

Freshwater Mollusks Assemblage (*Mollusca: Gastropoda*) with Notes on Invasive Species and its Environmental Parameters in Lake Oro, Esperanza, Mindanao, Philippines

Rainer P. Sularte^{1,3,*} and Joycelyn C. Jumawan^{1,2}

¹Graduate School, Caraga State University, Ampayon, Butuan City, Mindanao, Philippines

²Department of Biology, College of Arts and Sciences, Caraga State University, Ampayon, Butuan City, Mindanao, Philippines

³Sibagat National High School of Home Industries- Senior High School Department, Sibagat, Agusan del Sur, Mindanao, Philippines

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ABSTRACT

The study aimed to report the first freshwater molluscan faunal survey in Lake Oro, Esperanza, Agusan del Sur, Philippines. Three (3) species from three families were identified. Of the 3 species documented, one *Belamaya angularis* is Philippine endemic, one *Cristaria plicata* native, and one *Pomacea canaliculata* is considered an invasive species. All of the physico-chemical parameters documented were within the acceptable normal limits. Local residents utilized the whole lake particularly for inland fishing (*Tilapia*) and aquaculture, use for domesticated animals, and recreational activities (e.g. bathing and washing of clothes in the lake). We highlight ecological and environmental threats particularly conversion to agricultural land, pollution, increasing human settlers in the riparian areas, and overfishing. Lake Oro the home of 2 endemic molluscan species and should therefore be better managed and protected.

Keywords: Abundance, Anthropogenic, Endemic, Lake Oro, Mollusks

INTRODUCTION

Mollusks particularly snails and slugs belong to the second most diverse animal phylum molluska on earth's biodiversity and freshwater ecosystem. Mollusks act as soil producers and concentrators of calcium, and provide food for other vertebrate animals in forest ecosystems. Some mollusks are excellent bio indicators of environmental conditions specifically; there are species that are confined to undisturbed ecosystems whereas others are indicative of habitats degraded by human misuse. Some terrestrial mollusks are vectors of human and livestock diseases and others have contributed greatly to our understanding of genetics and the process of evolution (Tattersfield *et al.*, 2001). Generally, terrestrial mollusks have short life span (i.e. a few months or years) and their limited powers of dispersal make them excellent bio indicators in the ecosystems (Watters *et al.*, 2005). In the Philippines, data documented on mollusks 31% (22,000 out of 70,000 species) with about 2-4% endemism (Chavez and de Lara, 2011), but majority has remained undiscovered and undocumented (Flores, 2014).

Lake Oro is located in Barangay Oromica, Esperanza, Agusan del Sur. The lake is interconnected to Agusan River, however during flooding season the water will spread to the lake causing high rise of water in the area. The lake is approximately 10 hectares connected to Agusan River with on-going anthropogenic activities in the area like increase human settlements living in river banks, domesticated animals in the lake, invasive plant species, fish cages and electro-fishing.

Studies on mollusks on their relationship between the distribution and abundance and environmental

factors are scarce (Hermida *et al.*, 1995; Barker and Mayhill, 1999; Millar and Waite, 2002; Horsák *et al.*, 2007), and there is no published data on freshwater mollusks particularly bivalves and univalves in Lake Oro Esperanza, Agusan del Sur. Regardless of the importance of such studies in developing appropriate conservation strategies of freshwater mollusks (Lange and Mwinzi, 2003; Horsák *et al.*, 2007), much of the literature on mollusks focuses on systematics and taxonomy of species, with ecological studies being few and far between (Tattersfield *et al.*, 2001). Hubilla-Travis (2007) documented nine species of freshwater snails of which 1 Philippine endemic, 6 native species and 2 invasive species in different habitat types of Agusan marsh.

Thus, this study is designed to address this gap in knowledge by investigating the freshwater mollusks assemblage as well as the environmental variation in Lake Oro Esperanza, Agusan del Sur, Philippines. The result of this study will provide baseline information on how environmental parameters affect the population size and distribution of freshwater mollusks with special notes on invasive species in the area. Conservation status of freshwater mollusks particularly endemic species can be monitored and appropriate management will be taken.

MATERIALS AND METHODS

The study will be conducted in Lake Oro, Esperanza, Agusan del Sur, Philippines (Fig. 1). The locations of each sampling area were determined through Global Positioning System (GPS) with their corresponding

*Corresponding Author's E-mail: rainersularte2011@gmail.com



Figure 1. Map showing the three sampling sites in Lake Oro, Esperanza, Agusan del Sur, Philippines.

coordinates and elevation of the sites. The vegetation type of this area primarily composed of water hyacinth, water lettuce, tall grass, vines, shrubs, epiphytes and some tall trees along the river banks. Sampling surveys was conducted in January to February 2016 during the dry season in the area.

