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A New Species of *Parapleurocrypta* Chopra, 1923 (Isopoda, Epicaridea, Bopyridae) Parasitizing Shrimps of the Genus *Synalpheus* Spence Bate, 1888 (Decapoda, Caridea, Alpheidae) from the Fernando de Noronha Archipelago, Brazil

Amanda P. Horch^{1,}*[®], Jason D. Williams²[®], and Mariana Terossi¹

¹Programa de Pós-Graduação em Biologia Animal, Departamento de Zoologia (Laboratório de Carcinologia), Instituto de Biociências, Universidade Federal do Rio Grande do Sul, Porto Alegre, Rio Grande do Sul, Brazil. *Correspondence: E-mail: amandahorch@gmail.com (Horch) E-mail: mterossirm@gmail.com (Terossi)

²Department of Biology, Hofstra University, Hempstead, NY 11549, USA. E-mail: Jason.D.Williams@hofstra.edu (Williams)

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A new species of *Parapleurocrypta* Chopra, 1923, a parasitic isopod genus of the family Bopyridae found parasitizing two species of the snapping-shrimp genus *Synalpheus* Spence Bate, 1888, is described from Brazil. This is the first record of *Parapleurocrypta* in the Atlantic Ocean, and the first species of bopyrid parasite recorded from the Fernando de Noronha archipelago in northeastern Brazil. Females of *Parapleurocrypta duofratres* sp. nov. can be distinguished from the other two species of the genus, *P. alphei* Chopra, 1923 and *P. digitata* Bourdon, 1976, by the structure of the barbula, the reduced pleopods, the number of dorsolateral bosses, the absence of the frontal lamina (present in *P. digitata*), and pleomeres with lateral plates (vs. lateral plates absent in *P. digitata*). Males can be distinguished from those of *P. alphei* by the number of antennal articles. Variation in the specimens is discussed and ecological and reproductive data are provided. To accommodate the new features of *P. duofratres* sp. nov., the diagnosis of the genus is expanded. A review of the branchial bopyrids of *Synalpheus* is included, as well as a discussion of parasitism by members of *Parapleurocrypta*.

Key words: Atlantic Ocean, Bopyrinae, Bopyroidea, Parasitism, Taxonomy

BACKGROUND

The Fernando de Noronha archipelago is situated 345 km from the northeastern coast of Brazil, and comprises 21 volcanic islands, islets and crags (Alves et al. 2008; Serafini et al. 2010). The archipelago was first sighted by the Portuguese in the 1500s and, after a long and complicated history, in 1988 the archipelago was divided into a National Marine Park and an Environmental Protection Area (Serafini et al. 2010). A few studies have been conducted on the decapod crustacean fauna of the archipelago (Pocock 1890; Fausto-Filho 1974; Coelho et al. 2002; Coelho Filho 2006; Alves et al. 2008). However, despite there being over 130 species of decapods reported from Fernando de Noronha (Alves et al. 2008), no study has ever

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documented parasitic isopods from any hosts in the islands.

Isopods of the family Bopyridae Rafinesque, 1815 are ectoparasites known for their complex life cycle that includes infesting two crustacean hosts: an intermediate copepod host and a definitive decapod host (Williams and Boyko 2012). Globally, the family is divided into nine subfamilies and has approximately 640 described species (An et al. 2022; WoRMS 2023a). Twentyeight species of Bopyridae are currently known from Brazilian waters, ten of which belong to the subfamily Bopyrinae Rafinesque, 1815 (Ribeiro and Horch 2023). Bopyrinae is the second largest subfamily in Bopyridae with 120 species (WoRMS 2023b), all of which are exclusively found within the branchial chambers of caridean shrimps (Markham 1985a; An et al. 2015).

