Species composition, abundance and diversity of seaweeds along the intertidal zone of Nangaramoan, San Vicente, Sta. Ana, Cagayan, Philippines

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Abstract. This study was conducted to determine the species composition, abundance and diversity of seaweeds found along the intertidal zone of Nangaramoan, San Vicente, Sta. Ana, Cagayan. The line transect method was used to identify and quantify the seaweeds abounding the three established stations divided into five quadrates. Representative specimens were also taken and seaweed-associated flora and fauna were documented. A total of 31 different species of seaweeds were identified in the study area belonging Rhodophyta (Galaxauraceae, Gelidiellaceae, Corallinaceae, Gracilariaceae, Solieriaceae, Lomentariceae, Rhodomelaceae, Rhodymeniaceae), Phaeophyta (Dictyotaceae, Cystoseiraceae, Scytosiphonaceae, Sargassaceae) and Chlorophyta (Ulvaceae, Anadyomenaceae, Siphonocladaceae, Caulerpaceae, Halimedaceae, Dasycladaceae). The most abundant seaweed species across the three stations are: *Turbinaria ornata, Mastophora rosea, Coelothix irregularis, Padina australis, Padina sanctae-crucis, Padina minor, Ulva clathrata, Ulva fasciata, Chaetomorpha crassa, Caulerpa racemosa* and *Halimeda opuntia*. The seaweed species identified also have different densities ranging from 0.002 to 7.955 per m^2. *P. sanctae-crusis* had the highest density. With regards to frequency and relative frequency, *C. irregularis, P. australis, P. sanctae-crucis, P. minor, T. ornata, U. fasciata,* and *C. crassa*, appear in all 15 quadrates in Station 1, 2 and 3. Species richness, repetition index, Simpson's indices of diversity and its reciprocal were calculated to determine diversity of seaweeds along the study area. Station 3 obtained the highest species richness and repetition index. On the other hand, Station 2 recorded the highest diversity as indicated by the Simpson's index. When subjected to Simpson's index of diversity and Simpson's reciprocal index analyses, Station 2 also obtained the highest diversity. The intertidal zone of Nangaramoan San Vicente, Sta. Ana Cagayan has a diverse species of seaweeds as indicated by the results of abundance, distribution and diversity indices.
Key Words: species diversity, distribution, density, species richness, frequency.

Introduction. The Philippines has more than 390 species of seaweeds with known economic value (Trono & Ganzon-Fortes 1988). These plants dominate the marine flora in wide ranging type of habitat associated with a high diverse form of animal life. Many of the rocky beaches, mudflats, estuaries, coral reefs and lagoons along the Philippines coast provide ideal habitats for the growth of seaweeds (Rao & Mantri 2006).

Seaweeds are the macro benthic (large and attached) forms of marine algae. They are among the large primary producers in the shallow areas in the seas and oceans. They are able to manufacture or synthesize organic compounds from the simple compounds such as water and carbon dioxide in the presence of light as a source of energy because of their photosynthetic pigment which come in the different forms, e.g. chlorophylls (green), carotenoids (orange, brown), phycobilins (red and blue) and other accessory pigment. Seaweeds are named after the dominant photosynthetic pigment they posses. Thus, they are called red, brown, green and blue-green algae (Trono & Ganzon-Fortes 1988).

Seaweeds are limited to their distribution from the lower intertidal to the shallow subtidal zones in the marine environment. In general, the large forms are mainly concentrated in areas at, or a few meters below the 0 datum level. The differences in their vertical and horizontal distribution are reflective of their adaptability to the ambient conditions in the habitats. Thus, some species are found only in the sheltered bays and coves while others may be limited to the rocky exposed along the shore or margins of the reef. Many other species are found in a variety of intergrading environments the presence or absence of species in a habitat is therefore, the result of the combined and synergistic effects of the various physico-chemical factors on the distribution algae (Trono & Ganzon-Fortes 1988).

One basic problem which prevents the rapid development of the seaweeds resources in the Philippines and in other developing countries in the tropics is the lack of information on the identities and diversity economically important seaweeds species. The most common problem in the development and exploitation of natural stocks of economically important seaweeds species is lack of information on the kind of species, the amount of biomass available, where they are found, and when they are most profitable to harvest (Trono 1991).

