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Sponge-dwelling snapping shrimps (Alpheidae: *Synalpheus*) of Barbados, West Indies, with a description of a new eusocial species

KRISTIN M. HULTGREN[1], KENNETH S MACDONALD III[2] & J. EMMETT DUFFY[3]

[1]*Smithsonian Institution, National Museum of Natural History, MRC 163, P.O. Box 37012, Washington, D.C. 20013–7012, USA. E-mail: krhultgren@gmail.com*

[2]*Department of Biology, New Mexico State University, USA. E-mail: tripp@nmsu.edu*

[3]*Virginia Institute of Marine Science, The College of William and Mary, USA. E-mail: jeduffy@vims.edu*

Abstract

Sampling of eight sites along the west coast of Barbados, West Indies, yielded 14 species of sponge-dwelling shrimps in the *gambarelloides* group of the genus *Synalpheus*, including one new species described here as *Synalpheus microneptunus* **n. sp.** The new species is a member of the *S. paraneptunus* Coutière species complex and is distinguished from other species in that group by the combination of four carpal segments in the second pereopod, uropodal exopod with 2nd distolateral tooth smaller than the other two teeth and set in line with movable spine, and a small blade on the scaphocerite. *Synalpheus microneptunus* **n. sp.** is the smallest species in the complex (2.2-2.9 mm CL) and lives in small colonies, usually with fewer than 10 individuals, often with a single breeding female. *Synalpheus thele* Macdonald, Hultgren & Duffy is reported for the first time from outside its type locality in Jamaica. Sampling in Barbados produced fewer species than did similar efforts in Jamaica and Curaçao, possibly due to the relatively isolated position of the island at the eastern (windward) edge of the Caribbean Sea.

Key words: Decapoda, Caridea, *Synalpheus*, shrimp, symbiotic, coral reef, eusociality, new species, new records

Introduction

Alpheid shrimps associated with sponges have emerged as a model system for studying several general questions in evolutionary and behavioral ecology (Duffy 2007). Most previous research on sponge-dwelling alpheids has focused on the *gambarelloides* species group within the genus *Synalpheus* Bate, 1888. All species in the *S. gambarelloides* group inhabit the interior canals of sponges and molecular data strongly suggest that this group is monophyletic (Duffy *et al.* 2000; Morrison *et al.* 2004; Hultgren & Duffy 2011). The majority of species in the *S. gambarelloides* group live in the western Atlantic, with most taxonomic studies conducted on the Belize Barrier Reef in the vicinity of Carrie Bow Cay, in the western Caribbean Sea. This area has been extensively sampled and has produced numerous new species (Macdonald *et al.* 2006; Ríos & Duffy 2007). To better characterize the regional diversity and biogeography of sponge-dwelling *Synalpheus*, we undertook a series of collections at sites spanning the Caribbean Sea, including the centrally located Jamaica (Macdonald *et al.* 2009); Curaçao in the southern Caribbean (Hultgren *et al.* 2010); Bocas del Toro, Panama, in the southwestern Caribbean (Hultgren & Duffy, unpublished data); and Barbados at the eastern-most margin of the Caribbean. In this contribution, we report on collections from the last of these four sites.

Material and methods

Shrimps were sampled at eight sites along the west (leeward) coast of Barbados (Fig. 1) between 17 and 22 October 2008 (see site descriptions below). Sponges bearing shrimp were collected by hand while SCUBA diving or snorkeling. We concentrated our efforts on sponges previously known to host *Synalpheus* species (Macdonald *et al.*

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2006), but also examined as many other sponge species as possible. Previous work has shown that the diversity of *Synalpheus* is highest in the cryptic sponge assemblages growing among branches of living and dead corals, especially the finely branched coral *Madracis auretenra* Locke, Weil & Coates (formerly called *M. mirabilis* in Dardeau 1984; Macdonald et al. 2006, Rios and Duffy 2007). Therefore, we focused on patches of *M. auretenra* and branching *Porites* spp. during searches of dead and live coral reef framework, where we targeted cryptic sponges, including *Hymeniacidon caerulea* Pulitzer-Finali, *Lissodendoryx* sp., *Hyattella intestinalis* Lamarck, *Xestospongia proxima* Duchassaing & Michelotti, *X. subtriangularis* Duchassaing, *Spirastrella* sp., and *Agelas clathrodes* Schmidt. We also collected several species of sponges growing in the open, including *Agelas dispar* Duchassaing & Michelotti, *Aiolochroia* (formerly *Pseudoceratina*) *crassa* Hyatt, and *Hyrtios* cf. *proteus* Duchassaing & Michelotti. Sponges were transported to the Bellairs Research Station in mesh bags and retained in flowing seawater until processed. They were subsequently carefully dissected and all macrofauna was removed. Alpheid shrimps were sorted by species, usually counted and sexed, then preserved in 95% ethanol.

To assess how completely we sampled the sponge-dwelling *Synalpheus* fauna of Barbados, we tallied the accumulation of *Synalpheus* species and of shrimp/sponge associations (any unique pairing between a shrimp species and host sponge species) as a function of number of samples collected and estimated the true diversity of shrimp species, sponge species, and shrimp/sponge associations using the Michaelis–Menten logistic curve-fitting function (Colwell *et al.* 2004) in the program EstimateS (Colwell 2005). Three additional measures were also used to estimate true species richness: the Chao2 measure (Chao 1987), the Burnham and Overton second-order jackknife (Burnham & Overton 1978), and the Smith and van Belle bootstrap (Smith & van Belle 1984).

Over the course of the sampling period (6 days) and at all sites combined we collected 78 individual shrimp-hosting sponges belonging to 10 species (see above). Examination of shrimp material resulted in the identification of 14 species, all from the *Synalpheus gambarelloides* group, including an undescribed eusocial species from the *Synalpheus paraneptunus* Coutière species complex. The undescribed species is described below as new.

Type specimens and voucher material are deposited in the National Museum of Natural History, Smithsonian Institution, Washington, DC (USNM) and Virginia Institute of Marine Science, Gloucester Point, VA (VIMS). VIMS numbers refer to specimen numbers assigned in the field. Measurements correspond to carapace length (CL) in millimeters, taken along the dorsal midline from the most-posterior edge of the carapace to the base of the rostrum Specimens were figured from digital photos taken using an Olympus BX40 light microscope and an Olympus SZX7 dissecting microscope. Because sexes in some species of *Synalpheus* are difficult to distinguish based on external morphology (Tóth & Bauer 2007), we list specimens only as ovigerous females vs. non-ovigerous individuals. All specimens listed came from the canals of their respective host sponge.

Description of collecting sites

(cf. Fig. 1)

Cluff reef (13°20'16.20" N, 59°38'39.60"W; sampled 21 October 2008) is a high-energy reef dominated by gorgonians and live coral approximately 1.5 km off the northwest corner of Barbados, where the Caribbean Sea meets the open Atlantic Ocean. The reef also featured cold freshwater seeps. Sponges and coral rubble were collected at 23 m depth and included *Agelas dispar*, *Hyattella intestinalis* and *Aiolochroia crassa*.

Harrison's Point reef (13°18'30.96"N, 59°39'25.56"W; sampled 20 October 2008) lies ~0.7 km offshore of Harrison's Point on the NW coast of Barbados. Sponges were collected from depth of 9–11 m and included *Hyrtios* cf. *proteus* and *Hyattella intestinalis*.

Breach site (13°18'21.96"N, 59°39'16.56"W; sampled 20 October 2008) is a shallow consolidated reef with scattered head corals and *Acropora palmata* colonies, inshore of Harrison's Point reef, lying ~0.4 km offshore of Harrison's Point. Sponges were collected from standing dead *Porites* at a depth of around 4 m and included *Xestospongia proxima* and an unidentified yellow webby sponge.

Cement Factory site (13°17'21.84"N, 59°39'27.72"W; sampled 21 October 2008) is a relatively shallow reef with high cover of live coral, including dense beds of living and dead *Madracis auretenra*, ~0.8 km offshore of the island's cement factory. Sponges were collected in 11–12 m depth and included *Hyattella intestinalis, Hymeniacidon caerulea, Aiolochroia crassa, Xestospongia proxima* and an unidentified yellow webby sponge.

Pamir wreck site (13°15'27.00"N, 59°38'48.48"W; sampled 17 October 2008) is the wreck of a vessel used as a recreational scuba diving site, and is surrounded by small patches of coral and sponges, located ~0.2 km offshore of

Almond Beach, north of Speightstown. Sponges were collected from the bow of the wreck in ~6 m, and from the bottom to depths of 12 m. Sponges collected included *Hyrtios* cf. *proteus* and *Xestospongia proxima*.

Spawnee Reef (13°13'48.24"N, 59°39'1.38"W; sampled 17 October 2008) is a hard ground with relatively low live coral cover ~0.8 km off of Mullins Beach. Sponges were collected at 24 m depth from rubble and dead standing remains of branching *Porites* coral colonies, with abundant cryptic sponges among the branches. Sponges collected at this site included *Agelas clathrodes, Hyattella intestinalis, Hymeniacidon caerulea, Aiolochroia crassa, Xestospongia subtriangularis* and *Xestospongia proxima*.

