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Species composition, abundance and distribution of seagrasses in the brackish waters of Balingoan, Misamis Oriental in relation to environmental parameters

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Abstract

Seagrasses play an important role in marine and brackish waters both as primary producers and ecosystem engineers, thus sustaining biodiversity and ecosystem services. The ecology of seagrass was widely investigated in the marine region whereas their abundance and distribution in brackish waters is still limited. This study aimed to assess the composition, abundance and distribution of seagrasses in relation to some environmental parameters. Field sampling was conducted through transect-quadrat method and shoot density was determined along with water temperature, salinity, nutrients and water flow. The seagrass bed in Balingoan was a mixed community of *H. pinifolia*, *T. hemprichii*, *C. rotundata*, *H. ovalis* and *E. acoroides*. *H. pinifolia* dominated the area and its distribution extends from high to the lowest intertidal zone. Correlation analysis was significant between the seagrass species and the environmental parameters and it was species specific.

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Introduction

Seagrasses are rhizomatous marine angiosperms widespread in both marine and brackish shallow waters from temperate to tropical regions (Short *et al.,* 2007). In these regions, they often act as ecological engineers (Wright and Jones, 2006) forming extensive meadows that are among the most productive ecosystems on earth (McRoy and McMillan, 1997; Duarte and Chiscano, 1999). Seagrass meadows provide key ecosystem services, including organic carbon production and export, nutrient cycling, sediment stabilization, biodiversity, and trophic transfers to adjacent habitats (Duarte *et al.,* 2005; Duffy, 2006; Orth *et al.,* 2006; Cullen-Unsworth and Unsworth, 2013; Marco-Mendez *et al.,* 2015). The abundance and distribution of seagrasses are controlled by the physical, chemical and biological properties of their environment (Greve and Binzer, 2004). In most tropical seas, which are usually characterized by clear waters and high incoming irradiance throughout the year, seagrass growth is often limited by the availability of nutrients (Powell *et al*., 1989; Short *et al*., 1990; Duarte, 1995). In addition, water temperature, salinity and water motion are also important variables affecting seagrass abundance and distribution in tropical regions (Lin and Shao, 1998; Erftemeijer and Herman, 1994). The ecology of seagrass was widely investigated in the marine domain whereas their abundance and distribution in brackish waters is still not exhaustive (Boscutti *et al.,* 2015). Balingoan is a coastal municipality in the province of Misamis Oriental and its coastal water is part of the Gingoog Bay. The coastal area has underwater spring which causes the water to be less saline or brackish. This unique, unusual natural phenomenon provides viable platform for scientific exploration in the area because despite of its low salinity, the area encompasses a variety of tropical habitats including seagrasses. This study aimed to assess the abundance and distribution of seagrasses in relation to some environmental parameters in the area. This study provides additional data on the ecology of seagrasses and its trophic role in brackish waters especially in the tropical region.

Materials and methods

Study area

The study was conducted in Barangay Mantangale, Balingoan, Misamis Oriental (9°00'26.6"N 124°51'34.4"E, Figure 1).

