DIVERSITY AND COMMUNITY ASSEMBLY PATTERNS OF GASTROPODS IN ISLAND AND FRINGING MANGROVE FORESTS IN CALATAGAN, BATANGAS, PHILIPPINES

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Abstract: Mangrove forest modification effects on invertebrate communities, specifically on mollusks, are very limited in the Philippines. To address this, the distribution patterns of gastropod snails in Calatagan, Batangas, Luzon Island have been conducted. Forty-five (each quadrat 5m x 5m) quadrats were randomly set on island and fringing mangrove habitats. Environmental variables such as canopy cover, air temperature, mangrove forest age, and distance from agricultural lands were determined. A total of 13 species from four families (Neritidae, Littorinidae, Cerithidae, and Potamididae) were identified as being the most abundant in the mangrove ecosystem. Family Cerithidae dominated the gastropod assemblage in fringing and island mangroves with eight species identified. Among all species, *Clypeomorus bifasciata* was recorded on island mangroves though not encountered within the fringing mangroves. Canonical correspondence analysis (CCA) was performed to determine the relationship of snail diversity onto environmental variables and sampling sites. CCA revealed that snail distribution was associated with distance from agricultural lands, mangrove area, and tidal condition with most snails found during low tide, however both axes were not significant. Mangrove forest age also possibly influenced the gastropod distribution patterns since older mangrove stand (>10 years) recorded the highest diversity (H'=1.6) in the study site. Coastal or fringing mangroves can both serve as a functional habitat for mangrove-associated gastropod families in Calatagan. Mangrove forests with older mangrove stands (>15 years) recorded higher species abundance and diversity.

Keywords: Batangas, Calatagan, fringing mangroves, gastropods, island mangroves

Introduction:

The mangrove forest is an incredibly diverse habitat harboring species occurring in high densities and are adapted to distinct environmental requirements of the intertidal forces (Tomlinson 1986). It covers approximately 20 million ha worldwide, and are the primary vegetation type in protected intertidal areas along tropical and subtropical coastlines (Kathiresan and Binghan 2001; McGowan et al. 2010). However, the

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essential ecosystem services provided by mangrove forests are often unappreciated, resulting in extensive loss and degradation. The destruction of the mangrove forests, occurring globally with at least 35% of the area lost in the past two decades, exceeded those of the tropical rainforest and coral reefs (Valiela et al. 2001). In the Philippines, Long and Giri (2011) estimated the total mangrove cover (256,185 ha) among 66 out of the 82 provinces. The total mangrove area of the country has decreased by almost half which may be attributed to natural or human-made factors (Primavera 2000; 2005). The Philippines' total mangrove area (49,363 ha) is located within existing protected area networks (International Union for Conservation of Nature (IUCN) protected areas categories, I-VI), wherein the largest area of protected mangroves is located in Palawan. Despite several successful conservation efforts, there are still apparent gaps in the conservation and rehabilitation of mangrove forests (Garcia et al. 2014). Small-scale wood harvesting that accounts for 90% of stem mortality in both natural and plantation forests are not adequately regulated by the government or private sectors (Walters 2005). The reduction of mangrove forests and increased rate of anthropogenic disturbances could lead to the eradication of other ecologically important mangrove-associate invertebrate species.

The most conspicuous invertebrate inhabitants of mangrove forests are gastropods and bivalves (Mujiono 2009; Sälgeback and Savazzi 2006; Yolanda and Dharma 2016). The mangrove roots (pneumatophores) function as a food resource, refuge, and create microhabitats favorable for increased gastropod population density (Chapman et al. 2005). Although species of mangrove snails do not directly consume leaf litter, they contribute to 45 to 70% of total faunal biomass in the benthic fauna where most energy cycling occurs (Koch and Wolff 2002). Mangrove-associated snails are also studied as potential indicators of ecosystem health (Kabir et al. 2014; Koch and Wolff 2002). In addition, these mollusks are a significant food source for coastal populations, especially for low-income households. Due to increasing economic demand, the rapid conversion of mangrove forests to aquaculture ponds in the country poses a threat to the associated invertebrate fauna. Luckily, efforts to combat this rapid decline such as mangrove planting are in place. With this, ecological study on the influence of mangrove forest modification which includes mangrove reforestation and afforestation should be investigated.

