

Symposium Proceedings

Abundance and diversity of macroinvertebrates along the coral reefs of Lagonoy Gulf with notes on algal herbivory

Michael C. Borejón, Antonino B. Mendoza Jr*, and Joshua Karl B. Bista

Bicol University Tabaco Campus

Abstract

Foundation species, such as macroinvertebrates, are important in marine ecosystems, particularly in reef habitats. Some are herbivores and support corals by consuming algae, which is a competitor to coral. One of the three functional groups important in determining the status of coral reefs is herbivore species. Their relationship in coral and algae is critical in the coral recovery process. Fourteen municipalities including one City along Lagonoy Gulf were assessed the status of Coral reef together with the abundance of macroinvertebrates. Results were obtained from Inside MPA, Outside MPA and non-MPA. Ten species of herbivore macroinvertebrates belonging to 6 families were observed in which *D. setusom* was the most remarkable. Sea urchins were the densest herbivore macroinvertebrates observed in the Gulf, with the densest found in Rawis (a normal reef) at 1.21 ind/m², followed by the Tiwi MPA at 0.74 ind/m². Density of herbivore macroinvertebrates between reefs site were not significantly different ($p > 0.05$). Relationship between density of herbivore macroinvertebrates and macro algal cover shows significant negative correlation. Shannon Diversity Index show low diversity ($h = 1.44$). The role of herbivore macro invertebrates on coral reef resiliency were important considering factors such as herbivore fishes, reef type (MPA or non MPA) and physicochemical factors.

Key words: herbivores, Lagonoy Gulf, resiliency, macroinvertebrates

INTRODUCTION

Coral reefs are among the most productive marine ecosystems in terms of gross productivity (Klump & Pullfrich 1989). Over 500 million people worldwide rely on them for food, storm protection, employment, and recreation. Their resources and services are estimated to be worth 375 billion dollars per year, despite covering less than 1% of the Earth's surface (Obura and Grimsdith 2009). However, coral reefs at the present are under increasing pressure from anthropogenic (illegal fishing, etc.) and natural threats including typhoons, coral bleaching, etc. that causes extreme damage to corals. As a result, coral reefs and the essential ecosystem services they provide are already under threat (Licuanan 2020, Obura and Grimsdith 2009). Due to this phenomenon, it is necessary to determine the health of coral ecosystem although corals are said to be natural resilient (Maynard et al. 2017). In the recent years scientists developed strategies on how to determine the indicator on reef resiliency. According to Maynard et al.

(2017) indicators of resiliency are resistant coral species, coral diversity, Herbivore biomass, coral disease, macro algal cover, Recruitment, Temperature variability, Herbivore diversity, Habitat/structural complexity, mature colonies, light (stress), coral size-class distribution, and substrate suitability.

Herbivory is an ecological process that happens when animals consume plants. (Steneck et al. 2017). Herbivory on coral reefs is dominated by fish herbivore and herbivore macroinvertebrates which is essential and main components to the resilience of coral reefs (Mendoza 2023). Together with the herbivorous reef fishes, they control the growth of algae which is the competitor of corals. The small cover of algae will also pose little competition for corals in terms of space and light (Cervancia et al. 2014). Thus, this is important in the recruitment of corals because newly coral recruit will easily find hard substrate to settle.

A resilient coral reef is one that can withstand or recover from a large-scale stressful occurrence, such as bleaching or overfishing. It means that it can maintain or restore structure

*Correspondence. E-mail: antox.mendoza@gmail.com

and function while remaining in the same 'phase' as before coral mortality (Obura and Grimsdith 2009). As a result, resilient coral reefs are vital for providing sustainable reef ecosystem benefits. Thus, it is necessary to assess the abundance and diversity of herbivore macroinvertebrates in order to determine the health status of coral reefs.

METHODS

Macroinvertebrate survey

Visual census on herbivore macroinvertebrates (sea urchins and marine gastropods) was conducted together with the photo quadrat surveys for coral reef and fish visual census. Using Belt Transect Method (50m x 2m) organisms were recorded and identified from 22 sites in Lagonoy Gulf (8 Marine Protected Area and 8 non-MPA or referred as Regular Reef) with 4 replicates. Sample were photo documented and classified according to family up to the lowest possible taxon.

