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ZOOPLANKTON SPECIES COMPOSITION, ABUNDANCE AND DIVERSITY IN LAKES WITH DIFFERENT TROPHIC STATUS

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By

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Chairperson: Prof. Fatimah Md. Yusoff, PhD
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Zooplanktons are microscopic aquatic organisms that have short life cycle and rapid reproduction rate which enable them to respond quickly to environmental changes. Their distributions are influenced by various abiotic and biotic factors. Elevated nutrient input into water bodies leads to eutrophication, which would in turn affect the zooplankton distribution. This study was conducted to evaluate the zooplankton species composition, abundance and diversity in lakes with different trophic status in order to relate the changes in zooplankton community with different trophic levels, and to identify potential zooplankton species as bio-indicators. Bimonthly sampling was carried out in Subang, Putrajaya and Sembrong lakes at three stations in each lake, from April 2015 to February 2016. Duplicate zooplankton samples were collected from each station with a 60-µm mesh net using vertical hauls and preserved with 10% buffered formalin for identification and enumeration. Physicochemical parameters were measured *in situ*. Nutrient analyses and chlorophyll *a* determination were performed following the standard method. Conductivity, pH, total dissolved solid (TDS), turbidity, total phosphorus (TP), total nitrogen (TN) and chlorophyll *a* were significantly higher ($p < 0.05$) in Sembrong lake. Based on the Carlson Trophic Status Index (CTSI), Sembrong lake was classified as hypereutrophic lake, Putrajaya lake as meso-eutrophic lake and Subang lake as mesotrophic lake. The highest rotifer species was recorded in Putrajaya lake with 28 species. The highest ($p < 0.05$) rotifer density was observed in Putrajaya lake with a total mean density of 239.4 ± 30.3 ind. l^{-1}. Rotifer assemblage of Sembrong lake was dominated by *Brachionus forficula* (23.3 %) and *B. calyciflorus* (18.0 %). In Putrajaya lake, the major species was *Keratella cochlearis* which contributed to 38.0 %. Subang lake showed a clear domination of *P. libera* contributing to 76.1 %. Rotifer diversity was highest in Sembrong lake with H' = 1.9 ± 0.0. The abundance of *Brachionus* and *Keratella* were related to the eutrophic condition. *Ptygura libera* seemed to be associated

to waters with relatively high transparency. The highest microcrustacean species was recorded in Putrajaya lake with eight species. However, the highest (p < 0.05) microcrustacean density was observed in Sembrong lake with a total mean density of 293.7 ± 60.7 ind. l^{-1}. Microcrustacean species assemblage of Sembrong lake was dominated by *Ceriodaphnia cornuta* with 66.0 %. In Putrajaya lake, the dominant species was *Bosmina longirostris* which made up 46.8 %. Meanwhile, in Subang lake *Thermocyclops crassus* was the dominant species contributing to 74.0 %. The highest diversity of microcrustacean was observed in Putrajaya lake with H' = 1.3 ± 0.0. The abundance of small size cladocerans such as *C. cornuta* and *B. longirostris* were related to the eutrophic conditions of the lakes. This study illustrated that the zooplankton composition and abundance were related to the environmental characteristics and trophic status of lakes.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Sarjana Sains

