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Species Richness and Abundance of Bivalves and Gastropods in Mangrove Forests of Casiguran, Aurora, Philippines

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Abstract

The diversity and abundance of bivalves and gastropods were studied from April to July 2015. Two sampling stations, Tinib and Esteves, in Casiguran, Aurora were selected based on the presence of mangrove forest, bivalves, gastropods, muddy substrate, and gleaners for the establishment of a transect line. Each station was laid with 100 meters transect line overlaid continuously with 2 m × 2 m quadrat along each transect. A total of 50 sampling units covering 0.02 ha area per sampling station were surveyed. The transect line recorded six species of bivalves distributed among five families and 12 species of gastropods belonging to eight families. Three species of bivalves and five species of gastropods were common to both sampling stations. However, Tinib station had most diverse species of bivalves (0.55) while Esteves station had most diverse species of gastropods (0.43). Both stations revealed *Dendrostrea folium* (43%) (bivalve) and *Cerithidea cingulata* (93%) (gastropods) as most frequently occurring species. *Dendostrea folium* also emerged as the densest (10,640 ind·ha^{-1} and 6850 ind·ha^{-1}) and most abundant (58.52% and 77.84%) bivalve species. For gastropods, *Terebralia sulcata* (249,250 ind·ha^{-1}) was the densest and most abundant (96.97%) in Tinib while *Terebralia palustris* was the densest (747,050 ind·ha^{-1}) and most abundant (70.44%) in Esteves. Pooled results for bivalve species maintained *Dendrostrea folium* as the densest (8750 ind·ha^{-1}) and most abundant (64.81%). However, for gastropods, *Terebralia palustris* emerged as the densest (373,525 ind·ha^{-1}) and most abundant (56.70%) species. The mangrove forests of Casiguran, Aurora thus contain a variety of bivalves and gastropods with Tinib station dominated by bivalves while Esteves station dominated by gastropods.

Keywords

Diversity, Abundance, Bivalves, Gastropods, Mangrove Forest

1. Introduction

Mangrove forest is composed of salt-tolerant trees and shrubs living in coastal intertidal zone. Its root systems are shallow and partly exposed to the air allowing them to breathe, as these are flooded, during high tide. The roots also serve as barrier, slowing down the movement of tidal waters, aside from serving as habitat and breeding ground for fishes and other marine organisms including mollusks.

The two dominant classes of mollusks present in a mangrove forest are Bivalves and gastropods. These organisms are living in the mangrove forest at surface substrate, in substrate, and sticking on roots, stems, and mangrove leaves. These take shelter on mangrove roots during high tide and feed on leaf litters making them an important link in the transfer of organic matter from mangroves to the third trophic level such as fish and birds [1].

In Aurora province, out of 430 hectares of mangrove forest, 90% can be found in Casiguran and Dilasag [2]. Mangrove forests in these municipalities have continually served as sources of bivalves and gastropods for food and income especially by coastal communities. In fact, coastal communities can be commonly seen gleaning for bivalves and gastropods in the morning or in the afternoon during low tide.

In Casiguran, the increase in coastal dwellers, the unprecedented poaching that caused sedimentation, and the continued development of the town in terms of tourism and infrastructure have intensified the extent of exploitation of mangrove forests. The current condition of mangrove forests could affect the population of bivalves and gastropods species and yet these species remain undocumented. Therefore, there is the need to develop a database before a particular bivalve and gastropod species will become extinct in this municipality. This database will serve as basis for conservation and sustainable management of these resources.

This study was conducted to determine the species richness, diversity, frequency, and density of bivalves and gastropods in Casiguran mangrove forests.

2. Materials and Methods

Two sampling stations were selected based on the presence of mangrove forest, bivalves, gastropods, muddy substrate, and gleaners for the establishment of a transect line. One sampling station in Tinib and one in Esteves, both located in Casiguran, Aurora, Philippines (**Figure 1**).

Random shell collection within mangrove forests was done to obtain data on the number of species found including their economic importance. For transect survey, one 100 meters transect line was laid parallel to the intertidal zone. This was overlaid continuously with a 2 m × 2 m quadrat along the transect line. A total of 50 sampling units covering 0.02 ha area per sampling station were surveyed.

