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Quantitative assessment of sea grass diversity along some selected coastal sites of the Red Sea at Haql, Tabuk, Saudi Arabia

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Abstract

Sea grasses are well known for their ecological importance providing shelter and nurseries for various aquatic animal species, protect coral reefs from turbid waters, support biodiversity, and trapping nutrients received from terrestrial ecosystems. Sea grasses represent the major components of marine ecosystems and are strong indicators for the ecological health of coastal marine ecosystems. By assessing the eco-physiology of sea grasses, impacts of activities developed in that coastal area can be assessed and monitored. In this quantitative assessment of sea grass diversity, frequency, density, abundance, and dominance were determined on the selected coastal sites of the Red Sea at Haql in October 2020. Five common sea grass species namely *Cymodocea rotundata, Halodule pinifolia, Thalassodendron ciliatum, Halophila stipulacea,* and *Thalassia hemprichii* were selected for this study. Quadrats of 1m^2 were used for data collection. There was a marked difference in quantitative parameters of sea grass diversity. From the following research, it can be concluded that the sea grass diversity showed spatial variations within and between the selected coastal study sites. The results provide preliminary data which can be utilized to compare the diversity of observed sea grass species.

Keywords: Sea grass; Diversity; Red Sea; Coastal marine ecosystem.

1. Introduction

Sea grasses belong to angiosperms found submerged in marine habitats (Uku, 2005). This is a group of flowering plants different from the others as they are highly sensitive to the physiochemical and biological characteristics of water. They can tolerate saline to hyper saline waters (Orth *et al.,* 2006). Sea grasses belong to 4 families, 12 genera, and about

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60 species. They can be found in meadows, distributed in seashores, intertidal or tidal, in temperate to tropical habitats (McKenzie and Campbell, 2002). A continuous decline in sea grass species diversity has been reported due to habitat loss and water pollution as a result of anthropogenic activities (El Shaffai, 2011). Therefore, their distribution, composition, diversity, and occurrence vary with seasons and geographical locations. To understand the role of sea grasses, regular monitoring and assessment of sea grass ecosystems are required. Sea grasses are considered the most productive ecosystems on this earth planet and the biggest carbon sink ecosystem in the oceans (Duarte *et al*., 2011). They are the vital and dominant primary producers of marine ecosystems and provide strong support to the food chains, food webs, and biodiversity (Duarte *et al*., 2011). Sea grasses provide space for marine bacteria, microphytes, macrophytes, and invertebrates. Also, they provide a suitable environment for feeding, hiding places from predation, nursery, breeding for various crustaceans, fishes, and other invertebrates (Apostolaki *et al*., 2011; Orth *et al*., 2006).

Despite its ecological importance, sea grasses are threatened by anthropogenic activities worldwide (Waycott, 2009). It has been reported that there is an approximate 5% loss of sea grass diversity per year (Duarte *et al*., 2011, Kennedy and Björk, 2009). Various development projects and human settlements at the coastal areas are the major causes of habitat destruction of sea grasses (Erftemeijer and Lewis, 2006). Marine ecosystems support rich biodiversity (Agarwal and Agarwal, 2007; Sharma, 2005). One of the greatest challenges for today is to assess the mechanism of biodiversity losses (Murphy *et al*., 2003). One of the important causes of habitat destruction is the contamination of fresh and marine waters (Ansari and Khan, 2007). In this quantitative assessment of sea grass diversity, frequency, density, abundance, and dominance were determined on the selected coastal sites of the Red Sea at Haql in October, 2020.

2. Materials and methods

Five coastal sites of the Red Sea in Haql City (29.28598, 34.94510) were selected for this study, namely, S1: Ameer Fahad Bin Sultan Park (29.30112, 39.94064), S2: Palm Garden 29.29950, 34.94927), S3: Unnamed Park (29.32452, 34.94528), S4: Garden Durra (29.33318, 34.95075), S5: Border Guards Ahumaidh Center (29.22975, 34.91638) (Figure 1). The Haql city is located at 29^{o} 17’9.9” N 34^{o} 56’ 18.9” E and 230 Kms from the Tabuk city. The study sites were characterized by some resorts, hotels, and residential areas along the sea coast. This area is unprotected and open for visitors/tourists. Five sea grass species namely *Cymodocea rotundata, Halodule pinifolia, Thalassodendron ciliatum, Halophila stipulacea,* and *Thalassia hemprichii* were selected for this study based on their availability on different sites. This quantitative assessment on the diversity and distribution of sea grasses was based on the data collected on frequency, density, and abundance.