Data analysis

Density was determined by the number of individual herbivore macroinvertebrate per reef area. Statistical tools used were T-test, ANOVA and Regression at 0.05 confidence level. The data gathered from coral reef survey such as macro

algal cover using Coral Point Count with Excel Extensions (CPCe) were correlated with density of herbivore macroinvertebrates.

Study area

The study was conducted in Lagonoy Gulf located at 13. 4169° N, 124. 0641° E eastern part of Bicol Region, Philippines. Covering three provinces namely Albay, Camarines Sur, and Catanduanes, with 14 municipalities and 1 City. In the North side are the municipalities of Presentacion and Caramoan in Camarines Sur, in the West is the Municipality of Sagnay in Camarines Sur, in the East are the municipalities of San Andres and Virac in Catanduanes, and in the South are the Islands of San Miguel, Cagraray, Batan, and Rapu Rapu in Albay.

A total of 22 sites were selected as study sites (Table 1). Lagonoy Gulf is one of the major fishing grounds in Bicol. Reef-associated species account for more than 60% of all fish caught in the Gulf (Mendoza et al. 2021). It is also a regular path for 6-8 typhoons from the Pacific Ocean each year. (Mendoza & Soliman, 2013). Illegal fishing activities were also present, which contributed to the decline in MPAs along the Gulf. (Mendoza et al. 2021). As a result, resilience in the fishing grounds is vital.

Table 1. Study Sites.

PROVINCE	STUDY SITE	CHARACTERISTICS
Albay (13)	Acal	Small area of reef, deep, very close to the shore
	Dak Puro	Offshore reef, deep, drop off
	Gaba	Fringing reef, shallow, sloping
	Galicia	Fringing reef, deep, sloping
	Malinao IN	Offshore reef, deep, drop off
	Namanday	Offshore reef, drop off, deep
	Rawis	Fringing reef, shallow, drop off
	Sagurong IN	Fringing reef, shallow, sloping
	Sagurong OUT	Fringing reef, shallow drop off
	Tiwi IN	Offshore reef, shallow, flat reef
	Tiwi OUT	Offshore reef, shallow, flat reef
	Uson IN	Fringing reef, deep, sloping
	Uson OUT	Fringing reef, deep, sloping
Camarines Sur (5)	Atulayan IN	Fringing reef, deep, reef flat
	Atulayan OUT	Fringing reef, deep, drop off
	Gamban IN	Offshore reef, shallow, reef flat
	Gamban OUT	Offshore reef, deep, drop off
	Rose Island	Fringing reef, deep, sloping
Catanduanes (4)	Agojo IN	Fringing reef, deep, sloping
	Marilima IN	Fringing reef, shallow, sloping
	Marilima OUT	Fringing reef, deep, reef flat
	Bato	Fringing reef, shallow. sloping

IN – Inside MPA

OUT – Outside MPA

RESULTS AND DISCUSSION

Diversity of herbivore macroinvertebrates

Ten species of herbivore macroinvertebrates belonging to six (6) families were identified in the sampling sites in Lagonoy Gulf (Table 2). The sea urchin families Diadematidae and Toxopneustidae each have 4 and 2 representatives, respectively, while the other sea urchin families (Echinometridae and Echinothuriidae) each have one representative species. In terms of diversity, sea urchins in Lagonoy Gulf are considered to be low, with 10 species compared to the list of Mooi and Munguia (2011) on the diversity of sea urchins in the Philippines, which includes 210 species, but comparable to the study of Sonico (2018), which observed 5 species of sea urchin. One species represents macro gastropods such as spider conch (*Lambis lambis*) and sea snail (*Trochus* sp). The Shannon-Weiner Diversity Index in the Gulf is 1.44, indicating low diversity since a diverse area is characterized if the Shannon-Weiner Diversity Index value is greater than 1.5 (Sonico, 2018).

Abundance and density of herbivore macroinvertebrates

Species abundance shows that *Diadema setosum* is the most abundant with the mean abundance of 35.68 (Table 3). Second to *D. setosum* was *Echinometra mathaei* with 28.18. Most of all the top observed species in Lagonoy Gulf are sea urchins except for *Lambis lambis* which is a macro gastropod. In Addition, high abundance and presence (Table 4) of *D. setosum* in the Gulf was remarkable. This is because *D. setosum* is one of the most frequent intertidal sea urchins in the Indo-Pacific, particularly in coral reef habitats (Walag et al. 2018).

