.

Water pH, temperature, salinity, turbidity, conductivity and dissolved oxygen were recorded *in situ* with Hydrolab DS5X multiparameter water quality sonde. In addition, triplicate surface water samples were collected from the sampling location for further analysis. The water samples were brought to the laboratory and tested for dissolved inorganic phosphate following ascorbic acid method, and ammonia following Phenate method (APHA, 2017) and chlorophyll a following spectrophotometric method, nitrate following hydrazine reduction method (Kitamura *et al.*, 1982). Rainfall data were obtained from the Meteorological Department of Malaysia (2016-2017).

The fishes were collected using a gill net of mesh size of 4.45 cm, length of 152 m and a depth of 1.8 m. Three sampling exercises were conducted, once during each season. The gill net was deployed six times at the seagrass bed during each sampling effort each season. The sampling of fish was carried out with the fisherman by employing the encircling gillnet fishing method (Beare and Tanimomo, 1991). The fishes caught were preserved in 10% formalin and then processed for identification, measurement of total length and weight. Fish specimens were identified upto species level based as per available literature (Ambak *et al.*, 2010; Azmi *et al.*, 2010; Carpenter and Niem, 1999; Carpenter and Niem, 2001; Mansor *et al.*, 1998; Matsunuma *et al.*, 2011; Mohsin and Ambak, 1996).

Important Species Indices (ISIs) were calculated for each taxon at all sampling sites according to Rushforth and Brock (1991). The diversity of fish community was expressed in terms of Shannon-Wiener diversity index (H') and Shannon's equitability evenness index (E_{H}) (Shannon and Weaver, 1963). Cluster analysis was conducted using log-transformed percentage data of fish by Minimum Variance method with Squared Euclidian distance. One-way ANOVA was carried out to determine the seasonal variation of different physico-chemical parameters. Pearson's correlation coefficient was calculated to characterize relationship between biotic and abiotic parameters. Analysis was

done using SPSS version 16.0 and Multivariate Statistical Package (MVSP Ver3.13, Kovach, 1999).

Results and Discussion

The results of physico-chemical parameters of seawater found in this study is presented in Table 1. The pH ranged between 6.36 (dry season) to 7.92 (dry and intermediate season). The lowest (26.56 °C) and highest temperature (31.63 °C) was recorded during dry season. Salinity varied from 25.67 to 29.35 PSU, with the lowest salinity recorded in the intermediate season and the highest during dry season. Dissolved oxygen was highest during the intermediate season (6.71 mg l⁻¹) while the lowest DO was recorded during dry season (5.00 mg l⁻¹). Dissolved oxygen varied significantly ($p < 0.05$) within the seasons. The concentration of dissolved oxygen was influenced by photosynthetic plant and algal biomass, light intensity and water temperature, and are subject to diurnal and seasonal variations (Connell and Miller, 1988). Low salinity, temperature and dissolved oxygen during intermediate-wet season in Lawas was also observed in Sungai Pulai seagrass beds, showing similar seasonal effects on both seagrass beds (Mathias and Yusoff, 2014). The lowest (10.2 NTU) and the highest (106.40 NTU) turbidity was recorded during intermediate season.

For water nutrients, ammonia concentrations were significantly different within the seasons ($p < 0.05$). Ammonia was highest during dry season (0.54 mg l⁻¹) and lowest during intermediate season (0.10 mg l⁻¹). Chlorophyll a was found higher during dry season (1.84 mg m⁻³) and lower during intermediate season (0.06 mg m⁻³). The seasonal pattern of chlorophyll a in this study was similar to Kuala Sibuti river, while higher concentrations were recorded during dry season (Saifullah *et al.*, 2014). Distribution of nutrients is mainly influenced by seasonal variation, rate of fresh water discharge, land run-off and tidal condition (Nirmalkumar *et al.*, 2009).

