The Journal of Animal & Plant Sciences, 23(5): 2013, Page: 1305-1315
ISSN: 1018-7081

ECOLOGICAL CHARACTERISTICS OF POME PONDS WITH REFERENCE TO STUDY SOME OF THEIR INVERTEBRATE SPECIES IN PENINSULAR MALAYSIA

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ABSTRACT

Food is major factor for the survival of avian species and play significant role in their distribution and habitat selection. The food resources of POME ponds were examined using scoop net (a metal container) and avian species were determined direct visual observation from January to June, 2010. A total of 119126 invertebrate individuals of twelve species were recorded from POME pond number one and three. However, no individual was sampled from pond number two and four. Mosquito Larvae – *Aedes* sp. (40.71%) was the most abundant invertebrate species and Water Scavenger Beetles – *Hydrophilus* sp. (2.52%) was the rarest one. The relative abundance of aquatic invertebrate was significantly different in pond number one (i.e. $F_{11,\ 60} = 37.86$, $P < 0.05$) and three (i.e. $F_{11,\ 60} = 34.23$, $P < 0.05$). For POME pond number one, the higher species diversity, i.e. Shannon's ($N_1 = 2.21$), and species evenness, i.e. Pielou's J ($E = 0.89$) was determined in June and species richness, i.e. Margalef's ($R_1 = 1.73$) in May. In contrast, the lowest species diversity i.e. Shannon's N1 = 0.66, species richness, i.e. Margalef's ($R_1 = 0.35$), and species evenness, i.e. Pielou's J ($E = 0.47$) was recorded in January. Similarly, for POME pond number three, the highest invertebrate species diversity i.e. Shannon's ($N_1 = 2.17$) and evenness i.e. Pielou's J ($E = 0.87$) was recorded in June and the lowest invertebrate species diversity ($N_1 = 0.59$) and evenness ($E = 0.42$) was recorded in January. Likewise, the highest species richness such as Margalef's ($R_1 = 1.19$) was recorded in March and the lowest ($R_1 = 0.34$) in January. In addition, direct observation detected twenty one waterbird species that frequently utilized POME ponds for foraging and loafing purpose. The results of this study highlighted that POME ponds are highly productive and attractive habitats for diverse avian species particularly waterbirds due to occurrence of different invertebrate species.

Key words: Invertebrates, POME, Scoop net, Diversity, Aves, Island.

INTRODUCTION

Food resources in ponds distributed heterogeneously and are key factor that influences the habitat selection and reproductive success of waterbirds including egrets (Hafner *et al*., 1986; Guillemain & Fritz, 2002). Waterbirds such as egrets, herons, grebes, waterhens, ducks, snipes, lapwings and kingfishers usually stalk on wide array of aquatic invertebrates (i.e. insect's larvae, crustaceans, shrimps, and worms) and vertebrates such as fishes, amphibians and reptiles (Kushlan & Hancock 2005; Moran, 2010). Variation in foraging behavior of avian species is usually attributed to variation in the availability of prey (Erwin *et al*., 1985; Higuchi, 1988; Dimalexis *et al*., 1997). Wading birds often select foraging sites having shallow water with less emergent vegetation, because these areas densely concentrated with invertebrates and easy to catch (Pierce & Gawlik, 2010).

POME contains high compositions and concentrations of carbohydrate, protein, nitrogenous compounds, lipids and minerals (Phang, 1988; Habib *et al*., 1997). Due to richness of food resources, it is highly attractive to wide array of insect in order to feed, rest and breed. The food resources that occurs in POME ponds are mostly small aquatic invertebrates that preyed by wide array of avian species at Carey Island. Aquatic invertebrate are the most abundant macro-fauna in wetland habitat and have been considered as key element in food webs (Murkin, 1989; Brooks, 2000).

Aquatic invertebrates are an important food source for wetland birds particularly waterbirds (Magee, 1993). They play major role in waterbird habitat selection, distribution and reproductive success (Weber & Haig, 1997; Backwell *et al.*, 1998; Anderson *et al*., 2000). Many useful devices and techniques i.e. sweep nets, drift nets, pitfall traps; pan traps, dip net and scoop net have been used to sample the aquatic invertebrate in various water bodies (Murkin *et al*., 1983; Brinkman & Duffy, 1996; Turner & Trexler, 1997; Hanson *et al*., 2000).