Thunder Bay, also known as Lower Carlton (13°13'11.97"N, 59°38'35.77"W; sampled 18 and 22 October 2008), featured a shallow fringing reef at its south end, sloping from shore out to a spur-and-groove formation with high cover of *Madracis auretenra* and branching *Porites* on the spurs. Sponges were collected at depths of 3–6 m and included *Agelas clathrodes, Aiolochroia crassa, Hymeniacidon caerulea, Lissodendoryx* sp., and *Spirastrella* sp.

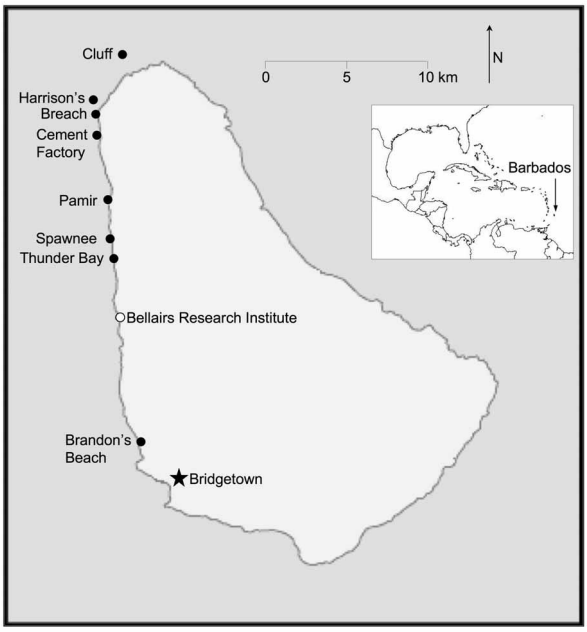

FIGURE 1. Map of Barbados showing sampling sites (black circles). Inset indicates location of Barbados in the Caribbean.

Brandon's Beach (13° 7'0.12"N, 59°37'52.68"W; sampled 19 October 2008) is a public beach fronting a wide shallow bay with scattered dead patch reefs, mostly in depths less than 6 m, covered mostly with standing dead *Porites* colonies. Cryptic sponges were common in the spaces among branches. Sponges collected were *Agelas clathrodes, Xestospongia proxima* and an unidentified yellow webby sponge.

Results

Over the course of six days, we collected 78 samples (individual sponges) that contained shrimp from a total of 10 sponge species. Fourteen species of *Synalpheus* in the *gambarelloides* group were identified, of which one is undescribed. Accumulation curves for shrimp species richness and sponge species richness (Fig. 2) began to approach an asymptote by the end of the collection period, while the number of unique shrimp/sponge associations continued to rise and showed no definitive asymptote. Observed richness of *gambarelloides*-group shrimp was 14 species; the Michaelis–Menten function estimated a "true" shrimp species richness of 17, while the Chao2, jackknife, and bootstrap estimated 14, 14, and 15 species respectively. The four functions estimated sponge species richness at 11, 10, 12, and 11 respectively, while 10 sponge species were observed. For shrimp/sponge associations, the four functions estimated 42, 38, 43, and 34 associations respectively (with 29 observed shrimp/sponge associations). Thus, we estimate that we have collected 83–100% of the total *Synalpheus gambarelloides*-group species, 83–100% of the shrimp-bearing sponge species, and recorded 68–86% of the unique shrimp/sponge associations from sites in Barbados.

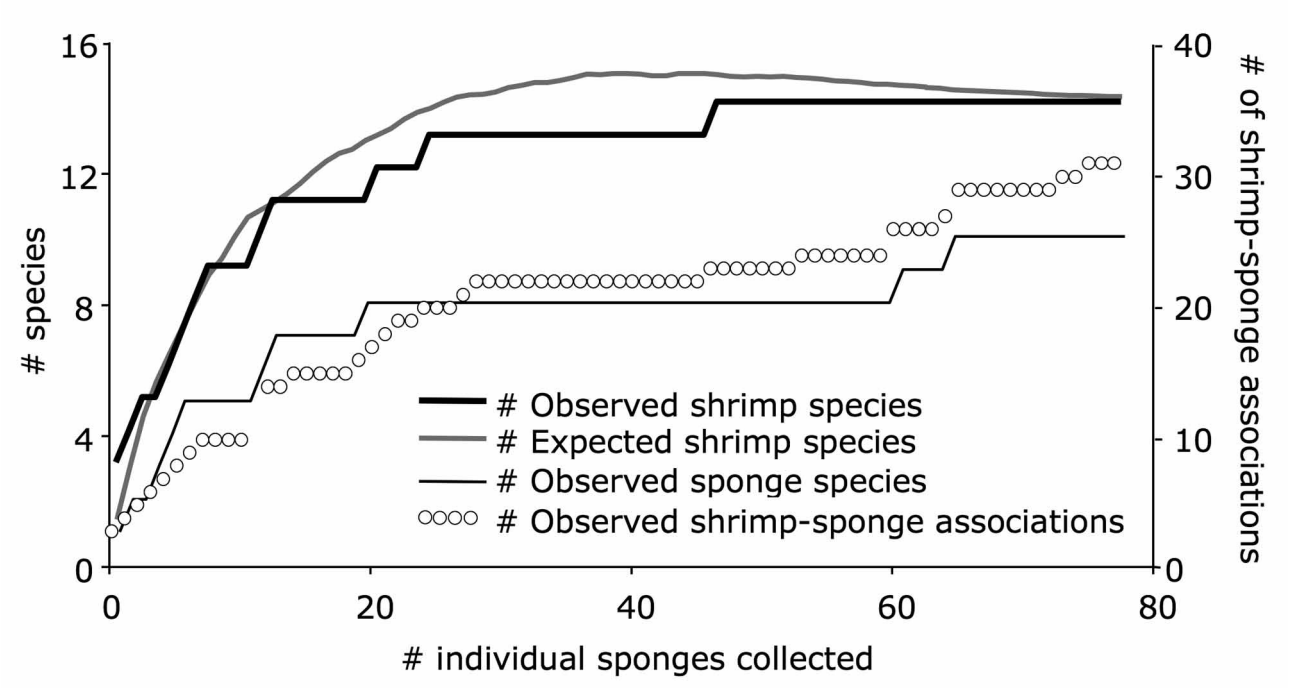

FIGURE 2. Observed accumulation of species in the *Synalpheus gambarelloides* group (thick black line); expected species accumulation curve (gray line) estimated using the bootstrap function in EstimateS (Colwell 2005); observed accumulation of unique sponge host species (thin black line); and observed accumulation of unique shrimp-sponge associations (white circles, right y-axis) as a function of collection effort (number of sponge specimens collected).

Taxonomy

Order Decapoda Latreille, 1802

Family Alpheidae Rafinesque, 1815

Genus *Synalpheus* Bate, 1888

***Synalpheus agelas* Pequegnat & Heard, 1979**

Material examined. Barbados: 1 non-ovigerous individual (VIMS 08BR5001), Brandon's Beach, from *Agelas clathrodes*. 1 non-ovigerous individual (VIMS 08BR8501), Cluff Reef, from *A. clathrodes*. 20 non-ovigerous individuals, 5 ovigerous females (VIMS 08BR8202–4, 08BR8302–3, 08BR8401–8404), Cluff Reef, from *Agelas dispar.* 1 non-ovigerous individual (VIMS 08BR601), Spawnee Reef, from *A. clathrodes*. Largest ovigerous female, CL 3.2 mm, largest non-ovigerous individual, CL 4.02 mm.

Color. Ovigerous females had green or orange ovaries and embryos.

Hosts and ecology. As is true elsewhere, *S. agelas* was found only within sponges of the genus *Agelas*. At Cluff reef at the northern end of Barbados, *S. agelas* dominated the fauna of *Agelas* spp., with up to 11 individuals per sponge. This contrasts with previously sampled sites in other regions, where *S. agelas* is usually a minor component of the fauna of *Agelas*, often occurring as one or two heterosexual pairs within a sponge (Macdonald *et al.* 2006; Macdonald *et al.* 2009; Hultgren *et al.* 2010).

Distribution. Florida Keys, USA (Morrison *et al.* 2004); Bahamas (Dardeau 1984); Gulf of Mexico (Pequegnat & Heard 1979; Dardeau 1984); Puerto Rico (Dardeau 1984); Cuba (Martínez Iglesias & García Raso 1999); Belize (Macdonald *et al.* 2006; Ríos & Duffy 2007); Jamaica (Macdonald *et al.* 2009) Curaçao (Hultgren *et al.* 2010); Barbados (this study); northeastern Brazil (Coelho Filho 2006).

Remarks. *Synalpheus agelas* can be easily distinguished from other species of *Synalpheus* occurring in *Agelas* spp. by the number of segments in the carpus of the second pereopod (4 in *S. agelas*, 5 in other species living in *Agelas* spp.).

