SPECIES DIVERSITY OF ZOOPLANKTON AND SOME PHYSICO-CHEMICAL WATER PARAMETERS OF NAUNG TONG LAKE, KYAING TONG TOWNSHIP, EASTERN SHAN STATE

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Abstract

Investigation on the species diversity of zooplankton species and water parameters in Naung Tong Lake were conducted during March, 2019 to January, 2020. A total of 17 zooplankton species, of ten genera, six families and four orders were recorded. Based on the relation between water parameters and zooplankton, the moderate positive relationship was observed between pH and zooplankton population. Other parameters (such as water temperature, turbidity, DO and BOD) and zooplankton were poorly correlated. This study revealed that physico-chemical fluctuations were negative impact on the zooplankton species richness and abundance in this lake.

Keywords: zooplankton, Naung Tong Lake, Water parameters, species richness and abundance

Introduction

In freshwater ecosystem, the zooplankton forms an important faunal group, as most of them live on primary producers and makes themselves available to be eaten by higher organisms in food chains including fish and contribute significantly to the biological productivity of this ecosystem (Michael, 1973). Zooplankton constitute important food item of many omnivorous and carnivorous fishes. The larvae of carps feed mostly on zooplankton (Dewan *et al*., 1977) because zooplankton provides the necessary amount of proteins. Zooplankton plays an important role in indicating the water quality, eutrophication status and productivity of a freshwater body (Mikschi, 1989). Zooplankton communities are typically diverse and are highly sensitive to environmental variation. Due to short life cycle, zooplankton communities often respond quickly to environmental change (Sharma *et al.*, 2007). The changes in physico-chemical conditions of water can be reflected directly on the biotic community of ecosystem. Physico-chemical parameters influence both vertical and horizontal migration of aquatic organisms. It affects their distribution, diversity and feeding. Physico-chemical parameters of water are determined largely by the climate, geochemical and geomorphological conditions of catchment basin. Factors such as temperature, pH, DO, transparency, and electrical conductivity form part of abiotic components of an aquatic ecosystem. When water temperature in outside tolerable range, abundance of zooplankton is affected directly (Abdullahi, 1998; Imam *et al*., 2011). High acidic or high alkaline pH could result to the death of aquatic organisms including zooplanktons. Zooplankton requires oxygen for energy metabolism. Sensitivity to low oxygen concentration differs between species, various life stages (eggs, larvae and adults), and different life processes including feeding, growth and reproduction (Imam and Balarabe, 2012). Water transparency influences vertical migration of zooplankton, which affects their diurnal rhythms (Verma and Agarwal, 2007). Investigations of freshwater zooplankton community structure have significant potential for assessing aquatic ecosystem health. The objectives of the present study are;

- to record the occurrence of zooplankton species in Naung Tong Lake
- to investigate the monthly diversity indices value of zooplankton in study area
- to assess relation between water parameters and zooplankton population in study area

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Materials and Methods

Study area

The present study was carried out in Naung Tong Lake. It is located in Kyaing Tong Town, the eastern part of Shan State. It lies between Latitude: 21º 17' 20.94" N - 21º17' 46.34" N and longitudes 99º 35' 51.08"E - 99 º35' 58.59" E. Water is stored in this lake within an area of 2526.92ft in length and about 711.67ft in width. In the flood season, its water level increases with a water depth about 1.824 m and in dry season, it reduces with a water depth about 1.117 m (Fig. 1).

Study period

The study period lasted from March, 2019 to January, 2020.

Collection of samples

Sample collection was carried out twice a month (second week and fourth week) on Saturdays, between 9:30 am-11:30 am. The samples were collected using plankton nylon net having 22 cm mouth diameter and 50 µm mesh size attached with one liter sampling bottle. Collections were made by horizontal hauling. The net was submerged and dragged hauled for about 10 seconds through a distance of 2 ft and hauled up for water sample. Into the collected water samples 10ml of 10% formalin solution was added before zoolplankton were studied. Before observation was made, it was ensured that all the preserved zooplankton samples were settled down. The amount of water samples were decanted to get approximately 10ml. Water sampling was carried out once in study area.

Identification of zooplankton

Samples were examined using a binocular compound microscope (Series-30002907 CETI China) under various magnifications: general screening of the specimen was made under the magnification of the 40X (4X x 10X), the whole specimen was viewed under 100X (10X x 10X). The specimens were photographed by using canon camera which is manually attached to the eyepiece of the microscope.