In every sampling site, three 10m x 10m quadrats were laid out at each of the 3 sampling sites. The quadrats were established 50 meters away from each other to avoid pseudoreplication. For each quadrat, three persons extensively searched for live freshwater mollusks (bivalves and univalves) using handpick in the area equivalent to a two-hour sampling efforts (de Chavez and de Lara 2011). Shell size was measured by a ruler (mm) and weighing of shells using digital weighing scale (grams). Freshwater mollusks were photographed using Nikon DSLR N3100. Collected mollusks samples were stored in 10 percent formalin with its corresponding name and label.

Environmental variables to be measured for each of the quadrats in a plot: water pH, water temperature, conductivity, Total Dissolved Solids, hardness, atmospheric temperature (maximum, average and minimum), soil temperature, relative air humidity (maximum, average and minimum), luminosity, canopy closure, number of individuals and morphotypes of individuals of herbaceous plants up to 50 cm height (Menez, 2002).

PAST software (Hammer *et al.*, 2001) will be used for the computation of biodiversity indices, cluster analysis and principal component analysis. Cluster analysis will be used to assess the similarity in species composition among plots. As the groups formed in the biological cluster analysis, the collection areas were grouped to perform a discriminant analysis using environmental data. A Pearson correlation matrix was constructed for the environmental variables to see if there was a high inter-correlation among them. When two variables were

highly inter-correlated (value > 0.65 in module), one was excluded from the discriminant analysis (Klecka, 1982) in order to minimize overestimating their effect. To compare the environmental data of the different sampling sites we used Analysis of Variance (ANOVA).

RESULTS AND DISCUSSION

There are 3 families of freshwater mollusks (Table 1) in Lake Oro and 3 species dominated in the area. The most abundant and widespread family in the area was Ampullariidae known as Golden Apple Snail. *Pomacea canaliculata* is the most abundant freshwater mollusks because they are invasive in the site. They thrive in the area basically they have no primary predator and they can reproduce easily. *Belamaya angularis* is a native species in the lake and in Philippines with posing a threat to its abundance and richness because of scarce population status in the area. Lowest numbers of individuals being captured were *Cristaria plicata* locally known as *Tambilaka*.

Travies *et al.* (2007) conducted an inventory of aquatic fauna in Agusan Marsh revealed that 14.1 percent were mollusks of which 67 percent were native species in the area and 22.2 percent were introduced species. According to their study most of this species were present in rivers, lakes and creeks as their primary habitats. Golden apple snail, *Pomacea canaliculata* and *Belamaya angularis* have the widest range of habitats among the invertebrates due to probably to their morphological structure (protective shells and chelipeds for hunting and defense) and euryphagous feeding habit (e.g. on detritus). Movement pattern of gastropods and bivalves in the area are benthic, thriving in swampy and shallow water habitats.

A total of 180 individuals of gastropods and bivalves captured in Lake Oro (Fig. 2 A,B) belonging to 3 families and 3 species. Station 2 had the highest number

Table 1. Freshwater mollusks in the three sampling sites of Lake Oro, Esperanza, Agusan del Sur, Philippines.

Phylum	Order	Family	Scientific Name	Origin	English Name	Local Name	Ecological niche & Movement patten	Population Status
Mollusca	Caenogastropoda	Ampullariidae	<i>Pomacea canaliculata</i>	Introduced	Golden Apple Snail	Kuhol	Benthic, crawling	Abundant
	Architaenioglossa	Viviparidae	<i>Belamaya angularis</i>	Philippine Endemic		Pung-gok	Benthic, crawling	Scarce
	Unionoida	Unionidae	<i>Cristaria plicata</i>	Native	Cockscomb Pearl Mussel	Tambilaka	Benthic, burrow in mud	Abundant

Table 2. Shell Morphometry of freshwater mollusks in the three sampling sites of Lake Oro, Esperanza, Agusan del Sur, Philippines.

