

Short communication

Role of two co-occurring Mediterranean sea urchins in the formation of barren from *Cystoseira* canopyD. Agnetta^{a,*}, F. Badalamenti^a, G. Ceccherelli^b, F. Di Trapani^c, C. Bonaviri^c, P. Gianguzza^c^a CNR-IAMC, Sede di Castellammare del Golfo, Via G. da Verrazzano 17, 91014 Castellammare del Golfo, TP, Italy^b Dipartimento di Scienze della Natura e del Territorio (DIPNET), Università di Sassari, Via Piandanna, 4, 07100 Sassari, Italy^c Dipartimento di Scienze della Terra e del Mare (DiSTeM), Università di Palermo, Via Archirafi, 22, 90123 Palermo, Italy

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ABSTRACT

In the Mediterranean Sea the co-occurring sea urchins *Paracentrotus lividus* and *Arbacia lixula* are usually considered to share the same ecological role in the formation of barren from *Cystoseira* canopy. However, their foraging ability may vary due to feeding behavior and species-specific morphological traits. The relative effects of *P. lividus* and *A. lixula* on *Cystoseira* canopy was tested experimentally both in the laboratory, at a density of about 20 ind./m², and in the field by gut content analysis. Field and laboratory results show that *A. lixula* is unable to affect *Cystoseira* spp. Furthermore, these results confirmed the great ability of *P. lividus* to consume *Cystoseira* canopy, thus supporting the evidence of the major role of this species in the creation of a barren state.

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1. Introduction

Canopy-forming brown algae are habitat formers able to locally modify physical and biological factors and understory assemblages (Ballesteros et al., 1998; Bulleri et al., 2002; Graham, 2004) leading to biological amelioration (*sensu* Moore et al., 2007). There is concern globally about their widespread loss across many rocky shores worldwide (e.g. Airoldi and Beck, 2007). This is a result of their sensitivity to several direct and indirect human stressors (Perkol-Finkel and Airoldi, 2010).

On Mediterranean rocky reefs, such habitat formers are well represented by the genus *Cystoseira* C. Agardh (Fucales, Phaeophyceae). These algae are distributed from the intertidal to the upper circalittoral and perform numerous ecosystem services as they provide high primary production and source of food, nutrient cycling, substrata for settlement, protection from predators and shelter from disturbance (Ballesteros et al., 2009).

Over the last few decades most of the *Cystoseira* species have experienced a severe decline in many Mediterranean regions (Thibaut et al., 2005; Mangialajo et al., 2008). Urbanisation is thought to have the most disrupting effects on *Cystoseira* canopy, particularly because it affects water clarity through eutrophication

and alters sedimentation and water motion (Mangialajo et al., 2008). Furthermore, anthropogenic stressors such as global warming and overfishing have also created this process. Overfishing of large sea urchin predator fish, especially *Diplodus* spp., can cause severe sea urchin outbreaks (*Paracentrotus lividus* and *Arbacia lixula*) and promote a shift in rocky benthic community structure (Hereu et al., 2008; Sala et al., 2012; Cardona et al., 2013). The variation in sea urchin grazing intensity may drive switches between one complex state, dominated by a stratified assemblage of several erect algae including the *Cystoseira* genus, to a simpler one, dominated by few encrusting algae, the so-called 'barren ground' (Shears and Babcock, 2002; Estes et al., 2011).

In the Mediterranean Sea *Paracentrotus lividus* and *Arbacia lixula* are commonly found in both barren grounds and erected macroalgae assemblages (Guidetti and Dulčić, 2007; Agnetta et al., 2013) and traditionally they have been considered a guild of herbivores (Bulleri et al., 1999, 2002). However recent investigations have distinguished the diets and trophic positions of the two species showing that *A. lixula* is an omnivore tending to carnivore, while *P. lividus* is basically a herbivore that can turn into an omnivore both on barren and vegetated rocky areas (Agnetta et al., 2013). Recent evidence suggests that the roles of the two species in maintaining the extension of barrens overlap (Bulleri et al., 1999; Bonaviri et al., 2011; Bulleri, 2013).

Despite the fact that sea urchin grazing is generally accepted to be very important to habitat modifications on Mediterranean rocky

* Corresponding author.

E-mail address: davide.agnetta@iamc.cnr.it (D. Agnetta).

shores, comparisons of the relative role of *Arbacia lixula* and *Paracentrotus lividus* to form barrens from *Cystoseira* canopy is largely overlooked and has not yet been studied in any great detail. In order to fill this important ecological gap we performed a laboratory experiment to observe the feeding behaviour of *A. lixula* and *P. lividus* and catch interspecific differences in their approach to *Cystoseira* spp. and to assess their relative ability to consume and dislodge *Cystoseira* spp. (i.e. barren formation). We also studied the gut content of these species in natural conditions with the aim of comparing the amount of *Cystoseira* consumed by the two predators in the field. We predicted that 1) different ways of approaching the algae would be demonstrated by the two species in the laboratory experiment; 2) only *P. lividus* would be able to consume *Cystoseira*, and 3) that *Cystoseira* spp. play a greater role in *P. lividus* diet rather than in *A. lixula*.

2. Material and methods

2.1. Study area

The study was performed in the upper infralittoral (3–6 m) of the Ustica Island, located off the north coast of Sicily (Western Mediterranean, 38°42'20"N–10°43'43" E), where crustose algae are interspersed with pools of *Cystoseira* spp. patches (mainly *Cystoseira brachicarpa* var. *balearica* and *Cystoseira compressa*) forming a binary patchy landscape (Gianguzza et al., 2010).