An ideal site to examine gastropod diversity and community patterns in different modified mangrove forest habitat is in Calatagan, Batangas Province. Calatagan is located in Luzon Island that primarily relies on fishing in their local water, where the macrobenthic organisms serves as a significant food source for fish and other valuable sea resources. Being a peninsula lying along the shores of the West Philippine Sea and other bodies of water, the shorelines of the municipalities are laced with mangrove areas and marshland that have been modified and converted into fishponds (CLUP 2010). In recent years, efforts have been made to preserve the remaining mangrove ecosystem such as Community-based forest management that attracts locals and tourists to indulge in eco-tourism activities such as mangrove planting. The mangrove resources of the area in Calatagan have increased and can be characterized as island mangroves planted trees and fringing with natural mangroves. This various habitat modifications can influence the mangrove inhabitants such as mollusks. Studies of mollusks have been conducted in the area, however are very limited or insufficient. In 1967, an inventory of the mollusks in Batangas Bay was conducted (Sahlmann 2014), yet, ecological assessment focusing on the effect of habitat modification is in need of additional study. Hence, this research aims to use common mangrove-associated gastropods to initially assess the influence of habitat modification in the area.

Specifically:

1) identify the snail species focused on common mangrove snail families Neritidae, Cerithidae, Potamididae, and Littorinidae;

2) compare the biodiversity and distribution of these mangrove-associated snails between island and fringing mangroves, and

3) assess the gastropod community assembly patterns in different mangrove habitats. The investigation of these species is necessary to contribute to the information available on mangrove gastropod diversity and community structure in modified habitats. These will further provide essential insights to enhance coastal resources that Calatagan depends on.

Materials and methods:

Study area

The study was conducted at Barangay Gulod, Calatagan, Batangas Province in southern Luzon Island (13° 51' 56.52" N, 120° 37' 53.12" E) (Fig. 1). It is situated facing the West Philippine Sea and has an area of 421 ha with approximately 267 ha of natural mangroves (fringing) and 75 ha of planted island mangroves (aged 2-15 years) (Fig. 2, Annexes). It is an ecotourism site managed by both private and government sectors. The area is comprised of three island mangrove patches characterized by sandy substrate with mangrove trees planted as part of mangrove reforestation programs in the site. The largest island mangrove (IM1) has planted trees that are 15 years and IM2 and IM3 are aged two years during the sampling. While, fringing mangroves have rocky to muddy substrate persisting adjacent to sugarcane plantation and aquaculture ponds. Some of the mangrove species found in the area belong to Family Avicenniaceae, Rhizophoraceae, and Sonneratiaceae.

Sampling Protocol

On each sampling site, a 5 x 5 m (25 m^2) quadrat was randomly placed at least 10 m apart in an accessible sampling area. A total of 45 quadrats were set based on the mangrove size (30 quadrats in island mangroves and 15 quadrats in fringing). A sampling effort of 30 minutes per quadrat was observed. Sampling was done from 6 am to 3 pm with the lowest tide in the morning.

In each quadrat, selected environmental parameters were also measured. Geographic coordinates were determined using a Garmin 12 hand-held Global Positioning System (Garmin International, Inc., USA). Air temperature and relative humidity by a portable digital hygrometer (Uni-T, Model UT333, China). Canopy cover using a concave spherical densiometer (Forest Suppliers, Inc., USA). Diameter at breast height (cm) of all mangrove trees, the number of mangrove trees encountered inside the quadrat, and the distance of the sampling points from agricultural lands were estimated. Substrate type, tidal condition, and other notable habitat observations were also documented.

Identification of gastropods to species level was based mainly on the morphological characters using Springsteen and Leobrera (1986), Marine Mollusks of the Philippines volumes I-III (Poppe 2008a, 2008b, 2010) and other published literatures.

Species of mangrove snails inside each quadrat were recorded, and only adult snails found on the ground, roots, and branches were handpicked and counted. The mangrove tree species associated with the snails were also recorded. All collected individuals were photographed for identification and were returned to their original habitat. Sampling was limited to accessible mangrove forest areas only.

Data analysis

The diversity of gastropod snail community was calculated using the Shannon-Wiener diversity index (H’) and Evenness index (E).

