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Diversity and abundance of plankton in different habitat zonation of Papan River, Lake Kenyir, Malaysia

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Abstract. *Ramlee A, Suhaimi H, Rasdi NW. 2021. Diversity and abundance of plankton in different habitat zonation of Papan River, Lake Kenyir, Malaysia. Biodiversitas 23: 212-221.* Lake Kenyir is the largest artificial lake in Malaysia, yet there is limited information regarding the lake's ecology. This study aimed to determine the diversity and abundance of phytoplankton and zooplankton in various habitat ecosystems along the Papan River, Lake Kenyir. Three distinct sampling points were chosen based on the diverse habitat conditions, namely sampling point A (high water current area), sampling point B (shallow and muddy area) and sampling point C (minimum water current area). Samples were collected horizontally using a 30µm plankton net with two distinct towing methods: boat and hand towing to specific areas. The result showed that all sampling points had low chlorophyll-*a* concentrations ranging between 10 and 20 g/ml, indicating that no algae bloom had occurred. Bacillariophyta were found to have the highest distribution of phytoplankton division in all of the stations (50.96%). The other division discovered was Chlorophyta (29.62%), followed by Charophyta (19.43%). Additionally, 140 individual zooplankton species were discovered across all sampling locations. The phylum Rotifera is the most dominant in terms of species distribution (60.00 %), followed by Arthropoda (31.43%), Ciliophora (7.14%), and Rhizopoda (0.71%). The Shannon diversity index, evenness, and species richness measurements at sampling point A, B, and C revealed a range of index values due to variation in plankton species due to interaction and habitat conditions. The variation in planktonic abundance in the Papan River was attributed to their habitat preferences due to the freshwater lake's ecosystem's different zones and conditions.

Keywords: Chlorophyll *a*, Lake Kenyir, Papan river, phylum, phytoplankton, zooplankton

INTRODUCTION

Lake Kenyir is one of Malaysia's reservoirs that requires serious management and conservation as many areas remain unexplored. Lake Kenyir is the largest artificial lake in Malaysia, covering an area of approximately 36,900 hectares. The mean-depth of Lake Kenyir is of 37 m (Kamaruddin et al. 2011). There are 340 islands, over 40 waterfalls, and numerous rapids and rivers, including the Papan River. The surrounding natural environment provides an ideal habitat for various aquatic organisms, including tiny microscopic organisms and plankton that have not been fully discovered in Lake Kenyir.

Phytoplankton and zooplankton are microscopic organisms that serve as the key producers in wetlands, especially lakes, due to their drifting and widespread existence in water currents. Freshwater plankton is a good bio-indicator for measuring water quality in aquatic systems due to their indispensable role and susceptibility to many ecological stresses (Awaludin et al. 2015; Zeng et al. 2017). At the bottom of these environments, phytoplankton is a significant organic carbon source (Shinde et al. 2012). The plankton community composition varies in response to nutrient availability, temperature, light intensity and other limnological factors such as lotic, lentic and coastal areas. Their sensitivity and changes in species composition are frequently sufficient explanations for demonstrating ecosystem change. Species diversity is a response to changes in environmental gradients and can characterize various interactions that contribute to the establishment of a community structure pattern. However, compared to lentic and lotic environments, the species composition and community structure of phytoplankton are still poorly characterised in both systems (Chen et al. 2019)

Freshwater zooplankton is a diverse collection of major taxonomic groups. Their forms exhibit distinct environmental and physiological characteristics. The abundance, variety and distribution of these organisms in any aquatic habitat provide information about the habitat's ecological conditions. Multiple environmental factors interact to create beneficial spatial and seasonal conditions for the growth of zooplankton (Khanna et al. 2019). The water body's nutritional status influences the diversity and density of zooplankton, abiotic variables, DO, food chain and soil-water chemistry. It is claimed that zooplankton has been used as bio-indicators to monitor aquatic ecosystems and water integrity (Dhembare 2011). Interspecific and intraspecific factors both influence the distribution and abundance of zooplankton, as well as the availability of phytoplankton (Ahmad et al. 2011). Unfortunately, there is no general agreement on which habitat factors regulate plankton communities in lotic and lentic environments (Wu et al. 2011; Thorp 2015).

There is limited information regarding the diversity and composition of phytoplankton and zooplankton in Lake Kenyir due to the vast extent of the lake. The purpose of this study is to determine how planktonic diversity fluctuates, the relationships between plankton and environmental habitat variables, species composition, population density, and community characteristics dependent on different habitat conditions. The regulation of water quality and ecological conditions on Kenyir Lake due to natural and anthropogenic activities has become a primary priority. Thus, it is critical to assess the biodiversity of both zooplankton and phytoplankton in Kenyir lake, as this will serve as a biological indicator of the research site's ecological status. According to our predictions, the findings of this study will be critical in establishing baseline data for monitoring environmental variances and defining their mutual relationships, as well as their roles in determining plankton community variation and dynamics in Lake Kenyir. Thus, this could play a role in restoring and protecting the water ecosystem, serving as a model for the management and conservation of Kenyir Lake.

MATERIALS AND METHODS

Study area and period

Lake Kenyir is the largest artificial lake in Malaysia and Southeast Asia. This lake was formed in 1985 when the Kenyir River was dammed and supplied water to the Sultan Mahmud Power Station (Dullah et al. 2020). The lake is located in Terengganu's eastern region, sharing a border with Kelantan to the west and Pahang to the south. The lake has an area of 260,000 hectares and serves as one of Malaysia's national park gates (Bhuiyan et al. 2016). The lake is surrounded by 340 islands, including hilltops and hills, 14 waterfalls, and several rapids and rivers. Lake Kenyir is Terengganu's primary ecotourism attraction. This exploratory study was conducted on the southern side of Lake Kenyir. As a landmark for this river, the Papan river of Kenyir Lake is located southwest of Pulau Sungai Besar and northwest of Pulau Hulu Sungai Buaya. Papan river is also a national park's border, making it a popular tourist and angler draw due to its spectacular waterfall and fishing site. This river is approximately 58 kilometres from Pengkalan Gawi's main jetty and takes about 45 minutes by speedboat. This investigation was carried out over three days as there was no significant difference in weather between the days.

Sampling point

Three different sampling points in Papan River (N 04º58.021' E 102º34.238') in Lake Kenyir were chosen for zooplankton and phytoplankton sampling, namely Point A, Point B and Point C (Figure 1). The sampling points were chosen based on the physical characteristic of the area as described in Table 1 to resemble varying physical conditions of plankton habitat.

Sampling protocol

The protocol of sample collection is presented in Figure 1. Sampling collection used a 30µm plankton net to collect zooplankton and phytoplankton. Samples were collected horizontally using two distinct towing methods: boat towing and hand towing (Schwoerbel 2016). The net was held horizontally at a specific depth for five minutes. Triplicate of sanitised 50mL bottle was used to collect the sample from 200mL of collective plankton in a bucket for each sampling point. A drop of 40% formalin was added to prevent bacterial decomposition during the preservation process (Abd Latif et al. 2014). Additionally, the scraping method was used to collect samples by focusing on the objects in the water body, such as stones, dead trees and leaves (Sabki et al. 2012). Water quality parameters, including turbidity, salinity, pH, temperature and dissolved oxygen (DO), were measured 3 replicate at each site using a portable YSI probe meter to ensure the data was taken precisely. Chlorophyll *a* concentrations were determined triplicate from different water samples of the sampling point. The water samples were extracted with methanol and shaken at a frequency of 30hz. The supernatant was collected following centrifugation. A 200µL sample was pipetted into a 96-well plate and analysed for chlorophyll a using a microplate reader (Wang et al. 2019).

