Baseline study of Decapoda and Mollusca diversity in La Union, Cabadbaran, Philippines

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Japhet D. Anunciado, Ailene B. Budiongan, Wennie C. Angeles, Franklin C. Budiongan

General Education Department, Faculty of Caraga State University Cabadbaran Campus, 8605 Cabadbaran City, Philippines. Corresponding author: J. D. Anunciado, jdanunciado@csucc.edu.ph

Abstract. The Cabadbaran Mangrove Eco-park is a newly established eco-park that would address major environmental and economical issues in the area such as providing sustainable livelihood and mangrove ecosystem rehabilitation. This study focused on the baseline study of Decapoda and Mollusca in La Union, Cabadbaran City, Philippines since they play an important role in the ecosystem and economy. Thus, this study aimed to identify the species composition, density and diversity of these two groups of benthic organisms. Preliminary results show that there were eight species of molluscs and fifteen species of crustaceans in the study area. In those identified species, the edible *Faunus ater* was the most dense species of mollusc with 19.13 individuals per square meter; however, it was reported that this species is attracted to the garbage coming from households and other establishments which was alarming since it is being sold in the wet market of Cabadbaran City. *Uca vocans* and *Uca annulipes* were the most numerous species of crustaceans with both 0.25 individuals per square meter. Furthermore, the diversity indices revealed that molluscs and crustaceans in La Union were in low category which can be attributed to anthropogenic activities such as the presence of banana (*Musa* sp.) and rice (*Oryza* sp.) plantations, encroaching human settlements and commerical eel (*Anguilla japonica*) farm and the unregulated collection of mangrove resources were observed within and around the new eco-park. This study suggests that regular monitoring of macrofauna in the area should be conducted to determine the success of the newly established mangrove eco-park in the years to come.
Key Words: crustacean, mollusc, eco-park, anthropogenic activities

Introduction. Mangal is a widely studied ecosystem from the smallest microbes (Liu et al 2019; Allard et al 2020; Alongi 2021) to the largest trees (Friess et al 2019; Giri 2021; Lee et al 2021). In addition, mangroves are significant to the economy by supplying revenues from the products and services provided by the ecosystem. Costanza et al (2014) reported that the estimated total global ecosystem services of mangroves was worth 125 trillion US dollars per year. In Bohol and Palawan in the Philippines, the total economic value of mangrove was 58.89 million Philippine pesos (1.17 million US dollars) combined (Carandang et al 2013). The products with the highest economic values came from the crustaceans with 26.20 million Philippine pesos (0.52 million US dollars) and molluscs with 22.35 million Philippine pesos (0.44 million US dollars) (Carandang et al 2013).

Crustaceans and molluscs play a vital role in sustaining the livelihood of residents residing near the mangrove forests (Aye et al 2019; Idrus et al 2019). They provide a good source of protein, which is one of the major nutrients needed by human body, as well as essential amino acids, bioactive peptides, long-chain polyunsaturated fatty acids, astaxanthin and other carotenoids, vitamin B_{12} and other vitamins, minerals, which includes copper, zinc, inorganic phosphate, sodium, potassium, selenium, and iodine (Mente 2006; Venugopal & Gopakumar 2017; Khan & Liu 2019). Ecologically, these macrobenthic species are responsible for several activities in the mangrove sediments (Nagelkerken et al 2008). They help in foraging on bacteria, microalgae, detritus and meiofauna attached to the trees (Warren & Underwood 1986; Smith et al 1991). Further, they are responsible for changing the physical and chemical attributes of the sediments by burrowing (Warren & Underwood 1986; Smith et al 1991). Most importantly, crustaceans and molluscs particularly crabs and gastropods, due to their seed predation ability, determines the mangrove community structure in the area (Smith et al 1989). Therefore, evaluating these macrobenthic organisms is important since they exhibit symbiotic relationship with mangroves.

