DIVERSITY, PHYTOCHEMICAL SCREENING AND UTILIZATION OF MACROALGAE

Christopher A. Masirag
St. Paul University Philippines

ABSTRACT

This study aimed to determine the diversity, utilization and phytochemical composition of macroalgae in the coastal towns of Cagayan. The macroalgae that were used in this study were collected from the intertidal zones of Sta.Praxedes, Claveria, Gonzaga and Sta. Ana Cagayan during a low tide using a transect line. The species covered by the 100 cm x 100 cm quadrant used were counted (Quadrat method). The researcher initially identified the macroalgae species using the book of Dr. Gavino C. Trono Jr. (2004) and was then brought to the Bureau of Fisheries and Aquatic Resources (BFAR) Regional Office, Tuguegarao City for further verification and validation. The macroalgae extracts were subjected to phytochemical screening to determine the different secondary metabolites present. Findings of the study revealed that there were forty eight (48) prevalent species of macroalgae found in the coastal towns of Cagayan for the months of October, November and December. The macroalgae was dominated by Rhodophyceae. Thirteen (13) species belongs to Chlorophyceae, eleven (11) species belongs to Phaeophyceae, and twenty four (24) species classified under Rhodophyceae. The qualitative analysis of the secondary metabolites present in the forty eight (48) macroalgae species through phytochemical screening revealed that the macroalgae species contain various amount of valuable phytochemicals. It was further found out that only Ulva lactuca and Chlorodesmis fastiaga contain all the six secondary metabolites tested. The most diverse coastal town in terms of the number of macroalgae species found was Sta. Ana with twenty six (26) species of macroalgae, followed by Gonzaga with twenty five (25) species of macroalgae, then Claveria with twenty two (22) species of macroalgae and the least with fifteen (15) species of macroalgae was Sta. Praxedes. The coastal town with the most abundant macroalgae species in terms of frequency and relative frequency was Sta. Ana, followed by Gonzaga, then Claveria and lastly Sta. Praxedes. Macroalgae growth is abundant in the month of November as compared to the months of October and December. The utilization of macroalgae by the local communities is based primarily on their economic uses as human food, herbal medicine and as items of trade, or as a source of livelihood.

INTRODUCTION

The Philippines is one of the most diverse ecological environments in the world and known for its wide variety of terrestrial and aquatic plant organisms. The intertidal zone that surrounds the 7,100 islands of the Philippines is renowned for its wonderful organisms and for providing one of the most diverse habitats of marine organism of the planet. Among those as pointed by Trono and Fortes (1988), which are conspicuous are the mangrove, macroalgae (seaweeds) and seagrasses. These plants dominate the marine flora in wide ranging type habitat associated with highly diverse forms of animal life. The importance of these plants not only prevent coastal erosion but they also serve as sites of high organic production, as habitat, feeding ground and nursery for shallow water fishes.

The macroalgae are among the major plant groups which have recently been the object of attention of multi-sectoral groups, fishermen and businessmen, the government and academe, for the reason that of their economic value as food, and as item of trade and research. Their importance as alternate source of livelihood for coastal inhabitants is further emphasized because of the slow but continuing depletion of the coastal fisheries in many parts of the country (Agatep and Lagundi, 2009).

Macroalgae or seaweeds farming is a major industry in our country that provides economic livelihood to thousands of coastal families. In 2006, the Philippines produced 1,338,597 metric tons of seaweeds and were the top carrageenan producer in the world as reported by the Agri Business Week (2008).

People resourcefulness has found many uses for algae. Algae provide food for people and livestock, serve as coagulant in some products like gelatin and ice cream, and are used as medicine against diseases.

Algae have been used for centuries, especially in Asian countries, for their purported powers to cure or prevent illnesses as varied as cough, gout, gallstones, goiter, hypertension, and diarrhea. Recently, algae have been surveyed for anticancer compounds, with several cyanobacteria appearing to contain promising candidates. Algae can also serve as indicators of environmental problems in aquatic ecosystems. Because algae grow quickly and are sensitive to changing environmental conditions, they are often among the first organisms to respond to changes (Steinman 2008).

What is fascinating now is that researchers from the National Cancer Institute recently published findings that carrageenan had properties that decreased human papillomavirus infections of cells in laboratory screenings (Buck et al. 2006). The current research report in biotechnology may increase the use of algae in our society. As a replacement of new pharmaceuticals from the rainforest, this may now be obtained from the oceans.

Actually, algae already speed along research in colleges, universities and in private laboratories worldwide, as the polysaccharides agar and agarose. These are also derived from red macroalgae, and are used to form the gel used to create Petri dishes that researchers use to work with bacteria, fungi, animal cells and phytoplankton. They are also used in a slew of experiments to study genes and DNA. Closer to home, the recent resurgence of holistic and homeopathic medicine has renewed interest in the use of macroalgal extracts. Lining supermarket shelves, many of the lotions, creams and moisturizers that claim to firm skin also contain extracts from macroalgae (Lardizabal, 2008).

