NUTRIENT CHARACTERIZATION, FRESHWATER PLANKTON AND SHRIMP DIVERSITY IN SUBTERRANEAN AND AVOVEGROUND STREAMS IN MARINDUQUE, PHILIPPINES

Doreen Mascareñas [1], Cesar G. Demayo[2]
[1] School of Fisheries, Marinduque State College, Banuyo, Gasan, Marinduque, Philippines;
[2] Department of Biological Sciences, College of Sciences and Mathematics,
Mindanao State University-Iligan Institute of Technology, Iligan City, Philippines.
Corresponding author: dorge_16@yahoo.com

***ABSTRACT**: Marinduque is endowed with subterranean and aboveground streams harbouring a variety of freshwater shrimps that has not been well documented and more importantly its relationship with the physical environment not established thus this study was conducted. Colorimetric analysis was used to determine, the nutrient contents of the water and sediment samples using a UV-Vis spectrophotometer. Nutrient analysis indicated that the concentration levels of phosphate, ammonium, and sulfate were within the acceptable levels of water quality for aesthetic and fisheries purposes. The observed differences in the concentration of nutrients between the subterranean and aboveground stream environments however, may indicate that these two aquatic ecosystems are relatively isolated from each other. Likewise, species richness of freshwater shrimps and phytoplankton were affected by the concentration of nutrients indicative of a positive correlation.*

Keywords: Phytoplankton, zooplankton, ammonium, sulfates, phosphates, freshwater shrimps, diversity

INTRODUCTION

Marinduque Island in the Philippines is endowed with a lot of subterranean and aboveground streams and their ecotourism potential has been recognized. The caves in particular are known to be harboring a variety of shrimps which are utilized as food source for the locals. These species have not been thoroughly documented and are also regarded as an added attraction for cave ecotourism. There is therefore a need to understand the dynamics between the physical environment and the shrimp biodiversity in this subterranean ecosystem where there is a dearth of information on its ecology, specifically shrimp diversity in relation to environmental parameters such as important nutrients like phosphate, nitrate and sulfate in stream productivity and food chain dynamics. Freshwater shrimps play an important role in the recycling of nutrients in the aquatic ecosystem especially in the processing of detritus, aquatic insects, polychaetes, other crustaceans, fish, mollusks and zooplankton, fragments of aquatic plants, planktonic algae and diatoms, and phytoplankton [1]. These organisms to sustain their existence in freshwater ecosystems require adequate light, carbon dioxide for energy fixation processes, oxygen for respiration, and supplies of major elements such as calcium, nitrogen, phosphorus, potassium and sulphur [2]. Since studies show nutrient availability provides a strong link between freshwater shrimp assemblage in the aquatic environment [3], understanding the possible connectivity of the subterranean and aboveground streams can provide environmental benchmarks for the management and conservation of the cave and aboveground stream ecosystems thus this study was conducted.

MATERIALS AND METHODS

Subterranean and aboveground streams in Sta. Cruz and Torrijos municipalities in Marinduque, Philippines were sampled in this study. The sites in Sta. Cruz are in proximity to copper mining activities in the past while the sites in Torrijos are relatively free from mining activities although it is sitting on a rich copper deposit. The subterranean and aboveground streams are in proximity with each other. Bagumbungan cave and Pahuan cave were sampled in Sta. Cruz and Torrijos, respectively.

The nutrient content especially phosphate, ammonium and sulfate of the water and sediment including pH in the subterranean and aboveground streams in relation to shrimp diversity and abundance were determined. Species richness, abundance of freshwater shrimps and planktons were also determined [4,5].

RESULTS AND DISCUSSIONS

The nutrient concentration levels of phosphate, ammonium, and sulphate are presented in Fig. 1. Differences in the concentration of nutrients between the subterranean and aboveground stream environments indicate that the aquatic ecosystems are relatively isolated from each other.