The information on invertebrate assemblages, distribution, relative abundance, and diversity in POME ponds of Malaysia is not sufficient. To date no detailed studies have been carried out in POME pond areas of Malaysia to examine the invertebrate species composition, relative abundance, and diversity and their importance for avian species. The main objective of this study was to determine the availability of food resources in POME ponds for avian species at Carey Island, Peninsular Malaysia.

MATERIALS AND METHODS

Study Site: Carey Island is located in Kuala Langat District, south to Port Klang and north to Klang River near Banting within the quadrant of 101°22′ E and 2°52′ N, in the state of Selangor, Peninsular Malaysia (Figure 1). It is separated from mainland by Langat River and connected by a bridge at Chondoior Teluk Panglima Garang near Banting. This island encompasses of 15,000ha, out of which 80.0% of area is belongs to Sime Darby Plantation Berhad while 20.0% is state land. This island is located at 2 meter below sea level (during high tide) encompass of diverse habitats such as narrow sea-shore, mudflats, sandy beach and swampy area.

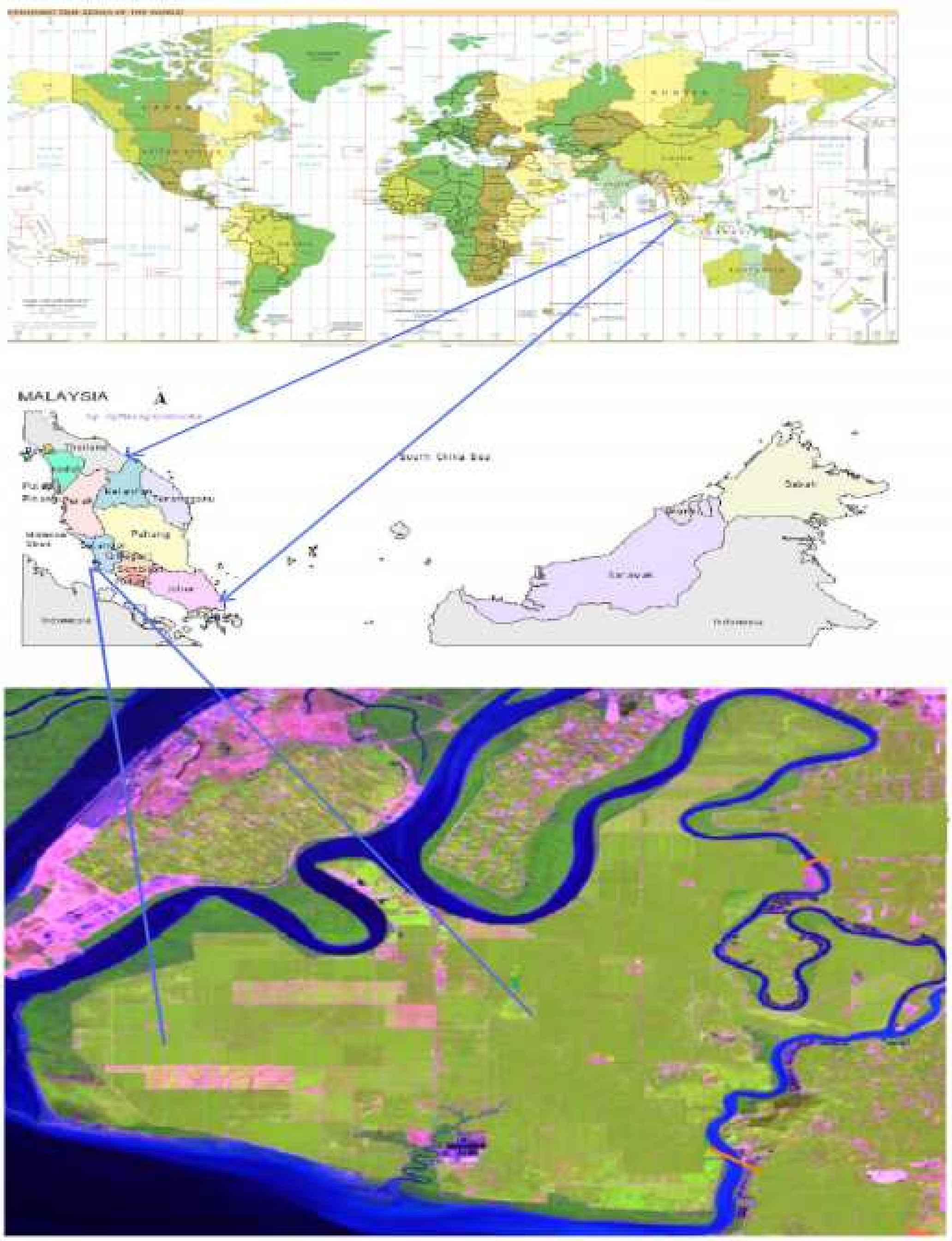
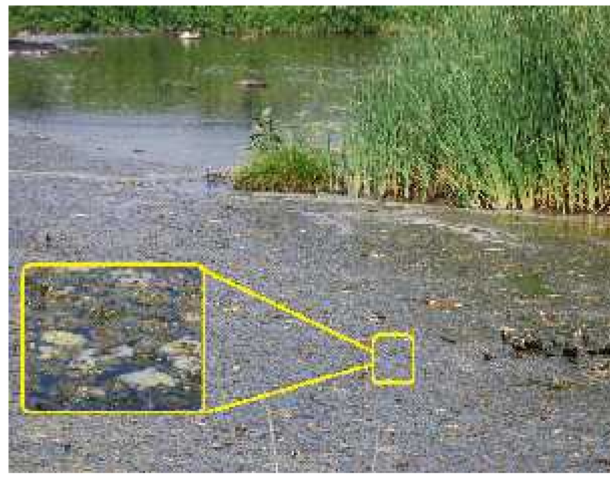