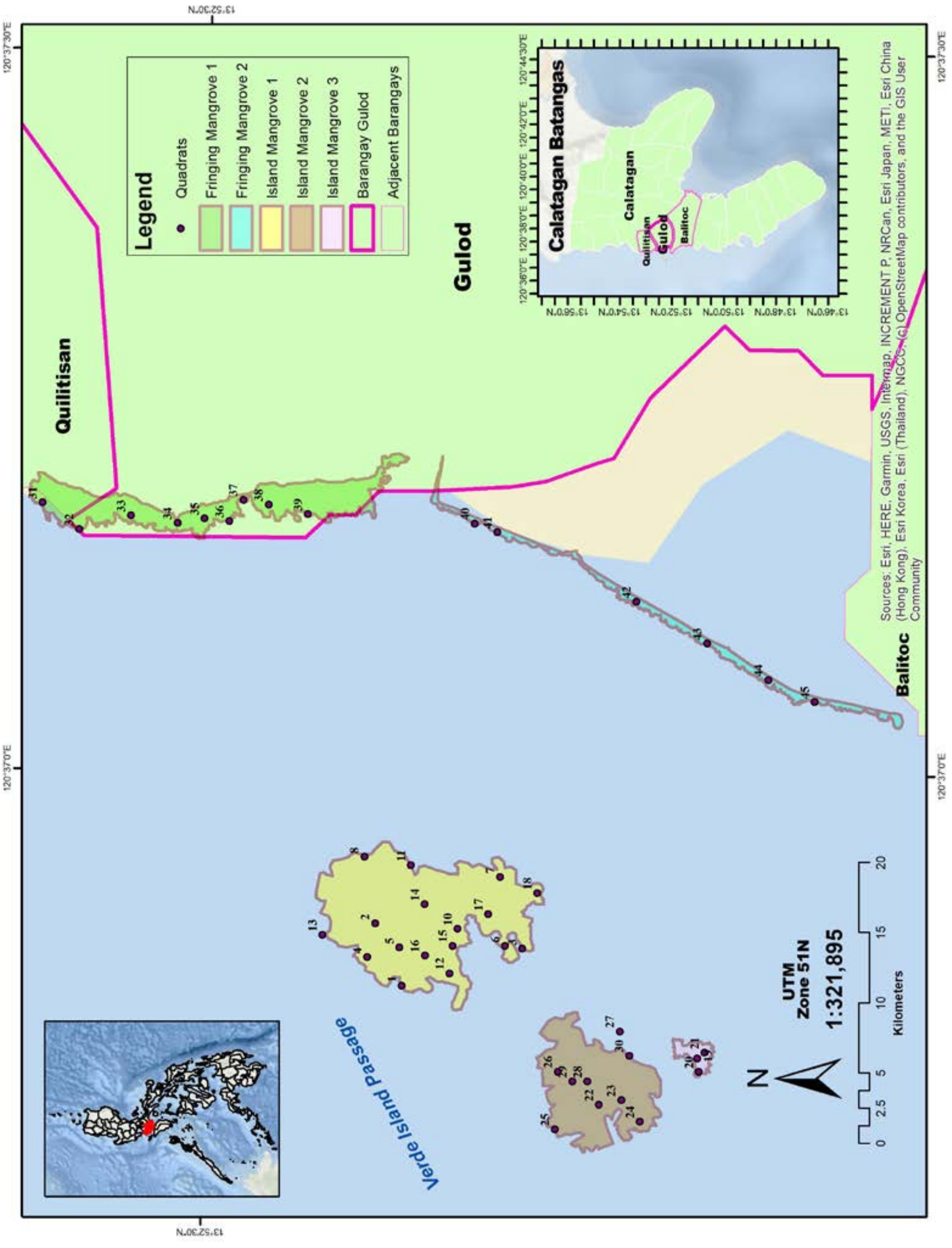


Figure no. 1 Sampling quadrats in Barangay Gulod, Calatagan in Batangas Province

The diversity of snail between mangrove forest types (planted vs. natural) was compared using the Independent Sample t-test.

Canonical correspondence analysis (CCA) was used to determine the pattern of snail diversity and abundance, environmental parameters, and sampling sites with the biplots generated using Paleontological Statistics ver. 3.14 (Hammer et al. 2016). The significance of each CC axis was calculated using Monte Carlo Test. Generalized linear mixed modeling (GLMM) was conducted to quantify the effect of selected environmental variables. Environmental factors such distance from agricultural lands, air temperature, canopy cover, diameter at breast height, tidal condition, mangrove area, and mangrove forest age were assigned as fixed factors, whereas abundance and species richness were the response factors. The global generalized linear mixed-effect model was run in R (v.3.1.3, R Foundation for Statistical Computing) with the use of *lmer* function in the lme4 package. After a global model was defined, input variables were standardized using arm package. A dredge function was implemented in the *MuMln* package to extract a submodel from the global model.