A total of 600 fish specimens were recorded in the seagrass ecosystem, comprising 60 fish species from 37 families

Table 1 : Mean values of different physico-chemical parameters recorded in different seasons in seagrass bed of Lawas, Sawark

Parameter/Season	Dry	Wet	Intermediate
pH	7.51 ± 0.47	7.72 ± 0.02	7.88 ± 0.35
Temperature (°C)	29.26 ± 1.47	29.79 ± 0.29	27.03 ± 0.14
Salinity (PSU)	28.22 ± 0.57	27.31 ± 0.51	25.63 ± 0.04
Conductivity (mS cm ⁻¹)	43.38 ± 1.66	42.47 ± 0.72	40.10 ± 0.05
Turbidity (NTU)	45.17 ± 8.41	28.83 ± 1.48	52.90 ± 28.29
Dissolved oxygen (mg l ⁻¹)	5.22 ± 0.19a	5.31 ± 0.05a	6.66 ± 0.03b
Nitrate (mg l ⁻¹)	1.01 ± 0.22	0.84 ± 0.23	0.63 ± 0.17
Ammonia (mg l ⁻¹)	0.52 ± 0.12a	0.14 ± 0.68b	0.08 ± 0.13b
Phosphate (mg l ⁻¹)	0.02 ± 0.01	0.01 ± 0.00	0.01 ± 0.00
Cholorophyll a (mg m ⁻³)	1.27 ± 0.53	0.84 ± 0.43	0.10 ± 0.02

Different letters (a and b within the row) indicate significant difference between means using Tukey's test at $p < 0.05$

(Table 2). It was observed that more than 80% of fish individuals were less than 20 cm length and 40 g weight (Fig. 2). A comparison of fish species recorded from previous studies for seagrass and mangrove habitats is given in Table 3. Sixty fish species recorded in the seagrass ecosystem of Lawas was comparatively higher than other seagrass habitats in Malaysia; 35 fish species in Merambong shoals, Johor (Arshad *et al.*, 2001; Aziz *et al.*, 2001) and 22 fish species in Merchang, Terengganu (Arshad *et al.*, 2006; Aziz *et al.*, 2006), however these numbers were lower than 75 fish species reported in Sungai Pulai, Johor (Sasekumar *et al.*, 1989). The number of fish species from the current study was also higher than that in the Kuantan mangrove estuary (Jalal *et al.*, 2012), but more similar to Sibuti mangrove estuary (Hoque *et al.*, 2015). The difference in results may probably be due to different sampling gears, techniques and various intensity of fishing effort at each site (Arshad *et al.*, 2006).

Indirectly, the use of only one mesh size in this study may have restricted the fish species diversity. Hoque *et al.* (2015) reported that comparatively higher number of fish species/taxa were collected by smaller mesh nets of 2.54 cm when compared to largest mesh sized nets, 5.08 cm and 10.16 cm. Further investigations using more nets with different mesh sizes may improve and increase the fish diversity in this seagrass bed.

The higher number of fish species and total number of fish were observed during the intermediate season (48 species, 321 fish), followed by wet season (28 species, 162 fish), and dry season (21 species, 118 fish). The high diversity and total number of fish species during the intermediate may coincide with changing seasonal patterns, creating suitable environmental conditions and utilization of blooming seagrass beds as nurseries and feeding grounds. The seagrass coverage in Lawas were observed to start peaking during the months of February till May,