Sampling was done in the mid of October 2020. For the sampling of sea grass species at different study sites, quadrats of $1m^2$ were used. At each study site, five replicates of quadrats (in a randomized manner) were used to collect the data for the quantitative assessment of sea grass diversity.

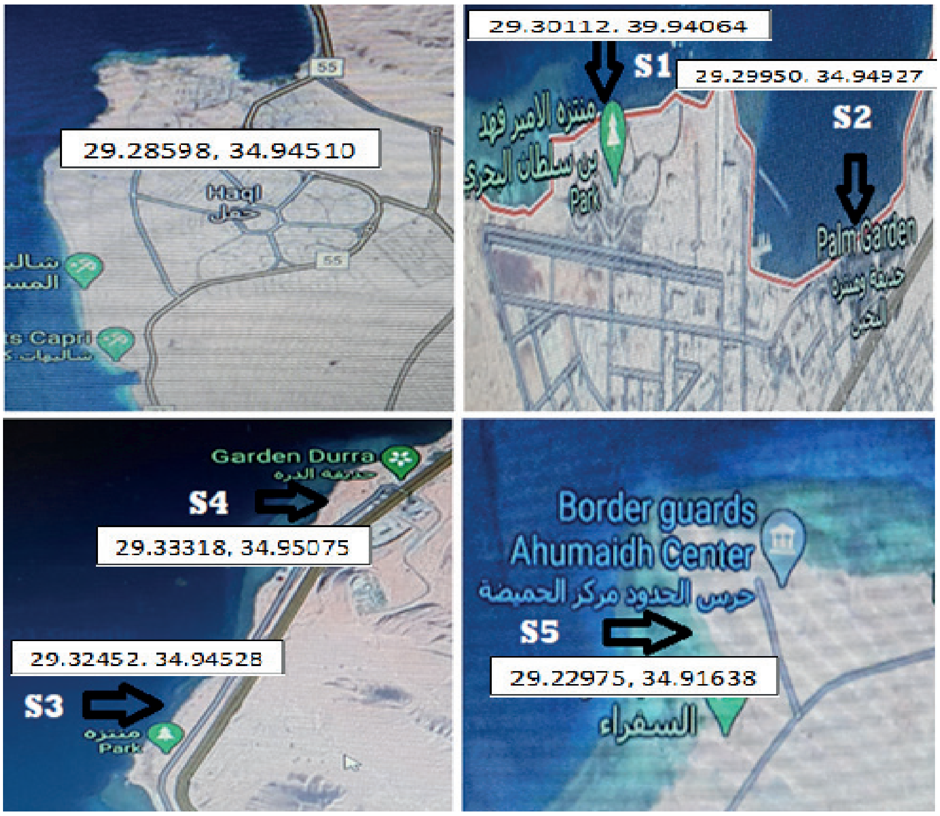

Figure 1. Five selected study sites at Haql, Tabuk, Saudi Arabia, S1: Ameer Fahad Bin Sultan Park, S2: Palm Garden, S3: Unnamed Park, S4: Garden Durra, S5: Border Guards Ahumaidh Center (Courtesy Google maps)

2.1. Calculations and data analysis for frequency, density, abundance, and dominance of each sea grass species

In this research, to determine the diversity and distribution of algal flora along with the coastal areas the data collected in Table 1.