Sample analyses

After sampling was completed, the phytoplankton and zooplankton were transported to the laboratory for species identification and analysis. The samples were observed with an OLYMPUS light compound microscope, and photos were recorded with a Dino-lite digital microscope and processed with Dino-capture 2.0 software. The results of this study on water quality were presented as mean ± standard deviation (SD) and assessed using one-way analysis of variance (ANOVA) to estimate the relationship between parameters at different sampling points. Tukey's and Duncan's multiple comparison tests were used to establish the significance level for mean differences between sampling points. The statistical significance level was set to P 0.05. Individual/ml samples were counted and examined to determine the Shannon's Diversity Index, Evenness Index and species richness (Shannon and Weaver 1949; Sihombing et al. 2017).

Table 1. Sampling points and description in Papan River, Lake Kenyir, Malaysia

Sampling point in Papan River	Description
Point A	The sample was taken from a stony area with high water current
Point B	The sample was taken at shallow muddy water with minimum water current
Point C	The sample was taken at the area with minimum water current

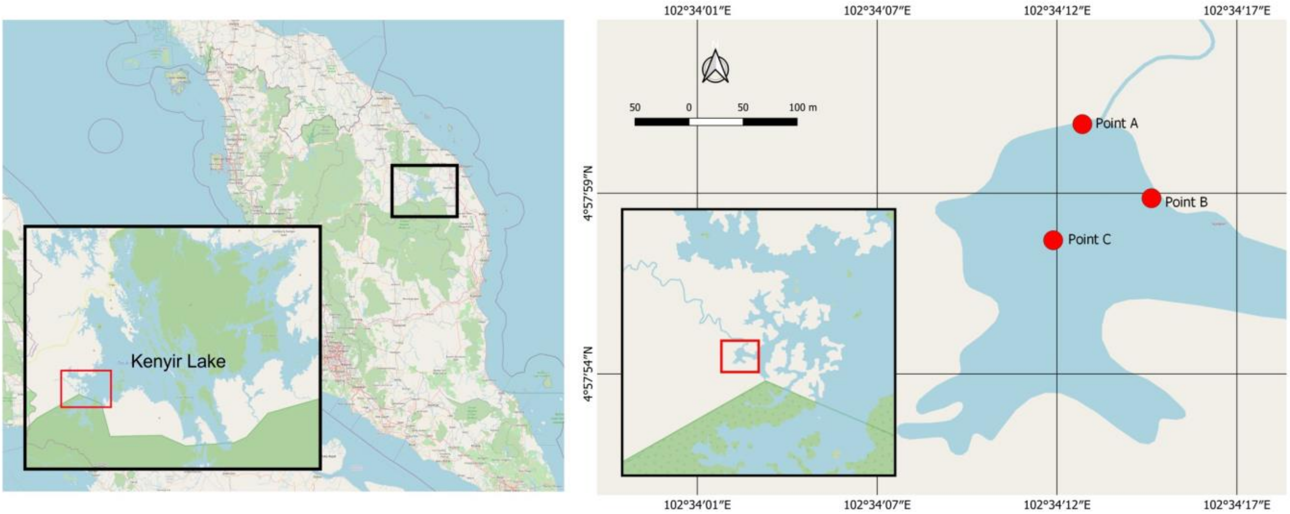

Figure 1. Map of the location of sampling point in Papan River. The label on the map indicate a different sampling point

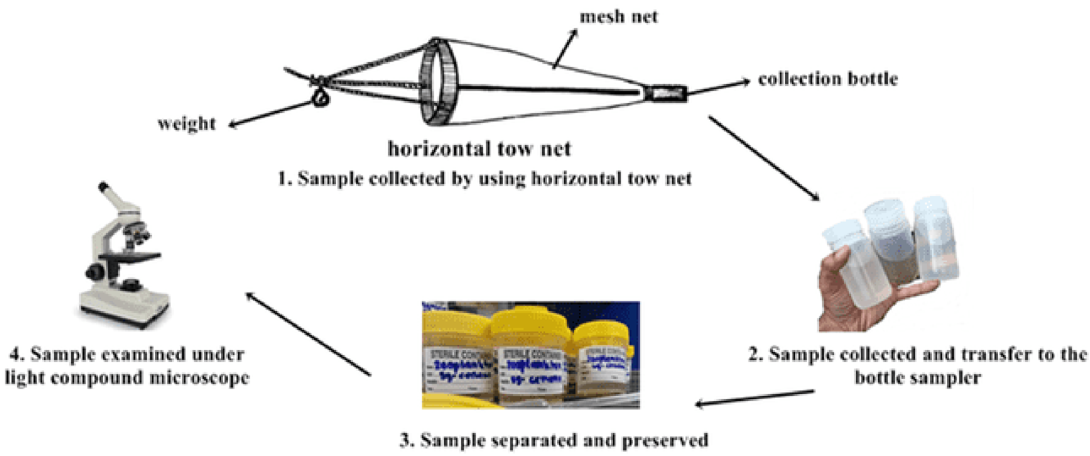

Figure 2. The graphical flow of phytoplankton and zooplankton sampling protocol

RESULT AND DISCUSSION

Water quality

According to Table 2, the water quality parameters at sample points A, B and C differed, indicating that the three sampling points had varying environmental conditions. The highest turbidity (NTU) was reported at sample point C (0.32±0.17), followed by sample point B (0.03±0.002) and A (0.029±0.003). The salinity of all sample points was less than 0.5 ppt, indicating that the river was pure freshwater (Ohrel and Register 2006). The maximum temperature observed was 31.44±0.22ºC at sampling site C, whereas 25.96±0.20ºC and 28.22±0.95ºC were recorded at sample points A and B, respectively, indicating the optimal temperature parameter for phytoplankton growth and development.

Abundance and variation of phytoplankton

Figure 3 showed the relative abundance of different phytoplankton phylum recorded in Papan River sampling points A, B, and C. A total of 314 phytoplankton species were found with Bacillariophyta (50.16%), which was the major division in all stations. The other division found were Chlorophyta (29.62%) followed by Charophyta (19.43%) and Ochrophyta (1.57%). Freshwater diatom species *Pinnularia biceps* was the dominant species in with 78 individuals recorded.

