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Zooplankton Composition and Abundance as Indicators of Eutrophication in Two Small Man-made Lakes

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Abstract: The distribution and abundance of zooplankton species of Harapan and Aman Lakes were investigated in relation to physical parameters and chlorophyll-*a* content. Both lakes were characterised by the occurrence of algal bloom problem. The composition of zooplankton was collected at monthly intervals from November 2013 to February 2014. The total number of taxa in Harapan and Aman Lakes were 23 and 27, respectively. Rotifera was the highest abundance group represent 64% of the total species recorded followed by Copepoda (29%) and Cladocera (7%). Three dominant zooplankton that been recorded in both the lakes are *Brachionus forficula*, *Brachionus nilsoni,* and *Trichocerca* sp. High abundance of these species indicates that the lakes are eutrophic water bodies. Overall, zooplankton species distribution and abundance in the study sites are influenced by various environmental factors such as water transparency and chlorophyll-*a* content.

Keywords: Zooplankton, Harapan Lake, Aman Lake, Rotifera, *Brachionus*

INTRODUCTION

Zooplankton are considered as one of the most important food source to the aquatic organisms particularly to planktivorous fish. Zooplankton community is the major route for energy flux in the plankton based food web causes them to become an important element in functioning of aquatic ecosystems (Santos-Wisniewski *et al.* 2006). In general, the characteristics of zooplankton community structure are characterised by the intrinsic factors including surface area, depth, trophic level, colour of water, and the biological community of the lake (Rahkola-Sorsa 2008). Thus, these creatures can be a useful tool for the determination of ecological status of a lake.

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Industrialisation and human activities are the main causes of water pollution. Polluted water contained chemical substances induce algal bloom which indirectly causes problem to aquatic ecosystem such as eutrophication. Zooplankton have close links with the surrounding environment throughout their life cycles and they demonstrate rapid changes in their populations when disturbance occurs such as eutrophication. Therefore, they are potential indicator species for water pollution (Jakhar 2013).

In this context, the present study was devoted to identify the three most common types of freshwater zooplankton; cladocerans, copepods, and rotifers in the eutrophic man-made lakes. We also aim to establish the degree of association between physical environmental variables and the species abundance in the zooplankton assemblages.

MATERIALS AND METHODS

Harapan and Aman Lakes were constructed in 1990 as retention ponds and for flood mitigation in Universiti Sains Malaysia (Fig. 1). The surface area of Harapan and Aman Lakes were approximately 7200 m^2 and 5800 m^2, respectively, while the average depth for both lakes were about 4 m. Both lakes are characterised by their greenish water colour due to rapid growth of algae and stagnant water conditions.