Worldwide, species of five of the 27 genera of Bopyrinae are known to parasitize snapping-shrimps of the genus Synalpheus Spence Bate, 1888, along with other caridean hosts (see DISCUSSION). These shrimps are frequently found dwelling in groups within sponges, with some species being considered eusocial (Hultgren et al. 2017). Species of Parapleurocrypta Chopra, 1923 are found in these shrimp hosts, and the genus currently includes only two species: P. alphei Chopra, 1923 and P. digitata Bourdon, 1976. Both species are known from different locations in the Indian Ocean (Chopra 1923; Bourdon 1976), with the former species parasitizing a specimen of Synalpheus sp., and the latter species documented from an unknown host. In this paper we describe a new species of Parapleurocrypta parasitizing two Synalpheus species from Brazil, making this the first record of the genus in the Atlantic Ocean, and the first species of bopyrid parasite reported from the Fernando de Noronha archipelago.

MATERIALS AND METHODS

Host shrimps were collected in two expeditions carried out in the Fernando de Noronha archipelago, state of Pernambuco, Brazil, in June of 2019 and June of 2022. Samples of sponges were collected by SCUBA diving to 8–17 m at six locations (Buraco do Inferno, 03°48'14.7"S, 32°23'12.4"W; Cagarras, 03°48'32.6"S, 32°23'50.9"W; Ilha do Meio, 03°49'11.5"S, 32°23'50.8"W; Laje Dois Irmãos, 03°50'40.2"S, 32°26'34.6"W; Ponta da Sapata, 03°51'53.5"S, 32°27'57.9"W; Ressureta, 03°49'00.9"S, 32°23'32.9"W) around the archipelago (Fig. 1), and brought to the laboratory for analysis. Specimens of *Synalpheus* were then removed from sponges and checked for the presence of parasites, discernible in one of the branchial chambers by the swelling of the carapace. The shrimps

were isolated, labeled and fixed in 80% ethanol.

At the laboratory, shrimps were identified using an identification key (Anker et al. 2012) and a stereomicroscope; the carapace length (CL), from the tip of the rostrum to the posterior margin of the carapace, was measured using calipers; sex was determined by analyzing the shape of the pleura of the first pleonal segment (rounded in females and projected ventrodistally or hook-shaped in males) (Banner and Banner 1975).

Bopyrid isopods were removed from each host branchial chamber and identified. Female and male parasites were measured for total length (TL), from the anterior margin of the head to the tip of the pleotelson, maximal width at broadest percomere, head length, head width, and pleon length using a stereomicroscope with an eyepiece micrometer. Three female parasites retained their eggs in the brood pouch after removal from the host, and eggs were counted manually.

Line drawings were made using a drawing tube attached to Olympus dissecting (SZX12) and Olympus compound microscopes (CX31 and BX41). Original drawings were scanned and subsequently traced using Adobe Illustrator. Light micrographs were produced using a Macropod Pro Kit (MacroscopicSolutions); resulting photographs were aligned and stacked using the software Zerene Stacker (10–20 images from bottom to top of specimens).

Male and female specimens were prepared for Scanning Electron Microscopy (SEM) through an ascending ethanol (EtOH) dehydration series, starting at 70% EtOH and ending at 100% EtOH. Dehydrated specimens were dried in a Samdri 795 Critical Point Dryer, then mounted on aluminum stubs and coated with gold using an EMS-550 Sputter coater. Specimens were subsequently viewed with a FEI Quanta 250 SEM. Adobe Illustrator and Adobe Photoshop CS6 were used to make final figures. A map of sampling locations (Fig. 1) was made using the program QGIS (Geographic Information System; http://www.qgis.org).

The holotype female and allotype male, along with the host, are deposited in the Museu de Zoologia of the Universidade de São Paulo, São Paulo, Brazil (MZUSP). Other type specimens and hosts are deposited in the Coleção de Crustáceos of the Departamento de Zoologia, Universidade Federal do Rio Grande do Sul, Porto Alegre, Brazil (DZ/UFRGS).