Based on the < 0.4 ppm standard set by DENR-EMB [7], concentrations of phosphates exceeding 0.020 mg/L are already considered eutrophic [4],thus, both the amount of phosphates in the sediments in subterranean (inside) and aboveground streams (outside) fall in this classification. The higher phosphate content inside the cave can be attributed to the presence of guano (droppings of bats) materials.

Ammonium content in subterranean sediments was higher than the aboveground streams (Fig. 01b).

However, the ammonium content in water did not differ significantly. These results however were within < 1ppm threshold for aquatic systems for aquaculture purposes [5].

The sulfate content in the Bagumbungan site was significantly higher in aboveground stream compared to the subterranean stream (Fig. 01c). The sulfate content of the water samples was within the < 2000 ppm standard set by the Iowa DNR (2009). Based on the study commissioned by Iowa DNR [6], sulfate is toxic only if coupled with high chloride and hardness concentrations. The Philippine standard for water quality for aesthetics use is 250 ppm [7].

The pH readings for the sediments show the subterranean sediments had lower pH compared to that of the samples from the aboveground stream.

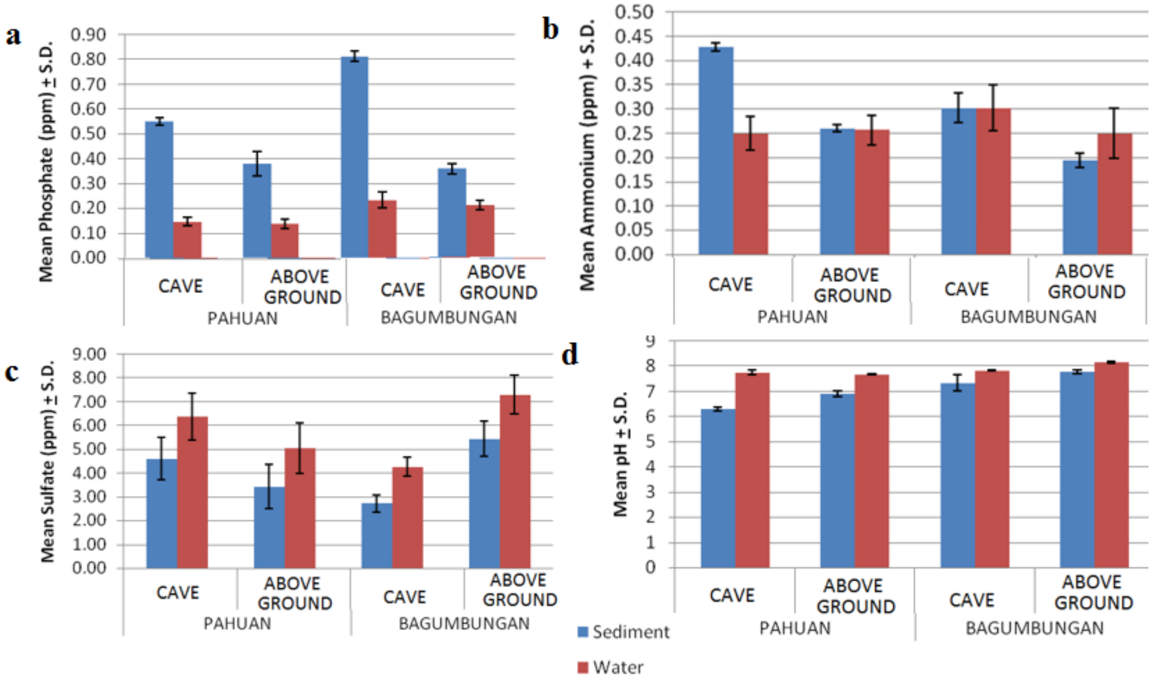

Fig. 01 Phosphate (a) Ammonium (b) Sulfate (c) and pH (d) content of the sediment and water in the subterranean and aboveground streams of Pahuan and Bagumbungan in Marinduque, Philippines

The same is true with the water samples from Bagumbungan sampling site (Fig. 01d). The pH is of concern since small changes in pH can also alter the chemical state of many pollutants such as copper and ammonia, changing their solubility, transport or bioavailability increasing the exposure to and toxicity of metals and nutrients to aquatic plants and animals [8].