A pipette was used to suck up the subsamples from bottle and a drop was put onto a clean glass slides, and then covered with cover glass, and scanned under a compound microscope. Identification was according to Pennak (1953), Edmondson (1966) and other relevant literatures.

Data analysis

To calculate the species richness and diversity of zooplankton species in study area, the data was analyzed using four diversity indices: Shannon-Wiener (1948), Simpson (1949), Margalef's (1958) and modified Hill's ratio (1981).

The Shannon-Wiener diversity index, H' is calculated using the following equation:

For Shannon-Wiener index (1948)

$$H' = -\sum_{i=1}^{s}\left[\frac{n_i}{n}\right]\ln\left[\frac{n_i}{n}\right]$$

H' = index of species diversity
S = number of species
n_i = number of individuals in i^{th} species in the sample
n = total number of individuals in the sample
ln = Natural logarithm

Simpson's diversity index is a measure of diversity. In ecology, it is often used to quantify the biodiversity of a habitat. It takes into account the number of species present, as well as the abundance of each species.

For Simpson's index (1949)

$$D = \sum_{i=1}^{S} \frac{n_i(n_i-1)}{n(n-1)}$$

D = Simpson's index

n_i = number of individuals in the i^{th} species

n = total number of individuals

Species richness was determined using the formula of Margalef's index (1958)

$$d = \frac{S-1}{\ln(N)}$$

d = Margalef's species richness index

S = number of species

N = Total number of individuals

For Hill's diversity number (1973)

Number 0 : N0 = S Where, S = total number of species

N0 = number of all species in the sample

Number 1: N1 = $e^{H'}$ Where, H' = Shannon's index

N1 = number of abundant species in the sample

Number 2 : N2 = $1/D$ Where, D = Simpson's index

N2 = number of very abundant species in the sample

Species evenness or equitability (or relative species abundances) was determined by using the evenness index of modified Hill's ratio (1981).

$$E = \frac{\left(\frac{1}{D}\right)-1}{e^{H'-1}} = \frac{N2-1}{N1-1}$$

Where, E = Hill's evenness index

D = Simpson's index of diversity

H' = Shannon's index of species diversity

N1 = number of abundant species in the sample

N2 = number of very abundant species in the sample

Measurement of water parameters

Before the zooplankton hauling, the temperature (ºC) of water was measured by dipping the thermometer slightly under the surface of water for about 5 minutes and recorded during the sampling period. To analyse water parameter, the water samples were collected every month from study area with 1liter plastic bottles bandaged by the black tape from about 5.1 cm depth water surface. Water samples were examined in Water and Soil Examination Laboratory, Ministry of Agriculture, Livestock and Irrigation, Department of Fisheries, Aquaculture Division, Freshwater Aquaculture Research, Yangon.

Source: Google Earth (2018)

Figure 1 Location map of the study area (Naung Tong Lake)

Results

A total of 17 zooplankton species of ten genera, six families of four orders from Naung Tong Lake were recorded. Among them, 15 species of rotifers and two species of copepods were found in Naung Tong Lake (Table 1).

Monthly occurrence of zooplankton species

A total 4262 individuals that represent 17 species of zooplankton were collected during March 2019 to January 2020. The highest number of species (15 species) was observed in April. The lowest number of species (7 species) was observed both in March, 2019 and January, 2020. The lowest number of individuals (234) was observed in March, 2019. The highest number of individuals (525) was occurred in June, 2020 (Table 2, Fig. 2).

Some seasonal physico-chemical parameters of water sample in study area

The maximum mean water temperature 30°C recorded in rainy season and minimum 21°C in cold season in Naung Tong Lake. In Naung Tong Lake, the minimum mean value of turbidity was 8.38 NTU in hot season and maximum 76 NTU in rainy season. The mean value of pH ranged between 7.1 to 8.5 during study period. The pH in this lake water was alkaline condition. The lowest mean value of DO was 2.0 ppm in hot season and the highest mean value 2.5 both in rainy and cold season of Naung Tong Lake. The lowest mean value of BOD was 3.5 mg/L in cold season and the highest 5 mg/L in hot season of Naung Tong Lake (Table 3).