KOMPOSISI, KELIMPAHAN DAN KEPELBAGAIAN SPESIES ZOOPLANKTON DI TASIK YANG BERBEZA TROFIK STATUS

Oleh

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Zooplankton adalah organisma akuatik mikroskopik yang mempunyai kitaran hayat yang singkat dan kadar pembiakan yang cepat membolehkan mereka bertindak balas dengan pantas terhadap perubahan persekitaran. Peredaran mereka adalah dipengaruhi oleh pelbagai faktor abiotik dan biotik. Peningkatan tahap nutrien di dalam air mengakibatkan eutrofikasi dan seterusnya menjejaskan peredaran zooplankton. Kajian ini dijalankan adalah untuk menilai komposisi spesies zooplankton, kelimpahan dan kepelbagaian dalam tasik yang berbeza tahap trofik untuk mengaitkan perubahan komuniti zooplankton dengan paras trofik yang berbeza, dan mengenal pasti spesies zooplankton yang berpotensi sebagai bio-indikator. Pensampelan telah dijalankan setiap dua bulan di tasik Subang, Putrajaya dan Sembrong di tiga stesen dalam setiap tasik bermula April 2015 sehingga Februari 2016. Zooplankton sampel di ambil sebanyak dua kali menggunakan jaring plankton berukuran 60-µm secara menegak dan di awet menggunakan 10 % formalin bufer untuk proses identifikasi dan pengiraan. Parameter fizikal-kimia di ukur secara *in situ*. Kaedah standard digunakan untuk menganalisis nutrient dan klorofil *a*. Konduktiviti, pH, jumlah pepejal yang dibubarkan (TDS), kekeruhan, fosforus (TP), nitrogen (TN) dan klorofil *a* adalah lebih tinggi ($p < 0.05$) di tasik Sembrong. Berdasarkan Indeks Status Carlson Trofik (CTSI), Tasik Sembrong dikelaskan sebagai tasik hipereutrofik, Tasik Putrajaya sebagai tasik meso-eutrofik dan Tasik Subang sebagai tasik mesotrofik. Bilangan spesies rotifer tertinggi dicatatkan di Tasik Putrajaya dengan 28 spesies. Kepadatan rotifer tertinggi ($p < 0.05$) direkodkan di tasik Putrajaya dengan purata 239.4 ± 30.3 ind. l^{-1}. Rotifer Tasik Sembrong didominasi oleh *Brachionus forficula* (23.3 %) and *B. calyciflorus* (18.0 %). Spesies rotifer di Tasik Putrajaya, diungguli oleh *Keratella cochlearis* dengan 38.0 %. Tasik Subang menunjukkan penguasaan *P. libera* menyumbang kepada 76.1 %. Kepelbagaian rotifer adalah tertinggi di tasik Sembrong dengan H' = 1.9 ± 0.0. Kelimpahan *Brachionus* dan *Keratella* adalah dikaitkan dengan keadaan eutrofik. *Ptygura libera* dikaitkan dengan keadaan air tasik yang mempunyai kecerahan yang tinggi. Spesies mikrokrustasea tertinggi dicatatkan di Tasik Putrajaya dengan lapan spesies.

Walau bagaimanapun, kepadatan mikrokrustasea tertinggi ($p < 0.05$) dicatatkan di Tasik Sembrong dengan purata 293.7 ± 60.7 ind. l^{-1}. Spesies mikrokrustasea tasik Sembrong didominasi oleh *Ceriodaphnia cornuta* dengan 66.0 %. Spesies utama di Tasik Putrajaya adalah *Bosmina. longirostris* yang terdiri daripada 46.8 %. Sementara itu, Tasik Subang dikuasai oleh *Thermocyclops crassus* yang menyumbang kepada 74.0 %. Kepelbagaian microcrustacean tertinggi di rekodkan di tasik Putrajaya dengan H' = 1.3 ± 0.0. Kelimpahan cladocera bersaiz kecil seperti *C. cornuta* dan *B. longirostris* adalah dikaitkan dengan keadaan eutrofik tasik. Kajian ini menunjukkan bahawa komposisi dan kelimpahan zooplankton adalah berkaitan dengan ciri-ciri alam sekitar dan status trofik tasik.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

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LIST OF ABBREVIATIONS

%	Percentage
°C	Degree Celcius
µg	Microgram
µm	Micrometer
µS	Microsiemens
CCA	Canonical correspondence analysis
Chl *a*	Chlorophyll *a*
Cm	Centimeter
CTSI	Carlson trophic status index
DO	Dissolved oxygen
G	Gram
H’	Diversity index
Ha	Hectare
HABs	Harmful algal blooms
Ind.	Individual
J’	Evenness index
km 2	Square kilometer
L	Liter
M	Meter
m 3	Cubic meter
Mg	Milligram
Ml	Milliliter
Mm	Millimeter
NMDS	Non-metric multidimensional scaling
NO_3-N+NO_2-N	Nitrate+nitrite
NTU	Nephelometric turbidity unit
OD	Optical density
PCA	Principle component analysis
R	Correlation
SD	Secchi disk
SRP	Soluble reactive phosphorus
TAN	Total ammonium nitrogen
TDS	Total dissolved solid
TN	Total nitrogen
TP	Total phosphorus
TSI	Trophic status index

