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Benthic molluscs in seagrass beds of barangay Liangan East and barangay Esperanza, Bacolod, Lanao del Norte, Northern Mindanao, Philippines

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Abstract

Seagrass meadows commonly occurred in intertidal areas and play a vital role in the ecosystem as source of food, refuge and nursery ground for marine fauna. Considering the benefits they provide, seagrass beds supports a variety of organisms which are often exploited by humans. As a result, the population of seagrass associated fauna, specifically the molluscs, are always vulnerable to the negative impacts of anthropogenic pressures. Owing to this, a call for active watch and monitoring of these fauna is needed, hence this study was carried out in order to provide knowledge on the diversity, abundance and distribution of molluscs. Samplings were done during spring low tide by employing the transect-quadrat method. A total of 25 mollusc species were identified, of which 23 were classified under Class Gastropoda and 2 were classified under Class Bivalvia. Diversity indices showed high diversity in both stations where species were observed to be evenly distributed. Comparing the number of edible species between stations revealed station 1 to be abundant than station 2 and it is suggested that this difference may be attributed to the on-going gleaning activities. The distribution of molluscan species showed particular preference to a specific stratum in the intertidal flat which we believed is governed by their feeding habits and uncontrolled fishing activity.

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Introduction

Seagrass beds are one of the important ecological unit in the marine ecosystem wherein many assemblages of associated species can thrive and reproduce. In particular, the canopy, leaves and stems of seagrass are very valuable in the sense that it provides shelter, food and protection from predators (Lee *et al.*, 2001; Ambo-Rappe *et al.*, 2016).Due to these vital functions, seagrass meadows are able to support highly abundant and rich number of species when compared to other habitats in the intertidal ecosystem (Lee *et al.*, 2001; Ambo-Rappe, 2016;Honkoop *et al.*, 2008).Many communities of marine organisms are associated with seagrasses and among the most abundant is the molluscan group. Molluscs that live in seagrass meadows, specifically, on leaves and stems, are vital for the continuance and preservation of the marine trophic web. For example, they prey on epiphytes (i.e. periphyton) which are numerous on the blades and stems thereby regulating its proliferation (Fong *et al.* 2000). In effect, molluscs also provide food to fishes and other fauna that scavenge the seagrass beds (Heck *et al.*, 2003; Blandon and Ermgassen, 2014).Aside from their important role in the marine food web, these organisms are of immense use to human society since they are a source of food, raw material for home ornaments and jewelry and medicine. More recently, molluscs have also been used for studies and applications in the field of modern medicine such as natural therapy for the treatment of cancer (Benkendorff *et al.*, 2011; Esmaeelian *et al.*, 2014), as anti-inflammatory and analgesic agents (Chellaram *et al.*, 2012; Adhikari *et al.*, 2015;Ahmad *et al.*, 2017), and as anti-microbial substance against human pathogens (Kanagasabapathy *et al.*, 2011; Periyasamy *et al.*, 2012; Giftson and Patterson, 2014; Karthikeyan *et al.*, 2014;Kiran *et al.*, 2014).Regardless of the major role of benthic molluscs to its surrounding and to human society, threats on their diversity and abundance have been reported as a result of increasing activities of humans either in the form of gleaning or tourism (Vaghela *et al.*, 2010). Monitoring endeavors on benthic molluscs, in particular, the commercially important species, is quite limited in this part of the country, hence there is a lack of reliable data to help establish the status of edible mollusc population. In order to address this gap, an assessment of the molluscan assemblages in this area in terms of species diversity, abundance and distribution were investigated.

Materials and methods

Description of the Study Area and Sampling Stations

Bacolod (8° 11' 0" N, 124° 1' 0" E) is a municipality in the Province of Lanao del Norte located in the Northern part of Mindanao. It is bordered by the neighboring municipalities of Kauswagan (8° 11' 24" N, 124° 03'48" E) and Maigo (8° 10' 31" N, 123° 59'14" E). Out of its 16 barangays, 7 are located along the coast and its coastlines are part of the famous Iligan Bay. Bacolod is flanked by two (2) rivers namely, the Rupagan River which is situated in the eastern side, and the Barongison River which is located in the western side and is also the biggest riverthat stretches in the center of the land area, leading up to the shores of Barangay Liangan East.

The intertidal flat of Bacolod, Lanaodel Norte has a bountiful amount of coastal resources varying from edible algae to fresh fish and shellfishes. Due to this, residents living near the coast usually perform shell-picking activities, the yield from which is used for consumption and/or for sale. The coastal area is also exposed to pollution due to the direct sewage discharges from residential bamboo houses located along the coast. Water temperature values recorded in the area ranges from 30.5-33.2°C which were one degree higher than those values set as standard for coastal waters (i.e. 26-30°C) by the Philippines Department of Environmental and Natural Resources (DENR-Administrative Order No. 2016-08). For the pH, it ranges from 7.68-8.45 which reflected a slightly alkaline value, a feature quite common in any body of seawater. In the case of water salinity, values were much lower and ranges between 23-28ppt. The presence of a river tributary, namely Barongison, which is situated near the area, transports freshwater into the sea thereby resulting to the dilution of the seawater.