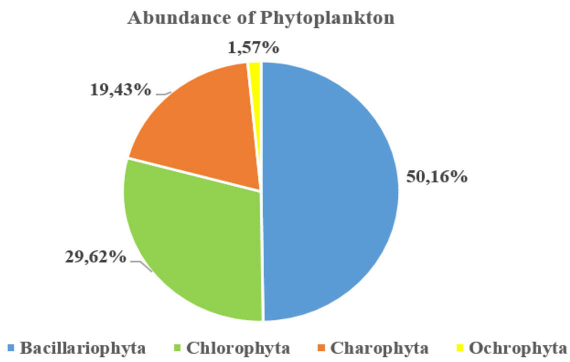

Figure 3. Relative abundance of a different phylum of phytoplankton in Papan River. Different area shaded in the chart indicates the percentage of relative abundance of phylum

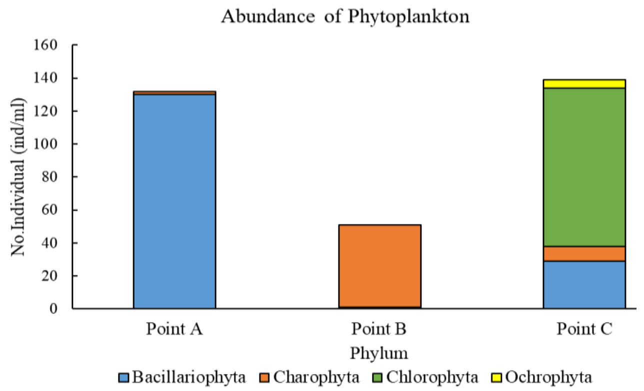

Figure 4. The abundance of individual phytoplankton in all sampling points of Papan River. Different shade on the bar indicates an individual number of species based on the phylum in the sampling point.

Based on Figure 4 and Table 3, in sampling point A there were 12 species of phytoplankton were recorded belonging to 3 different divisions. Bacillariophyta (98.48%) was the major division with 53 individuals, and *Pinnularia biceps* was the dominant species. Other distributions of division Charophyta (1.52%) were recorded with no division of Chlorophyta found. Meanwhile, in Sampling Point B, the distribution division of Charophyta (98.04%) was the highest, followed by Bacillariophyta (1.96%) with a total of 6 species of phytoplankton and *Cosmarium* sp. was the dominant species with 18 individuals. In Sampling Point C, a total of 10 species of phytoplankton were found with *Scenedesmus* sp. was the dominant species with 81 individuals. Division of Chlorophyta (73.28%) was recorded as the significant division followed by Bacillariophyta (22.13%) and Charophyta (6.87%), respectively. All recorded species of phytoplankton in all sampling points were shown in Figure 5.

Meanwhile, Figure 7 and Table 4 showed that sampling point A recorded 21 distinct species with Arthropoda (66.67%), the dominant phylum and freshwater copepod, Mesocyclops leuckarti dominant species. Other phylum were Rotifera (19.04%) and Ciliopora (14.29%), and no species from Rhizopoda were detected. In sample site B, *Rotaria neptunia* (69.86%) from the phylum Rotifera dominated with 30 individuals of the species observed. The distribution of the phylum Arthropoda (20.59%) was the second-highest, followed by Ciliophora (9.59%), and no species from the phylum Rhizopoda was reported. Meanwhile, Rhizopoda (64.44%) was identified as a prominent phylum in sampling site C, with *Rotaria neptunia* being the leading species with 12 individuals detected. The remaining species were from the phylum Arthropoda (33.33%) and Rhizopoda (2.22%), and no species from the phylum Ciliophora were found. As shown in Figure 8, all sampling points recorded 15 different genus and zooplankton species.

Table 3. Species list of phytoplankton in Papan River, Malaysia

Phylum	Species	Sampling point		
		A	B	C
Charophyta	*Staurastrum punctulatum*	-	+	+
	Cosmarium sp.	-	+	+
	Staurastrum anatinum	-	+	-
	Closterium parvulum	-	+	-
	Mougeotia sp.	-	+	-
	Micrasterias laticeps	-	-	+
	Cosmarium depressum	+	+	-
Chlorophyta	*Actinastrum hantzschii*	+	+	+
	Scenedesmus sp.	-	+	+
Bacillariophyta	*Pinnularia biceps*	+	-	+
	Melosira sp.	+	+	-
	Cyclotella sp.	+	-	-
	Pinnularia splendida	+	-	-
	Fragilaria sp.	+	-	-
	Achnanthes sp.	+	-	-
	Hantzschia sp.	+	-	-
	Cymbella sp.	+	-	-
	Frustulia rhomboides	+	-	-
	Nitzschia sp.	+	+	+
Ochrophyta	*Dinobryon sertularia*	-	-	+

Noted: '+': present, '- ': absent

Table 2. Water quality parameters across three sampling points in Papan River, Malaysia (Mean ± SD)

Parameter	Sampling point		
	Point A	Point B	Point C
Turbidity (NTU)	0.029± 0.003^a	0.03±0.002^a	0.32±.0.003^a
Salinity (ppt)	0.014±0.002^b	0.013±0.01^b	0.022±0.002^a
pH	7.73±0.32^a	7.82±0.93^a	7.94±0.78^a
Temperature (°C)	25.96± 0.58^c	28.21±1.06^b	31.44±0.22^a
DO	57.80± 1.52^b	59.03±1.64^b	67.44±1.50^a
Chl *a* (µg/mL)	10.90±0.27^b	12.15±0.69^b	21.18±0.38^a

Note: All values are mean ± standard deviation (n: 3). The different small letters indicate significant different between water quality parameters (P<0.05)