Quantitative parameters of diversity for each species were calculated as follows:

Frequency = $\frac{a}{b}X100$

Density = $\frac{b}{c}$

Abundance = $\frac{b}{a}$

Dominance = d + f

where,

a = Number of quadrats in which species has occurred

b = Number of individuals of a species in all the quadrats

c = Total number of quadrats studied

d = Density

f = Frequency

3. Results

Table 2 shows that the frequency of *Cymodocea* was 100% at sites S1, S4, and S5 and 80% at sites S2 and S3. However, the density and abundance of this species were highest at sites S4 and S5. This sea grass species was highly

Table 1. Data on the number of individuals of sea grass species collected at different study sites (S1-S5) using quadrats (Q)

	S1					S2					S3					S4					S5				
	Q1	Q2	Q3	Q4	Q5	Q1	Q2	Q3	Q4	Q5	Q1	Q2	Q3	Q4	Q5	Q1	Q2	Q3	Q4	Q5	Q1	Q2	Q3	Q4	Q5
Cymodocea	12	5	11	4	16	0	4	5	6	5	5	5	4	4	0	16	8	15	7	13	21	14	7	7	12
Halodule	20	6	14	12	5	3	7	0	6	8	6	4	3	2	4	25	20	15	12	10	28	16	6	13	6
Thalassodendron	4	3	4	0	3	0	3	2	2	1	2	0	1	2	0	10	5	8	7	5	4	8	4	4	7
Halophila	5	0	4	5	6	4	3	0	4	2	3	3	0	1	1	6	0	6	5	2	5	5	0	0	1
Thalassia	6	3	2	5	6	0	4	2	2	1	2	0	4	0	4	7	6	7	3	3	6	3	2	1	1

Table 2. Diversity and distribution (per $m^{2)}$ of individuals of each sea grass species at different study sites (S1-S5)

	S1				S2				S3				S4				S5			
	rF	nD	bA	mD	rF	nD	bA	mD	rF	nD	bA	mD	rF	nD	bA	mD	rF	nD	bA	mD
Cymodocea	100	9.6	9.6	109.6	80	4.0	5.0	84.0	80	3.6	4.5	83.6	100	11.8	11.8	111.8	100	12.2	12.2	112.2
Halodule	100	11.4	11.4	111.4	80	4.8	6.0	84.8	100	3.8	3.8	103.8	100	15.4	15.4	115.4	100	13.8	13.8	113.8
Thalassodendron	80	2.8	3.5	82.5	80	1.6	2.0	81.6	60	1.0	1.7	61.0	100	7.0	7.0	107.0	100	5.4	5.4	115.4
Halophila	80	4.0	5.0	84.0	80	2.6	3.3	82.6	80	1.6	2.0	81.6	80	3.8	4.8	83.8	60	2.2	3.7	62.2
Thalassia	100	4.4	4.4	104.4	80	1.3	2.3	81.3	60	2.0	3.3	62.0	100	5.2	5.2	105.2	100	2.4	2.4	102.4

(Fr = Frequency, Dn = Density, Ab = Abundance, Dm = Dominance)

