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Fish and Crustacean Communities and Fish Length-Weight Relationship of Lutong River, Miri, Sarawak, Malaysia

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Abstract: This study was carried out to determine the composition and diversity of fish and crustacean fauna in Lutong River, Sarawak and length-weight relationship of major fish species caught. A total of 33 species of fish and crustacean belonging to 28 genera and 23 families were recorded from the study area. Thirty-nine percent of the number of individuals caught was from the family Ambassidae, 15% from Penaeidae, 10% from Portunidae, 8% from Mugilidae, 6% from Megalopidae, 4% from Scatophagidae and 3% from Centropomidae. Many of the individuals caught were small-sized individuals indicating the role of the river, to a certain extent as a nursery area. However, compared to other less disturbed areas such as Paloh mangrove, the number of species and families recorded in Lutong River were only 47 and 58% respectively of those recorded in Paloh mangrove likely due to the lack of abundance of food as detritus were less in Lutong River. The values of parameter *b* of the length-weight relationships for nine fish species ranged from 2.65-3.10 with only three species showing positive allometric growth. The low number of species and low fish species with positive allometric growth were possibly due to the impacts of human settlement and petroleum industry.

Key words: Fish composition % Fish fauna % Length-weight relationship % Mangrove

INTRODUCTION

Mangrove forest is usually found at the mouth or estuary of most rivers in tropical and sub-tropical coastal regions. The low-energy intertidal zone encourages the development of this ecosystem [1] and is commonly associated with soft and muddy substrate. In Sarawak, mangrove forest covers an area of approximately 174,000 hectares and occupies about 60% of the 740 km length of its coastline. They are located mainly along the sheltered coastlines and estuaries within the major bays of Kuching Division, Sri Aman Division, Rajang Delta and Limbang Division [2]. Coastal aquaculture development has accelerated the loss of this extremely important habitat in many countries. In Sarawak, the demand for mangrove resources has been steadily increasing, not only for the products themselves but also for the land which is normally converted into sites for human settlement, industries, agriculture and aquaculture especially for shrimp and fish culture [3].

Mangrove forests are highly productive and valuable ecosystems [4]. They are important detritus contributor for the ecosystem food webs, which also benefit the estuarine and near shore fisheries. Mangrove forests also act as nursery, feeding, breeding and shelter areas for many species of aquatic life. Several fish species use mangrove habitats to breed and as their nursery ground especially for those in the juvenile stages [5-8]. Previous studies showed that juvenile fishes, including several of commercially important species, were found exclusively in mangrove areas [6, 9, 10]. In Sarawak, mangrove forests have traditionally been an essential resource for coastal communities. A small impoverished mangrove community also grows along the bank of Lutong River in Miri, Sarawak. In spite of the importance of mangrove as nursery, feeding, breeding and shelter areas for many species of aquatic life, almost no information is available on the fish communities of Lutong River. Furthermore, the length-weight relationship for fishes which is important for fish stock assessment has been reported in different

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parts of the world such as north-eastern Atlantic [11], western Mediterranean [12] and Kenya [13] is lacking in this part of the world. Therefore, the objective of this study was to determine the composition and diversity of fish fauna and the fish length-weight relationships of Lutong River.

MATERIALS AND METHODS

Field Samplings: Field samplings of the fish fauna at Lutong River were carried out from 25 to 27 October 2007. Fish fauna were sampled from four stations, 1 to 4 (Fig. 1). Station 1 was the area at the mouth of Lutong River, near to the squatter's area; Station 2 was the area at the junction of Lutong River and the tributary; Station 3 was the area between SSB Bridge and Pipe Bridge; and Station 4 was the area at the Pipe Bridge. Fishing methods used during the field sampling were gill net of four different mesh sizes (2.5, 4.0, 5.0 and 10.0 cm) and cast net. Each fishing method was employed in a similar manner in all the stations. Four gill nets, each with a different mesh size were placed at each station for a period of 48 hours. Fifteen throws of cast net at each station were also carried out during low tide.