Figure 1. Location map of study site in Carey Island, Selangor, Peninsular Malaysia

The study site was comprised of four POME ponds and each pond varied in size, water level, floating material, vegetation cover and structure. POME pond number one was dominated by compacted waste material along the sides as well as in center, the edges were covered with Cattail (*Typha* sp.) and somewhere with trees i.e. Blush Macaranga (*Macaranga tanarius*), Oil Palm (*Elaeis guineensis*), Timar (*Avicennia marina*), and *Rhizophora apiculata.* POME pond number two contains small size floating waste material and around 40% is covered with Cattail and along sides Blush Macaranga and Oil Palm. Pond number three was quite different as compared to pond number one and two i.e. it contains dead fallen trees and some mud mounds covered with Climbing Fern (*Stenochlaena palustris*) andThree Square Bulrush (*Scirpus olneyi*). Pond number four was densely covered with algae and look lush green, along the edge covered with Climbing Fern and Blush Macaranga and Oil Palm (Figure 2).

POME Pond Number One



POME Pond Number Two

POME Pond Number Three

POME Pond Number Four

Figure 2: Morphological Features of Four POME ponds of Carey Island

Food Sample Collection: Aquatic invertebrates in four POME ponds were sampled using scoop net (20 cm X 20 cm) (Figure 3) and metal container (Figure 4) and then casted into plastic containers to determine the species composition, relative abundance, and species diversity. The plastic containers were brought into the laboratory and screened one by one using nylon cycle net. After screening, the invertebrates were sorted and preserved into 70% alcohol for identification. The invertebrates were counted in plastic tray and identified with the help of field guides, entomologist and with the comparison of museum samples. The sampled were collected twice in a month during 0900 - 1400 hrs from January to June, 2010. During each sampling, four samples were collected from each pond along the corners and one from centre. The methodology followed was described in detail by Voslamber *et al.* (2010).

Figure 3: Scoop net (Square).

Figure 4: Sample of Invertebrates

Data Analysis: The relative abundance (%) of invertebrates was determined using the following expression: n/N x 100,

Where n is the number of a particular invertebrate species and N is the total number recorded over all invertebrate species.

The invertebrate's diversity index such as species diversity, richness and evenness was determined using Henderson and Seaby's (2007) Community Analysis Package Software (CAP, Version 4.0). A diversity index is a mathematical measure of species variation in a community. Species diversity is an index that incorporates the numbers of species in an area and also takes into account their relative abundance and provides more information about community composition such as rarity and commonness of species in a community than simply species richness.

For example Shannon's diversity index:

$H = - \Sigma (ni/n) \ln (ni/n)$:

Where, *ni* = Σ individuals of species i; n = Σ Individuals of all species.

Species richness is the number of different species in a given area. It also provides information on homogeneity and rarity of species.