With the major aim of conserving the mangroves in La Union, Cabadbaran City, a Memorandum of Agreement was signed by several agencies like the Local Government Unit, Department of Education, Department of Environment and Natural Resources, Bureau of Fisheries and Aquatic Resources, local community organizations and the academe to create the first mangrove eco-park in the city. This eco-park was established to address the decreasing mangrove cover in the area, increasing presence of garbage, continuing encroachment of human settlement and increasing demand for protein. One component of this undergoing was the assessment of macrofauna in the designated mangrove eco-park and this includes crustaceans and molluscs. At present, data on the composition and diversity of crustaceans and molluscs in La Union, Cabadbaran City is lacking. Thus, this study aimed to provide a data on the communities of crustaceans and molluscs. Specifically, it aimed to 1) identify their species composition, 2) evaluate the density (individuals sq.m.$^{-1}$) of the different species and 3) determine its diversity indices using dominance, evenness, and Shannon-Wiener diversity indices. Assessing the crustaceans and molluscs is relevant in providing baseline data which can be used to measure the success of the eco-park, in terms of biodiversity conservation, in years to come.

Material and Method

Description of the study sites. The study was conducted at the designated mangrove eco-park in La Union, Cabadbaran City, Philippines. The study area was characterized by undetermined area size of abandoned fishponds and 116.9 hectares of mangrove forest as of the year 2020. The abandoned fishponds, originally a mangrove forest, are subjected to mangrove rehabilitation through the efforts of different government stakeholders that signed the Memorandum of Agreement. Adjacent to the mangrove forest were banana (*Musa* sp.) and rice (*Oryza* sp.) plantations that are subjected to daily areal spraying especially for banana. On the other side of the mangrove forest are the presence of human settlements and a commercial eel (*Anguilla japonica*) farm that are encroaching the forest. It is also important to take note the discharge of pig and human wastes in the estuarine water of the area. On the other hand, a series of tributaries are influenced with daily tidal inundations which allows the regular supply of seawater in the mangroves. With regards to the mangrove species and mangrove associates, thirteen species were identified namely *Avicennia marina*, *Avicennia alba*, *Avicennia rumphiana*, *Rhizophora mucronata*, *Rhizophora apiculata*, *Sonneratia alba*, *Sonneratia caseolaris*, *Bruguiera sexangula*, *Aegiceras corniculatum*, *Nypa fruticans*, *Acanthus volubilis*, *Acanthus ilicifolius* and *Acanthus ebracteatus*. Figure 1 shows the study area in La Union, Cabadbaran City, Philippines.

Collection of samples. The samples were collected from August to November 2019 starting at 0600 to 1700 hours. The methods for sampling molluscs was patterned based on the work of Beasley et al (2005). In each of the sampling station, four 10m x 10m plots with six quadrats with an area of 1m x 1m were established. Using Global Positioning System (Garmin eTrex10), coordinates were recorded prior to sample collection in each quadrat. All visible molluscs found on the sediment or the epifaunal species were handpicked and placed in plastic polyethylene bags. For the collection of infaunal species, sediments were extracted with a depth of 15 cm and sieved to remove the sediments (Kumar & Khan 2013). Organisms retained on the sieve screen were placed in a plastic polyethylene bag. For arboreal species, 6 mangrove individuals nearest to the quadrat were inspected from its leaves, stem, trunk, roots and were collected and placed separately in plastic bags (Printrakoon et al 2008). All collected samples were preserved in a bottle containing 10% formalin. For the identification of the mollusc species, Mangrove Environments and Molluscs: Abatan River, Bohol and Panglao Islands, Central Philippines by Lozouet & Plaziat (2008) and Worldwide Mollusc Species Data Base were used.

The collection of decapods was done using stratified-random method performed by Lapolo et al (2018). In 4 assigned stations (10m x 10m), 6 quadrats having an area of 1 sq.m.$^{-1}$ were placed and all the decapods present inside were collected for further documentation. For burrowing crustaceans, individual burrows were checked to determine the presence of the samples. Additionally, observation point was assigned inside the station in order to record the species absent inside the quadrats but present inside the station. After the collection of decapods, the species was identified using the work of Lapolo et al (2018) and an online repository, World Register of Marine Species or WoRMS.