The standard length, total length and weight of each individual fish caught were recorded. Fish species were identified at the laboratory. Specimens were preserved in 10% formalin before they were brought back to the laboratory. In the laboratory, these specimens were transferred to 70% ethanol. Fish identification followed those of Mohammed Shaari [14], Masuda *et al*. [15], Kottelat *et al*. [16] and Lim and Gambang [17] and crustaceans followed those of Tamaei [18] and Keenan *et al*. [19].

Diversity Indexes: At each station, the diversity, evenness and richness indices were calculated based on formulae (1) to (3):
Shannon-Weiner Diversity Index (H) [20]

$$H = n \log \frac{n - \sum f_i \log f_i}{n} \quad (1)$$

n = Total number of individual
f_i = Number of individual each species

Margalef Richness Index (D) [21]

$$D = \frac{(S-1)}{\log_{10} n} \quad (2)$$

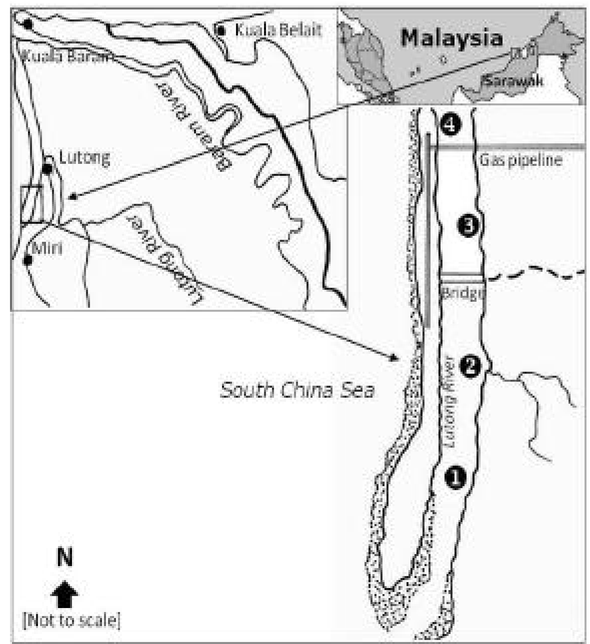

Fig. 1: Location of the fish and crustacean fauna sampling stations (1 to 4).

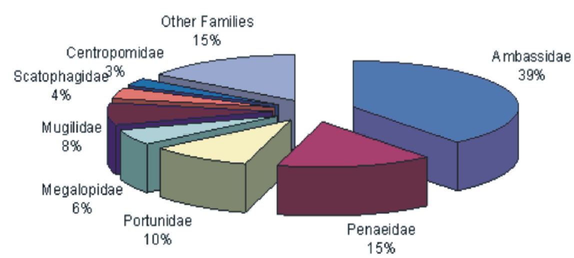

Fig. 2: Percentages of the seven dominant families in terms of the number of individuals caught from the study area.

S = Total number of species.
n = Total number of individual

Pielou Similarity Index (J) [22]

$$J = \frac{H}{\ln S} \quad (3)$$

H = Diversity of species
S = Total number of species

The length-weight relationships can be expressed as equation (4):

$$W = a L^b \quad (4)$$

Where ‘W’ is the weight of the fish in gram and ‘L’ is the length of the fish (cm). ‘b’ indicates the allometry of the fish where b<3 indicates negative allometry and b>3 positive allometry. Logarithmic transformation was performed to convert it to a linear relationship as shown in equation (5):

$$\log W = b \log L + \log a \quad (5)$$

Linear regression of log W on log L using PASW 18 software package gives the slope ‘b’ and the intercept log a.

RESULTS

Fish and Crustacean Communities: A total of 436 individuals comprising 23 families and 33 species were caught from the study area (Table 1). The percentages of the seven dominant families based on the number of individuals caught from the study area are shown in Figure (2). Thirty-nine percent of the number of individuals caught was from the family Ambassidae, 15% from Penaeidae, 10% from Portunidae, 8% from Mugilidae, 6% from Megalopidae, 4% from Scatophagidae and 3% from Centropomidae.