Results and discussion:

Gastropod Assemblage in Calatagan, Batangas

A total of 1455 individuals were counted belonging to thirteen (13) species of the four families investigated and two (2) morphospecies (mp) (Tab. 1). Eleven (11) species were recorded in natural fringing mangroves, while nine (9) species were identified in the planted island mangroves. The most abundant were *Clypeomorus pellucida*, Cerithiidae (57.5%) in large fringing mangroves and *Terebralia sulcata*, Potamididae (26.2%) in the island mangroves. Six species were observed in both sites throughout the study period including *Littoraria scabra*, *Nerita antiquata*, *Terebralia sulcata*, *Cerithidiopsila cingulata*, *Cerithium coralium* and *Clypeomorus pellucida*. Family Neritidae was represented by *Nerita antiquata* and *Clithon oualaniense* found usually seen creeping on trunk and branches, and rocks. Family Littorinidae have one species *Littoraria scabra* found in mangrove prop roots and leaves of *Rhizophora* trees in the island mangroves. Family Cerithiidae (7 species) dominated the gastropod assemblage, with Potamididae (3 species), Littorinidae (1 species) and Neritidae (2 species). Families Littorinidae and Potamididae are predominant mangrove families while Cerithiidae and Neritidae are not strict inhabitants of mangroves being found in other areas like intertidal zones and mudflats (Reid et al. 2008; Zvonareva et al. 2015). All investigated families were found during the entire period of sampling and their abundance and distribution is attributed to their mobile characteristics (Htwe 2019).

Among the gastropods, *Pirinella cingulata*, *Telescopium telescopium*, and *Clithon oualaniense*, *Cerithium coralium* are conspicuous species inhabitants of the soft muddy substrate. *P. cingulata*, *C. coralium* and *T. telescopium* apparently prefer muddy substrate with high salinity and constantly wet ground hence mostly found seaward (Mujiono 2014). During the sampling, *Rhizophora* propagules were numerous in fringing mangroves which also serve as main food for this mud-dwelling mangrove gastropod species (Pape et al. 2008). The abundance of *Rhizophora* and *Sonneratia* mangroves is favored by their preference for muddy to rocky substrate with higher salinity compared to other species (Nuestro Baleta and Casalamitao 2016). Rocky substrate was observed towards the land with fewer gastropods encountered littered by garbage. In the study area, fringing mangrove areas persist adjacent to the fishponds and sugarcane plantation and human settlements hence the evident anthropogenic disturbance (mangrove cuttings, human wastes, and backyard piggery). Mangrove forest age was estimated to be around 20 years based on information from the locals and tree sizes with DBH of trees outside the quadrats ranging approximately 20-110 cm and a canopy cover of 3-77%.

Table no. 1 Diversity, abundance and density of gastropod snails in the sampling areas

Family and Species	CCA Code	IM1	IM2	IM3	FM1	FM2	TOTAL
Littorinidae							
Littoraria scabra (Linnaeus, 1758)	Lis	69	18	19	5	3	114
Neritidae							
Nerita antiquata (Récluz, 1841)	Nea	167	20	10	7	5	209
Clithon oualeniense (Lesson, 1831)	Clo	0	0	0	1	6	7
Potamididae							
Terebralia sulcata (Born, 1778)	Tes	240	32	0	62	10	344
Pirenella cingulata (Gmelin, 1791)	Cei	0	6	0	14	2	22
Telescopium telescopium (Linnaeus, 1758)	Tet	0	0	0	2	0	2
Cerithiidae							
Cerithium coralium (Kiener, 1841)	Cec	233	3	0	22	3	261
Clypeomorus pellucida (Hombron and Jacquinot, 1848)	Clp	131	70	1	210	31	443
Cerithium mp. 1	Cem	9	0	3	12	12	36
Clypeomorus purpurastoma (Houbrick, 1985)	Clu	2	0	0	0	10	12
Clypeomorus bifasciata (G.B. Sowerby II, 1855)	Clb	2	0	0	0	0	2
Rhinoclavis vertagus (Linnaeus, 1767)	Rhv	0	1	0	0	0	1
Cerithium mp. 2	Cep	0	0	0	1	1	2
Total individuals		853	150	33	336	83	1455
Number of species	13	7	7	4	10	10	
The density of all species/m^2		76	13	3	29	7	
Diversity (H')		1.60	1.45	1.00	1.24	1.90	
Evenness (J')		0.62	0.61	0.68	0.35	0.67	

Note: IM- island mangrove forest; FM-fringing mangrove forest.

