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Prevalence of Monogenean Gill Parasites of Two Pond-Cultured Fish Species in Perlok, Malaysia

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ABSTRACT

Studies on the diversity, distribution and abundance of fish gill parasites (monogenean) of two fish species in two 0.2 ha fish ponds was conducted in Perlok, Malaysia between 2010 and 2011 using standard parasitological examination methods. A total of 800 fish comprising of 400 *Hampala macrolepidota* Van Hasselt and Kuhl 1823 and 400 *Hemibagrus nemurus* Valenciennes 1840 was sampled and examined. Five monogenean species were detected from the gills of the examined fishes. Namely; *Dactylogyrus macrolepidoti, Dactylogyrus quadribrachiatus, Dactylogyrus hampali* from *Hampala macrolepidota* fish species and *Cornudiscoides malayensis* and *Cornudiscoides sundanensis* from *Hemibagrus nemurus* fish species. The results revealed that seasonality had some significant influence on the distributions and diversities of monogeneans on the two fish species. The prevalence of the parasite infestation was higher (100%) during non-monsoon (March – July) and lower (44%) during the monsoon (November – February) on both fish species. A high positive correlation ($P < 0.05$) was observed between the water temperature and monogenean prevalence. Interestingly, low monogenean diversity and distributions were noticed during monsoon period (November – February) compared to non-monsoon (March – July) in both fish species. In this study, calculated indices such as Shannon-Weaver (H') Simpson index (1/D), Margaleff Diversity Index (d), Mackintosh Diversity Index (Mc), and Berger-Parker dominance Index (1/d) revealed that the diversity and distribution of these monogeneans in their respective fish hosts were affected by the water quality variables and seasonality during the study period.

Key words: Prevalence, Gill parasites, Monogeneans, Pond-Cultured Fish Species, Perlok, Malaysia

INTRODUCTION

Knowledge of parasite species diversity and distribution is very important because it indicates the health and stability of ecosystems and is important in the management of wildlife and aquaculture systems (Lim, 1998). In Malaysia, comprehensive studies on the monogenean diversity in relation to water quality are rarely conducted and most of the researches done on this group of worms were morphologically and taxonomically base (Lim and Furtado (1984, 1986; Lim, 1986, 1989, 1992). Due to inadequate data on monogenean diversity and distribution in relation to water quality for comparison among fishes, this present study was carried out to determine the diversity of the monogenean community from these two fish species.

Monogenea are found worldwide in freshwater, brackish and marine environments. According to Reed *et al*., (2012), there are more than 100 families of monogenea found on fishes of the world. They are normally found on the external surfaces of fish (skin, fins, gills, mouth cavity, and nostrils). Most monogeneans are browsers, moving about on the body surface and feeding on skin mucus and gill debris. Monogenea have a direct life cycle i.e. without intermediate hosts and can reproduce in a wide range of temperatures (Roberts and Janvoy, 2000). Roberts and Janvoy, 2000 added that adult freshwater monogenea produce brownish yellow, ovoid, operculated eggs with polar filaments. The eggs which are released through the genital pore will fall into the surrounding water.
Dactylogyrus and *Gyrodactylus* are two common genera of monogenean parasites; they differ in reproductive strategies and attachment sites (Reed *et al*., 2012). *Dactylogyrus* are commonly found on

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gills of fish; they are oviparous, produce or release eggs into the aquatic habitat. However, *Gyrodactylus* commonly occur in skin or fins of fish and they are viviparous (produce live young). Monogenea do not cause much problem to fish in the wild but will cause disease when fish are crowded together in the culture systems such as hatcheries, pond and cage culture (Roberts *et al.*, 1996). The objective(s) of the study are to establish the relationship between the abundance, diversities and distribution of monogenean gill parasites, water and season.

