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Canonical correspondence analysis (CCA) of genus *Sonneratia* along the selected estuarine areas of Butuan Bay and Gingoog Bay, Mindanao, Philippines

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Abstract

Several studies show that mangrove trees possess high species- and site-related trait allometry, suggesting large morphological plasticity that might be related to environmental conditions, but the causes of such variation are not clearly understood and systematic quantification is still missing. The result of the study was a big help and contribution in understanding mangrove morphological response specifically the Genus Sonneratia to the salinity and temperature with the use of Canonical Correspondence Analysis (CCA). Genus *Sonneratia* was selected because these species were present in a selected area along coastal area of Butuan City, Buenavista and Gingoog City, Philippines. The *Sonneratia* in Gingoog City usually has the highest value with average height of 10.8, 34cm dbh, 6 meters' canopy diameter and branch of 6 followed by Butuan City and Buenavista. In terms of salinity and temperature, still, Gingoog obtained the highest average value of 30.0ppt and 32 Degree Celsius respectively. All obtained environmental variables were used in Canonical Correspondence Analysis (CCA) to determine the relationship between variables to the Genus *Sonneratia*. Result revealed that one species of *Sonneratia* or *Sonneratia alba* was associated with salinity and other variables as it goes upward going to positive direction. Results further explain that the genus *Sonneratia* seems not to prefer to thrive in a high temperature.

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Introduction

Mangroves are usually located along coastal and marine areas which plays a vital role to sustain the balance of the shoreline ecosystem ((Benfield, 2002). Mangroves are also used by many indigenous peoples for traditional uses including as a source of medicine (Bandaranayake, 1998) as well as for building materials (Walters, 2005). Mangroves commonly known species that protects and can conserves water, and hold stream banks to prevent washout (Wani and Mughai, 2012). Philippines has about 7,100 islands with 3 major island, Luzon, Visayas and Mindanao has about 18,000 km of shorelines and vast areas of mangroves totaling to 500,000 hectares. Butuan Bay is located and the extension of Bohol Sea in the northeast section of Mindanao in the Philippines. The Butuan bay is also the river mouth and part of the Agusan River Basin (Miyazato, 2004). In the data of Philippine Statistics Authority in the year 2016, Gingoog City is considering as the 2nd class city at the province of Misamis Oriental, Philippines. Within this city, Gingoog Bay is located at the mouth of the City. Both Butuan Bay and Gingoog Bay were essential in understanding mangrove habitat assessment and identification. Both bay experience habitat degradation due to many anthropogenic activities. The development of coastal resources in the Philippines has been traditionally exploitative in nature. Government policies, which dictated development in both the uplands and coastal areas, have been based mainly on abundant available resources without due consideration for sustainability (Melana *et al.*, 2005). Vegetation of an area is crucial the primary source of production in an ecosystem and is an important bioindicator of environmental changes (Burianek *et al.*, 2013). Large areas of mangrove forests may often be cleared to make way for shrimp aquaculture in developing countries (Primavera, 2000).

To address some issues on mangrove degradation and habitat loss in Butuan and Gingoog Bay this study generally aims to identify and record selected environmental variables and used these in analyzing mangrove response of genus *Sonneratia* using Canonical Correspondence Analysis (CCA). Genus *Sonneratia* was the only mangrove and model species selected for CCA because these were commonly found in both Butuan and Gingoog Bay last ocular site survey. The data gathered from the study served to provide baseline information on Genus *Sonneratia* response in terms of diameter breast height (DBH), canopy diameter, height and number of seedlings and branches to the changes environment in terms of temperature and salinity present in both bay.

Materials and method

Site Description

The designed and methods of this present study is guided by the work of Anies and Demetillo (2016). The study utilized descriptive research design to assess the local area. Site selection was done using convenience sampling since the researchers selected the area because it is very convenient to the researcher's location. The study will be along the selected estuarine areas of Butuan Bay and Gingoog Bay (Fig. 1).