Synalpheus androsi Coutière, 1909

Material examined. Barbados: 8 non-ovigerous individuals, 5 ovigerous females (VIMS 08BR6706–7, 08BR6802–3, 08BR7101–2), Cement Factory, from *Hyattella intestinalis*. 1 non-ovigerous individual (VIMS 08BR8002), Cluff Reef, from *H. intestinalis.* 12 non-ovigerous individuals, 5 ovigerous females (VIMS 08BR1402–3 08BR1405–11), Spawnee Reef, from *H. intestinalis*. Largest ovigerous female, CL 4.08 mm, largest non-ovigerous individual, CL 3.78 mm.

Color. Transparent, slightly opaque whitish, with olive-colored embryos (see Ríos and Duffy 2007, Plate 1).

Hosts and ecology. As in Belize and Jamaica (Macdonald *et al*., 2006; Ríos and Duffy, 2007; Macdonald *et al*., 2009), in Barbados *S. androsi* lives only within the sponge *Hyattella intestinalis*, apparently in heterosexual pairs; we found up to five pairs of adults within a single sponge.

Distribution. Bahamas (Coutière 1909); Belize (Macdonald *et al.* 2006; Ríos & Duffy 2007); Jamaica (Macdonald *et al.* 2009); Barbados (this study).

Remarks. *Synalpheus androsi* can be easily distinguished from other species of *Synalpheus* living in *H. intestinalis* by the thin lateral flanges on flexor margins of the merus and carpus of the third and fourth pereopods.

Synalpheus belizensis Anker & Tóth, 2008

Material examined. Barbados: 1 non-ovigerous individual, 1 ovigerous female (VIMS 08BR 5701–2), Brandon's Beach, host unknown. 3 non-ovigerous individuals (VIMS 08BR4101–2, 08BR4301), Brandon's Beach, from *Xestospongia proxima.* 3 non-ovigerous individuals, 1 ovigerous female (VIMS 08BR5801–2, 08BR5901), Breach Reef, from *X. proxima.* 5 non-ovigerous individuals, 3 ovigerous females (VIMS 08BR7003–4, 08BR7301, 08BR7401–2, 08BR7601–2, 08BR6901–2), Cement Factory, from *Xestospongia proxima.* 1 non-ovigerous individual (VIMS 08BR107), Pamir, from *Hyrtios* cf. *proteus*. 1 non-ovigerous individual (VIMS 08BR9501), Thunder Bay, from *X. proxima.* Largest ovigerous female, CL 4.37 mm, largest non-ovigerous individual, CL 4.72 mm.

Color. Ovigerous females had yellowish-green ovaries and embryos.

Hosts and ecology. *Synalpheus belizensis* was most common in wider canals of *Xestospongia proxima*, which it often shared with the closely related, but much smaller and social *S. microneptunus* **n. sp.** (see below).

Distribution. Belize (Anker & Tóth, 2008); Jamaica (Macdonald *et al.* 2009) Curaçao (Hultgren *et al.* 2010); Barbados (this study).

Remarks. *Synalpheus belizensis* can be distinguished from the closely related *S. microneptunus* **n. sp.** by the larger body size of *S. belizensis* (3.03 – 4.72 mm CL vs. 2.16–2.73 mm CL for *S. microneptunus* **n. sp.**) and the number of segments in the carpus of the second pereopod (5 in *S. belizensis*, 4 in *S. microneptunus* **n. sp.**). Some individuals of *S. belizensis* were infested with branchial bopyrid isopods.

Synalpheus bousfieldi Chace 1972

Material examined. Barbados: 8 ovigerous females, 1 non-ovigerous individual (VIMS 08BR3701, 3801–2, 4501, 4601, 4701–2, 4801, 5101), Brandon's Beach, from *Agelas clathrodes.* Largest ovigerous female, CL 3.67 mm, largest non-ovigerous individual, CL 3.43 mm.

Color. Ovigerous females had ovaries that ranged in color from pinkish-brown to a brownish brick red, with embryo color ranging from pink to brick red.

Hosts and ecology. In Barbados, *S. bousfieldi* only occurred in *Agelas clathrodes* from a single site. *S. bousfieldi* commonly occurs in *Hyattella intestinalis* in Belize (Macdonald *et al.* 2006) and Curaçao (Hultgren *et al.* 2010), but was never found in this sponge in Barbados.

Distribution. Bahamas (Dardeau 1984); Cuba (Martínez Iglesias & García Raso 1999); Gulf of Mexico (Dardeau 1984); Yucatan Peninsula, Mexico (Chace 1972); Belize (Macdonald & Duffy 2006; Ríos & Duffy 2007); Curaçao (Hultgren *et al.* 2010); Barbados (this study); possibly Brazil (Christoffersen 1979, 1998).

Remarks. *Synalpheus bousfieldi* can be distinguished from other morphologically similar species in the *S. brooksi* complex occurring in Barbados by the tuft of setae on the minor chela (forming a thick brush in *S. bousfieldi* vs. with two parallel rows in *S. thele*), the typical third and fourth pereopods (vs. with thin lateral flanges in *S. androsi*), and the shape of the dorsal projection on the major chela (pointing downwards in *S. bousfieldi* vs. pointing forwards in *S. idios*).

Synalpheus herricki Coutière, 1909

Material examined. Barbados: 2 ovigerous females, 4 non-ovigerous individuals (VIMS 08BR8101–5), Cluff Reef, from *Aiolochroia crassa.* 2 ovigerous females, 4 non-ovigerous individuals (VIMS 08BR1501–2, 1601, 2101–2), Spawnee Reef, from *A. crassa.* 1 ovigerous female, 5 non-ovigerous individuals (VIMS 08BR8901–3), Thunder Bay, from *A. crassa.* Largest ovigerous female, CL 6.46 mm, largest non-ovigerous individual, CL 5.33 mm.

Color. In Barbados *S. herricki* had a drab, non-descript body color; ovigerous females had grass-green to brownish-green developing ovaries and embryos.

Hosts and ecology. In Barbados, *S. herricki* only occurred in the common sponge *Aiolochroia crassa.*

Distribution. Florida (Coutière 1909); Gulf of Mexico (Coutière 1909; Dardeau 1984); Belize (Ríos & Duffy 2007), Curaçao (Hultgren *et al.* 2010); possibly Brazil (Christoffersen 1998).

Remarks. Many of the *S. herricki* collected in Barbados were juveniles. Some individuals had abdominal bopyrid parasites.

Synalpheus hoetjesi Hultgren, Macdonald, & Duffy 2010

Material examined. Barbados: 2 ovigerous females, 8 non-ovigerous individuals (VIMS 08BR6701–5, 8, 12, 6801), Cement Factory, from *Hyattella intestinalis*. 1 non-ovigerous individual (VIMS 08BR6401), Harrison's Point reef, from *Hyattella intestinalis*. 1 non-ovigerous individual, 1 ovigerous female (VIMS 08BR9603–4), Thunder Bay, from *Agelas clathrodes*. Largest ovigerous female, CL 3.84 mm, largest non-ovigerous individual, CL 3.26 mm.

Color. Semitransparent with dull brown major chelae; females with dull olive to orange ovaries and brownish to yellowish-orange embryos.

Hosts and ecology. In Barbados, *Synalpheus hoetjesi* was collected in the sponges *Hyattella intestinalis* and *Agelas clathrodes*; it also occurs in the sponges *Hyattella intestinalis, Xestospongia proxima,* and *X. subtriangularis* in Curaçao (Hultgren *et al.* 2010).

Distribution. Curaçao (Hultgren *et al.* 2010); Barbados (this study); Caribbean Panama (Hultgren & Duffy 2011).

Remarks. The Barbados specimens of *Synalpheus hoetjesi* were similar in morphology to type specimens from *Hyattella intestinalis* in Curaçao and grouped with these specimens in phylogenetic trees based on DNA sequences (Hultgren *et al.* 2010; Hultgren & Duffy 2011). They can be distinguished from the related *S. ul* Rios and Duffy by the relative width of the distal telson spines (medial spines distinctly thicker than lateral spines in *S. hoetjesi*, similar in thickness in *S. ul*) and relatively larger body size (CL = 3.29 MM ± 0.144 SE for *S. hoetjesi* vs. 2.37 mm CL ± 0.107 for *S. ul*), and from *S. pandionis* by the development of the scaphocerite blade (generally absent or vestigial in *S. hoetjesi* vs. >40% of the length of scaphocerite spine in *S. pandionis*).

Synalpheus idios (Rios & Duffy 2007)

Material examined. Barbados: 14 non-ovigerous individuals, 2 ovigerous females (VIMS 08BR6502, 08BR6601–4), Harrison's Point reef, from *Hyrtios* cf. *proteus*. 17 non-ovigerous individuals, 4 ovigerous females (VIMS

08BR101–5), Pamir reef, from *Hyrtios* cf. *proteus*. Largest ovigerous female, CL 3.90 mm, largest non-ovigerous individual, CL 4.66 mm.

Color. As elsewhere in the Caribbean, *S. idios* females had brick-red ovaries and embryos.

Hosts and ecology. In Barbados, *S. idios* was found in groups of several individuals (with numerous ovigerous females present) in *Hyrtios* cf. *proteus*; it has been found in a similar host in Curaçao (Hultgren *et al.* 2010).