MATERIALS AND METHODS

The study site

Aquaculture Extension Centre (AEC, Perlok) is located at Jerantut (3º 56'48.62" N, 102º 22'47.57" E) in Pahang, Malaysia. It is a state owned fisheries development center for the purpose of producing fish fingerlings for supply to commercial and other fish culturist in and around the state and the sub-region of the Peninsula Malaysia. AEC, Perlok, has more than 54 earthen fish ponds and concrete tanks of various sizes in two different Hatcheries. The ponds are fed by stream (River Jerantut) as its water source. In Peninsular Malaysia, virtually two basic seasons (monsoon – rainy season and non-monsoon – dry, hot season) are identified; although there are some inter-seasons that occur between the two main seasons as postulated by Rouf (2010).

Fish sampling and examination

A total of 800 fish comprising of 400 *Hampala macrolepidota* Van Hasselt and Kuhl 1823 and 400 *Hemibagrus nemurus* Valenciennes, 1840 was sampled and examined from a 0.2 ha fish pond in Perlok, Malaysia. The fish were caught by seine net (mesh size 2"). Captured fish were brought in an aerated plastic bucket with pond water to the laboratory. Fish were killed by pithing using a scalpel, according to Berland (2005), measured and recorded following the method described by Fernando *et al.* (1972). The gills were excised immediately after death and placed in separate Petri dishes containing saline water. Each gill was examined for parasites and the parasites found were mounted on glass slide; then observed under light microscope equipped with phase contrast optics (Nikon – Eclipse E200) for measurement of hard parts and reproductive organs for identification. A standard method described by Berland (2005); Řehulková and Gelnar (2006) was adapted for identification of the parasites.

Water quality determination

Virtually water coming from nearby stream which used to feel the ponds is clean and void of most predators and parasites, except some build-up of pathogens as a result of culture intensity. At the Centre, fish were fed with high protein food supplements to increase productivity and two ponds were extensively studied in this work. Pond 'A' contained *Hampala macrolepidota* while Pond 'B' contained *Hemibagrus nemurus*. Water quality parameters, namely; Temperature, Dissolved Oxygen (DO), pH, Salinity Nitrite, Nitrate, and Ammonia were determined according to APHA (1985). The parameters like temperature, DO, pH and salinity were determined directly in the ponds using YSI 556 meter; while the ammonia, nitrate and nitrite were determined in the laboratory using HACH kit (Model DR2400).

Data analysis

Parasite infestation was quantified according to Bush *et al.,* (1997). Thus, the percentage of infestation (Prevalence) is expressed as a number of fish infested by individual species of parasite divided by number of fish examined multiplied by 100. While the Mean Intensity (MI) is given by the total number of parasites divided by number of fish infested. The correlation between monogenean infestation and water quality was determined using Pearson Correlation Coefficient with SPSS 16 software. A pair sample statistical T-Test was used to compare the means among water quality parameters of the two ponds. Using Biodiversity Professional Software (Biodiversity Pro V2) (Mcaleece, 1997) indices such as Shannon-Wiener index (H'), Simpson's index (1/D), Margaleff Diversity Index, Mackintosh Diversity Index (D & E) and Berger-Parker index (1/d) was used to determine the species diversity, richness and evenness among the monogenean recovered from the host fishes.

Shannon-Wiener (H') was used in most biological systems analysis to determine the heterogeneity of a given sample (Modu *et al*., 2012). The index values are between 0.0 – 5.0. The product of this index generally lies in the range of 1.5 and 3.5, which have rarely exceeded 4.5. The values above 3.0 indicate the stability and balanced of a given habitat; while values below 1.0 indicate that the environment is either degraded or polluted in nature (Mandaville, 2002).

The Simpson index was a dominance index because it gives more weight to common or dominant species. In this case, a few rare species with only a few representatives will not affect the diversity (Mcaleece, 1997). Simpson index (1/D) varies between 0 and 1. But while calculating, the final result is subtracted from 1 to correct the inverse proportion.

Margaleff Diversity Index was calculated from the total number of species present and the abundance or total number of individuals. The higher the index, the greater the diversity in a given population in the ecosystem (Magurran, 1988). This index has no limit and it shows a variation depending upon the number of species. Thus, it's used for comparison of the sites (Boyle *et al*., 1995).

