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Research Article

Diversity and Habitat Characteristics of Local Freshwater Gastropoda (Caenogastropoda) from Sarawak, Malaysia

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Abstract

Background and Objective: Gastropoda communities are the most diverse class of mollusc and considered as foremost constituent in the freshwater ecosystems and fisheries economy. However, there is knowledge gap and documentation of freshwater gastropods (Caenogastropoda) in Malaysia particularly in Sarawak. Therefore, this study was performed to identify the species composition and to determine the diversity and abundance of freshwater gastropods communities from selected Bintulu, Sarawak freshwater ecosystems. **Materials and Methods:** Number of individual and gastropod species were count randomly at triplicate quadrat (1 × 1 m) from 5 sampling location in Bintulu, Sarawak Malaysia. Data of identified species was analyzed for diversity index and correlation with water parameters. **Results:** Present study revealed a total of 5 species from Pachychilidae and Thiaridae families at the 5 sampling locations. *Melanooides tuberculata* was the most abundant species. Shannon indices and Simpson's indices revealed the species diversity and richness were highest at station 3 compared to the other four study locations. Abiotic parameters (dissolved oxygen, pH, water temperature, turbidity and conductivity) indicated significantly difference ($p < 0.05$) among the stations. Dissolved oxygen indicates highly positive relation with the diversity of gastropods. **Conclusion:** New distribution of local freshwater gastropod from Sarawak has been documented and dissolved oxygen level in the water as one measure to assess diversity of freshwater gastropods in the environment.

Key words: Abiotic factors, borneo, freshwater habitat, gastropod and diversity

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Caenogastropoda is the most dominant gastropod group in terms of abundance and distribution of species and including their ecological and commercial importance. Among the living snails, Caenogastropoda encompass almost 60% of the reported species¹. They are the largest and most diverse group of gastropods and can therefore, be found in a wide range of environments, some of which can be found in freshwater, brackish water, coastal and terrestrial areas. Furthermore, they also have diverse habits as they can be benthic epifaunal or burrowers, pelagic drifters or dynamic swimmers; herbivores or grazing or active carnivores, detritus or sedentary suspension feeders, ectoparasites or shell-less internal parasites².

Gastropod has the widest range of ecological niches among the molluscs. Freshwater gastropods can be found in almost all aquatic habitats including lakes, rivers, swamps, springs, ponds, drainage and other seasonal water. Most of the freshwater gastropods were submerged and some had unique habitats such as stones, aquatic vegetation, wood, dead leaves and soft sediment³. Pulmonate snails commonly favoured calmer waters, while prosobranchs normally tended to prefer lotic environments⁴. Snail's shell exhibits some structural features in response towards their habitat preferences. Gastropod plays a significant role in the environmental field and promotes the global economy. In ecology, gastropods are reliable water quality indicators and the abundance of some species may tell the current status of any water impoundment⁵. In the market, some of the edible molluscs are considered economically important⁶.

Apparently, there are few in-depth studies of freshwater gastropod in Malaysia^{7,8}. In Sarawak, little study was conducted diversity and abundance of gastropods. Some of the studies were to evaluate the abundance of marine gastropod and bivalves in Sampadi Island, Lundu, Sarawak by Long⁹, diversity of edible mollusc (gastropod and bivalvia) at nominated division in Sarawak by Hamli *et al.*^{10,11}, distribution of macrofauna including gastropod in Rajang River, Sarawak carried out by Long⁹. However, most of the reports involve marine and brackish water species. Despite their ecological and economic importance, freshwater gastropods around the world are battle with loss and decline in number. Freshwater gastropods encounter threats from habitat loss and degradation³. However, the overall diversity of freshwater gastropods in Malaysia, particularly in Sarawak remains poorly documented in comparison to other part of Southeast Asia region. This situation is exacerbated by the lack of knowledge, conservation and management effort on freshwater Caenogastropoda in Malaysia particularly in Sarawak. Therefore, present study is aim to provide more information on habitat characteristic of Caenogastropoda and species that presence in the Bintulu.

MATERIALS AND METHODS

The present study was conducted in Bintulu, Sarawak which was carried out at five selected sampling points (Fig. 1). The locations were chosen due to the pristine environment from human development. The study was conducted from September, 2017 to April, 2018.

