

Ectosymbionts of the Sea Anemone *Stichodactyla gigantea* at Kosrae, Micronesia

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ABSTRACT

We studied the ectosymbionts associating with the sea anemone *Stichodactyla gigantea* at Kosrae, Micronesia. Ectosymbionts of seven species associated with 60.7% of *S. gigantea* (n = 28), with a mean of 2.4 per anemone and 3.9 per occupied anemone. Anemones hosting one or more ectosymbionts did not differ significantly in size from anemones lacking ectosymbionts and there was no significant correlation between anemone size and the number of ectosymbionts. Of 67 ectosymbionts observed, the sea cucumber *Stichopus vastus* comprised 23.9%, followed by the shrimp *Thor amboinensis* (20.9%), unidentified hermit crabs (Paguroidea; 20.9%), the cardinalfish *Ostorhinchus novemfasciatus* (20.9%), the shrimp *Periclimenes brevicarpalis* (9.0%), the sea cucumber *Holothuria hilla* (3.0%), and an unidentified brachyuran crab (1.5%). This study documents the first records of *S. vastus*, *H. hilla*, and *O. novemfasciatus* associating with *S. gigantea*, and the first locality records of *S. gigantea*, *T. amboinensis*, *P. brevicarpalis*, and *S. vastus* for Kosrae. Because humans often harvest *S. gigantea* for food at Kosrae, we recommend protecting the symbiotic assemblage of *S. gigantea* by establishing a sustainable system of harvesting.

Keywords: ectosymbionts, *Holothuria hilla*, Kosrae, Micronesia, *Ostorhinchus novemfasciatus*, *Periclimenes brevicarpalis*, *Stichodactyla gigantea*, *Stichopus vastus*, *Thor amboinensis*

INTRODUCTION

Sea anemones provide microhabitat, shelter, and trophic links for a variety of ectosymbiotic species, especially crustaceans (Bruce, 1976; Ross, 1983) and fishes (Dunn, 1981; Fautin and Allen, 1997; Arvedlund et al., 2006; Karplus, 2014). The gigantic sea anemone *Stichodactyla gigantea* (Forsskål, 1775) occurs throughout the Indian and western Pacific Oceans, typically inhabiting shallow areas with sandy substrates such as the margins of seagrass beds in reef lagoons (Dunn, 1981; Fautin and Allen, 1997). At least three species of decapod crustaceans, an unidentified sea cucumber, and eight species of fishes have been reported associating with *S. gigantea* (Dunn, 1981; Fransen, 1989; Fautin and Allen, 1997). However, much remains to be learned about the relationships between *S. gigantea* and its ectosymbionts. In this study we quantitatively describe the association of four species of decapod crustaceans, two sea cucumbers, and a cardinalfish with *S. gigantea* in Kosrae, Micronesia.

MATERIALS AND METHODS

Rising to an elevation of 630 m above sea level, Kosrae (5°19'N, 162°59'E) represents the easternmost high island of the Caroline Islands of Micronesia in the tropical western Pacific Ocean. It is a 110-km² volcanic island surrounded by fringing coral reefs and a few small satellite islands. The marine environment of Kosrae was described by Eldredge et al. (1979).

We searched for *S. gigantea* anemones in suitable shallow-water habitat at Walung, Tafunsak, and Lelu (Fig. 1) while wading, snorkeling, kayaking, and motorboating during 19–28 Jun 2013 and 20–27 Jun 2014. For each *S. gigantea* found we measured its size by measuring the maximum width (nearest cm) of its oral disc with a plastic ruler or by photographing the anemone beside an underwater writing slate of known length and later extrapolating the maximum width. We searched each *S. gigantea* for ectosymbionts and counted the number of individuals present. We attempted to photograph each species of ectosymbiont to confirm its iden-

