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Marine macroalgal diversity assessment of Biri Island and Dalupirit Island, Northern Samar, Philippines

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The Philippines with 7,641 islands is considered to have one of the most diverse aquatic ecosystem endowed with rich marine flora. This study focused on the assessment of macroalgae in the two islands of Northern Samar, Biri Island and Dalupirit Island, as well as their diversity, abundance and distribution. During collection on July 2016, the complete thalli of live specimens were gathered and their counts and distribution patterns were determined by using 15 quadrats in Dalupirit Island and 26 quadrats in Biri Island. A transect line length of 150 m and 260 m were used, respectively. About 86 macroalgal taxa were gathered and identified for both islands in which 22 out of the 86 taxa were found common to both islands. In Biri Island, 57 taxa were found with 35 being unique to the island. In Dalupirit Island, 51 taxa were identified with 29 being unique to the island. Rhodophyceae showed dominance both in Biri Island and Dalupirit Island having 46% and 43%, respectively, followed by Chlorophyceae with 33% in Biri Island, and 39% in Dalupirit Island, and lastly, Phaeophyceae having 19% for Biri Island and 20% for Dalupirit Island. In terms of percent cover, Phaeophyceae and Chlorophyceae are the most abundant in Biri Island and Dalupirit Island, respectively. *Padina japonica* is the most evenly distributed in Biri Island while *Ulva reticulata* is the most evenly distributed in Dalupirit Island.

Keywords: Biri Island, Chlorophyceae, Dalupirit Island, Macroalgae, Phaeophyceae, Rhodophyceae

Introduction

Situated at the apex of the coral triangle, the Philippines is known to be the richest marine eco-region in the world. With its 7,641 islands, the long coastline has provided a suitable habitat for seaweeds or macroalgae. Seaweeds contribute largely to marine production as evidenced by their presence in algal beds and reefs.

Seaweeds can also grow in shallow waters where they are found in estuaries and brackish waters thriving on substrates such as rocks, dead corals, pebbles, shells, and other plant materials. They

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contribute to the trophic structure in the coastal ecosystem where most marine animals feed and live on them.

In the Philippines, works on algae started in the 1960's when Filipino phycologists participated in algal research especially in the field of algal taxonomy. As early as the 1960s, studies on Philippine marine algae of the Hundred Islands were done by Meñez [1], followed by the significant contributions of Cordero [2] on the red algae, and Trono [3] on the marine benthic algae.

In the 1980s, notable works on macroalgae were contributed by Cordero [4]1980, Liao and Sotto [5] in Cebu, Marcos-Agngarayngay [6, 7] in Ilocos Norte, and Hurtado-Ponce *et al.* [8], in Panay Island. In the past decade, some interesting species included in the checklist of macroalgae from Southern Philippines were recorded by Geraldino *et al.* [9]. Following this was an updated names of taxa of the three major phyla of marine macroalgae from the Philippines by Ang *et al.* [10].

More recently, interest on utilization of macroalgae resulted to discovery of some bioactive substances present in the plant itself. Preliminary studies on phytochemical screening and antioxidant activity of some brown algae *Sargassum* species from Eastern Samar was conducted by Balanguit and Fuentes [11].

Among Philippines islands are Biri and Dalupirit, both lying in the east central periphery of the country, part of the Northern Samar in Eastern Visayas. At present, there has been no information available on the marine macroalgal flora of Biri Island and its adjacent islands. Therefore, it is the purpose of this research to contribute initial information on the marine macroalgal composition and distribution in the major islands of Northern Samar such as the Biri Island and Dalupirit Island. In addition, the study aims to determine the diversity, abundance, and dominance of macroalgae in both islands. This paper will add to the present available information on the distribution, species composition and diversity of macroalgal species in the Philippines.

Methodology

Study sites. The study sites are located along the coastal area of Northern Samar province (Fig. 1) 12°41'18" N, 124°'22"49 E for Biri Island and 12°26'0" N, 124°14'32" E for Dalupirit Island. The island of Dalupirit is a semi-exposed area because it is found within the internal waters of the Philippines. On the other hand, Biri Island is an exposed area located in the periphery of the Philippine archipelago facing directly to the Pacific Ocean. Dalupirit Island is characterized by its sandy beaches, while the natural habitat of Biri Island consists of naturally sculptured rock formations along the northern shore. The distance of the island of Biri and Dalupirit is approximately 32.1 km.