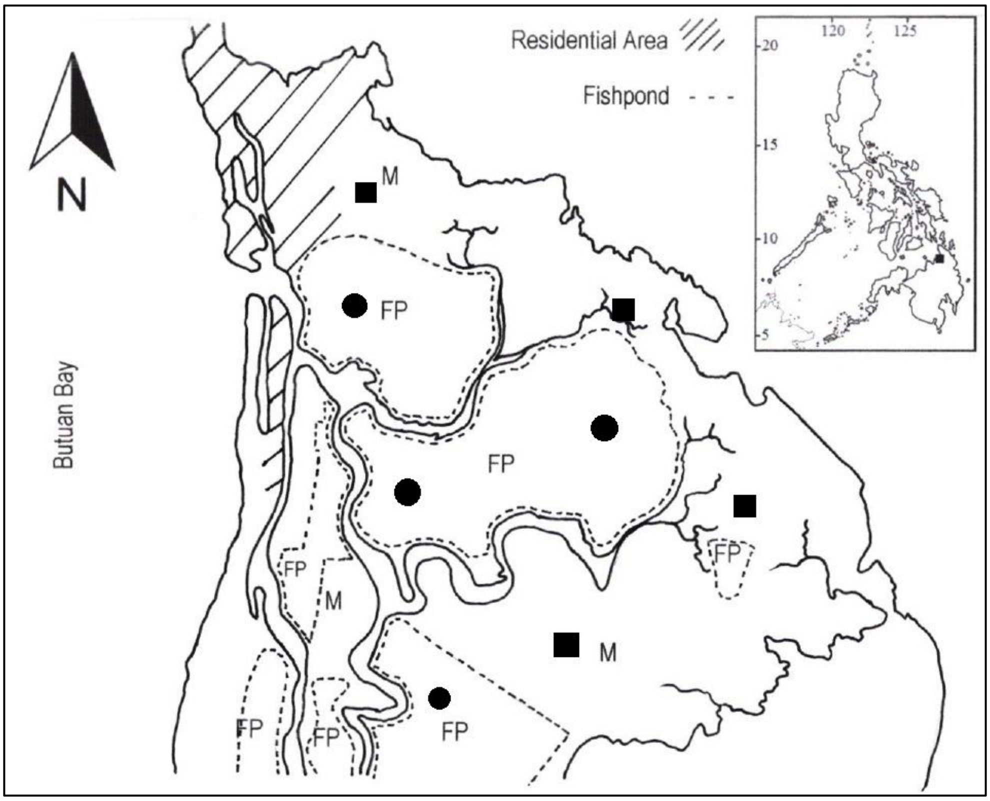

Figure 1. The mangrove eco-park in La Union, Cabadbaran City, Philippines. Black circles = sampling stations in the abandoned fishponds; black squares = sampling stations in the mangrove forest; FP = fishpond site; M = mangrove site.

Statistical analysis. The diversity indices were determined with the use of a freeware Paleontological Statistics version 2.17c (Hammer 2012). Moreover, the work of Fernando (1998) was used to categorize the diversity index values.

Results and Discussion

Molluscs. Eight species of molluscs were documented in the mangroves of La Union, Cabadbaran City with a total count of 2416 individuals. The 8 species came from the 7 families namely Pachychilidae, Neritidae, Potamididae, Littorinidae, Mytilidae, Cyrenidae and Ostreidae. The families that belong to Class Gastropoda, formerly Class Univalvia, are Pachychilidae, Neritidae, Potamididae and Littorinidae. These species exhibit a single shell majority of them has a conical shape. On the other hand, Mytilidae, Cyrenidae and Ostreidae belong to Class Bivalvia. Bivalves are composed of two shells connected together by strong ligaments. Table 1 shows the composition of molluscs found in La Union, Cabadbaran City.