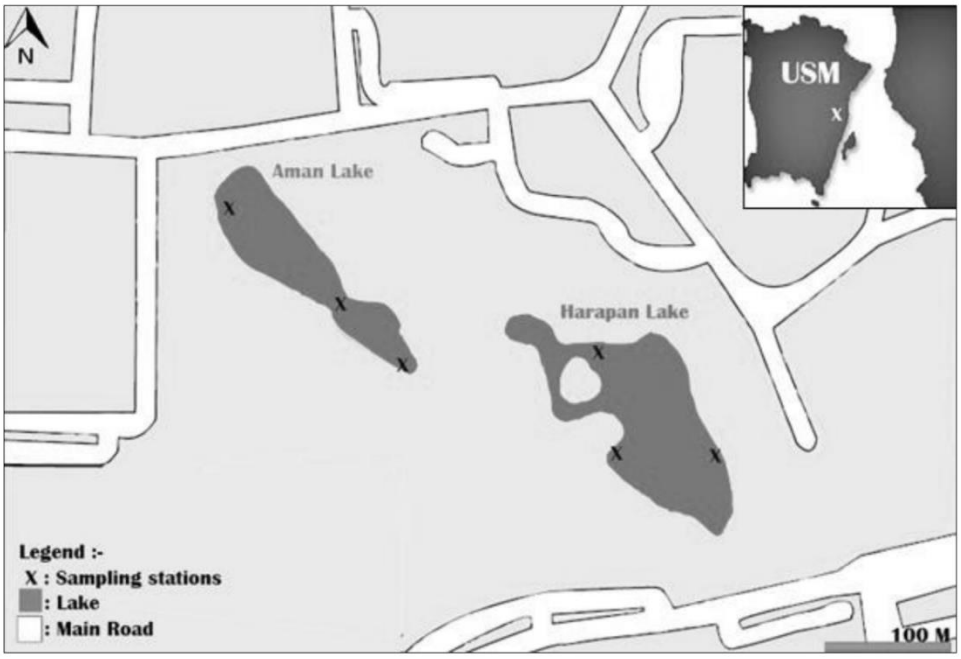

Figure 1: Sampling locations of Harapan and Aman Lakes.

Field sampling was conducted from November 2013 to February 2014 at monthly intervals and three stations at the littoral zone were selected as sampling locations for each lake (Fig. 1). Zooplankton sampling was carried out by filtering 40 L of surface lake water through a conical plankton net with mesh size of 35 µm. Three sample replicates were collected at each sampling station and all filtered samples were preserved with 70% ethanol. In situ parameters including dissolved oxygen, temperature, and pH were measured using YSI Multiparameter (Model 556 MPS) prior to zooplankton sampling. Water transparency was determined with a Secchi disc while water samples for chlorophyll-*a* analysis were measured in the laboratory.

Sorting, identification, and counting was carried out under a dissecting microscope (Olympus model SZ61TR-CCD) and a compound microscope (Olympus model BX41-CCD) equipped with a camera at various magnifications (10×, 20×, 40×, and 100×). One mL of a sub-sample was randomly taken from the bottle by using an adjustable volume of pipette. The sub-sample was placed into a Sedgewick Rafter counting cell and slowly covered with a cover slip. Zooplankton identification was analysed at the lowest possible taxonomic level according to the standard taxonomic references (Idris 1983; Shiel 1995). Pearson correlation analyse was performed between physical parameters and zooplankton abundance to determine whether the two variables are associated.

RESULTS AND DISCUSSION

The mean values of physical characteristics of water samples in both lakes are given in Table 1. According to Vollenweider and Kerekes (1980), lakes are considered to be oligotrophic, mesotrophic, and eutrophic when chlorophyll-*a* concentrations are around 5, 16, and > 25 mg/m^3, respectively. Therefore, the content of chlorophyll-*a* indicated that Harapan and Aman Lakes are eutrophic lakes with the measurement of 0.16 mg/L and 0.14 mg/L, respectively. Hasan *et al.* (2011) also indicated that both lakes are eutrophicated.

Table 1: Environmental characteristics of study sites.

Variables	Average ± SE	
	Harapan Lake	Aman Lake
Area (ha)	0.72	0.58
Average depth (m)	4.00	4.00
Temperature (°C)	30.89 ± 0.04	31.60 ± 0.06
Dissolved oxygen (mg/L)	4.21 ± 0.17	4.51 ± 0.13
Water transparency Depth (m)	0.22 ± 0.02	0.27± 0.01
pH	8.88 ± 0.15	9.58 ± 0.22
Chlorophyll-*a* (mg/L)	0.16 ± 0.02	0.14 ± 0.03

Table 2: Occurrence of zooplankton species in Harapan and Aman Lakes during the study period.