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Zooplanktons occupy a key position in shaping the aquatic food web as they have significant roles in the transfer of energy and organic matter from phytoplankton to other consumers. Zooplankton composition, abundance and diversity are affected by various factors such as water quality, nutrient availability, predation rates and food quality. Moreover, their community structure is highly related to the phytoplankton composition and abundance which depends on the size and the type of phytoplankton available. Nutritious phytoplankton species such as diatoms and some green algae are beneficial for healthy growth of zooplankton (Hemaiswarya et al., 2011). However, the abundance of toxic species like certain blue-green algae species such as *Microcystis* can be detrimental to zooplankton populations (Čeirans, 2007). Therefore, in eutrophic ecosystem with high abundance of blue-green algae, zooplankton populations tend to decline due to unavailability of suitable food, microalgal toxicity and poor environmental conditions (Sendacz et al., 2006). However, in some cases, zooplankton abundance and diversity are highest in eutrophic conditions because of the availability of other types of food resulting from organic matter decomposition, such bacteria and detritus which serve as food resources for zooplankton.

Rapid reproduction rate and short life cycles of zooplanktons enable them to be one of the important components as bioindicators in biological monitoring programs. Potentiality of zooplankton as bioindicators is very high because their growth and distribution are highly dependent on environmental conditions. At the same time, different zooplankton groups may have contrasting responses to environmental changes due to differences in reproductive rates, filtering capacities and specializations in acquiring food (Fileto et al., 2005). Alteration of zooplankton community structure could be the result of intra and inter specific zooplankton competition. Effects of predation and competition among zooplankton groups also influence zooplankton community structure. Fussman (1996) pointed out that rotifers and crustaceans could compete for the same algal resources. At the same time, rotifers are the prey for copepods. Besides, the preference of larger-sized zooplankton by planktivorous fish also results in shifting of zooplankton communities towards dominance by smaller species, such as rotifers (Walls et al., 1990a). This is because bigger zooplanktons are easier to be seen and captured by the visual predators, including fish.

1.2 Problem Statement

The process of lake aging is called eutrophication, which occur naturally. However, continuous accumulation of nutrients mainly phosphorus and nitrogen derived from anthropogenic activities from point-sources and non-point source, accelerate eutrophication. Point sources are relatively identifiable and can be controlled by treatments at the source, for example municipal sewage treatment. However, non-point sources are tend to be difficult to control as they are diffuse sources, for example, run off from agricultural sites which can be considered as the main contributor for most nutrient loadings in water bodies. Abdel-Raouf et al. (2012) reported that high nutrient loadings into the water encourage the growth of aquatic plants which resulted in the formation of phytoplankton blooms or macrophyte infestation. Khan and Ansari (2005) noted that in nutrient-enriched waters, algae tend to grow rapidly in a short period resulting in increase of organic matters that need to be decomposed. Decomposition requires high oxygen consumption which causes dissolved oxygen in water to decrease. Low oxygen results in hypoxic conditions and causes mortality to most aquatic organisms. At the same time, nutrients are recycled back through dead particles which then increase nutrient concentrations in the water. To some extent, eutrophication produces harmful algal blooms (HABs) leading to production of noxious toxins which affect developmental, immunological, neurological and reproductive capacities of other organisms (Chislock et al., 2013). These problems could cause a decline of zooplankton abundance and diversity in lake ecosystems.

1.3 Objectives

The objectives of this study are:-

1) To assess the environmental parameters and evaluate trophic status of three selected lakes.
2) To determine the rotifer and microcrustacean (cladoceran and copepod) species composition, distribution and diversity in lakes with different trophic status.
3) To establish species bioindicators for the lakes with different trophic status.
4)

This study can contribute toward biodiversity conservation and sustainability of lake aquatic ecosystem in Malaysia.

1.4 Hypothesis

Null hypothesis (H_o): Zooplankton species composition, abundance and diversity do not differ in lakes with different trophic status.

Alternative hypothesis (H_A): Zooplankton species composition, abundance and diversity are differ in lakes with different trophic status.

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