Sampling procedures. Random quadrat and transect line were used in order to determine the algal counts and distribution patterns. During the collection conducted on July 2016, transect lines were laid in an area where there was a gradual transition between substrates. In Dalupirit Island, the transect line consisted of 150 m long plastic twine. On the other hand, 260 m long plastic twine was used for Biri Island. Both transect lines were marked at every 10 m.

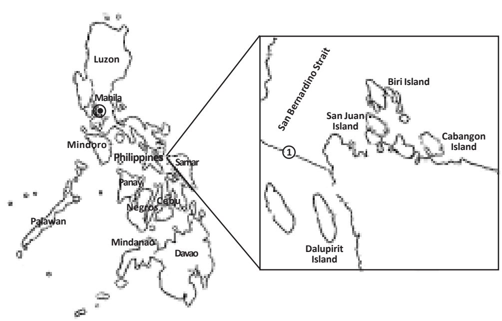

Figure 1. Map of Biri Island and Dalupirit Island, Northern Samar, Philippines

The quadrats measured at 0.5 × 0.5 m of polymerize vinyl chloride (PVC) pipes. The division for the regions of the quadrat was made via computer creating 25 regions within the quadrat. The sampling for the quadrats was done by randomly tossing the quadrat along the inner and outer sides of the transect lines every 10 m.

Collection and preservation of specimens. Macroalgae were gathered by wading or snorkeling. The complete thalli of live specimens were collected by hand and/or by using a shovel. Quadrats and macroalgal specimens that were gathered were photographed using an underwater camera (GoPro). Specimens were then placed inside a zip lock containing 95% salt water and 5% formaldehyde. The zip locks were then labeled with the quadrat number, specimen number and location. Afterwards, zip locks with specimens and water samples were then placed in a cooler box for preservation and protection from external temperature. The icebox was then transported to the laboratory for specimen cleaning, preservation, herbarium and identification.

In the UST Graduate School Laboratory, herbarium specimens were prepared initially by removing sediments from the specimens, letting the water flow through it and using a horse brush to remove smaller stones and debris attached to the specimens. Cleaned specimens were allowed to dry and were glued on to a Bristol board by using PVC glue. The different macroalgal genera were classified accordingly as red, green, or brown algae. Classification was based on Ganzon-Fortes [12] and Ang *et al.* [10] and identification by gross morphology and internal features following the works of Cordero [2, 4]. Final verification of the specimens was done by Dr. Paciente A. Cordero Jr., a distinguished seaweed taxonomist in the Philippines.

Results

Macroalgal composition of Biri Island and Dalupirit Island. A total of 86 macroalgal taxa were identified for both sites. All collections represented the three classes of macroalgae (Table 1): Rhodophyceae (red algae), Chlorophyceae (green algae), and

Table 1. Checklist of the 86 macroalgal taxa in Biri Island and Dalupirit Island

Genera	Biri Island	Dalupirit Island
Chlorophyta (33)		
Anadyomene plicata C. Agardh 1823	X	
Avrainvillea lacerata Harvey ex J. Agardh 1887		X
Boergesenia forbesii (Harvey) Feldmann 1938	X	X
Boergesenia sp.	X	
Boodlea composita (Harvey) F. Brand 1904	X	
Boodlea sp.		X
Boodlea struveoides M. Howe 1918	X	
Caulerpa cupressoides (M. Vahl) C. Agardh 1817	X	
Caulerpa racemosa (Forsskal̓) J. Agardh 1873	X	
Caulerpa serrulata (Forsskal̓) J. Agardh 1837	X	
Caulerpa sertularioides (S. G. Gmelin) M.A. Howe 1905	X	
Caulerpa taxifolia (M. Vahl) C. Agardh 1817	X	
Centroceras clavulatum (C. Agardh) Montagne 1846	X	
Centroceras sp.	X	
Chaetoceros calcitrans (Paulsen) H.Takano 1968		X
Chaetomorpha crassa (C. Agardh) Kuťzing 1845		X
Chaetomorpha sp.	X	X
Cladophora albida (Nees) Kuťzing 1843		X

Table 1. (Continuation)

