Seasonal and microhabitat variability in the demography and morphology of *Ericaria selaginoides* (Linnaeus) from a mid-western Alboran sea population: Characterization and pilot restoration experience

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Abstract

This study aimed to assess the seasonal population dynamics and morphological changes of the canopy-forming macrophyte *Ericaria selaginoides* from a mid-western Alboran sea population (La Araña, Málaga, Spain). Demographic and morphological variables were analysed in relation to coast orientation and microhabitat, in three seasonal samplings in 2021. *Ericaria selaginoides* presented a population cover of 22±18% in summer to 42±22% in winter. Population density was higher in the southwest, for all seasons and microhabitats, reaching maximum values in winter, exposed to higher hydrodynamic forces. Individuals from SW tide-pools showed a gradual increase in length during the growth season. Summer individuals from tide-pools had higher bushiness index than in intertidal platforms. Juveniles of *E. selaginoides* reached 1.4±0.5 mm after 53 days of *ex situ* culture. Spring storms limited the growth of *E. selaginoides* and explained losses in population cover over the growing season. This fact, together with human trampling and scouring, also led to an unfruitful *ex situ* restoration, making essential to redesign restoration strategies for exposed intertidal habitats. Since extreme weather events will become more frequent with global change, it might contribute to this population decline by constraining its growth and recruitment.

Keywords: *Cystoseira,* Demography, Marine Forests.

Introduction

Ericaria selaginoides (Linnaeus) Molinary & Guiry (2020) (*ex Cystoseira tamariscifolia*) is a brown canopy-forming alga from intertidal to shallow subtidal environments in the Mediterranean and east Atlantic coast. Populations from the Alboran sea constitutes a hotspot of genetic diversity for this species, but threatened by global change stressors (Bermejo et al., 2018). Restoration actions of *Cystoseira sensu lato* forests have been developed in the Mediterranean recently (De La Fuente *et al.*, 2019). Here, we characterized the seasonal changes in population demography and morphological traits of this species from a mid-western Alboran sea population, in relation to coast orientation and microhabitat. This represents a fundamental preliminary step to design species and site-specific restoration actions.

Material and methods

Demographic (cover, density) and morphological variables (individual length, bushiness) were analysed in relation to coast direction (south, S *vs* southwest, SW) and microhabitat (intertidal platforms, PT *vs* intertidal pools, PZ), in three seasonal samplings in 2021 (winter, spring, summer). Standard methods for transects (n=4/ coast direction) and quadrats (n=3/ coast direction × microhabitat) were applied to obtain population cover and density. Individual length and bushiness index (circumference-to-length ratio) were estimated for all individuals of each quadrat. *Ex situ* culture and restoration was made following the methods described in De La Fuente *et al.* (2019).

Results and discussion

Population cover declined from winter (42±22%) to summer (22±18%). Density was higher in the SW, for all seasons and microhabitats, with maximum values in winter (Fig. 1). Length and bushiness of individuals from intertidal platforms peaked in spring (Fig. 1). Summer declines in cover, density and length contrasted with the expected increase during growth season, attributed to dislodging and breakage of individuals due to spring storms, and probably human trampling. Individuals from SW tide-pools experienced a gradual increase in length over the growth season (Fig. 1). By the end of that period, tide-

pools had significantly higher bushiness than those from intertidal platforms, suggesting that hydrodynamic forces in tide-pools from the more exposed zone benefits the growth of this species.

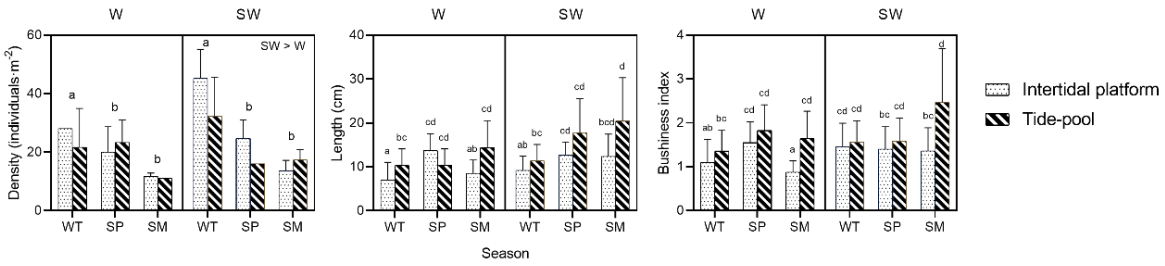

Figure 1. Population density, individual length, and bushiness of *E. selaginoides*. Letters indicate homogeneous groups from *post-hoc* analyses. Winter (WT), spring (SP) and summer (SM). West (W), Southwest (SW).

Juveniles of *E. selaginoides* reached 1.4±0.5 mm after 53 days of *ex situ* culture, with mean growth rates of 3.6±0.1 % d^{-1} (Fig. 2). Juveniles followed the expected milestones during ontogeny, showing proper development of rhizoids, apical meristems, dichotomy and branching (Falace *et al.*, 2018).

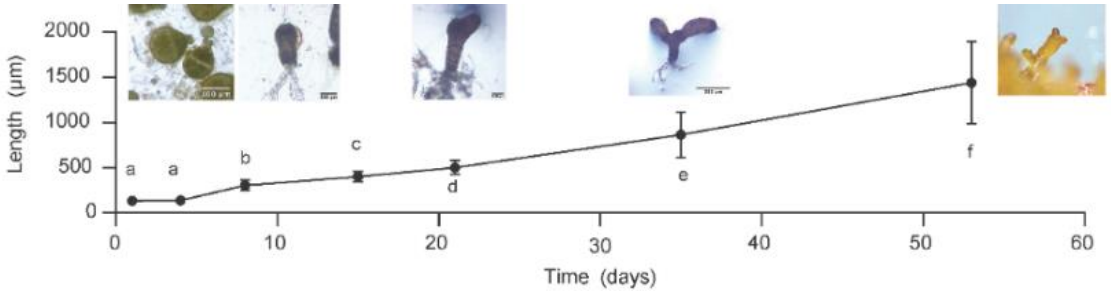

Figure 2. Length of embryos and juveniles of *E. selaginoides* during the *ex-situ* culture, showing micrographs at days 1, 8 (bar 100 µm), 21 (bar 300 µm), 35 (bar 500 µm) and 53 days. Letters indicate homogeneous groups of data.

Extreme hydrodynamic forces disrupted the expected seasonal dynamics of *E. selaginoides*, a process that might be exacerbated due to the predicted increase in extreme weather events. Tide-pools promoted its growth but scouring effects during storms made restoration unfeasible under these conditions. This fact, together with human trampling, also led to an unfruitful *ex situ* restoration, making essential to redesign strategies for exposed intertidal habitats and local conditions.

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