Literature on the taxonomy of commercially-important seaweeds is very meager. The correct name attached to seaweed is very important because it is clue to the identity of the species which is the basis for determining the value of the product (Trono 1991).

The results of the study will provide baseline information on the species composition, abundance and diversity of seaweeds abounding the research area. Academic and research institutions may use this as a baseline information for the further exploration of the potentials of locally available seaweeds. The result may also be used by policy as a basis for formulating and implementing guidelines for coastal resources management.

This study was conducted to determine the species composition, abundance and diversity of seaweeds found along the intertidal zone of Nangaramoan, San Vicente, Sta. Ana, Cagayan, Philippines.

Material and Method

Study area. The study was conducted along the intertidal zone of Nangaramoan (coordinates: 18º31'14.33" N, 122º12'54.66" E), San Vicente, Sta. Ana, Cagayan, Philippines. The intertidal zone of the area is mainly characterized by rocky substrata composed primarily of dead and live corrals. At low tide, part of the area is exposed to direct sunlight. The sandy portion of the area is mainly dominated by seagrasses. The transect line method was used for identification, enumeration and collection of samples from intertidal and sub-tidal regions. The areas were divided into three stations along the study area. Each station is measured 500 m^2 and is divided into 5 quadrates measuring 10 m x 10 m. The distance between stations were 90 m.

Identification and enumeration of samples. Seaweeds were identified based on the following literature: "The seaweeds of Panay" by Hurtado et al (2006), "Field guide and atlas of the seaweed resources of the Philippines by Trono (1997), and "Philippine seaweeds" by Trono & Ganzon-Fortes (1988). The seaweeds were observed and enumerated during the low tide from tidal flats of rocky area through their color and particular division or group to which they belong. The green seaweeds (Chlorophyta) are almost green, although some species may be yellow green or brownish green. The brown seaweeds (Phaeophyta) are usually light to dark brown, yellow brown, brownish red, orange brown but others may be bluish-green. Seaweeds that are red or purple even in part usually belong to Rhodophyta.

Preservation of sample specimens. Representative samples from each identified seaweed species were collected. The station and quadrate from which the seaweed was collected were also recorded. The representative samples were preserved in 15% formaldehyde diluted in seawater. The samples were later measured and the distinguishing features were recorded.

Abundance and distribution. The abundance of species was determined by counting the total population in each station and using the following scale recommended by Odum

(1955): - Not found; + Rare- more than 1; ++ Few- more than 10 ; +++ Many- more than 20; ++++ Abundant- more than 50.

Density. This is measured by counting the total number of individuals divided by the total area.

Relative density. Relative density of a species is measured by counting the number of one kind of species and comparing these species against the total number of different species.

Frequency. Frequency was measured by counting the number of quadrates that contains individuals of a species.

Relative frequency. This is measured by counting the frequency of one species expressed as a percentage of the sum of frequency values for all species present.

Species richness. This was measured by counting the number of different kinds of species present in a particular area (Hickman et al 2007).

Repetition index. This index represents the estimate of the minimum number of sub-samples necessary to cover all diversity present in a group of samples. This is computed by dividing species richness by the number of species present in the area.

Simpson's index (D). This parameter measures the probability that two individuals randomly selected from a sample will belong to the same species. With this index, 0 represents infinite diversity and 1, no diversity. That is the bigger the value of D, the lower the diversity (Simpson 1949). This is computed with the formula:

$$D = \frac{\Sigma\, n\,(n-1)}{N\,(N-1)}$$

Where:

n = the total number of organisms of a particular species
N = the total number of organisms of all species.

Simpson's index of diversity (1-D). This refers to the value ranging between 0 and 1; the greater the value, the greater the sample diversity.

Simpson's reciprocal index (1/D). The value of this Index starts with 1 as the lowest possible figure. This figure would represent a community containing only one species. The higher the value, the greater the diversity. The maximum value is the number of species in the study area (Simpson 1949).

Results and Discussion

Species composition. There were 31 species of seaweeds identified from 17 families belonging to Rhodophyta, Phaeophyta, Chlorophyta (Table 1).