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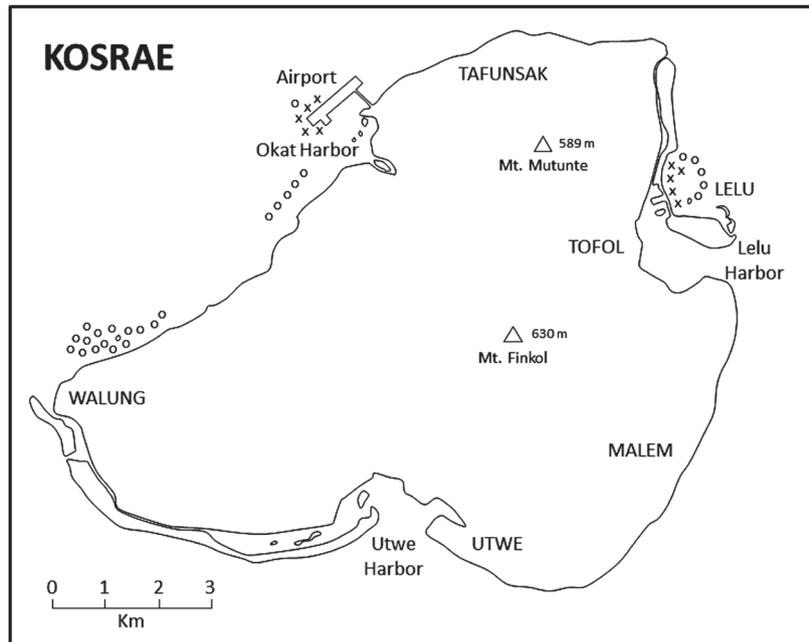


Fig. 1. Map of Kosrae, Micronesia, showing localities of successful (x) and unsuccessful (o) searches for *Stichodactyla gigantea* anemones.

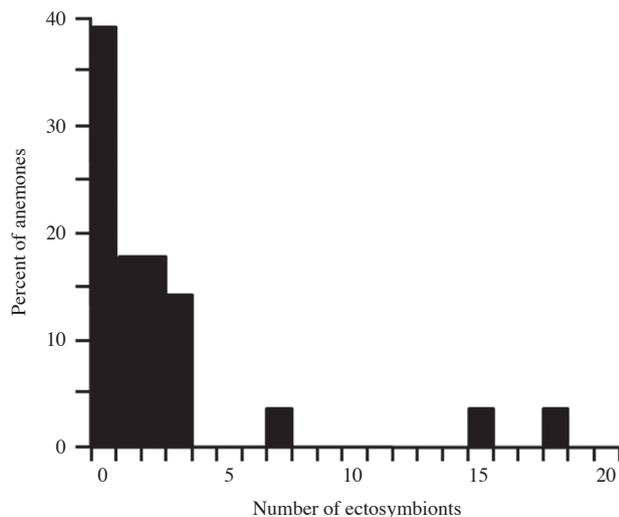


Fig. 2. Number of ectosymbionts per *Stichodactyla gigantea* anemone at Kosrae (n=28).

tification by consulting field identification and classification literature (Myers, 1991; Fautin and Allen, 1997) and experts on taxonomy (see “Acknowledgments”).

A Mann-Whitney U test (U statistic) (Zar 2009) was used to test for differences in width between anemones with and without ectosymbionts, and a Spearman rank correlation coefficient (r_s statistic) (Zar 2009) was used to test for a cor-

relation between anemone width and the number of ectosymbionts.

RESULTS

Despite extensive searches we found only 28 *S. gigantea* anemones, all in shallow water from 0–1 m deep at low tide on the inner reef flat between Blue Hole and the causeway at Lelu (n=17), and along both sides of the airport runway at Okat Harbor (n=11) (Fig. 1). The anemones all occurred in areas with sandy substrates and seagrasses, but usually beside a hard substrate such as a rock or a dead or living coral. The mean maximum width of the anemones was 21.3 cm (SD, 5.5; range, 12–31 cm).

Ectosymbionts (n=67) of seven species associated with 60.7% of *S. gigantea*. The number of ectosymbionts per anemone was positively skewed, with a mean of 2.4 per anemone (SD, 4.3) and 3.9 per occupied anemone (SD, 5.0; range, 1–18) (Fig. 2). Anemones hosting one or more ectosymbionts did not differ significantly in size (mean, 20.9; SD, 4.9; n=17) from anemones lacking ectosymbionts (mean, 21.9; SD, 6.6; n=11; U=105, p=0.60), and there was no significant correlation between anemone size and the number of ectosymbionts ($r_s = -0.02$, p=0.92).