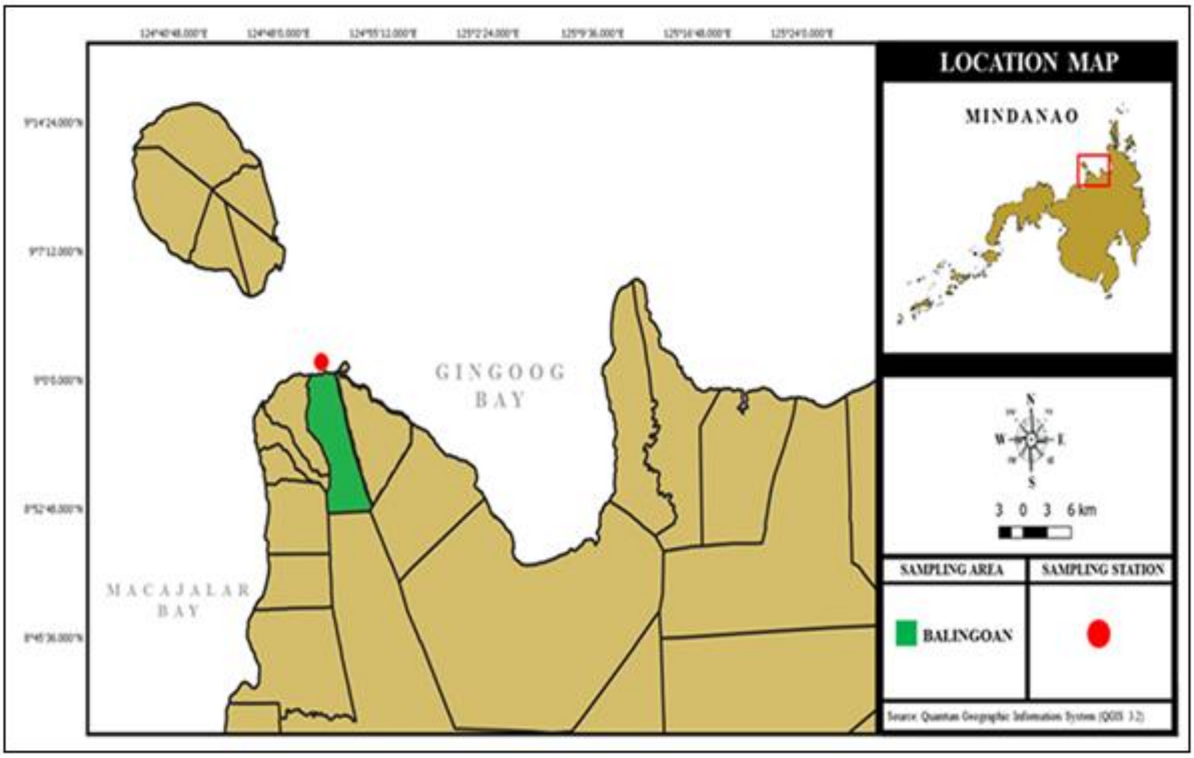

Fig. 1. Location of the sampling site in Balingoan, Misamis Oriental (Sources: QGIS version 3).

The coastal area of Mantangale in Balingoan has an underwater spring that caused the water to be less saline or brackish. It had a salinity that ranged from 4-9‰ with a mean value of 6‰. The sampling site is known to encompass a variety of tropical habitats including mangroves, seagrass beds and coral reefs.

Field sampling

The study was carried out during low tide when seagrasses were exposed. The whole intertidal flat was divided into three regions: high, middle and low. For each region, a 50-meter transect line (with 3 replicates) was placed parallel to the shore, and for every 10 m-interval, a 0.5 m x 0.5 m quadrat was laid down at the right side of the transect line. All the seagrasses inside the quadrat were identified and recorded following the taxonomic keys of Calumpong and Meñez (1997) and Kuo and den Hartog (2001). Shoot density was measured by carefully counting the shoots per species for each quadrat and the shoot numbers were expressed as density (shoot/m^{-2}). The density and relative density were calculated using the formula:

$$\text{Density} = \frac{\text{Number of shoots per species}}{\text{Total area of quadrat } (m^{2})}$$

$$\text{Relative Density} = \frac{\text{Density of a species}}{\text{Total density of all species}} \times 100$$

Environmental Parameters

Environmental parameters were measured randomly in the brackish waters surrounding the seagrass bed. Water temperature was measured in situ using an ordinary mercury thermometer while salinity was measured using a handheld refractometer. Water flow was estimated using clod cards (Doty, 1971) and the calculation of water flow (cm^{-2}) was done based on the method of Anzai (2001). Nutrient analysis was carried out following the method of Grasshoff *et al.* (1983).

Statistical analysis

The difference in abundance represented by shoot density among species was analyzed through One-Way Analysis of Variance (One-Way ANOVA, level of significance, P of 0.05) in SPSS (version 8.0). Pearson's correlation analysis was used to determine the correlation coefficients between environmental factors with seagrass abundance.

Results and discussion

A total of five (5) seagrass species were identified in the area: *Cymodocea rotundata* (Ehrenberg and Hemprich, ex Ascherson), *Enhalus acoroides* (L.f.) Royle, *Halophila ovalis* (R. Brown), *Halodule pinifolia* (Miki) den Hartog and *Thalassia hemprichii* (Ehrenberg) Ascherson (Table 1).

Table 1. Identification of seagrasses in Balingoan, Misamis Oriental (Calumpong and Meñez, 1997; Kuo and den Hartog, 2011).