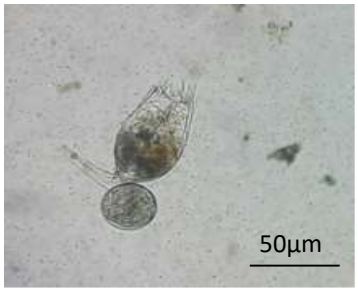
Species richness and diversity indices value of recorded zooplankton species in naung tong Lake during March, 2019 to January, 2020

The Margalef index value was the highest d = 2.49 in April and the lowest d = 1.02 in January. Shannon-Wiener value was the highest in December (H' = 4.37) and the lowest in January (H' = 1.28), and the Simpson's index was the highest in March (D = 0.98). The lowest in January (D = 0.7). The highest evenness value was 0.24 in March and the lowest 0.01 in December were observed (Table 4).

A. *Rotaria neptunia*

B. *Anuareopsis fissa*

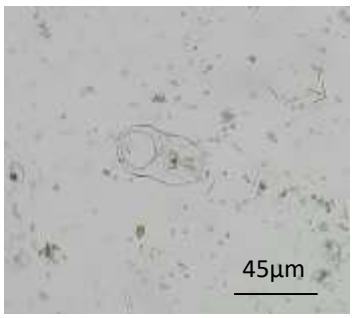
C. *Brachionus angularis*



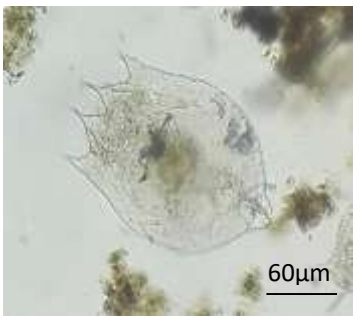
D. *Brachionus calyciflorus*

E. *Brachionus caudatus*

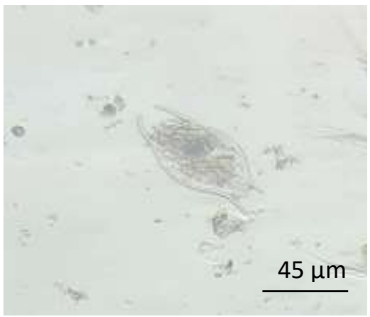
F. *Brachionus falcatus*



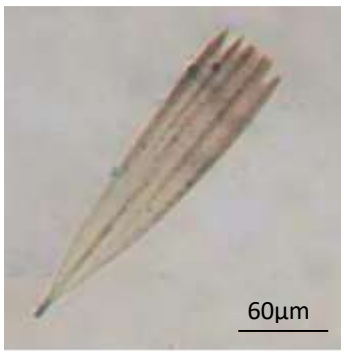
G. *Brachionus forficula*



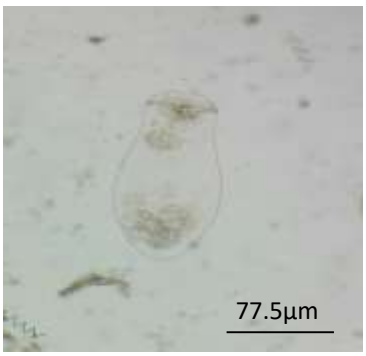
H. *Brachionus ruben*



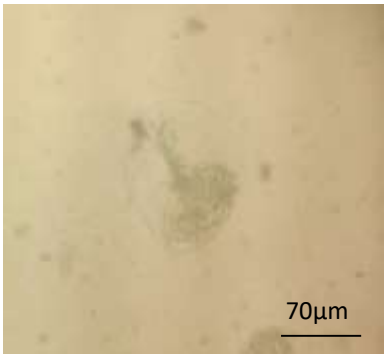
I. *Brachionus diversicornis*



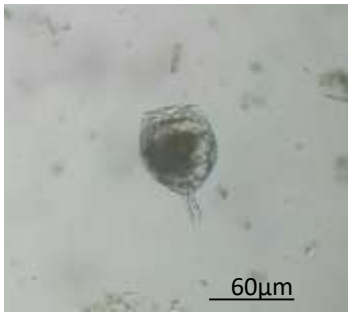
J. *Notholca acuminate*



K. *Asplanchna brightwelli*

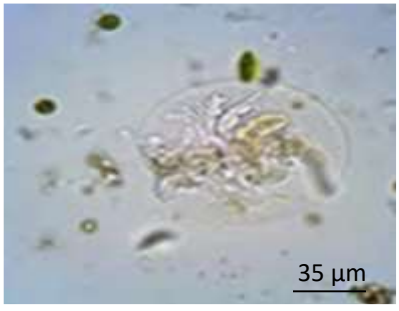


L. *Asplanchna herriki*



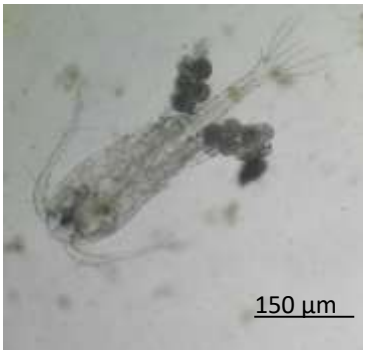
M. *Monostyla bulla*

N. *Pompholyx sulcata*

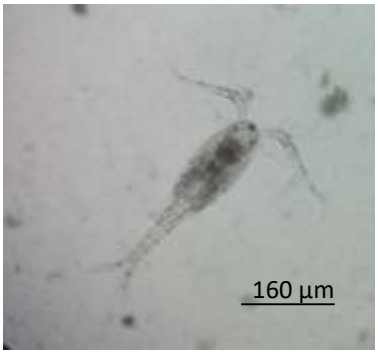


O. *Testudinella patina*

Plate 1 Recorded of some rotifer species



P. *Microcyclops* sp



Q. *Paracyclops* sp

Plate 2 Recorded of copepods species

Table 1 List of recorded zooplankton species in Naung Tong Lakes during study period

Order	Family	Species
Bdelloida	Philodinidae	1. *Rotaria neptunia*
Ploima	Brachionidae	2. *Anuareopsis fissa*
		3. *Brachionus angularis*
		4. *Brachionus calyciflorus*
		5. *Brachionus caudatus*
		6. *Brachionus falcatus*
		7. *Brachionus forficula*
		8. *Brachionus ruben*
		9. *Brachionus diversicornis*
		10. *Notholca acuminate*