Table 1

Mollusc species and the number of individuals in two sampling sites of La Union, Cabadbaran City

Class and Family	*Species*	*Abandoned fishponds*	*Mangroves*
Gastropoda			
Pachychilidae	*Faunus ater*	459	387
Neritidae	*Nerita planospira*	13	195
	Vittina coromandeliana	100	254
Potamididae	*Telescopium telescopium*	3	48
Littorinidae	*Littoraria scabra*	16	16
Bivalvia			
Mytilidae	*Brachidontes* sp.	108	401
Cyrenidae	*Geloina expansa*	67	55
Ostreidae	*Crassostrea* sp.	293	1
	Total no. of individuals	1059	1357
	Total no. of species	8	8

The highest density of mollusc was recorded for *Faunus ater* found in abandoned fishponds with 19.13 individuals sq.m.$^{-1}$ while *Crassostrea* sp. (16.71 individuals sq.m.$^{-1}$) had the highest density in the mangrove site followed by *F. ater* (16.13 individuals sq.m.$^{-1}$) and *Geloina expansa* (10.58 individual sq.m.$^{-1}$), an economically important species. Figure 2 shows the density of molluscs species at different sites in La Union, Cabadbaran City.

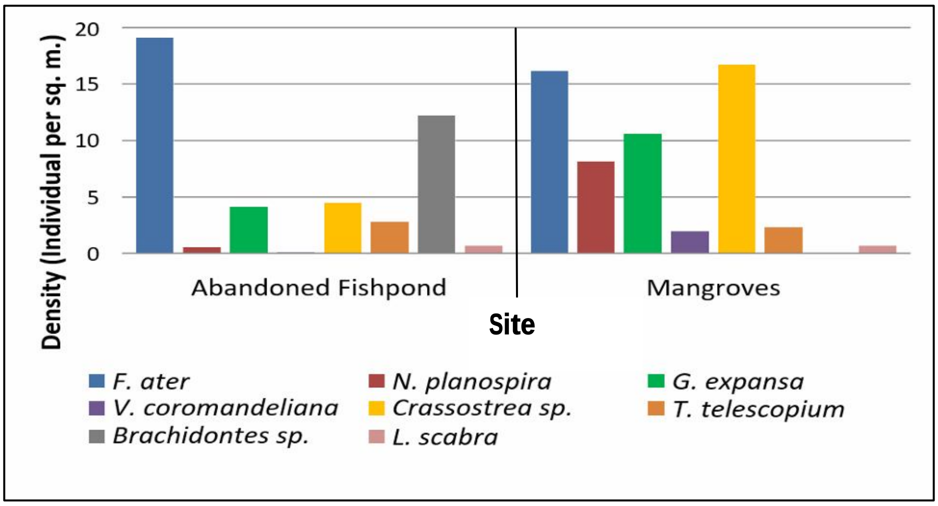

Figure 2. Density of mangrove molluscs collected in two different sites of the designated mangrove eco-park in La Union, Cabadbaran City.

According to Lopez & Urcuyo (2012), *F. ater* is found in East Asia, including the Philippines, where this species is abundant. It is naturally abundant in brackish water especially in mangroves (Das et al 2018). Lozouet & Plaziat (2008) reported that *F. ater* has a wide salinity tolerance and thus capable of thriving along different areas in the estuary. Despite being numerous in mangroves, their presence does not correlate to the abundance of organic detritus in the sediments contrary to the fact that detrivorous gastropod's abundance is highly determined by food availability. However, it was reported that this species is allured to the garbage coming from households and other sources (Lozouet & Plaziat 2008). This alarming issue must be thoroughly addressed once proven by another studies, in this case, in La Union since *F. ater* is one of the major sources of protein in this coastal community. This shell is being sold in the wet market of Cabadbaran City. The marketing of this species for human consumption in the Philippines was already reported in the early 1990s (Houbrick 1991). On the other hand, *Crassostrea* sp. had the highest density in the mangrove site. Its density is high since they survive in aggregates. Numerous individuals were collected in a small area such as mangrove roots. They are essential in filtering the water since they are filter feeder though they were of little value economically since the people in the area were not accustomed in consuming the mangrove oyster. Another economically important mollusc is the *G. expansa*, a species that can survive in the mud and wide salinity level. Yahya et al (2018) reported that *G. expansa* is harvested for consumption in India, Australia, Malaysia and the Philippines since it contains high protein level.