There is, therefore; the urgent need to determine the diversity and abundance of macroalgae in Cagayan, in order to develop them for the improvement of the quality of life of the people in the coastal towns of Cagayan.

Statement of the Problem

This study generally aimed to determine the diversity, utilization and phytochemical composition of macroalgae in the coastal towns of Cagayan.

Specifically, it sought:

1. to identify the taxonomic classification of macroalgae;
2. to determine the secondary metabolites present through pythochemical analysis;
3. to determine the abundance of macroalgae of Cagayan;
4. to compare the abundance of macroalgae by location, month and species; and
5. to identify the utilization of macroalgae by the local communities.

METHODOLOGY

This chapter presents the materials and the different experimental procedures that were used in the study.

Collection and Identification of Macroalgae

Materials

The following materials used in the study were: labeling materials (pen, masking tape, sticker), plastic bags, pair of scissors, knife, pegs, quadrat (1 m x 1 m), styrofoam box and transect line.

Identification of the Sampling Sites per Coastal Town

The sampling sites were situated at the Intertidal Zone of Sta. Praxedes, Claveria, Gonzaga and Sta. Ana, Cagayan which was identified by the Bureau of Fisheries and Aquatic Resources (BFAR) Regional Office No. 2. The collection site was identified using a transect line. The transect line was laid down from the seashore to the intertidal zones. The distance between the sampling sites was measured 100 m. Data were collected at every interval of 10 m.

Descriptions of the Sampling Station

The sampling sites were characterized by sandy, rocky and coralline substrata.

Collection of Seaweed

The macroalgae that were used in this study were collected from the intertidal zone of Sta.Praxedes, Claveria, Gonzaga and Sta. Ana, Cagayan during a

low tide using a transect line. The species covered by the 100 cm x 100 cm quadrant used were counted (Quadrat method). Samples of every species were uprooted with the help of a knife or scraping tool to obtain the complete plant (including the holdfast) from the substrate. The macroalgae collected were placed in a Ziploc or plastic with enough seawater. The macroalgae were brought to Saint Paul University Philippines, Science Laboratories the next day for phytochemical screening.

Identification of Specimen

The specimen for initial identification was cleaned and properly labeled. The macroalgae species were initially identified using the book of Dr. Gavino C. Trono Jr. in (2004). The specimen were initially identified basing on their morphological characteristics using references in terms of their thallus (branched or unbranched), leaves (ventrally, horizontally, attached, small, large), holdfast (scutate, dicoid-lobe), leaf margin (serrate, denticulate), blade (reticulate, nonreticulate) and habitat (rocky, sand), and were then brought to the Bureau of Fisheries and Aquatic Resources (BFAR) Regional Office, Tuguegarao City for further verification and validation.

Classification

The algae collected were classified according to their division namely Chlorophyta, Rhodophyta, and Phaeophyta using primarily the reference "Field Guide & Atlas of the Seaweed Resources of the Philippines", authored by Dr.Gavino Trono, Jr. of the University of the Philippines, Diliman, Quezon City.

Frequency and Density

The dominant species were determined through frequency and relative frequency using the method described by Smith and Smith (2001).
Frequency was determined by means of counting the number of intervals or points where the species occurs and dividing it to the total number of sample plots or points (see Appendix).
Relative frequency is an index based on the number of sample points or plots in which a species is found to occur relative to the total number of samples taken (see appendix).

Statistical Treatment of Data

For the difference of abundance of species in terms of frequency and relative frequency in relation to location and month the frequency count, percentage, mean, standard deviation d and analysis of variance were used.

Procedure for Phytochemical Analysis

In an erlenmeyer flask, twenty (20) grams of seaweeds are weighed and 100 ml 80% ethyl alcohol are added and covered with a funnel that will act as a condenser to minimize evaluation as the solvent. Place the flask over a hot water bath and reflux for an hour. The mixture was poured while it was still hot through a Buchner funnel line with filter paper and filled to a suction flask. The flask and seaweeds material was rinsed with fresh portion of 80% methyl alcohol and the seaweeds residue was discarded. The extracts are concentrated to about 45 ml and keep this in a tightly stopped container. (Guevara, 2005)

Test for Alkaloids

Ten (10) ml seaweeds ethanolic extract was taken and placed in an evaporating dish. The extract was evaporated to a syrup consistency over a water bath. Five (5) ml of 2M (HCL) was added then heated while stirring for five 5 min and then cooled. About 0.5 grams of (NaCl) are added and the mixture was filtered. The residue was washed with enough freshly prepared 2M HCL to bring the filtrate to a volume of about 5 ml. A one milliliter of the filtrate was taken and tested with 2 to 3 drops of Wagner's reagent. Reddish Precipitation observed indicate the presence of alkaloids.