RESULTS

TAXONOMY

Order Isopoda Latreille, 1816 Suborder Epicaridea Latreille, 1825 Superfamily Bopyroidea Rafinesque, 1815 Family Bopyridae Rafinesque, 1815 Subfamily Bopyrinae Rafinesque, 1815

Genus Parapleurocrypta Chopra, 1923

Type-species: Parapleurocrypta alphei Chopra, 1923 by original designation.

Diagnosis: Female: Body more or less rounded, slightly asymmetrical; head distinct from first percomere, with or without frontal lamina; eyes present or absent; maxilliped with non-articulated palp, bearing long setae; barbula with one or two pairs of lateral projections on each side; dorsolateral bosses present on at least percomeres 1–4; coxal plates absent or present on percomeres 1–4; tergal projections absent; lateral projections present or absent on pleon; pleopods uniramous or absent; uropods uniramous.

Male: Head distinct from pereon, eyes present. All pleomeres completely fused, pleopods and uropods absent.

Other species: Parapleurocrypta digitata Bourdon, 1976, Parapleurocrypta duofratres sp. nov. (described below).

Remarks: The generic diagnosis has been expanded to include morphological characters from *Parapleurocrypta duofratres* sp. nov. (see *Remarks* for the new species below). Some morphological characters described by Bourdon (1976) for *P. digitata* also expand Chopra's (1923) original diagnosis of the genus, and were also included in the updated diagnosis provided above (presence of frontal lamina on the head, coxal plates on percomeres 1–4, and absence of lateral plates on pleomeres).



Fig. 1. Map of Fernando de Noronha archipelago, showing the six SCUBA diving locations where specimens of *Synalpheus* sp. parasitized by *Parapleurocrypta duofratres* sp. nov. were collected.

Parapleurocrypta duofratres sp. nov.

(Figs. 2–6) urn:lsid:zoobank.org:act:5A61CE00-FB4B-48CE-B968-712EE003EE5C

Material examined: Fernando de Noronha, Pernambuco, Brazil. *Holotype*: mature female (1.75 mm TL) (MZUSP #44176), Laje Dois Irmãos, 30 June 2022, infesting left branchial chamber of male *Synalpheus herricki* Coutière, 1909 (3.1 mm CL; MZUSP #44175). *Allotype*: mature male (1.13 mm TL) (MZUSP #44177), found with holotype.

Paratypes: mature female (1.96 mm TL) and mature male (1.13 mm TL) (DZ/UFRGS #7006), same collection data as holotype, infesting right branchial chamber of male S. herricki (4.8 mm CL; DZ/UFRGS #7007); mature female (1.98 mm TL) and mature male (1.21 mm TL) (DZ/UFRGS #7076), same collection data as holotype, infesting left branchial chamber of male S. herricki (3.4 mm CL; DZ/UFRGS #7077), both used for SEM; mature female (broken) and mature male (1.35 mm TL) (DZ/UFRGS #7008), same collection data as holotype, infesting right branchial chamber of male S. herricki (4.3 mm CL; DZ/UFRGS #7009); mature female (3.00 mm TL) and mature male (1.45 mm TL) (DZ/UFRGS #7000), same collection data as holotype, infesting right branchial chamber of male S. herricki (4.1 mm CL; DZ/UFRGS #7001); mature female (2.43 mm TL) and mature male (1.44 mm TL) (DZ/UFRGS #7002), same collection data as holotype, infesting right branchial chamber of male S. herricki (4.6 mm CL; DZ/UFRGS #7003); mature female (3.35 mm TL) and mature male (1.68 mm TL) (DZ/ UFRGS #7078), same collection data as holotype, infesting left branchial chamber of male S. ruetzleri Macdonald & Duffy, 2006 (5.4 mm CL; DZ/UFRGS #7079); mature female (1.85 mm TL) and mature male (1.17 mm TL) (DZ/UFRGS #7080), same collection data as holotype, infesting left branchial chamber of male S. herricki (3.7 mm CL; DZ/UFRGS #7081); mature female (2.27 mm TL) and mature male (1.47 mm TL) (DZ/UFRGS #7004), same collection data as holotype, infesting left branchial chamber of female S. herricki (4.8 mm CL; DZ/UFRGS #7005); mature female (2.69 mm TL) and mature male (1.25 mm TL) (DZ/UFRGS #6998), same collection data as holotype, infesting right branchial chamber of male S. herricki (4.2 mm CL; DZ/UFRGS #6999); mature female (2.76 mm TL) and mature male (1.44 mm TL) (UFRGS #6994), Ponta da Sapata, 30 June 2022, infesting right branchial chamber of male S. herricki (5.0 mm CL; DZ/UFRGS #6995); mature female (2.48 mm TL) and mature male (1.33 mm TL) (DZ/UFRGS #7082), Ponta da Sapata, 30 June 2022, infesting right branchial

