Biochemical Systematics and Ecology 38 (2010) 146–153

Contents lists available at ScienceDirect

Biochemical Systematics and Ecology

journal homepage: www.elsevier.com/locate/biochemsyseco

Influence of size and spatial competition on the bioactivity of coral reef sponges

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ARTICLE INFO

Article history:
Received 8 September 2009
Accepted 23 December 2009

Keywords:
Coral reefs
Spatial competition
Size
Sponge
Bioactivity

ABSTRACT

Sponges biosynthesize a wealth of secondary metabolites, many with novel structures and strong biological activity. Such compounds may serve multiple ecological roles including anti-predation, anti-fouling functionalities and are implicated in border defense or attack during spatial competition. Relative size of benthic organisms may also play an important role in competitive interactions. To determine if a relationship exists between individual size and bioactive metabolite production in the context of spatial competition, we examined three sponge species with different morphologies: the massive *Coscinoderma matthewsi*, the club-shaped branching *Hyrtios erecta*, and the fan-shaped *Ianthella basta*. Extracts from sponges of various sizes and competitive environments were examined using a cell based bioassay as a proxy of bioactivity. For *I. basta*, sponge size was correlated with bioactivity; the largest individuals generally being the most bioactive. In contrast, there was no correlation between size and bioactivity for either *C. matthewsi* or *H. erecta*. Bioactivity of sponges in this study were however highly variable among individuals, regardless of levels of competition. The prevalence of encroaching organisms was not correlated with sponge size for any of the three sponge species, suggesting that potential bioactivity is not influenced by surrounding competition.

1. Introduction

Sponges represent a diverse and significant component of benthic communities (Duckworth et al., 2008; Reswig, 1973; Wilkinson and Cheshire, 1989), they also provide a rich source of novel secondary and biologically active metabolites (Faulkner, 2000; Paul et al., 2006). Bioactive metabolites from sponges have various ecological roles, including to deter predation (Burns et al., 2003; Chanas and Pawlik, 1995; Pawlik et al., 1995), prevent fouling of their surfaces (Becerro et al., 1994; Uriz et al., 1992), combat microbial attacks (Kelman et al., 2001), and aiding in spatially competitive interactions (Engel and Pawlik, 2000; Lopez-Victoria et al., 2006). Some sponge metabolites may even have multiple ecological roles (Becerro et al., 1997). Thus far, the majority of research has focused on metabolites functioning to deter predators, showing for example that spongivores, such as fish and urchins, can greatly control the abundance and distribution patterns of chemically undefended sponges (Pawlik et al., 1995; Wulff, 1994).

In comparison, the role of sponge metabolites in competitive interactions is less clear. Competitive interactions between benthic invertebrates are often influenced by an organism's size, with larger, thicker organisms usually being superior

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0305-1978/$ – see front matter
doi:10.1016/j.bse.2009.12.024

competitors (Sebens, 1986). For sponges, the intensity and outcome of competitive interactions may also be dependent on morphology, with upright sponges, for example, probably experiencing less spatial competition than encrusting sponges. The outcome of any competitive interaction would also be mediated by species-specific bioactive metabolites (Engel and Pawlik, 2005). Sponge size may affect metabolite biosynthesis and overall toxicity further influencing the outcome of competitive interactions, but few studies have explored this relationship (Abdo et al., 2007; Becerro et al., 1995; Luter et al., 2007). Becerro et al. (1995), for example, found that small individuals of *Crambe crambe* had relatively low concentrations of bioactive metabolites and suggested this was due to the small sponges investing their energy into growth rather than chemical defense. For the tropical sponge, *Iotrochota* sp., individual size was positively correlated with toxicity, with larger sponges being most toxic (Luter et al., 2007). Both *C. crambe* and *Iotrochota* sp. are encrusting sponges, where growth involves spreading laterally along the substratum and thus both species are likely to encounter higher numbers of spatial competitors than branching or fan species, where growth can take place vertically possibly evading competitors.