For example: Margalef's Richness Index:

(R) = S-1/ln (n):

Where, S= Σ species in plot; n =Σ Individuals of all species.

Evenness is a measure of the relative abundance of different species of particular area.

The results were compared using analysis of variance (ANOVA) and Tukey's (HSD) test to determine the significant difference.

RESULTS

Invertebrates Species Composition and Relative Abundance: A total of 119126 invertebrate individuals of twelve species were recorded from POME ponds during January to June, 2010. The result shows that Mosquito Larvae – *Aedes* sp. (40.71%), Hoverfly Larvae – *Eristalis* sp. (17.67%), and Water Beetles – *Stenolopus* sp. (10.25%) were three the most abundant invertebrate species, while Predaceous Diving Beetles – *Cybister* sp. (3.03%), Housefly Maggot – *Tabanus* sp. (2.99%), and Water Scavenger Beetles – *Hydrophilus* sp. (2.52%) were the rarest invertebrate's species recorded in the study area (Table 1).

Table 1. List of Invertebrates obtained from POME ponds.

Common Name	Scientific Name	Total captured	%
Mosquito larvae	*Aedes* sp.	48493	40.71
Hoverfly larvae	*Eristalis* sp.	21044	17.67
Water beetles	*Stenolopus* sp.	12214	10.25
Water diving beetles	*Eretes* sp.	6078	5.10
Solitary midges	*Thaumalea* sp	5700	4.78
Midge fly larvae	*Chironomus* sp.	4125	3.46
Great diving beetles	*Dytiscus* sp.	3920	3.29
Water bugs	*Sphaerodema* sp.	3749	3.15
Watersnipe fly larvae	*Atherix* sp.	3623	3.04
Predacious diving beetle	*Cybister* sp.	3614	3.03
House fly maggots	*Tabanus* sp.	3563	2.99
Water scavenger beetle	*Hydrophilus* sp.	3003	2.52
	Total	**119126**	**100**

Pond Wise Insect Relative Abundance: A total of 57,900 individuals aquatic invertebrate from pond one and 61226 individuals from pond three were recorded during study period. The result indicated that Mosquito larvae – *Aedes* sp. (19.46%) in pond number one and (21.25%) in pond number three was the most dominant invertebrates. In contrast, Water Scavenger Beetles – *Hydrophilus* sp. (1.21%) in pond number one and 1.31% in pond number three was the rarest invertebrate. However, no individual of invertebrate in POME pond number two and four was sampled (Table 2).

Table 2. List of insect species with relative abundance recorded from POME ponds.

Species Name	Pond 1	%	Pond 2	Pond 3	%	Pond 4
Aedes sp.	23180	19.46	0	25313	21.25	0
Eristalis sp.	9941	8.34	0	11103	9.32	0
Stenolopus sp.	6067	5.09	0	6147	5.16	0
Eretes sp.	3543	2.97	0	2157	2.16	0
Thaumalea sp.	2347	1.97	0	1402	1.18	0
Chironomus sp.	2248	1.89	0	1877	1.58	0
Dytiscus sp.	1886	1.58	0	2034	1.71	0
Sphaerodema sp.	1866	1.57	0	4212	3.54	0
Atherix sp.	1833	1.54	0	1730	1.45	0
Cybister sp.	1795	1.51	0	1828	1.53	0
Tabanus sp.	1754	1.47	0	1860	1.56	0
Hydrophilus sp.	1440	1.21	0	1563	1.31	0
Total	**57900**	**100**	**0**	**61226**	**100**	**0**

Month Wise Invertebrate Relative Abundance in POME pond number one: The results show that Mosquito larvae (*Aedes* sp.) i.e. 19.46% had highest relative abundance during February, for Water Bug (*Sphaerodema* sp.) 31.40% during March and for Great Diving Beetle (*Dytiscus* sp.) i.e. 30.70% was recorded in April. Furthermore, the highest relative abundance of nine invertebrates namely Hoverfly larvae (*Eristalis* sp.) i.e. 28.28%, Water Beetles (*Stenolopus* sp.) 31.14%, Water Diving Beetle (*Eretes* sp.) 36.92%, Midge Fly larvae (*Chironomus* sp.) i.e. 31.45%, Watersnipe Fly larvae (*Anterix* sp.) 35.62%, Predacious Diving Beetle (*Cybister* sp.) 33.98%, Housefly larvae (*Tabanus* sp.) 28.16%, Water Scavenger Beetle (*Hydrophilus* sp.) 43.19%, and Solitary Midges (*Thaumalea* sp.) i.e. 41.29% was determined during June. Furthermore, nine invertebrate species were absent during January and four species during February (Table 3).