chamber of male S. herricki (3.7 mm CL; DZ/UFRGS #7083); mature female (0.94 mm TL) and mature male (0.99 mm TL) (DZ/UFRGS #6996), Ponta da Sapata, 30 June 2022, infesting right branchial chamber of male S. ruetzleri (2.5 mm CL; DZ/UFRGS #6997); mature female (1.69 mm TL) and mature male (1.08 mm TL) (DZ/UFRGS #6992), Ilha do Meio, 26 June 2022, infesting right branchial chamber of male S. ruetzleri (3.1 mm CL; DZ/UFRGS #6993); mature female (2.00 mm TL) (DZ/UFRGS #7084), Buraco do Inferno, 26 June 2022, infesting right branchial chamber of male S. ruetzleri (3.0 mm CL; DZ/UFRGS #7085); mature female (2.97 mm TL) and mature male (1.57 mm TL) (DZ/UFRGS #6990), Buraco do Inferno, 26 June 2022, infesting left branchial chamber of male S. herricki (5.2 mm CL; DZ/UFRGS #6991); mature female (1.47 mm TL) and mature male (1.01 mm TL) (DZ/ UFRGS #6986), Cagarras, 25 June 2022, infesting right branchial chamber of male S. herricki (2.9 mm CL; DZ/ UFRGS #6987); mature female (2.72 mm TL) (DZ/ UFRGS #6984), Cagarras, 25 June 2022, infesting left branchial chamber of male S. herricki (4.5 mm CL; DZ/ UFRGS #6985); immature female (2.14 mm TL) (DZ/ UFRGS #6988), Ressureta, 25 June 2022, infesting left branchial chamber of male S. herricki (4.0 mm CL; DZ/UFRGS #6989); mature female (2.19 mm TL) and mature male (broken in half) (DZ/UFRGS #7010), Buraco do Inferno, 18 June 2019, infesting left branchial chamber of male S. herricki (4.3 mm CL; DZ/ UFRGS #7011).

Description of female: Holotype female (Figs. 2A–B, 3A–B): total body length 1.8 mm, maximal width 2.1 mm at percomere 3, head length 0.5 mm, head width 0.7 mm, pleon length 0.5 mm. Body nearly symmetrical, slight sinistral rotation, body wider than long, broadest at percomere 3. All body regions and percomeres distinct. Irregular spots of pigmentation on dorsal surface of head, posterior percomeres and anterior pleomeres (Fig. 2A–B).