Table 1: List of fish families and species caught from the four stations

Family	Species	1	2	3	4	n
Ambassidae	*Ambassis interrupta*	x	x	x	x	120
	Ambassis kopsii	x	x	x	x	43
	Ambassis urotaenia	x	x	x	x	8
Anabantidae	*Anabas testudineus*	x	-	-	-	1
Ariidae	*Arius argyropleuron*	-	x	x	x	6
Bagridae	*Mystus gulio*	-	-	-	x	4
Carangidae	*Caranx ignobilis*	x	x	-	x	4
	Selar sp.	x	-	-	-	1
Centropomidae	*Lates calcarifer*	-	x	x	x	12
Cichlidae	*Oreochromis mossambicus*	x	-	-	x	2
	Oreochromis niloticus	x	x	x	-	4
Clariidae	*Clarias teijsmanni*	-	-	-	x	1
Elopidae	*Elops machnata*	x	x	x	-	8
Engraulidae	*Stolephorus dubiosus*	-	-	x	-	1
Gerreidae	*Gerres filamentosus*	x	x	-	-	3
Gobiidae	*Bathygobius cyclopterus*	-	x	x	-	6
	Glossogobius aureus	x	x	x	-	3
Limulidae	*Tachypleus tridentatus*	x	-	-	-	2
Lutjanidae	*Lutjanus argentimaculatus*	-	x	x	-	2
Megalopidae	*Megalops cyprinoides*	-	x	x	x	24
Mugilidae	*Liza melinopterus*	x	-	x	x	15
	Mugil cephalus	x	-	x	x	11
	Valamugil buchanani	x	-	x	x	9
Penaeidae	*Metapenaeus burkenroadi*	-	x	x	-	12
	Penaeus monodon	-	x	x	x	45
	Penaeus penicillatus	-	x	x	-	9
Plotosidae	*Paraplotosus albilabris*	-	-	x	-	1
Portunidae	*Scylla olivacea*	-	x	x	x	9
	Scylla tranquebarica	x	x	x	x	35
Scatophagidae	*Scatophagus argus*	x	x	x	x	17
Sciaenidae	*Johnius trachycephalus*	x	x	x	-	3
Tetraodontidae	*Arothron reticularis*	x	-	-	x	9
Theraponidae	*Terapon jarbua*	x	x	x	x	6
TOTAL 23	33	20	21	24	19	436

“x” indicates the presence of the species in that station and ‘n’ is the number of individuals caught from all stations

Table 2: List of fish families, species, number of individuals (n), average standard length (SL), total length (TL) and weight (WT) with their standard deviations (SD) caught from Station 1

Family	Species	n	SL±SD (cm)	TL±SD (cm)	WT±SD (g)
Ambassidae	*Ambassis interrupta*	35	4.89±0.43	6.52±0.57	3.68±0.96
	Ambassis kopsii	15	4.54±0.30	6.00±0.37	3.02±0.66
	Ambassis urotaenia	4	4.72±0.23	6.05±0.43	2.50±0.40
Anabantidae	*Anabas testudineus*	1	15.20	19.20	144.94
Carangidae	*Caranx ignobilis*	2	8.30±1.69	10.50±1.98	17.22±9.21
	Selar sp.	1	10.90	13.20	31.47
Cichlidae	*Oreochromis mossambicus*	1	13.60	17.40	84.99
	Oreochromis niloticus	1	14.10	17.50	92.91
Elopidae	*Elops machnata*	2	19.00±1.69	26.00±3.53	164.48±51.91
Gerreidae	*Gerres filamentosus*	1	9.10	12.10	26.60
Gobiidae	*Glossogobius aureus*	1	11.20	14.20	23.18
Limulidae	*Tachypleus tridentatus*	2	-	-	-
Mugilidae	*Liza melinopterus*	7	6.36±0.31	8.00±0.39	6.31±0.74
	Mugil cephalus	5	14.55±8.41	17.80±10.04	104.42±125.22
	Valamugil buchanani	2	14.01±9.08	17.42±11.26	178.71±356.30
Portunidae	*Scylla tranquebarica*	3	-	-	67.87±8.58
Scatophagidae	*Scatophagus argus*	2	10.65±1.91	11.64±4.19	62.22±27.95
Sciaenidae	*Johnius trachycephalus*	1	-	-	130.68
Tetraodontidae	*Arothron reticularis*	6	3.20±1.33	4.10±1.57	3.31±4.29
Theraponidae	*Terapon jarbua*	1	11.60	14.90	43.26