Family	Genus and Species	Common Name	Local Name
Hydrocharitaceae	*Thalassia hemprichii*	Sickle-grass	Lusay
	Halophila ovalis	Paddle weed	Lusay
	Enhalus acoroides	Tape-grass	Lusay
Cymodoceaceae	*Cymodocea rotundata*	Manatee-grass	Lusay
	Halodule pinifolia	Needle-grass	Lusay

The total seagrass taxa of Balingoan represent 33.33% of the 15 reported taxa from the Philippines (Meñez *et al.,* 1983; Short and Coles, 2001; Green and Short, 2003; Short *et al.*, 2007). The five (5) seagrass species in this study are interesting information considering the total of fifteen (15) species for the entire Philippines. The seagrass bed of Mantangale, Balingoan was characterized as mixed meadow and the seagrasses that form this mixed bed encompass a considerable size range, from the smallest (*Halophila ovalis*) to the largest (*Enhalus acoroides*). According to the following authors (Brouns, 1987; Fortes, 1995; Terrados *et al.*, 1998) most of the seagrass bed in SE is composed of mixed seagrass communities typically comprise of up to 13 species, ranging broadly in size from small *Halophila sp.* to the large *Enhalus acoroides*. Likewise, Philippine seagrass beds are generally mixed (Meñez *et al.,* 1983; Tomasko *et al.,* 1993) in response to nutrient enrichment (Agawin *et al.,* 1996), disturbance (Duarte *et al.,* 1997), competition (Duarte, 2000) and water depth (Taplin *et al.,* 2005).

Table 2. Correlation coefficients (R) in relative density (%) with environmental parameters among seagrass species in Balingoan, Misamis Oriental.

Species	Coefficient of Correlations				
	Temp	Sal	PO_4	NO_3	Water flow
H. pinifolia	-0.147	-0.748**	0.510	0.097	0.305
	0.69	0.03	0.13	0.79	0.91
C. rotundata	-0.073	-0.310	0.689**	0.307	0.075
	0.83	0.35	0.02	0.16	0.21
H. ovalis	-0.007	-0.693	0.234	0.052	0.725
	0.98	0.51	0.15	0.97	0.48
T. hemprichii	-0.999**	-0.284	0.303	0.374	0.207
	0.03	0.37	0.14	0.23	0.52
E. acoroides	-0.629	-0.029	0.433	0.500	0.843**
	0.26	0.94	0.27	0.39	0.02

Legend: ** represents significant differences at $p<0.05$.

The abundance of seagrass represented by shoot density varies among species (One-Way ANOVA, $p < 0.05$). *H. pinifolia* had the highest shoot density followed by *C. rotundata* and *T. hemprichii* (Figure 2). *H. pinifolia* is widely distributed throughout the Indo-west Pacific and is almost ubiquitous in tropical seagrass meadows often being dominant (Meñez *et al.,* 1983; Waycott *et al.,* 2004).

This species is a rapid colonizer from seed and through vegetative growth; it plays an important role in maintaining seagrass habitat in areas of high disturbance and actively stabilizes sediments with an intertwining mat of rhizomes and fibrous roots. Likewise, this species was also dominant in the coastal lagoon of the east coast of Malaysia (Sidik *et al.*, 2010), Valachchenai lagoon (Udagedara *et al.*, 2017) and Negombo lagoon in Sri Lanka (Samarakoon and Van Zon, 1991). *C. rotundata* was second in rank in terms of abundance. This species is also an ecologically important tropical pioneer seagrass species distributed in the Indo-Pacific region. It is also found in Puttalam lagoon in Sri Lanka (Ranahewa *et al.,* 2018) and one of the dominant seagrass species in Tongsha island in Taiwan (Lin *et al.,* 2005). *T. hemprichii* was third in abundance and it is also one of the most widely distributed seagrass species dominating in many mixed meadows (den Hartog, 1970; Brouns, 1987; Vermaat *et al.,* 1995; Gullström *et al.,* 2002; Prathep, 2003). This species is known to be an important food source for dugongs and sea turtles and provides critical grazing habitat for fish (Phillips and Meñez, 1988). Two species, *H. ovalis* and *E. acoroides* have the lowest abundance. *Halophila* plants in mixed populations have low abundance due to high competition with other species in terms of light, space and nutrients (Japar Sidik, 2010). Moreover, the low abundance of *E. acoroides* was attributed to its slow growth rate because large seagrasses are slow growing with limited colonizing capacity (Duarte, 1991).

Compared to other tropical seagrass species, *E. acoroides* is a very recognizable type of seagrass for it has long, wide and stiff leaves (Kuo and den Hartog, 2001) and known to have the widest tolerance and can live on muddy, sandy and sandy-muddy substrate (Dewi and Sukandar, 2017).