While, *Clypeomorus bifasciata* and *Rhinoclavis vertagus* were recorded present only on the island mangroves. An empty shell of *Rhinoclavus vertagus* has only have been collected and it may have been brought to the mangroves by current or other factors. These island mangroves are approximately 400-600 m away from the main coast and the area constantly visited by tourists. The dominance of small *Avicennia* and *Sonneratia* trunks with DBH ranging 4.4 - 90.7 cm reflects a young mangrove forest (Cudiamat and Rodriguez 2017). Air temperature during the sampling ranged from 32-40 ˚C. The substrate type was sandy in the seaward side while muddy towards the center. The vegetation is dominated by mangrove species *Avicennia* and *Sonneratia* ecologically adapted to the sandy substrate with patches of seagrass towards the sea.

The study showed lower species richness (10 species) compared to other studies in the Philippines. There were 11 gastropod species in La Union (Mamhot et al. 2018), 27 gastropods in Catanduanes (Masagca et al. 2010) some 151 gastropod species in Bohol Island, Philippines (Lozouet and Plaziat 2008), 13 gastropod species in Ormoc, Leyte

(Olor-Pogado and Evangelio 2020) in fringing mangroves. The lower species richness of the site may be attributed to evident environmental degradation such as favored sites for sewage disposal and domestic effluents, logged mangroves trees due to its proximity to human residences, conversion to agricultural lands and aquaculture. As reported by (Irma and Sofyatuddin 2012; Kabir et al. 2014) gastropod diversity is affected by overexploitation practices, human activity stress, expansion of agricultural diversity, and activities in the neighboring communities. These human-induced changes in the environmental conditions of mangrove habitats could elicit major effects on mangrove ecosystem such as alteration of regional hydrology or modification of the mangrove basin geomorphology (Lugo 1990; Jimenez et al. 1985). Also, fringing mangroves are very dynamic being geographically located on the coastline usually impacted by waves, wind, storm surges, tidal change, and flushing (Howai 2019).

Species richness varied from two to eight per quadrat with quadrat 45 (10 species) in the fringing mangroves having the highest. Species richness in the planted island mangroves (7 species) is also lower compared to other planted mangroves. The 9-year old mangrove plantation of Central Vietnam recorded a total of 30 gastropod species (Zvonareva et al. 2015), and 20 gastropod species in restored mangroves (about 10 years) in South Malang, Indonesia (Siswandari et al. 2020).

The physical structure of the mangrove forest includes the variation in substrate, and surface complexity that could have influenced the species richness. Most island mangroves in the study area have mangroves saplings which offers less canopy cover (canopy cover was 3-55%) compared to older growth stands. The island mangrove habitat favors soft sediments and sheltered conditions like sea level, salinity, and drainage are important factors controlling distribution and composition (Melana et al. 2000; King et al. 2002; Salmo and Duke 2010). The occurrence of species in island and fringing mangroves denotes that different habitats support varying densities and species of gastropods. Representative photos for the identified species are presented in Figure 3.

In terms of diversity, fringing natural mangroves (FM1) obtained the highest gastropod diversity (H' = 1.90) followed by island planted mangroves (IM1; H' = 1.60) (Tab. 1). Both FM2 (8040 m^2) and IM1 (25,482 m^2) had large mangrove area and older mangrove age (> 15 years), hence the higher density of gastropods similar to other studies (De Vera et al. 2015; Zvonareva et al. 2015; Siswandari et al. 2020). The gastropods' preference to mangrove forest type was not clearly observed in the site, however, most snails were found numerous on larger mangrove areas (IM1 25,482 m^2; average density of 76 individuals/m^2; fringing mangrove with 29 individuals/m^2) and during low tide conditions revealed by the canonical correspondence analysis (CCA) biplot (Fig. 4) and generalized linear mixed model (Tab. 2).

The presence of older mangrove trees in this larger area offers greater surface area in the trunk and various pneumatophores for attachment, and a more extensive canopy cover. This finding is consistent that when mangrove density increases, the abundance of gastropod also increases as mangrove vegetation dictates an increase in litter production and organic matter favorable to gastropods (Nurfitriani et al. 2019). The CCA biplot further showed that gastropod distribution was also possibly influenced by distance from agricultural lands (sugarcane plantation, aquaculture ponds). CCA accounted for the probable influence of the measured environmental factors to the gastropod distribution, with the first two axis explaining 50.85% and 25.21% of the data gathered during the study period. The first canonical axis was associated with tidal condition (0.31), mangrove forest age (0.28), distance to agricultural lands (-0.52) and mangrove area (-0.30). Meanwhile, the second canonical axis was associated with distance from agricultural land (0.23), mangrove forest age (-0.47), air temperature (-0.40), and mangrove area (-0.27). However, the first and second axis had a p-value of 0.07 and 0.25 respectively, both of which were not significant at alpha = 0.05. This suggests that the environmental variables that were considered did not strongly affect the gastropod composition across the sampling sites.