Table 1

Summary of identified seaweeds species

Class	*Order*	*Family*	*Scientific Name*
RHODOPHYCEAE	Nemaliales	Galaxauraceae	*Actinotrichia fragilis*
	Gelidiales	Gelidiellaceae	*Gelidiella acerosa*
	Corallinales	Corallinaceae	*Amphiroa faliacea* *Cheilosporum cultratum* *Mastophora rosea*
	Gracilariales	Gracilariaceae	*Gracilaria edulis* *Gracilaria eucheumatiodes*
	Corallinales	Solieriaceae	*Eucheuma denticulatum* *Kappaphycus striatum*
	Rhodymeniales	Lomentariceae Rhodomelaceae Rhodymeniaceae	*Ceratodictyon spongiosum* *Polysiphonia fragilis* *Coelothix irregularis*
PHAEOPHYCEAE	Dictyotales	Dictyotaceae	*Padina australis* *Padina sanctae-crucis* *Padina minor*
	Fucales	Cystoseiraceae	*Hormophysa cuneiformis*
		Sargassaceae	*Sargassum crassifolium* *Sargassum oligocystum* *Turbinaria conoides* *Turbinaria ornata*
CHLOROPHYCEAE	Ulvales	Ulvaceae	*Ulva clathrata* *Ulva fasciata*
	Cladophorales	Anadyomenaceae	*Chaetomorpha crassa*
	Siphonocladales	Siphonocladaceae	*Boergesenia forbesii*
	Caulerpales	Caulerpaceae	*Caulerpa lentillifera* *Caulerpa racemosa*
		Halimedaceae	*Halimeda macrolaba* *Halimeda opuntia* *Halimeda tuna* *Halimeda cylindracea*
	Dasycladales	Dasycladaceae	*Bornotella spherical*

Abundance and distribution. The abundance and distribution of seaweeds found along the intertidal zone of Nangaramoan, San Vicente, Sta. Ana, Cagayan, Philippines is shown in Table 2. Results showed that the most abundant species in all the three stations are: *T. ornata, M. rosea, C. irregularis, P. australis, P. sanctae-crucis, P. minor, U. clathrata, U. fasciata, C. crassa, C. racemosa and H. opuntia. P. fragilis* is only abundant in station 3 while *B. forbessi* and *H. tuna* is only abundant in Station 1 and 2. *C. spongiosum* is abundant in Station 2 and many in Station 3. H. tuna is also abundant in Station 2 and many in Station 1. Many *G. edulis* and *K. striatum* can be found in Station 1 but they are rare in Station 2 and 3. There are few *E. denticulatum*, *G. acerosa* in Stations 1 and 2, but they are rare in Station 3. *H. cylindracea* is found to be rare in the three stations. On the other hand, *C. cultratum, G. eucheumatoides, H. cuneiformis, S. crassifolium and C. lentilifera* are present but rare in Stations 1 and 2. *S. oligocystum* and *B. spherical* is also present but rare in Stations 1 and 3. *A. foliacea* is present but rare in Station 1 only, similar with *T. conoides* which can be found only in Station 1.

Table 2

Abundance and distribution of seaweeds at Nangaramoan, San Vicente, Sta. Ana, Cagayan, Philippines

No.	Species composition	Stations		
		1	2	3
1	*Actinotrichia fragilis*	-	+	++
2	*Gelidiella acerosa*	++	++	-
3	*Amphiroa faliacea*	-	-	+
4	*Cheilosporum cultratum*	+	+	-
5	*Mastophora rosea*	++++	++++	++++
6	*Gracilaria edulis*	+++	+	+
7	*Gracilaria eucheumatoides*	+	+	-
8	*Eucheuma denticulatum*	++	++	+
9	*Kappaphycus striatum*	+++	+	+
10	*Ceratodictyon spongiosum*	+	++++	+++
11	*Polysiphonia fragilis*	-	++++	-
12	*Coelothix irregularis*	++++	++++	++++
13	*Padina australis*	++++	++++	++++
14	*Padina sanctae-crucis*	++++	++++	++++
15	*Padina minor*	++++	++++	++++
16	*Hormophysa cuneiformis*	+	+	-
17	*Sargassum crassifolium*	+	+	-
18	*Sargassum oligocystum*	+	-	+
19	*Turbinaria conoides*	+	-	-
20	*Turbinaria ornata*	++++	++++	++++
21	*Ulva clathrata*	++++	++++	++++
22	*Ulva fasciata*	++++	++++	++++
23	*Chaetomorpha crassa*	++++	++++	++++
24	*Boergesenia forbesii*	++++	++++	-
25	*Caulerpa lentillifera*	+	+	-
26	*Caulerpa racemosa*	++++	++++	++++
27	*Halimeda macrolaba*	++++	++++	++
28	*Halimeda opuntia*	++++	++++	++++
29	*Halimeda tuna*	+++	++++	+
30	*Halimeda cylindracea*	+	+	+
31	*Bornotella spherica*	+	-	+