Among MPA, Tiwi has the highest density with 0.73 ind/m² followed by Uson with 0.47 ind/m² while the least was found in Agojo with 0.02 ind/m². However, In outside MPA, Uson has the highest followed by Sagurong with 0.40 ind/m² and 0.17 ind/m² respectively. This result was comparable to the result of the study of Gonzales et al. (2014) in Palawan and Sonico (2018) in Davao which had 300 ind/ha or 0.03 ind/m² and 0.99 ind/m² respectively. Furthermore, among regular reef Rawis has the highest density with 1.21 ind/m² which is also the highest along Lagonoy Gulf whereas the lowest was in Namanday with 0.01 ind/m² which is also the lowest in the

Table 2. Species diversity of Herbivore macroinvertebrates observed in Lagonoy Gulf.

Family	Species	Abundance
Diadematidae	<i>Diadema setosum</i>	905
	<i>Lissodiadema Lorioli</i>	469
	<i>Echinothrix calamaris</i>	75
	<i>Echinothrix diadema</i>	33
Toxopneustidae	<i>Tripneus ventricosus</i>	4
	<i>Tripneustes gratilla</i>	3
Echinometridae	<i>Echinometra mathaei</i>	652
Echinothuriidae	<i>Asthenosoma sp</i>	3
Strombidae	<i>Lambis lambis</i>	84
Trochidae	<i>Trochus sp</i>	32
Total		2260
Shannon Diversity Index		1.44
Evenness		0.624
Species Richness		10

Table 3. The top 5 Most Abundant Herbivore Macroinvertebrates.

Family	Species	English Name	Mean Abundance	Min	Max
Diadematidae	<i>D. setosum</i>	Long spined urchin	35.68	2	445
Echinometridae	<i>E. mathaei</i>	Burrowing urchin	28.18	2	258
Diadematidae	<i>L. lorioli</i>	sea urchin	18.68	29	143
Strombidae	<i>L. lambis</i>	Spider conch	2.95	3	25
Diadematidae	<i>E. calamaris</i>	Black sea urchin	2.72	2	22
Other six species			3.63		

Gulf. In general, the highest and lowest density of herbivore macroinvertebrates are both found in regular reef site (Fig. 1). Abundance and diversity of herbivore macroinvertebrates particularly sea urchins were greatly affected by various physicochemical factors such as temperature, salinity, and pH (Walag et al. 2018; Llacuna et al. 2016). Moreover, presence of more herbivore macro invertebrates signifies degraded state of reef ecosystem however they are also important factor in coral-algal dynamics (Obura & Grimsdith, 2009).

Diadema setusom was omnipresent in Lagonoy Gulf except in Bato, Gamban MPA and Tiwi OUT. *Echinometra mathaei* was present in 14 sites distributed in Regular reef, MPA and Outside MPA. *Lissodiadema lorioli* was found in 4 sites that is mostly in MPA while *Echinothrix calamaris* was found in 7 sites (3 in Regular and MPA, 1 site in Outside MPA). Moreover, *Echinothrix diadema* was present in 5 sites which is distributed mainly in regular reef and MPA site. On the contrary, both species of sea urchin in family Toxopneustidae (*Tripneus pileolus*, and *Tripneustes gratilla*) was only present in Sagurong MPA and *Asthenosoma* sp in Sagurong OUT. *Lambis lambis* on the other hand was present in 6 sites especially in MPA site. However, in terms of number of species, Sagurong MPA was the highest with 7 species, followed by Malinao MPA, then by Uson MPA and Out then by Dakulang Puro and nil in Galicia. It is observed that species richness was high in MPA compared to outside and regular reef. This is because MPAs have a lesser impact from disruptive anthropogenic activities than regular and outside reefs. As a result, the ecological conditions in MPAs were favorable to herbivore macroinvertebrates, whose diversity and abundance are greatly influenced by human activities (Walag et al. 2018; Llacuna et al. 2016). Likewise, no herbivore macro invertebrates obtained in Galicia. This can attributed to the presence of beach resort to the sampling site which can be adverse to the herbivore macro invertebrates.

Analysis of Variance (ANOVA) shows that the abundance or density of herbivore macroinvertebrates between reefs site were not significantly different ($p > 0.05$). The result of the present study is in contrary with the findings of Samuel et al (2017) in Indonesia that the difference in locations has a significant effect on the abundance of sea urchins. In the MPAs, only Gamban in and Gamban out has significant difference in terms of density of herbivore macroinvertebrates with p value of 2.6619E-06.