The sea urchins *Paracentrotus lividus* and *Arbacia lixula* co-occur in this system (annual mean density of adults $\times \text{m}^{-2} \pm \text{SE}$ was 2.70 ± 0.63 and 3.10 ± 0.72 , respectively $N = 160$ individuals \times species) providing an optimal opportunity to assess their grazing on *Cystoseira* spp.

2.2. Laboratory trials

A laboratory experiment was done from May to July 2011 to evaluate the ability to consume *Cystoseira* canopy by *Paracentrotus lividus* and *Arbacia lixula* (Fig. 1). The experiment was set up randomly collecting adult sea urchins (both *P. lividus* and *A. lixula* 35–50 cm in test diameter without spines) and cobbles covered by *Cystoseira* spp. (external face from about 10×10 cm to 18×15 cm) from a small bay of Ustica Island. After field collection cobbles were placed in large sealed plastic tanks containing oxygenated seawater for transportation to the laboratory. The sea urchins were brought to the same laboratory packed in ice. Before starting the experiment, *P. lividus* and *A. lixula* were starved for 2 weeks and kept in separate tanks (300 L) to ensure that the two species had experienced similar conditions and to prevent changes in natural feeding responses (Rochette et al., 1994). Sessile organisms on cobbles, or

on *Cystoseira*, were removed. *Cystoseira* were maintained in different storage tanks (300 L). All organisms were maintained with circulating natural seawater, at ambient light (12 h light and 12 h darkness) and at a temperature of 20 °C for the whole duration of the experiment.

The experiment was aimed at assessing both the feeding behaviour and the relative ability of sea urchins to consume *Cystoseira* and consisted of a treatment with three levels of urchin presence carried out in replicated ($n = 3$) aquaria: 1) only *Arbacia lixula* present, 2) only *Paracentrotus lividus* present, and 3) no urchins (controls) present. Each aquarium was $45 \times 50 \times 50$ cm in size (ca. 100 L of seawater). In each aquarium a cobble covered with *Cystoseira* spp. was positioned. Twenty individuals of one sea urchin species (a density of about 20 ind./m²) were then supplied where needed according to the experiment protocol. Controls were considered in order to assess the performance of *Cystoseira* (i.e. weight loss) in the absence of sea urchins. The cobbles with *Cystoseira* were weighed before being introduced into the aquarium, then sea urchins were allowed to forage until either the canopy disappeared, or a maximum of thirty days, whichever occurred first. When *Cystoseira* disappeared, we recorded the number of days spent for total consumption. Moreover, in order to estimate consumption of *Cystoseira* (g), cobbles were re-weighed when the canopy disappeared, or at the end time of the experiment. To ensure the independence of data, each pool of sea urchins was used only once (Underwood, 1997). A total of 18 h was spent observing the feeding behaviour of the sea urchins. Observation times were equally distributed between the morning and afternoon for each of the first 3 days of the experiment. Each observation was 10 min in duration and dedicated to each aquarium where sea urchins were present.

2.3. *Cystoseira* spp. gut contents

The sea urchins were collected over four seasons: summer and autumn 2007, winter and spring 2008. For each season, collection took place on two random dates. Each time two sites, 400 m apart with similar orientation and hydrodynamic conditions, were randomly selected on the western side of Ustica Island (as in Gianguzza et al., 2013). In order to analyse sea urchin gut contents we collected six adult individuals of both species (>35 mm test diameter) at each site and time, at 3–6 m of depth. Sea urchins were dissected as soon as possible in order to avoid gut evacuation. After dissection, gut contents were immediately frozen. We later took at random two equal volumes of gut contents from each sample and placed them on a 2.5×2.5 cm grid in a Petri dish under a $40 \times$ microscope in order to discern the gut items ingested and to evaluate the percentage of *Cystoseira* spp. out of the whole content.

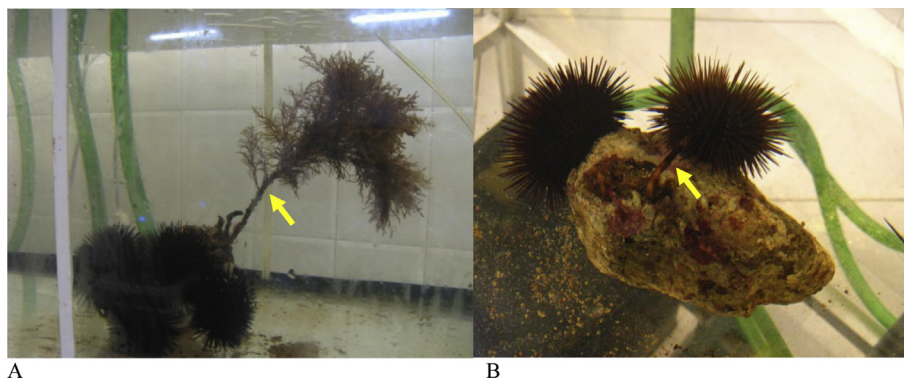


Fig. 1. Not consumed vs consumed *Cystoseira* spp. (arrows) canopy by *A. lixula* (A) and *P. lividus* (B) at the end of the foraging experiment (30 and 3 days respectively).

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