Cladophora sp.		X
Cladophoropsis gracillima E. Y. Dawson 1950	X	
Cladophoropsis sp.		X
Codium sp.		X
Enteromorpha chaetomorphoides Børgesen 1911		X
Enteromorpha sp.		X
Halimeda macroloba Decaisne 1841	X	X
Halimeda opuntia (Linnaeus) J. V. Lamouroux 1816	X	X
Halimeda sp.	X	
Ulva lactuca Linnaeus 1753		X
Ulva pertusa Kjellman 1897		X
Ulva reticulata Forsskal 1775	X	X
Ulva sp.		X
Valonia fastigiata Harvey ex J. Agardh 1887	X	
Valonia ventricosa J. Agardh 1887		X
Phaeophyta (14)		
Dictyota cervicornis (Kutzing) De Paula & De Clerck 2006	X	X
Dictyota dichotoma (Hudson) J. V.		X
Hormophysa triquetra (C. Agardh) Kützing 1843	X	X
Padina australis Hauck 1887	X	X
Padina japonica Yamada 1931	X	
Padina minor Yamada 1925	X	X
Padina sp.	X	X
Padina tetrastromatica Hauck 1887	X	X
Sargassum crassifolium J. Agardh 1848		X
Sargassum currimaoense G. C. Trono 1994	X	
Sargassum hemiphyllum (Turner) C. Agardh 1820	X	X
Sargassum piluliferum (Turner) C. Agardh 1820		X
Sargassum polycystum C. Agardh 1824	X	
Sargassum sp.	X	
Rhodophyta (39)		
Acanthophora sp.	X	
Acanthophora spicifera (M. Vahl) Børgesen 1910	X	
Amphiroa fragilissima (Linnaeus) J.V. Lamouroux 1816	X	X
Amphiroa sp.	X	
Coelothrix irregularis (Harvey) Børgesen 1920	X	X
Corallina sp.	X	X
Eucheuma sp.	X	
Galaxaura falcata Kjellman 1900	X	
Galaxaura fastigiata Decaisne 1842	X	
Gelidiella acerosa (Forsskål) Feldmann & Hamel 1934	X	X
Gelidiopsis intricata (C.Agardh) Vickers 1905	X	
Gelidiopsis repens (Kützing) Weber-van Bosse 1928		X
Gelidiopsis sp.	X	
Gelidium sp.		X
Gracilaria bursa-pastoris (S. G. Gmelin) P. C.Silva 1952	X	X
Gracilaria confervoides (Linnaeus) Greville 1830		X
Gracilaria fastigiata J. Agardh 1852		X
Gracilaria opuntia Durairatnam 1962	X	
Gracilaria salicornia (C. Agardh) E. Y. Dawson 1954	X	
Gracilaria sp.	X	X

Table 1. (Continuation)

Hypnea cervicornis J. Agardh 1851		X
Hypnea charoides J. V. Lamouroux 1813		X
Hypnea esperi Bory 1828		X
Hypnea musciformis (Wulfen) J. V. Lamouroux 1813		X
Hypnea seticulosa J. Agardh 1851	X	X
Hypnea sp.	X	X
Hypnea valentiae (Turner) Montagne 1841	X	
Jania adhaerens J.V. Lamouroux 1816	X	
Jania sp.	X	
Laurencia intermedia Yamada 1931	X	X
Laurencia obtusa (Hudson) J. V. Lamouroux 1813		X
Laurencia papillosa (C. Agardh) Greville 1830		X
Laurencia sp.	X	X
Leveillea jungermannioides (Hering & G. Martens Harvey 1855)	X	
Mastophora rosea (C. Agardh) Setchell 1943		X
Neurymenia fraxinifolia (Mertens ex Turner) J. Agardh 1863		X
Peyssonnelia rubra (Greville) J. Agardh 1851	X	
Rhodymenia sp.	X	
Spyridia sp.	X	

Phaeophyceae (brown algae). Out of 86 genera, 39 (46%) belong to the Rhodophyceae, 33 (38%) for Chlorophyceae and lastly, 14 (16%) for Phaeophyceae. Of the 86 identified taxa, 62 were listed on the species rank and 24 on the genus rank.

From the total of 86 taxa, 22 were found common in both islands (Fig. 2). In Biri Island, 57 taxa were identified and only 35 were found unique. In Dalupirit Island, 51 taxa were identified although only 29 taxa were found unique.