Each quadrat was surveyed by two observers gleaning along in one direction

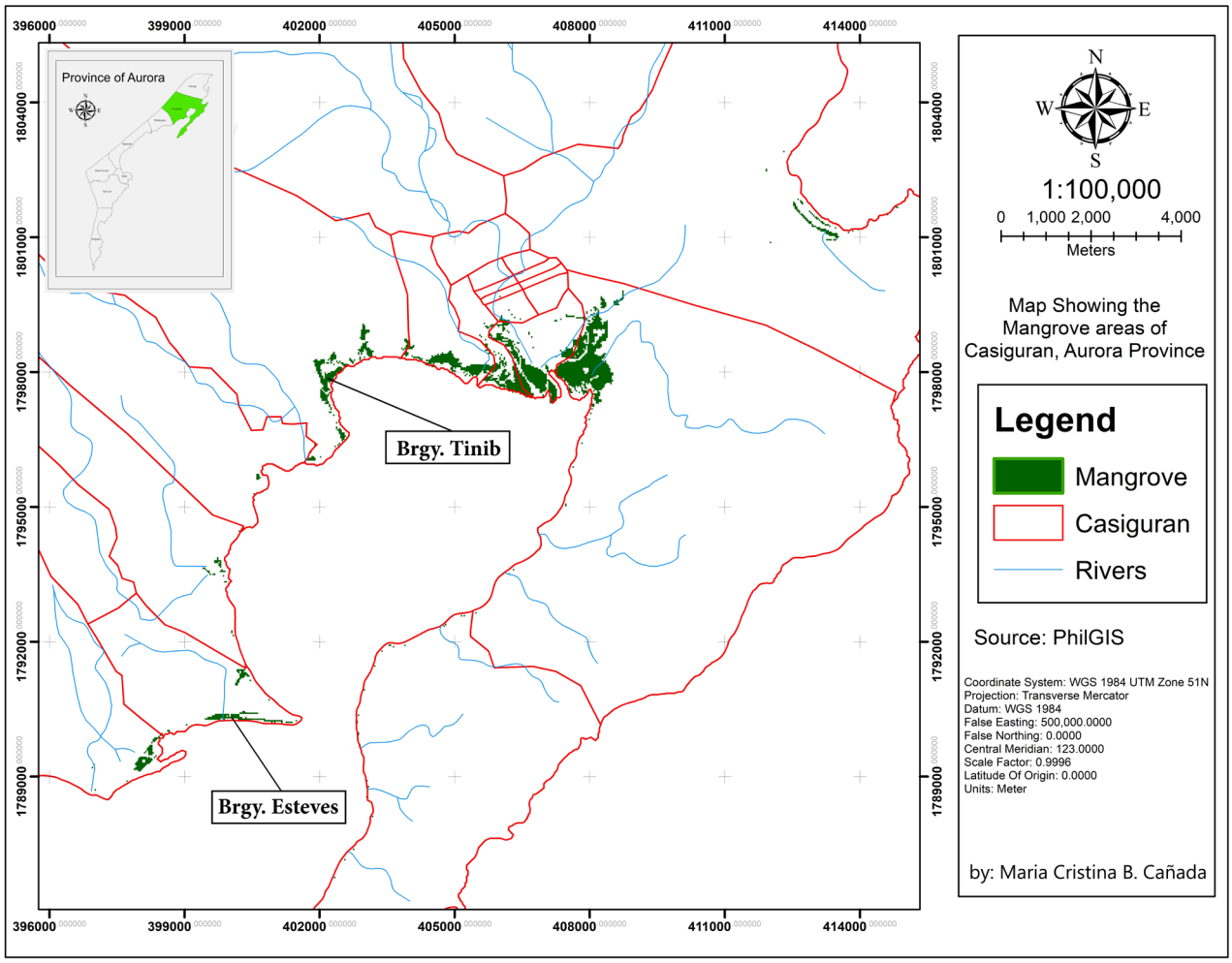

Figure 1. Location of the study site.

parallel to the length of the transect line. Gleaning was done by handpicking of epifaunal species. However, for infaunal species, a bolo was used in digging the substratum to a depth of 15 cm.

All live bivalves and gastropods found inside each quadrat were photographed, identified, counted, and listed on the field notebook. Representative samples of each species were collected and preserved for future reference.

The surveys were conducted during the months of April to July 2015 during the lowest tide of the day. The GPS coordinates of each mangrove forest were taken for mapping purposes using Garmin Etrex-10.

Data Analysis

The following formulae were used in the analysis of data:

The species diversity was computed using Simpson's Diversity Index (D_s):

$$D_s = \frac{\sum n_i \left(n_i - 1\right)}{N\left(N - 1\right)} \quad (1)$$

where:

n_i = number of individuals of the species.

N = total number of individuals in the sample.

