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Determination of the Density of Mats Formed by the Non-native Seagrass *Halophila Stipulacea* in Mersin Bay (Akkum)

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Abstract

Halophila stipulacea is a seagrass species that was one of the first species to enter the Mediterranean Sea with the Lepsian migration, forming local beds as far away as the Caribbean. This species has a wide geographical distribution and its distribution is known to be influenced by many anthropogenic factors. The aim of this study was to determine the mat density of *H. stipulacea* in Akkum coast of Mersin Bay. The quadrat method was used for sampling. Biometric measurements were made on 100 samples randomly selected from six 1 m^2 stations in the sampling area. The average number of shoots was determined to be (488 shoots m^{-2}). The average leaf length of the samples was 42.33±7.17 mm, leaf width was 5.82±0.92 mm, and the length between two nodes was 5.96±1.97 mm. Based on the field observations, it was found that the distribution of mats was denser up to a depth of 8 m, and this density decreased with depth.

1. Introduction

Halophila stipulacea (Forsskål) is a dioecious species of seagrass belonging to in the family Hydrocharitaceae of the order Alismatales, native to the Red Sea, Indian Ocean. Due to its wide salinity and temperature tolerance, it can form dense and extensive beds in tropical and temperate waters in a very short time. The species was one of the first Lessepsian species to enter the Mediterranean and is now reported to be distributed as far as the Caribbean Islands (Scheibling et al., 1998; Gerakaris and Tsiamis, 2015; Winters et al., 2020; Toso and Musco, 2023). The first record from the Mediterranean was given by Fritsch, (1895), and Politis (1926), Forti (1928), Aleem (1962), Lanfranco (1970), Lipkin (1975) reported new records of the species from the Levantine basin. The species gradually forms extensive beds in the northeastern Mediterranean and records from the western Mediterranean are given (Villari, 1988; Biliotti and Abdelahad, 1990; Rindi et al., 1999). The first Atlantic record was reported by Ruiz and Ballantine (2004) in Grenada in 2002, followed by records from Martinique, Dominica and St. Lucia in 2006-2008 (Willette and Ambrose, 2009; Maréchel et al., 2013). It has been reported that *H. stipulacea* continues

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to persist in the recorded marine areas (Willette et al., 2014; van Tuseenbroek et al., 2016; Vera et al., 2014).

The interaction of *H. stipulacea* with local seagrass beds has been evaluated in limited studies (Willette and Ambrose, 2009; Maréchel et al., 2013; Becking et al., 2014). In the Mediterranean, *H. stipulacea* has been reported to displace the native species *Cymodocea nodosa* (Winters et al., 2020). In the Atlantic, the species has been reported to interact or mix with the native species *Thalassia testudinum* and *Syringodium filiforme* in monospecific stands (Willette and Ambrose, 2009; Maréchel et al., 2013), while in the Caribbean, *H. stipulacea* has been reported to invade native seagrass beds (Winters et al., 2020). Of the limited studies that have examined the ecological impacts of the species, dense mats of *H. stipulaceae* have been reported to increase the amount of nutrients in the sediment in association with native species, resulting in an increase in the abundance of small invertebrates, epifauna, and the fish that feed on them (van Tuseenbroek et al., 2016; Willette and Ambrose, 2012).

It has been reported that there is a distinction between the distribution of *H. stipulacea* in the Mediterranean and the Caribbean, and that it is distributed in small and limited areas in the Mediterranean, while in the Caribbean it is distributed in larger areas and in a shorter period of time (Winters et al., 2020). It has been reported that *H. stipulacea* beds have been found at depths of 1-3 m in the port of Otranto, Italy (Toso and Musco, 2023). In its natural habitat, the species is distributed at depths of 0.5-70 m in the Red Sea, 1-14.5 m in the Arabian Gulf, 1.5-37 m in the Indian Ocean, while outside its natural habitat, the species is distributed at depths of 0-27 m in the Mediterranean Sea and 0.2-32 m in the Caribbean Sea (Winters et al., 2020).

Local seagrass beds on the island of Bonaire in the Gulf of Lac (Caribbean Netherlands) are known to be an important grazing area for *Chelonia mydas*. The rapid spread of *H. stipulacea* in this area has begun to threaten the local seagrass beds. Researchers are concerned that *C. mydas* may want to feed on the rapidly spreading *H. stipulacea* and have reported that *C. mydas* has been feeding on the invasive species in monitoring studies conducted for this purpose (Becking et al., 2014).