Shrimps collected from the sampling sites belong to 3 genera: *Atyopsis*, *Atyoida* and *Macrobrachium* (with possible 7 species) (Table 01, Fig. 02). The subterranean sampling site has more species than the aboveground stream in Bagumbungan (Table 01).

The diversity of shrimps in the Bagumbungan cave may be explained by the diversity of phytoplankton and zooplankton in the area, where they were most diverse as well compared to the other sampling sites. *Macrobrachium* shrimps are omnivores where their natural diets include detritus, chironomidae larvae, odonata nymphs and fragments of macroalgae [9].

A total of 26 phytoplankton species was encountered in this study (Table 02, Fig. 03). For the zooplanktons, a total of 12 species was observed (Table 03, Fig. 04). The sites in Bagumbungan had the highest species richness for both phytoplankton and zooplankton. Of interest in this study is dominance of the phytoplankton *Microsystis* sp. and its relationship with phosphates and the zooplankton which may influence the freshwater shrimp population in the caves. *Microcystis* bloom is associated with a sufficient supply of nitrogen and phosphorus [10]. However, with the presence of zooplankton, the bloom did not occur during the sampling period.

Results of the correlation analysis are shown in Table 04. A relationship was observed between ammonium and freshwater shrimp species richness; phosphate and phytoplankton species richness; phytoplankton abundance and zooplankton abundance; and phytoplankton abundance and pH. These relationships have bearing on the food web in the aquatic ecosystems.

The strong relationships between the nutrients and planktons particularly phosphates supports the earlier studies [11]. Although freshwater shrimp assemblage in caves did not show significant relationship with the planktons, the positive correlation can possibly indicate dependence of the shrimps on the planktons for food.

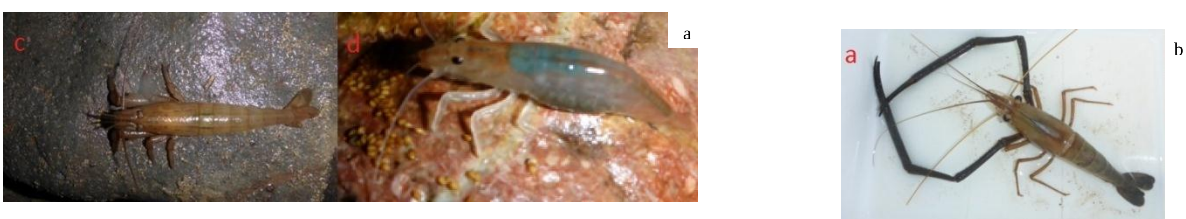

Fig. 02 Representative species of the 3 shrimp genera observed (a. *Macrobrachium lar*, b. *Atyopsis spinipes,* d. *Atyoida pilipes*).