Table 3. Month wise insect relative abundance recorded in POME pond number one from January to June (n = 12)

Species Name	January	February	March	April	May	June	Total
Aedes sp.	4381	4511	3645	3541	3452	3650	23180
Eristalis sp.	682	931	905	1866	2746	2811	9941
Stenolopus sp.	402	964	887	860	1065	1889	6067
Eretes sp.	0	387	520	587	741	1308	3543
Thaumalea sp.	0	0	301	335	742	969	2347
Chironomus sp.	0	245	316	367	613	707	2248
Dytiscus sp.	0	0	301	579	500	506	1886
Sphaerodema sp.	0	0	586	367	421	492	1866
Atherix sp.	0	108	367	303	402	653	1833
Cybister sp.	0	112	302	367	404	610	1795
Tabanus sp.	27	283	293	316	341	494	1754
Hydrophilus sp.	0	0	113	315	390	622	1440
Total	**5492**	**7541**	**8536**	**9803**	**11817**	**14711**	**57900**

One-way analysis of variance (ANOVA) and Tukey's (HSD) test was used to test significant difference among invertebrate's relative abundance in pond number one. The results showed that relative abundance was significantly different, i.e. $F_{11, 60} = 37.86$, $P < 0.05$ (Table 4 and Appendix 1).

Table 4. Comparison of insect relative abundance in POME pond number one at Carey Island, Peninsular Malaysia

Insect Name	Mean Relative Abundance
Aedes sp.	3863.3 a
Eristalis sp.	1656.8 b
Stenolopus sp.	1011.2 b
Sphaerodema sp.	590.50 c
Eretes sp.	391.17 c
Dytiscus sp.	374.67 c
Chironomus sp.	314.33 c
Tabanus sp.	311.00 c
Cybister sp.	305.50 c
Atherix sp.	299.17 c
Hydrophilus sp.	292.33 c
Thaumalea sp.	240.00 c

(The mean values in columns with same letter are not significant at P = 0.05, Tukey's HSD test; Critical Value, 819.32)

Month Wise Invertebrate Relative Abundance in POME Pond Number Three: The highest relative abundance of Mosquito larvae (*Aedes* sp.) i.e. 21.31% was recorded in January and Great Diving Beetle (*Dytiscus* sp.) i.e. 31.66% was recorded in March. The highest relative abundance of five invertebrates such as Hoverfly larvae (*Eristalis* sp.) i.e. 27.80%, Midge Fly larvae (*Chironomus* sp.) i.e. 27.70%, Housefly larvae (*Tabanus* sp.) 29.46%, Water Scavenger Beetle (*Hydrophilus* sp.) 36.47%, and Solitary Midges (*Thaumalea* sp.) i.e. 33.74% was recorded in June. Likewise, the highest relative abundance of five invertebrates namely Water Bug (*Sphaerodema* sp.) 27.73%, Water Diving Beetle (*Eretes* sp.) 26.75%, Water Beetles (*Stenolopus* sp.) 27.09%, Predacious Diving Beetle (*Cybister* sp.) 26.70%, and Watersnipe Fly larvae (*Anterix* sp.) 31.79% was recorded during May. Furthermore, eight invertebrate species were absent during January and four species during February (Table 5).

The significant difference of insect relative abundance in pond number three was compared by applying one-way analysis of variance (ANOVA) and Tukey's (HSD) test. The results showed that the insect relative abundance in pond number three was significantly different, i.e. $F_{11, 60} = 34.23$, $P < 0.05$ (Table 6 and Appendix 2).

Table 5. Month wise insect relative abundance in POME pond number three from January to June.