Legend: - not found + rare (more than one) ++ few (more than ten) +++ many (more than twenty) ++++ abundant (more than fifty) Odum (1955).

Density and frequency parameters. The density, relative density, frequency and relative frequency of seaweeds found along the intertidal zone of Nangaramoan, San Vicente, Sta. Ana, Cagayan, Philippines is shown in Table 3.

Table 3

Density, relative density, frequesncy and relative frequency of seaweeds in Nangaramoan, San Vicente, Sta. Ana, Cagayan, Philippines

No.	*Species composition*	*Density (n/1500 m^2)*	*Relative density (d/Dx100)*	*Total frequency*	*Total relative frequency (f/Fx100)*
1	*Actinotrichia fragilis*	0.00733	0.02463	3	20.00
2	*Gelidiella acerosa*	0.03200	0.10749	9	60.00
3	*Amphiroa faliacea*	0.00467	0.01568	2	13.33
4	*Cheilosporum cultratum*	0.00200	0.00672	2	13.33
5	*Mastophora rosea*	1.00200	3.36588	10	66.66
6	*Gracilaria edulis*	0.02667	0.08958	4	26.66
7	*Gracilaria eucheumatoides*	0.00467	0.01568	3	20.00
8	*Eucheuma denticulatum*	0.02400	0.08062	8	53.33
9	*Kappaphycus striatum*	0.02267	0.07614	6	40.00
10	*Ceratodictyon spongiosum*	0.06467	0.21723	10	66.66
11	*Polysiphonia fragilis*	0.03667	0.12317	4	26.66
12	*Coelothix irregularis*	3.71133	12.46697	15	100.00
13	*Padina australis*	4.80267	16.13294	15	100.00
14	*Padina sanctae-crucis*	7.95533	26.72325	15	100.00
15	*Padina minor*	1.43867	4.83271	15	100.00
16	*Hormophysa cuneiformis*	0.00333	0.01120	3	20.00
17	*Sargassum crassifolium*	0.00400	0.01344	3	20.00
18	*Sargassum oligocystum*	0.00467	0.01568	3	20.00
19	*Turbinaria conoides*	0.00400	0.01344	2	13.33
20	*Turbinaria ornata*	0.16533	0.55538	15	100.00
21	*Ulva clathrata*	1.58000	5.30748	13	86.66
22	*Ulva fasciata*	3.56267	11.96757	15	100.00
23	*Chaetomorpha crassa*	2.49333	8.37551	15	100.00
24	*Boergesenia forbesii*	1.40400	4.71626	9	60.00
25	*Caulerpa lentillifera*	0.00333	0.01120	2	13.33
26	*Caulerpa racemosa*	0.48867	1.64151	11	73.33
27	*Halimeda macrolaba*	0.13600	0.45685	8	53.33
28	*Halimeda opuntia*	0.53667	1.80275	13	86.66
29	*Halimeda tuna*	0.23133	0.77709	8	53.33
30	*Halimeda cylindracea*	0.01467	0.04927	8	53.33
31	*Bornotella spherica*	0.00200	0.00672	2	13.33
	Total	29.76933	100.00000	251	1,673.33

It can be seen that all of the species identified have different densities ranging from 0.002 to 7.955 per 1500 m^2. *P. sanctae-crusis* had the highest density with 7.955 individuals per m^2 followed by *P. autralis* and *C. irregularis* with 4.80 and 3.71

individuals per 1500 m^2, respectively *C. cultratum* and *B. spherica* recorded the lowest density of 0.002 individuals per 1500 m^2.

