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Short communication

The establishment of the non-native seaweed *Polysiphonia morrowii* in Northern Patagonia: Size of thallus and reproduction

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ABSTRACT

A population of *Polysiphonia morrowii*, recently introduced in the South West Atlantic Ocean, was studied to determine the degree of its establishment. Monthly variations of: thallus size, proportion of life history phases, and tetrasporangia production, were evaluated from June to October 2010. The erect thalli appeared in autumn, and decayed in spring when they became overgrown by epiphytic diatoms. Vegetative thalli were usually smaller than fertile thalli. In spring, the thalli had the maximum mean values of length (199.5 mm), thickness (52 mm) and dried weight (4 g). Although tetrasporophytes represented between 73% and 90% of the thalli collected each month, a few cystocarpic thalli were also found. Variations of thallus size and proportion of life history phases were also studied between 2010 and 2014. The inter-annual increase in the proportion of the tetrasporophytic phase and the progressive increase of the size of *P. morrowii* thalli indicated an ongoing establishment of the population in this habitat.

1. Introduction

The genus *Polysiphonia* comprises species of filamentous macroalgae with a widespread distribution and a variety of life habits (Fralick and Mathieson, 1975; Guiry and Guiry, 2016). The dispersal and acclimation capacity together with the morphological plasticity of some species of *Polysiphonia* has lead to their introduction in several coasts where they are considered as invasive (Eno, 1996; McIvor et al., 2001; Sliwa et al., 2009).

Polysiphonia morrowii is a conspicuous species because the thalli can attain a great size (Kudo and Masuda, 1992; Curiel et al., 2002), and has been listed as one of the 'worst' marine invasive species in the Mediterranean (Streftaris and Zenetos, 2006), presumably dispersed through mariculture activities. It is native from the coasts of Japan, China and Korea (Yoon, 1986; Kudo and Masuda, 1992), but it has been found in the Atlantic Ocean, the Mediterranean Sea and the South Pacific Ocean (Curiel et al., 2002; Kim et al., 2004; Geoffroy et al., 2012; Mamoozadeh and Freshwater, 2012; Croce and Parodi, 2014; Raffo et al., 2014).

P. morrowii was discovered in recent years at the coastal marshes of northern Patagonia (Argentina), forming extensive patches of 340 g m^{-2} (wet weight) and living in epizootic association with the Japanese oyster *Crassostrea gigas*, a highly invasive species which is known to be colonizing the Patagonian coasts (dos Santos and Fiori, 2010). Considering that *P. morrowii* is the second introduced marine species that has been recorded in this habitat, the monitoring of this population must be addressed.

This study was conducted to investigate the periodicity of *P. morrowii* in northern Patagonia, with the aim to determine the degree of establishment of this population. The monthly and inter-annual variability of length, thickness and dried weight of thalli were evaluated as well as the reproductive periodicity of the population.

2. Materials and methods

The collection of thalli was carried out in a shallow coastal marsh located in Los Pocitos, northern Patagonia (40° 26′ 14″ S; 62° 25′ 8″ O). The marsh is formed by seagrass meadows and reefs of the Pacific oyster *Crassostrea gigas* (Borges, 2006).

Preliminary monthly observations were carried out to determine the collection period. *P. morrowii* lived in the intertidal pools that arise in the oyster reefs, always covered with water, being more

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Table 1
Water surface temperature, daylength and concentration of silicate in the water obtained at noon, and mean values of vegetative and reproductive variables of *Polysiphonia morrowii* from June to October 2010 in northern Patagonia. nd = not detected; (±) = standard deviations.

Month	Water temperature (°C)	Daylength	Silicate (μmol L^{-1})	% Fertile thalli	No. fertile branchlets	No. tetrasporangia per fertile branchlet
Jun	8	9 h 16 m	16.23	73.3	2.96 (±2.6)	3.28 (±1.5)
Jul	9.2	9 h 33 m	19.46	73.3	1.81 (±1.4)	3.09 (±1.7)
Aug	11	10 h 33 m	25.08	75	1.63 (±1.2)	3.19 (±1.4)
Sep	12	11 h 45 m	10.63	90	1.74 (±1.6)	3.19 (±1.5)
Oct	20.5	13 h 1 m	13.78	76.5	0.95 (±0.7)	2.72 (±1.2)

abundant in the lower intertidal. The erect thalli were found from autumn to spring.

Thirty attached thalli were haphazardly collected at monthly intervals from June to October 2010. Additionally, 20 thalli were collected in September of 2011, 2013 and 2014.

Water surface temperature was measured at noon, and daylength was estimated from time records of sunrises and sunsets. Water samples were collected at noon at a depth of 0.5 m to determine silicate concentration in the water.

Each thallus was rinsed with filtered seawater and examined under a Nikon Eclipse 80i microscope to determine life history stage.