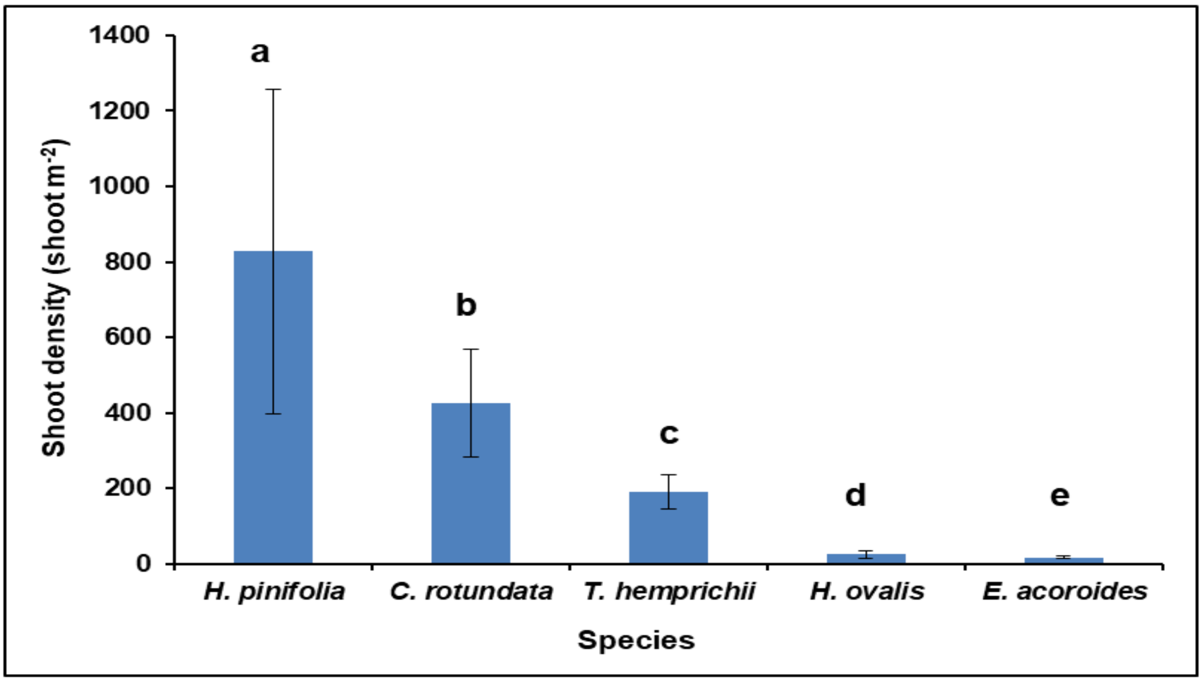

Fig. 2. The shoot density of seagrasses in Balingoan, Misamis Oriental. Different letters compared horizontally indicate statistically significant differences between the means at the level of 5% probability by Tukey test.

The seagrass community was found 150 meters from the shoreline in a depth of 3 meters during high tide. The seagrasses were in patchy distribution and extends from high to the lowest intertidal zone but its species composition decreases which might be related to water depth and light availability (Duarte, 1991). The five species were present in the high intertidal region and dominated by *H. pinifolia* with 66% relative density (Figure 3). In mid region, all species were still present and *C. rotundata* dominated with 59% relative density. In the low intertidal region, only three species were found such as *H. pinifolia*, *C. rotundata* and *T. hemprichii*. *H. pinifolia* had the highest relative density (57%) followed by *C. rotundata* (38%).