Decapod crustaceans (n=35) of four species comprised 52.2% of the ectosymbionts and associated with 39.3% of



Fig. 3. The shrimp *Thor amboinensis* associating with the anemone *Stichodactyla gigantea* at Lelu, Kosrae, on 19 Jun 2013. Photo by Floyd E. Hayes.



Fig. 4. The shrimp *Periclimenes brevicarpalis* associating with the anemone *Stichodactyla gigantea* at Lelu, Kosrae, on 20 Jun 2014. Photo by Brandon J. Painter.

the anemones, with a mean of 1.3 decapods per anemone (SD, 3.0) and 3.2 decapods per occupied anemone (SD, 4.2; range, 1–15). The squat shrimp *Thor amboinensis* (de Man, 1888) comprised 20.9% of the ectosymbionts and 40.0% of the decapods, and associated with 10.7% of the anemones, with a mean of 0.5 per anemone and 4.7 per occupied anemone (SD, 5.5; range, 1–11; $n=3$). Individuals occurred both above and below the oral disc of the anemones (Fig. 3). Unidentified hermit crabs (superfamily Paguroidea) represented 20.9% of the ectosymbionts and 40.0% of the decapods, and associated with 17.9% of the anemones, with a mean of 0.5 per anemone and 2.8 per occupied anemone (SD, 2.2; range, 1–6; $n=5$). All individuals were under the oral disc of the anemones. The glass anemone shrimp *Periclimenes brevicarpalis* (Schenkel, 1902) accounted for 9.0% of the ectosymbionts and 17.1% of the decapods, and associated with 14.3% of the anemones (Fig. 4), with a mean of 0.2 per anemone and 1.5 per occupied anemone (SD, 0.6; range, 1–2; $n=4$). All occurred above the oral disc of the anemones (Fig. 4). A small, unidentified species of crab (infraorder Brachyura) was observed under the oral disc of an anemone, comprising 1.5% of the ectosymbionts and 2.9% of the decapods.

Sea cucumbers of two species comprised 26.9% of the ectosymbionts and associated with 10.7% of *S. gigantea*, with a mean of 0.6 per anemone and 6.0 per occupied anemone (SD, 8.7; range, 1–16; $n=3$). The brown curryfish sea cucumber *Stichopus vastus* Sluiter, 1887 represented 23.9% of the ectosymbionts and 88.9% of the sea cucumbers, and associated with 3.6% of the anemones, with a mean of 0.6 per anemone. We observed 16 small individuals under the oral disc of a single anemone (Fig. 5). The tiger-tail sea



Fig. 5. The sea cucumber *Stichopus vastus*, one of 16 found underneath the anemone *Stichodactyla gigantea* at Lelu, Kosrae, on 20 Jun 2014. Photo by Floyd E. Hayes.

cucumber *Holothuria hilla* Lesson, 1830 represented 3.0% of the ectosymbionts and 11.1% of the sea cucumbers, and associated with 7.1% of the anemones, with a mean of 0.07 per anemone and 1.0 per occupied anemone. Twice we observed a small individual under the oral disc of an anemone (Fig. 6).

The seven-striped cardinalfish *Ostorhinchus novemfasciatus* (Cuvier, 1828) represented 20.9% of the ectosymbionts and associated with 25.0% of *S. gigantea*, with a mean of 0.5 per anemone and 2.0 per occupied anemone (SD, 0.8; range, 1–3; $n=7$). It occurred above or beside the oral disc of the anemones and often occurred very close to or possibly contacting the tentacles of the anemones (Fig. 7).