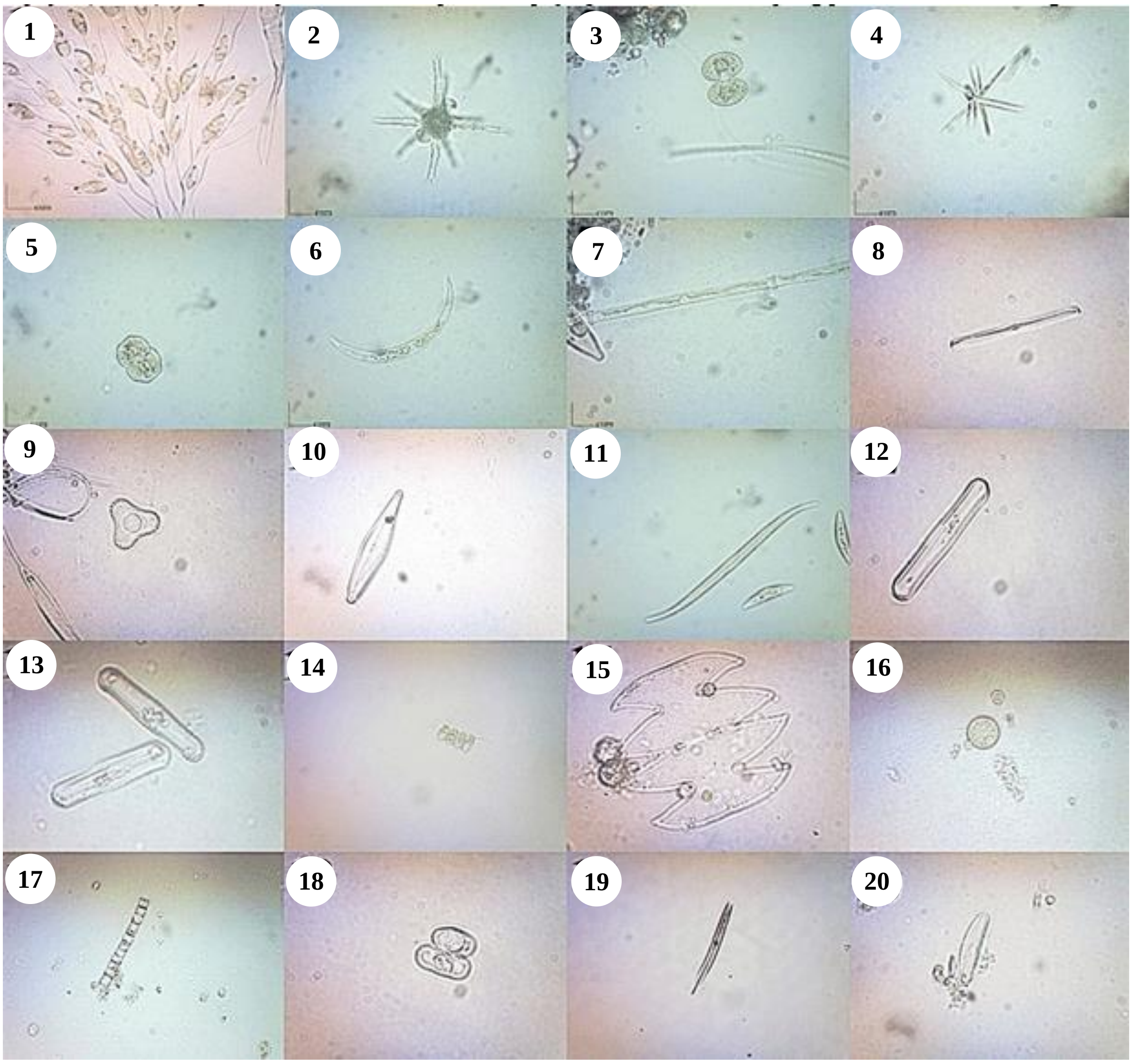

Figure 5. Phytoplankton species recorded in Papan River, Malaysia: 1. *Dinobryon sertularia*; 2. *Staurastrum anatinum*; 3. *Cosmarium* sp.; 4. *Actinastrum hantzschii*; 5. *Cosmarium depressum*; 6. *Closterium parvulum*; 7. *Mougeotia* sp.; 8. *Fragilaria* sp.; 9. *Staurastrum punctulatum*; 10. *Frustulia rhomboides*; 11. *Nitzschia* sp.; 12. *Pinnularia splendida*; 13. *Pinnularia biceps*; 14. *Scenedesmus* sp.; 15. *Micrasterias laticeps*; 16. *Cyclotella* sp.; 17. *Melosira* sp.; 18. *Achnanthes* sp.; 19. *Hantzschia* sp.; 20. *Cymbella* sp.

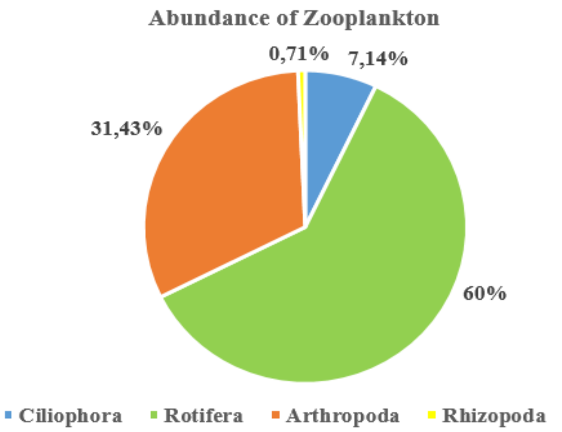

Figure 6. Relative abundance of zooplankton phylum in Papan River, Malaysia. Different area shade in the chart indicates the percentage of relative abundance of the phylum.

Shannon's diversity index, species richness and evenness index

Figure 9 showed the Shannon Diversity Index, which revealed that phytoplankton in sampling point A with H': 1.89 was more diverse than the other sampling sites. This demonstrated that rocky areas had a greater diversity of phytoplankton, dominated by diatom species, which were more likely to be attached in rocky areas with strong currents or streams. However, in terms of the zooplankton community, sampling point C had the highest diversity, evenness, and species richness, with H: 1.69 of diversity index, 0.94 of evenness index, and 1.94 of species richness (Figure 10). This implies more diverse zooplankton in both shallow littoral water with the low water current and pelagic depth zone.

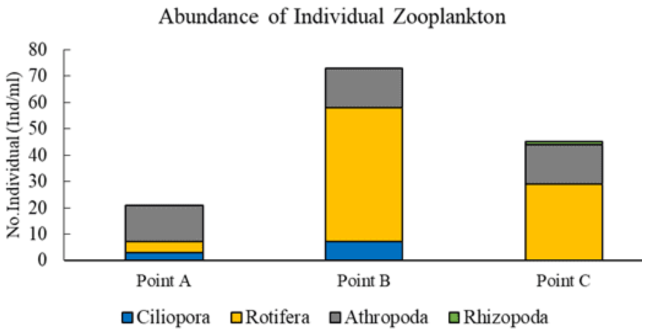

Figure 7. Abundance of individual zooplankton phylum in all sampling points of Papan River, Malaysia. Different shade on the bar indicates the individual number of species based on the phylum in sampling point

Table 4. Species list of zooplankton in Papan River, Malaysia

Phylum	Species	Sampling Point		
		A	B	C
Rotifera	*Rotaria neptunia*	-	+	+
	Polyarthra vulgaris	-	+	-
	Trichocerca sp.	-	+	-
	Lecane sp.	+	-	-
	Brachionus plicatilis	-	-	+
	Brachionus urceolaris	-	-	+
Ciliophora	*Paramecium* sp.	-	+	+
	Vorticella sp.	+	-	+
Arthropoda	*Leberis diaphanus*	-	+	-
	Chyndorus sp.	+	+	-
	Hemicypris sp.	-	-	+
	Kurzia sp.	-	-	+
	Mesocyclops leuckarti	-	-	+
	Thermocyclops crassus	+	-	-
Rhizopoda	*Euglypha tuberculata*	-	-	+

Noted : '+'= present , '-' = absent

Discussion

Chlorophyll a

Chlorophyll *a* was considerably higher at sampling point C than at the other sampling sites. Chlorophyll *a* levels varied substantially among all sampling points, with sampling point C recording 21.18 µg/mL, while sampling points A and B recording 10.90 µg/mL and 12.15 µg/mL, respectively. Chlorophyll *a* has been used to determine the number of phytoplankton in an aquatic habitat. According to Ismail (2012), algal blooms can occur as chlorophyll-a levels rise, suggesting that some phytoplankton species grow quickly enough to produce enormous cell densities. However, no algal bloom was seen throughout the study in this location where the chlorophyll *a* content was below a eutrophic range as assessed by Carlson's trophic status index (Carlson 1977; Ayoade et al. 2019).