Table 2 : Species of fish recorded in the seagrass ecosystem in Lawas, Sarawak

Species	N	F	R	Species	N	F	R
<i>Lethrinus lentjan</i> (Lacepède, 1802)	77	100	19	<i>Pomadasys argenteus</i> (Forsskal, 1775)	4	67	1
<i>Thryssa hamiltonii</i> Gray, 1835	49	67	10	<i>Saurida tumbil</i> (Bloch, 1795)	2	33	1
<i>Hyporhamphus limbatus</i> (Valenciennes, 1847)	51	67	7	<i>Scomberoides commersonianus</i> ³	5	33	1
<i>Gerres erythrorus</i> (Bloch, 1791)	40	100	7	<i>Leiognathus fasciatus</i> (Lacepède, 1803)	4	67	1
<i>Gerres oyena</i> (Forsskal, 1775)	45	67	6	<i>Sillago asiatica</i> McKay, 1982	4	67	1
<i>Gnathanodon speciosus</i> (Forsskal, 1775)	29	67	6	<i>Rachycentron canadum</i> (Linnaeus, 1766)	3	67	<1
<i>Leiognathus equulus</i> (Forsskal, 1775)	50	67	5	<i>Carangoides praeustus</i> ⁴	3	33	<1
<i>Lutjanus fulviflamma</i> (Forsskal, 1775)	16	67	4	<i>Carangoides caeruleopinnatus</i> ⁵	4	67	<1
<i>Ostorhinchus fasciatus</i> (White, 1790)	10	33	3	<i>Terapon theraps</i> Cuvier, 1829	3	67	<1
<i>Illisha elongata</i> (Anonymous [Bennett], 1830)	12	33	2	<i>Lutjanus johnii</i> (Bloch, 1792)	2	67	<1
<i>Sphyræna jello</i> Cuvier, 1829	13	100	2	<i>Coilia dussumieri</i> Valenciennes, 1848	3	33	<1
<i>Scomberomorus commerson</i> ¹	15	33	2	<i>Megalopsis codryla</i> (Linnaeus, 1775)	2	67	<1
<i>Nibea soldado</i> (Lacepède, 1802)	14	67	2	<i>Scatophagus argus</i> (Linnaeus, 1766)	2	67	<1
<i>Triacanthus nieuhofii</i> Bleeker, 1852	14	33	1	<i>Chirocentrus dorab</i> (Forsskal, 1775)	1	33	<1
<i>Selaroides leptolepis</i> (Cuvier, 1833)	13	33	1	<i>Echeneis naucrates</i> Linnaeus, 1758	1	33	<1
<i>Dussumieria elopsoidea</i> Bleeker, 1849	13	33	1	<i>Tripodichthys blochii</i> (Bleeker, 1852)	1	33	<1
<i>Nuchequula longicornis</i> ²	13	33	1	<i>Pomadasys maculatus</i> (Bloch, 1793)	1	33	<1
<i>Gerres macracanthus</i> Bleeker, 1854	10	67	1	<i>Trichiurus lepturus</i> Linnaeus, 1758	1	33	<1
<i>Paraplagusia bilineata</i> (Bloch, 1787)	5	67	1	<i>Arius maculatus</i> (Thunberg, 1792)	1	33	<1
<i>Platycephalus indicus</i> (Linnaeus, 1758)	8	100	1	<i>Atherinomorus lacunosus</i> (Forster, 1891)	1	33	<1
<i>Ellochelon vaigiensis</i> (Quoy & Gaimard, 1825)	4	67	1	<i>Alectis indicus</i> (Rüppell, 1830)	1	33	<1
<i>Siganus javus</i> (Linnaeus, 1766)	5	67	1	<i>Anodontostoma chacunda</i> (Hamilton, 1822)	1	33	<1
<i>Hemiramphus far</i> (Forsskal, 1775)	4	67	1	<i>Tenualosa macrura</i> (Bleeker, 1852)	1	33	<1
<i>Amblygaster</i> Bleeker, 1849	6	67	1	<i>Brevitrygon walga</i> (Müller & Henle, 1841)	1	33	<1
<i>Strongylura strongylura</i> van Hasselt, 1823	7	67	1	<i>Drepane punctata</i> (Linnaeus, 1758)	1	33	<1
<i>Moolgarda seheli</i> (Forsskal, 1775)	5	67	1	<i>Pomadasys kaakan</i> (Cuvier, 1830)	1	33	<1
<i>Nemipterus hexodon</i> (Quoy & Gaimard, 1824)	4	67	1	<i>Lactarius lactarius</i> (Bloch & Schneider, 1801)	1	33	<1
<i>Rastrelliger kanagurta</i> (Cuvier, 1816)	3	67	1	<i>Upeneus</i> sp. Cuvier, 1829	1	33	<1
<i>Atule mate</i> (Cuvier, 1833)	5	67	1	<i>Epinephelus coiodes</i> (Hamilton, 1822)	1	33	<1
<i>Gazza minuta</i> (Bloch, 1795)	3	67	1	<i>Lepturacanthus savala</i> (Cuvier, 1829)	1	33	<1
Parameter / Season	Dry	Wet	Int				
Total Fish Species	21	28	48				
Total Fish Recorded	118	162	321				