The aim of this study was to examine the influence of individual size and spatial competition on the bioactivity of three coral reef sponges of differing morphologies: *Coscinoderma matthewsi* (Lendenfeld, 1886) is a massive, hemispherical sponge, grayish black in color and can grow over 50 cm in length (Bergquist, 1995; Duckworth and Wolff, 2007); *Hyrtios erecta* (Keller, 1889) is a club-shaped branching sponge that grows erect from the substrate, with branch lengths reaching up to 10 cm and is brown-black in color (Bergquist, 1995; Duckworth and Wolff, 2007); and *Ianthella basta* (Pallas, 1766) is a fan-like sponge found in a variety of color morphs (yellow, brown, green, blue, or purple) reaching heights of approximately 1 m (Cervino et al., 2006; Hooper and Van Soest, 2002). All three sponges can be found on coral reefs throughout the Indo-Pacific and represent a significant portion of the total sponge biomass at the study location (Cervino et al., 2006; Duckworth and Wolff, 2007; Hooper and Van Soest, 2002; Wilkinson and Cheshire, 1989). The chemistry of all three sponges has been well studied, yielding a wealth of secondary metabolites with potentially useful and as yet little studied, but varied range of biological activities (Fu et al., 1999; Pettit et al., 1996; Youssef, 2005).

2. Material and methods

2.1. Study site and collection

This study was conducted at Masig Island, central Torres Strait, Australia, which is located between Papua New Guinea and northern Queensland, Australia (for map, see Fig. 1 in Duckworth and Wolff, 2007). Eight sites, separated by at least 200 m, were surveyed for *C. matthewsi*, *H. erecta* and *I. basta* (yellow color morph only). At each site, three randomly positioned 30 × 1-m transects were surveyed, each separated by at least 20 m to retain statistical independence. All transects were done on sloping reef between 10 and 12 m, a depth where all three sponges are common (Duckworth and Wolff, 2007; personal observation). To examine size-frequency distribution patterns for *C. matthewsi* and *I. basta*, the greatest dimension of each surveyed sponge was measured and used as an approximation of overall sponge size. Due to the branching morphology of *H. erecta*, the length of each individual branch was included to give an overall measurement. Sponges were also assigned

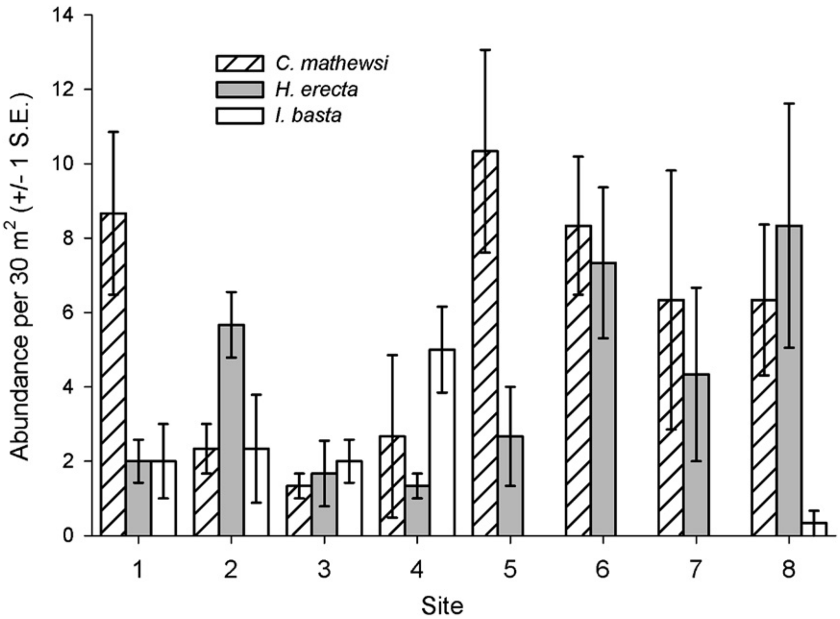

Fig. 1. Mean abundance of *C. matthewsi, H. erecta* and *I. basta* among the 8 sites around Masig Island. Sites separated by ∼200 m. Standard error represents variation among the three transects at each site.