Figure no. 3 Representative mangrove snails with dorsal and ventral view sampled in Calatagan, Batangas. (A) *Pirenella cingulata*, (B) *Terebralia sulcata*, (C) *Cerithium coralium*, (D) *Clypeomorus pellucida*, (E) *Clypeomorus bifasciata*, (F) *Clypeomorus purpurastoma*, (G) *Littorraria scabra*, (H) *Nerita antiquata* and (I) *Clithon oualaniense.*

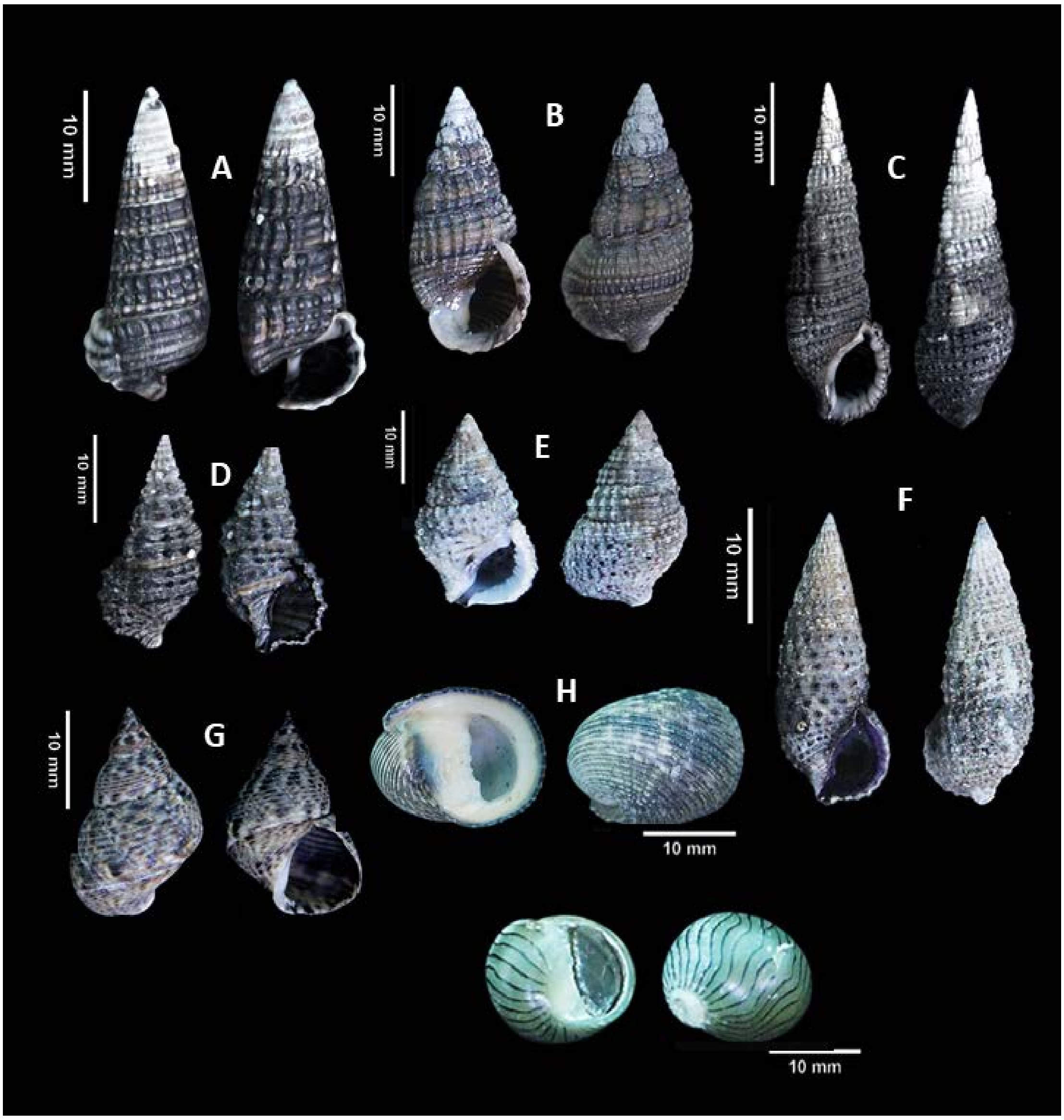
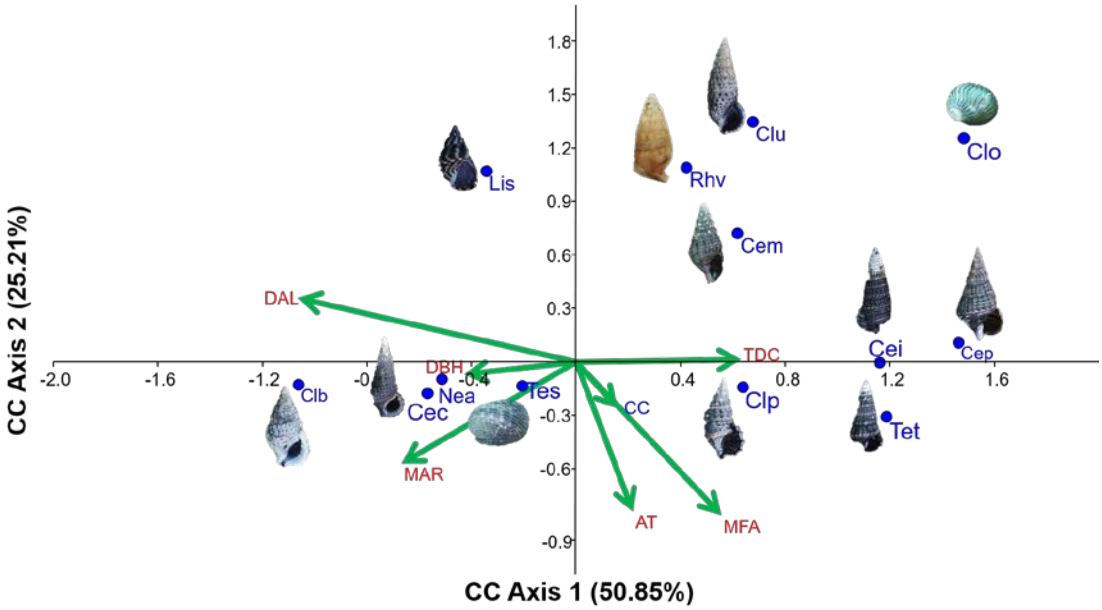