Order/Taxa	Family	Species	Harapan Lake	Aman Lake
Diplostraca	Sidiidae	*Diaphanosoma aspinosum*	–	+
		Diaphanosoma excisum	+	+
		Diaphanosoma sarsi	+	+
Anomopoda	Chydoridae	*Aloninae* cf. *anthalona*	–	+
Bdelloidea			++++	++++
Floscullariacea	Chonochilidae	*Conochilus* sp.	++	+++
	Testudinellidae	*Testudinella patina*	+	+
Ploimida	Asplanchnidae	*Asplanchna* sp.	++	++
	Brachionidae	*Anuraeopsis* sp.	++	+++
		Brachionus caudatus	+++	+
		Brachionus falcaltus	++	+
		Brachionus forficula	++++	++++
		Brachionus nilsoni	++++	+++
	Dichranophoridae	*Dicranophorus* sp.	+	++
	Lecanidae	*Lecane bulla*	++	+
		Lecane closterocerca	–	+
		Lecane papuana	+	++
		Lecane ungulata	+	+
		Lecane hamata	–	+
	Lepadellidae	*Lepadella* sp.	++	++
		Colurella uncinata	++	++
	Mytilinidae	*Lopocharis* sp.	++	+
	Notommatidae	*Notommata* sp.	++	–
	Synchaetidae	*Polyarthra* sp.	–	+
	Proalidae	*Proalides* sp.	+++	+++
	Trichocercidae	*Trichocerca* sp.	++++	++++
Cyclopoida			++	++
Calanoida			++	++
Total			23	27

Notes: ++++: abundant (76%–100%), +++: common (51%–75%), ++: occasional (26%–50%), +: rare (1%–25%), –: absent (0%).

The total number of zooplankton taxa in Harapan and Aman Lakes were 23 and 27 taxa, respectively as listed in Table 2. With regard to the abundance, overall average is 78 ind/L in Harapan Lake while 62 ind/L in Aman Lake were recorded (Fig. 2). Rotifers were the most rich species group in both lakes followed by cladocerans and copepods (Fig. 3). This present study was in agreement with other studies (Barrabin 2000; Saler 2004) that rotifers are the most dominant group in freshwater ecosystems. Rotifer composition can be used as biological indicator and water quality assessment as they respond to the changes of environmental variables (Sladecek 1983). According to Aboul-Ezz

et al. (1996), rotifers are the most important zooplankton in eutrophic waters. In the present study, rotifers were dominating the zooplankton in both lakes with 16 and 19 species were recorded in Harapan and Aman Lakes, respectively. Ceirans (2007) also indicated that rotifers particularly species of *Brachionus* are better trophy indicators than crustaceans as they are less affected by algae bloom. Therefore, the presence of some other taxa of this micro-crustaceans is not so unequivocal.

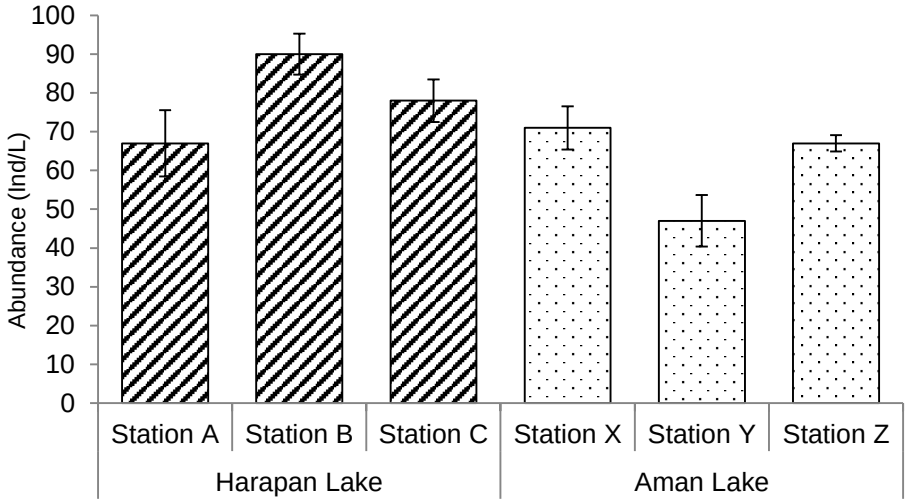

Figure 2: The abundance of zooplankton (ind/L) in Harapan and Aman Lakes during the sampling period.