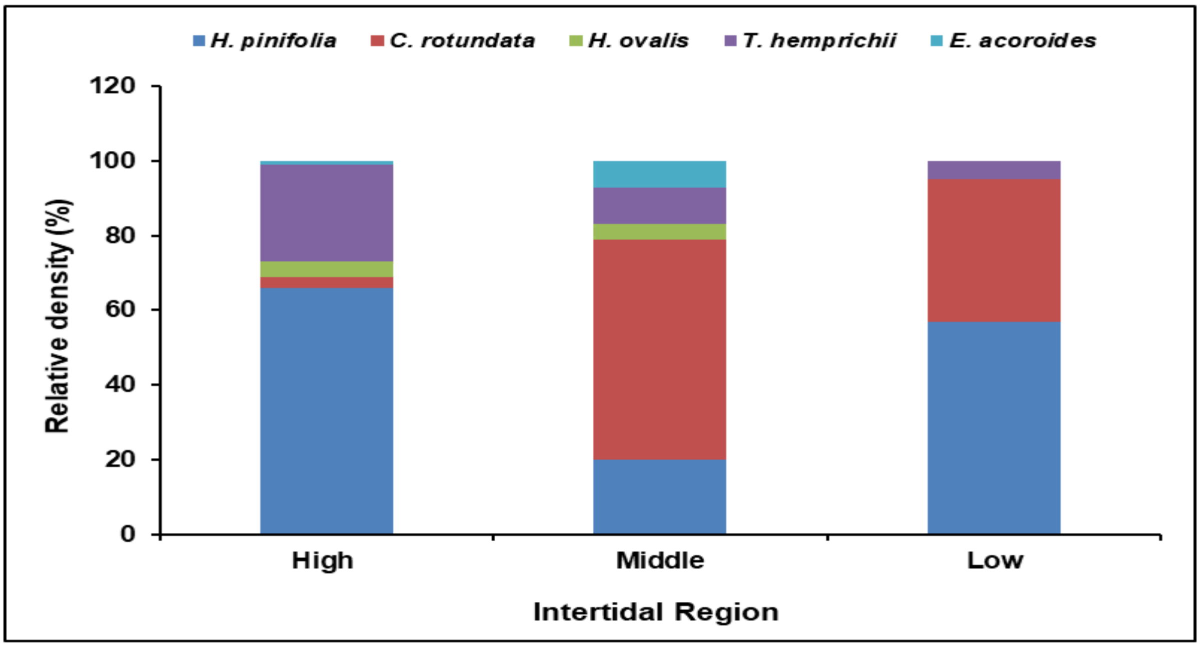

Fig. 3. The distribution of seagrasses in the intertidal flat of Balingoan, Misamis Oriental.

Significant correlation was detected in *H. pinifolia*, *T. hemprichii*, *C. rotundata* and *E. acoroides* with the environmental parameters measured in the area (Pearson's Correlation, $p<0.05$, Table 2). Water temperature showed a significant negative correlation with *T. hemprichii* while *H. pinifolia* negatively correlated with salinity indicating that these species have low capability to produce high shoot density with changing temperature and salinity. Temperature is considered a major factor controlling seagrass growth because an increase in water temperature will affect the biochemical processes involved in photosynthesis and respiration (Tutin, 1942; Phillips *et al.*, 1983; Lee and Dunton, 1996; Lee *et al.*, 2005). Related study shows that high temperatures can reduce growth and productivity of *T. testudinum* (Barber and Behrens, 1985). Likewise, an increase in salinity would affect the morphology and physiology of seagrasses (Kuo and den Hartog, 2006; Taiz and Zeiger, 2009). A study done on *H. wrightii* shows that no increase in growth was seen and the leaf chloroplast was affected when the plant was exposed to salinity of 45ppt (Ferreira *et al.,* 2017). On the other hand, phosphate was positively correlated with *C. rotundata* suggesting that an increase in phosphate would stimulate growth of this species, hence increases its shoot density and vice versa. Nutrient enrichment studies suggest that additions of inorganic nutrients can stimulate seagrass growth (Orth, 1977; Harlin and Thorne-Miller, 1981; Iizumi *et al.*, 1982; Dennison *et al.*, 1987; Short *et al.*, 1990; Pérez *et al.*, 1991; Murray *et al.*, 1992; Williams and Ruckelshaus, 1993; Lee and Dunton, 2000) and this was observed in an experiment done on *C. rotundata* in Cape Bolinao, Pangasinan in response to nutrient addition (Agawin *et al.,* 1996). Moreover, water flow was positively correlated with *E. acoroides* because strong water motion could increase the absorption of carbon dioxide and increase the nutrient uptake at the leaf surface of *E. acoroides* (Agawin *et al.,* 2001; Hillman, 1989).

Conclusion

The recent research on seagrasses in the brackish waters of Balingoan has provided additional and important information on the composition, abundance and distribution of seagrasses in which data were still limited. Current findings suggest that the seagrass bed in Balingoan was a mixed stands comprised primarily of *H. pinifolia*, *C. rotundata*, *T. hemprichii*, *H. ovalis* and *E. acoroides*. It was dominated by *H. pinifolia* and its distribution extends from high to the lowest intertidal zone. Seagrass beds consisting of *H. pinifolia* contributed importantly to coastal ecosystems in Balingoan brackish waters because of its high density. Furthermore, the significant correlation between seagrasses and the environmental parameters in the area indicate the existence of a species specific relationship.

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