Table 3: List of fish families, species, number of individuals (n), average standard length (SL), total length (TL) and weight (WT) with their standard deviations (SD) caught from Station 2

Family	Species	n	SL±SD (cm)	TL±SD (cm)	WT±SD (g)
Ambassidae	*Ambassis interrupta*	22	4.96±0.45	6.49±0.51	3.53±0.67
	Ambassis kopsii	9	4.53±0.37	5.97±0.49	2.99±0.78
	Ambassis urotaenia	1	4.90	6.10	2.58
Ariidae	*Arius argyropleuron*	3	18.00±3.67	22.75±4.88	84.77±34.05
Carangidae	*Caranx ignobilis*	1	10.80	14.10	31.70
Centropomidae	*Lates calcarifer*	5	19.68±1.37	23.77±1.17	186.62±10.47
Cichlidae	*Oreochromis niloticus*	1	13.70	17.60	83.25
Elopidae	*Elops machnata*	1	17.80	23.40	127.78
Gerreidae	*Gerres filamentosus*	2	8.90±0	11.90±0	25.05±0
Gobiidae	*Bathygobius cyclopterus*	1	14.50	18.20	109.54
	Glossogobius aureus	3	10.65±1.20	13.65±1.48	20.22±4.58
Lutjanidae	*Lutjanus argentimaculatus*	1	22.00	27.40	360
Megalopidae	*Megalops cyprinoides*	3	21.27±2.06	27.33±3.29	201.61±42.62
Penaeidae	*Metapenaeus burkenroadi*	10	-	-	-
	Penaeus penicillatus	1	-	-	-
	Penaeus monodon	5	-	-	-
Portunidae	*Scylla olivacea*	4	-	-	52.77±11.23
	Scylla tranquebarica	14	-	-	53.86±9.72
Scatophagidae	*Scatophagus argus*	4	12.66±3.15	15.37±3.75	140.26±108.03
Sciaenidae	*Johnius trachycephalus*	1	-	-	114.38
Theraponidae	*Terapon jarbua*	1	10.10	12.30	35.99

Table 4: List of fish families, species, number of individuals (n), average standard length (SL), total length (TL) and weight (WT) with their standard deviations (SD) caught from Station 3

Family	Species	n	SL±SD (cm)	TL±SD (cm)	WT±SD (g)
Ambassidae	*Ambassis interrupta*	25	4.86±0.55	6.67±0.73	4.03±1.25
	Ambassis kopsii	9	4.20±0.85	5.63±1.14	2.69±1.49
	Ambassis urotaenia	1	5.10	6.70	3.76
Ariidae	*Arius argyropleuron*	2	24.8±14.42	30.80±18.67	380.80±458.49
Centropomidae	*Lates calcarifer*	6	19.10±4.06	23.64±4.90	256.00±155.02
Cichlidae	*Oreochromis niloticus*	2	18.70±0.85	23.10±0.71	171.56±6.01
Elopidae	*Elops machnata*	5	19±2.48	24.27±1.89	124.21±35.73
Engraulidae	*Stolephorus dubiosus*	1	7.90	9.20	6.16
Gobiidae	*Bathygobius cyclopterus*	2	14.60±0.57	18.25±0.49	84.69±1.93
	Glossogobius aureus	2	8.30±5.23	10.60±6.93	12.25±15.23
Lutjanidae	*Lutjanus argentimaculatus*	1	15.30	18.10	109.18
Megalopidae	*Megalops cyprinoides*	5	22.75±0.35	29.20±0	203.56±0.45
Mugilidae	*Liza melinopterus*	4	8.57±3.00	10.50±3.96	19.75±18.44
	Mugil cephalus	2	14.00±2.82	17.55±3.74	70.82±42.05
Mugilidae	*Valamugil buchanani*	1	12.90	16.40	47.38
Penaeidae	*Metapenaeus burkenroadi*	2	-	-	-
	Penaeus monodon	3	-	-	-
	Penaeus penicillatus	44	-	-	-
Plotosidae	*Paraplotosus albilabris*	1	-	23.10	72.99
Portunidae	*Scylla olivacea*	1	-	58.41	-
	Scylla tranquebarica	14	-	54.37±5.66	-
Scatophagidae	*Scatophagus argus*	7	7.95±2.63	9.75±3.12	36.50±29.04
Sciaenidae	*Johnius trachycephalus*	1	-	-	204.06
Theraponidae	*Terapon jarbua*	2	6.50±4.41	8.25±1.91	10.76±7.12