* N: total no. of fish recorded; F: frequency (%); R: relative abundance (%), Int: Intermediate; ¹: (Lacepède, 1800); ²: Kimura, Kimura & Ikejima, 2008; ³: Lacepède, 1801; ⁴: (Anonymous [Bennett], 1830); ⁵: (Rüppell, 1830)

Table 3 : Diversity of fishes from seagrass and mangrove ecosystems in Malaysia

Ecosystem	Fish species	Dominant species
Riverine Kuantan Estuary (Jalal <i>et al.</i> , 2012)	19	<i>Arius maculatus</i> , <i>Arius sumatranus</i> , <i>Arius tenuispinis</i> , <i>Arius thalassinus</i>
Mangrove Sibuti Estuary (Hoque <i>et al.</i> , 2015)	60	<i>Coilia dussumieri</i> , <i>Nemapteryx caelata</i> , <i>Otolithes ruber</i> , <i>Ilisha elongata</i>
Seagrass Beds, Sungai Pulai Johor (Sasekumar <i>et al.</i> , 1989)	75	<i>Pervagor tomentatus</i> , <i>Apogon endekataenia</i>
Seagrass beds Merambong Shoals, Johor (Arshad <i>et al.</i> , 2001)	35	<i>Ilisha</i> spp., <i>Stolephorus indicus</i> , <i>Thryssa hamiltoni</i> , <i>Hippocampus</i> spp., <i>Lates calcarifer</i> , <i>Lutjanus chrysotaenia</i> , <i>Plotosus canius</i> , <i>Apolynemus sextarius</i> , <i>Rastrelliger kanaqurta</i> , <i>Siganus guttatus</i> , <i>S. javus</i> , <i>Siganus</i> sp., <i>Epinephalus</i> sp. and <i>Therapon</i> spp.
Seagrass Beds Merchang, Terengganu (Arshad <i>et al.</i> , 2006)	22	<i>Tetraodon nigroviridis</i> , <i>Siganus guttanus</i> , <i>Leiognathus equulus</i>
Current study Seagrass Beds Lawas Sarawak Malaysia	60	<i>Lethrinus lentjan</i> , <i>Hyporhamphus limbatus</i> , <i>Leiognathus equulus</i> , <i>Thryssa hamiltonii</i> , <i>Gerres erythrourus</i> , <i>Gerres oyena</i> , <i>Gnathanodon speciosus</i> , <i>Platycephalus indicus</i> , <i>Saphyraena jello</i>

Fig. 2 : Histogram of total length (cm) and weight (g) of fish found in the seagrass ecosystem of Lawas, Sarawak.

right after wet season (Ahmad-Kamil *et al.*, 2013).

The dominant seagrass species in Lawas are represented by *Halodule pinifolia* and *Cymodocea tuncata* (Ahmad-Kamil *et al.*, 2013). The seagrass species *Halodule* is known to associate with high presence of fish species (Sundra *et al.*, 1992). In Sungai Pulai seagrass bed of Johor, the abundance of fish larvae peaked during February and March (Intermonsoon), utilizing seagrass beds for spawning (Ara *et al.*, 2011). The dominant fish species observed were *Lethrinus lentjan* (12.83%), *Hyporhamphus limbatus* (8.50%), *Leiognathus equulus* (8.33%), *Thryssa hamiltonii* (8.17%), *Gerres erythrourus* (6.67%), *Gerres oyena* (7.5%), and *Gnathanodon speciosus* (4.83%). Four fish species that were found in all seasons were *L. lentjan*, *G. erythrourus*, *Platycephalus indicus* and *Saphyraena jello*.