Abundance and variation of phytoplankton

Sampling point A discovered more species of the Bacillariophyta class of diatoms. Diatoms are frequently the dominant component of epiphytic communities that are highly sensitive to various limnological and environmental changes. The structure of diatom communities can adapt rapidly to changing physical, chemical and biological conditions in the environment (Rühland et al. 2015; Gökçe 2016). The state of sampling point A at a rocky location with rapid water movement may affect the number of diatom species. According to a recent study by Taxböck et al. (2020), most diatom species found their habitat in rocky areas frequently exposed to running water. According to Wibawa (2017), the most numerous and frequent diatom species found were on the substrates of standing dead trees, rocks and woodlands, which were reasonably comparable across all substrate types in the lake environment. Apart from that, diatom variation can monitor aquatic habitat water quality because diatoms respond directly to growth stimulants such as nutrients, physical factors, excellent water quality, contaminants and habitat changes (Ahmad et al. 2013; Dalu and Froneman 2016).

This variation indicated that the aquatic ecosystem in the Papan River was in good health. The predominance of the desmid phytoplankton, such as *Closterium*, *Cosmarium* and *Scenedesmu*s, were found in both sample points B and C. Desmids may be found in almost every aquatic area in Malaysia. At the same time, certain species may be specialised in specific environmental circumstances. The majority of the water quality in sampling points B and C was hazy, making it an ideal home for desmids algae. Similar to the earlier study by Shaharuddin et al. (2016), Desmid has been observed in Malaysia's fresh water system of the lake with cloudy water conditions, which supported a more significant density of phytoplankton population than the transparent water system. This population could be due to the high concentration of suspended solids in the clear water system. Desmids are critical primary producers in all ecosystems and their filamentous forms may provide critical habitat for invertebrates, fish and other algae (Bestová et al. 2018). *Mougeotia* and other filamentous desmids are abundant in ditches, ephemeral pools and streams. Certain *Spirogyra* and *Mougeotia* species, in particular may be able to tolerate elevated levels of contaminants present in disturbed ecosystems (Stancheva et al. 2013; Messyasz et al. 2018). In these conditions, *Closterium* and *Cosmarium* species are also prevalent. As a result, this microorganism is the most abundant source of food and oxygen for heterotrophic species. Additionally, desmid flora has been used as a bio-indicator for determining oligotrophic (clean) ecosystems (Sabki et al. 2012; Shetty and Gulimane 2021).

Lakes' lotic and lentic ecosystems are likely to affect phytoplankton populations and dynamics. However, the biophysical state of both sample points was tributary, indicating that river water enters the lake contaminated with animal feces and organic debris. According to Dhanalakshmi et al. (2013), the runoff water is rich in clay, silt and colloidal organic matter, which contributes to the excessive phytoplankton development in the river during specific seasons, providing a habitat for a variety of fish species and wild animals that contribute to the river's organic wastes. For example, it is believed that high nutrient concentrations, irradiance and the food web structure in conjunction with the physicochemical conditions in lakes and ponds provide the environmental template against which these phytoplankton populations form (Pal and Choudhury 2014).

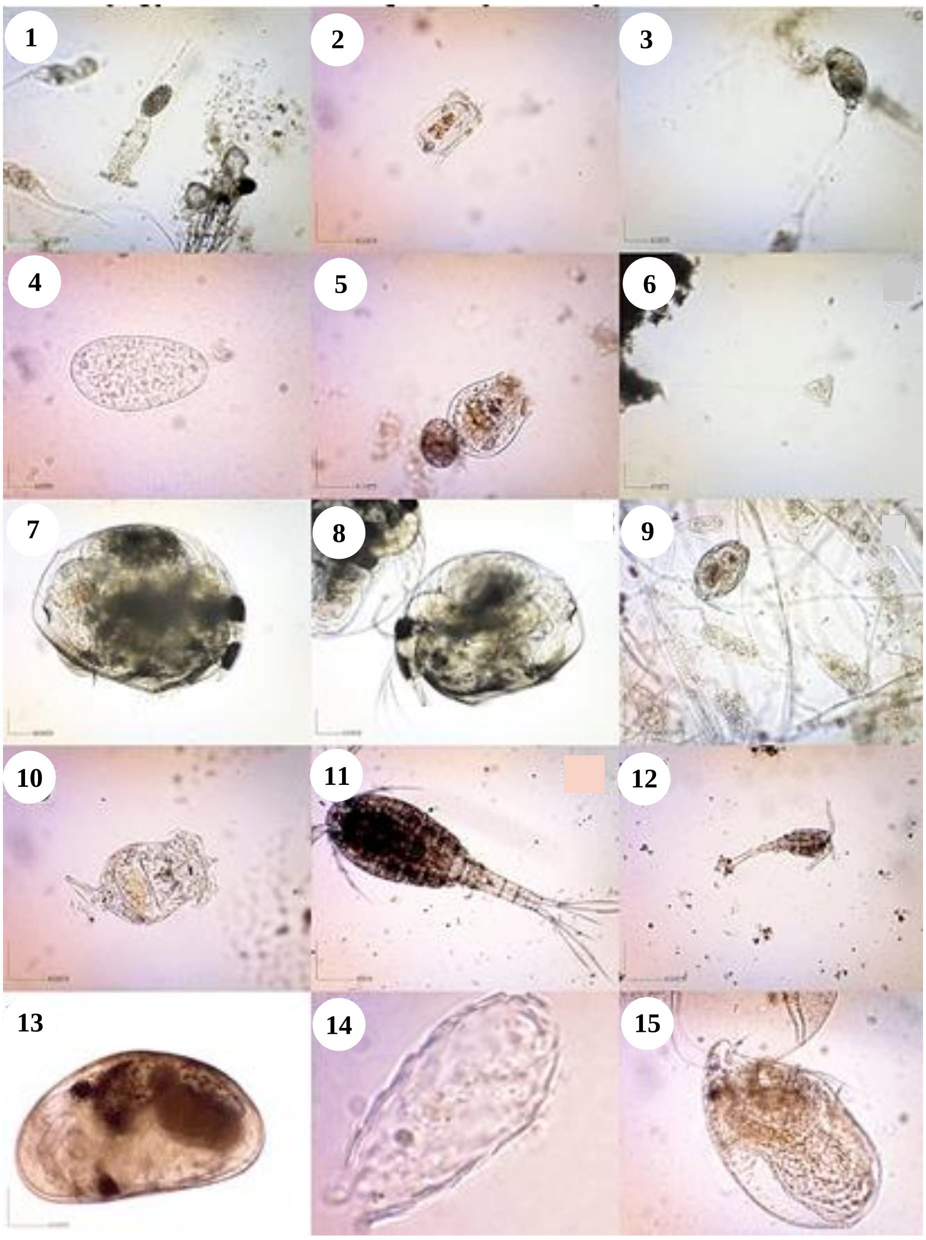

Figure 8. Zooplankton species recorded in Papan River, Malaysia: 1. *Rotaria neptunia*; 2. *Polyarthra vulgaris*; 3. *Trichocerca* sp.; 4. *Paramecium* sp.; 5. *Brachionus urceolaris*; 6. *Vorticella* sp.; 7. *Leberis diaphanous*; 8. *Chyndorus* sp.; 9. *Lecane* sp.; 10. *Brachionus plicatilis*; 11. *Mesocyclops leuckarti*; 12. *Thermocyclops crassus*; 13. *Hemicypris* sp.; 14. *Euglypha tuberculate*; 15. *Kurzia* sp.