Distribution. Belize (Macdonald *et al.* 2006; Ríos & Duffy 2007), Curaçao (Hultgren *et al.* 2010), Barbados (this study).

Remarks. In Barbados, *S. idios* can be distinguished from the related species *S. bousfieldi* by the shape of the distal projection on the major chela, which is conical-shaped in *S. idios* and lacks the small secondary projection typically found in *S. bousfieldi.* These closely related species also appear to be limited to different hosts (*Hyrtios* cf. *proteus* for *S. idios, Agelas clathrodes* for *S. bousfieldi*).

Synalpheus mcclendoni Coutière, 1910

Material examined. Barbados: 3 non-ovigerous individuals (VIMS 08BR4001–2, 08BR4401), Brandon's Beach, from *Agelas clathrodes.* 1 non-ovigerous individual (VIMS 08BR6711), Cement Factory, from *Hyattella intestinalis.* 2 non-ovigerous individuals, 1 ovigerous female (VIMS 08BR8201, 08BR8301, 08BR8405), Cluff Reef, from *Agelas dispar.* 1 non-ovigerous individual (VIMS 08BR8106), Cluff Reef, from *Aiolochroia crassa*. 1 ovigerous female (VIMS 08BR8001), Cluff Reef, from *H. intestinalis*. 2 non-ovigerous individuals (VIMS 08BR6503), Harrison Reef, from *Hyrtios* cf. *proteus*. 5 non-ovigerous individuals (VIMS 08BR106, 08BR110), Pamir reef, from *H.* cf. *proteus*. 3 non-ovigerous individuals, 2 ovigerous females (VIMS 08BR1401, 08BR1413–16), Spawnee Reef, from *H. intestinalis*. 1 non-ovigerous individual (VIMS 08BR801), Spawnee Reef, no host recorded. 3 non-ovigerous individuals, 2 ovigerous females (VIMS 08BR9001–3, 08BR9101–2), Thunder Bay, from *A. clathrodes.* Largest ovigerous female, CL 3.76 mm, largest non-ovigerous individual, CL 3.41 mm.

Color. *Synalpheus mcclendoni* from Barbados were overall yellow or orange in color, with the distal portion of the major chela much brighter orange or red. The distal portion of the major chela had additional markings that varied among individuals, although these markings were generally consistent among shrimp co-inhabiting a host. All individuals had a white bar across the palm near the base of the fingers. Some individuals additionally had a blue bar proximally adjacent to the white bar. Finally, some white-barred and all blue-white barred individuals had a white crescent following the extensor margin of the dactyl. Embryos and ovaries varied from bright orange-yellow to green-yellow.

Hosts and ecology. *Synalpheus mcclendoni* was one of the most frequently encountered species of *Synalpheus* in Barbados, occurring in five different sponge hosts (*Agelas clathrodes, A. dispar, Aiolochroia crassa, Hyattella intestinalis, Hyrtios* cf. *proteus*) and at most of the surveyed locations. This distribution contrasts strongly with some other locations, where *S. mcclendoni* is a rarely encountered species (Macdonald *et al.* 2006; Ríos & Duffy 2007; Macdonald *et al.* 2009; Hultgren *et al.* 2010).

Distribution. Florida (Coutière 1910); Bahamas (Dardeau 1984); Cuba (Martínez Iglesias & García Raso 1999); Jamaica (Macdonald *et al.* 2009); St. Lucia, Tobago Cays, Yucatan Mexico (Chace 1972); Belize (Macdonald *et al.* 2006; Ríos & Duffy 2007); Caribbean Panama (Duffy 1992); Curaçao (Hultgren *et al.* 2010); Barbados (this study).

Remarks. *Synalpheus mcclendoni* can easily be distinguished from other species of *Synalpheus* by the shape of the major chela fingers (curved in *S. mcclendoni*, not curved in other species). Specimens assigned to *S. mcclendoni* have been reported from a variety of sponge species and display a considerable variation in color pattern and body size. Therefore, it is possible that *S. mcclendoni* includes a number of cryptic species, but resolving this issue will require a comprehensive morphological and genetic comparison of numerous specimens from throughout the species' range.

***Synalpheus microneptunus* n. sp.**
(Figures 3–6)

Synalpheus "microneptunus" in Hultgren & Duffy (2011)

Type material. Holotype: Ovigerous female, CL 2.73 mm (USNM 1154070, original VIMS 08BR7001), Cement Factory (13°17'21.84"N, 59°39'27.72"W), from *Xestospongia proxima*, 21.X.2008. *Paratypes*: 1 non-ovigerous individuals, CL 2.16–2.49 mm (USNM 1154071–1154082, original VIMS 08BR7002–1 to 7002–12), same collection data as holotype.

Additional material examined. 2 non-ovigerous individuals (VIMS 08BR5103, 5703), Brandon's Beach, no host recorded. 8 ovigerous females, 31 non-ovigerous individuals (VIMS 08BR3601–3, 4103–4, 5201–3, 5302–3, 5401–2), Brandon's Beach, from *X. proxima*. 1 non-ovigerous individual (VIMS 08BR6301), Breach Reef, no host recorded. 1 ovigerous female, 3 non-ovigerous individuals (VIMS 08BR6001–2, 6101), Breach Reef, from *X. proxima*. 1 non-ovigerous individual (VIMS 08BR6710), Cement Factory, no host recorded. 1 ovigerous female, 11 non-ovigerous individuals (VIMS 08BR301, 1701), Spawnee Reef, from *X. proxima.* 2 ovigerous females, 8 non-ovigerous individuals (VIMS 08BR401, 2001–2, 2302), Spawnee Reef, from *Xestospongia subtriangularis*. Largest ovigerous female, CL 2.86 mm, largest non-ovigerous individual, CL 2.55 mm.

Description: Body subcylindrical; carapace smooth, sparsely setose, posterior margin with distinct cardiac notch. Rostrum longer and narrower than ocular hoods (Fig 3), latter dorsally convex; blunt distally, separated from rostrum by adrostral sinus. Stylocerite acute, with blunt tip reaching beyond midpoint of first segment of antennular peduncle. Basicerite with blunt projection on dorsomesial corner, with longer ventrolateral spine, latter not reaching third segment of antennular peduncle and about 3/4 length of scaphocerite. Scaphocerite with short blade ranging from vestigial to <1/4 length of distolateral spine, latter robust, acute, reaching almost to distal end of third segment of antennular peduncle; lateral margin concave. Third maxilliped (Fig. 3) with distal circlet of approximately seven spines on distal segment.

Major first pereopod (Fig. 3) massive, with fingers clearly shorter than half-length of palm; fixed finger slightly shorter than dactyl. Palm of chela with distodorsal protuberance tapering to acute point, curved toward dactyl. Minor first pereopod (Fig. 4) with palm less than two times longer than high; fingers clearly shorter than palm; dactyl with flexor margin concave, blade-like, with three distinct distal teeth, latter subequal in length; fixed finger with flexor margin excavate, trowel-like, and with single distal tooth.Second pereopod (Fig. 4) with carpus four-segmented, subequal in length to merus; chela fingers distally filiform.Third pereopod (Fig. 5) slender; dactyl biunguiculate, mesial margin of flexor unguis strongly convex; propodus with row of five movable spines on flexor margin and one pair of distal movable spines flanking base of dactyl; carpus with distal movable spine on flexor margin; merus almost four times longer than wide, without movable spines. Fourth pereopod (Fig. 5) similar to third, slightly weaker, with four spines on flexor margin of propodus. Fifth pereopod (Fig. 5) weaker than fourth; carpus without distal spine; propodus with one spine on flexor margin and five transverse combs of stout setae on ventral face.First pleura (Fig. 6) of male with posterior corner slightly produced ventrally into rounded bulge; second pleura of non-ovigerous individuals broadly rounded; third to fifth pleura of male with rounded anterior corner and slightly obtuse posterior corner.

Telson (Fig. 6) with convex marginal lobe on distal margin; posterior corners adjacent to spines obtuse. Dorsal spines large, clearly removed from lateral margins. Posterior margin with six setae between two sets of spines, lateral spines half-length of mesial. Distance between distal spines 35-50% width of telson distal margin. Width of distal margin of telson 40–45% width of base of telson. Uropods (Fig. 6) with three fixed teeth on distolateral margin of exopod; two of these teeth are subequal in size, one located anterior to the movable spine, the second (the lateral tooth of the diaeresis) is posterior to the movable spine. The third tooth is reduced in size and located between the larger teeth, in line with the base of the movable spine.

FIGURE 3. *Synalpheus microneptunus* **n. sp.** Holotype, ovigerous female, CL 2.72 mm (USNM 1154070, original VIMS BR08-7001) from *Xestospongia proxima*, Cement Factory, Barbados: A, carapace, anterior region, and cephalic appendages, dorsal view; allotype, non-ovigerous individual, CL 2.44 mm (USNM 1154072, original VIMS BR08-7002-2) from *Xestospongia proxima*, Cement Factory, Barbados: B, anterior carapace and cephalic appendages, dorsal view; C, chela of major first pereopod, ventral view; D, same, dorsal view; E, same, anterior region; F, third maxilliped. Scale bar = 1 mm for A, D; 1.33 mm for B, 1.5 mm for C, E; 0.4 mm for F.