Table 5: List of fish families, species, number of individuals (n), average standard length (SL), total length (TL) and weight (WT) with their standard deviations (SD) caught from Station 4

Family	Species	n	SL±SD (cm)	TL±SD (cm)	WT±SD (g)
Ambassidae	*Ambassis interrupta*	38	4.98±0.43	6.87±0.54	4.50±1.53
	Ambassis kopsii	10	4.44±0.64	6.02±0.86	2.77±1.18
	Ambassis urotaenia	2	3.70±0.14	4.95±0.21	1.31±0.19
Ariidae	*Arius argyropleuron*	1	1.00	17.90	21.80
Bagridae	*Mystus gulio*	4	12.63±1.32	16.20±1.63	49.55±11.27
Carangidae	*Caranx ignobilis*	1	10.20	13.30	28.52
Centropomidae	*Lates calcarifer*	1	18.50	22.10	151.72
Cichlidae	*Oreochromis mossambicus*	1	12.00	14.60	58.22
Clariidae	*Clarias teijsmanni*	1	23.50	27.40	178.86
Megalopidae	*Megalops cyprinoides*	16	20.02±1.96	25.87±2.37	154.73±47.26
Mugilidae	*Liza melinopterus*	4	11.32±3.21	13.93±3.94	39.15±31.47
	Mugil cephalus	4	6.75±1.10	8.55±1.33	7.87±3.17
	Valamugil buchanani	6	11.87±3.56	14.62±4.31	41.65±22.81
Penaeidae	*Penaeus monodon*	1	-	-	-
Portunidae	*Scylla olivacea*	4	-	56.15±8.68	-
	Scylla tranquebarica	4	-	55.70±4.66	-
Scatophagidae	*Scatophagus argus*	4	10.57±0.33	12.65±0.44	81.14±21.11
Tetraodontidae	*Arothron reticularis*	3	2.40±0.10	3.17±0.06	1.04±0.19
Theraponidae	*Terapon jarbua*	2	7.30±0.28	9.20±0.56	14.54 ±0.46

Table 6: The values of diversity, evenness and richness indices for each station

Station	Diversity Index (H')	Richness Index (D)	Evenness Index (J)
1	0.79	9.65	0.32
2	1.10	10.16	0.36
3	1.05	10.67	0.33
4	0.99	8.87	0.34

Table 7: Length-weight relationships for nine species of fish caught at Lutong River