Species Name	January	February	March	April	May	June	Total
Aedes sp.	5393	3752	4753	5034	3225	3156	25313
Eristalis sp.	851	1023	1215	2064	2863	3087	11103
Stenolopus sp.	298	683	1167	714	1665	1620	6147
Sphaerodema sp.	0	0	1087	906	1168	1051	4212
Eretes sp.	0	332	327	364	577	557	2157
Dytiscus sp.	0	0	644	396	447	547	2034
Chironomus sp.	0	336	272	374	375	520	1877
Tabanus sp.	24	275	286	326	401	548	1860
Cybister sp.	0	181	361	315	488	483	1828
Atherix sp.	0	199	203	282	550	496	1730
Hydrophilus sp.	0	0	188	349	456	570	1563
Thaumalea sp.	0	0	174	351	404	473	1402
Total	**6566**	**6781**	**10677**	**11475**	**12619**	**13108**	**61226**

Table 6. Comparison of insect relative abundance in POME pond number three at Carey Island, Peninsular Malaysia.

Insect Name	Mean Relative Abundance
Aedes sp.	4218.8 a
Eristalis sp.	1850.5 b
Stenolopus sp.	1024.5 b
Sphaerodema sp.	702.00 c
Eretes sp.	359.50 c
Dytiscus sp.	339.00 c
Chironomus sp.	312.83 c
Tabanus sp.	310.00 c
Cybister sp.	304.67 c
Atherix sp.	288.33 c
Hydrophilus sp.	260.50 c
Thaumalea sp.	233.67 c

(The mean values in columns with same letter are not significant at P = 0.05, Tukey's HSD test; Critical Value, 953.82)

Diversity Indices of Insects: The diversity indices of insects in POME pond number one was determined in order to examine the fluctuation in insect community.

Diversity of Insects in POME Pond Number One: The diversity test indicated that invertebrate species diversity, richness and evenness varied from January to June. For example, the higher invertebrate diversity, i.e. Shannon's (N_1 = 2.21), and species evenness, i.e. Pielou's J (E = 0.89) was determined in POME pond number one in June, but highest invertebrate richness, i.e. Margalef's (R_1 = 1.73) was recorded in May. In contrast, the lowest invertebrate species diversity i.e. Shannon's N1 = 0.66, species richness, i.e. Margalef's (R_1 = 0.35), and species evenness, i.e. Pielou's J (E = 0.47) was recorded in January at POME pond number one (Figure 5).

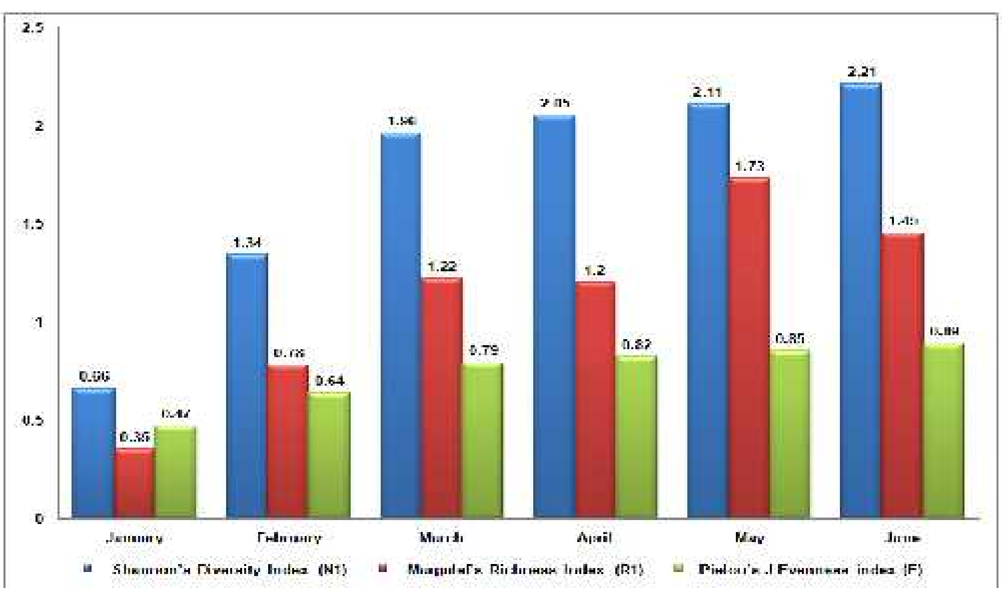


Figure 5. Comparison of insect diversity from January to June in POME pond number one.

Diversity of Insects in POME Pond Number Three: The highest invertebrate species diversity i.e. Shannon's (N_1 = 2.17) and evenness i.e. Pielou's J (E = 0.87) was recorded in June and the lowest invertebrate species diversity (N_1 = 0.59) and evenness (E = 0.42) was recorded in January in POME pond number three. Likewise, the highest species richness such as Margalef's (R_1 = 1.19) was recorded in March and the lowest (R_1 = 0.34) in January (Figure 6).