	Asplanchnidae	11. *Asplanchna brightwelli*
		12. *Asplanchna herriki*
	Lecanidae	13. *Monostyla bulla*
Floscullariaceae	Testudinellidae	14. *Pompholyx sulcata*
		15. *Testudinella patina*
Copepoda	Cyclopoidae	16. *Microcyclops* sp.
		17. *Paracyclops* sp.

Table 2 Monthly occurrence of zooplankton individuals and species in Naung Tong lake during March, 2019 to January, 2020

No.	Species	Mar	April	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Jan	Total number of individuals in each species
1	*Rotaria neptunia*	-	6	9	18	1	-	3	1	6	-	3	47
2	*Anuareopsis fissa*	2	10	10	3	-	2	-	2	3	8	3	43
3	*Brachionus angularis*	-	11	15	10	-	5	-	12	-	10	-	63
4	*Brachionus calyciflorus*	28	22	48	57	44	44	84	108	82	22	98	637
5	*Brachionus caudatus*	-	3	-	6	-	-	-	1	-	8	-	18
6	*Brachionus falcatus*	-	14	-	-	-	6	-	2	3	7	-	32
7	*Brachionus forficula*	-	-	3	-	10	-	1	-	-	3	-	17
8	*Brachionus ruben*	67	60	95	83	100	129	82	81	102	124	102	1025
9	*Brachionus diversicornis*	50	12	13	41	47	-	7	4	24	-	-	198
10	*Notholca acuminate*	-	5	3	19	1	11	3	5	15	2	4	68
11	*Asplanchna brightwelli*	-	2	-	34	2	1	-	6	3	-	-	48
12	*Asplanchna herriki*	-	-	-	5	-	-	-	-	-	-	-	5
13	*Monostyla bulla*	-	1	-	12	-	-	-	5	3	5	-	26
14	*Pompholyx sulcata*	1	1	-	-	-	3	-	-	-	-	-	5
15	*Testudinella patina*	-	2	1	-	3	1	-	-	2	-	-	9
16	*Microcyclops* sp.	38	23	28	85	56	33	45	42	51	19	8	428
17	*Paracyclops* sp.	48	106	144	152	163	172	131	167	213	161	136	1593
	Total number of individuals	234	278	369	525	427	407	356	436	507	369	354	4262
	Total number of species	7	15	11	13	10	11	8	13	12	11	7	17

Table 3 Some seasonal physico-chemical parameters of water sample in study area

Parameters	Hot season	Rainy season	Cold season
Temperature (ºC)	24	30	21
Turbidity (NTU)	8.38	76	51
pH	7.1	8.5	7.1
DO (ppm)	2.0	2.5	2.5
BOD (mg/L)	5	4.0	3.5

Table 4 Monthly species richness and diversity indices value of zooplankton in Naung Tong Lake during March, 2019 to January, 2020