Family	Species	n	Minimum TL (cm)	Maximum TL (cm)	a	b	R^2
Ambassidae	*Ambassis interrupta*	118	5	7.5	0.0131	2.984	0.902
Ambassidae	*Ambassis kopsii*	43	4.5	7.2	0.0152	2.937	0.908
Ambassidae	*Ambassis urotaenia*	8	5.6	6.7	0.0214	2.653	0.850
Centropomidae	*Lates calcarifer*	10	16.2	29.9	0.0144	3.021	0.818
Elopidae	*Elops machnata*	8	9.2	28.5	0.0064	3.102	0.991
Megalopidae	*Megalops cyprinoides*	24	22.6	29.8	0.0173	2.793	0.831
Mugilidae	*Liza melinopterus*	8	6.2	14.7	0.0149	2.952	0.986
Scatophagidae	*Scatophagus argus*	16	6.2	19.7	0.0308	3.034	0.972
Tetraodontidae	*Arothron reticularis*	9	2.8	7.1	0.0359	2.952	0.984

Twenty species from 14 families were caught from Station 1 (Table 2). In terms of the number of individuals caught, the dominant species was from the family Ambassidae (58%). In Station 2, twenty-one species from 15 families were caught (Table 3). The dominant species were from the families Ambassidae comprising 34% of the total number of individuals caught, Portunidae comprised 19% of the total number of individuals caught and 17% was from the family Penaeidae. In Station 3, twenty-four species from 17 families were caught and the dominant species was from the family Penaeidae comprising 34% of the number of individuals caught. Ambassidae and Portunidae comprised 26% and 11% of the total number of individuals caught respectively (Table 4). Nineteen species from 14 families were caught from Station 4. Forty-seven percent of the individuals caught were from the family Ambassidae, 15% from Megalopidae and 13% from Mugilidae (Table 5). The mean standard length, total length and weight of every species caught from each station are shown in tables (2 - 5). Although some of the individuals caught were large sized, most were small sized indicating that they were mostly in juvenile stage.

The diversity indices, richness indices and evenness indices are shown in Table (6). The diversity indices ranged from 0.85 at Station 1 to 1.10 at Station 2. The richness indices ranged from 8.43 at Station 1 to 10.67 at Station 3. Evenness indices ranged from 0.30 at Station 1 to 0.36 at Station 2. Length-weight relationships of 9 species of fish caught were examined and the results given in table (7). Coefficient of determination showed that most of the variations explained by the relationship were more than 90%. The value of parameter *a* ranged from 0.0064 to 0.0359 and the value of parameter *b* ranged from 2.653 for *Ambassis urotaenia* to 3.102 for *Elops machnata*.

Fisheries: During field sampling, four groups of fishermen were observed fishing in the study area. Two groups used cast net, one group used crab trap and one group used hooks and lines. These fishermen were believed to fish here part time during their off days from work. This is not surprising as many of the fish families found in the river such as Centropomidae, Elopidae, Lutjanidae, Megalopidae, Mugilidae and Scatophagidae and crustacean such as Penaeidae and Portunidae are commercially important species. Some of the fish caught are also larger sized individuals and these include *Oreochromis niloticus* (176 g), *Elops machnata* (201 g), *Megalops cyprinoides* (260 g), *Lutjanus argentimaculata* (360 g), *Lates calcarifer* (485 g), *Arius argyropleuron* (750 g) and *Liza melinopterus* (980 g). Whether fish and crustacean from this river are safe for human consumption is not known as no studies have been carried out to determine the content of pollutants in the tissues of these organisms.

DISCUSSION

The results obtained from Lutong River showed that the river supports substantial number of fish species and many of them are also important commercial species. However, the values of diversity index, richness index and evenness index were much lower than those recorded for well developed mangrove areas in Sarawak such as Paloh mangrove area [23]. For example, the number of species recorded from Lutong River was only about 47% of those recorded for Paloh Mangrove and the number of families only 58% of those present in Paloh mangrove. When compared to studies in other mangrove areas, the results obtained in Lutong River were also lower that those reported for mangroves in Sabah [24, 25], Peninsular Malaysia [26] and the Indo-Pacific [27].