In this study, *G. expansa* was most abundant in the mangrove site compared to the abandoned fishpond site. Their relationship to the mangroves was somewhat close because the spaces between the mangrove roots provide juvenile shells protection against predators which that will result in high survivality (Nagelkerken et al 2008). This species is also an important protein source for the people in the community. They are being sold the wet market in varied sizes. It is important to take note that there are no regulations in the collection of this species for human consumption. Thus, harvesting of juvenile individuals was rampant in Cabadbaran City. Their abundance indicated their reproductive success but overharvesting may result in the decrease in number few years from now.

The Shannon-Wiener diversity index revealed that the abandoned fishpond site was slightly higher than the mangrove site with a difference of 0.07. Overall, the two sites had the average index of 1.14 that was categorized to be low in diversity (Fernando 1998). On the other hand, the species evenness was slightly higher in the abandoned fishpond site. The average evenness values was 0.39 which indicated to be low. It implies that the species in both sites were not evenly distributed. Furthermore, the species dominance was marginally higher in the mangrove site than in the abandoned fishponds. The average species dominance value in the two sites was 0.47 which implies that no single species dominated both sites. The diversity indices of mangrove-associated molluscs in the designate mangrove eco-park in La Union, Cabadbaran City is shown in Table 2. The low diversity indices manifest stressful environmental conditions as an effect of anthropogenic disturbances in the area (Yolanda et al 2015). Destructive human activities eventually lead to habitat loss which is the major cause of biodiversity loss (Polidoro et al 2010). This occurrence was observed in this study. Water outlet from the banana and rice plantations to the mangrove area were conspicuous and could possibly carry excess pesticides and fertilizers that can kill macrobenthic organisms. These hazardous chemicals can poison several sensitive molluscs especially those immobile species with no capability to escape. In addition, pig and human waste effluents which were evident in this present study was also a possible culprit in the low diversity of molluscs. Not to mention the presence of various types of garbage in the area. Vermeij & Zipser (1986) pointed out that the presence of anthropogenic wastes in the habitat of molluscs caused massive death to numerous individuals. Moreover, Suratissa & Rathnayake (2017) reported that the low diversity and abundance of molluscs in the coast of Fiji Island was suspected to be linked to chemical pollution. This study attributed anthropogenic activities for the low diversity of molluscs in the designated mangrove eco-park in Cabadbaran City.

Table 2

Diversity indices of mangrove-associated molluscs in two sites of La Union, Cabadbaran City

Diversity indices	*Abandoned fishponds*	*Mangroves*
Shannon-Wiener	1.17	1.10
Evenness	0.40	0.37
Dominance	0.45	0.49

Crustaceans. A total of 15 species of crustaceans that belonged to 5 families namely Portunidae, Grapsidae, Ocypodidae, Penaeidae and Paguridae, were documented in the estuary of Brgy. La Union, Cabadbaran City. Commercially important species such as *Scylla serrata*, *Scylla tranquebarica*, *Portunus pelagicus*, *Thalamita crenata* and *Charybdis* *hellerri* belonged to family Portunidae. The *Metopograpsus frontalis* is the only species recorded under family Grapsidae while Family Ocypodidae or the fiddler crabs recorded the most number of species with seven and these were *Uca vocans*, *U. perplexa*, *U. tetragonon*, *U. crassipes*, *U. annulipes*, *Tubuca coarctata* and *T. dussumieri*. *Penaeus monodon* and *Pagurus* sp. belong to family Penaeidae and Paguridae, respectively. Table 3 shows the crustacean species composition at different sites of the designated mangrove eco-park in La Union, Cabadbaran City.