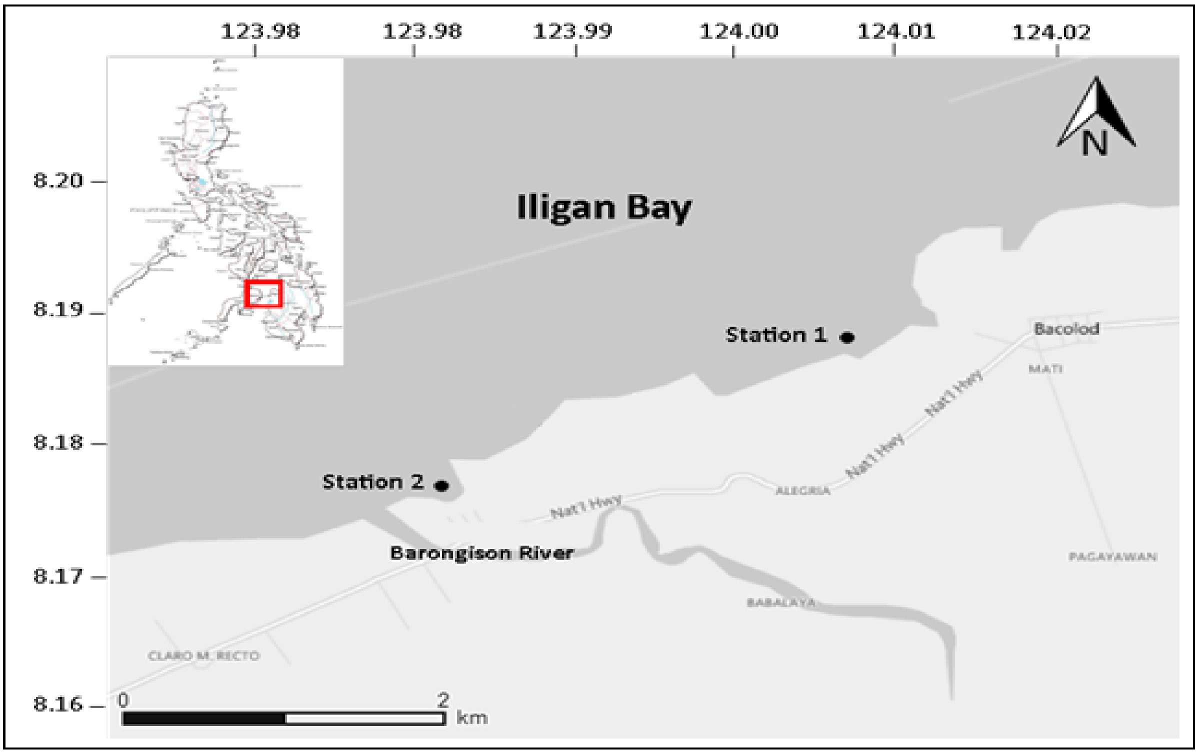

Fig. 1. Geographical locations of the two sampling stations in the intertidal zone of Barangay Esperanza (Station 1) and Barangay Liangan East (Station 2), Bacolod, Lanaodel Norte. (Map source: www.maphill.com).

A total of two sampling sites were positioned on the intertidal zones of Bacolod, Lanaodel Norte for the assessment of molluscs (Fig 1). Station 1 was positioned outside the 7-hectare fish sanctuary of Barangay Esperanza and the substrate is predominantly sandy and is mainly composed of fine to very fine sand particles. Station 2 was positioned in Barangay Liangan East and its substrate is characterized with fine sand mixed with some small pebbles. Both stations are covered by seagrass beds dominated by *Thalassia hemprichii*, *Enhalus acoroides*, *Cymodocea rotundata*, *Halophila ovalis* and *Syringodium isoetifolium*. The coastlines are bordered by lush stands of mangroves.

Collection of Biological Samples

On the intertidal zonein each station, a 100m transect line was arranged parallel to the shoreline. There were three transects that were put up, in which the distance between each line was 20m. Transect 1 was laid down near the shore and this represents the high stratum, whereas transect 3 was established towards the sea before the subtidal area and representing the low stratum. Transect 2, on the other hand, was assembled between transects 1 and 3 and represents the middle stratum Along each of the positioned transect lines, 10 quadrats, with a size of 0.5m x 0.5m, were set out. Between each quadrat, a distance of 10m was established. Epifaunal molluscs encountered in each quadrat were recorded and counted, whereas data on infaunalmolluscs were obtained from sediments collected 20cm depth which were sieved through a sieve screen with 20mm mesh opening. Alive specimens were preserved in 10% formalin-seawater solution.

Laboratory Analyses of the Biological Samples

Shells of preserved specimens were cleaned by washing it with sea water in order to get rid of attached debris and epiphytes. Specimens were classified to species level by referring to several published works on molluscs (Springsteen and Leobrera, 1986; Poppe *et al.*, 2006; Dolorosa and Galon, 2014; Picardal and Dolorosa, 2014). Photographs of identified molluscs were taken using a digital camera (Olympus, 16 MP). Afterwards, each species were tallied and expressed as density (individuals per m^2) and relative abundance.