Test for Glycosides

Ten (10) ml seaweeds ethanolic extract taken, was dissolved in 5 ml hot distilled water and filtered. The filtrate was used for the test. 2 ml of the extract was placed in each of the two test tubes. One ml of diluted HCl was added to sample one (1) while nothing was added to sample two (2). The two test tubes were placed in a boling water bath for 5 minutes. Then let the test tubes cooled. Both samples were neutralized samples by adding anhydrous sodium carbonate until no more effervescence is produced. Fehling's solution

was added to the test tubes then heat over a water bath for two minutes. An increase in amout if brick red precipitatate in hydrolyzed sample as compared to the other sample indicates the presence of glycosides.

Test for Tannins

Ten (10) ml of the macroalgae extract was allowed to evaporate to incipient dryness over a water bath. The residue was extracted with 20-ml of hot distilled water and cooled. To remove undesirable constituents, 5 drops of 10% sodium chloride was added and the residue was filtered with a filter paper. The filtrate was further filtered and equally divided into two test tubes to be labeled as test tubes A and B. Control treatment was the test tube A where no solution was added. Three drops of ferric chloride solution were added to test tube B. For the presence of tannins, a blackish green color or precipitate was observed.

Test for Saponins

Froth test was used for the determination of saponins. Ten (10) ml of hot distilled water was added to two (2) ml of the extract then shaken vigorously for about thirty (30) seconds and allowed to stand and observed over a period of thirty minutes. A positive result showed the formation of honeycomb froths at a height of three (3) cm above surface of the liquid.

Test for Flavonoids

For the determination of flavonoids color test was used. Two (2) ml of the extract was treated with two (2) ml of 10% HCL then a small piece of magnesium ribbon was dropped into the solution. A formation of reddish color was evidence of a positive result.

Test for steroids and Triterpenoids

Two (2) ml of the extract was dissolved in one (1) ml acetic anhydride. Then the soluble portion was decanted and two (2) drops of concentrated sulfuric acid were added. A green color either immediately or gradually turning to red and blue tones indicated a positive result.

Data Gathering Procedure on the Utilization of Macroalgae

The researcher gathered information through an interview using an interview guide to obtain information regarding the utilization of macroalgae in the localities.

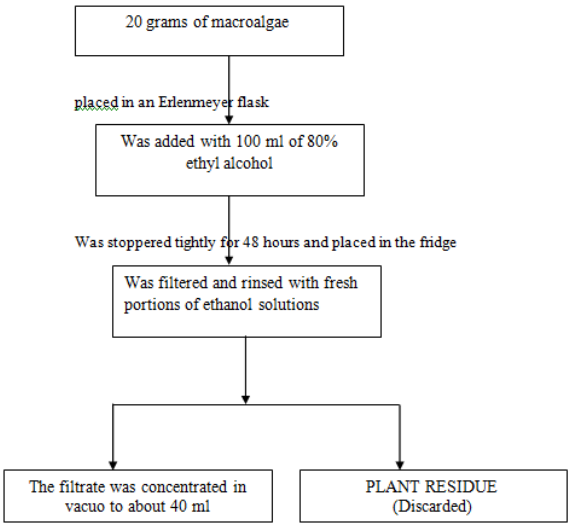

Figure 1. Schematic Diagram of of the Crude Extraction of Macroalgae

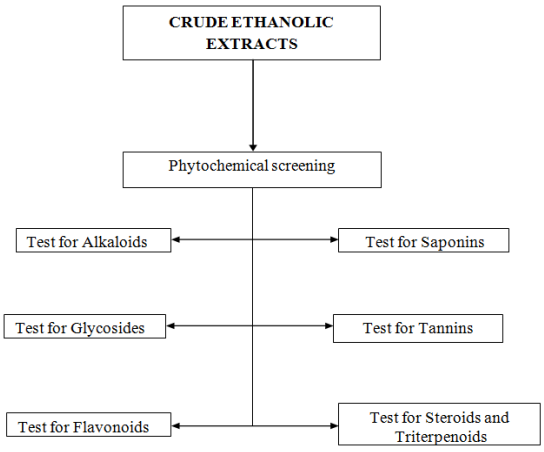

Figure 2. Schematic Diagram of the Phytochemical Screening of Macroalgae

RESULTS AND DISCUSSION

Taxomonic Classification of Macroalgae

The comprehensive study of the different macroalgae in the intertidal zones of the coastal towns of Cagayan revealed that forty eight (48) species of macroalgae were identified and collected in the four different sampling sites. The divisions are as follows:

Chlorophyceae

There were thirteen (13) species of green macroalgae belonging to four (4) orders. As shown in Table 1 there was only one (1) species identified for order Cladophorales family Cladophoraceae, this was Chaetomorpha crassa. For order Ulvales family Ulvaceae, two (2) species were identified, namely Ulva lactuca and Ulva reticulata. For order Siphonoclades family Valoniaceae, two (2) species were also identified namely Dictyosphaeria cavernosa and Valonia Aegagrophila. For order Bryopsidales, there were eight (8) species identified belonging to four (4) families. For family Udoteaceae, two (2) species were identified, namely Chlorodesmis fastiaga and Chlorodesmis hildebrandtii. There were also two (2) species identified for family Caulerpaceae, namely Caulerpa racemosa and Caulerpa taxifolia. Three (3) species were identified belonging to family halimedaceae, namely Halimeda macroloba, Halimeda opuntia and Halimeda tuna. And finaly for family Codiaceae, only Codium elude was identified.

Phaeophyceae

There were eleven (11) species of the brown macroalgae belonging to two (2) orders. For order Dictyotales family Dictyotaceae, four (4) species were identified, namely Dictyota cervicornis, Dictyota dichotoma, Padina Japonica and Padina Minor. There were seven (7) species belonging to order Fucales. For family Sargassaceae, namely Sargassum crassifolium, Sargassum cristaefolium, Sargassum gracillimum, Sargassum oligocystum, Sargassum polycystum, and Turbinaria ornata. And for family Cystoseiraceae only Hormophysa triquetra was identified.

Rhodophyceae

Twenty four (24) species of red macroalgae that were identified belong to nine (9) orders and eleven (11) families. Order Gigartinales has the greatest number of species. For order Gigartinales twelve (12) species belong to four (4) families. For family Gracilariaceae seven (7) species were identified, namely Ceratodictyon spongiosum, Gracilaria arcuata, Gracilaria coronopifolia, Gracilaria edulis, Gracilaria eucheumoides, Gracilaria firma and Gracilaria salicornia; for family Solieriaceae two (2) species were identified, namely Euchema denticulatum and Kappahycus cottonni; for family Hypneaceae two (2) species were also identified, namely Hypnea pannosa and Hypnea valentiae; and for Rhizophyllidaceae only one (1) species was identified known as Portieria hornemannii. For order Bangiales family Bagiaceae only Porphyra crispata was identified. For order Bonnemaisoniales family Galaxauraceae two (2) species were identified, namely Actinotrichia fragilis and Galaxaura oblongata. For order Gelidiales family Gelidiaceae only Gelideilla acerosa was identified. For order Corallinales family Corallinaceae three (3) species were identified namely Amphiroa fragillissima, Cheilosporum cultratum, and Mastophora rosea. For order Nemaliales family Liagoraceae only Liagora sp. was identified. For order Ceramiales family Rhodomelaceae two (2) species were identified namely Acanthophora muscoides and Acanthophora specifera. And finally for order Cryptonemiales family Cryptonemiaceae two (2) species were identified namely Halymenia durvillaei and Halymenia dilatata.

Phytochemical Screening

Thirteen (13) species of chlorophyceae (Chaetomorpha crassa, Ulva lactuca, Ulva reticulata, Dictyosphaeria cavernosa, Valonia aegagrophila, Chlorodesmis fastiaga, Chlorodesmis hildebrandtii, Caulerpa racemosa, Caulerpa taxifolia, halimeda macroloda, Halimeda opuntia, Halimeda tuna and Codium Edule), six (6) species of phaeophyceae (Dictyota cervicornis, Dictyota dichotoma, Padina japonica, Padina minor, Sargassum cristaefolium, and Sargassum oligocystum), and eighteen (18) species of rhodophyceae (Porphyra crispata, Actinotrichia fragilis, Galaxaura oblongata, Gelideilla acerosa, Amphiroa fragillissima, Cheilosporum cultratum, Mastophora rosea, Acanthophora muscoides, Halymenia durvillaei, Eucheuma denticulatum, Kappahycus cottonii, Hypnea pannosa, Hypnea Valentiae, Portieria hornemannii, Ceratodictyon spongiosum, Gracilaria edulis, Gracilaria eucheumoides, Gracilaria firma, and Gracilaria salicornia) showed positive results with alkaloids.