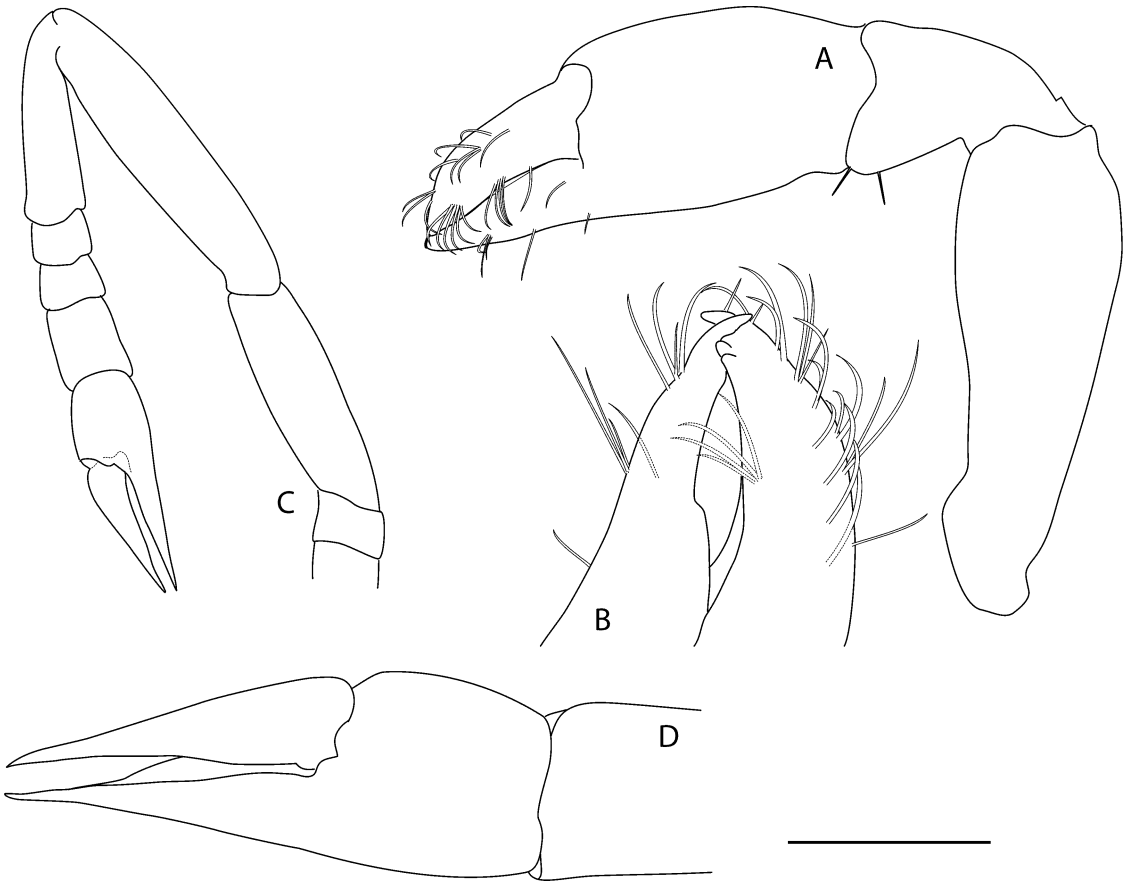

FIGURE 4. *Synalpheus microneptunus* **n. sp.** Paratype, non-ovigerous individual, CL 2.44 mm (USNM 1154072, original VIMS BR08-7002-2) from *Xestospongia proxima*, Cement Factory, Barbados: A, minor first pereopod; B, same, distal region of fingers; C, second pereopod, setae not drawn; D, same, distal region. Scale bar = 0.33 mm for A, 0.16 mm for B, 1 mm for C, 0.4 mm for D.

Color. Color in life pale, non-descript, distal portions of extremities tending towards dull yellow-orange; ovaries and embryos green.

Etymology. The species name is derived from its small size and its affinity with species of the *Synalpheus paraneptunus* species complex.

Variation. There is variation in the size of the scaphocerite blade: while the blade is extremely small and difficult to find in most individuals, it is more conspicuous in others, however, but never reaches 1/4 length of the lateral spine of scaphocerite.

Hosts and ecology. In Barbados, we have found *S. microneptunus* **n. sp.** commonly in sponges in the genus *Xestospongia* (*X. proxima* and *X. subtriangularis*), with only two individuals found associated with other sponges, possibly as "contaminants" that moved during field collection from adjacent or attached *Xestospongia* spp. (listed as no host recorded). In Barbados, *S. microneptunus* **n. sp.** appears to be a specialist in *Xestospongia* spp.

Distribution. The type locality is Cement Factory reef off the North-West coast of Barbados. Presently known only from Barbados.

Remarks. Anker and Tóth (2008) recently reviewed *Synalpheus paraneptunus* and separated five new species from *S. paraneptunus sensu stricto*. This complex can be distinguished from the remainder of the *S. gambarelloides* group by the reduced setal brush on the dactyl of the minor chela, and the excavate, trowel-shaped flexor surface of the fixed finger of the minor chela. Although clearly a member of this complex, *S. microneptunus* **n. sp.** can be distinguished from all of the other species therein by several morphological characters. The most important diagnostic character is the consistent presence of four carpal segments on the second pereopod in both juveniles and adults of the new species; compared with five segments in all other taxa in the *S. paraneptunus* complex. *Synalpheus microneptunus* **n. sp.** appears to be most similar to *S. duffyi* Anker & Tóth, 2008 and *S. ríosi* Anker & Tóth, 2008 in that all three species possess a blade on the scaphocerite. However, while all three species also have

three teeth on the distolateral margin of the uropodal exopod, in *S. microneptunus* **n. sp.**, the middle tooth is consistently reduced in size and located directly in line with the movable spine, whereas in both *S. duffyi* and *S. riosi*, the middle tooth is anterior to the moveable spine and subequal in size to the other teeth. Colonies of *S. microneptunus* **n. sp.** also appear to be consistently smaller than those of *S. duffyi*, often with typically fewer than 10 individuals per colony (maximum = 15) in Barbados; in contrast, *S. duffyi* was found in colonies of up to 81 individuals at its type locality in Isla Grande, Panama (Anker & Tóth 2008), and typically had 50–60 individuals in Jamaica (Macdonald et al. 2009), while *S. riosi* is known from only a single colony of 140 individuals from Dominica (Anker & Tóth 2008). These differences in colony size may of course reflect the sizes of sponges occupied, but they appear nevertheless to be consistent across geographic regions. *Synalpheus microneptunus* **n. sp.** is also noticeably smaller than all other species of the *S. paraneptunus* complex. Finally, a new multi-locus phylogeny indicated that *S. microneptunus* **n. sp.** appears to be most closely related to *S. duffyi* and to another undescribed species in the *S. paraneptunus* complex (Hultgren & Duffy 2011).