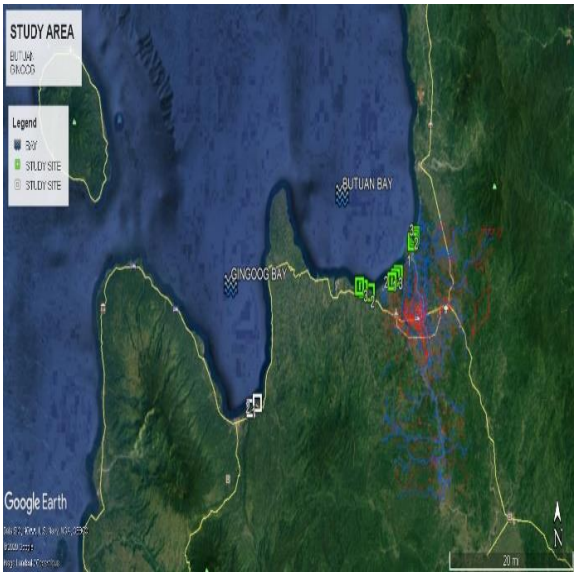

Fig. 1. Study Area showing the Butuan (in green) and Gingoog (in white) sampling site located at the northern side of Mindanao, Philippines courtesy with Google Earth.

Time Frame

Plant sample was collected from the month of November- December, 2019 at low tide.

Sampling Method

Thirty (30) samples in every sampling sites were collected similar to the study of Anies and Demetillo (2016). Further, no collection of plant will be made to the species that are still in a juvenile stage. There were three sampling stations: the estuarine and areas of (1) Butuan City (Latitude 8.83686◦, Longitude 125.06955◦, Altitude 53m) and (2) Buenavista as part of Butuan Bay (Latitude 8.92567◦, Longitude 125.00459◦, Altitude 86m) and in Gingoog Bay. A total of four 10mx10m plot were established for each of the sampling station. Within the plot, all Genus *Sonneratia* were recorded and measured in terms of DBH, average height, average canopy diameter, average seedlings generated and average branch per species. Transect plot technique/quadrat sampling were employed to assess the mangrove communities (Gomez Roxas *et al*., 2005). Identification of genus *Sonneratia* was identified using Philippines Mangroves by Primavera *et al* (2004).

Physico-Chemical Analysis

The salinity in each selected area were recorded and measured and process in a laboratory. Temperature were measured using electronic gadgets.

Data Analysis

Paleontological Statistics Software ver. 2.17c. was used to analyze the data through Canonical Correspondence Analysis was used to extract major gradients among combination of data sets. This is applicable to samples that are randomly and independently collected (McGarigal, K.S & S. Stafford, 2000). The analysis presented the relationship between physico-chemical parameters to the selected species. Further, CCA is a multivariate method to elucidate the relationship between biological assemblages of species and their environment.

Results and discussions

Three randomly selected areas were identified to measure the mangrove plasticity based on the changes of morphology in relation to the salinity and temperature. Among the mangroves species, genus *Sonneratia* was selected because this species is present in Butuan City, Buenavista and Gingoog City. Average morphological features of *Sonneratia* were documented and noted. Table 1 below is the presentation of average morphological structures in all areas. The noted features were closed to the study of Annies and Demetillo (2016) and. Thirty (30) samples of genus *Sonneratia* were collected in every sampling sites.

Table 1. Morphological average of genus *Sonneratia* in all areas.

Area	Ave Height (M)	Ave dbh (cm)	Ave Canopy Diameter (M)	Ave. No of Branch	Ave. Seedlings below the canopy
Butuan City	10.0	33.0	6.0	5.0	3.0
Buenavista	8.4	29.0	5.0	4.0	2.0
Gingoog City	10.8	34.0	6.0	6.0	4.0

The *Sonneratia* in Gingoog City usually has the highest value compared to other areas followed by in Butuan City and Buenavista respectively. One of the factors for these differences was the ecological disturbances such as land degradation and conversion. The study of Polidoro, *et al.,* 2010 already identified these disturbances in all mangroves habitat. However, the percent salinity may be a factor also to consider for the changes of morphological features of genus *Sonnerstia*. According to the study of Peter, *et al.,* 2010, Sodium Chloride is the main substance in the marine which has an average salinity of 35ppt and further, mangroves has an estimated average of 0.5 to 35ppt. The range probably depends on the distance of mangrove species to the shoreline. Basically, the higher the distance from the shoreline the higher the salinity. Table 2 below is the average salinity where the *Sonneratia* located versus the salinity recorded in all areas.