Statistical analysis

Species diversity was obtainedby calculatingthe Shannon-Weaver (H) and equitability (J) indices using the PAl eontological ST atistical or PAST software version 2.17c (http://folk.uio.no/ohammer/past/) (Hammer *et al.,* 2001).

Results and discussion

Species Composition

List of benthic molluscs on the seagrass meadows of the intertidal zone of Bacolod, Lanao del Norte is shown in Table 1.

Table 1. Species composition of benthic mollusks in the seagrass beds of the intertidal zone of Barangays Esperanza and Liangan East, Bacolod, Lanao del Norte, Philippines.

Class	Family	Species Name	Station	
			1	2
Bivalvia	Arcidae	*Anadara maculosa**e (Reeve, 1844)	+	+
	Cardiidae	*Trachycardium flavum**e(Linnaeus, 1758)	+	-
Gastropoda	Cerithiidae	*Cerithium rostratum**e(A. Adams and G. B. Sowerby II, 1855)	-	+
		*Clypeomorus bifasciata**(G. B. Sowerby II, 1855)	-	+
	Columbellidae	*Euplicascripta** (Lamarck, 1822)	+	+
		*Pyrenee pamella**(Duclos, 1840)	+	-
		*Pyrene viscolor**(G. B. Sowerby I, 1832)	+	+
	Conidae	*Conuslitteratus**e(Linnaeus, 1758)	+	-
		*Conus quercinus**e(Lightfoot, 1786)	+	-
	Costellariidae	*Vexillum virgo* (Linnaeus, 1767)*	-	+
	Cypraeidae	*Monetaria annulus** (Linnaeus, 1758)	+	-
		*Monetaria moneta** (Linnaeus, 1758)	-	+
	Muricidae	*Muricodrupafiscella** (Gmelin, 1791)	-	+
	Nassariidae	*Hebracorticata**(A. Adams, 1852)	+	+
		*Nassarius globosus**(Quoy and Gaimard, 1833)	+	+
		*Nassarius pullus**(Linnaeus, 1758)	+	-
	Naticidae	*Polinices maurus**e(Lamarck, 1816)	+	-
		*Polinices mamilla**e(Swainson, 1840)	+	-
	Neritidae	*Clithonoualaniensis**(Lesson, 1831)	+	+
	Olividae	*Oliva albofasciata**e(Dautzenberg, 1927)	+	-
		*Olivatigridella**e(Duclos, 1835)	+	-
	Strombidae	*Canarium erythrinum**e (Dillwyn, 1817)	+	-
		*Canari umurceus**e (Linnaeus, 1758)	+	-
	Tegulidae	*Tectus fenestratus**e(Gmelin, 1791)	+	+
	Trochidae	*Herpetopomaatrata**(Gmelin, 1791)	+	+
Total Number of Individuals			209	337

Legend: + present; - absent; *infauna, *epifauna; eedible.

There was a total of 25 mollusc species recorded, in which twenty (20) of these species were found in station 1 and thirteen (13) were noted in station 2. Out of the 25 species, 23 of these belong under Class Gastropoda under 13 families while the other 2 species are classified under Class Bivalvia belonging to 2 families. Infaunal molluscs (indicated by red asterisk) noted in the present study area are the two bivalve species (i.e. *Anadara maculosa* and *Trachycardium flavum*) and 4 gastropod species (i.e. *Polinices maurus, P. mamilla, Oliva albofasciata, O. tigridella*), while the rest of the 19 gastropods are epifauna (indicated by black asterisk). The present results shows that species under Class Gastropoda are more numerous compared to species under Class Bivalvia in a seagrass environment and this is comparable to the results of previous works done in other parts of the Philippines (Manzo *et al.*, 2014; Picardal and Dolorosa, 2014; Jumawan *et al.*, 2015;Libres, 2015; Herceda *et al.*, 2016; Walag, 2016). Among the 25 molluscs recorded, half are edible species and the other half are non-edible ones.

Table 2. Diversity profiles of mollusk taxa in the two sampling stations in Bacolod, Lanao del Norte, Mindanao, Philippines.

Diversity Index	Station	
	1	2
Taxa (S)	20	13
Individuals	209	337
Dominance (D)	0.1524	0.3523
Shannon (H)	2.286	1.31
Equitability (J)	0.763	0.5108

Species Richness, Diversity and Abundance

Diversity index of benthic mollusc species on the seagrass beds of the 2 sampling stations is presented in Table 2.The current results reflected diverse living molluscan assemblage in the 2 sites with station 1 supporting a more highly diverse community as shown in its high Shannon index (H=2.286, Table 2). Although a difference in the number of taxa between the 2 stations was observed, the molluscan species for both sites were distributed evenly as displayed in the high equitability (J=0.763-0.5108) and low dominance (D<1) values.

Table 3. Practices and knowledge of gleaners regarding collection of mollusks in Barangays Esperanza and Liangan East, Bacolod, Lanao del Norte, Philippines.