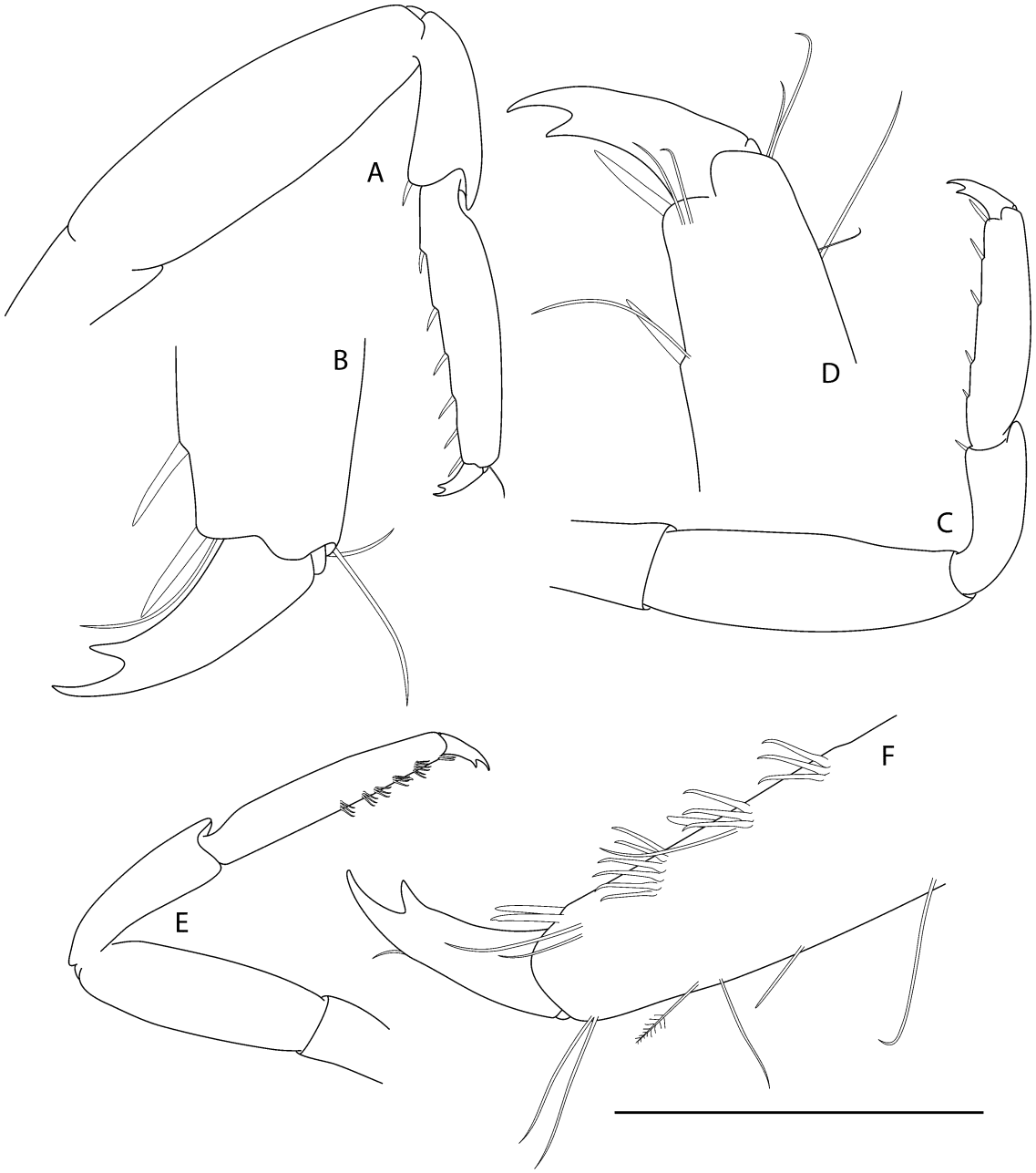

FIGURE 5. *Synalpheus microneptunus* **n. sp.** Paratype, non-ovigerous individual, CL 2.44 mm (USNM 1154072, original VIMS BR08-7002-2) from *Xestospongia* proxima, Cement Factory, Barbados: A, third pereopod; B, same, distal region; C, fourth pereopod; D, same, distal region; E, fifth pereopod; F, same, distal region. Scale bar = 1 mm for A, C, E; 0.27 mm for B, D, F.

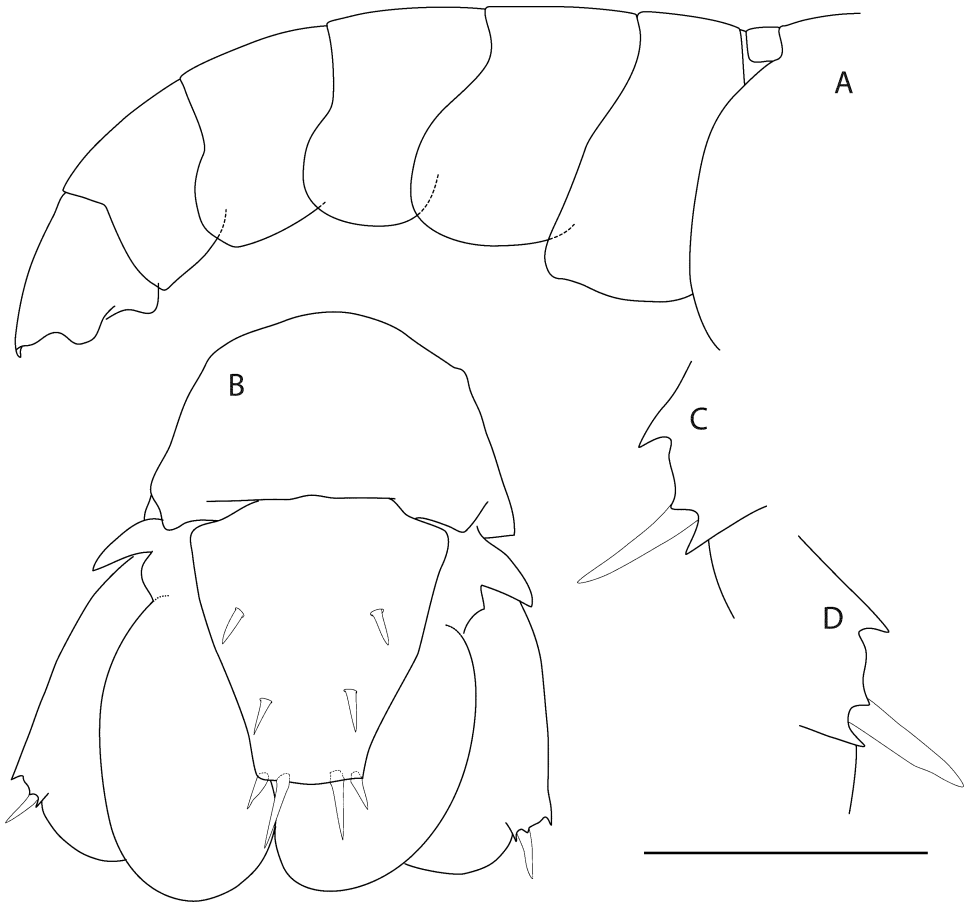

FIGURE 6. *Synalpheus microneptunus* **n. sp.** Paratype, non-ovigerous individual, CL 2.49 mm (USNM 1154071, original VIMS BR08-7002-1) from *Xestospongia proxima*, Cement Factory, Barbados: A, abdomen, right side; paratype, non-ovigerous individual, CL 2.44 mm (USNM 1154072, original VIMS BR08-7002-2) from *Xestospongia proxima*, Cement Factory, Barbados: B, telson, dorsal view; C, distolateral margin of left uropodal exopod, dorsal view; paratypes, non-ovigerous individual, CL 2.44 (USNM 1154073, original VIMS BR08-7002-3) from *Xestospongia proxima*, Cement Factory, Barbados: D, distolateral margin of right uropodal exopod, dorsal view. Scale bar = 1 mm for A, 1.4 mm for B, 0.25 mm for C, D.

Synalpheus pandionis Coutière, 1909

Material examined. Barbados: 2 ovigerous females, 3 non-ovigerous individuals (VIMS 08BR8602–6), Thunder Bay, from *Lissodendoryx* sp. 1 ovigerous female, 1 non-ovigerous individual (VIMS 08BR2706, 8702), Thunder Bay, from *Spirastrella* sp. Largest ovigerous female, CL 3.90, largest non-ovigerous individual, CL 3.28 mm.

Color. Bright orange, ovigerous females with even more brilliant orange ovaries; both sexes with dark orange-brown major chelae.

Hosts and ecology. In Barbados, *Synalpheus pandionis* was collected from the orange sponges *Spirastrella* sp. and from an unidentified species of *Lissodendoryx*, both growing among and infilling the interstices of coral branches.

Distribution. Bahamas (Lemaitre 1984); Cuba (Martínez Iglesias & García Raso 1999); Virgin Islands (Coutière 1909; Chace 1972); Gulf of Mexico (Dardeau 1984); Belize (Macdonald *et al.* 2006; Ríos & Duffy 2007); Discovery Bay, Jamaica (Macdonald *et al.* 2009); Barbados (this study).

Remarks. In Barbados, *S. pandionis* occurred with its close relative *S. ul* in *Spirastrella* sp. and *Lissodendoryx* sp. It can be distinguished from *S. ul* in these hosts by body size in adults (*S. pandionis* > *S. ul*), length of the scaphocerite blade (typically >1/2 length of the distoventral spine of scaphocerite in *S. pandionis*, <1/4 length in *S. ul*), and the posterior corner of the male second pleura (acute in *S. pandionis*, obtuse in *S. ul*). The relative size of the scaphocerite blade varied among specimens of *S. pandionis* from Barbados: while some individuals had blades reaching only 40–60% of the scaphocerite spine, others had well-developed blades that extended 75–90% of the

length of the scaphocerite spine and roughly twice the width of the spine. In Coutière's (1909) type series of *S. pandionis*, the scaphocerite blade was similar in width to, and less than half the length of, the scaphocerite spine. However, individuals with larger blades were not phylogenetically distinct from individuals with more typical blades (Hultgren & Duffy 2011).

Synalpheus sanctithomae Coutière, 1909

Material examined. Barbados: 2 non-ovigerous individuals (VIMS 08BR7103), Cement Factory, from *Hyattella intestinalis*. 4 non-ovigerous individuals, 1 ovigerous female (VIMS 08BR1001, 08BR1201–2), Spawnee Reef, from *Agelas clathrodes*. 3 non-ovigerous individuals, 1 ovigerous female (VIMS 08BR901–2, 1901), Spawnee Reef, no host recorded. Largest ovigerous female, CL 3.43, largest non-ovigerous individual, CL 2.97 mm.

Color. Ovigerous females had green ovaries and greenish-orange embryos and all individuals had a drab orange body color, deepening distally in their extremities, as in other locations (Ríos & Duffy 2007; Macdonald *et al.* 2009; Hultgren *et al.* 2010).