Head: subquadrangular, deeply inset into first percomere (Fig. 3A). Frontal lamina absent. Eyes well developed, suboval and close to anterior margin of head (Fig. 3A); single irregular spot of pigmentation present dorsally between eyes (Fig. 3A). Antennules of three articles each, all with setae on distolateral edges and articles covered by fine scales, approximately seven setae on terminal article (Figs. 3C, 4B). Antennae of three articles each, terminal article with approximately six setae, all articles covered by scales (Figs. 3C, 4C). Barbula with single broad projection on each side, without medial projections (Fig. 3D). Maxilliped (Figs. 3G, 4F) with anterior article longer than posterior; palp prominent and non-articulated, slightly inset into anterior margin; inner margin of palp fringed with four

long setae (Figs. 3G, 4G), bearing spinous scales at the base and setules along length and tip (Fig. 4G); spur stout and short; margins of both articles covered in fine scales.

Pereon: broader than long, broadest across third pereomere (Fig. 3A). First pereomere shorter than others. Dorsolateral bosses present on both sides of pereomeres 1–5, boss on left side of pereomere 5 not as prominent (Fig. 3A). Pereomere 2 with large swelling on longer side, posterior to dorsolateral boss (Fig. 3A). Coxal plates and tergal projections absent. Marsupium open (Fig. 3B). Oostegite 1 (Figs. 3E–F, 4H) anterior lobe rounded; inner ridge smooth and without digitations (Figs. 3E, 4H), surface covered with small scales (Fig. 4J); posterior lobe inner margin rounded with small notches, outer margin with lateral projection slightly longer than anterior lobe and rounded (Fig. 3E– F), margins setose (Fig. 4I). Oostegite 5 with long setae on posterior margin (Fig. 3B). Pereopods increase in size slightly in posterior segments; each with six articles (Figs. 3H–I, 4D); all articles except dactylus covered with small scales (Fig. 4D–E). Pereopod 1 (Figs. 3H, 4D) with three long setae on outer margin of carpus, near propodus. Pereopod 7 (Figs. 3I, 4E) with two long setae on outer margin of carpus, similar to pereopod 1. Pereomeres 4–7 with few dorsolateral spots of pigmentation (Figs. 2A, 3A).

Pleon of six segments (Fig. 3A). Pleomeres 1–5 with lamellar lateral plates (Fig. 3B). Pleopods absent in holotype (Fig. 3B; but see Variation in paratypes below). Uropods uniramous, similar in shape and size to lateral plates. Pleomeres 1 and 2 with irregular spots of pigmentation on dorsal surface (Figs. 2A, 3A).

Description of male: Allotype male (Figs. 2D, 5A–B): total body length 1.1 mm, maximal width 0.5 mm at percomere 3, head length 0.1 mm, head width 0.4 mm,



Fig. 2. *Parapleurocrypta duofratres* sp. nov., female holotype (MZUSP #44176) and male allotype (MZUSP #44177), and host *Synalpheus herricki* Coutière, 1909 (DZ/UFRGS #7079). A, Female parasite habitus, dorsal view; B, Female parasite habitus, ventral view (with four eggs remaining in brood chamber); C, Host shrimp lateral view, arrow shows parasite in branchial chamber; D, Male parasite habitus, dorsal view. Scale bars: A-B = 0.5 mm; C = 0.5 cm; D = 0.3 mm.



Fig. 3. *Parapleurocrypta duofratres* sp. nov., female holotype and paratypes. A, habitus, dorsal view (MZUSP #44176); B, habitus, ventral view (MZUSP #44176); C, antennules, antenna (shown on right side only), and oral cone (DZ/UFRGS #7006); D, barbula (DZ/UFRGS #7076); E, right oostegite 1, inner view (DZ/UFRGS #7006); F, right oostegite 1, outer view (DZ/UFRGS #7006); G, right maxilliped, outer view (DZ/UFRGS #7010); H, left percopod 1 (DZ/UFRGS #7006); I, right percopod 7 (DZ/UFRGS #7006); J, pleon, ventral view, with reduced pleopods on right side, absent on left side (DZ/UFRGS #6998). Scale bars: A–B = 0.5 mm; C = 0.05 mm; D = 0.25 mm; E–G = 0.2 mm; H = 0.1 mm; I = 0.15 mm; J = 0.4 mm.