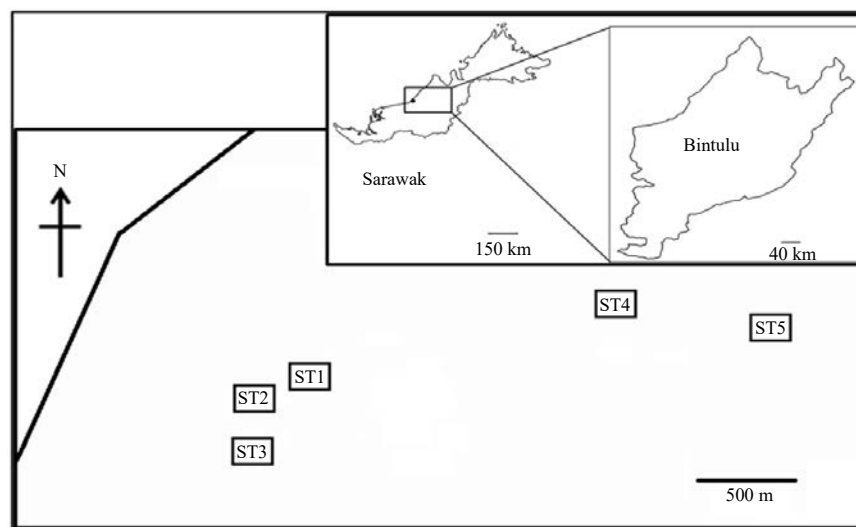


Fig. 1: Freshwater gastropod sampling area
Source: Google map

Sampling technique: At each sampling area, triplicates of quadrat (1 m × 1 m) were laid. Specimens were counted and randomly collected from each sampling point and stored in the zip bags for identification process. Specimens were identified based on the taxonomy characteristics based on Perez¹², Von Rintelen and Glaubrecht¹³, Kohler and Glaubrecht¹⁴, Kohler and Dames¹⁵, Von Rintelen *et al.*¹⁶, Marwoto and Isnainingsih¹⁷ and Madsen and Hung¹⁸. Identified specimens were then photographed using a digital camera and redraw to expose any faint characters on the shell. A triplicate of abiotic variables such as water temperature, pH, turbidity, conductivity and dissolved oxygen (DO) were obtained *in situ* using multi-parameter water quality checker (Model WQC-24, DKK-TOA Corporation, Tokyo, Japan)¹⁹.

Statistical analysis: Abiotic variables were analyzed with one way analysis of variance (ANOVA) and significant difference in mean was compared using Tukey test using Statistical Package for Social Science (SPSS) software (IBM Corporation, New York, United State). The individual number and species of each site were evaluated for the Shannon diversity index (H'), Pielou's evenness index (J') and Margalef's richness index (D) using Plymouth Routines In Multivariate Ecological Research (PRIMER) version 5.2.8 (Massey University, Auckland, New Zealand). Correlation between abiotic variables with diversity indices was analyzed using SPSS software.

RESULTS AND DISCUSSION

Species distribution: A total of 551 individuals were recorded from 5 sampling sites with 5 species from 2 families. The existing gastropods species revealed that, *Melanooides tuberculata* has been found at all stations (Table 1). Meanwhile, *Tylomelania* sp. was recorded at station 1, 2 and 3. Other species such as *S. testudinaria*, found at station 1 and *Brotia siamensis* and *Sulcospira schmidti* were distributed at two separate stations (station 2 and 3).

According to Coelho *et al.*²⁰ *M. tuberculata* is invasive species that currently distributed until South America from the tropical region. Furthermore, molecular work by Chiu *et al.*²¹ emphasized that two lineages of *M. tuberculata* from Malaysia have invaded the world. Not all species that capable to develop sustainable population at the wider tolerance range of environmental parameters. This indicated that *M. tuberculata* has developed a unique life history strategy which enables to develop population at any watercourse around the globe. Nonetheless, other gastropod species can only be found under a specific condition that is mostly

Table 1: Species distribution of freshwater gastropod at selected areas in Bintulu, Sarawak

Family/genus/species	Stations				
	S1	S2	S3	S4	S5
Thiaridae					
<i>Melanooides tuberculata</i>	+	+	+	+	+
Pachychilidae					
<i>Tylomelania</i> sp.	+	+	+	-	-
<i>Brotia siamensis</i>	-	+	+	-	-
<i>Sulcospira schmidti</i>	-	+	+	-	-
<i>Sulcospira testudinaria</i>	-	-	+	-	-

+: Present, -: Absent

pristine. The ideal ecosystem capable of supporting large and diverse species of fauna has been clarified in the present study. Analysis shown that station 3 consist the highest diversity and richness indices compared to others. Station 4 and 5 showed the lowest diversity, richness and evenness indices (Table 2). In spite of this, station 1 presented the highest evenness index value and station 4 and 5 revealed as the lowest.