Characteristics		Station 1		Station 2		Total	
		N=30	(%)	N=30	(%)	N=60	%
No. of Years Gleaning	<1 year	0	0	1	3.33	1	1.67
	1-10 years	11	36.67	13	43.33	24	40.00
	11-20 years	8	26.67	10	33.33	18	30.00
	21-30 years	5	16.67	2	6.67	7	11.67
	>30 years	6	20	4	13.33	10	16.67
Frequency of Gleaning	Daily	9	30	13	43.33	22	36.67
	Once/week	3	10	5	16.67	8	13.33
	Twice/week	7	23.33	3	10.00	10	16.67
	≥ Twice	11	36.67	9	30.00	20	33.33
No. of Hours Spent in Gleaning/day	0 hr - 1 hr	4	13.33	7	23.33	11	18.33
	2 hr - 3 hr	21	70	22	73.33	43	71.67
	> 3 hrs	5	16.67	1	3.33	6	10.00

These findings may suggest rich community of benthic molluscs still thriving in association with the seagrass meadows on the intertidal zones of Esperanza and Liangan East, Bacolod, Lanaodel Norte. The present results can be compared with earlier reports where gastropod species were quite diverse on vegetated intertidal flats than on areas with no vegetation (Lee *et al.*, 2001; Honkoop *et al.*, 2008; Ambo-Rappe, 2016).

Out of the 25 molluscan fauna encountered for both sites, 12 were important as food source, while 13 species were non-edible. The density between edible and non-edible molluscs for the 2 stations were compared. Among the edible molluscs, for instance in station 1 (Fig. 2a), *Tectus fenestratus* was mostly encountered and represents about 14 ind m^{-2} or 6.2% of the entire molluscs community. This was followed in decreasing rank by *Canari umurceus* at 7.5 ind m^{-2}(or 3.3%), *Anadara maculosa* at 6 ind m^{-2}(or 2.8%), *Policines mamilla* and *Canarium erythrinum* both representing 3.2 ind m^{-2} (or 1.4%).

