Experimental evaluation of amphipod grazing over biomass of *Sargassum filipendula* (Phaeophyta) and its dominant epiphyte

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Abstract

In this study we quantified the biomass variation of the brown alga *Sargassum filipendula* and its dominant epiphyte *Hypnea musciformis* caused by grazing of two gammarid amphipods (*Cymadusa filosa* and *Hyale nigra*). An inclusion chamber experiment with three treatments (*S. filipendula, H. musciformis* and *C. filosa; S. filipendula, H. musciformis* and *Hyale nigra;* Algae without amphipods) was designed to estimate algal biomass variation due to amphipod consumption. The experimental unit was kept submerged for 15 days and after this period the algae were evaluated for differences relative to their initial wet weight. The results indicated that only *C. filosa* significantly reduced *H. musciformis* biomass (Kruskal-Wallis: H = 10.24; p = 0.006). For *S. filipendula,* it was registered only a weight decrease for all treatments, with no significant difference among treatments (H = 4.48; p = 0.11). The caging experiment generated some artifacts such as the accumulation of sediment and periphyton that may have served as an alternative food source for amphipods. However, the algal consumption by the ampithoid amphipod was evident. *Cymadusa filosa* use of *S. filipendula* as tube-building material is likely to occur since it could be more suitable for camouflage and defense and it is very abundant in the local habitat.

Key words: Amphipoda, *Sargassum,* epiphytes, grazing.

Introduction

The growth and the primary production derived from marine plants are the outcome of the photosynthetic rate regulated by physical factors such as light intensity, nutrient availability and temperature (Orth and van Montfrans, 1984; Moore and Wetzel, 2000; Neckles *et al.,* 1994). Biological factors such competition between epiphytes and their host and the grazing pressure of macro and mesoherbivores also have great influence onto these plants, regulating their population and influencing their community dynamics (Williams and Ruckelhaus, 1993; Jernakoff *et al.,* 1996; Duffy and Hay, 2000).

Epiphytic macroalgae commonly grow faster than their macroalgal host (Bravin and Yoneshigue-Valentin, 2002). The epiphyte presence may hinder the host by reducing the photosynthetic rate due shading (Cambridge *et al.,* 1986; Borum, 1987; competition for nutrients and CO_2 (Sand-Jensen, 1977), drag increase and stipe breakage (Borowitzka and Lethbridge, 1989) and decrease in the reproductive output (D'Antonio, 1985).

The top-down control of macroalgal communities by macroherbivores such as fishes and sea urchins is well established in the literature (Morrison, 1988; Horn, 1989; Larkum and West, 1990; Mazzella *et al.,* 1992; Klumpp *et al.,* 1993). Mesoherbivore activity of gastropods, isopods and amphipods has also been pointed out as playing an important role in epibiosis and fowling control (Howard, 1982; Robertson and Mann, 1982; D'Antonio, 1985; Duffy, 1990; Duffy and Hay,

2000; Stachowitz and Whitlatch, 2005). Their grazing reduces the competitive ability of epiphytes, but also may harm the host since some mesoherbivores feed upon them (Shacklock and Croft, 1981; Duffy and Hay, 1991, 2000). Chemically defended seaweeds are considered "enemy-free space" for the commensal mesoherbivores, since macroherbivores should avoid eating such algae (Hay *et al.* 1989, 1990). These chemically defended algae include phaeophyceans of the genus *Sargassum* (Norton and Benson, 1983; Duffy, 1990).

In southeastern Brazil, the subtidal rock-shores with macroalgal beds are usually dominated by *Sargassum*, especially in the Rio de Janeiro and São Paulo state's coasts (Paula and Oliveira Filho, 1980; Széchy and Paula, 2000). It has been identified 81 infrageneric taxa of epiphytic macroalgae associated with *Sargassum* species; most of them were red algae (Széchy and Paula, 1997). On *Sargassum* beds, the most common epiphytic algae is the rhodophycean *Hypnea musciformis* (Berchez *et al.,* 1993) which is commonly attached to the apical region of *Sargassum* fronds (Széchy and Paula, 1997).

Both *Sargassum* and *Hypnea* are consumed by macroherbivores. Berchez and Oliveira-Filho (1990) have reported high consumption of *Hypnea musciformis* by fishes and by the gastropod *Aplysia* sp. in experimental farms. The relative lower herbivory rate on *Sargassum* is often related to the polyphenolic content of the brown algal tissues which acts as an herbivore deterrent. The load of these compounds may vary accordingly to the species, to the part of the algae considered or to differential spatially-related herbivory pressure (Cronin and Hay, 1996; Pereira and Yoneshigue-Valentin, 1999; Sotka *et al.,* 2002; Ceh *et al.,* 2005).