Glycosides on the other hand were observed in the ten (10) species of clorophyceae (Chaetomorpha crassa, Ulva lactuca, Valonia aegagrophila, Chlorodesmis fastiaga, Chlorodesmis hildebrandtii, Caulerpa racemosa, Caulerpa taxifolia, halimeda macroloda, Halimeda opuntia, Halimeda tuna and

Codium Edule), eight (8) species of phaeophyceae (Dictyota cervicornis, Dictyota dichotoma, Padina minor, Sargassum crassifolium, Sargassum gracillimum, Sargassum polycystum, turbinaria ornate, and Hormophysa triquetra) and 15 species of rhodophyceae (Porphyra crispata, Galaxaura oblongata, Cheilosporum cultratum, Mastophora rosea, Acanthophora specifera, Halymenia durvillaei, Eucheuma denticulatum, Kappahycus cottonii, Hypnea pannosa, Portieria hornemannii, Ceratodictyon spongiosum, Gracilaria coronopifolia, Gracilaria edulis, Gracilaria eucheumoides, and Gracilaria firma). Several plants store important chemicals in the form of inactive glycosides; if these chemicals are needed, the glycosides are brought in contact with water and an enzyme, and the sugar part is broken off, making the chemical available for use. Many such plant glycosides are used as medications.

The presence of tannins were seen in seven (7) species of chlorophyceae (Chaetomorpha crassa, Ulva lactuca, Ulva reticulata, Chlorodesmis fastiaga, Caulerpa taxifolia, halimeda macroloda, and Halimeda tuna), seven (7) species of phaeophyceae (Padina minor, Sargassum cristaefolium, Sargassum gracillimum, Sargassum oligocystum, Sargassum polycystum, turbinaria ornata, and Hormophysa triquetra) and six (6) species of rhodophyceae (Kappahycus cottonii, Hypnea Valentiae, Portieria hornemannii, Ceratodictyon spongiosum, Gracilaria arcuata, and Gracilaria firma), which only indicates the ability to react with and precipitate proteins forming stable water-insoluble compounds.

The presence of saponins were observed in eleven (11) species of chlorophyceae (Ulva lactuca, Ulva reticulata, Dictyosphaeria cavernosa, Valonia aegagrophila, Chlorodesmis fastiaga, Chlorodesmis hildebrandtii, Caulerpa racemosa, Caulerpa taxifolia, halimeda macroloda, Halimeda opuntia, and Codium Edule), ten (10) species of phaeophyceae (Dictyota cervicornis, Dictyota dichotoma, Padina minor, Sargassum crassifolium, Sargassum cristaefolium, Sargassum gracillimum, Sargassum oligocystum, Sargassum polycystum, turbinaria ornata, Hormophysa triquetra) and fourteen (14) species of rhodophyceae (Porphyra crispata, Actinotrichia fragilis, Galaxaura oblongata, Gelideilla acerosa, Cheilosporum cultratum, Liagora sp., Halymenia durvillaei, Halymenia dilatata, Eucheuma denticulatum, Hypnea pannosa, Hypnea Valentiae, Portieria hornemannii, Ceratodictyon spongiosum, Gracilaria eucheumoides, and Gracilaria firma).

There are also eleven (11) species of chlorophyceae (Ulva lactuca, Ulva reticulata, Dictyosphaeria cavernosa, Valonia aegagrophila, Chlorodesmis fastiaga, Chlorodesmis hildebrandtii, Caulerpa racemosa, Caulerpa taxifolia, halimeda macroloda, Halimeda opuntia, and Codium Edule), eleven (11) species of phaeophyceae (Dictyota cervicornis, Dictyota dichotoma, Padina japonica, Padina minor, Sargassum crassifolium, Sargassum cristaefolium,Sargassum gracillimum, Sargassum oligocystum, Sargassum polycystum, turbinaria ornata, Hormophysa triquetra), and thirteen (13) species of rhodophyceae (Porphyra crispata, Actinotrichia fragilis, Galaxaura oblongata, Gelidiella acerosa, Cheilosporum cultratum, Liagora sp., Halymenia durvillaei, Halymenia dilatata, Hypnea pannosa, Hypnea Valentiae, Ceratodictyon spongiosum, Gracilaria arcuata, and Gracilaria edulis), showed positive for flavonoids test.

Moreover, eight (8) species of chlorophyceae (Ulva lactuca, Ulva reticulata, Valonia aegagrophila, Chlorodesmis fastiaga, Chlorodesmis hildebrandtii, Caulerpa racemosa, Halimeda tuna and Codium Edule), nine (9) species of phaeophyceae (Dictyota cervicornis, Dictyota dichotoma, Padina japonica, Sargassum crassifolium, Sargassum cristaefolium, Sargassum gracillimum, Sargassum oligocystum, Sargassum polycystum, Hormophysa triquetra), and thirteen (13) species of rodophyceae (Porphyra crispata, Actinotrichia fragilis, Amphiroa fragillissima, Cheilosporum cultratum, Acanthophora muscoides, Acanthophora specifera, Halymenia durvillaei, Eucheuma denticulatum, Hypnea pannosa, Portieria hornemannii, Gracilaria arcuata, Gracilaria edulis, and Gracilaria salicornia) have also showed positive result for the presence of steroids.