Avian Species: Direct observation detected a total of twenty one waterbird species that frequently utilized POME ponds for foraging and loafing purpose (Table 7).

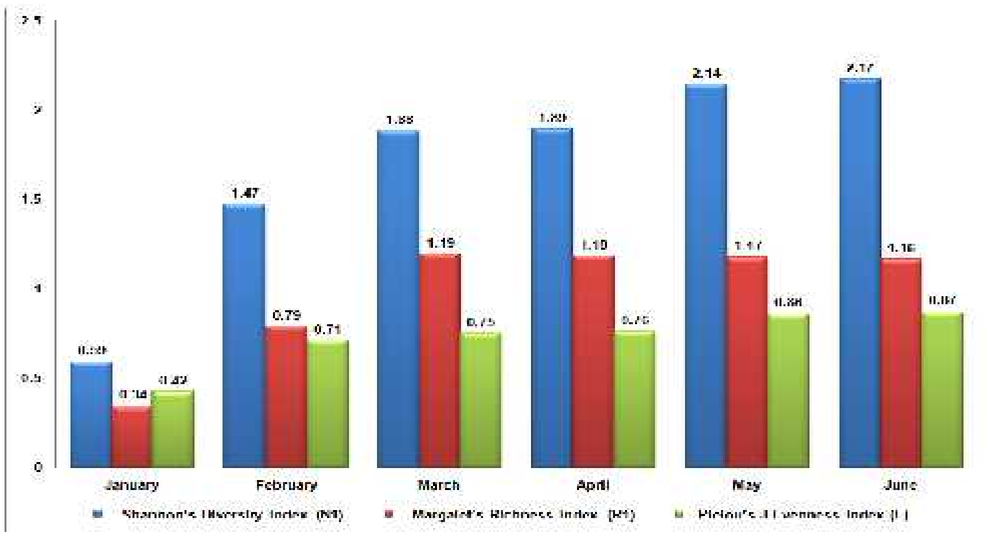


Figure 6. Comparison of insect diversity from January to June in POME pond number three.

Table 7. Avian species detected at POME ponds of Carey Island, Peninsular Malaysia

Family Name	Common Name	Scientific Name
Halcyonidae	Collard Kingfisher	*Todiramphus chloris*
Alcidinidae	Common Kingfisher	*Alcedo atthis*
	Stork-billed Kingfisher	*Pelargopsis capensis*
	White-throated Kingfisher	*Halcyon smyrnensis*
Anatidae	Lesser Whistling Duck	*Dendrocygna javanica*
Ardeidae	Black-crowned Nightheron	*Nycticorax nycticorax*
	Cattle Egret	*Bubulcus ibis*
	Chinese Egret	*Egretta eulophotes*
	Great Egret	*Chasmerodius albus*
	Grey Heron	*Ardea cinerea*
	Intermediate Egret	*Egretta intermedia*
	Javan Pond Heron	*Ardea speciosa*
	Little Egret	*Egretta garzetta*
	Little Heron	*Butorides striatus*
	Purple Heron	*Ardea purpurea*
Charadriidae	Red-wattled Lapwing	*Vanellus indicus*
Podicipedidae	Little Grebe	*Tachybaptus ruficollis*
Rallidae	Common Moorhen	*Gallinula chloropus*
	White-breasted Waterhen	*Amaurornis phoenicurus*
Scolopacidae	Common Sandpiper	*Tringa hypoleucos*
	Pintail Snipe	*Gallinago stenura*

DISCUSSION

The recording of twelve aquatic invertebrates species in POME ponds shows that these area are most suitable habitat for wide array of aquatic invertebrates. Results also revealed that invertebrate abundance changes dramatically from January to June, 2010 and may vary in four POME ponds. Furthermore, a change in invertebrate occurrence among four POME ponds was recorded i.e. pond number one and three was heavily utilized by aquatic invertebrate where as pond number two and four was avoided. In addition, fluctuation in invertebrate occurrence during six consecutive months was recorded i.e. only four insect species were recorded during January while eight species were absent. Likewise, four invertebrate species were absent during February. The change in occurrence and abundance in aquatic invertebrates was due to fluctuation in water level, water temperature, or effluent discharge from palm oil mill factory that affects on water quality. The other reason may be that these species didn't breed during January and February because mostly larvae of these aquatic invertebrates were recorded.