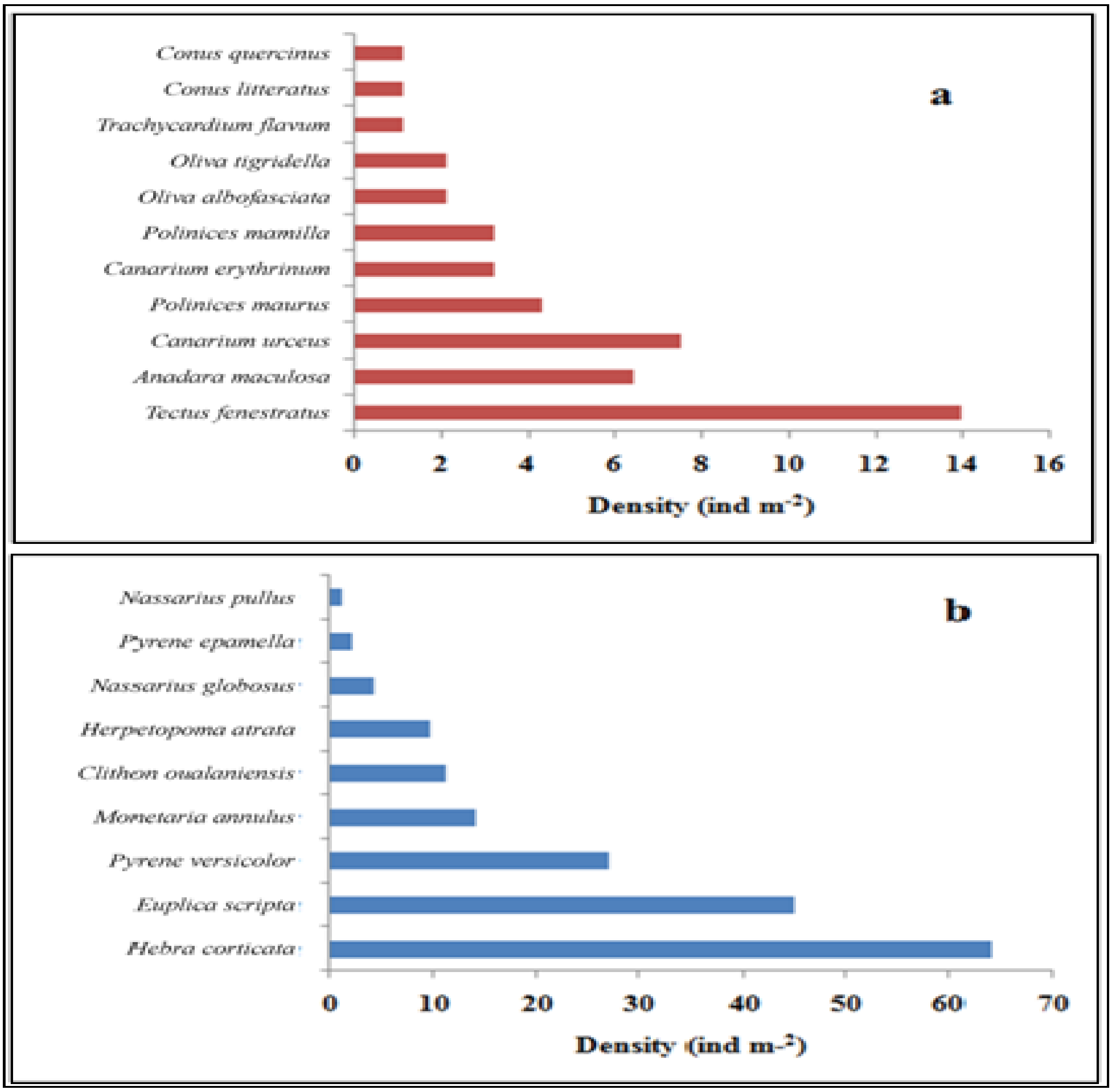

Fig. 2. Density (ind m^{-2}) of (a) edible and (b) non-edible benthic mollusks in station 1 (Esperanza), Bacolod, Lanao del Norte, Philippines.

The rest of the edible species were least frequently seen and obtained less than 1% of the whole molluscs population. On the contrary, for the non-edible group in station 1 (Fig. 2b), *Hebra corticata* was highly dominant which represents 64 ind m^{-2} or 28% of the molluscan community. Next in rank were *Euplica scripta* (44.8 ind m^{-2} or 20%), *Pyrene versicolor* (27 ind m^{-2} or 11%), *Monetaria annulus* (14 ind m^{-2} or 6.2%), *Clithonoualaniensis* (11 ind m^{-2} or 4.7%) and *Herpetopomaatrata* (9.6 ind m^{-2} or 4.3%). The remaining non-edible molluscs were less than 4% of the total molluscan assemblage. On the other hand, only 3 species of edible molluscs were recorded in station 2 (Fig. 3a), with *Tectus fenestratus* still being the most abundant at around 9% (or 33.1 ind m^{-2}), while the other 2 edible ones were less than 3% of the entire molluscs in station 2. For the non-edible group (Fig. 3b), the most numerous species were *Hebra corticata* and *Clithonoualaniensis* both of which dominated 80% of the whole assemblage. The other non-edible species were low in numbers and less than 1% of the population.

Although both stations support diverse molluscan species, station 1 was noted to be rich and teeming with diverse species of benthic molluscs compared to station 2. This may be partly due to the presence of a marine protected area located in the station 1.

Further, the site had more edible population compared to few species in station 2 and it is assumed that this may be attributed to the difference in the frequency of gleaning activities occurring in both stations. It is noteworthy that 43% of our interviewed gleaners in station 2 spent gleaning or collecting edible molluscs everyday as compared with station 1 where only 30% from the total gleaners did spent daily collections of edible species (Table 3).