Index	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan
No. of individuals	234	278	369	525	427	407	356	436	507	369	354
No. of species	7	15	11	13	10	11	8	13	12	11	7
d	1.10	2.49	1.69	1.91	1.48	1.66	1.19	1.97	1.76	1.69	1.02
D	0.98	0.79	0.76	0.84	0.24	0.71	0.75	0.25	0.75	0.69	0.7
H´	1.62	1.83	1.70	2.06	1.61	1.46	1.47	1.61	1.62	4.37	1.28
N1	5.05	6.23	5.47	7.84	5.02	4.30	4.30	5.00	5.05	79.04	3.59
N2	0.02	0.26	0.31	0.19	1.31	0.40	0.33	1.33	0.33	0.45	0.42
E	0.24	0.14	0.15	0.12	0.07	0.18	0.20	0.08	0.16	0.01	0.22

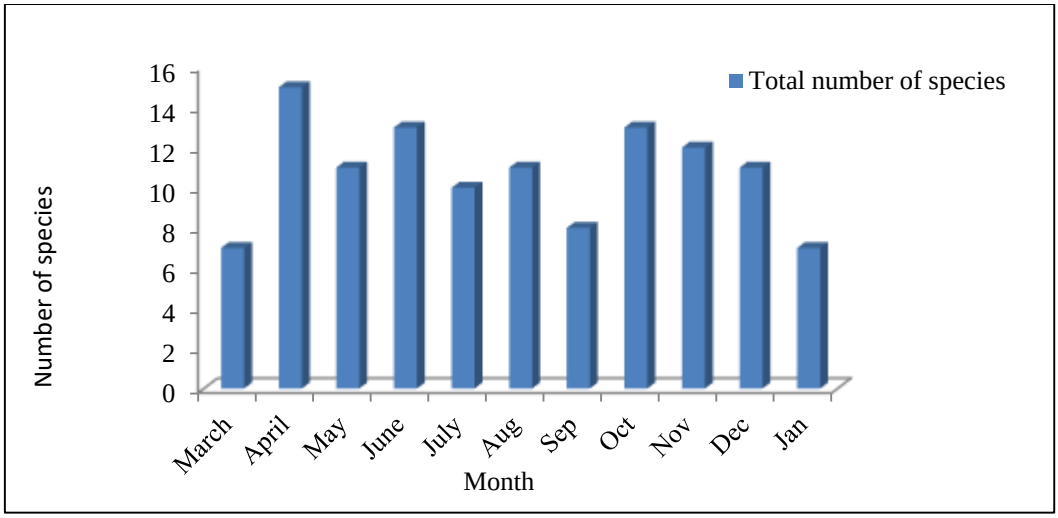


Figure 2 Monthly occurrence of zooplankton species during March, 2019 to January, 2020

Discussion

In the present study, a total of 17 zooplankton species in which 15 species of Rotifera and two species of Copepoda were recorded in Naung Tong Lake. During the study period, great variability in zooplankton abundance was recorded in the lake. Especially, rotifer was the most abundant group in lake.

Dumont (1999) recorded the higher species richness is characterized by longer food chain. At Naung Tong Lake, the highest species richness was recorded in cold season and the index value range 1.02 to 2.49.

Simpsons' index is used to quantify the biodiversity of habitats (Chatterjee, 2014). Whittaker (1965) reported that the Simpson diversity index is always higher where the community is dominated by less number of species and when the dominance is shared by large number of species (cited by Shah and Pandit, 2013). Vincent *et al.* (2012) reported the higher values of species diversity index suggest decreasing species richness with increasing trophic status. The similar trend was occurred in present study; Naung Tong showed higher species richness value.

The greater species diversity means longer food chain (Ludwik and Reynolds, 1998). Based on Shannon-Wiener legislation, the aquatic environment is classified as very good when H' is > 4, good quality 4 – 3, moderate quality 3 – 2, poor quality 2 – 1 and very poor quality < 1. Plafkin *et al.* (1989) reported that species diversity decreases when stress increases in the environment and a community dominated by a relatively few species indicate environment stress. According to the index, the H' index was 4.37 in Naung Tong lake indicating best water quality.