Mean Morphometric Data of Mollusks in the Three Sampling Sites				
		Weight (g)	Length (mm)	Size of Aperture (mm)
<i>P. canaliculata</i>	S1	26.71	24.29	15.29
	S2	32.88	30.48	20.04
	S3	30.2	27.76	18.36
<i>B. angularis</i>	S1	13.38	13.39	9.92
	S2	29.81	31.36	25.14
	S3	27.78	27.83	23.28
<i>C. plicata</i>	S1	0	0	0
	S2	136.33	134	0
	S3	0	0	0

of individuals of mollusks due to little human settlements, presence of trees and tall grasses in the area. While, station 1 had the lowest number of individuals captured due to increase human settlements, presence of some animals and cattle in the lake and fragmented habitat. One-way Analysis of Variance showed that there is no significant difference among the number of individual in three stations p-value 0.3457. *Cristaria plicata* locally known as *Tambilaka* has the lowest numbers of individuals being captured and only found in station 2 probably due to suitable soil quality in the area.

As depicted above (Table 2), *P. canaliculata* has the lowest weight of 27 grams while 113 grams was the highest weight recorded. Longest length of the shell was 66 mm and 29 mm was the lowest. Highest shell apertures were 39 mm while the lowest were 16 mm. The longest length of *B. angularis* were 45 mm and the lowest 20 mm. Lowest size of shell aperture 15 mm and the highest were 44 mm. Lowest length of *Cristaria plicata* was 120 mm while the highest were 140 mm. All species were of adult stage. Studies of Flores (2014) on abundance and population of profile of *Helicostyla daphnis* in Cebu, Philippines revealed that adult snails were the most dominant of the age groups with significant spatial and seasonal variability in abundance with correlation to its physico-chemical parameters. It comprised 87 percent of the total snail abundance during the dry

season and 74 percent during wet season. Length-weight relationship (LWR) of *Pomacea canaliculata* and *Belamaya angularis* (Figure 3) in the three sampling sites of Lake Oro, Esperanza, Agusan del Sur, Philippines. Length of *P. canaliculata* ranged from 66 to 29 mm while weight from 113 to 27 grams. Regression analysis revealed r^2 0.8697 which length-weight relationship of *P. canaliculata* in the three sampling stations. 45 to 20 mm was the ranged of length of *B. angularis* while the weight varied from 47 to 21 grams. Regression analysis revealed r^2 0.8792 which length-weight relationship of *B. angularis* found in the three sampling stations. The average length of *Cristaria plicata* was 134 mm while the weight of the shell was 136.33. Mahilum and Demayo (2014) believed that *P. canaliculata* is the most variable species among the group Ampullariidae where intra- and inter-population variations in shapes and size of their shell are qualitatively distinguishable.

Physico-chemical parameters (Fig. 4 A,B) recorded the five (5) selected physico-chemical parameters waters and soil analysis of Lake Oro, Esperanza, Philippines. All of the physico-chemical parameters were documented within the acceptable normal values. Except for the pH of the water from the three sampling sites were alkaline which was above the normal range. pH readings ranged from 8.65 to 9.41. While, the highest temperature recorded 32.7°C in Station 1 and the lowest temperature

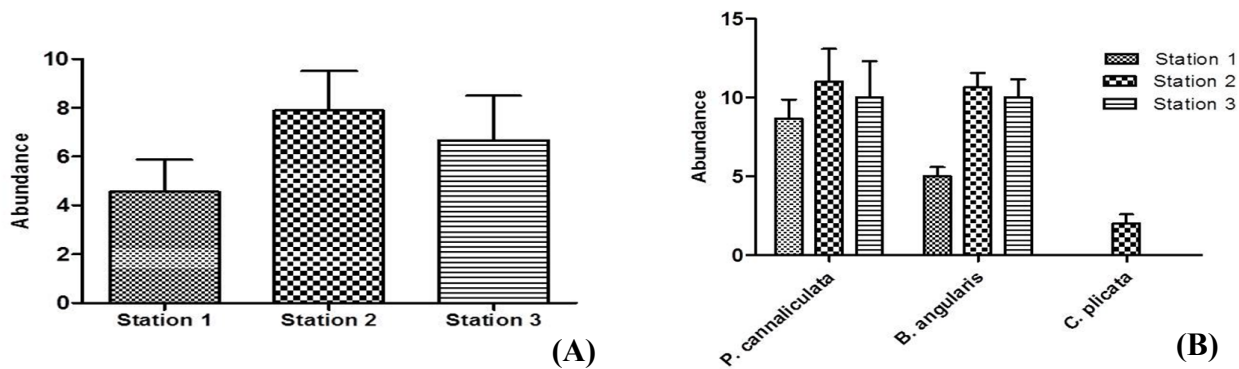


Fig. 2. Abundance of freshwater mollusks in Lake Oro, Esperanza, Agusan del Sur, Philippines. (A) Total number of individuals per sampling stations; (B) Total number of mollusks per species in the three sampling sites.