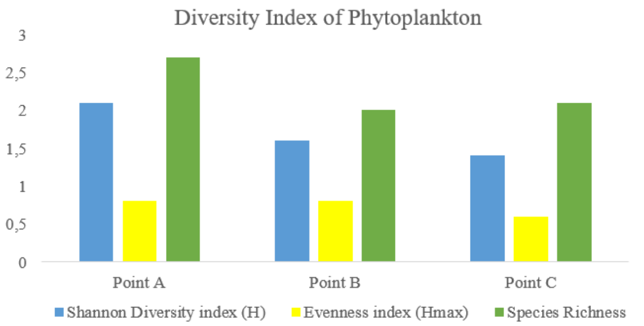

Figure 9. Shannon Diversity index, Evenness index and Species Richness of phytoplankton in Papan River, Malaysia

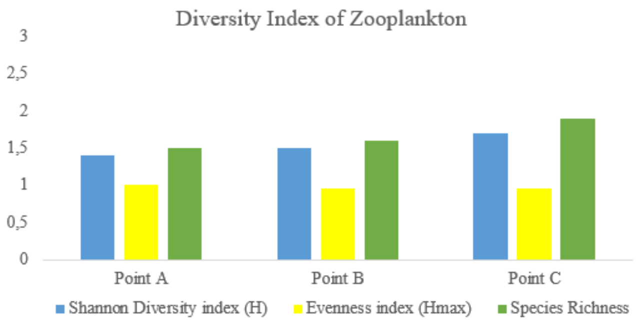

Figure 10. Shannon Diversity index, Evenness index and Species Richness of zooplankton in Papan River, Malaysia

Abundance and variation of zooplankton

In terms of species abundance, Rotifera, Copepoda, and Cladocera densities were lower than those found in the other river of Lake Kenyir, Tembat River (Saidin 2016). Rotifers were the most abundant zooplankton in the Papan River, while copepods and cladocerans constituted the typical zooplankton population in tropical freshwater lake ecology. The low diversity of species and zooplankton abundance at the research site were almost certainly due to environmental factors. As Gilbert (2017) mentioned, the population density of rotifers is determined by food availability in deep and shallow water. Additionally, the shallow water area was most significant at sample site B, resulting in a high rotifer density and biomass, whereas competition between zooplankton species was observed at sample points A and C. This study established two distinct groups of zooplankton: a sizable group of purely littoral/benthic species that dominated in-stream and shallow habitats (Sampling points A and B) and another group that freely roamed group within pelagic depth habitats (Sampling site C).

Littoral species feature prominently because littoral environments have a greater diversity of niches than deeper pelagic environments. Arthropoda and Rotifera of the littoral zone have diverse habitat preferences, including submerged sediments, sand, rock surfaces and the water column (Gomes et al. 2020). Thus, the abundance of littoral species may indicate adaptive radiation in terms of food preferences and geographic niches. Additionally, it reflects that numerous taxa of zooplankton with a high diversity of species, such as rotifers and Arthropoda, including cladocerans, have a littoral origin (Brandorff et al. 2011; Kuczyńska-Kippen and Basińska 2014). Similar to the previous study by Sanoamuang et al. (2012), the rotifer species most likely to dominate Lake Kud-Thing's shallow area in Thailand are remarkably diverse in terms of freshwater lake rotifer species. It should be noted that, due to the geographic diversity of the littoral zone and possible limitations on proper and representative sampling techniques in the coastal zone, the accurate number of species in the littoral zone is more likely to be underestimated than in the pelagic habitat. As a result, our stated dominance of littoral species should be regarded as an approximation at best.

Rotaria neptunia, a bdelloid rotifer, was the primary zooplankton in the Papan River, a commonly documented rotifer species in tropical freshwater bodies. Previous research by Jaturapruek (2016) found that most *Rotaria neptunia* species are found in lakes, reservoirs, and rivers in Thailand, with tropical environment factors and parameters influencing their distribution. This study found that similar characteristics controlled the distribution of this species in the Papan River. Bdelloid rotifers are small aquatic animals found in freshwater habitats. According to Örstan and Plewka (2017), bdelloid rotifer may be identified by the pair of ciliated, eversible discs (corona) that most species have on their heads, as well as their distinctive creepings like an inchworm or a leech, and the majority of this bdelloid rotifer is found in shallow areas. Previous research from Nowell et al. (2021) found that the spread of bdelloid rotifers is inversely related to the depth of the freshwater environment. Campillo et al. (2011) also stated that species and population numbers might drop as habitat depth increases. This may have reinforced the current findings, in which most bdelloids, including *Rotaria neptunia*, are found in the shallow littoral zone. Furthermore, *Rotaria* species may float on the surface of aquatic plants. Most of them survive by relying on food and nutrients along the surface area, indicating that *Rotaria* is prevalent in the shallow littoral zone (Wallace et al. 2015; Jaturapruek et al. 2020). However, due to the variety of bdelloids rotifer in most freshwater habitats, the genuine behaviours and environmental preferences of bdelloids rotifer, particularly *Rotaria neptunia*, is still under early observation.

Shannon's diversity index, species richness and evenness index

According to Teittinen et al. 2016, the diversity of diatom communities found on the stones of a stream river was significantly greater (1.86-2.72) than the diversity of diatom communities found in another habitat. However, sampling points B and C had low levels of diversity, evenness and species richness, as would be expected in a shallow and low-flowing lake environment, resulting in elevated nutrient concentrations (Browning et al. 2014). At both sample points B and C, most species were desmid algae, resulting in low levels of richness due to the limited variation among algal taxa. Similar to a previous study by González and Roldán (2019), a low richness value of the phytoplankton community was detected in the tropical Pampulha reservoir as a result of blooms or high densities of desmid and cyanobacteria. The difference in diversity index of all sampling points may also be due to the interaction between zooplankton and phytoplankton, which affected zooplankton abundance at all Papan river sampling points. Phytoplankton is the primary food source for zooplankton and other aquatic organisms in most freshwater habitats. The region's growing phytoplankton population, mainly desmid algae, increased zooplankton diversity at all sample points. A recent study by Shah et al. (2012) discovered that environmental factors promoting phytoplankton development also resulted in expanding predatory zooplankton populations in Malaysia's Pedu reservoir. Furthermore, Rahman et al. (2016) stated that increasing phytoplankton diversity increased variable zooplankton mean growth rate, abundance and diversity. Additionally, phytoplankton diversity is a strong predictor of zooplankton dispersal and a critical metric for studying the dynamics of zooplankton populations (Striebel et al. 2012).

The observed effect of phytoplankton diversity on zooplankton abundance fluctuations may have implications for the dependability of resource availability further down the food chain in the Papan River ecosystem. As a result, the Papan River is home to a diverse assemblage of phytoplankton and zooplankton taxa, indicating planktonic species are plentiful in Lake Kenyir. In other words, their natural bio-ecological characteristics or behaviour patterns influence the niches they occupy. Varying zonation between depth and subsurface resulted in zooplankton variation was influenced by other water quality parameters also reported at Bakun Dam in Malaysia (Long et al. 2014). In Lake Danau Biru, West Sumatera of Indonesia, distinct zones have been established based on species composition, abundance and diversity (Nurwisma et al. 2017). The present findings suggest that habitat zonation, environmental variables and interaction most likely mask phytoplankton and zooplankton variability.