Although the amphipods are the most conspicuous taxa on *Sargassum* in Brazilian waters (Wakabara *et al.,* 1983; Jacobucci and Leite, 2002), the ecological relationships between algae and this group are poorly understood. Among the gammaridean amphipods, the tubiculous ampithoids, often herbivores or detritivores, and the free-living hyalids notably omnivorous, are conspicuous (Zimmerman *et al.,* 1979; Tararam *et al.,* 1985). Although these taxa are widely spread and well represented in the studied region (Leite *et al.,* 2000; Tanaka and Leite, 2003; Leite *et al.,* 2007), only few experimental and laboratory studies have effectively determined the feeding habits of some

hyalid species (Tararam *et al.,* 1985, 1990; Fleury *et al.,* 1994; Pereira and Yoneshigue-Valentin, 1999). Experimental field approaches have never been conducted to evaluate the effect of local herbivorous amphipods upon algae.

The aim of this study was to evaluate the effect of grazing by two species of amphipods over the biomass of both *Sargassum filipendula* and its dominant epiphyte *Hypnea musciformis.*

Material and Methods

Study Area

The frond sampling were made in January 2003 at Fortaleza Beach in Fortaleza Inlet (23°32'S, 45°10'W), Ubatuba, northern coast of São Paulo State, Brazil. The sampled rocky shore has 2.5 meters deep and moderate wave action (after parameters set by Széchy and Paula, 2000). *Sargassum filipendula* is the dominant macroalgae but *Galaxaura stupocaulon* (Rhodophyta), *Padina gymnospora* (Phaeophyta) and *Caulerpa racemosa* (Chlorophyta) are also locally well represented. The typical epiphytes are the phaeophyceans *Dictyopteris delicatula* and *Dictyota cervicornis* (Széchy and Paula, 1997), but the rhodophyte *Hypnea musciformis* was the most common at the time of the collection.

Experiment set up

An inclusion chamber experiment was set up in the Segredo Beach at the Marine Biology Center of the São Paulo University (CEBIMar-USP), São Sebastião channel. Both areas, Fortaleza and Segredo beaches, have *Sargassum* beds and similar hydrodynamic characteristics.

The chamber units were made of a 5 liter transparent plastic recipient with a 200 μm mesh closing the upper end opening. This meshed aperture allowed the water to flow in and out the chamber and prevented escape of organisms from the experimental unit. These units were tied together with nylon lines and attached to a rope moored at the entrance of the beach's inlet (Fig. 1). This procedure lasted 30 minutes.

Each chamber contained one stipe of *S. filipendula* with the epiphyte *H. musciformis.* The chambers were organized in two treatments with amphipods and a control without amphipods. Each
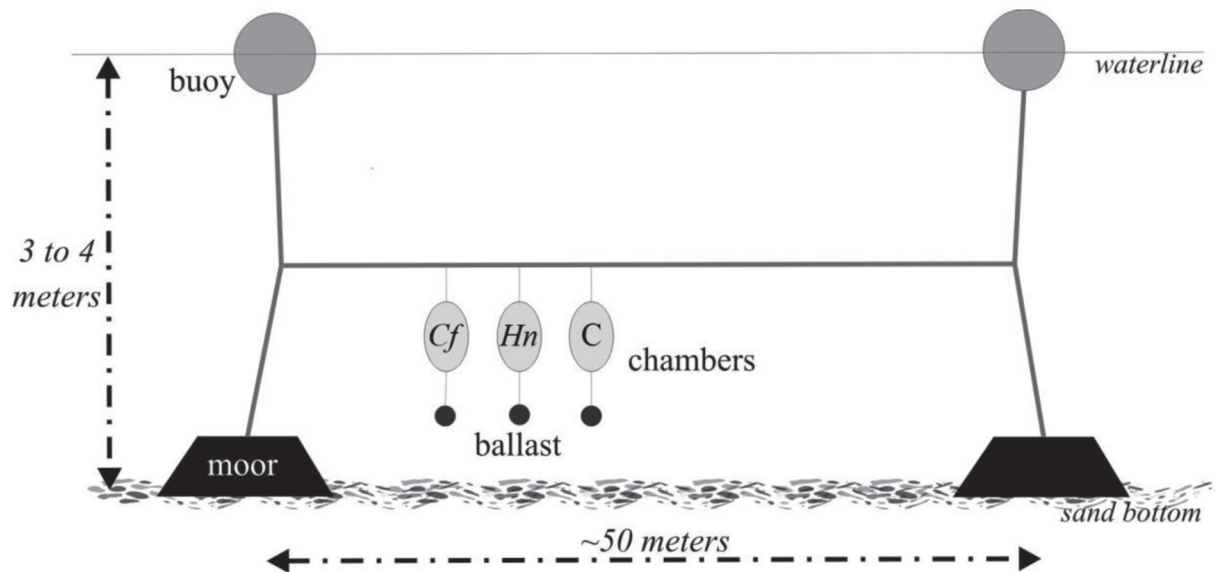
Figure 1. Schematic design of the experimental set at Segredo beach (CEBIMar-USP) indicating one chamber of each treatment (Cf) *Cymadusa filosa* treatment, (Hn) *Hyale nigra* treatment and (C) control. Not in scale.