Table 2. Average salinity and temperature in all selected areas.

Area	Ave. Salinity (ppt)	Ave. Temp
Butuan City	28. 5	33
Buenavista	29. 8	32
Gingoog	30	32

Still, Gingoog Bay recorded to have a high average salinity compared to other areas. Butuan City

obtained the lowest because of the several factors influencing the salinity level considering human population, level of disturbances, improvements and river basin structure. The table 2 above showed that salinity may contribute to the morphological features of *Sonneratia* as presented also in table 1. All areas obtained almost the same temperature which could also be enough for the *Sonneratia* to live. The morphological differences of the species could indicates the availability of nutrients from the soil and this must be considered for further study. The phenotypic differences of *Sonneratia* in all areas were visible initially in relation to the changes of salinity.

In data analysis using Canonical Coreepsondence Analysis (CCA) showed the relationship between salinity and other parameters to the genus *Sonneratia* (Fig. 2).

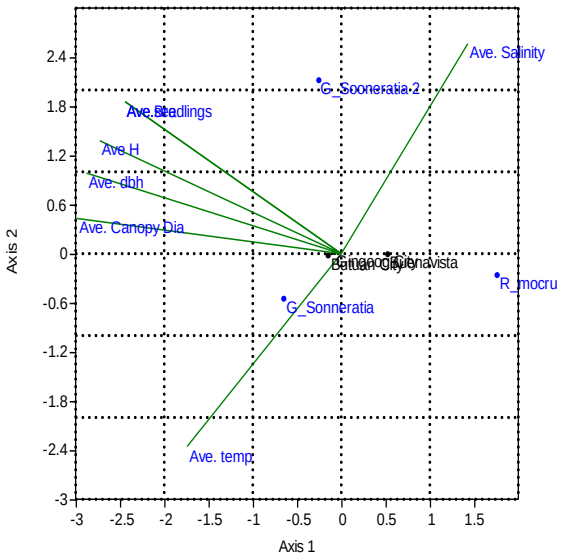

Fig. 2. Canonical Correspondence Analysis (CCA) of Genus *Sonneratia*.

From the result above two species of genus *Sonneratia* relates to the value of salinity and other parameters except to the average temperature. The recorded average temperature does not affect the phenotypic structures (going downwards) of the mangrove because these ranges only from 32 to 33 degree Celsius. All other parameters are basically requirements for the positive growth of genus *Sonneratia*. Moreover, the result of the analysis help researcher understand the importance of that parameters or biological variables in the morphological development of the genus *Sonneratia*.

Conclusions

The study provides information regarding the relationship between the recorded and selected environmental variables to the genus *Sonneratia* along Butuan and Gingoog Bay using Canonical Correspondence Analysis (CCA)

Genus *Sonneratia* in the Ginoog City provides more positive phenotypic development and structures. All mangroves not just under the Genus *Sonneratia* were in ecological threat due to the massive anthropogenic factors such as land conversion, clearing and housing. Salinity initially provides one of the major factor to the phenotypic structures and development of genus *Sonneratia* as presented also the Canonical Correspondence Analysis (CCA). Ecological variables presented are very important to consider to study the health condition of every mangrove species.

Recommendations

Protection and conservation in the remaining mangrove areas along Butuan and Gingoog Bay. Further variables and parameters to consider in studying mangrove morphology such as soil and water analysis. Field sampling both in wet and dry season must be considered knowing that the rain water also affects the percent salinity in estuaries. Lastly, Canonical Correspondence Anlysis must be considered in analyzing variables from wet and dry season data.

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