Table 3

The species composition of crustaceans found in two sampling sites in La Union, Cabadbaran City

Family	*Species*	*Abandoned fishponds*	*Mangroves*
Portunidae	*Scylla serrata*	0	3
	Scylla tranquebarica	0	2
	Portunus pelagicus	0	2
	Thalamita crenata	0	11
	Charybdis hellerii	0	5
Grapsidae	*Metopograpsus frontalis*	0	32
Ocypodidae	*Uca vocans*	84	50
	Uca perplexa	23	20
	Uca tetragonon	6	26
	Uca crassipes	22	54
	Uca annulipes	66	97
	Tubuca coarctata	15	9
	Tubuca dussumieri	71	51
Penaeidae	*Penaeus monodon*	0	2
Paguridae	*Pagurus* sp.	46	19
	Total no. of Individuals	333	383
	Total no. of Species	8	15

With regards to species density, *Uca vocans* in abandoned fishpond site appeared to be the most dense species with 0.25 individuals per square meter while *Uca annulipes* found in the mangrove site recorded the same value. *Tubuca dussumieri* came in second with 0.21 individuals per square meter. Generally, Ocypodidae or fiddler crabs dominated the crustacean populations in two different sites of the estuary of La Union, Cabadbaran City. Family Ocypodidae is usually common and plentiful in mangrove settings and their physiological, behavioral and ecological importance were well documented by numerous studies (Carlson 2011; Saher & Qureshi 2011; Rodrigues-Tovar et al 2014; Mokhtari et al 2015). Saher & Qureshi (2011) reported that the density distribution of Ocypodidae crabs were highly related to the sediment characteristics such as organic matter content and porosity. This present study observed the sediment type of La Union, Cabadbaran City to be sandy to muddy type. However, this was not considered in this study. Nevertheless, the density of different species in two different sites can possibly be correlated to the type of sediment present in the site. Building a burrow using a stable substrate allows the efficiency of the crabs to escape from predators (Macintosh 1988). This successful adaptation assures them to increase in reproduction and decrease in mortality. These macrobenthic organisms are well-suited to survive the muddy sediments of the estuary given the fact that these species are burrowing specialists. Physical factors such as soil organic content and porosity are factors that correlate to the density distribution of these species (Saher & Qureshi 2011). Figure 3 shows the density of different crustacean species in La Union.

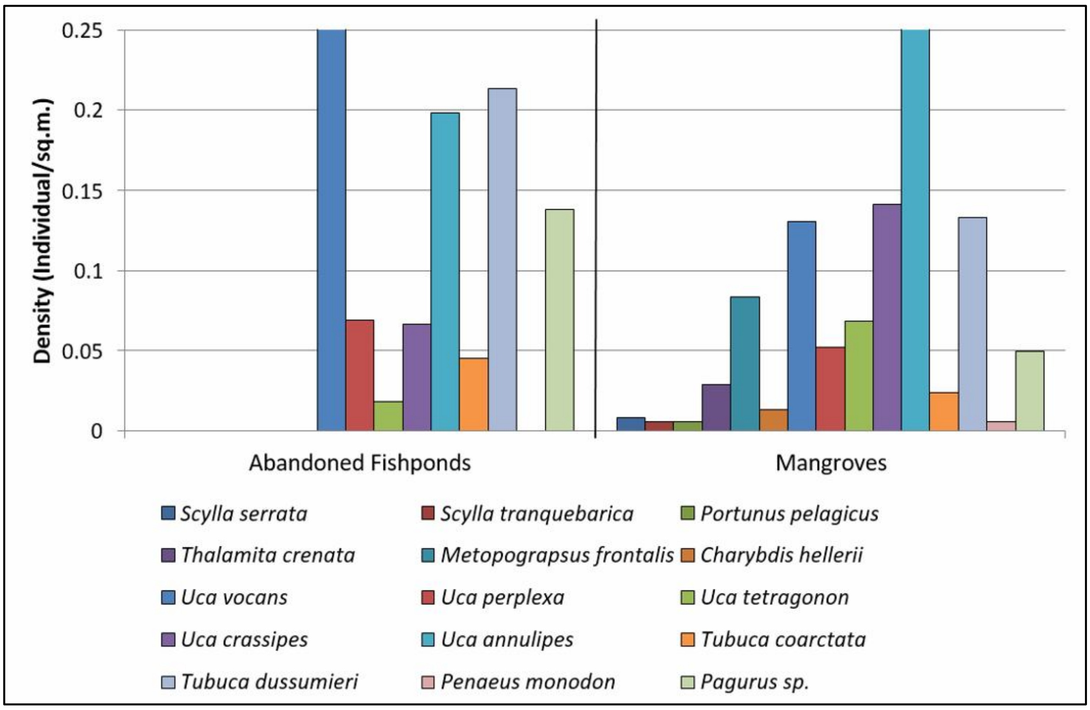

Figure 3. The density (individual per square meter) of different crustacean species found in two different sampling sites of La Union, Cabadbaran City.