Fig. 4. *Parapleurocrypta duofratres* sp. nov., female paratype (DZ/UFRGS #7076), SEM. A, habitus, dorsal view; B, left antennule; C, right antenna (A1) and antennule (A2); D, left percopod 1; E, left percopod 7; F, right maxilliped, arrow shows maxilliped palp; G, long setae of right maxilliped palp, bearing spinous scales at the base and setules along length and tip; H, right oostegite 1, inner view; I, right oostegite 1, lateral projection of folded posterior lobe; J, right oostegite 1, inner surface with scales. Scale bars: A = 0.5 mm; B, I = 0.02 mm; C, G = 0.01 mm; D = 0.05 mm; E = 0.04 mm; F = 0.1 mm; H = 0.15 mm; J = 5 μ m.

pleon length 0.2 mm. All body regions and percomeres distinct, pleomeres 1–5 fused. Pigmentation irregularly distributed on all body regions and segments (Figs. 2D, 5A–B).

Head: slightly inset into first percomere, middle portion extending dorsally into percomere 1 (Fig. 5A). Eyes large, approximately kidney shaped and present towards posterolateral margin of head. Antennules (Figs. 5C, 6B) of three articles each, all articles with approximately four setae on anterior margins; terminal article with approximately five very long setae. Antennae (Figs. 5C, 6B) of four articles each, all articles with one setae on distal margins, approximately five long setae on terminal article; second article with few small scales (Fig. 6B). Irregular pattern of pigment on left side of head (Figs. 2D, 5A).

Pereon of seven segments, broadest at third pereomere (Fig. 5A). Pereopods each of six articles (Figs. 5D-E, 6C-D), all similar in size (Fig. 5B).

Pereopod 1 (Figs. 5D, 6C) and pereopod 7 (Figs. 5E, 6D) with setae on outer margin of carpus, near propodus; no scales visible on any articles (Fig. 6C–D). Irregular pigment pattern on dorsal side of all pereomeres, ranging from isolated spots to meandering lines, denser on pereomeres 6 and 7 (Figs. 2D, 5A).

Pleon with all pleomeres fused (Figs. 5A–B, 6A). Pleopods and uropods absent. Pigmentation pattern similar to that of posterior percomeres, distributed dorsally on anterior half of pleon (Figs. 2D, 5A), few spots of pigment on ventral side (Fig. 5B).

Variation: Other females from the type series show variation in the number of dorsolateral bosses (Fig. 4A) and the presence and number of pleopods (Fig. 3J). One female has well defined dorsolateral bosses on percomeres 1–4, and small, indistinct bosses on percomeres 5–7 on both sides (DZ/UFRGS #7010). Three females have dorsolateral bosses on percomeres 1–7 on a single side only, with last three bosses



Fig. 5. *Parapleurocrypta duofratres* sp. nov., male allotype and paratype. A, habitus, dorsal view (MZUSP #44177); B, habitus, ventral view (MZUSP #44177); C, left antennule and antenna (DZ/UFRGS #6986); D, right pereopod 1 (DZ/UFRGS #6986); E, left pereopod 7 (DZ/UFRGS #6986). Scale bars: A = 0.25 mm; B = 0.3 mm; C-E = 0.05 mm.

indistinct, and opposite side similar to the holotype (DZ/UFRGS #6994, DZ/UFRGS #7000, DZ/UFRGS #7082). Females lack (15 specimens) or have reduced (six specimens) pleopods. Of the six females with reduced pleopods, they are always uniramous and of varying numbers (one to four), nearly all only on one side of the pleon. One female has four reduced pleopods on the shorter side but absent on the opposite side and the pleon is asymmetrical, with the terminal pleomere lacking a lobe on the shorter side (DZ/UFRGS #6998) (Fig. 3J). One female has a larger pleopod 1, while pleopod 2 is reduced to a small, round nub only on the longer side of the pleon, and no other pleopods are visible (DZ/UFRGS #7082). Another female has a larger pleopod 1 and small, round nubs on pleomeres 2 and 3, but only on the longer side of the body (DZ/UFRGS