Quantitative Analysis on the Abundance of Macroalgae in the Coastal Towns of Cagayan

A total of 48 species were collected and identified in the four coastal towns of Cagayan over the three month period from October to December 2011. It was found out that the macroalgae species present in the four locations for the entire duration of the study

were Chaetomorpha crassa, Halymenia durvillaei and Sargassum cristaefolium.

There were also species that were found in one of the locations only (appendix table 2), these were Acanthophora muscoides, Acanthophora specifera, Gelidiella acerosa, Gracilaria eucheumoides, Gracilaria firma and Halimeda dilatata which were only located in Gonzaga, Cagayan. Amphiroa fragillisima, Caulerpa taxifolia, Dictyota cervicornis, Dictyota dichotoma, Euchema denticulatum, Gracilaria coronopifolia, Halimeda tuna, Hypnea valentiae and Turbinaria ornata were found ony in the coastal areas of Sta. Ana, Cagayan. Likewise, for Caulerpa racemosa, Codium edule and Portieria hornemannii were found in Sta. Praxedes, Cagayan. Furthermore, Padina minor and Ulva lactuca were the species located only in Claveria, Cagayan. Moreover, Chaetomorpha crassa, Halymenia durvillaei and Sargassum cristaefolium were common in all the locations.

Macroalgae Present by Month

The month of November has the highest total individuals counted with a mean of 5.60 and has a frequency mean of 0.198, December has a mean total individual of 5.18 and mean frequency of 0.183, and October has the lowest total individuals with a mean of 4.64 and a frequency mean of 0.177.
The few population of macroalgae in October may be attributed to environmental factors, such as typhoons Pedring and Quiel which had affected Cagayan on the last week of September and the first week of October 2011, respectively. The growth of macroalgae is believed to be directly influenced by the storm. The observed increase of the number of macroalgae in November is attributed to the stability of the weather condition of the month.

Macroalgae Parameters by Location

The coastal areas of Sta. Praxedes has the highest mean total individual of 12.78, although it has the lowest number of population which is 45 and a mean frequency of 0.231. This is attributed to Porphyra crispata which has low frequency but has the highest relative density. Besides, it was found in large clumps where it did occur. Gonzaga followed next with mean total individuals of 3.15 and a mean frequency of 0.192. On the other hand, macroalgae found in Claveria has mean total individuals of 5.47 and a frequency mean of 0.180. Macroalgae in Sta. Ana has the lowest mean total individuals of 2.37 and a frequency mean of 0.159, even though it has the most number of populations. This situation is attributed to the few number of individuals of macroalgae found in the coastal area.

Total Macroalgae Count by Location

There are 78 species found in Sta. Ana, 65 species has a count of 1-10 and there were 13 species which was not found in once or twice of the three-month duration of the study. For Gonzaga, there were 70 species has a count of 1-10 and 5 species was not found once on the course of the study. Furthermore, Sta. Praxedes has 4 species has a count of 21 and above, 11 species has a count of 11-20, 28 species has a count of 1-10 and only 2 species was not found in one of the three-month duration of the study. Lastly, Claveria has 4 species with a count value of 21 and above, 5 species has 11-20 counts, 51 species has 1-10 counts and 6 was not found once or twice during the duration of the study. As observed, the macroalage found in all locations have frequency count of 1-10. It is interesting to note that there were 4 macroalgae that had a count of 21 and above for both Sta. Praxedes and Claveria, hence these macroalgae are abundantly found in their coastal areas.

The highest number of macroalgae was found in Sta. Ana; however they have few numbers of counts. In contrast, in Sta. Praxedes and Claveria few macroalgae were found but were found abundant. This is attributed to the kinds of species of macroalgae found in the four locations.

Analysis of Variance on the Total Macroalgae Count by Location

Results of the analysis of variance yielded an F-ratio of with associated probability of 0.00, thus, the null hypothesis is rejected. There are significant differences in diversity and abundance of macroalgae in the coastal towns of Cagayan. This finding implies that the diversity and abundance of macroalgae in the coastal towns of Cagayan vary significantly in terms of its local distribution. This trend is attributed to the differences of substratum of the four coastal towns of Cagayan where macroalgae locally inhabit.

Total Macroalgae Count by Month

The month of November has the highest macroalgae count with three species counted from 21 and above, seven species with 11-20 counts, 73 species with 1-10 counts and five species were not found during this month. For the month of December, two species were found to have 21 and above counts, five species had 11-20 counts, 71 species had 1-10 counts and 10 species were not found. Lastly, October had the lowest counts of species during the entire duration of the study with three species with 21 and above counts, four species with 11-20 counts, 70 species with 1-10 counts. Eleven species were not found during this month.

Analysis of Variance on the Total Macroalgae Count by Month

The analysis of variance yielded an F-ratio of 0.189 with associated probability of 0.828, thus, the null hypothesis is accepted. This signifies that the monthly macroalgae count across the coastal towns does not vary significantly. This can be attributed to the season where the study was conducted.