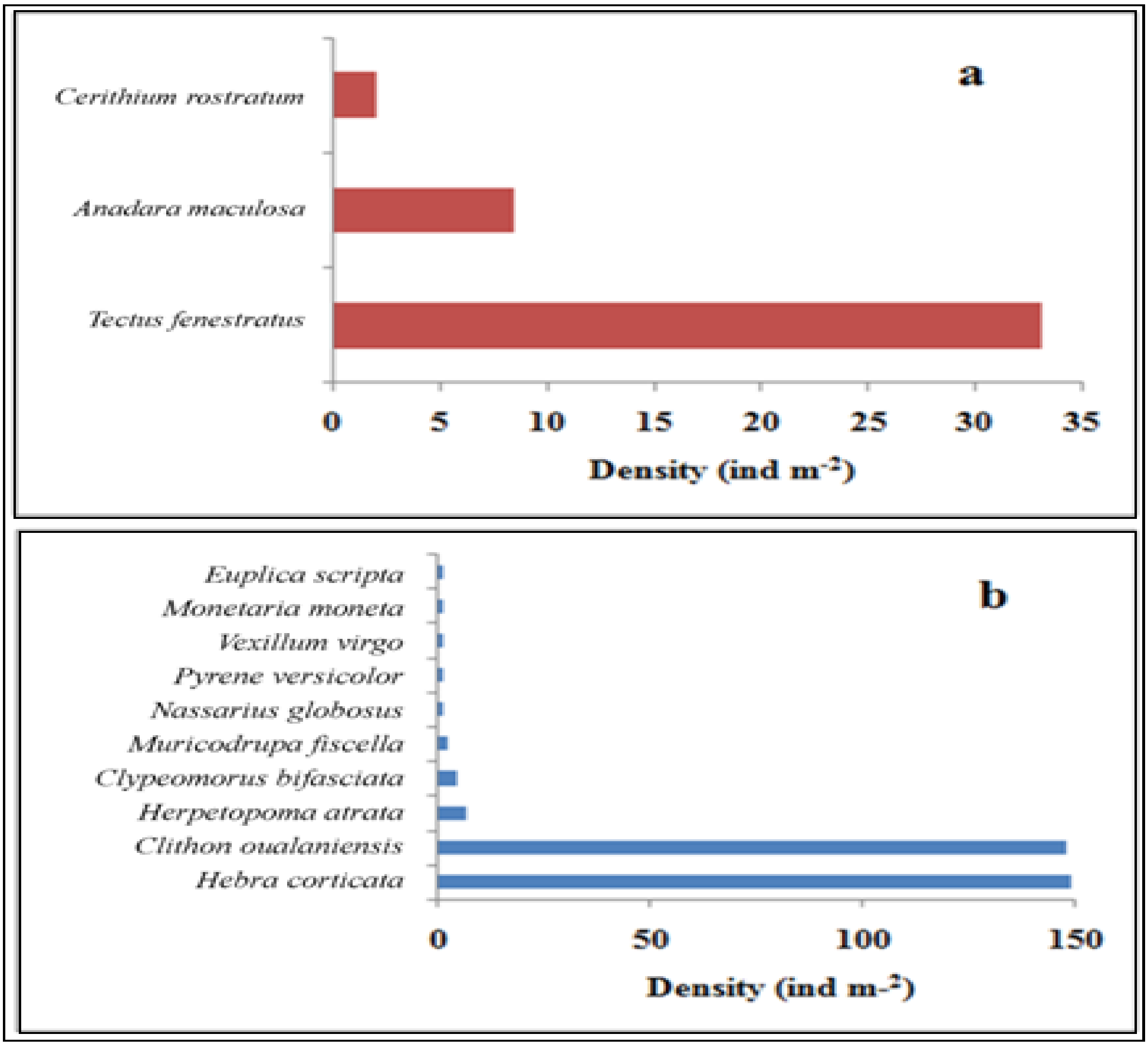

Fig. 3. Density (ind m^{-2}) of (a) edible and (b) non-edible benthic mollusks in station 2 (Liangan East), Bacolod, Lanao del Norte, Philippines.

Based on this information, it is possible then that by the time we did our field assessments in station 2 these gleaners may have already exhausted most of the edible molluscs such that what were left behind during our samplings were only few individuals from few edible species but more non-edible ones. The current data may point out that gleaning was quite common and uncontrolled in both stations and that the negative pressure inflicted by this activity may have already been experienced in these areas as evidenced in the low abundance of edible species but high dominance of non-edible molluscs. *Clithon oualaniensis* are herbivorous and presumed to feed by scraping algae and diatoms (CSIRO, 2007). As pointed out by Satumanatpan *et al.* (2011), *C. oualaniensis* were feeding on algae and diatoms on the blades of seagrasses aside from using them as protection. Other studies also affirm the abundance of *C. oualaniensis* in seagrass beds (Lee *et al.*, 2001; Meyer *et al.*, 2008). *Tectus fenetratus* or commonly known as turban snail are herbivorous gastropods that are commonly seen in intertidal flats and shallow waters where seaweeds or weed-covered rocks are present (Springsteen and Leobrera, 1986). On the other hand, *Hebra corticata* are widespread in intertidal zones where seagrass meadows are present. This gastropod, being deposit feeders, were observed to inhabit the seagrass leaves where they consumed the detritus that settles abundantly on the blades.