In Biri Island, 46% belongs to Rhodophyceae, followed by Cholorophyceae with 33% and lastly, Phaeophyceae having 19%. In Dalupirit Island, 43% belongs to Rhodophyceae, followed by Chlorophyceae with 39%, and lastly, Phaeophyceae with 20% (Fig. 2).

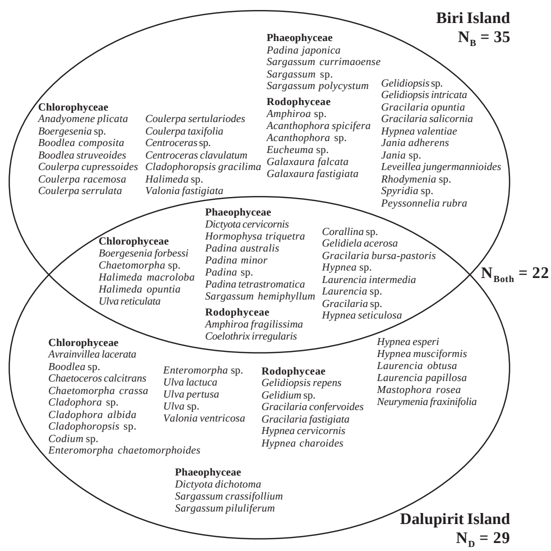

Figure 2. Venn diagram of macroalgal composition in Biri Island and Dalupirit Island

Distribution and abundance of macroalgae in Biri Island and Dalupirit Island. The substratum or rock empty spaces showed 27% cover in Biri Island. Phaeophyceae had the greatest percent cover with 36%, followed by Chlorophyceae with 21% and the least is Rhodophyceae with 17% (Fig. 3). In Dalupirit Island, seagrass dominated with 46% cover and the subratum or rock empty spaces with 10%. Chlorophyceae had the greatest percent cover with 20%, followed by Rhodophyceae with 16% and the least is Phaeophyceae with 9% cover (Fig. 3).

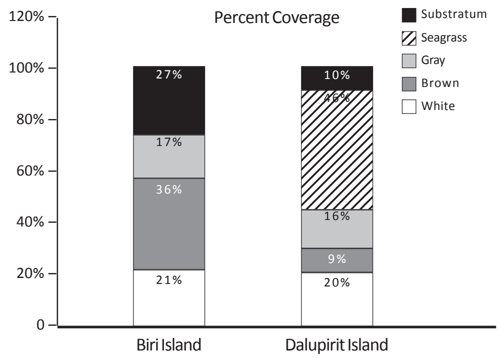

Figure 3. Percent cover in Biri Island and Dalupirit Island

In Fig. 4, most of the genera present in Biri Island are evenly distributed. On the other hand, most of the genera in Dalupirit Island are not evenly distributed.

Furthermore in Biri Island, *Padina japonica* is the most evenly distributed being present in 21 out of 26 quadrats. In Dalupirit Island, *Ulva reticulata* is the most evenly distributed being present in eight out of 15 quadrats (Fig. 4).

Discussion

In the Philippines, there are 543 published species of red algae, 197 species of green algae and 153 species of brown algae or a total of 893 species of macroalgae by Ang *et al.* [10]. In the present study, 86 taxa were identified with 62 species and 24 genera suggested as new records on the available literature of the marine flora and phytogeographic map in Northern Samar (Table 1).

Rhodophyceae showed the most number of species collected in both sites (Fig. 2). According to Lee [13], there are more Rhodophyceae in the world than all of the other major seaweed groups combined. Although marine red algae occur at all latitudes, there is a marked shift in their abundance from the equator to colder seas. There are few species in polar and subpolar while in temperate and tropical regions, the red algae predominates. This class have multicellular rhizoidal holdfast that serves as a strong attachment of thalli to substrates. In addition, Rhodophyceae have multiple life stages that help in their adaptation for survival. Their triphasic life cycle also explains why compared to brown and green algae, red algae are the most adaptable and morphologically diverse [14].

The lowest number of species collected in both sites belong to the class Phaeophyceae (Fig. 2). Since majority of the brown algae could be seen in the temperate region rather than the tropical region, it is expected to have low species diversity in the Philippines [14].