Mackintosh Diversity Index (D & E); a biological community can be envisaged as a point in an *S*-dimensional hyper volume and that the Euclidean distance of the assemblage from its origin and could be used as a measure of diversity; such diversity measurement was postulated in the year 1967 by a re-known statistician Mackintosh (Mcaleece, 1997). The species diversity, richness and evenness among the monogenean recovered from the host fishes.

Berger-Parker index: This simple intrinsic index expresses the proportional importance of the most abundant species. As with the Simpson index, the reciprocal form of the Berger-Parker index is usually adopted so that an increase in the value of the index accompanies an increase in diversity and a reduction in dominance (Mcaleece, 1997).

RESULT

Five (5) species of gill monogenean parasites were identified in the two fish species (*Hampala macrolepidota* and *Hemibagrus nemurus*) studied, namely: *Dactylogyrus hampali*, *Dactylogyrus macrolepidoti and Dactylogyrus quadribrachiatus,* from *Hampala macrolepidota*; *Cornudiscoides malayensis* and *Cornudiscoides sundanensis* from *Hemibagrus nemurus* (Table 1). The results also revealed that prevalence of the parasites was higher during non-monsoon (March – July) then monsoon (November – February) seasons for both fish species from both ponds (Table 1). Table 1 also shows that water temperature varied with the atmospheric temperature, i.e. being higher during non-monsoon (29.14 ^{O}C) than monsoon (25.72 ^{O}C) seasons.

Dactylogyrus macrolepidoti showed higher prevalence (100%) among the three species identified parasitizing *H. macrolepidota* during the hot season (March – July; Temperature 31.9 ^{O}C). However, moderate and lower prevalence of *Dactylogyrus hampali* and *Dactylogyrus quadribrachiatus* was observed the same season respectively. On the other hand, *Cornudiscoides malayensis* had the higher prevalence (95%) compared to *Cornudiscoides sundanensis* parasitizing *Hemibagrus nemurus*.

Table: 1. Prevalence and Mean Intensity for five Monogenean Gill Parasites in relation to Water Temperature in Two Ponds (November 2010 – December 2011).

Fish species	*Hampala Macrolepidota* Pond A (N = 400)						*Hemibagrus nemurus* Pond B (N = 400)				Mean Monthly Temperature (^{O}C)	
Monogenean species	DH		DM		DQ		CM		CS		Pond A	Pond B
Month/Year	P%	MI	P%	MI	P%	MI	P%	MI	P%	MI		
Nov.10	49	13	47	9	60	7	60	11	40	2	24.2	24.8
Dec.10	45	9	56	7	55	3	55	10	48	2	27.5	28.8
Jan.11	48	11	53	10	45	3	48	7	45	3	22.6	25.4
Feb.11	75	18	75	10	63	0	75	12	65	6	28.6	26.8
Mar.11	76	18	80	11	60	8	68	9	60	4	30.1	30.2
Apr.11	80	14	80	7	35	7	80	15	88	11	27.3	29.3
May.11	83	29	83	19	56	11	95	23	85	7	26.3	25.7
Jun.11	82	9	85	21	75	7	89	19	75	14	30.1	29.9
Jul.11	100	10	100	36	60	3	95	27	85	16	31.9	30.1
Aug.11	53	17	56	11	26	0	20	4	20	5	24.9	25.4
Sep.11	48	12	51	7	36	5	54	9	48	6	26.8	25.6
Oct.11	90	33	100	32	56	0	85	16	68	11	26.7	28.6
Nov.11	48	26	45	6	54	11	50	8	43	5	26.1	27.3
Dec.11	44	31	55	11	26	0	45	5	35	3	25.3	25.2

Note: DH = *Dactylogyrus hampali,* DM = *Dactylogyrus macrolepidota,* DQ = *Dactylogyrus quadribrachiatus*, CM = *Cornudiscoides malayensis,* CS = *Cornudiscoides sundanensis*; P% = Prevalence; MI = Mean Intensity.