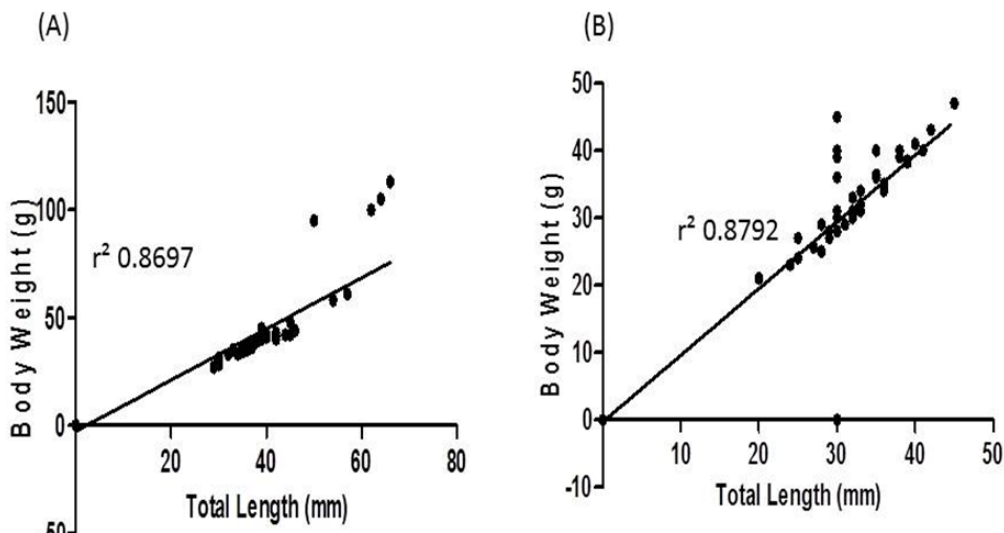


Fig. 3. Length-weight relationship (LWR) of *Pomacea canaliculata* in the three sampling sites of Lake Oro, Esperanza, Agusan del Sur, Philippines. (A) LWR of *Pomacea canaliculata*, (B) LWR of *Belamaya angularis*.

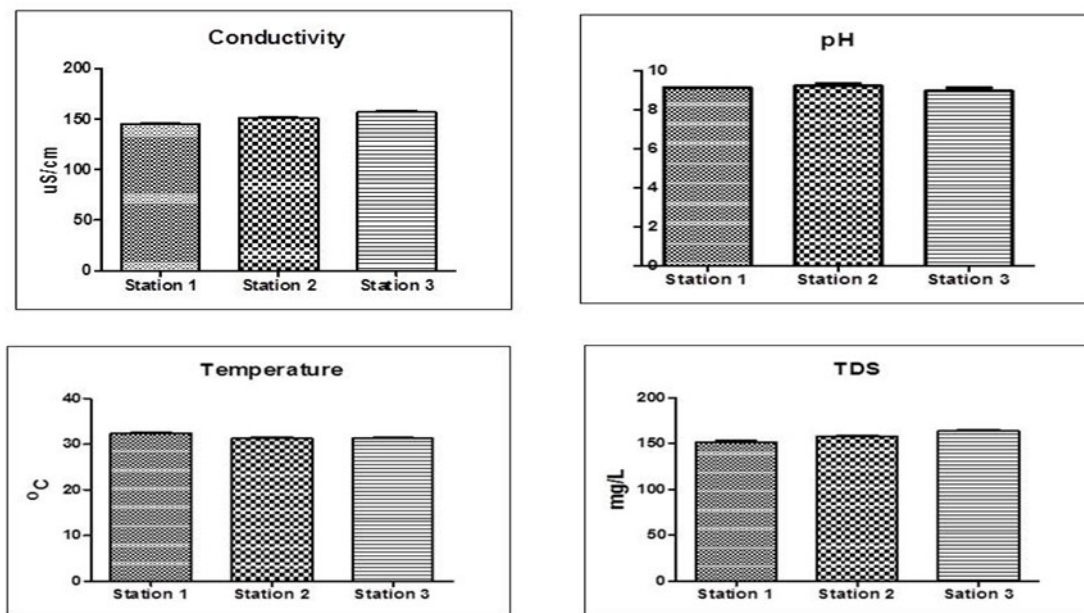


Fig. 4. Physico-chemical parameters in the three sampling sites of Lake Oro, Esperanza, Agusan del Sur, Philippines. (A) Conductivity (B) pH (C) Temperature (D) Total Dissolved Solids.