Figure no. 4 Canonical correspondence analysis (CCA) of mangrove gastropod species and environmental variables in Calatagan, Batangas



Note: Biplot represents mangrove snails (blue circles with image) and (red) continuous environmental variables (vectors). DAL (Distance from agricultural lands), MAR (Mangrove area), MFA (Mangrove Forest Age), DBH (Diameter at Breast Height), AT (Air temperature), TDC (Tidal Condition) and CC (Canopy Cover).

Table no. 2 General linear mixed models testing each environmental variable on the species richness and abundance of mangrove snails between mangrove forest types.

Parameter	Estimate	SE	P	Relative Importance
Species Richness				
Tidal Condition	0.16	0.19	0.26	0.16
Distance from Agricultural Lands	-0.03	0.11	0.37	0.19
Mangrove Forest age	0.03	0.13	0.81	0.54
Abundance				
Distance from agricultural lands	0.05	0.41	0.12	0.42
Mangrove area	0.38	0.40	0.96	0.60
Mangrove forest age	0.43	0.46	0.92	0.61

Despite the lack of strong relationship between the environmental variables and gastropod composition, it can still be inferred in the biplot that *Nerita antiquata* and *Cerithium coralium* can possibly be found on trees with larger DBH as observed. Canopy cover was also highly correlated with mangrove forest age with the highest canopy cover in old-growth trees, as seen in the overlapping of vectors in these two variables. *Rhinoclavis vertagus*, *Clypeomorus purpurastoma*, *Littoraria scabra*, *Clithon oualaniensis*, *Telescopium telescopium*, *Cerithidiopsilla cingulata*, and the two *Cerithium* morphospecies showed no apparent relationship with other environmental variables as revealed by the distant points from the vectors. Based on General Linear mixed modelling (GLMM), the age of mangrove forest was the top predictor, although not statistically significant, of gastropod species richness (Tab. 2). The combination of mangrove forest age and tidal condition was the most parsimonious model (DAICc = 1.77, *w*AICc = 0.16) to explain species richness (Tab. 3). For snail abundance, the combination of distance from agricultural lands and mangrove forest age was the most parsimonious model (DAICc = 0.00, *w*AICc = 0.23) which is reflected by island mangrove (IM1). There is a positive relationship between the species richness and abundance and mangrove forest age suggesting more species were expected to be found on old-growth stand mangroves which is a similar observation in Thailand (Choosak et al. 2016) and Central Vietnam. The present status of the island mangroves shows that with conservation practices and strengthened management, the planted island mangroves in Calatagan can be able to support gastropod colonization in its transitional state similar to the rehabilitated mangrove forests in Western Pangasinan, Philippines (De Vera et al. 2015).