Herbivore macroinvertebrates as Indicator in reef resiliency

Herbivore macroinvertebrates consume mostly algae (Fig. 2). They control algae growth by feeding on it. It is beneficial to the coral considering algae compete for space with the corals. Together with herbivore reef fishes, they can consume a large number of seaweeds, up to 90% of their daily production, thereby maintaining a grazing area and preventing the establishment of an algal community (Mendoza, 2023). As a result, the higher the herbivore macroinvertebrates, the lower the algal cover and the higher the coral cover. Higher coral cover indicates that the reefs are also resilient (Maynard et al. 2017)

The result of this study shows significant negative correlation between densities of sea urchin to algal composition similar to the study of Ishikawa et al. (2016) and Benayahu, (1977). This means that there is an effect on algal composition with the density of herbivore macroinvertebrates. Although there were areas that showed opposite, where there were more counts of algae and relatively high density of macro inverts (Wright et.al, 2005: Alves et.al, 2001: Francis et. al, 2019; Samuel et al. 2017). Herbivore macroinvertebrates becomes denser when there is a presence of food. After that, they move to another place to find more food. This situation can explain why in some instances there are areas with high

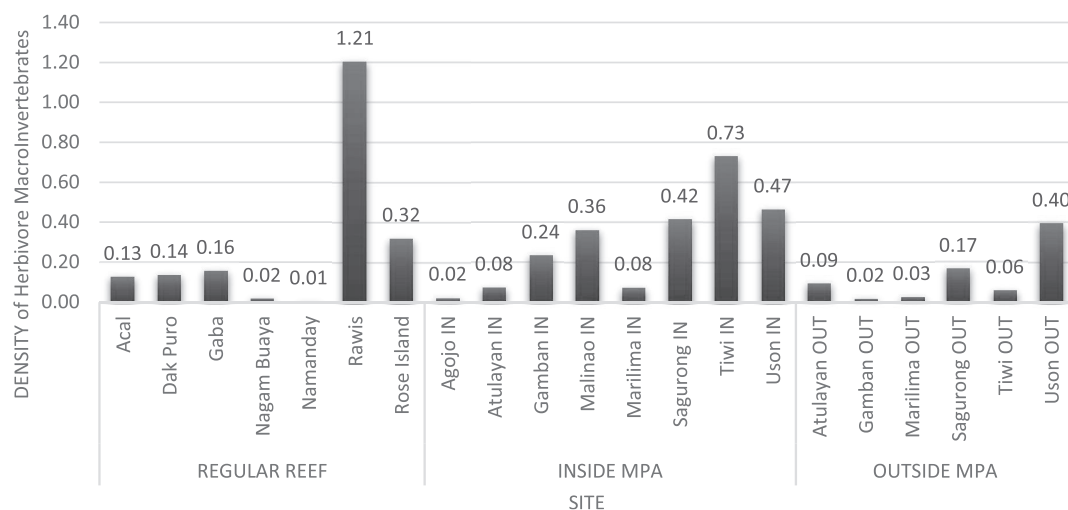


Fig. 1. Density of herbivore macroinvertebrates along Lagonoy Gulf.

Abundance and diversity of macroinvertebrates along the coral reefs of Lagonoy Gulf

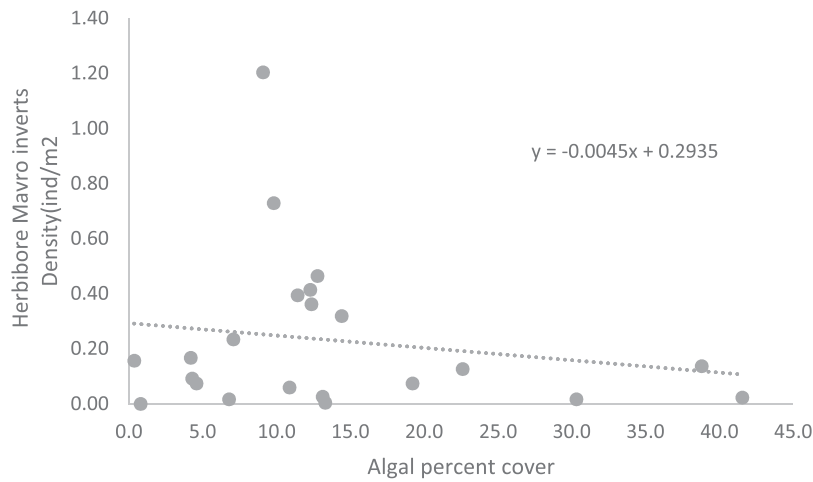


Fig. 2. Relationship between density of herbivore macroinvertebrates and macro algal cover.

