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Note

First Record of the Tropical Seagrass *Halophila stipulacea* (Forsskål) Ascherson, 1867 in the Punic Port of Carthage-Salammbô (Northern Tunisia)

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Abstract: The bioinvasion has increased in recent years with climate change, and some invasive species have caused significant damage to the marine ecosystem, including a great loss of biodiversity. The studied seagrass *Halophila stipulacea* is a marine tropical Mognoliophita introduced in the Mediterranean at the end of the 19th century and in southern Tunisia in 2003. In this study, we record this species for the first time in northern Tunisia, precisely in the Punic Port of Carthage-Salammbô. Surveys were carried out on foot around the Punic Port, and measurements/photos were taken on site and others in the laboratory on taken samples. Most of these measures do not differ from those carried out elsewhere in the Mediterranean. For the moment, the plant does not occupy a large part of the port buttom, but there is always a serious risk that it will invade more area in the future.

Keywords: Halophila stipulacea; invasive species; first records; Punic Port; Tunisia; Mediterranean.

1. Introduction

Biological invasion (or bioinvasion) has been accentuated in recent decades with the increase of maritime activities (e.g., trade, navigation, port activities, travels, fishing, etc.) and climatic change (Mannino et al., 2017). It is considered by many international organizations, including IUCN, as the second cause of biodiversity loss after habitat degradation, since it affects ecosystems and native species (Ounifi-Ben Amor et al., 2016; Mannino et al., 2017; Mili et al., 2020).As example of marine invasive species in Tunisia, we can cite the Magnoliophyta *Halophila stipulacea* (Forsskål) Ascherson, 1867 which belongs to the Class of Magnoliopsida, the Order of Alismatales, and the Family of Hydrocharitaceae. It is of the same Order as the Mediterranean endemic species *Posidonia oceanica* (Linnaeus) Delile, 1813 (Family of Posidoniaceae). *H. stipulacea* is originally native to the western part of the Indian Ocean, including the Red Sea, the Arabian Sea, and the Persian Gulf (Den Hartog,

1970 in García-Escudero et al., 2022). According to Boudouresque & Verlaque (2002), *H. stipulacea* is introduced in the easthern Mediterranean *via* the Suez canal, it was first reported in Rhodes (Greece) in 1894 (Fritsch, 1895). Then, it has progressively spread throughout the Mediterranean, colonizing firstly the eastern basin and, in recent decades, the western basin (Biliotti & Abdelahad, 1990; Winters et al., 2020; García-Escudero et al., 2022). For Tunisian waters, it was recorded for the first time in the Gulf of Gabès probably during 2003 (Missaoui et al., 2003), and in 2010-2011, it was observed in different regions of the South/Center of Tunisia; Kerkennah Islands – Allama and Al Attaya, Monastir - Marina Cap, and Keiss Islands, on muddy/sandy bottoms and also associated with *Posidonia* meadows (Al Attaya) (Hattour & Ben Mustapha, 2013, 2015; Sghaier et al., 2011, 2015).

In this Short communication, we record for the first time the presence of *Halophila stipulacea* in the Punic Port of Carthage-Salammbô in northern Tunisia, with some descriptions of the seagrass.

2. Status and distribution of *Halophila stipulacea* (Forsskål) in the Punic Port of Carthage-Salammbô

Surveys were carried out on foot around the Punic Port of Carthage-Salammbô in December 2022 using a camera and two quadras of 1 m² surface, one for phynology measures and the other for H. *stipulacea* extend (Figures 1 and 2). Eight stations (<2m deep) were visited; samples of *H. stipulacea* were taken for laboratory analysis, and some measurements and photos were taken on site.

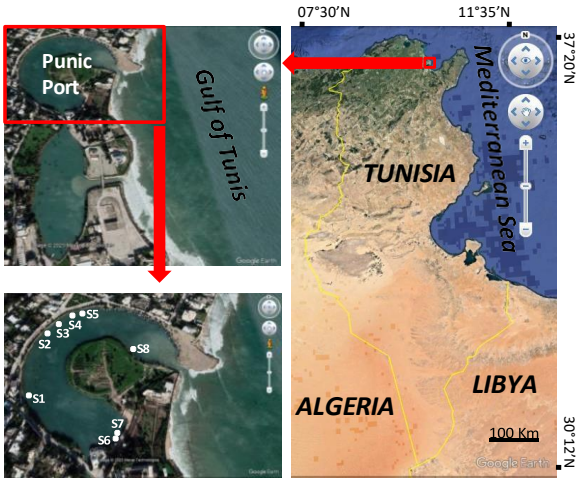

Figure 1. Stations with *H. stipulacea* visited in the Punic Port of Carthage-Salammbô (S1 to S8) (Photos, *Google Earth 2023*)