In conclusion, the number of phytoplankton and zooplankton observed in this study varied significantly between sampling points along the Papan River in Lake Kenyir. Lotic area of sampling point A showed the highest individual of diatom species in terms of phytoplankton abundance as turbidity and dissolved oxygen were lower than other sampling points, indicating suitable water quality parameters among all sampling points. However, zooplankton abundance in shallow areas of sampling point B was highest due to the mostly composition of Rotifera as their partiality distributed on high dissolved oxygen and turbidity area. This may reflect their niche or habitat preferences, depending on the lake's zonation and health. Alteration in lake ecosystem conditions may increase phytoplankton and zooplankton populations, providing fish and other aquatic organisms. Variation in phytoplankton and zooplankton density may be critical for managing aquatic organisms in Malaysian freshwater lakes over the long term. However, another factor that should be investigated further seems to be whether another factor influences the quantity of phytoplankton and zooplankton. This information can be beneficial for developing sustainable fisheries and lake management in general, particularly for aquatic ecosystem conservation and vulnerability in terms of biodiversity richness.

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REFERENCES

Abd Latif L, Husin SM, Kutty AA. 2014. Variation of phytoplankton at Kenyir Lake, Tembat River and Terengganu Mati River. Sci J Environ Eng Res 2014: 177. DOI: 10.7237/sjeer/177.

Ahmad U, Parveen S, Khan AA, Kabir HA, Mola HRA, Ganai AH. 2011. Zooplankton population in relation to physico-chemical factors of a sewage fed pond of Aligarh (UP), India. Biol Med 3: 336-341.

Ahmad AK, Othman MS, Lim EC, Aziz ZA. 2013. Analisis kualiti air Tasik Chini menggunakan pendekatan multivariat. Sains Malaysiana 42 (5): 587-596. [Indonesian]

Awaludin AS, Dewi NK, Ngabekti S. 2015. Koefisien saprobik plankton di perairan Embung Universitas Negeri Semarang. Indones J Math Nat Sci 38 (2): 115-120. DOI: 10.15294/ijmns.v38i2.5780. [Indonesian]

Ayoade AA, Osuala BO, Adedapo TA. 2019. Physico-chemical parameters, chlorophyll a and phytoplankton community as trophic state indices of two tropical lakes, southwestern Nigeria. Eur Asian J Bio Sciences 13 (1): 15-22.

Bestová H, Munoz F, Svoboda P, Škaloud P, Violle C. 2018. Ecological and biogeographical drivers of freshwater green algae biodiversity: From local communities to large-scale species pools of desmids. Oecologia 186: 1017-1030. DOI: 10.1007/s00442-018-4074-x.

Bhuiyan MAH, Siwar C, Ismail SM. 2016. Sustainability measurement for ecotourism destination in Malaysia: A study on Lake Kenyir, Terengganu. Soc Indic Res 128 (3): 1029-1045. DOI: 10.1007/s11205-015-1068-5.

Brandorff GO, Pinto-Silva VANGIL, Morini AAET. 2011. Zooplankton: Species diversity, abundance and community development. In: Junk WJ, Da Silva CJ, Nunes CC, Wantzen KM (eds). The Pantanal: Ecology, Biodiversity and Sustainable Management of a Large Neotropical Seasonal Wetland. Pensoft, Sofia, Moscow.

Browning TJ, Bouman HA, Moore CM, Schlosser C, Tarran GA, Woodward EMS, Henderson GM. 2014. Nutrient regimes control phytoplankton ecophysiology in the South Atlantic. Biogeosci 11 (2): 463-479. DOI: 10.5194/bg-11-463-2014.

Campillo S, García-Roger EM, Carmona MJ, Serra M. 2011. Local adaptation in rotifer populations. Evol Ecol 25: 933-947. DOI: 10.1007/s10682-010-9447-5.

Carlson RE. 1977. A trophic state index for lakes. Limnol Oceanogr 22: 361-369. DOI: 10.4319/lo.1977.22.2.0361.

Chen W, Ren K, Isabwe A, Chen H, Liu M, Yang J. 2019. Stochastic processes shape microeukaryotic community assembly in a subtropical river across wet and dry seasons. Microbiome 7 (138): 1-16. DOI: 10.1186/s40168-019-0749-8.

Dalu T, Froneman PW. 2016. Diatom-based water quality monitoring in southern Africa: Challenges and future prospects. Water SA 42: 551-559. DOI: 10.4314/wsa.v42i4.05.

Dhanalakshmi V, Shanthi K, Remia KM. 2013. Physicochemical study of eutrophic pond in Pollachi town, Tamilnadu, India. Intl J Curr Microbiol Appl Sci 2: 219-227.

Dhembare AJ. 2011. Diversity and its indices in zooplankton with physico-chemical properties of Mula Dam Water Ahmednagar, Maharashtra, India. EJ Exp Biol 1: 98-103.

Dullah H, Malek MA, Hanafiah MM. 2020. Life cycle assessment of nile tilapia (*Oreochromis niloticus*) farming in Kenyir Lake, Terengganu. Sustainability 12 (6): 2268. DOI: 10.3390/su12062268.

Gilbert JJ. 2017. Resting-egg hatching and early population development in rotifers: A review and a hypothesis for differences between shallow and deep waters. Hydrobiologia 796 (1): 235-243. DOI: 10.1007/s10750-016-2867-7.

Gökçe D. 2016. Algae as an Indicator of Water Quality. Algae-Organisms for Imminent Biotechnology. InTech, Rijeka, Croatia.

Gomes ML, Riedman A, O'Reilly S, Lingappa U, Metcalfe K, Fike DA, Knoll AH. 2020. Taphonomy of biosignatures in microbial mats on Little Ambergris Cay, Turks and Caicos Islands. Front Earth Sci 8: 387. DOI: 10.3389/feart.2020.576712.

González EJ, Roldán G. 2019. Eutrophication and phytoplankton: Some generalities from lakes and reservoirs of the Americas. In: Vítová M (eds). Microalgae-From Physiology to Application. IntechOpen, London.

Ismail AH. 2012. Community Structure and Algal Feeding Preferences of Zooplankton in Myponga and South Para Reservoirs. [Thesis]. University of Adelaide, Australia.

Jaturapruek R. 2016. Taxonomy of Freshwater Bdelloid Rotifers in the Genus *Rotaria* (Rotifera, Bdelloidea, Philodinidae) in Thailand. [Thesis]. Prince of Songkla University, Thailand.

Jaturapruek R, Fontaneto D, Maiphae S. 2020. The influence of environmental variables on bdelloid rotifers of the genus *Rotaria* in Thailand. J Trop Ecol 36: 267-274. DOI: 10.1017/S0266467421000018.