One of the reasons that higher diversity of fish occurred in other mangrove areas was possibly due to the abundance of food supplies. Studies in Paloh mangrove showed large quantities of detritus found at the bottom of the estuaries whereas detritus were significantly less in Lutong River. This is mainly because of the narrow strip of impoverished mangroves along the river bank. Food sources in mangrove areas were consumed either directly as detritus or indirectly through the structure features attracting many preys [28]. Invertebrates that were abundant at vegetated areas were suitable for juvenile fishes particularly plankton as their source of food [29, 30]. The abundance of benthic diatoms on mangrove roots in Paloh was also source of food for many herbivores species [31]. The complexity of the mangrove habitat structures also attracted many species of fishes to utilize mangrove as their breeding and nursery ground for their juveniles. The roots of mangrove trees are a suitable and complex habitat for fishes and also reduced the risk of them being eaten by piscivorous predators [6, 32, 33]. However, such structures were not found in the narrow strip of impoverished mangroves along the banks of Lutong River.

Nevertheless, anthropogenic influence might be more significant than the biological factors in regulating the community of fish and crustacean in Lutong River. Two months prior to this study, an oil spill occurred from one of the pipelines at the bank of Lutong River and impact of the spill on surrounding vegetations was still observable. It was also reported by the residents that many fishes and crustaceans died after the spill. Oil spill potentially lead to short and long term effects. Death occurred likely due to the oil's physical effects and chemical toxicity [34] such as reduced oxygen availability to the fish. According to Spaulding *et al*. [35], direct impacts of oil could occur through hydrocarbon-induced egg and larval mortality. Sánchez *et al*. [36] reported that there were significant reductions in the abundance of Norway lobster, *Plesionika heterocarpus* and four-spot megrim in the Prestige oil spill maximum impact area. Souza-Bastos and Freire [37] reported that osmoregulation of a resident estuarine fish, *Atherinella brasiliensis*, in tropical estuarine system in southern Brazil was still affected by an oil spill, 7 months after the accident. Surprisingly, substantial number of fishes were caught during this study and thus we believe that sea water flushing during high tides could effectively minimize the effects of the spill. Edgar *et al*. [38] who reported little impact of Jessica oil spill suggested that moderate wave action was one of the possible factors that contributed to minimum impact observed. Immediate mitigation measures taken by the relevant oil company have also reduced the impacts.

Petroleum industry at the bank of Lutong River has also been in existence for decades. The long term effects of this industry as well as input of pollutants from the human settlement along the rivers may have impacted the fish communities there. According to Wake [39], oil refineries effluent contains many different chemicals and toxicity tests have shown that most refinery effluents are toxic but to varying extents depending on species and life cycle. It was also reported that sublethal tests have found that not only can the effluents be lethal but also they can often have sublethal effects on growth and reproduction. Other than the oil refinery located in the vicinity, human settlement has most likely contributed to the decrease in fish diversity through increase in pollution that affected the benthic habitats. A study of the Santubong River in Sarawak showed that stations near residential and construction of residential area showed high total suspended solids and nitrate-nitrogen [40]. Review of studies on the Gulf of Mexico showed that residential development activities was one of the activities that caused the observed deterioration in most benthic habitats [41]. Parameter *b* values of *Elops machnata*, *Lates calcarifer and Scatophagus argus* were more than 3 showing positive allometric growth but the rest were less than 3 showing that the growth was negative allometric, that is, 66.7% showing negative allometric growth. This is in contrast to the report of only 19% of the 25 species studied showing *b* value of less than 3 in a tropical estuary in west Africa where there was no major disturbances [42]. The high percentage of negative allometric growth in the present study was probably associated with polluted environment and lack of food sources that may potentially hampered normal growth of the fishes.

CONCLUSION

Although Lutong River supports a substantial number of fish fauna, the number of species and families are far less when compared with other mangrove areas in other parts of Sarawak, Sabah, Peninsular Malaysia and in the Indo-Pacific. Apart from the shallowness of the river and the long history of exposure to the petroleum industry in the area, the thin impoverished strip of mangrove along the river banks may not be adequate to support a large population and thus a large number and many species of fish and crustacean. It is postulated that the fish population found in the river especially the larger-sized individuals are sporadic visitors to the area. They visited the river from the open sea during flooding and leave the area during ebbing.

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