Bronmark²² reported that the diversity and distribution of freshwater gastropod was influenced by area and number of macrophytes. Gastropod uses macrophyte as a shelter from predator. The higher the number of macrophytes will increase the survival rate of the gastropod. The state of the water body as well significantly affects the diversity of gastropods as emphasized by Ghosh and Panigrahi²³. Current study suggested that there was significant difference ($p < 0.05$) between stations for water quality parameters (Table 3). Stations 1, 2, 4 and 5 were shown to be significantly high ($p < 0.05$) for conductivity and pH, water temperature, turbidity and dissolved oxygen respectively. Meanwhile, station 5 displayed significantly low conductivity, pH, turbidity and dissolved oxygen levels. Station 4 was shown to have a low water temperature level compared to other stations. Low dissolved oxygen from the station 5 was negatively correlated with high water temperatures as stated by Durmishi *et al.*²⁴. Moreover, the habitat feature of station 5 was exposed to direct sunlight, which causes high water temperatures during the day (Table 3). Abiotic factors such as conductivity, water temperature, pH, turbidity, dissolved oxygen play an important role in the richness and composition of freshwater gastropod species, shell formation, growth and survival²⁵⁻²⁹.

Present study only indicated that dissolved oxygen is substantially positively correlated with species diversity in the study areas (Table 4). Koopman *et al.*³⁰ suggested that caenogastropoda has a lower heat tolerance under hypoxia, similar to the station 5.

Table 2: Diversity, richness and evenness indices of freshwater gastropod of each station in Bintulu, Sarawak

Stations	Number of species (S)	Number of individual (N)	Margalef's richness index (d)	Pielou's evenness index (J')	Shannon-Weiner diversity index (H')
S1	2	150	0.1996	0.8462	0.5865
S2	4	157	0.5933	0.7991	1.108
S3	5	212	0.7467	0.7852	1.264
S4	1	4	0.0	0.0	0.0
S5	1	28	0.0	0.0	0.0

Table 3: Abiotic variables (Mean \pm SD) of each station at the study area

		Parameters				
Stations	Descriptions	Conductivity ($\mu\text{S cm}^{-1}$)	Water temperature ($^{\circ}\text{C}$)	pH	Turbidity (NTU)	DO (mg L^{-1})
1	Shaded rocky stream with clear water	11.7 \pm 0.0 ^a	26.30 \pm 0.1 ^a	7.2 \pm 0.3 ^a	35.0 \pm 8.7 ^a	4.50 \pm 0.482 ^b
2	Partially shaded rocky stream with clear water	5.9 \pm 0.1 ^b	26.30 \pm 0.1 ^a	7.0 \pm 0.2 ^b	12.3 \pm 1.4 ^b	5.98 \pm 0.051 ^a
3	Partially shaded sandy stream with clear water	5.3 \pm 0.4 ^b	26.60 \pm 0.1 ^b	6.8 \pm 0.1 ^{ab}	12.4 \pm 1.6 ^b	5.81 \pm 0.035 ^a
4	Sheltered sandy stream with clear water	2.8 \pm 0.5 ^c	25.30 \pm 0.1 ^c	7.0 \pm 0.6 ^a	36.2 \pm 7.4 ^a	3.74 \pm 0.367 ^c
5	Exposed rocky and sandy stream with clear water	0.7 \pm 0.0 ^d	27.00 \pm 0.1 ^d	6.1 \pm 0.3 ^b	9.4 \pm 0.1 ^b	1.39 \pm 0.010 ^d

Means in the same column followed by the same letter do not differ significantly according to the Tukey test ($p < 0.05$)

Table 4: Pearson's correlation coefficient r between environmental parameters and Shannon Weiner diversity index (H') of freshwater gastropod

Water variables	R	Significance (2-tailed)
Conductivity ($\mu\text{S cm}^{-1}$)	0.45547	0.4408
Water temperature ($^{\circ}\text{C}$)	0.25327	0.6810
pH	0.40528	0.4985
Turbidity (NTU)	-0.39295	0.5129
DO (mg L^{-1})	0.88543*	0.0457*

*Correlation was significant ($p < 0.05$)

CONCLUSION

The results from the study indicate that a total of 5 species from 2 families of freshwater gastropods had been identified with *Melanoides tuberculata* as being the most abundant species. The presence of this species could be the biological indicator for the stream water quality. Station 3 had the highest diversity and richness index value in compared to other stations. The index value reflected that station 3 had the most stable and highly favourable abiotic conditions for freshwater gastropod habitat. Furthermore, the study suggested that partially or fully sheltered habitat provide ideal water temperature and oxygen concentration for various species of freshwater gastropod to expand, colonized and thrive.

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SIGNIFICANCE STATEMENT

This study discovers the diversity and habitat characteristic of local freshwater gastropod that beneficial to the malacological study in Borneo. This study will help the researcher to uncover the critical areas of distribution, species diversity and habitat feature of freshwater gastropod that many researchers were not able to explore. Thus a new theory on gastropod population and distribution may be arrived at.

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