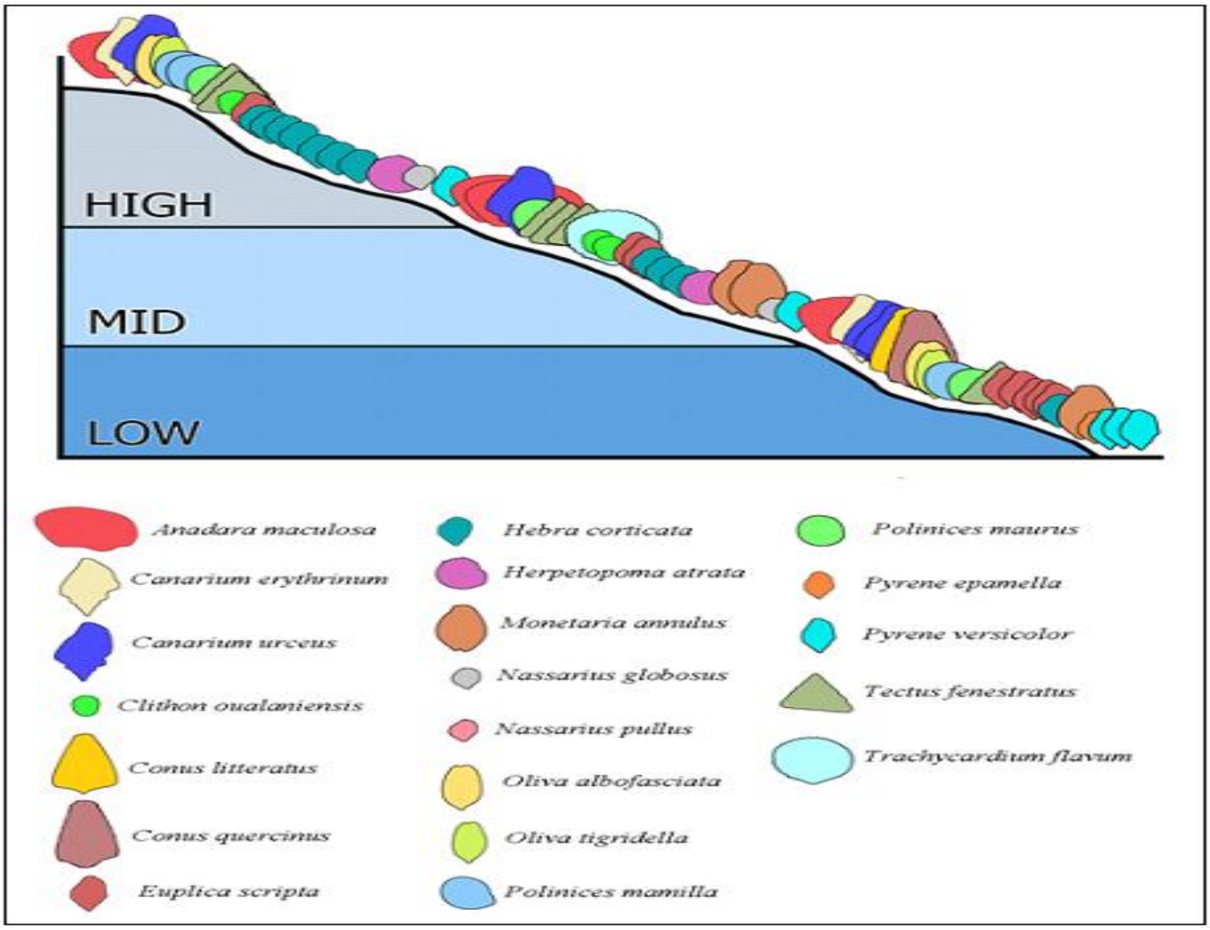

Fig. 4. Spatial distribution of edible and non-edible mollusks in station 1 (Barangay Esperanza), Bacolod, Lanao del Norte, Philippines.

Spatial Distribution of Molluscs

Patterns in the spatial distribution among benthic molluscs along the seagrass meadows of the 2 sampling stations were presented in Fig. 4 and Fig. 5.Edible and non-edible molluscs at both stations were observed to be widely distributed and scattered all over the established 3 strata of the intertidal flats covered by the seagrass beds. There are certain species or groups which exhibited preferences to a specific stratum or zone by manifesting increased abundance. For instance, in station 1 (Fig. 4), the top 4 dominant edible molluscs, namely *Tectus fenestratus, Anadara maculosa, Canarium urceus* and*Polinices maurus* were noted in all 3 strata but *T. fenestratus, A. maculosa* and *C. urceus* showed high abundances in the middle and low belts, respectively, whereas *P. maurus* displayed few individuals in all 3 strata. Other edible molluscs such as *Canarium erythrinum, Oliva albofasciata, O. tigridella* and *Polinices mamilla* occurred in both high and low strata in few numbers, while the 2 *Conus* species (*C. litteratus* and *C. quercinus*) and *Trachycardium flavum* were exclusively restricted in the lower and middle strata, respectively. For non-edible molluscs, some of the dominant species such as *Euplica scripta, Pyrene viscolor* and *Hebra corticata* occurred in all 3 strata with *E. scripta* and *P. viscolor* showing an increased in abundance from high to low belts, whereas *H. corticata*displayed an increasing abundance from low to high strata. On the contrary, *Clithon oualaniensis, Herpetopoma atrata* and *Nassarius globosus* prefers the high and middle zones, whereas *Monetaria annulus* favors the middle and low belts. *Nassarius pullus* and *Pyrene epamella* were restricted to the middle and lower strata of the intertidal flat. In general, most of the edible and non-edible mollusks seems to predominate the middle and lower belts of the intertidal zone.In station 2 (Fig. 5), all edible species were found in all 3 strata, where *Tectus fenestratus* and *Anadara maculosa* prefers to lived abundantly in the middle and high belts, respectively, while *Cerithium rostratum* were scattered in low numbers in the high and middle strata. For non-edibles, *Hebra corticata* and *Clithon oualaniensis* were noted in all 3 strata, with *H. corticata* showing an increasing abundance from low to high belts. *Clypeomorus bifasciata, Monetaria moneta, Muricodrupa fiscella* and *Vexillum virgo* prefers exclusively the high zone, while *Euplica scripta, Nassarius globosus* and *Pyrene viscolor* were restricted to the lower belt. *Herpetopoma atrata* was seen scattered in few numbers in both high and low strata of the intertidal flat.