Relative Frequency of Macroalgae Found by Location

Gonzaga has the highest relative frequency of macroalgae found in each of the coastal towns of Cagayan. From the relative frequency ranges 0.3 to 0.5, twenty one species or 31.3 per cent of the sixty seven species found in Gonzaga. And for the relative frequency ranges 0.1 to 0.2, fifty one species or 29.8 per cent of the one hundred seventy one species were found in Sta. Ana, on the other hand forty nine was found in Gonzaga, followed by Claveria with forty six species and twenty five species found in Sta. Praxedes. Macroalgae in Sta. Praxedes has the lowest relative frequency recorded.

Analysis of Variance on the Relative Frequency of Macroalgae by Location

As manifested in Table 12, the relative frequencies of macroalgae grouped by location differ significantly as evidenced from the result of the analysis of variance yielded an F-ratio of 4.879 with associated probability of 0.003, thus the null hypothesis "There is no significant difference on the relative frequency of macroalgae in the coastal towns of Cagayan when compared in terms of location" is rejected. There are significant differences in diversity and abundance of macroalgae in the coastal towns of Cagayan.

This implies that the relative frequencies of macroalgae grouped by location differ significantly. This can be attributed to the differences in the physical and biological factors present in each of the coastal towns (sampling sites). With few exemptions, macroalgae are strictly benthic plants; that is they are always attached to the seabed or a solid substratum such as natural reef, rocks, shells, mangrove roots, boat hulls, jetty pilings, mooring lines, etc. When dislodged, most macroalgae have a limited lifespan as free floating seaweeds drift and they may only live for hours to several months. Direct human impact such as mechanical damage, eutrophication, aquaculture, siltation, coastal constructions and alteration of food web; along with indirect human impacts, including the impacts of climate change, can contribute to a widespread loss of macroalgae.

Relative Frequency of Macroalgae by Month

The month of November was the highest with 27 species from the total number of species which is 67. For the relative frequency value of 0.1 to 0.2, the month of December was the highest with 58 species out of 171. Furthermore, the table manifest that there was an increase of the relative frequency of the macroalgae from October to November and a slight decrease in the relative frequency from November to December. However, the relative frequency value of the three months duration of the study has almost constant value. This can be attributed to the prevailing season during these months.

Analysis of Variance on Macroalgae Relative Frequency by Month

The obtained F-ratio value associated with probability of 0.410 signifies the relative frequency of macroalgae observed per month does not vary significantly, hence the null hypothesis that "there is no significant difference in the relative frequency of macroalgae in the coastal towns of Cagayan when compared in terms of month of collection" is accepted. As stated in the previous discussion, this may be attributed to the constant prevailing climatic

environmental conditions within the months of collection.

Utilization of Macroalgae by the Local Communities

Seaweeds have long been utilized as food by many coastal populations in Cagayan. Their recognition as a fishery resource is only very recent. Based on the interview conducted by the researcher, the economic uses known by the local communities of the different coastal towns of Cagayan is for food and as item of trade or as a source of livelihood. The present problem encountered by these people was that seaweed species that are economically valuable are seasonal; they could only have high productivity during the time these macroalgae abundantly grow in the wild since there is no present seaweed farming in their locality.

From the interview made by the researcher, seaweeds have long been traditionally utilized as food in the form of salad vegetables (blanched fresh seaweeds garnished with onions and tomatoes and/or flavored with calamansi juice). When the researcher surveyed on the local public markets for available seaweeds for trade, unfortunately, there are no single seaweed found. The local fisher folks of Sta. Ana and Gonzaga say that seaweeds are only available during the summer season where these macroalgae abundantly thrive in the wild.

Gamet (Porphyra) was abundantly found in the rocky coastal areas of Sta. Praxedes, based from the interview conducted on the seaweed gatherers, during the months of October where prevailing rainfall takes place, this gamet starts to grow. From the researcher's interview on the importance of gamet, old folks in the community used gamet not only as usual food but also as herbal medicine for stomach ache, they usually pan fry the dried gamet, pulverize and then add with hot water and will be given to person who is suffering from stomach ache. Gamet is also used to treat vitamin C deficiency. Other macroalgae like the Ulva lactuca (lab-labig), Sargassum (aragan) and Codium edule (pukpuklo) are said to be antihelmintic, treats goiter and gout.

Gamet gathering starts on the later month of October, November till February. The average income of the fisherfolk per month is Php 5,460.00 (data from BFAR RO2); during gamet season the average harvest was 13 pieces per day. The local trade in the public market have a selling price of Pph 28.00-35.00 per piece with an average mass of 15-16 grams per piece (dry), the average selling price of dried gamet per kilogram is amounting to Pph 2,333.00 while Pph 750.00-1500.00 for fresh per kilogram. Their number of seaweed gathering days is usually every other day or 15 days per month.