According to the results of Shannon-Wiener diversity index, an average value of 2.04 was categorized to be low category. However, between the two sites, mangroves exhibited higher value of Shannon-Wiener diversity index compared to abandoned fishponds. Moreover, evenness and dominance values were higher in abandoned fishpond site than in the mangroves. Despite the large area of 116.9 hectares of mangrove cover, the diversity level of the crustaceans in La Union was still low. The low diversity can be related to the cause of low diversity of mollusc which was anthropogenic activities. Ravichandran et al (2011) identified mangrove crabs as ”keystone species” due to its importance in the mangrove system. As a keystone species, the low diversity of these species in the study area indicated that the eco-park is ecologically disturbed. The continuous disturbance of the mangrove ecosystem in Cabadbaran City must be addressed promptly since crustaceans use mangroves in many different ways. For prawns, postlarvae utilizes vegetated ecosystem such as mangroves to survive before migrating back to the sea (Staples et al 1985). Furthermore, Bosire et al (2004) reported that mangrove is a highly suitable habitat for crabs. As a matter of fact, crabs like the *Uca* sp. highly dominated the mangrove areas in Brazil (Nordhaus 2003). Therefore, the low diversity of crustaceans in La Union, Cabadbaran City called for an prompt rehabilitation actions to revert the collapsing decapod community due to human activities. The diversity indices of decapods in the abandoned fishponds and mangrove site is presented in Table 4.

Table 4

Diversity indices of decapods in two sites of the designated mangrove eco-park in La Union, Cabadbaran City

Diversity indices	*Abandoned fishponds*	*Mangroves*
Shannon-Wiener	1.85	2.22
Evenness	0.79	0.61
Dominance	0.18	0.14

Conclusions. This present study documented the baseline result on the composition, density and diversity of Decapoda and Mollusca community in the designated mangrove eco-park in La Union, Cabadbaran City, Philippines. The result revealed a total 8 species for mollusc and 15 species for crustaceans. *F. ater* was the most dense species of mollusc while two species of fiddler crabs, *U. vocans* and *U. annulipes* revealed to be highly dense for crustaceans. The low category of diversity indices of both group of benthic organisms revealed that the area was greatly disturbed by human activities. Human settlements, commercial aquaculture, pig and human waste effluents, banana and rice plantations and collections of mangrove resources were observed to be the causes of mangrove disturbance in the area. The assessment of decapod and mollusc, as bioindicator, was a helpful tool in determining the ecological status of the mangroves in Cabadbaran City. With the establishment of the Cabadbaran Mangrove Eco-park (CaME), forceful implementation of mangrove rehabilitation may revert the disturbed forest back to its original condition. This study recommend that annual monitoring of macrobethic species must be conducted to determine whether the establishment of the eco-park can sustain the mangrove ecosystem of the city.

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Authors:
Japhet D. Anunciado, Caraga State University Cabadbaran Campus, T. Curato St., 8605, Cabadbaran City, Philippines, e-mail: jdanunciado@csucc.edu.ph
Ailene B. Budiongan, Caraga State University Cabadbaran Campus, T. Curato St., 8605, Cabadbaran City, Philippines, e-mail:abbudiongan@csucc.edu.ph
Wennie C. Angeles, Caraga State University Cabadbaran Campus, T. Curato St., 8605, Cabadbaran City, Philippines, e-mail:wcangeles@csucc.edu.ph
Franklin C. Budoingan, Caraga State University Cabadbaran Campus, T. Curato St., 8605, Cabadbaran City, Philippines, e-mail:fcbudiongan@csucc.edu.ph

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