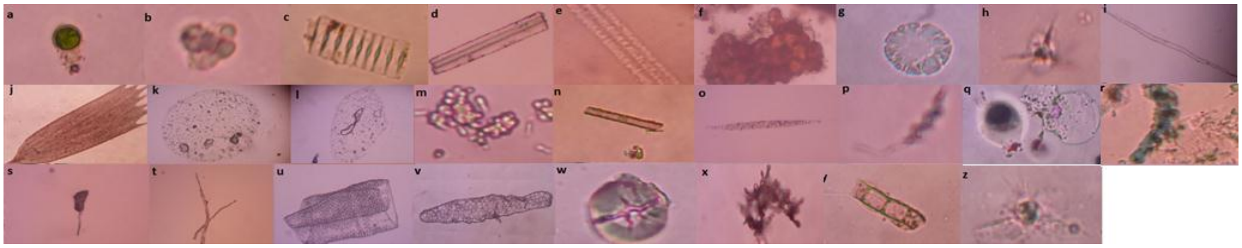

Fig. 03 Phytoplankton species observed in the 2 sites in Marinduque, Philippines (a- *Actinocyclus sp.*, b- *Cocconeis sp.*, c- *Diadesmis sp.*, d-*Synedrasp*, e-*Tetracyclus sp.*, f- *Hydrodictyon sp.*, g- *Micrasterias sp.*, h- *Treubaria sp*, i- *Nitzschia sp.*, j-*Aphanizomenon sp.*, k- *Aphanocapsa sp.*, l- *Aphanothece sp.*, m-*Microcystis sp.*, *n-Nodulariaspumigena, o- Raphidiopsis sp.*, p- *Spirulina sp.*, q- *Rufusiella sp.*, r- Unidentified sp. 1, s- Unidentified sp. 2, t- Unidentified sp. 3, u- Unidentified sp. 4, v- Unidentified sp. 5, w- Unidentified sp. 6, x- Unidentified sp. 7, y- Unidentified sp. 8, z- Unidentified sp. 9.

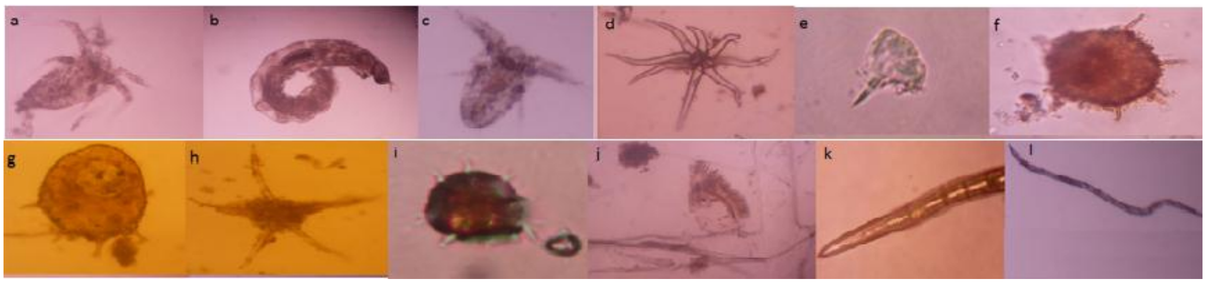

Fig. 04. **Zooplanktons (a- *Copepod sp.*, b- *Culex sp.* (larva), c- *Cyclopoid sp.*, d- *Actinula* sp. (larva), e- *Polyarthra sp.*,f-*Centropyxis sp.*, g-*Arcella sp.*, h- Unidentified sp. 1, i- Unidentified sp. 2, j- Unidentified sp. 3, k-Unidentified sp. 4, l- Unidentified sp. 5.**

Table 01 - Representative species of the 3 shrimp genera observed inside and outside the caves in the 2 sites in Marinduque

Species	Pahuan		Bagumbungan	
	Aboveground	Subterranean	Aboveground	Subterranean
Macrobrachium sp.	+	+	+	+
Atyopsis spinipes	-	-	-	+
Atyoida pilipes	+	-	-	+
Species Richness	2	1	1	3

Table 02 - Distribution of phytoplankton inside and outside the two sampling caves

Species	Above-ground	Cave	Above-ground	Cave	Species	Above-ground	Cave	Above Ground	Cave
Actinocyclus sp.	50	0	0	0	*Nodularias pumigena*	50	0	0	0
Cocconeis sp.	50	0	0	0	*Raphidiopsis sp.*	100	150	50	150
Diadesmissp	0	0	150	0	*Spirulina sp.*	0	50	0	0
Synedrasp	100	50	0	0	*Rufusiella sp.*	0	100	0	0
Teracyclussp	50	0	0	0	Unidentified sp. 1	0	50	50	0
Hydrodictyon sp.	50	0	0	0	Unidentified sp. 2	0	50	0	0
Micrasterias sp.	0	50	0	50	Unidentified sp. 3	200	600	1600	550
Treubariasp	100	100	0	0	Unidentified sp. 4	50	300	500	600
Nitzschia sp.	100	0	0	0	Unidentified sp. 5	50	200	850	650
Aphanizomenon sp.	50	100	0	0	Unidentified sp. 6	0	0	0	100
Aphanocapsa sp.	0	50	0	0	Unidentified sp. 7	0	0	0	50
Aphanothece sp.	0	50	0	0	Unidentified sp. 8	0	0	50	0
Microcystis sp.	>50000	>5000	0	0	Unidentified sp. 9	150	100	0	0