The aim of this study was to report new mats formed by *H. stipulacea* between depths of 1-20 m in Mersin Bay (Akkum) and to determine the density status of mats formed by the non-native seagrass *H. stipulacea* between depths of 5-6 m.

2. Material and Methods

Sampling was done using 1 m^2 squares randomly placed at six stations in the sampling area (Figure 1). Sub-squares were not used to determine the number of shoots. The sampling site was selected at a depth of 5-6 m, where the species has a dense distribution. A total of one hundred samples (n = 100) were randomly collected for measurements from all quadrats in the sampling area. Mean leaf length (mm), mean leaf width (mm), and internode length (mm) were measured using electronic calipers.

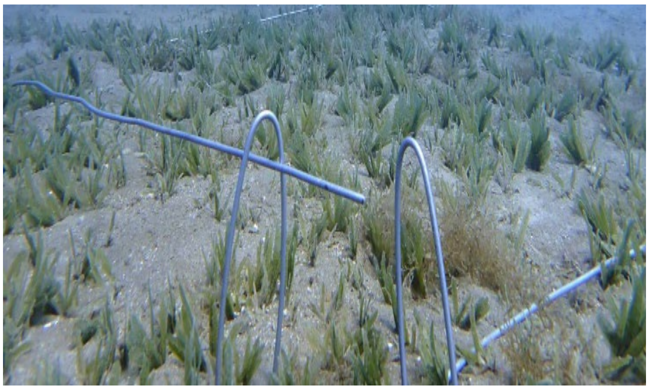

Figure 1. View of a quadrat used to determine the number of shoots.

3. Results

The distribution of *H. stipulacea* mats in Akkum marine area of Mersin Bay was observed between 1-20 m depth. The number of shoots per m^2 was counted by placing six 1 m^2quadrats between 5-6 m depth, where seagrass was most abundant. The average number of shoots was determined as 488 shoots m^{-2}. The average leaf length of the samples was 42.33±7.17 mm, leaf width was 5.82±0.92 mm, and the length between two nodes was 5.96±1.97 mm (Table 1). Based on the field observations, it was found that the distribution of mats was denser up to a depth of 8 m, and this density decreased with depth.

4. Discussion

H. stipulacea was one of the first species to enter the Mediterranean following the opening of the Suez Canal. Studies reporting the gradual distribution of *H. stipulacea* in the Mediterranean, Atlantic, and Caribbean have shown that the species has invasive potential (Georgiou et al., 2016). In the 125 years since its introduction to the Mediterranean, it has been reported to have reached Egypt, Lebanon, Syria, Turkey, Cyprus, Greece, Albania, Tunisia, Libya, Malta, Italy (Sicily and Campania), and more recently the northern coast of Sardinia (Pica et al., 2021) and the coast of Cannes in northern France (Thibaut et al., 2012) (see Toso and Musco, 2023). In this study, *H. stipulacea* mats were found in the Akkum marine area of Mersin Bay, between 1-20 m depths, and the results of quantitative analyses in the distribution area of the species were compared with the results of previous biometric analyses of *H. stipulacea* mats in the southern and northern Mediterranean reported by Sghaier et al. (2011), Gambi et al. (2009), Di Martino et al. (2006), Procaccini et al. (1999), Cancemi et al. (1994) (Table 1). In the Akkum marine area of Mersin Bay, the species was found to be distributed up to 20 m depth, which is similar to the results of previous studies in the Sicilian marine area in the northern Mediterranean (Di Martino et al. 2006; Procaccini et al. 1999). In a previous study in the southern Mediterranean (Tunisia, Libya), *H. stipulace* was reported to be distributed up to 2 m (Sghaier et al. 2011). The species is known to range up to 70 m in its natural habitat and up to 32 m in the Caribbean (Winters et al., 2020). It is difficult to distinguish between biometric data and latitudinal distribution depth. On the other hand, it is thought that there may be a niche overlap between this species and other seagrass species, with this species establishing new populations in habitats where local species have disappeared due to anthropogenic impacts.