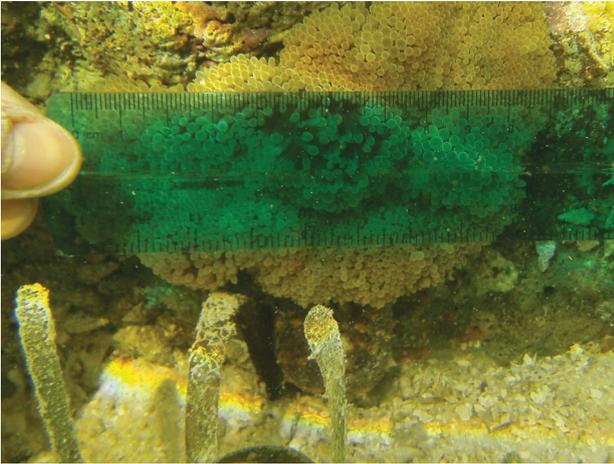


Fig. 6. The sea cucumber *Holothuria hilla* protruding from beneath the anemone *Stichodactyla gigantea* at Lelu, Kosrae, on 20 Jun 2014. Photo by Brandon J. Painter.

Five anemones (17.9%) hosted two species of ectosymbionts. The combinations included (1) 11 *T. amboinensis* and four hermit crabs; (2) six hermit crabs and one *H. hilla*; (3) two hermit crabs and an unidentified crab; (4) one *T. amboinensis* and two *O. novemfasciatus*; and (5) 16 *S. vastus* and two *O. novemfasciatus*.

DISCUSSION

This study represents the first quantitative analysis of ectosymbionts associating with *S. gigantea*. Our lack of a correlation between anemone size and the number of ectosymbionts was also reported for studies of the shrimp *T. amboinensis* associating with the anemone *Stichodactyla helianthus* (Ellis, 1768) (see Baeza and Piantoni, 2010), the shrimp *Ancylomenes pedersoni* (Chace, 1958) associating with the anemone *Condylactis gigantea* (Weinland, 1860) (see Nizinski, 1989), and the shrimp *Ancylomenes holthuisi* (Bruce, 1969) associating with the anemone *Stichodactyla haddoni* (Saville-Kent, 1893) (see Khan et al., 2003). However, a significantly positive correlation between anemone size and the number of ectosymbionts was reported for decapod crustaceans associating with the anemone *Telmatactis cricoides* (Duchassaing, 1850) (see Wirtz, 1997) and the shrimp *Periclimenes rathbunae* Schmitt, 1924 associating with the anemone *S. helianthus* (Hayes and Trimm, 2008).

Only one of the seven species observed in this study, the shrimp *P. brevicarpalis*, is an obligate commensal of anemones (Bruce and Svoboda, 1983). All other species are facultative associates. Consistent with our observations, others have reported that *P. brevicarpalis* occurs singly or in pairs

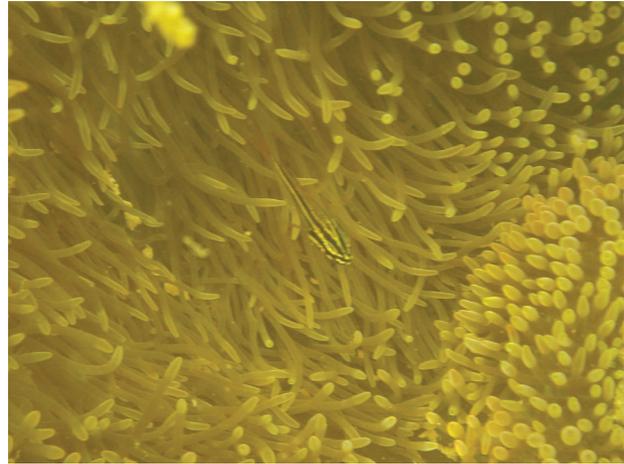


Fig. 7. The cardinalfish *Ostorhinchus novemfasciatus* associating with the anemone *Stichodactyla gigantea* at Lelu, Kosrae, on 20 Jun 2014. Photo by Brandon J. Painter.

(Bruce and Svoboda, 1983; Fransen, 1989; Guo et al., 1996; Khan et al., 2004).

The shrimp *T. amboinensis* is an associate of many species of sea anemones and other invertebrates (e.g., Fransen, 1987), and often occurs in large groups lacking social structure (Baeza and Piantoni, 2010). Our maximum count of 11 *T. amboinensis* with *S. gigantea* equaled the maximum counts of *T. amboinensis* with the anemones *S. helianthus* (Baeza and Piantoni, 2010) and *Stichodactyla tapetum* (Hemprich and Ehrenberg in Ehrenberg, 1834) (Guo et al., 1996). Wirtz (1997) reported up to 18 *T. amboinensis* associating with the anemone *T. cricoides*.