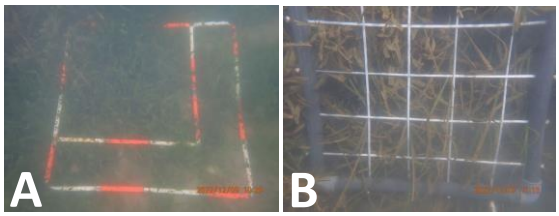

Figure 2. Quadras used for underwater prospecting; (A) for phynology measures, and (B) for *H. stipulacea* extend

In the laboratory, the different parts of the seagrass were measured, and a zoomed photo of the leaf margin was taken (Figure 3). As described by Winters et al. (2020), the leaf margin of *H. stipulacea* in the Punic Port of Carthage-Salammbô is serrated and minute trichomes are present on one side of the leaf surface

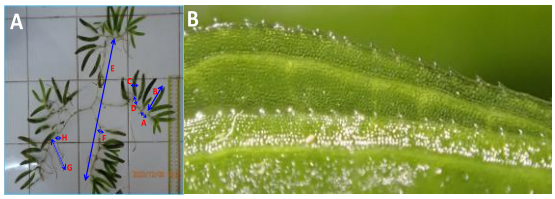

Figure 3. (A) different parts of *H. stipulacea* measured (the caption of the symbols (A to H) is reported in table 1), (B) leaf margin

The principal characters of the different parts of the seagrass sampled in the Punic Port of Carthage-Salammbô are reported in Table 1. They agree for the most of them with those measured by García-Escudero et al. (2022) in the Mediterranean Sea. To date, the extent of H. stipulacea is

confined to certain scattered points in the Punic Port and not exceeding 15 m² (Table 2). The presence of some young leaf shoots testifies that the species is already acclimated, and now it is in the process of progression.

According to Wesselmann et al. (2020), the lower thermal limit for shoot recruitment of *H. stipulacea* is at 17°C in native and exotic populations, whereas optimum temperature for shoot recruitment differs significantly between regions, mainly between Mediterranean populations (Greece 20-34°C) and those of the Red Sea (25-38°C).

Table 1: Principal characters of *H. stipulacea* collected in the Punic Port of Carthage-Salammbô

Character (cm, number)	Average value	Standard deviation	Symbol on Fig. 3
Number of bundles / rhizome (N=12)	16.50	10.15	-
Number of leaves / bundle (Constant)	2.00	0.00	-
Average length of internodal distance (cm, N=12)	2.60	0.40	**A**
Total number of leaves / rhizome (N=12)	32.17	18.99	**-**
Total length of leaves (cm, N=307)	7.05	1.69	**B+D**
Length of limbus (cm, N=307)	5.19	1.21	**B**
Length of petioles (cm, N=307)	1.86	0.84	**D**
Width of limbus (cm, N=307)	0.62	0.35	**C**
Length of rhizomes (cm, N=307)	38.00	24.01	**E**
Width of rhizomes (cm, N=307)	0.20	0.03	**F**
Number of roots / rhizome (N=108)	9.00	3.59	**-**
Length of roots (cm) (N=108)	5.07	3.07	**G**
Width of roots (cm) (N=108)	0.10	0.02	**H**

Table 2: Extent of *H. stipulacea* in the Punic Port of Carthage-Salammbô, presence of the associated phanerogam *Cymodocea*, and water temperature at sampled stations

Station	Area covered (m²)	Coverage rate (%)	Number of bundles / m²	Presence of *Cymodocea*	Water temperature (°C)
S1	1.5	100	3000	No	16
S2	15	100	3504	No	16
S3	12.5	100	3056	No	16
S4	13	100	3736	No	16
S5	10	100	3580	No	16
S6	0.1	48	96	Yes	16
S7	0.01	8	80	Yes	16
S8	60	68	4232	Yes	16

Conclusion

According to local fishermen who land inside the Punic Port, *H. stipulacea* is abundant in the viccinity of the port, mainly in the entrance area. This means that this seagrass is already well established in the Gulf of Tunis and probably in all of the North coast of Tunisia. In the Punic Port of Carthage-Salammbô, the phanerogam *Cymodocea* exists, even though timidly, in certain distribution areas of *H. stipulacea*. But it is very early to affirm that it can cohabit with it and with the other native phanerogams.

In general, the establishment of alien marine species is governed by two essential conditions; their introduction in a new geographical area (regardless of the way of introduction), and their adaptation to the conditions of the new environment. Although the ways for the introduction of new marine species have existed since the first human (maritime traffic, fishing, ballast water, etc.), the bioinvasion was limited probably because of thermal barriers between waters from one region to another. It has only become a worrying problem in recent decades. This means that the major factor currently accentuating the phenomenon of marine bioinvasion is climate change, mainly the warming of seawater. Thus, in recent years, we have witnessed a tropicalization of the Mediterranean, which provides favorable conditions for Lesseptian species with hot affinity (of Indo-Pacific origin).

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