Some researchers have emphasized that the rapid spread of the species in the Caribbean may be the result of the transport of plant parts by yachts (Ruiz and Ballantine, 2004; Vera et al., 2014; Willette et al., 2014). Only sterile or male plants have been reported in the Caribbean (Vera et al., 2014; Willette et al., 2014). The absence of female individuals may indicate that the species reproduces vegetatively (Sghaier et al. 2011). Another view is that the rapid spread of *H. stipulacea* is due to its physiological characteristics and broad salinity and temperature tolerance (Winters et al., 2020).

Increases in temperature and salinity due to the tropicalization of the Mediterranean Sea and the opening of a second canal parallel to the Suez Canal are thought to cause the disappearance of local seagrass mats (Winters et al., 2020). Jorda et al. (2012) reported that climate change may cause the disappearance of *Posidonia oceanica* mats within this century. In this case, invasive species are expected to replace the local seagrass meadows that are disappearing under the influence of climatic factors. *P. oceanica* is the native seagrass of the Mediterranean and is a species that is easily damaged by anthropogenic activities such as fishing, pollution, coastal recreation and port construction, and is not resilient enough to regenerate itself except in the presence of changing abiotic factors. The contribution of this fragile species to primary production and oxygenation is quite high. It is the main food source for a large number of vertebrate and invertebrate species, providing them with breeding, spawning and shelter areas, as well as its role in stabilizing sediments and preventing erosion by breaking strong currents and waves (Dumay et al., 2002). Since 1984, *P. oceanica* mats have been invaded by *Caulerpa taxifolia* and *Caulerpa racemosa* (Dumay et al., 2002).

Table 1. *H. stipulacea* biometric data for southern and northern Mediterranean regions (Sghaier et al., 2011).

Depth (m)	Mean Density (no.of shoots m^{-2})	Mean Leaf Length (mm)	Mean Leaf Width (mm)	Internode length (mm)	Location	References
0.5-5	10500±2700	33.3-55.7	4.4-6.8	-	Harbour of Palinuro (Italy)	Gambi et al. 2009
21	1967	42-73	-	11.5-11.6	Peninsula of Maddalena (Sicily-Italy)	Di Martino et al. 2006
5-25	12795-15170	40.3-67.5	5.1-7.8	9.5-22.8	Vulcano Island (Sicily-Italy)	Procaccini et al. 1999
2	25345±4324	63.8-84.3	8.3-10.1	18.7-29.1	Oliveri-Tindari (Sicily-Italy)	Procaccini et al. 1999
2	19728	-	-	17	Naxos-Taormina (Sicily-Italy)	Cancemi et al. 1994
1-2	9900±3509	58.2±4.3	7.1±0.7	13.3±2	Marina Cap Monastir (Tunisia)	Sghaier et al. 2011
1-1.5	476±83	47	55	-	Tobrouk Bay (Libya)	Sghaier et al. 2011
5-6	488.625±122.12	42.33±7.17	5.82±0.92	5.96±1.97	Mersin Bay Akkum Basin	Present study

5. Conclusion

H. stipulacea has been reported to increase the abundance of small invertebrates, epifauna, and the fish that feed on them (van Tuseenbroek et al., 2016; Willette and Ambrose, 2012). However, it is likely that *H. stipulacea* beds are not as suitable for many species as *P. oceanica*. This species has been reported to be used as food by *C. mydas* (Becking et al., 2014), but little is known about its interactions with fish communities (Winters et al., 2020). Indeed, like many species considered invasive, *H. stipulacea* needs to be better understood in terms of its ecological impacts. Studies on habitat modification of native species in the Mediterranean due to competition with *H. stipulacea* (Williams, 2007; Tsiamis et al., 2010) may indicate that the invasion success of *H. stipulacea* is limited. There is even evidence that native species shift habitat under the influence of anthropogenic factors and that non-native species occupy vacated areas (Winters et al., 2020). In this case, niche overlap is likely. Monitoring studies should be continued to determine the ecological impact of *H. stipulacea* in Akkum Bay, the new distribution area of *H. stipulacea* in Mersin Bay.

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Author contributions

AYAS D; Conceptualization, Methodology, Data Curation, Review and Editing, Visualization; ÇİFTÇİ N; Writing - Original Draft, Writing-Review and Editing, TANIŞ Y; Samling, Writing - Original Draft, ACAR MC; Sampling, Writing - Original Draft

Conflicts of interest

There is no conflict of interest between the authors.

Statement of Research and Publication Ethics

Research and publication ethics were complied with in the study.

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