Furthermore, the local government of Sta. Praxedes through the Department of Agriculture Municipal Unit created a cooperative for gamet. The cooperative purchases the gamet from local seaweed gatherers and process the gamet for trade.

Among the macroalgae that are locally known by the people in the coastal towns of Cagayan as edible are the following (given their local name): aru-rusip (Caulerpa racemosa), lab-labig (Ulva lactuca), pukpuklo (Codium edule), ar-aritus (Valonia aegagropila), Gayong- gayong (Halymenia durvillaei), gamet (Phorphyra crispata), guraman or caocaoayan (Gracilaria), aragan (Sargassum), cawat-cawat (Chaetomorpha crassa), and canot-canot (Euchema denticulatum).

CONCLUSIONS

Based on the results obtained, the following conclusions are drawn:

The coastal towns of Cagayan have a diversified macroalgae species; the growth of macroalgae was highly affected by the different physical and biotic factors every month. The high abundance and diversity of macroalgae in the intertidal zones of the coastal areas of Cagayan support a great diversity of life. These coastal areas of Cagayan could become breeding grounds for local varieties and seaweeds farming. The local communities of the coastal towns of Cagayan used macroalgae species as human food and as items of trade; however, these species also have a wide potential for pharmaceutical and commercial purposes, thus paving the way for the people along the coastal areas a wider utilization.

RECOMMENDATIONS

The following recommendations are presented:

1. That macroalgae species that are rapidly decreasing in abundance as a result of being phased out by superior varieties should be preserved through the establishment of more gene banks. Hence, the Local Government units of the coastal towns of Cagayan should come up with a municipal ordinance to regulate seaweed gathering and to control the over harvesting that contribute to the decreasing abundance of macroalgae.

2. Researchers on the improvement of the present uses of or on the novel uses of macroalgae be encouraged in order to save the species from eminent extinction.

3. Further investigation on the diversity and abundance of macroalgae in relation to the physic-chemical parameters of the intertidal zones of the coastal towns of Cagayan for a year-round duration is conducted.

4. A follow-up study should be conducted to quantify, isolate, and identify the types of alkaloids, glycosides, tannins, flavonoids, saponins, steroids and triterpenoids present in each of the macroalgae species.

5. Further investigation of seaweeds claimed to possess therapeutic or curative properties be carried out on more technologically advanced laboratories manned by highly trained research workers.

6. Information education campaign and training should be provided to the fisher folks and seaweed gatherers on the wide utilization of macroalgae and seaweed propagation and farming to contribute to food security by the Department of Agriculture-Bureau of Fisheries and Aquatic Resources (DA-BFAR) in cooperation with the different Local Government Units of the coastal towns of Cagayan.

References

[1] Fortes, E. G. & Trono, G. C. Jr. (1988). Philippine Seaweeds. National Bookstore. Inc. Diliman, Quezon City, Philippines

[2] Guevara, B. Q. (2005). A Guidebook to Plant Screening: Phytochemical and Biological. UST Publishing house.

[3] Levine J. S. & Miller K. R. (1995) Biology. Prentice Hall. USA. pp 442

[4] Mariner, J. L. (1986). Understanding Ecology Second Edition. Independent Schools Press, Inc. USA. pp 108

[5] Pan, J.F., Lin, R.G. & Ma, L. (2000). A review of heavy metal adsorption by marine algae [in English]. Chinese Journal of Oceanology and Limnology, 18: 260-264.

[6] Smith L. S. & Smith, T. M. (2001). Ecology & Field Biology. Sixth Edition. Addison Wesley Longman, Inc.

[7] Stein, J. R. & Borden, C. A. (1984). Causative and beneficial algae in human disease conditions: a review. Phycologia. 23: 485-501

[8] Taiz & Zeiger. (1991). Plant Physiology. Benjamin/ Cummings Publishing Company, Inc. California

[9] Trono, G. C. Jr. (2004). Field Guide & Atlas of the Seaweed Resources of the Philippines. Bureau of Agricultural Research, Department of Agriculture. Diliman, Quezon City

[10] Agatep, R. C. and Lagundi G. M. (2009). Taxonomy of Macroalgae in Cabugao, Ilocos Sur. Unpublished Thesis, St. Paul University Philippines, Tuguegarao City

[11] Macababbad, H. C. and Taccad, W. J. (2009). Resurvey of Macroalgae in Palaui Is., Sta., Ana, Cagayan. Unpublished Thesis, St. Paul University Philippines, Tuguegarao City

[12] Villarao (1999). The Effect of Sargassum polycystum on the morphology and histology of Gallus domesticus or the white-leghorn chicken. Unpublished Thesis, St. Paul University Philippines, Tuguegarao City