The fluctuations in water temperature in both fish ponds were somehow similar. But, Pond 'A' had the lowest mean water temperature (22.6 ^{O}C) and the highest mean water temperature (31.9 ^{O}C) (table 1). The lowest water temperatures were recorded during the monsoon season (November to February) while the higher values were recorded during non-monsoon season (March to July) in both ponds. Monogenean parasites prevalence in these fish ponds varied. In Pond 'A', high prevalence (> 90%) was observed at higher temperatures (> 25 ^{O}C) and moderate prevalence (≥ 50%) was recorded at moderate temperatures while low prevalence (≤ 40%) was noticed at lower temperatures (≥25^{O}C) (Fig. 1). The monogenean parasites fluctuation in pond 'B' showed higher prevalence at higher temperatures (≥ 29 ^{O}C) and moderate temperatures supported moderate monogenean prevalence while low monogenean prevalence was found at moderate water temperatures (Figure 2).

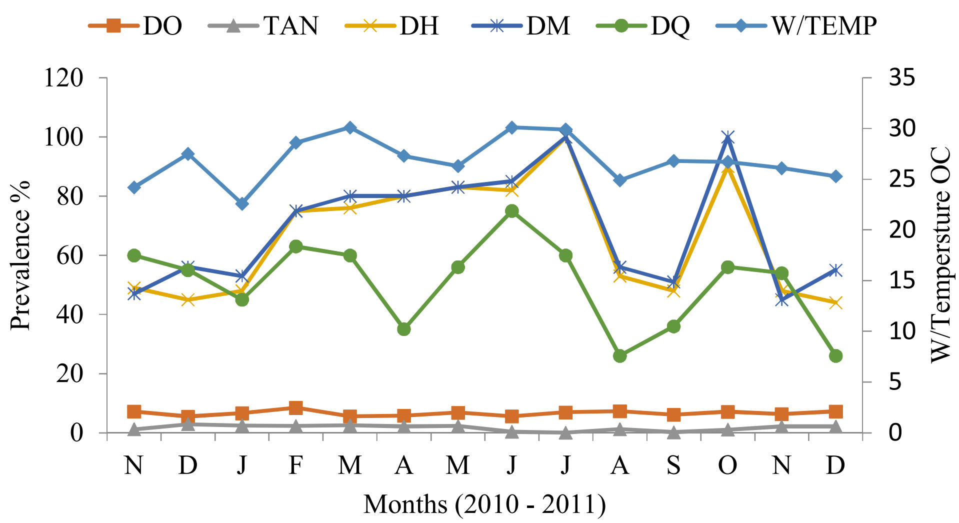

Fig: 1. Prevalence of three (3) Monogenean Parasites in relation to water quality and Temperature prevalence in Pond 'A'

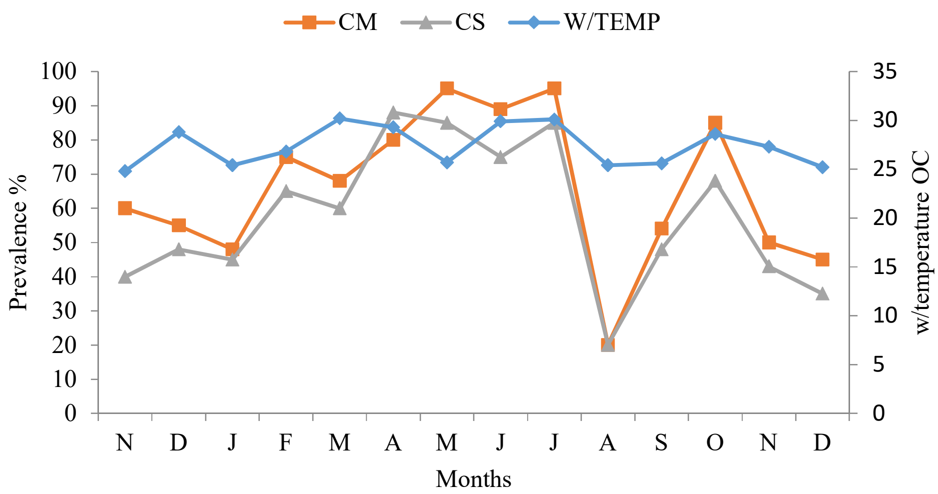

Fig. 2: Prevalence of two (2) Monogenean parasites in relation to water temperature prevalence in pond 'B'