Hosts and ecology. In Barbaros, *S. sanctithomae* lived in the sponges *Hyattella intestinalis* and *Agelas clathrodes*.

Distribution. Florida, USA (Gore 1981); Virgin Islands (Coutière, 1909); Jamaica (Macdonald *et al.* 2009); Belize (Macdonald *et al.*, 2006; Ríos & Duffy, 2007); Curaçao (Hultgren *et al.* 2010); Brazil (Christoffersen, 1979); Barbados (this study).

Remarks. In Barbados, *Synalpheus sanctithomae* can be distinguished from the morphologically similar species *S. mcclendoni* by the number of setae on the posterior margin of the telson: a sparse tuft of <6 setae in *S. sanctithomae* vs. a well-developed fan of 10 or more setae in *S. mcclendoni* (Rios & Duffy 2007).

Synalpheus thele Macdonald, Hultgren & Duffy 2009

Material examined. Barbados: 2 non-ovigerous individuals (VIMS 08BR6709), Cement Factory, from *Hyattella intestinalis*. 1 ovigerous female (VIMS 08BR1401), Spawnee Reef, from *H. intestinalis.* 1 ovigerous female, 1 non-ovigerous individual (VIMS 08BR701), Spawnee Reef, from *Hymeniacidon caerulea.* 1 ovigerous female (VIMS 08BR802), Spawnee Reef, no host unknown . 1 ovigerous female (VIMS 08BR9905), Thunder Bay, from *Spirastrella* sp. Largest ovigerous female, CL 3.28 mm, largest non-ovigerous individual, CL 3.22 mm.

Color. Ovigerous females had pale grass-green ovaries.

Hosts and ecology. In Barbados, *S thele* was found primarily in the sponges *Hyattella intestinalis* and *Hymeniacidon caerulea*, but not in *Agelas clathrodes*, which was the only known sponge hosting *S. thele* in Jamaica (Macdonald *et al.* 2009).

Distribution. Discovery Bay, Jamaica (Macdonald et al. 2009); Barbados (this study).

Remarks. In Barbados, *S. thele* can be distinguished from other morphologically similar species in the *S. brooksi* complex by several characters. For instance, the tuft of setae on the minor chela forms two parallel rows in *S. thele*, but forms a thick brush in other members of the complex. The distodorsal protuberance of the major chela in *S. thele* is short and distinctly rounded distally, unlike the longer and more acute protuberance of *S. idios* and *S. bousfiel*di in Barbados.

Synalpheus ul (Rios & Duffy 2007)

Material examined. Barbados: 1 ovigerous female, 4 non-ovigerous individuals (VIMS 08BR3901, 4901, 5002–3, 5102), Brandon's Beach, from *Agelas clathrodes*. 1 ovigerous female (VIMS 08BR202), Pamir reef, from *Xestospongia proxima*. 3 ovigerous females, 8 non-ovigerous individuals (VIMS 08BR3101, 08BR9004, 08BR9201–2, 08BR9601–2, 9605, 08BR10101–2), Thunder Bay, from *Agelas clathrodes*. 1 non-ovigerous individual (VIMS 08BR2801), Thunder Bay, from *Hymeniacidon caerulea*. 9 ovigerous females, 14 non-ovigerous individuals (VIMS 08BR2602–3, 08BR2701–5, 08BR8703–6, 08BR9301–2, 08BR9901–4, 08BR10001–2), Thunder Bay,

from *Spirastrella* sp. 1 non-ovigerous individual (VIMS 08BR3501), Thunder Bay, host unknown. 1 non-ovigerous individual (VIMS08BR 9401), Thunder Bay, in *Xestospongia proxima.* Largest ovigerous female, CL 2.82 mm, largest non-ovigerous individual, CL 3.00 mm.

Color. Individuals typically had a body color that ranged from orange-tinged to yellowish orange or orange; major chelae had brownish-orange tips; females had orange ovaries.

Hosts and ecology. In Barbados, *S. ul* occurred primarily in *Spirastrella* sp. and *Agelas clathrodes*, and to a lesser degree in *Hymeniacidon caerulea* and *Xestospongia proxima*.

Distribution. Curaçao, Panama (Hultgren *et al.* 2010); Belize (Macdonald *et al.* 2006; Ríos & Duffy 2007); Jamaica (Macdonald *et al.* 2009); Barbados (this study).

Remarks. Although *S. ul* often co-occurs with closely related species, sometimes in the same individual sponges, it can be distinguished from them using a combination of morphological characters. In *Lissodendoryx* and *Spirastrella* spp., *S. ul* can be distinguished from *S. pandionis* by the scaphocerite blade (typically <25% of the length in *S. ul,* vs. 40–90% the length of the ventral spine of the scaphocerite in *S. pandionis*), and the posterior corner of the male second pleura (obtuse in *S. ul,* acute in *S. pandionis*). In *Agelas clathrodes*, *S. ul* can be distinguished from *S. hoetjesi* by the relative width of the distal telson spines (medial spines similar in thickness in *S. ul* vs. distinctly thicker than lateral spines in *S. hoetjesi*) and relatively larger body size of *S. hoetjesi* (mean CL = 2.37 mm CL ± 0.107 for *S. ul* vs. 3.29 mm ± 0.144 in *S. hoetjesi*).

Synalpheus williamsi Ríos & Duffy, 1999

Material examined. Barbados: 1 non-ovigerous individual, 1 ovigerous female (VIMS 08BR7501–2), Cement Factory, from *Hymeniacidon caerulea*. 1 ovigerous female (VIMS 08BR1412), Spawnee Reef, host unknown (in rubble with *H. caerulea*). 5 non-ovigerous individuals, 2 ovigerous females (VIMS 08BR502–3, 08BR1101, 08BR1103, 08BR1301, 08BR2401), Spawnee Reef, from *H. caerulea.* 1 non-ovigerous individual (VIMS 08BR1702), Spawnee Reef, host unknown (in rubble with *H. caerulea*). Largest ovigerous female, CL 3.44 mm, largest non-ovigerous individual, CL 2.85 mm.

Color. The body color of *S. williamsi* ranged from almost colorless to dull orange, with distal portion of the major chela brilliant orange; ovaries were green, embryos bright orange-yellow.

Hosts and ecology. In Barbados, *S. williamsi* appears to be a specialist in the sponge *Hymeniacidon caerulea*, as is the case in Belize and Jamaica (Macdonald *et al.* 2006; Ríos & Duffy 2007; Macdonald *et al.* 2009). Although some individuals were found in loose rubble or on the surface of other sponges embedded in rubble, the rubble always contained *H. caerulea.*

Distribution. Jamaica (Macdonald *et al.* 2009); Curaçao (Hultgren *et al.* 2010); Belize (Macdonald *et al.* 2006; Ríos & Duffy 2007); Barbados (this study).

Remarks. *Synalpheus williamsi* can be distinguished from other species of *Synalpheus* inhabiting the sponge *Hymeniacidon caerulea* by the number of spines on the uropod (3–6 fixed marginal teeth anterior to the moveable spine, vs. 1 fixed tooth in *S. thele*) or the relative length of the basicerite and scaphocerite spines (basicerite <75% length of scaphocerite in *S. williamsi,* basicerite >75% length of scaphocerite in *S. ul*).

Discussion

During six days of sampling on Barbados we found 14 species of sponge-dwelling snapping shrimp and 29 unique shrimp/sponge species associations. Despite the brief duration of our sampling, we feel confident that we have collected most of the sponge-dwelling species of *Synalpheus* present on the west coast of Barbados; estimates of remaining undiscovered shrimp diversity range from 0–3 species. Both observed and estimated values of species richness of sponge-dwelling *Synalpheus* in Barbados were lower than that recorded from similar surveys in Curaçao (16 species: Hultgren *et al.* 2010), Belize (25 species: Macdonald *et al.* 2006; Rios & Duffy 2007), or Jamaica (22 species: Macdonald *et al.* 2009), possibly due to the relatively geographically isolated location of Barbados relative to other surveyed sites.

Unlike shrimp assemblages in Jamaica and Belize, where eusocial species are the most numerically abundant sponge-dwelling *Synalpheus* (65%–81% of total abundance), in Barbados the single eusocial species (*S. microneptunus* **n. sp.**) constituted only 24% of total abundance of sponge-dwelling *Synalpheus*. This could be due to several demographic and distributional factors. First, there is a higher diversity of eusocial species in Belize (4 species) and Jamaica (3 species) compared to Barbados (1 species). Second, the eusocial species of *Synalpheus* living in Jamaica and Belize tend to form larger colonies (mean colony size = 61 and 46, respectively) than *S. microneptunus* **n. sp.** in Barbados (mean colony size = 6 individuals). This could be due to the smaller size of sponges hosting eusocial *S. microneptunus* **n. sp.** in Barbados (sponge volume = 3–200 ml, mean = 46 ml), relative to sponges hosting eusocial species in other areas, such as Jamaica (volume = 35–955 ml, mean = 279 ml). Finally, in other locations eusocial species tend to use a greater number of sponge hosts than pair-living species (Duffy & Macdonald 2010), this is for instance the case in Belize (mean host range = 4); in contrast, in Barbados, *S. microneptunus* **n. sp.** inhabits only *Xestospongia proxima* and *X. subtriangularis*.