density of macroinvertebrates and high dense algae and seagrass at the same time. On the other hand, we can find areas with low algal density and low macroinvertebrate count. This could mean that most of them had already moved to nearby areas with denser algal cover. This situation occurred because of several of factors, including the time of sampling. Almost all fleshy macro algae removal was done by nocturnal macroinvertebrates (Francis et al, 2019). Nocturnal macroinvertebrates can be seen during night. This organism may be overlooked if samples are taken during the day. Another is that the density of herbivore macroinvertebrates such as sea urchins is greatly influenced by water environmental conditions (Samuel et al. 2017; Walag et al. 2018; Llacuna et al. 2016). Likewise, in the study of Alves et. al (2001) suggest that a high algal cover does not prevent sea urchins from occurring in high densities. This means that dense cover of algae can have a higher densities of sea urchins. Furthermore, herbivory on coral reefs is associated both fish and invertebrate herbivores. Measuring their diversity and biomass are indicators in reef resiliency (Maynard et. al 2017). Study of Korzen et al (2011) shows that the impact of removal

of algae and coral spats, was due to daily grazing by fishes, whereas the sea urchins show their significant impact greatly on coral recruits.

Figure 3 shows a decrease in algal cover from 25% to 9% in just 6 weeks. This was a result of an undergraduate study of students of their *in-situ* experiment on sea urchin. The blue line represents the algal cover with herbivores while the orange line represents the algal cover without herbivores. There was a decreased in the percent cover of algae through time. Other study also showed that there is drastically decrease in cover, biomass and density of algae particularly *Sargassum spp.* when there is presence of sea urchin (Ishikawa et al. 2016). This is because sea urchins feed mainly in macro algae (Francis et. al, 2019).

CONCLUSION AND RECOMMENDATION

Herbivore macroinvertebrates in Lagonoy Gulf are found to be interacting with corals and algae creating a more balance reef ecosystem. *D. setusom* was the most remarkable herbivore macroinvertebrates in which it also the most common sea

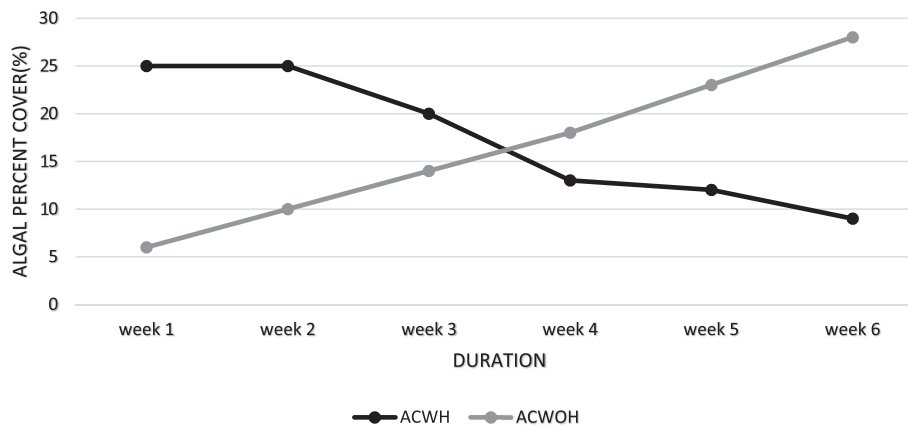


Fig. 3. Result of Macroinvertebrates-Algal Herbivory Study for 6 weeks.

urchin. Diversity of herbivore macroinvertebrates in Lagonoy Gulf were low compared to other studies but comparable in terms of abundance in density. Moreover, they are good indicators in coral reef resiliency because they provide space for coral settlement and development by consuming algae.

Future further investigations on herbivorous macroinvertebrates on coral settlement and development is highly recommended as coral recruits is also one of the indicators of resiliency. It also recommended to investigate the physicochemical parameters since it affects the distribution of herbivore macroinvertebrates.

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