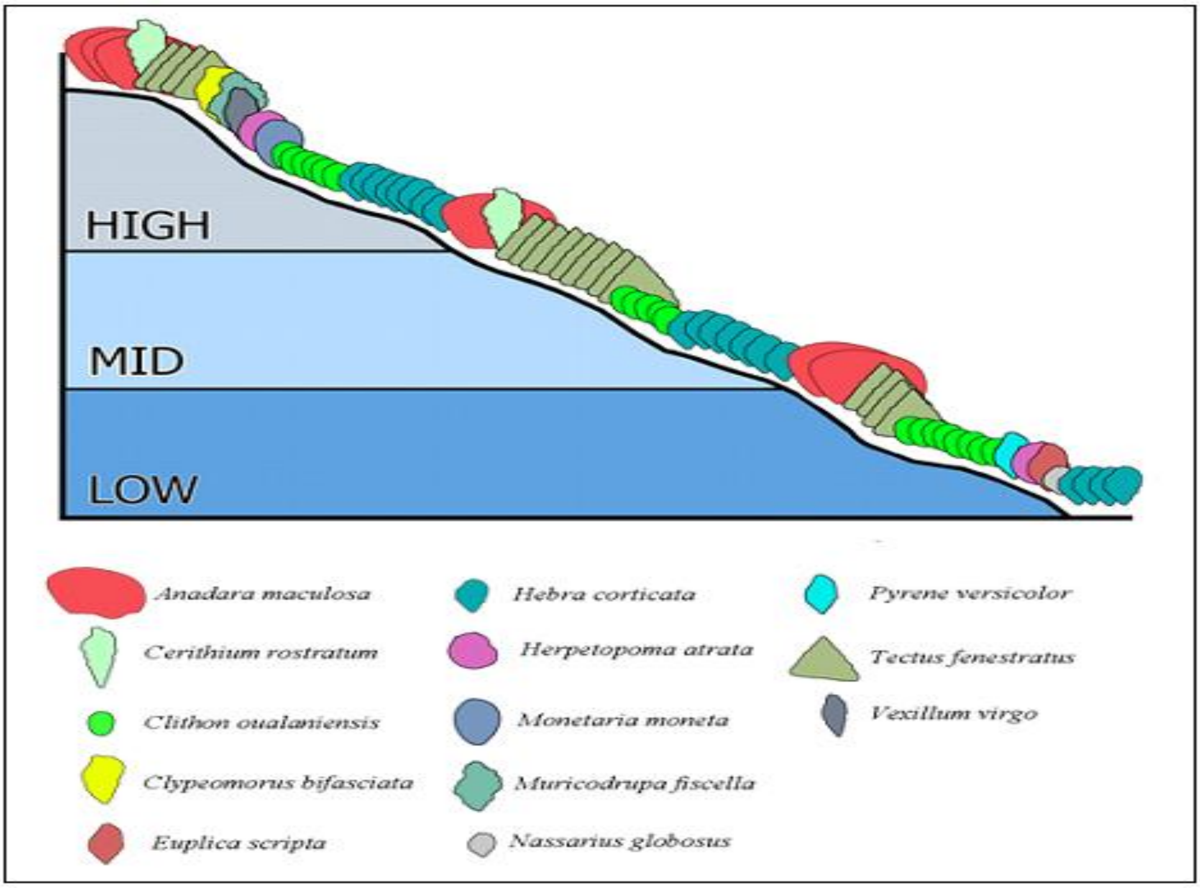

Fig. 5. Spatial distribution of edible and non-edible mollusks in station 2 (Barangay Liangan East), Bacolod, Lanao del Norte, Philippines.

Generally, the pattern of distribution of molluscan population was heterogeneous, with each molluscan species showing a particular preference to a specific stratum in the intertidal flats of the 2 study areas by displaying high abundances in their favored zone. It has been reported that the spatial distribution of benthic molluscs at the intertidal level often are governed by their feeding habits and uncontrolled fishing activities. The distribution of gastropods, whether the organism is a detritivore, herbivore or carnivore, is directly affected by the amount of food available in each stratum. That is, the favored distribution of some species, for instance in the lower stratum of the flats, is probably attributed to the extended period of water submersion and to the availability of detritus carried along by the incoming tide which tend to reach first the lower banks of the flat when compared to the upper stratum (Rhoads and Young, 1970; Boehs *et al.*, 2004). Due to this, deposit feeders and herbivores molluscs which comprises the major bulk of the molluscan assemblage in the current study were therefore restricted or highly abundant in the lower and middle parts of the intertidal flats. Concerning the bivalve *Anadara maculosa*, they were noted to occupy a much broader strata in the present study since this species is a filter feeding organism wherein they just simply filter the water for the extraction of food (Rhoads and Young, 1970). The spatial distribution of intertidal molluscs may likewise be influenced by human activity, *i.e.* gleaning practices, which is considered to be a common event in most intertidal flats in the country. The diminishing numbers of edible molluscs in the higher stratum of the intertidal zone may be attributed to its easy accessibility by gleaners such that most of the edible molluscs were concentrated in the lower and middle belts where these strata may not be easily reached because of its submersion by the incoming tide.

Conclusion

The diversity profiles of the molluscan assemblage in the seagrass meadows of the present study area revealed high diversity (H) and evenness values, suggesting the presence of lush and flourishing community of seagrass associated molluscs in the intertidal shores of Barangay Esperanza and Barangay Liangan East of Bacolod, Lanao del Norte. Comparison among the 2 sampling stations strongly demonstrated the existence of more molluscs in station 1 when compared with those in station 2, however, the majority of the population were non-edible species. We believed that the on-going and uncontrolled gleanings observed in both stations may be responsible for the low numbers of edible species. The distribution pattern of molluscs were different, that is, each species favors a particular stratum or zone in the intertidal shore where they can proliferate and be abundant. It is assumed that such preference may be associated to the mode of feeding wherein the type of food present in a specific stratum can largely influenced their existence and survival. Since human pressures greatly affect the abundance and distribution of the seagrass associated molluscs, it is recommended that harvesting of edible species be regulated by banning collection in certain days of a month to allow the organisms time to grow and spawn successfully.

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