Community dominance by pair-living species of sponge-dwelling *Synalpheus* has also been recorded from Curaçao, where eusocial species of *Synalpheus* were completely absent. Similar to Curaçao, low diversity and abundance of eusocial species in Barbados are not due to lack of appropriate sponge host species, since in Barbados we collected most of the sponge species that host eusocial species elsewhere — *Agelas clathrodes, Hyattella intestinalis, Hymeniacidon caerulea, Xestospongia proxima,* and *X. subtriangularis* — and these species together accounted for approximately 64% of the occurrences and ~74% of the abundance of social species in Belize (Macdonald *et al.* 2006).

Our data from Barbados add to the growing body of evidence that closely related species of sponge-dwelling *Synalpheus* tend to use the same or related host species, and are not infrequently found in the same individual sponge. For example, we found two members of the *S. paraneptunus* complex (as defined by Anker & Toth 2008), *Synalpheus belizensis* and *S. microneptunus* **n. sp.**, inhabiting the same sponge species (*Xestospongia* spp.) and in some cases the same individual sponges. Across the Caribbean, members of the *S. paraneptunus* complex are most frequently found in sponges of the genus *Xestospongia* (Macdonald *et al.* 2006; Anker & Tóth 2008; Macdonald *et al.* 2009; Hultgren *et al.* 2010). Similarly, *S. ul* often co-occurred with other members of the *S. longicarpus* clade (cf. Morrison *et al.* 2004), namely with *S. pandionis* in *Spirastrella* sp. and with *S. hoetjesi* in *Agelas clathrodes.* This lends further support to the pattern of conservative sponge host associations observed among closely related shrimp species, suggesting that adaptations to species- or genus-specific sponge characteristics such as chemistry may limit host use by sponge-dwelling species of *Synalpheus* (Hultgren & Duffy 2010).

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Literature cited

Anker, A. & Tóth, E. (2008) A preliminary revision of the *Synalpheus paraneptunus* Coutière, 1909 species complex (Crustacea: Decapoda: Alpheidae). *Zootaxa,* 1915, 1–28.

Bate, C.S. (1888) Report on the Crustacea Macrura dredged by H.M.S. Challenger during the years 1873–76. *In:* J. Murray (Ed), *The voyage of the H.M.S. Challenger. Zoology* 24, xc+942. Eyre and Spottiswoode, London.

Burnham, K.P. & Overton, W.S. (1978) Estimation of the size of a closed population when capture probabilities vary among animals. *Biometrika,* 65, 623–633.

Chace, F.A. (1972) The shrimps of the Smithsonian-Bredin Caribbean expeditions with a summary of the West Indian shallow-water species (Crustacea: Decapoda: Natantia). *Smithsonian Contributions to Zoology,* 98, 1–179.

Chao, A. (1987) Estimating the population size for capture-recapture data with unequal catchability. *Biometrics,* 43, 783–791.

Christoffersen, M.L. (1979) Campagne de la Calypso au large des côtes Atlantiques de l'Amerique du Sud (1961–1962), I. 36. Decapod Crustacea: Alpheoida. Résultats Scientifiques des Campagnes de la Calypso, 11. *Annales de L'Institut Océ-*

anographique, 55, 297–377.
Christoffersen, M.L. (1998) Malacostraca, Eucarida, Caridea, Crangonoidea and Alpheoidea (except Glyphocrangonidae and Crangonidae). *In:* Young, P. S. (Editor), *Catalogue of Crustacea of Brazil*. Museu Nacional, Rio de Janeiro. Sèrie Livros, 6, 351–372.
Coelho-Filho, P.A. (2006) Checklist of the decapods (Crustacea) from the outer continental shelf and seamounts from Northeast of Brazil-REVIZEE Program (NE III). *Zootaxa*, 1184, 1–27.
Colwell, R.K. (2005). EstimateS: Statistical estimation of species richness and shared species from samples. Version 7.5. Available from: http://purl.oclc.org/estimates.
Colwell, R.K., Mao, C.X. & Chang, J. (2004) Interpolating, extrapolating, and comparing incidence-based species accumulation curves. *Ecology*, 85, 2717–2727.
Coutière, H. (1909) The American species of snapping shrimps of the genus *Synalpheus*. *Proceedings of the United States National Museum*, 36, 1–93.
Coutière, H. (1910) The snapping shrimps (Alpheidae) of the Dry Tortugas, Florida. *Proceedings of the United States National Museum*, 37, 485–487.
Dardeau, M.R. (1984) *Synalpheus* shrimps (Crustacea: Decapoda: Alpheidae). I. The Gambarelloides group, with a description of a new species. *Memoirs of the Hourglass Cruises*, 7, 1–125.
Duffy, J.E. (1992) Host use patterns and demography in a guild of tropical sponge-dwelling shrimps. *Marine Ecology-Progress Series*, 90, 127–138.
Duffy, J.E. (2007) Ecology and evolution of eusociality in sponge-dwelling shrimp. *In:* J. E. Duffy & M. Thiel (Eds), *Evolutionary ecology of social and sexual systems: crustaceans as model organisms*. Oxford University Press, Oxford.
Duffy, J.E. & Macdonald, K.S. (2010) Kin structure, ecology and the evolution of social organization in shrimp: a comparative analysis. *Proceedings of The Royal Society B-Biological Sciences*, 277, 575–584.
Duffy, J.E., Morrison, C.L. & Rios, R. (2000) Multiple origins of eusociality among sponge-dwelling shrimps (Synalpheus). *Evolution*, 54, 503–516.
Gore, R.H. (1981) Three new shrimps, and some interesting new records of decapod Crustacea from a deep-water coral reef in the Florida Keys. *Proceedings of the Biological Society of Washington*, 94, 135–162.
Hultgren, K.M. & Duffy, J.E. (2010) Sponge host characteristics shape the community structure of their shrimp associates. *Marine Ecology-Progress Series*, 407, 1–12.
Hultgren, K.M. & Duffy, J.E. (2011) Multi-locus phylogeny of sponge-dwelling snapping shrimps (Caridea: Alpheidae: *Synalpheus*) supports morphology-based species concepts. *Journal of Crustacean Biology*, 31, 356–364.
Hultgren, K.M., Macdonald, K.S. & Duffy, J.E. (2010) Sponge-dwelling snapping shrimps of Curaçao, with descriptions of three new species. *Zootaxa*, 2372, 221–262.
Latreille, P.A. (1802) *Histoire naturelle générale et particulière des Crustacés et des Insectes*, vol. 3, 1–467.
Lemaitre, Rafael (1984) Decapod crustaceans from Cay Sal Bank, Bahamas, with notes on their zoogeographic affinities. *Journal of Crustacean Biology*, 4, 425–447.
Macdonald, K.S. & Duffy, J.E. (2006) Two new species of sponge-dwelling snapping shrimp from the Belizean Barrier Reef, with a synopsis of the *Synalpheus brooksi* species complex. *American Museum Novitates*, 3543, 1–22.
Macdonald, K.S., Hultgren, K.M. & Duffy, J.E. (2009) The sponge-dwelling snapping shrimps (Crustacea, Decapoda, Alpheidae, *Synalpheus*) of Discovery Bay, Jamaica, with descriptions of four new species. *Zootaxa*, 2199, 1–57.
Macdonald, K.S., Rios, R. & Duffy, J.E. (2006) Biodiversity, host specificity, and dominance by eusocial species among sponge-dwelling alpheid shrimp on the Belize Barrier Reef. *Diversity And Distributions*, 12, 165–178.
Martínez Iglesias, J.C. & García Raso, J.E. (1999) The crustacean decapod communities of three coral reefs from the southwestern Caribbean Sea of Cuba: species composition, abundance and structure of the communities. *Bulletin of Marine Science*, 65, 539–557.
Morrison, C.L., Rios, R. & Duffy, J.E. (2004) Phylogenetic evidence for an ancient rapid radiation of Caribbean sponge-dwelling snapping shrimps (*Synalpheus*). *Molecular Phylogenetics & Evolution*, 30, 563–581.
Pequegnat, L.H. & Heard, R.W. (1979) *Synalpheus agelas*, new species of snapping shrimp from the Gulf of Mexico and Bahama islands (Decapoda: Caridea: Alpheidae). *Bulletin of Marine Science*, 29, 110–116.
Ríos, R. & Duffy, J.E. (2007) A review of the sponge-dwelling snapping shrimp from Carrie Bow Cay, Belize, with description of *Zuzalpheus*, new genus, and six new species (Crustacea: Decapoda: Alpheidae). *Zootaxa*, 1602, 3–89.
Smith, E.P. & van Belle, G. (1984) Nonparametric estimation of species richness. *Biometrics*, 43, 119–129.
Tóth, E. & Bauer, R.T. (2007) Gonopore sexing technique allows determination of sex ratios and helper composition in eusocial shrimps. *Marine Biology*, 151, 1875–1886.