treatment consisted of *Cymadusa filosa* Savigny, 1816 or *Hyale nigra* (Haswell, 1879) amphipods in a density of 6 individuals per *Sargassum* fragment. This density was set after data gathered along a one-year monthly field survey (unpublished data) on the mean density of amphipods on the *Sargassum* bed at Fortaleza beach. It represents the overall mean density value over the studied period, considering both species. Only adult amphipods (males and non-ovigerous females) with similar sizes were used in the experiment, in order to minimize differences in consumption related to amphipod size and metabolic rate. The number of replicates for each treatment and control was eleven (N = 11).

Two days before the beginning of the experiment, 40 individuals of *S. filipendula* were randomly sampled from the Fortaleza's rocky shore, enclosed with a 200 μm mesh bag and then detached from substrate. The samples were kept in seawater and taken to the CEBIMar-USP laboratory, where they were placed in aerated aquaria. Each frond was sought out for hyalids and ampithoids of similar sizes, to minimize a size related influence on the herbivory rate. The animals were reserved in aerated aquaria with previously defaunated *Sargassum* fragments.

The *Sargassum* fronds were defaunated rinsing the fronds for 3 minutes in freshwater, a technique that successfully removes about 95% of the amphipods from the algae without harming them (Holmlund *et al.,* 1990). From these algae, 20 to 25 cm long stipes (20 to 30 g wet weight) were

selected and cleaned from any epiphytes on them but a 5 mm piece of *H. musciformis* on each *Sargassum* stipe. The initial mean weight of these pieces (0.5 mg) was estimated weighting other ten pieces of *H. musciformis* of equivalent size. The *Sargassum* stipes were wet weighed after drying the algae with paper towel for 60 s and then laid in the inclusion chambers. Thereafter, the amphipods were added to the chambers and readily placed in the field experiment structure.

To prevent clogging by sediment and micro-algal covering, the chambers were daily inspected and cleaned. Past 15 days, the chambers were removed in the same sequence they were first tied, to avoid exposure differences of algae to amphipods. The number of surviving amphipods was counted, the algae were sorted and, again, wet weighed.

The initial and final weights of each algal species were calculated and then compared using Kruskal-Wallis test. *Post-hoc* comparisons using the Dunn's method were made when the differences were significant (Zar, 1999).

Results

Amphipod mortality was relatively low and similar in both treatments (eight individuals of *Hyale nigra* and seven *Cymadusa filosa*). The treatment with *C. filosa* showed significant reduction (Kruskal-Wallis: H = 10.24; p = 0,006) (Fig. 2a) in the *Hypnea musciformis* biomass (only 8.5 mg).

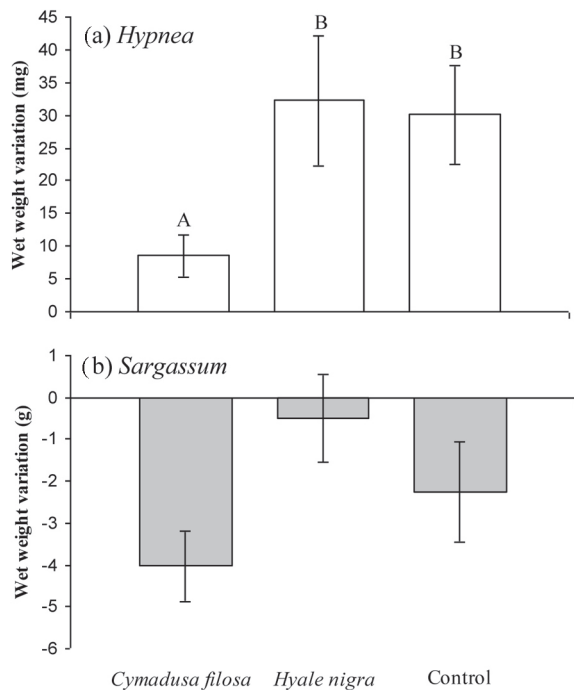**Figure 2.** Mean (and ±SE) of the experiment results after 15 days: (a) *Hypnea musciformis* wet weight variation relative to the initial weight (in milligrams) and (b) *Sargassum filipendula* wet weight variation relative to the initial weight (in grams). Same letter denotes no difference among treatments.