For marine algae, water motion affects almost every aspect of their ecology including their distribution and abundance across habitats of different wave pressure [15] as observed in Biri Island, and the distribution of gases and nutrients [16, 17]. This will ultimately affect growth and their reproduction capacity [18], thus affecting their morphology [19, 20]. Water motion can also influence both static shape of an organism directly [19]. Macroalgae found in exposed intertidal zone (Biri Island) are tougher and shorter with narrower thalli, therefore they are more prone to wave motion compared to those growing in calmer areas [21] as exemplified by Dalupirit Island.

Brown algae species had the greatest cover in Biri Island (Fig. 3). Generally, brown algae exhibit larger biomasses than red algae due to their larger size [22]. Most brown algae species normally grow on bedrock, which is the substratum of Biri Island [23]. Brown algae in the intertidal zone exposed to wave action are usually tougher and shorter, with narrower thalli and are therefore more susceptible to action waves than those growing in calmer areas [21]. Among the brown algal species that were collected, one of the most prominent was from the genus *Sargassum*. *Sargassum* is widely distributed in the intertidal and shallow sub tidal rocky substrata of the tropical and subtropical coastal waters including the Philippines [24, 25]. *Sargassum* species are tough with its massive holdfast and can easily withstand wave motion. The presence of air bladders aid them float or stay upright, thus helping them to resist/tolerate strong wave motion.

The percent cover of green algae in Dalupirit Island is most abundant compared to red and brown algae (Fig. 3). This is due to fact that the water motion in Dalupirit Island is slow moving because of the islands protecting the site. For instance, the holdfast of the green alga like *Halimeda* is not strong enough compared to

Figure 4. Presence and absence of genera per quadrat in Biri Island and Dalupirit Island

other algae when it comes to fast moving water motion [14]. Seagrasses, also, have a huge percent cover in Dalupirit Island. One of the possible reasons for this is that they usually grow in sheltered coastal waters or bays, typified by Dalupirit Island due to its surrounding islands. Its short structure makes it capable of burrowing their roots in sandy or muddy areas complemented with good light. Generally, sheet-like and filamentous seaweeds, such as *Ulva* sp. and *Cladophora* sp., are dominant in unstable or polluted habitats [26–28].

In Biri Island, Phaeophyceae showed dominance than the other two classes (Fig.4). High dominance in species of Phaeophyceae means low diversity. Species of the marine brown algal genus *Padina* are widely distributed throughout the tropics [9]. *Padina japonica* belongs to Order Dictyotales and species that belong to this group are commonly found in warmer waters [14]. The lifecycle of *Padina japonica* is dominated by the sporophyte generation. The sporophyte dominance may be due to its greater resistance (longevity of individuals) to water movement that helps them establish their population [29]. This can be a possible reason for the evenness in the distribution of *Padina japonica* in Biri Island. Phaeophyceae showed dominance, but the distribution of the macroalgae in Biri Island is uneven.

Ulva reticulata is the most evenly distributed in Dalupirit Island (Fig. 4). It belongs to Class Ulvaceae, which are predominantly marine species. The growth of this species is not primarily influenced by water motion; rather it is influenced by lunar cycle [14]. The influence of lunar cycle in the growth of *Ulva* rather can be a possible reason why they are evenly distributed in Dalupirit Island. *Ulva* is also proliferated in many areas that receive anthropogenic nutrients [14]. Dalupirit Island consists of residential communities that contribute to anthropogenic nutrients, which makes it a suitable environment for *Ulva reticulata*. Also, a feature of nuisance growths of *Ulva* in enclosed and semi-enclosed waters as this compromises a large proportions of drift plants [14]. Since the species in Dalupirit Island did not show pronounced dominance, we could say that their distribution is even.

Conclusion

This paper easily provides a first account on the marine macroalgae in Biri Island and Dalupirit Island which reported a total of 86 taxa of which 62 were listed on the species rank and 24 on the genus rank. Collectively, the most number of species identified belongs to the Class Rhodophyceae, followed by Chlorophyceae and lastly, Phaeophyceae. By comparison of the percent cover, brown algae are the most abundant in Biri Island while green algae are the most abundant in Dalupirit Island. In terms of distribution, the macroalgae in Dalupirit Island showed evenness while in Biri Island, unevenness was exhibited due to some species dominance and possibly, temporally varied physico-chemical conditions. Thus, based on the above, Dalupirit Island is highly diverse than Biri Island.

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