Highest relative density of 26.72 was recorded for *P. sanctae-crusis*, followed by *P. autralis* (16.13%) and *C. irregularis* (12.47%). For the Station 1 and 3, *P. sanctae-crusis* recorded the highest relative density with 34.03 % (Station 1), 21.18 % (Station 2) and 25.28 % (Station 3). The lowest relative density was recorded with *C. cultratum* and *B. spherical* with 0.007%.

Result of frequency analysis showed that *C. irregularis, P. australis, P. sanctae-crucis, P. minor, T. ornata, U. fasciata,* and *C. crassa*, appear in all 15 quadrates in Station 1, 2 and 3. *U. clathrata, H. opuntia*, is present in 13 quadrates. Meanwhile *C. racemosa* are found in 11 quadrates. The *C. spongiosum, M. rosea*, is present in 10 quadrates sampling units. The *B. forbesii, G. acerosa* is present in 9 quadrates. The species found in 8 quadrates are *H. macrolaba, H. tuna, H. cylindracea, E. denticulatum* while *K. striatum*, are found in 6 quadrates. *G. edulis, P. fragilis* are found in 4 quadrates. The *H. cuneiformis, S. crassifolium, S. oligocystum, G. eucheumatoides, A. fragilis* are found in 3 quadrates. *The C. lentillifera, C. cultratum, B. spherica, A. faliacea, T. conoides* were found in 2 quadrates in different stations.

With regards to relative frequency, *P. sanctae-crucis, C. irregularis, P. australis, P. minor, T. ornata, U. fasciata, C. crassa* were noted in all station. The difference in the species composition in the station may be attributed to the differences in the type of substrate and the depth of the water or sea level.

Species diversity. The diversity of seaweeds species in San Vicente Sta. Ana Cagayan was measured by the following parameters: species richness, richness index, Simpson's index of diversity and Simpson's reciprocal index. The result of diversity indices is presented in Table 4.

Table 4

Diversity of seaweeds in Nangaramoan, San Vicente, Sta. Ana, Cagayan, Philippines

Diversity parameters	*Station 1*	*Station 2*	*Station 3*	*Mean*
Number of samples (a)	28	27	22	25.67
Species richness (b)	14,153	14,522	15,979	14,884.67
Repetition index (b/a)	505.46	537.85	726.32	589.88
Simpson's index (D)	0.194	0.124	0.152	0.16
Simpson's index of diversity (1-D)	0.806	0.876	0.848	0.84
Simpsons reciprocal index (1/D)	5.155	8.065	6.579	6.70

Species richness is a measure of the number of different kinds of seaweeds present in the area. In this study, species richness varies in the different stations. It is highest in the Station 3 with 15,979, followed by Station 2, with 14,522 and Station 1 with (14,153).

Repetition index represent the estimate of the minimum number of sub-samples necessary to cover all diversity present in a group of samples. In our study, Station 3 got the highest repetition index with 726.32, followed by Station 2 (537.85) and Station 1 (505.46). This concludes that more sub-samples are needed in Station 3 to cover all diversity present.

The Simpson's Index (D) measures the probability that two individuals randomly selected from a sample will belong to the same species. With this index, 0 represent infinite diversity and 1, no diversity. That is the bigger the value of the D, the lower the diversity. The Simpson's index was calculated 0.194 in Station 1 followed by Station 2 with 0.124 and 0.152 in Station 3. This value indicates that species diversity of seaweeds in Nangaramoan San Vicente, Sta. Ana, Cagayan is very high.

The Simpson's index of diversity (1-D) value ranges between 0 and 1 the greater value, the greater the sample diversity. Simpson's index of diversity in this study was calculated at 0.806 in Station 1 followed by 0.876 in Station 2 and 0.848 in Station 3. This indicate that the study area have a great diversity of species.

The Simpson's reciprocal index (1/D) represent whether a community contains only one species it can also measure the diversity of a given ecosystem, the higher value the greater the diversity. The maximum value is the number of species in the sample. In our study, highest Simpson's reciprocal index was recorded at Station 2 (8.065), followed by Station 3 (6.579) and Station 1 (5.155). This indicates that Station 2 had a greater diversity between the two other Stations.