There was no difference between the treatment with *H. nigra* and the control, both presenting a weight increase of over 30 mg in 15 days. The mean *H. musciformis* growth was nearly 3.5 times greater in the control than in the ampithoid treatment.

For *Sargassum,* it was registered only a weight decrease for all treatments, with no significant difference among treatments (H = 4.48; p = 0.11), although a greater reduction of the *Sargassum* stipes for the *C. filosa* treatment was registered (Fig. 2b).

Observations made during the experiment showed that there is some evidence of herbivory from the *Sargassum* blades found on the bottom of the experimental units. These blades were partially torn and showed irregular edges, suggesting some mesoherbivore activity on them, although there was no evidence of herbivory when the *Sargassum* biomass treatments were compared (Figure 2b).

Discussion

Considering that *Hypnea musciformis* has a faster growth rate than *Sargassum filipendula,* it is possible that the herbivore activity have been masked by the more intense growth of the epiphyte,

resulting in a greater biomass from the start of the experiment. Conversely, *Sargassum* has a lower growth rate, showing decrease in the biomass at the end of the study. The growth ability of *H. musciformis* can be 5 times greater than *Sargassum cymosum* var. *nanum* (a sympatric species of *S. filipendula*) (Reis *et al.,* 2003). Indeed, Bravin and Yoneshigue-Valentin (2002) showed that *H. musciformis* can add up till 20% of it own mass per day, depending on the environmental conditions.

The treatment with *Cymadusa filosa* presented the least *H. musciformis* load, a sign that this alga can be used as food or as material for tube construction. This kind of use has been previously registered for other epiphytic species (Brawley and Adey, 1981; Norton and Benson, 1983; Duffy, 1990; Duffy and Harvilicz, 2001). Tube construction is likely to be the cause for the high decrease in the *S. filipendula* biomass in the ampithoid treatment, since there is a preference for use of high chemically defended algae as host (Duffy and Hay, 1991). High defended seaweeds, such as brown algae, are preferred as a host because they are less palatable for larger herbivores such as fishes that could incidentally consume the amphipods (Hay *et al.,* 1988, 1990). The use of *S. filipendula* as tube-building material is likely to occur since it is more suitable for camouflage and defense (unpalatability) and more abundant in the habitat.

Considering the high growth rate of *H. musciformis,* amphipods play an important role in controlling the epiphyte population. At North Carolina, USA, Hay (1986) observed that *H. musciformis* removal by fishes, sea-urchins and amphipods kept the epiphyte at low biomasses, preventing their deleterious effect upon the host-algae. The elevated grazing rates over *H. musciformis* (Berchez and Oliveira-Filho, 1990) and the weight ratio between *H. musciformis* and *S. filipendula* at Fortaleza beach (unpublished data) suggests the same mechanism may act in the region.

The cages with *C. filosa* treatment showed a high decrease in *Sargassum* biomass. This could be due the tubicolous habit of this species, which uses the blades of algae to build tubes to envelope themselves. Also in this treatment there was the lowest *H. musciformis* biomass, but probably this alga was used for feeding, since its cylindrical branching thallus may be unsuitable for tube construction. In an assessment among different kinds of algae at the east coast of USA there was no significant difference between the nutritional qualities and feeding

preference by *Ampithoe longimana* (an ampithoid) of *H. musciformis* and *S. filipendula,* although the red algae was slightly more nutritive and consumed (Cruz-Rivera and Hay, 2001).

The reduction in *S. filipendula* biomass was the lowest and the *Hypnea* biomass was the highest for *Hyale nigra* treatment. Artifacts due the caging experiments may lead to restrictions on data interpretation (Brawley, 1992). Although there was a daily maintenance of cages, there should be some accumulation of sediment and periphyton inside that may serve as an alternative food source, especially for hyalids (Zimmerman *et al.,* 1979; Tararam *et al.,* 1985; Brawley and Fei, 1987; Barnard and Karaman, 1991).

Besides some constraints present in the experiment, we can make some assertions about the effects of these amphipods on the phytal communities of the southeastern Brazilian coast. Mesograzers such as amphipods and gastropods play an essential role in shaping the landscape, as has been demonstrated elsewhere (Duffy and Hay, 2000; Stachowicz and Whitlatch, 2005). In this study, we employed a mean density found in wild conditions, so the effects could be intensified or minimized as the amphipod populations seasonally fluctuates on the algal beds, influencing the dynamics between *H. musciformis* and *S. filipendula.*

We strongly recommend further investigations upon the roles of mesoherbivores, especially amphipods, upon the phytal assemblages on Brazilian coast. Field and mesocosm experiments should be conducted to directly address the issues over top-down control by amphipods upon host and epiphytic algae. Evidences on this could lead to a broader understanding over the relationships and dynamics of this important coastal habitat.

Acknowledgements

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