The species frequency was obtained from the index (C):

$$C = \frac{P}{N} \times 100 \quad (2)$$

where:

P = number of quadrats containing the species.

N = total number of quadrats.

The population density per species was calculated based on the index (D):

$$D = \frac{n_i}{A} \quad (3)$$

where:

n_i = total number of individuals per species.

A = total area covered in hectares.

The relative abundance per species was based on the index (% Ab):

$$\%Ab = \frac{D}{\sum D} \quad (4)$$

where:

D = population density per species.

$\sum D$ = the sum total of all population densities of all species.

3. Results and Discussion

3.1. Species Richness

A total of 6 bivalves and 12 gastropods were found during a random shell collection within the mangrove forest (**Table 1**). More bivalves were found in Tinib (5 species) while more gastropods were found in Esteves (11 species).

The Tinib sampling station had higher tree density 2300 ind·ha^{-1} distributed in a wider and longer continuous stretch of mangrove forest as compared to the Esteves station (1050 ind·ha^{-1}). This station had more mangrove roots that served as shelter and attachment sites for bivalves during high tide. The presence of *Isognomon ephippium* in Tinib indicates the presence of a suitable habitat for this species that requires being attach to a solid substrate such as mangrove roots [3]. In addition, the mudflats within the mangrove forest were observed as most preferred by epifaunal bivalve species (*Glauconome virrens*, *Isognomon ephippium*, and *Gafrarium tumidum*). *Gafrarium tumidum* species is also found in mud within mangrove forest in Sri Lanka [4].

The abundant number of gastropods than bivalves in Esteves station could be attributed to the nature of the species that are adapted to various macrohabitat of the mangrove system [1]. This station had muddy sand substrate where gastropods can just freely graze for organic matter available and then move up the tree during high tide to avoid immersion. Physical factors such as sediment type affect the distribution of mangrove gastropod species [5].

Table 1. Bivalves and gastropods found in mangroves forests of Casiguran, Aurora.

Family Name	Scientific Name	Local Name	Tinib	Estev-es	Eco-nomic Use
Bivalves					
Glauconomidae	*Glauconome virens*	Kimpi	+	-	Food
Isognomonidae	*Isognomon ephippium*	Lapes	+	-	Food
Mytilidae	*Modiolus aratus*	Ubet ng Agta	-	+	Food
Ostreidae	*Dendrostrea folium*	Sise	+	+	Food
Veneridae	*Gafrarium tumidum*	Parek	+	+	Food
	Pitar citrinus	Gume-gumean	+	+	Food
Gastropods					
Columbellidae	*Sp 1*	-	-	+	Food
Littorinadae	*Littoraria scabra*	Buteng	+	+	Food
Melongenidae	*Volema myristica*	Alan-alan	+	+	Food
Muricidae	*Cronia margariticola*	-	-	+	Food
Neritidae	*Nerita planospera*	Katte	+	+	Food
	Nerita chameleon	Katte	-	+	Food
	Nerita polita	-	-	+	Food
Potamididae	*Cerithidea cingulata*	Balilit	+	+	Food
	Terebralia sulcata	Balilit	+		Food
	Terebralia palustris	Balilit	-	+	Food
Trochidae	*Monodontia labio*	Buteng	+	+	Food
Turbinidae	*Turbo cinereus*	Buteng	-	+	Food

This result was lower than what was obtained in mangrove forest of Catanduanes, Philippines that recorded a total of 27 gastropods and 30 bivalves [6]. However, the families with several species found were similar to this work. These families include Veneridae (2 species), Potamididae (3 species) and Neritidae (3 species).

All species found in Tinib and Esteves were exploited by the coastal dwellers living within the study sites as source of food and additional source of income.

3.2. Species Diversity

The transect survey revealed Tinib sampling station to have the most diverse species of bivalves (0.55) (Table 2). The bivalves found in Tinib were infaunal species that are suited in the mudflat. In addition, the wider stretch of mangrove forest with tree density of 2300 ind·ha^{-1} as compared with Esteves station (1050 ind·ha^{-1}) provided more roots branching underground that served as anchor for bivalves during high tide. The higher abundance of bivalves in mangrove forest could be due to the presence of root branching which are used by bivalves in clinging on [7].

Table 2. Species diversity (*Ds*) of bivalves per sampling station.