Kamaruddin IS, Kamal AM, Christianus A, Daud SK, Abit LY. 2011. Fish community in pengkalan gawi-pulau dula section of Kenyir Lake, Terengganu, Malaysia. J Sustain Sci Manag 6 (1): 89-97.

Khanna N, Sridhar A, Subramanian R, Pandit S, Fosso-Kankeu E. 2019. Phycoremediation: A solar driven wastewater purification system. In: Kankeu EF (eds). Nano and Bio-Based Technologies for Wastewater Treatment: Prediction and Control Tools for the Dispersion of

Pollutants in the Environment. Scrivener Publishing LLC, United States.
Kuczyńska-Kippen N, Basińska A. 2014. Habitat as the most important influencing factor for the rotifer community structure at landscape level. Intl Rev Hydrobiol 99: 58-64. DOI: 10.1002/iroh.201301704.
Long S, Ismail N, Ak Chukong N, Yusoff NM, Ngau HT. 2014. Freshwater zooplankton of Bakun Dam Sarawak, Malaysia. Asian J Biol Life Sci 3 (2): 120-124.
Messyasz B, Pikosz M, Treska E. 2018. Biology of freshwater macroalgae and their distribution. In: Chojnacka K, Wieczorek PP, Schroeder G, Michalak I (eds).. Algae Biomass: Characteristics and Applications. Springer, Cham.
Nowell RW, Wilso CG, Almeida P, Schiffer PH, Fontaneto D, Becks L, Barraclough TG. 2021. Evolutionary dynamics of transposable elements in bdelloid rotifers. Elife 10: e63194. DOI: 10.7554/eLife.63194.
Nurwisma N. 2017. Komposisi dan Struktur Komunitas Plankton di Danau Biru Kawasan Pasca Tambang Batu Bara Kota Sawahlunto, Sumatera Barat. [Dissertation]. Universitas Andalas, Indonesia. [Indonesian]
Örstan A, Plewka M. 2017. An introduction to bdelloid rotifers and their study. http://www.quekett.org/starting/microscopic-life/bdelloid-rotifers.
Pal R, Choudhury AK. 2014. Physicochemical environment of aquatic ecosystem. In: Pal R, Choudhury AK (eds). An Introduction to Phytoplanktons: Diversity and Ecology. Springer, Germany.
Rahman A, Pratiwi NTM, Hariyadi S. 2016. Struktur komunitas fitoplankton di Danau Toba, Sumatera Utara. Jurnal ilmu pertanian Indonesia 21 (2): 120-127. DOI: 10.18343/jipi.21.2.120. [Indonesian]
Rühland KM, Paterson AM, Smol JP. 2015. Lake diatom responses to warming: Reviewing the evidence. J Paleolimnol 54 (1): 1-35. DOI: 10.1007/s10933-015-9837-3.
Saidin ANB. 2016. Water Quality and Zooplankton Community Structure of Tembat River, Hulu Terengganu. [Thesis]. Universiti Sains Malaysia, Malaysia.
Sabki NS, Salleh A, Nasrodin. 2012. S. Desmid flora in Tasik Sungai Semuji, Kuantan, Pahang, Malaysia. Proceedings of the 2nd. International Conference on Arts, Social Sciences and Technology Penang, Malaysia. Malaysia, 3-5 March 2012.
Sanoamuang LO, Segers H, Shiel RJ, Gulati R. 2012. Rotifera IX. Proceedings of the IXth International Rotifer Symposium. Khon Kaen, Thailand, 16-23 January 2000.
Schwoerbel J. 2016. Methods of Hydrobiology: Freshwater Biology. Elsevier, Amsterdam.
Shah ASRM, Ismail J, Latief D, Omar WMW. 2012. The spatial structure of zooplankton communities of Pedu Reservoir, Malaysia. Wetl Sci 10 (4): 423-428.
Shaharuddin S, Ghani AA, Zakaria NA. 2016. Relationship assessment for freshwater phytoplankton and a water quality index during dry and wet season in a free water surface constructed wetland in Malaysia. 11th International Symposium on Ecohydraulics (ISE 2016). Engineers Australia, 7-12 February 2016.
Shannon CE, Weaver W. 1949. The Mathematical Theory of Communication. Urbana Univ. Illinois Press, United States.
Shetty K, Gulimane K. 2021. Biomonitoring of freshwater lentic habitats using desmids. Limnology 100. DOI: 10.1007/s10201-021-00664-0.
Shinde SE, Pathan TS, Sonawane DL. 2012. Seasonal variations and biodiversity of phytoplankton in Harsool-Savangi dam, Aurangabad, India. J Environ Biol 33: 643-647.
Sihombing VS, Gunawan H, Sawitri R. 2017. Diversity and community structure of fish, plankton and benthos in Karangsong Mangrove Conservation Areas, Indramayu, West Java, Indonesia. Biodiversitas 18 (2): 601-608. DOI: 10.13057/biodiv/d180222.
Stancheva R, Hall JD, McCourt RM, Sheath RG. 2013. Identity and phylogenetic placement of S pirogyra species (Zygnematophyceae, Charophyta) from California streams and elsewhere. J Phycol 49: 588-607. DOI: 10.1111/jpy.12070.
Striebel M, Singer G, Stibor H, Andersen T. 2012. “Trophic overyielding”: Phytoplankton diversity promotes zooplankton productivity. Ecology 93: 2719-2727. DOI: 10.1890/12-0003.1.
Taxböck L, Karger DN, Kessler M, Spitale D, Cantonati M. 2020. Diatom species richness in Swiss springs increases with habitat complexity and elevation. Water 12: 449. DOI: 10.3390/w12020449.
Teittinen A, Kallajoki L, Meier S, Stigzelius T, Soininen J. 2016. The roles of elevation and local environmental factors as drivers of diatom diversity in subarctic streams. Freshw Biol 61 (9): 1509-1521. DOI: 10.1111/fwb.12791.
Thorp JH. 2015. Functional relationships of freshwater invertebrates. In: Thorp JH, Rogers DC (eds). Thorp and Covich's Freshwater Invertebrates. Academic Press, United States.
Wallace RL, Snell TW, Smith HA. 2015. Phylum rotifera. In: Thorp JH, Rogers DC (eds). Thorp and Covich's Freshwater Invertebrates. Academic Press, United States.
Wang Q, Peng H, Higgins BT. 2019. Cultivation of green microalgae in bubble column photobioreactors and an assay for neutral lipids. J Vis Exp 143: e59106. DOI: 10.3791/59106.
Wibawa I. 2017. Identifikasi plankton jenis diatom pada habitat kerang abalone di pantai tanah Lot Tabanan. [Dissertation]. Universitas Warmadewa, Indonesia. [Indonesian]
Wu N, Schmalz B, Fohrer N. 2011. Distribution of phytoplankton in a German lowland river in relation to environmental factors. J Plankton Res 33: 807-820. DOI: 10.1093/plankt/fbq139.
Zeng Q, Liu Y, Zhao H, Sun M, Li X. 2017. Comparison of models for predicting the changes in phytoplankton community composition in the receiving water system of an inter-basin water transfer project. Environ Pollut 223: 676-684. DOI: 10.1016/j.envpol.2017.02.001 .