The size of each thallus was determined through the following variables: dried weight (DW), after drying in an oven at 60 °C for 48 h up to constant weight; length, measured from the basal prostrate axes to the end of the longest erect axis of the thallus; and thickness, measured with a caliber at the bulkiest part of each thallus.

For each tetrasporophytic thallus collected in 2010, the monthly production of tetrasporangia was determined. A total of 10 fragments of 5 mm were sectioned from the apical part of each fertile thallus. In each fragment, the number of fertile branchlets was counted. The number of tetrasporangia per fertile branchlet was estimated based on 75 fertile branchlets from all fragments sectioned per month.

Water samples were vacuum filtered through Whatman GF/C glass fiber and the concentration of silicate was determined with an autoanalyzer Technicon II.

Differences in length, thickness, and DW of *P. morrowii* thalli between sampling times were analyzed through ANOVA and Tuckey poshoc comparisons, after testing for normality and homoscedasticity, without the need of transformations.

The percentage of fertile and vegetative thalli of the population was calculated for each month and year, and the monthly and inter-annual variation of this percentage was evaluated through goodness of fit with χ^2. The monthly variation of the production of tetrasporangia was evaluated in the samples collected in 2010 through generalized linear models (GLM) with quasipoisson errors, Tuckey comparisons and frequency of Poisson distribution.

Statistical analyses were done with R software (R Development Core Team, 2011).

3. Results

Thalli collected from June to September were dark red and slender with few epiphytic diatoms colonies, while those collected in October were clustered, brownish, and were almost completely covered by epiphytic diatoms.

Silicate levels ranged between 10 μmol L^{-1} and 25 μmol L^{-1}, with a maximum in August (Table 1).

The vegetative thalli were larger in September and October ($F = 6.02$; $df = 4$; $p = 0.002$), whereas the fertile thalli showed no variation in length among months ($F = 1.97$; $df = 4$; $p = 0.11$) (Fig. 1a). Fertile thalli were larger than vegetative thalli in June ($F = 8.61$; $df = 1$; $p \ll 0.01$) and August ($F = 4.35$; $df = 1$; $p < 0.05$).

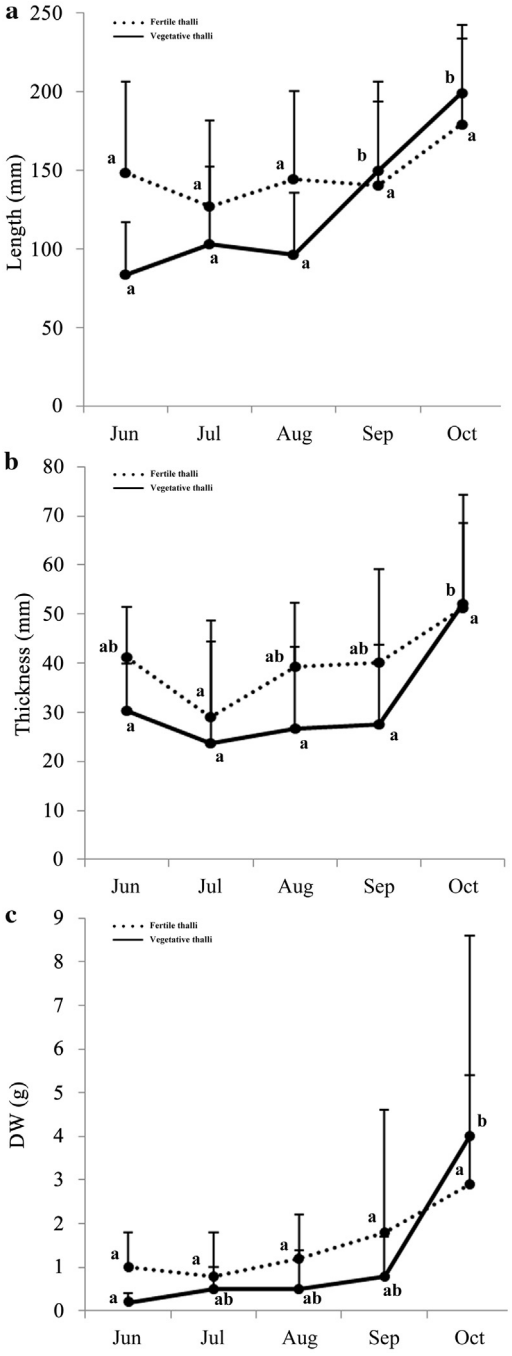

Fig. 1. Mean monthly variations of size of *Polysiphonia morrowii* thalli during 2010: (a) length; (b) thickness; (c) dried weight (DW). Vertical bars represent standard deviations (±SD). Letters above and below each line represent Tuckey poshoc comparisons among months. n = 30.