The important species index was employed on the fish relative abundance and frequency data and showed eleven most important species in the seagrass ecosystem (Table 4). *L. lentjan* is still ranked as having the highest importance (19.28) followed by *G. erythrourus* (6.73), *T. hamiltonii* (6.52), *H. limbatus* (4.82), *G. oyena* (3.73), *G. speciosus* (3.71) and *L. equulus* (3.53). The pink ear emperor fish, *L. lentjan*, is a very important commercial species for marine fisheries in the subtropical and tropical regions and its juveniles have been reported to inhabit and utilize seagrass and mangrove habitats (Ditch, 2015; Rohani *et al.*, 2013). In the Lawas seagrass bed, *L. lentjan* was recorded as the most dominant and important fish species, however this was not observed in other seagrass beds (Sasekumar *et al.*, 1989; Arshad *et al.*, 2006; Phinrub *et al.*, 2015). There were also some variations in the dominant species/families of fish recorded from

Table 4 : Important fish species (ISI index > 1.0), mean total length and weight, relative abundance, frequency and important species index (ISI) of fish recorded in the seagrass bed of Lawas, Sarawak

Species	Code	Mean TL (cm)	Mean weight (g)	Relative abundance			Mean R	F	ISI
				Dry	Wet	Int			
<i>Lethrinus lentjan</i>	Lle	13.56±0.16	34.24±1.19	0.53	0.01	0.04	0.19	100	19.28
<i>Gerres erythrouus</i>	Ge	11.47±0.27	25.19±1.83	0.06	0.08	0.06	0.07	100	6.73
<i>Thryssa hamiltonii</i>	Th	12.76±0.26	13.14±0.95	0.00	0.28	0.01	0.10	67	6.52
<i>Hyporhamphus limbatus</i>	Hl	18.31±0.38	18.42±0.97	0.00	0.12	0.10	0.07	67	4.82
<i>Gerres oyena</i>	Go	11.74±0.15	21.58±1.13	0.00	0.06	0.11	0.06	67	3.73
<i>Gnathanodon speciosus</i>	Gs	11.84±0.13	17.41±0.50	0.00	0.15	0.01	0.06	67	3.71
<i>Leiognathus equulus</i>	Le	9.57±0.17	9.40±0.48	0.00	0.01	0.15	0.05	67	3.53
<i>Lutjanus fulviflamma</i>	Lfl	15.55±0.36	53.56±3.96	0.09	0.00	0.02	0.04	67	2.42
<i>Sphyræna jello</i>	Sje	27.51±1.87	84.30±8.23	0.03	0.03	0.02	0.02	100	2.40
<i>Platycephalus indicus</i>	Pi	24.96±1.00	78.38±7.97	0.01	0.01	0.02	0.01	100	1.11
<i>Nibeas soldado</i>	Ns	13.45±0.41	25.58±0.50	0.00	0.01	0.04	0.02	67	1.04

* R: relative abundance, SE: standard error

Fig. 3 : Seasonal variation of diversity indices : Shannon-Wiener diversity index (H') and Evenness index (EH) of fisheries abundance in the seagrass ecosystem of Lawas, Sarawak.

the seagrass ecosystems compared to other seagrass ecosystems:- *Pervagor* and *Apogon* dominance in Sungai Pulau seagrass beds, Johor (Sasekumar et al., 1989), *Leiognathidae*, *Tetraodon nigroviridis* dominance in Merchang seagrass bed, Terengganu (Arshad et al., 2006), and *Antherinomorus duodecimalis*, *Sillagosihama* and *Pelates quadrilineatus* in seagrass beds of Sikao bay, Thailand (Phinrub et al., 2015).