Both *P. brevicarpalis* and *T. amboinensis* were reported to associate with and occasionally cohabit with *S. gigantea* in Indonesia, but no data on the frequency of association were provided (Fransen, 1989). We did not observe both species cohabiting an anemone. The only other positively identified species of decapod crustacean reported associating with *S. gigantea* is *Petrolisthes ohshimai* (Miyaki, 1937) (Dunn, 1981).

Sea cucumbers generally do not associate with anemones (Bakus, 1973). However, Dunn (1981) reported that “there was often a holothurian tucked in under the overhanging oral disc” of *S. gigantea* in Jakarta Bay, Indonesia. Our observations of *H. hilla* and *S. vastus* associating with *S. gigantea* represent new records of association and the first identified species of sea cucumbers associating with *S. gigantea*. However, the association may be incidental rather than intentional because these species of sea cucumbers often seek shelter under the nearest overhang or crevice, which is usually a live or dead coral, or a rock (Alexander M. Kerr, personal communication). Evidently *S. gigantea* also provides a

suitable shelter.

Our observation of the cardinalfish *O. novemfasciatus* associating with *S. gigantea* represents a new record of association. Only one other species in the genus, *Ostorhinchus nanus* (Allen, Kuiter, and Randall, 1994), had previously been reported to associate with an anemone (Randall and Fautin, 2002; Arvedlund et al., 2006). Seven other species of fishes have been reported to associate with *S. gigantea* (Dunn, 1981; Fautin and Allen, 1997). Karpplus (2014) listed an eighth species of fish, but it was not reported to associate with *S. gigantea* in the literature citation provided.

This study documents the first locality records of *S. gigantea*, *P. brevicarpalis*, *T. amboinensis*, and *S. vastus* for Kosrae. In Micronesia, *S. gigantea* has been recorded from Yap Island and Ulithi Atoll (Dunn, 1981), *P. brevicarpalis* has been recorded from Palau (Miyake and Fujino, 1968), Guam (Paulay et al., 2003), and Eniwetok Atoll in the Marshall Islands (Bruce, 1979), *T. amboinensis* has been recorded from Palau (Miyake and Hayashi, 1966), Ifaluk Atoll in Yap (Chace, 1972), Guam (Paulay et al., 2003), and the Marshall Islands (Bruce, 1989), and *S. vastus* has been recorded from Palau (Pakoa et al., 2009), Yap (Pakoa et al., 2009), Chuuk (Lee and Shin, 2014), and Pohnpei (Kinch, 2012). None of these species was reported from a comprehensive survey of the marine environment of Kosrae in the late 1970s (Eldredge et al., 1979) or in subsequent surveys of anemones (Hobbs et al., 2013) and sea cucumbers (Kerr, 1994; Kerr et al., 2008; Lee and Shin, 2013). However, *S. gigantea* was observed in Kosrae during a brief visit in 1992 by anemone researcher Daphne Fautin (personal communication) and *S. vastus* was recently photographed in Kosrae by Doug Beitz of Kosrae Nautilus Resort (A. M. Kerr, personal communication), but these records were never published.

Several human residents of Kosrae informed us that *S. gigantea* is often harvested as a source of food, which may explain why it was relatively difficult for us to find it. Des Rochers (1992) listed unidentified anemones among the marine invertebrates harvested for food in Kosrae, but Lambeth and Abraham (2001) did not. Dunn (1981) reported that the people of Jakarta Bay, Indonesia, also eat *S. gigantea*. Given the diversity of invertebrates and fishes that often associate with *S. gigantea* (Dunn, 1981; Fautin and Allen, 1997), overharvesting of *S. gigantea* may have a devastating effect on multiple species of ectosymbionts. We recommend protecting the ectosymbiotic assemblage of *S. gigantea* by establishing a sustainable system of harvesting.

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