Invertebrate occurrence, distribution and reproduction directly or indirectly related with water level, sediment and emergent vegetation. Emergent vegetation offer variety of food resources and suitable breeding grounds for aquatic invertebrate communities.

In addition, it has also been reported that detritus i.e. dead or decaying vegetation is an ideal substrates for invertebrate production (Krull, 1970; Voigts, 1976), thus potentially enhancing the amount of food available to waterbirds (Twedt *et al*., 1998). It has been reported that aquatic invertebrate communities such as beetle larvae, midge larvae, nymph, naids, snails, crustaceans and polycheats are associated with hydrology, sediment and emergent vegetation (Little, 2000). The availability of food resources in wetlands may vary depends on water depth, water temperature, dissolved oxygen, turbidity and type and density of vegetation (Mitsch & Gosselink, 1993).

Recording of twenty one waterbird species indicated that POME ponds are attractive to diverse avian species and it provides variety of food resources for them. Food abundance and richness are important factors that influence the distribution and richness of avian species particularly wading birds such as White Storks (*Ciconia ciconia*) by Dallinga & Schoenmakers (1987), Goriup & Schulz (1991) and Antczak *et al.* (2002), Wading Birds by Hafner (1997) and Great Blue Heron by Gibbs & Kinkel (1997).

Direct observation indicated that the changes in effluent discharged from oil mills may affect water quality and water temperature that directly influence the distribution of aquatic invertebrates assemblages. The results also indicate that occurrence of aquatic invertebrate's abundance, richness and distribution affects on the abundance and distribution of avian species in POME ponds. For example no avian species was recorded in pond number two while lesser whistling ducks and little grebes used POME pond number four. This was due to absence of aquatic insect in POME pond number two and occurrence of algae in pond number four. This means the availability of food resources such as aquatic invertebrates are highly important and can influence on avian habitat selection and distribution.

The results indicate that POME number one and three have higher aquatic invertebrate abundance and low emergent vegetation cover. However, POME pond number four was densely covered with algae look a lush green (see figure 2). This shows that Ardeidae avoid area with dense vegetation because vegetation cover inhibits foraging success and reduce prey vulnerability. A similar finding also has been reported for suitable habitat for purple heron by Campos & Lukuona (2001), for foraging ecology of egrets by Richardson *et al.* (2001), for wading bird foraging habitat by Pierce & Gawlik (2010) and for effects of water depth and submerged aquatic vegetation on the selection of foraging habitat and foraging success of wading birds by Lantz *et al*. (2010).

In this study it was found that less vegetated area have higher abundance of aquatic invertebrates, POME pond number one and three for example have more aquatic invertebrates compared to POME pond number two and four. The results of this study are different from previous studies such as Masifwa *et al.* (2001) and Sharitz & Batzer (1999) founded that aquatic plants provide ideal habitat for larger macro-invertebrates. Higher abundance of macro-invertebrates is closely associated with aquatic vegetation (Olson *et al.,* 1995). Nelson and Kadlec (1984) stated that invertebrate biomass, density and diversity may depend on aquatic plant composition and physiognomic characteristics i.e. surface area. De Szalay and Resh (2000) demonstrate that invertebrate communities may be different within plant stands with heterogeneous amounts of emergent cover i.e. mosquitoes, brine flies and hover flies were positively correlated with amount of plant cover, and water boatmen, midges and water scavenger beetles were negatively correlated with plant cover. Murkin *et al.* (1996), Streever *et al.* (1995) and Batzer and Resh (1992) recorded that the change in the vegetation composition and structure influence the distribution of invertebrate communities in wetland. But the results of this study indicated that vegetated area avoided by aquatic invertebrates while less vegetated area supported higher abundance of aquatic invertebrates.

Conclusion: The results of this study highlighted that POME ponds are highly productive and attractive habitats for diverse avian species particularly waterbirds due to occurrence of different invertebrate species.

Acknowledgement: We thank Sime Darby Plantation Berhad for allowing us to conduct this study in their estate. Field assistance from Sime Darby Berhad and Institute of Biological Sciences staffs is highly appreciated. This study was funded by Sime Darby Plantation Berhad (55-02-03-1034) and University of Malaya Research Grant.

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