Family Name	Species Name	**Tinib** (muddy sand)		**Esteves** (sandy mud)	
		n	**n (n − 1)**	**n**	**n (n − 1)**
Glauconomidae	*Glauconome virens*	20	380	0	0
Isognomonidae	*Isognomon ephippium*	13	156	0	0
Mytilidae	*Modiolus aratus*	0	0	17	272
Ostreidae	*Dendrostrea folium*	213	45,156	137	18,632
Veneridae	*Gafrarium tumidum*	118	13,806	14	182
	Pitar citrinus	0	0	8	56
Σn(n − 1)		59,498		19,142	
Total (N)		364		176	
Species Diversity (*Ds*)		0.55		0.38	

Gastropods in Esteves were diverse (0.43) (Table 3). This station had muddy sand substrate with sparsely populated mangrove forest (1050 ind·ha^{-1}) forming an islet. The substrate could either be dry or wet depending on its sun exposure during low tide such that species like *Litoraria scabra* can be found on dry and wet areas but more commonly seen attached singly or in groups on young tree stems.

3.3. Species Frequency

Dendrostrea folium revealed as the most frequently occurring bivalve species in both Tinib and Esteves (43%) (Table 4). This species was commonly found attached to mangrove roots, stems, and leaves of young mangrove trees in groups. This species belongs to the Ostreidae family which also exhibited as the most abundant family in mangrove forest in Indonesia [7]. On the other hand, *Gafrarium tumidum* was found common in muddy substrates of both stations.

Cerithidea cingulata was the most frequently occurring species in both Tinib and Esteves (93%) (Table 5). This same species was also found common in mangrove forests in Sri Lanka [4]. This could be attributed to the ability of this species to inhabit in the mud, cling on roots, and attach to stems of mangroves.

3.4. Species Density

Dendrostrea folium revealed as the most dense (10,650 ind·ha^{-1} and 6850 ind·ha^{-1}) and most abundant (58.52% and 77.84%) bivalve species in Tinib and Esteves (Table 6). This species can be found in mangrove swamps in the Philippines feeding on algae or detritus [8]. The presence of coastal dwellers adds up to the increase of detritus in the area that serves as food for this species.

Gastropods belonging to Potamididae family were found as most dense in Tinib and Esteves stations (Table 7). In particular, *Cerithidea cingulata* was most dense (249,250 ind·ha^{-1}) and most abundant (96.97%) in Tinib while *Terebralia palustris* was most dense (747,050 ind·ha^{-1}) and most abundant (70.44%) in

Table 3. Species diversity (*Ds*) of gastropods per sampling station.

Family Name	Species Name	**Tinib** (muddy sand)		**Esteves** (sandy mud)	
		n	**n (n − 1)**	**N**	**n (n − 1)**
Columbellidae	*Sp 1*	0	0	13	156
Littorinadae	*Littoraria scabra*	41	1640	70	4830
Melongenidae	*Volema myristica*	12	132	33	1056
Muricidae	*Cronia margariticola*	0	0	148	21,756
Neritidae	*Nerita planospera*	8	56	9	72
	Nerita chameleon	0	0	190	35,910
	Nerita polita	0	0	2	2
Potamididae	*Cerithidea cingulata*	4985	24,845,240	5800	33,634,200
	Terebralia sulcata	91	8190	0	0
	Terebralia palustris	0	0	14,941	223,218,540
Trochidae	*Monodontia labio*	4	12	3	6
Turbinidae	*Turbo cinereus*	0	0	1	0
Σn(n − 1)		24,855,270		256,916,528	
Total (N)		5141		21,210	
Species Diversity (*Ds*)		0.06		0.43	

Table 4. Frequency of bivalve species found per sampling station.

Family Name	Species Name	**Tinib** (muddy sand)	**Esteves** (sandy mud)	**Species Frequency (%)**
Glauconomidae	*Glauconome virens*	+++++	-	5
Isognomonidae	*Isognomon ephippium*	++	-	2
Mytilidae	*Modiolus aratus*	-	+++	3
Ostreidae	*Dendrostrea folium*	++++++++++ ++++++++++ +++++	++++++++++ ++++++++	43
Veneridae	*Gafrarium tumidum*	++++++++++ ++++++++++ +++	+++++	28
	Pitar citrinus	-	+++++	5

+ = 2 × 2 m quadrat.

Table 5. Frequency of gastropod species found per sampling station.