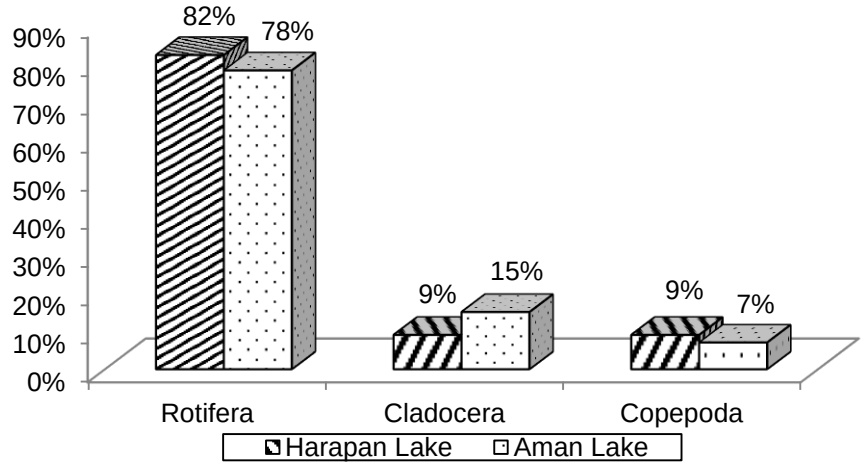

Figure 3: Percentage of zooplankton groups in Harapan and Aman Lakes.

The occurrence of rotifers at high species number and abundance in the present study was expected as both lakes are eutrophic lakes. Such trophic state is often favourable for rotifers (Cajander 1983). Rotifers are not really visible to predatory fish due to the low water transparency in the study sites and their small size. As pointed out by Attayde and Bozelli (1998), rotifers *Asplanchna, Brachionus, Filinia,* and *Polyarthra* were good indicators of eutrophic conditions. They also proposed that *Brachionus* can be considered a target taxon for more intensive monitoring of water quality and conservation planning on aquatic environment. Further experimental work by Dadhich *et al.* (1999) demonstrated that among the other genera, *Brachionus* and *Trichocerca* are reported to occur in eutrophic environment. In the present study, *Brachionus forficula* and *Trichocerca* sp. were the most dominant rotifers in both Harapan and Aman Lakes.

Other groups of zooplankton, cladocerans and copepods accounted of 29% and 7% of total abundance, respectively (Fig. 3). Both groups are larger in size compared to rotifers which are smaller than 250 µm (Shiel 1995). The large size of cladocerans and copepods will decrease their abundance due to fish predation (Karus 2014). Based on the survey by Shah and Othman (2013), the most common types of fish in the Harapan and Aman Lakes are *Oreochromis mossambicus* and *Oreochromis niloticus* which might be predators to both groups. Planktivorous fish is probably a major factor for the decreasing of cladocerans and copepods abundance in the study sites. Therefore, the low composition of larger zooplankton size resulted in higher smaller species particularly rotifers.

Based on the output of Pearson correlation coefficients between mean zooplankton abundance and physical parameters in all sampling stations (Table 3), water transparency showed a strong significant negative correlation (p<0.05) with zooplankton abundance. This is good evidence that eutrophication in the both lakes is altering water transparency and has the potential to affect zooplankton community dynamics.

Table 3: Pearson correlation coefficients between zooplankton abundance and physical parameters in all sampling stations during the study period.

	Zooplankton	Temperature	DO	Transparency	pH	Chlorophyll-*a*
Zooplankton	1	–.009	–.187	–.269*	–.181	–.071
Temperature	–.009	1	.771**	–.087	.575**	–.266*
DO	–.187	.771**	1	–.094	.634**	–.140
Transparency	–.269*	–.087	–.094	1	–.218*	–.006
pH	–.181	.575**	.634**	–.218*	1	–.153
Chlorophyll-*a*	–.071	–.266*	–.140	–.006	–.153	1

Notes: *: Correlation is significant at the 0.05 level (1-tailed).
**: Correlation is significant at the 0.01 level (1-tailed).

CONCLUSION

Rotifers are important group of zooplankton which can be considered as a valuable component of freshwater ecosystem. Their community structure can be used as bio-indicator of water quality assessment whereas their long-term changes need to be monitored. Presumably, the abundance of rotifers is strongly dependant on the trophic state of the water bodies.

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