In this study, there were 28 species identified in Station 1, 27 in station 2, and 22 identified species in station 3, therefore the highest possible value would be 28, 27, 22 for the three stations, respectively. The Simpson's reciprocal index was calculated at 5.155 in station 1, followed by 8.065 in station 2, and 6.579 in station 3, respectively.

Among the 390 identified species of seaweeds found in the Philippines (Trono 1986), there were 31 different species of seaweeds found in Nangaramoan, San Vicente, Sta. Ana Cagayan, Philippines.

Abundance of *T. ornata, M. rosea, C. irregularis, P. autralis, P. sanctae-crusis, P. minor, U. clathara, U. fasciata, C. crassa, C. racemosa* and *H. opuntia* along the intertidal zone of Nangaramoan, San Vicente, Sta. Ana Cagayan may be attributed to the physical characteristic of the substratum of the station various characteristics, which accounts for the abundance and species at a particular substratum.

The offshore area (30-100 m from the shoreline) of Nangaramoan is characterized by a rocky substratum expose to strong water turbulence which favors the growth of *T. ornata* and *M. rosea* (Trono 1986). The inner portion toward the shoreline of the intertidal zone is characterized by sand flats, deep tide pools, and reef flats, which serve as a ideal substrate for *C. irregularis, Padina* spp, *Halimeda* spp. The shallow portion of the intertidal zones characterized by a sandy-rocky substratum favors the growth *of U. clathara, U. fasciata, C. crassa* and *C. racemosa* (Hurtado et al 2006).

Results of the diversity indices (Species Richness, Repetition Index, Simpson's Indices of Diversity and its Reciprocal) used revealed that the intertidal zone of Nangaramoan, San Vicente, Sta. Ana, Cagayan had high seaweed diversity. The Philippines is a tropical country, and even though this country is the 3rd largest producer of cultured seaweed in the world, diversity of seaweeds in the whole country may seem to be quite low as compared to reports on the diversity of seaweeds in the temperate countries. The highest diversity of seaweed species occurs in the temperate regions of the world, especially Japan and southern Australia. Many tropical seaweed genera and species tend to be very widely distributed (pan-tropical), and investigators will find many similarities in seaweed floras of quite widely separated regions. A significant number of other genera and species, however, have a discontinuous distribution (Indo-Pacific and W. Atlantic, but not W. Africa; Lüning 1990).

The ecological factors affecting the biology of the seaweeds in tropical water may be primary and secondary (Doty 1946). Primary factors are major phenomena, like monsoons and tides, observable as large- scale changes in earth's surface, exerting their effect on considerably large areas and influencing a number of the requirements of the seaweeds. The secondary factors, on the other hand, are those like temperature, light, turbidity, salinity and grazing which are more limited and specific in their effects, generally subjected to the fluctuations in the primary factors (Doty 1946). In nature, however, these latter factors cannot and should not be isolated from one another because their effects are known to be interactive. The growth of the seaweeds is more the resultant effect of several factors acting together either synergistically or antagonistically, in the multidimensional niche of that species (Ganzon-Fortes 1991).

Traditionally, marine ecologists have used the direct sampling method to characterize shallow and intertidal water marine habitats. However, this method is neither time nor cost effective for vast expanses. Remote sensing tools such as aerial photography, airborne and satellite imagery are appropriate for surveying and classifying marine habitats in the tidal zone (Guillaumont et al 1993; Guillaumont et al 1997; Meleder 2003; Combe et al 2005). Acoustic methods are suitable to remotely sample sea floor texture and depth in waters as deep as 200 m (Brown et al 2002).

Conclusions. Different species of seaweeds vary in abundance in the different stations. It is evident that there were types of species that are abundant and well distributed in most stations. There is high species density of seaweeds in Nangaramoan San Vicente, Sta. Ana Cagayan. This implies that there is high number of individual species of seaweeds in the study area. Among the identified species, *P. sanctae-crucis* had the highest density in the three stations. The intertidal zone of Nangaramoan San Vicente, Sta. Ana Cagayan has a diverse species of seaweeds as indicated by the results of diversity indices.

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