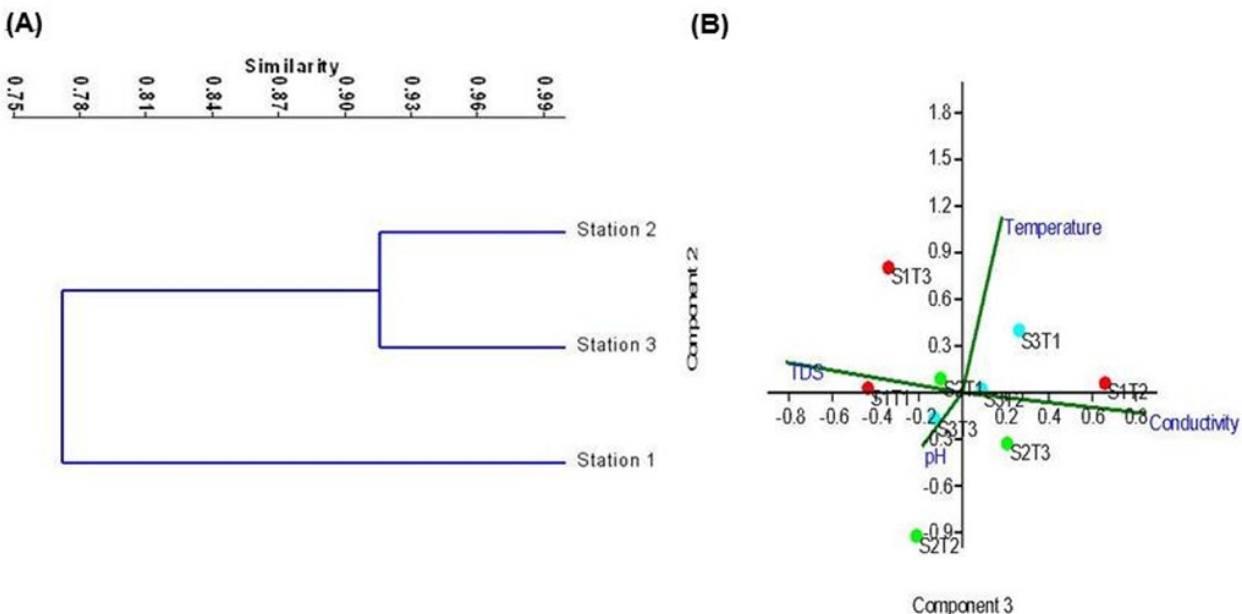


Fig. 5. Multivariate relationships between study stations based on their physico-chemical parameters. A: Dendrogram of similarity of sampling sites based on physico-chemical features; B: Principal component analyses (PCA) showing distinct relationships physicochemical data from three sampling sites within Lake Oro, Esperanza, Agusan del Sur, Philippines.

found in Station 2 which was 30.8°C. Lowest conductivity in water with 142.9 while the highest was 159.7 in Station 3. Soil analysis showed that pH readings ranged from 6.44 to 6.92 followed the organic matter reached from 1.7 to 2.1. Phosphorus content in soil ranged from 10 to 17 ppm while 190 to 291 ppm of the Philippines. Sufficient score in Calcium and Magnesium were revealed and given to the three sampling stations. Zinc was sufficient only in Station 1 and the rest were moderately deficient.

CONCLUSION

The study is the first report on the freshwater mollusks in the three areas of Lake Oro, Esperanza, Agusan del Sur, Philippines. There were 180 individuals of gastropods and one bivalve captured in Lake Oro belonging to 3 families and 3 species. One (1) Philippine endemic and native species in the area while one (1) invasive species of *P. canaliculata* was documented. Station 2 had the highest number of individuals of mollusks due to little human settlements in the riparian zone, absent trees and tall grasses in the area. All of the physico-chemical parameters were documented within the acceptable normal values. Except for the pH from the three sampling sites were alkaline. Most of the local residents utilized the whole lake particularly in inland fishing (*Tilapia*) and aquaculture, presence of carabao in the lake, local residents do bathing and washing of clothes in the area, and agriculture. At present the on-going anthropogenic activities in the lake specifically increasing human settlers in the riparian areas, overfishing, recreational activities (e.g. bathing and washing of clothes in the lake), run-off of pesticides and heavy metals and conversion of riparian zones to agricultural land. Strict implementation of environmental laws and ordinance in order to protect the

remaining malacofauna and other faunal species in the said lake. There should be better management and conservation of freshwater molluscan fauna from this critically important lake ecosystem.

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