Table no. 3 Summary statistics of model averaging for species richness and abundance of mangrove snails in Calatagan, Batangas. Models are ranked based on Akaike's information criterion for (AICc), where AICc weights (wAICc) < 0.10 are excluded. Predictor variables: MFA mangrove forest age), DAL (distance from agricultural lands), TDC (Tidal condition), and MAR (Mangrove area size).

Model component		k	AICc	ΔAICc	wAICc
Species richness					
	MFA	4	169.65	0.00	0.38
	Null	3	170.35	0.70	0.27
	DAL	4	171.05	1.40	0.19
	TDC + MFA	5	171.42	1.77	0.16
Abundance					
	DAL + MFA	5	403.74	0.00	0.23
	MAR + MFA	5	403.91	0.18	0.21
	MAR	4	403.97	0.24	0.20
	DAL + MAR	5	404.09	0.36	0.19
	MFA	4	404.29	0.56	0.17

Note: k- number of parameters

Conclusions:

Mangrove forest age (>15 years) either planted or natural in Calatagan, Batangas has been recorded with higher gastropod abundance, and diversity. The larger area the old-growth mangrove occupies, the higher gastropod density. Importantly, mangrove forests paired with minimal habitat modification, conservation efforts and optimal environmental conditions can promote the succession of mangrove-associated gastropods in both island and fringing mangroves.

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Rezumat:

DIVERSITATEA ȘI MODELELE DE ASAMBLARE COMUNITARĂ ALE GASTROPODELOR ÎN PĂDURILE DE MANGROVE INSULARE ȘI MARGINALE DIN CALATAGAN, BATANGAS, FILIPINE

Efectele modificării pădurii de mangrove asupra comunităților de nevertebrate, în special asupra moluștelor, sunt foarte limitate în Filipine. Pentru a rezolva acest lucru, au fost efectuate modelele de distribuție a melcilor gasteropode în Calatagan, Batangas și insula Luzon. Patruzeci și cinci de pătrate (fiecare pătrat 5 m x 5 m) au fost așezate aleatoriu pe insulă și habitatele de mangrove marginale. Au fost determinate variabile de mediu, cum ar fi coronamentul, temperatura aerului, vârsta pădurii de mangrove și distanța față de terenurile agricole. Un total de 13 specii din patru familii (Neritidae, Littorinidae, Cerithidae și Potamididae) au fost identificate ca fiind cele mai abundente în ecosistemul de mangrove. Familia Cerithidae a dominat ansamblul gasteropodelor din mangrovele marginale și insulare, cu opt specii identificate. Dintre toate speciile, *Clypeomorus bifasciata* a fost înregistrată pe mangrovele insulei, deși nu a fost întâlnită în mangrovele marginale. Analiza corespondenței canonice (CCA) a fost efectuată pentru a determina relația dintre diversitatea melcilor cu variabilele de mediu și locurile de prelevare. CCA a dezvăluit că distribuția melcilor a fost asociată cu distanța față de terenurile agricole, zona mangrovelor și starea mareelor, cu majoritatea melcilor găsiți în timpul refluxului, totuși ambele axe nu au fost semnificative. De asemenea vârsta pădurilor de mangrove posibil că a influențat, modelele de distribuție a gasteropodelor, deoarece arborii mai bătrâni de mangrove (>10 ani) au înregistrat cea mai mare diversitate (H'=1,6) în zona de studiu. Mangrovele de coastă sau marginale pot servi ambele ca habitat funcțional pentru familiile de gasteropode asociate mangrovelor din Calatagan. Pădurile de mangrove cu arbori și mai bătrâni de mangrove (>15 ani) au înregistrat o abundență și o diversitate mai mare a speciilor.

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Annexes:

Figure no. 2 The mangrove forest: a1, a2, a3, a4 - in fringing coastal (natural); b1, b2, b3, b4 - in island mangrove forest (planted)


a1


a2


a3


a4

b1

b2


b3


b4