Correlations between monogenean prevalence and water quality parameters

The pond water temperature showed apparently a perfect correlation ($P < 0.01$) in all cases of monogenean prevalence on both fish species investigated (Table 2). Table 2 also shows that the pond water pH had little or no significant influence over the parasite proliferation ($P > 0.05$). The dissolved oxygen of the pond water also showed little relationship with most of the monogeneans except a weak negative association that was observed between the pond DO and *D. quadribrachiatus* in pond 'A'. Total ammonia-nitrogen (TAN) in the pond 'A' showed a weak negative relation with the prevalence of *D. hampali* and *D. macrolepidoti* being r = - 0.326 and r = - 0.290 respectively. In *D. quadribrachiatus* a weak positive correlation was observed (r = 0.224) (Table 2). Contrary to Pond 'A', Pond 'B', TAN had a strong negative correlation with *C. malayensis* and *C. sundanensis* (r = - 0.239 and r = - 0.160). Nitrite-nitrogen (NO_2-N) on the other hand had a weak positive significant with *D. hampali* and *D. macrolepidoti* in pond 'A' and the similar relation was noticed in pond 'B' for *C. malayensis* and *C. sundanensis* (Table 2). A perfect negative non-significant relation was observed between un-ionized ammonia with all cases of monogenean species ($P > 0.05$) in both fish ponds. Total alkalinity of the water for both ponds showed a weak positive relation with regards to monogeneans prevalence and a similar relationship was also observed with water transparency (Table 2). Nitrate-nitrogen (NO_3-N) of the water for both ponds showed a weak negative relation with two monogenean species (i.e. *D. hampali* and *D. macrolepidoti* parasitizing *H. macrolepidota*) while a weak positive association was observed between *D. quadribrachiatus*. However, *C. malayensis* had also weak positive association with *H. nemurus* (table 2).

Diversity and distribution of monogeneans on the gills of *Hampala macrolepidota* in pond A.

Monthly variations in the diversity of monogenean on the gills of *Hampala macrolepidota in* Pond A are shown in Table 3. The highest diversity of monogenean was observed during November 2010 (Shannon H' = 0.462; Simpson 1/D = 2.823) followed by the month of April, 2011 (H' = 0.453; 1/D = 2.723) while the lowest diversity was recorded in August 2011 (H' = 0.287; 1/D = 1.889). No significant variation in monogenean diversity was observed between monsoon and non-monsoon season ($P > 0.05$). Margaleff and Mackintosh richness indices showed that there was a higher species richness during April, 2011 (Margaleff d = 0.974, McIntosh D = 1.089) followed by July 2011(d = 0.971; D = 1.078).

Table: 2. Pearson Correlation Matrix between prevalence of five gill monogenean species and water quality parameters in two fish ponds

Water quality Parameters	**Fish species**				
	***Hampala macrolepidota* (Pond A)**			***Hemibagrus nemurus* (Pond B)**	
	Monogenean species			**Monogenean species**	
	DH	**DM**	**DQ**	**CM**	**CS**
$T^{O}C$	0.764**	0.698**	0.889**	0.659**	0.660**
pH	-0.162	-0.168	0.062	-0.098	-0.073
DO (mg/L)	0.191	0.152	-0.501	-0.118	-0.214
TAN (mg/L)	-0.326	-0.29	0.224	-0.239	-0.16
NO_2-N (mg/L)	0.241	0.245	-0.221	0.11	0.09
NH_3-N (mg/L)	-0.098	-0.107	-0.106	-0.103	-0.099
ALK. (mg/L $CaCO_3$)	0.198	0.145	0.423	0.416	0.39
TRANSP. (m)	0.381	0.335	-0.046	0.195	0.288
NO_3-N (mg/L)	-0.24	-0.292	0.296	0.054	-0.16