#6994). One female has pleopods 1 and 2 present on the longer side of the body, both as long as lateral plates, but no other pleopods visible (DZ/UFRGS #6986). One female has a single pleopod 1 on the longer side of the pleon but no other visible pleopods (DZ/UFRGS #6984). Lastly, one female has a pair of large pleopods on the sides of pleomere 1, but no other visible pleopods (DZ/ UFRGS #6990).

Males vary in the broadest percomere; four individuals are broadest at percomere 3, five are broadest at percomere 4, and five are broadest at percomeres 3 and 4.

Etymology: The species is named after the type locality in the Fernando de Noronha archipelago, Laje Dois Irmãos, translated into Latin. Dois Irmãos (Two Brothers in English and Duo Fratres in Latin), is the



Fig. 6. Parapleurocrypta duofratres sp. nov., male paratype (DZ/UFRGS #7076), SEM. A, habitus, ventral view; B, left antennule and antenna; C, right percopod 1; D, right percopod 7. Scale bars: A = 0.25 mm; B-D = 0.05 mm.

name of the famous pair of rocky peaks that emerge from the ocean near the shore of the archipelago's main island. The type locality is a diving spot close to the twin peaks that are its namesake.

Type locality: Laje Dois Irmãos, Fernando de Noronha, state of Pernambuco, Brazil $(03^{\circ}50'40.2"S, 32^{\circ}26'34.6"W)$ (Fig. 1).

Distribution: To date the species has been found at six locations around the Fernando de Noronha archipelago in Brazil (Fig. 1).

Hosts: Synalpheus herricki Coutière, 1909 (type host) (Fig. 2C), and Synalpheus ruetzleri Macdonald & Duffy, 2006.

Ecology and Reproduction: The host shrimps were collected from sponges at depths of 8–17 m. In total, across all the specimens of *Synalpheus* species collected, approximately 12.7% (20 of 158) of the shrimps were infested with *Parapleurocrypta duofratres* sp. nov.

The brood size of *Parapleurocrypta duofratres* sp. nov. was 719.33 ± 621.44 eggs (n = 3): DZ/UFRGS #6998: 1303 eggs; DZ/UFRGS #6996: 66 eggs; DZ/UFRGS #7002: 789 eggs.

Remarks: Parapleurocrypta duofratres sp. nov. is the third species of Parapleurocrypta described, the first species collected from the Atlantic Ocean, and the first to have its host identified to species. The present specimens fit well with Chopra's (1923) original description of the genus, but necessitate a slightly expanded diagnosis for the genus which now contains species with barbula of one (P. duofratres sp. nov.) or two lobes (P. alphei and P. digitata) and either lacks pleopods (P. duofratres sp. nov.) or has uniramous pleopods (P. alphei and P. digitata). Some researchers might argue that these differences justify the establishment of a new genus, but considering the intraspecific variation seen in the pleopods of P. duofratres sp. nov., and without more data on the intra- and interspecific variation in these features as well as molecular data on all species within the genus Parapleurocrypta, we do not feel this is warranted. The specimens appear to be most morphologically similar to P. alphei parasitizing Synalpheus sp., collected from Andaman Island (Indian Ocean). In addition to the features indicated above, the new species can be distinguished from *P. alphei* based on the number of dorsolateral bosses in females (present on at least percomeres 1-5 in the new species vs. present only on percomeres 1-4 in P. alphei) and the number of antennal articles in males (four articles on the new species vs. three in P. alphei).