Table - 03 Zooplankton (number/Liter) in the cave and above ground from 2 sampling areas

Species	Bagumbungan		Pahuan	
	Above-ground	Cave	Above-ground	Cave
Copepod sp.	0	50	0	100
Culex sp. (larva)	0	0	100	0
Cyclopoid sp.	0	0	0	100
*Actinula*sp. (larva)	100	0	0	0
Polyarthra sp.	0	50	0	0
Centropyxis sp.	0	0	50	0

Species	Bagumbungan		Pahuan	
	Above-ground	Cave	Above-ground	Cave
Arcella sp.	100	0	100	0
Unidentified sp. 1	150	0	0	0
Unidentified sp. 2	0	50	0	0
Unidentified sp. 3	50	0	0	0
Unidentified sp. 4	0	50	0	0
Unidentified sp. 5	0	50	0	0

Table - 04 Correlation Matrix between the variables examined

	PO4	NH4	SO4	Phyto SR	Zoo SR	Phyto AB	Zoo AB	pH
FwS	0.465	**0.010**	0.103	0.521	0.529	0.607	0.728	0.746
PO4		0.384	0.892	**0.007**	**0.073**	0.502	0.486	0.339
NH4			0.159	0.446	0.487	0.661	0.757	0.825
SO4				0.952	0.918	0.290	0.428	0.364
Phyto SR					**0.041**	0.420	0.394	0.278
Zoo SR						0.374	0.294	0.286
Phyto AB							**0.025**	**0.029**
Zoo AB								**0.073**

The above ground streams negative correlation may indicate the dependence of the shrimps more on other food sources such as detritus materials.

It was shown from the results that freshwater shrimps were affected by ammonia concentrations while phytoplankton diversity was by phosphate. Several studies on the distribution patterns of planktons between the different aquatic environments can be correlated with the observed differences in nutrients [12]. The ecological water quality of the different aquatic sampling areas can be connected to the differences in plankton productivity and dominance of some plankton species as shown by the results (Tables 3 and 4). Since phytoplankton richness is one of the initial biological components from which the energy is transferred to higher organisms such as the zooplankton and the shrimps [13], the differences observed from one sampling area to another indicate differences in water quality and the degree of eutrophication of the sampling areas [14, 15].

CONCLUSION

This study provided the environmental bench mark in understanding the dynamics between the physico-chemical and biological components and the connectivity of the cave and above ground streams.

Marinduque subterranean and aboveground streams harbor a variety of freshwater shrimps and planktons which can be attributed to the variations in the concentration levels of nutrients. Nutrient analysis
indicated that the concentration levels of phosphate, ammonium, and sulfate were within the acceptable levels of water quality for aesthetic and fisheries purposes. In particular, species richness of freshwater shrimps was affected by ammonia concentrations and phytoplankton diversity by phosphates.

Phytoplankton diversity was positively correlated with zooplankton diversity. Similarly, the phytoplankton assemblage was correlated with the zooplankton assemblage. A correlation was also established between pH and zooplankton assemblage. Species richness cluster of freshwater shrimps and phytoplankton yielded similar groupings indicating some direct relationship between the two.

Variations in diversity of plankton richness also vary between the subterranean and aboveground stream environments indicating that these two aquatic ecosystems are relatively isolated from each other.

ACKNOWLEDGEMENT

The assistance of Efren L. Delos Reyes (DENR Staff), Ronald Atienza, Ate Virgie, Ka Batoy, Allan, Duing, and KaJovs Raza, during the fieldworks and to Dr. Leila Ombat and Prof. Roy Olsen de Leon, for the technical assistance in the identification of the samples and nutrient analysis.

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