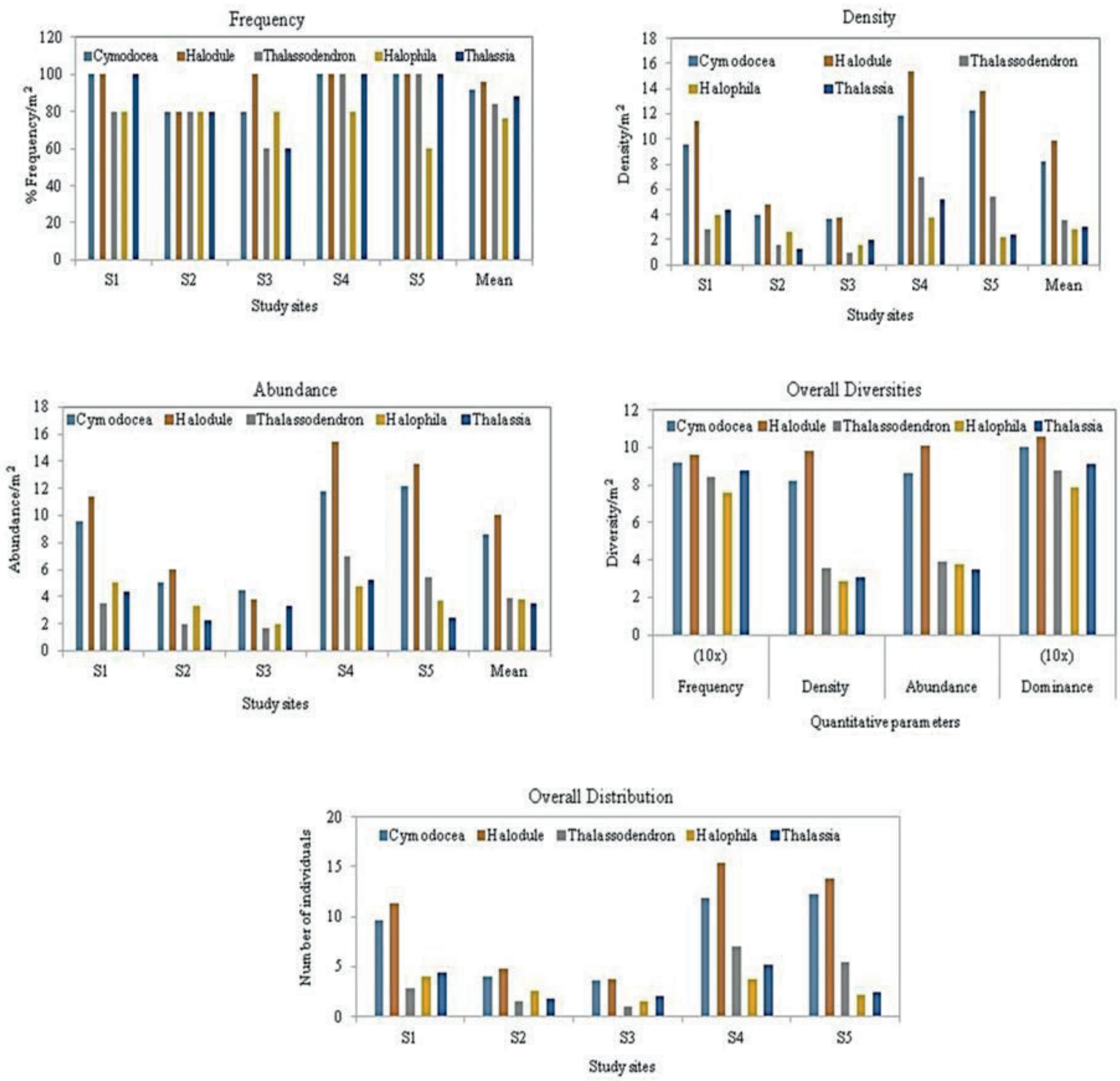

Figure 2. Diversity and distribution of sea grass species studied at five coastal sites (S1-S5) at Haql

dominant at site S5. The frequency of *Halodule* was 100% at sites S1, S3, S4, and S5 and the density and abundance of this species were highest (15.4) at site S5. This species was found highly dominant at site S4. *Thalassodendron* showed the frequency of 100% at sites S4 and S5 and 80% at sites S1 and S2. The density and abundance of this species were highest at site S4. This sea grass species was also dominated at site S5. *Halophila* showed the frequency of 80% at sites S1, S2, S3, and S4. The density, abundance, and dominance of this species were higher at sites S1 and S4 as compared to the other study sites. *Thalassia* showed the highest frequency of 100% at sites S1, S4, and S5, whereas the lowest frequency and density were observed at sites S3. This sea grass species was highly dominated (115.4) at site S4 as compared to the other study sites. Among all the sea grass species at all the study sites *Halodule* and

Thalassodendron were highly dominated at sites, S4 and S5, respectively (Table 2).