Family Name	Species Name	**Tinib** (muddy sand)	**Esteves** (sandy mud)	**Species Frequency (%)**
Columbellidae	*Sp* 1	-	++++	4
Littorinadae	*Littoraria scabra*	++++++++	+++++++	15

Continued

Melongenidae	*Volema myristica*	++++++++++ +	++++++++++ +++++	26
Muricidae	*Cronia margariticola*	-	++++++++++ ++++++++++ +++	23
Neritidae	*Nerita planospera*	+++++	+++++	10
	Nerita chameleon	-	++++++++++ ++++++++++ ++++++++++ ++++++	36
	Nerita polita	-	+	1
Potamididae	*Cerithidea cingulata*	++++++++++ ++++++++++ ++++++++++ ++++++++++ +++++++++	++++++++++ ++++++++++ ++++++++++ ++++++++++ ++++	93
	Terebralia sulcata	+++++++++ ++++++++	-	18
	Terebralia palustris	-	++++++++++ ++++++++++ ++++++++++ ++++++++++ ++++	44
Trochidae	*Monodontia labio*	++	+	3
Turbinidae	*Turbo cinereus*	-	+	1

+ = 2 × 2 m quadrat.

Table 6. Density (*D*) and relative abundance (% *Ab*) of bivalve species per sampling station.

Family Name	Species Name	Tinib		Esteves		Pooled	
		D	% *Ab*	*D*	% *Ab*	*D*	% *Ab*
Glauconomidae	*Glauconome virens*	1000	5.49	0	0	500	3.70
Isognomonidae	*Isognomon ephippium*	650	3.57	0	0	325	2.41
Mytilidae	*Modiolus aratus*	0	0	850	9.66	425	3.15
Ostreidae	*Dendrostrea folium*	10,650	58.52	6850	77.84	8750	64.81
Veneridae	*Gafrarium tumidum*	5900	32.42	700	7.95	3300	24.44
	Pitar citrinus	0	0	400	4.55	200	1.48
Total		**18,200**		**8800**		**13,500**	

Table 7. Density (*D*) and relative abundance (% *Ab*) of gastropod species per sampling station.

Family Name	Species Name	Tinib		Esteves		Pooled	
		D	% *Ab*	*D*	% *Ab*	*D*	% *Ab*
Columbellidae	*Sp 1*	0	0	650	0.06	325	0.05

Continued

Littorinadae	*Littoraria scabra*	2050	0.80	3500	0.33	2775	0.42
Melongenidae	*Volema myristica*	600	0.23	1650	0.16	1125	0.17
Muricidae	*Cronia margariticola*	0	0	7400	0.70	3700	0.56
Neritidae	*Nerita planospera*	400	0.16	450	0.04	425	0.06
	Nerita chameleon	0	0	9500	0.90	4750	0.72
	Nerita polita	0	0	100	0.01	50	0.008
Potamididae	*Cerithidea cingulata*	249,250	96.97	290,000	27.35	269,625	40.93
	Terebralia sulcate	4550	1.77	0	0	2275	0.35
	Terebralia palustris	0	0	747,050	70.44	373,525	56.70
Trochidae	*Monodontia labio*	200	0.08	150	0.014	175	0.03
Turbinidae	*Turbo cinereus*	0	0	50	0.005	25	0.004
Total		**257,050**		**1,060,500**		**658,775**	

Esteves. A higher density of Potamididae (151 ind/m^2) in a mangrove area can also be found in Aceh Besar and Banda Aceh districts in Indonesia [7].

4. Conclusion

Based on the results, the following conclusions are drawn: The mangrove forests of Casiguran, Aurora contain a variety of bivalves and gastropods with economic value, most bivalve species belong to the family Veneridae (two species) while most gastropods belong to Potamididae (three species) and Neritidae (three species) families, the diverse species of bivalves found in Tinib is because of the wider stretch of mangrove forest that provided more roots branching underground for bivalves to anchor during high tide, the rich gastropods species found in Esteves could be due to the active nature of the organism that enables them to go up and down the mangrove tree following the tide, the dense (10,650 ind·ha^{-1} and 6850 ind·ha^{-1}) and abundant (58.52% and 77.84%) *Dendrostrea folium* in both Tinib and Esteves could be due to coastal dwellers adding up detritus that serve as food for these organisms, and the dense and abundant family of Potamididae could be attributed to the species adaptation on environmental condition in the sampling sites.

5. Recommendations

For a more comprehensive survey of bivalves and gastropods species found in mangrove forests of Casiguran, Aurora, it is recommended that the following factors be included: the survey must be conducted for 12 months to cover the changes of species richness and abundance during different seasons, the substrate must be analyzed to determine the organic matter content and soil texture, the population structures of bivalves, gastropods and mangrove trees be analyzed to determine the relationship between the size of mangrove trees and abundance of bivalves and gastropods.

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Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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