*Correlation is significant at the 0.05 level (2-tailed). **Correlation is significant at the 0.01 (2-tailed). Monogenean species: DH = *Dactylogyrus hampali*, DM = *Dactylogyrus macrolepidota,* DQ = *Dactylogyrus quadribrachiatus,* CM = *Cornudiscoides malayensis,* CS = *Cornudiscoides sundanensis.* Parameters: T. = Temperature, DO = Dissolved oxygen, TAN = Total ammonia-nitrogen, NO_2-N = Nitrite-Nitrogen, NH_3-N = Unionized ammonia, ALK. = Alkalinity, TRANSP. = Transparency, NO_3-N = Nitrate-Nitrogen. Note: values shown here are correlation coefficient 'r' values intercept with corresponding variables.

The monogenean richness was lower in the month of January, 2011 (d = 0.756; D = 1.046). Thus, indicating that richness was higher during non-monsoon season compared to monsoon time. Berger-Parker (1/d) index showed higher dominance in November, 2010 (1/d = 2.245) followed by May, 2011 (1/d = 2.5028). Parasites dominance was lower in August, 2011(1/d = 1.599). No significant variation in the evenness was observed among sampling period, which showed the homogenous distribution of species throughout the 14 months of this study. However, slight variation in species evenness was noted between dry and rainy seasons.

Table 3: Monthly variation in the diversity and distribution of monogeneans on the gills of *Hampala macrolepidota* in Pond A.

Month/Year	**Index Shannon H**	**Simpsons (1/D)**	**Margaleff (M)**	**Mackintosh (D)**	**Mackintosh (E)**	**Berger-Parker (1/d)**
Nov. 10	0.462	2.823	0.787	1.055	2.362	2.245
Dec. 10	0.432	2.514	0.860	1.046	2.356	1.901
Jan. 11	0.426	2.447	0.756	1.053	2.360	1.841
Feb. 11	0.290	1.906	0.789	1.070	2.357	1.629
Mar. 11	0.442	2.596	0.865	1.068	2.349	1.952
Apr. 11	0.453	2.723	0.974	1.089	2.333	2.018
May. 11	0.445	2.635	0.812	1.056	2.352	2.028
Jun. 11	0.443	2.587	0.771	1.050	2.356	1.934
Jul. 11	0.298	1.992	0.971	1.078	2.314	1.797
Aug. 11	0.287	1.889	0.855	1.062	2.344	1.599
Sep. 11	0.447	2.648	0.900	1.070	2.336	1.965
Oct. 11	0.300	2.000	0.857	1.062	2.341	1.870
Nov. 11	0.437	2.522	0.840	1.059	2.343	1.846
Dec. 11	0.301	2.011	0.932	1.073	2.325	1.918

Note: All computation were done in based on 10

Table 4: Monthly variation in the diversity and distribution of monogeneans on the gills of *Hemibagrus nemurus* in Pond 'B'

Index	Months (Nov., 2010 – Dec., 2011)													
	Nov. 10	**Dec. 10**	**Jan. 11**	**Feb. 11**	**Mar. 11**	**Apr. 11**	**May. 11**	**Jun. 11**	**Jul. 11**	**Aug. 11**	**Sep. 11**	**Oct. 11**	**Nov. 11**	**Dec. 11**
Shannon H'	0.293	0.297	0.295	0.294	0.298	0.290	0.293	0.288	0.294	0.287	0.292	0.280	0.294	0.278
Simpsons (1/D)	1.934	1.974	1.954	1.946	1.982	1.916	1.940	1.888	1.940	1.909	1.944	1.838	1.954	1.823
Margaleff (M)	0.420	0.372	0.386	0.395	0.437	0.435	0.412	0.379	0.404	0.554	0.518	0.460	0.502	0.456
Mackintosh (D)	1.066	1.045	1.050	1.053	1.068	1.067	1.058	1.045	1.054	1.102	1.090	1.071	1.083	1.068
Mackintosh (E)	3.404	3.407	3.403	3.400	3.386	3.384	3.390	3.398	3.389	3.293	3.318	3.357	3.324	3.355
Berger-Parker 1/d)	1.674	1.779	1.722	1.701	1.789	1.639	1.686	1.603	1.688	1.600	1.667	1.531	1.690	1.515