Figure 2 is based upon the mean of the data collected from all the study sites (S1-S5) which shows the variation in frequency, density, abundance, and dominance. The frequency of *Halodule pinifolia* was highest at 96% whereas *Halophila stipulacea* showed the lowest at 76% as compared to the other sea grass species. Among all the sampling sites overall frequency for sea grass species had the maximum value at Site S5. The density of sea grass species *Halodule pinifolia* was highest (9.84) and was lowest (2.84) for *Halophila stipulacea* as compared to the other sea grass species. The maximum density of sea grass species was recorded at site S4 as compared to the other sampling sites. The abundance of *Halodule pinifolia* was the highest (10.08) and of *Thalassia hemprichii* was the lowest (3.52) among all the sea grass species. Among all sampling sites, S4 was highly abundant for sea grass species. The overall results on quantitative assessment of sea grass diversity reveal that among all the sea grass species *Halodule pinifolia* was the most abundant and dominant species whereas *Thalassodendron ciliatum* was the least abundant at the different sampling sites at Haql. Based on the number of individuals of each sea grass species at each study site, a significant variation in distribution was recorded. All the sea grass species were distributed at all the study sites. The highest number of individuals of *Halodule pinifolia* and *Cymodocea rotunda* were recorded at the sites S4 and S5 respectively, as compared to other sea grass species (Figure 2).

4. Discussion

In this study, the data on the diversity and distribution of sea grass species were recorded. Variation in occurrence of sea grass species was observed at all the study sites which may be an influence of some environmental factors (Ochieng and Erftemeijer, 2003). The abundance and diversity of sea grass species showed spatial variation within and between the study sites (Aboud and Kannah, 2017). The sea grass diversity and distribution along the selected coastal sites showed variable patterns (Campbell *et al*., 2006). A distinct variation between and within the sea grass species at different study sites indicates the local ecological conditions and their impact in determining the productivity of sea grass ecosystems (Nobi *et al*., 2011).

Sea grass ecosystems are distributed in inshore shallow waters at the depth of approximately 10 meters, which is a major reason for their overexploitation (Ochieng and Erftemeijer, 2003; Gwada, 2004). Anthropogenic activities such as fishing, motorboats propellers, anchors, dredging, filling, silt, sewage discharges, and oil pollution are the major causes of perturbations in sea grass ecosystems. Moreover, the entry of various alien sea grass species affects the sea grass diversity Gwada, 2004). Increasing human population and settlements along with the coastal areas also aggravate the loss of sea grass diversity (Short, 2011). Despite knowing the ecological importance, the number of researches and reports on the sea grass ecosystems are still very few (Duarte *et al*., 2011). Biological, chemical, and physical characteristics influence the diversity and distribution of a species (Ansari, 2005; Ansari and Khan, 2006; Ansari and Khan, 2009) which indicated the ecological health of an ecosystem (Burgi *et al*., 2003). The study of Purvaja *et al*. (2018) concluded that the sea grass ecosystems can serve as an ecological proxy for the assessment of the health of coral reef ecosystems. Quantitative assessment with the parameters such as frequency, density, abundance, and dominance of a species in a community provides preliminary data for the estimation and forecast of diversity required to its conservation (Ansari *et al*., 2020) Effective policies and measures are need of the hour to secure the future of biodiversity (Stehlik Casperson *et al*., 2007).

The management plans in Tabuk regions are not directly focused on sea grass diversity and its conservation. Also, the researches on Red sea coasts specifically on sea grass ecosystems is in need of the hour to forecast the future of coastal biodiversity. Therefore, it is important to report sea grass diversity and distribution which may help in the identification of coastal areas of the Red Sea where the conservation of sea grass ecosystem is urgently required. Keeping given the ecological importance of sea grasses in this study we are focused to determine the patterns of species diversity, distribution, abundance, and dominance, which may provide a piece of preliminary information on the community structure of sea grass ecosystems along with the coastal areas of the Red sea at Haql, Tabuk.

Conclusion

It can be concluded from this study that the sea grass frequency, density, abundance, dominance, and distribution showed a significant variation within and between the various study sites. Among the five sea grass species namely *Cymodocea rotundata, Halodule pinifolia, Thalassodendron ciliatum, Halophila stipulacea,* and *Thalassia hemprichii* studied in this field sampling, the *Halodule pinifolia* was the most dominant species at all the study sites followed by *Cymodocea rotunda, Thalassia hemprichii, Thalassodendron ciliatum,* and *Halophila stipulacea*. At some study sites occurrence of all the sea grass species was higher whereas at some sites only a few individuals of a species were recorded. We observed a site restriction species to species, which may be due to physicochemical characteristics of waters, influence of some other environmental factors, human settlements and visitors at the coastal sites.

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