Changes in the total and dominant species are often related to geographical locations and different types of seagrass habitats (Arshad et al., 2001). Fish species from the family Gerreidae such as *G. erythrouus* and *G. oyena* are highly dominant temporarily and permanently in seagrass habitats (Phinrub et al., 2015). For instance, another fish species, *Illisha elongata*, is more dominant in coastal waters and mangrove habitats in Sarawak:- 3.9% in coastal waters of Bintulu (Nyanti et al., 2014) and 5.8% in Sibuti river estuary (Hoque et al., 2015), as compared to the current seagrass ecosystem (2%). *I. elongata*

Fig. 4 : Dendrogram showing clusters of important fish species assemblages in the seagrass ecosystem of Lawas, Sarawak.

has been described as a mangrove associated fish specie (Abu Hena et al., 2017). In seagrass-mangrove related habitats, transient fishes often move between the seagrass and mangrove areas for feeding (Vaslet et al., 2012).

Univariate analysis showed the diversity index and evenness index of fish assemblage according to seasons (Fig. 3). The diversity index (H') was lowest during dry season (1.937), followed by wet season (2.474) and intermediate season (3.169). The evenness index showed a similar pattern with the dry season (0.636), followed by wet season (0.743) and intermediate season (0.819), both indices showed increasing trend from dry to intermediate season. The dominant presence of *L. lentjan* and low number of other fish species during dry season are also the cause for low observation of evenness index. The results suggests that the intermediate season plays an important role in terms of fish diversity and abundance in the seagrass ecosystem, and these findings are similar to the findings of other ecosystems studied (Hoque et al., 2015). Larval fishes were also reported to be most abundant in the seagrass habitats during the intermediate season (Ara et al., 2011).

Cluster analysis revealed three fish species assemblages; dry season fish assemblage comprised of *L. lentjan* and *L. fulvivlamma*, Intermediate season fish species assemblage comprised of *Nibeas oldadu*, *Platycephalus indicus* and *L. equulus*, while the wet-intermediate season fish assemblage was represented by *H. limbatus*, *G. erythrourus*, *T. hamiltonii*, *Gerres oyena*, *Sphyaenajello* and *Gnathanodon speciosus* (Fig. 4). *G. erythrourus* and *Thryssa hamiltonii* were reported to be more abundant and associated with the wet season (Phinrub et al., 2014). In this study, the abundance of *L. lentjan* in the seagrass ecosystem was found abundant during dry season. A similar pattern of distribution was observed when juveniles of *L. lentjan* were found to utilize the seagrass-mangrove habitats as feeding grounds during dry season in the seagrass beds of Setiu lagoon Terengganu. Gut content analysis by stable isotope also showed that *L. lentjan* mainly consumed seagrass-based food sources (Le et al., 2018). The abundance of important species (*L. lentjan*, *G. oyena*, *L. erythrourus* and *P. indicus*) was found to have correlation (positive or negative) with the physico-chemical: phosphate, dissolved oxygen, temperature and nitrate. Positive correlation was observed for *L. lentjan* with phosphate ($r=0.99$; $p<0.05$), *L. equulus* with dissolved oxygen ($r=0.99$; $p<0.05$) and *P. indicus* with temperature ($r=0.99$; $p<0.05$). *G. oyena* were negatively correlated with nitrate ($r=-0.99$; $p<0.05$) content.

The findings suggest that the seagrass ecosystem of Lawas, harbours a rich and diverse group of fish communities including juvenile and adult stages, indicating an important fishery resources habitat, especially for the commercially important fishes such as *L. lentjan*, *H. limbatus*, *L. equulus*, *G. erythrourus*, *T. hamiltonii*, *G. oyena* and *G. speciosus* that inhabit the seagrass ecosystems. The findings of this study provide fundamental baseline knowledge on the fish species inhabiting the seagrass beds of Lawas. This information can be further used for in-depth study of fish population and stocks, seagrass-mangrove linkages with economic value to local fishermen communities and can also be used for the Sarawak government plan to convert the Kuala Lawas seagrass beds area into a Marine Park.

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