Note: all computation was done in based on 10.

Diversity and distribution of monogeneans on the gills of *Hemibagrus nemurus* in pond B.

Table 4 shows the monthly variation in the diversity of monogeneans on the gills of *Hemibagrus nemurus* in Pond 'B'. The highest diversity of monogenean community was observed in the month of March, 2011 (Shannon H' = 0.298; Simpson 1/D = 1.982) followed by December, 2010 (H' = 0.297; 1/D = 1.974) while the lowest diversity was recorded during December, 2011 (H' = 0.278; 1/D = 1.823). No significant variation in the monogenean diversity was observed between monsoon and non-monsoon season ($P > 0.05$). Margaleff and Mackintosh indices showed that there was a higher species richness in August, 2011 (Margaleff d = 0.554; McIntosh D = 1.102) followed by September, 2011 (d = 0.518; D = 1.090). The richness was lower in December, 2010 (d = 0.372; D = 1.041) and a higher during non-monsoon period. Berger-Parker (1/d) index showed higher dominance during March, 2011 (1/d = 1.789) followed by December, 2010 (1/d = 1.779) and lower dominance value was noted in December, 2011 (1/d = 1.515). There was no significant variation ($p>0.05$) in evenness the during study period, which showed homogeneity of the distribution of species for the 14 months sampling period. However, very slight variation in species evenness was observed between dry and rainy period (Table 4).

DISCUSSION

The impact of environmental factors on monogenean communities has been stressed by many authors (Koskivaara, 1992; Mackenzie *et al.,* 1995; Galli *et al.,* 2001; Sures 2004; Marcogliese 2005; Hudson *et al*., 2006; Bayoumy *et al.,* 2008). The environmental factors include water temperature, dissolved oxygen, pH, and total ammonia-nitrogen, which could influence monogenean proliferation in different fish species. In this study, the water chemistry investigated from the two ponds in relation to monogenean prevalence has revealed some considerably affected changes in monogenean diversity and distribution on the two fish species examined. Very few studies have considered the interaction between monogenean and water quality parameters, especially in field-based studies. For example, Koskivaara *et al.* (1991) demonstrated a correlation between Gyrodactylids diversity with roach and water quality. Bayoumy *et al*., (2008) correlated five monogenean species with water temperature and heavy metals in some Egyptian Rea Sea fishes and confirmed that water quality, especially temperature, enhances monogenean life cycles.

A rise in water temperature accelerates chemical reaction, reduces the solubility of gases, amplifies taste and odour, and elevates the metabolic activity of organisms (Chandrasekhar, 2006). The water temperatures observed in these ponds were considerably lower compared to natural water bodies in the region (e.g. Kenyir Lake). The maximum water temperature recorded in pond 'A' and pond 'B' were 31.9 and 30.2^{O}C while the highest temperature of Kenyir Lake was 32.83^{O}C (Modu *et al.,* 2012). This variation may be attributed to several factors such as human activity and pond inputs like feeds and fertilizers. The Ponds in the study site are mechanically aerated to increase oxygen content and such process can easily decrease the water temperature, because as the pond water bubbles, the free atmospheric oxygen is mixed and thereby increasing the oxygen content in the pond water, which may influence the proliferation of monogeneans (Bayoumy *et al*., 2008). In all cases of the monogenean species investigated, prevalence was higher during non-monsoon (April to July) period and lower during monsoon (November to February). According to Boyd and Tucker, (1998), seasonal pond water temperature changes may impair immune function of fish, even if changes occur within the range considered to be optimal.