Amalesh *et al.* (2014) stated that species evenness is a measure of the relative abundance of each species in an area. Species evenness will be decreased if the population size of different species varies. Equitability takes a value between 0 and 1, with one being complete evenness. The index when applied in the present study, the value of evenness was ranged 0.01 to 0.24 at Naung Tong Lake. Overall results in the lake, Simpson index, Shannon-Wiener diversity index values and species evenness was highest in Naung Tong Lake. The highest Margalef's index was observed in Naung Tong Lake. Zooplankton diversity and abundance in Naung Tong Lake indicate that the lake water may be rich in nutrients.

Davies *et al*. (2009) reported that the fact that plankton distribution and abundance are affected by season, physical and chemical parameters and water movement. In present study, some

physico-chemical water parameters were measured seasonally and relation with zooplankton were discussed in following chapter.

Mahar (2003) reported the water temperature is important in terms of its effect on aquatic life. During the study period, the average temperature is 30° C in Naung Tong Lake. Kamat (2000) and Gaikwad *et al*. (2008) recorded the water temperature in the range between 13.5°C and 32°C is found to be suitable for the development of the zooplanktonic organisms. According to the present result, temperature is not exceeded in 32°C. In the present study that the water temperature might also be the factor affecting the abundance of zooplankton individuals and species. Temperature is an important factor for zooplankton growth, and low temperatures reduce embryonic and post-embryonic development rates (Gillooly *et al*., 2002).

Lloyd *et al*. (1987) indicated a high correlation between increased turbidity levels and reduced zooplankton densities in Alaskan lakes (r = 0.96). Turbid lakes exhibited less than 5% of the zooplankton densities often associated with clear lakes. However, some literature suggests that increased turbidity is beneficial to large zooplankton (e.g., Fiksen and Giske 1995). In the present study, the highest turbidity level of Naung Tong Lake ranged 8.38 to 76 NTU. The relation between turbidity and zooplankton is found negative correlation in both lakes.

In the present study, the range of pH value was 7.1 to 8.5 in Naung Tong Lake. The low pH value was recorded in hot season. In this season zooplankton populations were found the lowest individuals when compare to another season. During study period, certain species of zooplankton were inclined at low pH while many of them prefer high pH medium. The value of pH was higher in the lake during rainy season. The results of the present study agree with the finding of the Pennak (1953) who reported that alkaline waters (above pH 7.0) contain relatively few species but large numbers of individuals.

Roy *et al*. (2010) recorded that the range of dissolved oxygen was 3 mg/L to 8 mg/L. The value of DO was range in 2.0 to 2.5 at Naung Tong Lake. The distribution of DO is affected by the solubility of many inorganic nutrients, which are governed by seasonal shifts from aerobic to anaerobic environments (Benson and Krause, 1980). The higher the concentration of dissolved oxygen, the better is the water quality.

Biological oxygen demand is a parameter to assess the organic load in a water body (ICMR, 1975, cited by Bhadja and Vaghela, 2013). According to Hynes (1960, cited by Banita *et al*, 2013), BOD values between 1-2 mg/L or less represent clean water, 2-7 mg/L represent slightly polluted water and more than 8 mg/L represent severe pollution. In the present study, BOD values range between 3.5 and 5 mg/L were recorded in Naung Tong Lake. According to the above author, Naung Tong Lake is slightly polluted. The high BOD may be due to the presence of high organic load released from industrial sewage (Jalilzadeh *et al*, 2008). Various water parameters of Naung Tong Lake with national and international standards guideline, pH, the levels of DO and BOD are within the permissible levels of drinking water standards except turbidity in Naung Tong Lake.

This study revealed the values of different physico- chemical conditions from the study area. The increase in number of zooplanktons was in accordance with temperature of its habitat. The study also showed that zooplankton species survive in the neutral condition. Thus, the status of the lake could said to be eutrophic as indicated by the diversity of zooplankton.

Physico-chemical conditions of the lake can be changed because of various anthropogenic effluents which release to the water. Therefore, conducting further studies in this area is essential to measuring the diversity of zooplanktons. The variation of zooplankton species was the indicator of lake water. The diversity indices are also creating a signal about the good health of aquatic environment. This study revealed that physico-chemical fluctuations was negative impact on the

zooplankton species richness and abundance, thus, the need for the government to establish catchment management agency in order to curtail the menace that disrupt the aquatic ecosystem.

Conclusion

A total of 17 zooplankton species in ten genera, six families belonging to four orders were recorded. During the study period, phylum Rotifera was the most abundant group. Rotifers are generally abundant in eutrophic lakes and permanent dominant species have been reported. Therefore, it could be concluded that the present result revealed the characteristics of eutrophication and important bioindicator of water quality in the lake.

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