The pH values recorded in pond 'A' and pond 'B' were not similar. Pond 'A' is an alkaline pond as observed in the water quality analysis (pH > 9). This pond had some vegetation cover, and photosynthetic processes, possibly add some nutrients, while death and decay of plants may enhance build-up of microbes which in turn changed the water chemistry (Lafferty, 1997). Hydrogin irons (pH) in pond 'B' never reached 8.5 and hence considered as an ideal pond for the stocked catfish to survive. In both ponds, however, relation between pH and prevalence of the five gill monogeneans were not significant ($P < 0.05$).

The DO concentrations recorded in the ponds were within the safe level (5.5 – 8.4 mg/L) as suggested by Svobodova *et al.* (1993). During the non-monsoon season DO tends to be low due to increase in metabolic activities and diurnal fluctuation due to respiration. During this season, aeration activity was observed in both fish ponds because it is the only possible means of increasing the DO level in the ponds. Monogenean prevalence at this time was observed to be higher, at this condition that usually favour monogenean proliferation. However, any deviation from this act or depletion in a DO and sudden decrease in water temperature tend to reverse the condition (Bauer *et al*., 1973). Unlike their temperate counterparts, tropical monogeneans can easily proliferate faster during high DO and high temperature period. This situation was clearly observed in this work, where four among the five monogenean species (*D. hampali, D. macrolepidota, C. malayensis* and *C. sundanensis*) recovered from two fish species examined at AEC, Perlok, Malaysia showed high peak of infestation (> 75%) during non-monsoon period (table 1). During the monsoon period constant rain and air turbulence enhance solubility of free oxygen to the ponds thereby increase the level of DO.

Total ammonia-nitrogen (TAN) in an aquatic ecosystem is a by-product of fish protein metabolism and bacterial decomposition of organic matter (Francis-Floyd *et al*., 2009). Total ammonia-nitrogen is the combined measure of its two forms; un-ionized ammonia (NH_3-N) and ammonium ion (NH4+). The decay of uneaten food and organic matter to create small amounts of ammonia, but in most aquaculture systems, fish themselves are the primary source of the compound. The more feed a fish receives, the more ammonia is produced (Francis-Floyd *et al*., 2009). The concentration of TAN observed in both fish ponds was depended to an increase in the pond water temperature and pH as suggested by Boyd (1982).

In the present study results showed that concentrations of TAN and unionized ammonia in pond 'A' increased as pond water temperature and pH increased. This condition might influence monogenean proliferation, by reducing their population, especially during non-monsoon period. According to Colt and Armstrong (1979), as ammonia level increases in water, ammonia excretion by fish decreases and levels of ammonia in blood and tissues increase. Boyd (1982) added that the outcome of such situation can adversely affect enzyme-catalysed reactions and membrane stability, thus fish immune capability reduces (Perpana, 1996). This will favour parasites and other microbes to build up in the affected fish. In general, according to Boyd and Tucker (1998), the rate of ammonia production in a cultured pond is proportional to the feeding rate. In a nutshell, about 0.03 Kg of ammonia-nitrogen is excreted by fish per 1kg of high quality (25 – 40% crude protein) feed consumed. Elevated levels of ammonia in the ponds at AEC, Perlok, Malaysia presented in this study might be in line with the postulated thought of Boyd and Tucker (1998), since the fish from this organization are apparently fed with high quality feed supplements (45% crude protein).

Conclusion

In conclusion, the calculated indices from this study, such as Shannon-Weaver (H'), Simpson index (1/D), Margaleff Diversity Index (M), Mackintosh Diversity Index (D & E) and Berger-Parker dominance Index (1/d) apparently revealed that the diversity and distribution of the five monogenean gill parasites in their respective fish hosts were affected by the water quality variables and seasonality during the study period.

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