Parapleurocrypta digitata was described from an unknown host (likely an alpheid shrimp) collected in Madagascar, but unfortunately only the females of the

species are known (Bourdon 1976). The females of *P. duofratres* sp. nov. can be distinguished from *P. digitata* based on the absence of frontal lamina (present in *P. digitata*), the presence of dorsolateral bosses on at least percomeres 1-5 (vs. present only on percomeres 1-4 in *P. digitata*), and pleomeres with lateral plates (vs. lateral plates absent in *P. digitata*) (Bourdon 1976).

Regarding the long setae on the maxilliped palp of Parapleurocrypta duofratres sp. nov., similar setae were also noted in P. alphei by Chopra (1923), who wrote that "some of the long setae of the palp bear small secondary hairs". Bourdon (1976) did not mention any "secondary hairs" or setules on the maxilliped palp setae of P. digitata, but he did mention that the maxilliped has a "palpe bien développé orné de grandes soies" (well-developed palp adorned with large setae). Considering that description and the illustration of the maxilliped provided by Bourdon (1976), it is likely that the palp setae of P. digitata also bear setules along their length. Visualization of these setae is difficult without using SEM, though as shown by Chopra (1923) they can also be observed at higher magnification on a light microscope. Further work on these and other features could provide additional taxonomically informative characters for Parapleurocrypta.

DISCUSSION

Five genera within Bopyrinae contain species that are branchial parasites of Synalpheus shrimps: Bopyrella Bonnier, 1900, Bopyrione Bourdon & Markham, 1980, Parabopyrella Markham, 1985a, Synsynella Hay, 1917, and Parapleurocrypta (Chopra 1923; Markham 1985a; An et al. 2015). However, no species in any of these genera are exclusively parasites of species of Synalpheus; several of these bopyrines also infest other alpheid shrimps and some are even found in caridean shrimps from other families (Markham 1985a; An et al. 2015). Of the seven currently described species of Bopyrella, four have hosts within Synalpheus: B. calmani (Richardson, 1905), B. harmopleon Bowman, 1956, B. malensis Bourdon, 1980 and B. tanytelson Markham, 1985b (Bourdon 1980; Markham 1985b). Only B. harmopleon is known from the Atlantic Ocean, including the coast of Brazil (Ribeiro and Horch 2023). Bopyrione has five described species, but only B. synalphei Bourdon & Markham, 1980 and B. woodmasoni (Chopra, 1923) have hosts in species of Synalpheus (Markham 1985a; Romero-Rodríguez and Álvarez 2020), and none of them occur in Brazil (Ribeiro and Horch 2023).

Parabopyrella is the largest of the five genera, with 28 species described and known hosts from both

Alpheidae and Hippolytidae (An et al. 2015). Of these 28 species, five have hosts within *Synalpheus* (Markham 1990; Boyko 2006): *P. choprai* (Nierstrasz & Brender à Brandis, 1929), *P. distincta* (Nierstrasz & Brender à Brandis, 1923), *P. hodgarti* (Chopra, 1923), *P. indica* (Chopra, 1923), and *P. pacifica* (Shiino, 1933). It should be noted, however, that there is some doubt regarding the record of *P. choprai* on *Synalpheus* sp., as discussed by Boyko (2006) and An et al. (2015). *Parabopyrella lata* is the only species of the genus found in Brazil (Ribeiro and Horch 2023), but its known hosts are shrimp species of *Alpheus* Fabricius, 1798 and *Lysmata* Risso, 1816 (Ribeiro et al. 2019).

All five *Synsynella* species parasitize one or more species of *Synalpheus*, and all are distributed in the north Atlantic Ocean (Markham 1985a; Markham 1988) except *S. inoi* (Shiino, 1949), which is from Japan. No species of *Synsynella* has been found south of the equator. Finally, the present work expands the genus *Parapleurocrypta* to three species, of which *P. digitata* has an unknown host, whereas *P. duofratres* sp. nov. and *P. alphei* parasitize *Synalpheus* hosts (Chopra 1923; Bourdon 1976; present study). Chopra (1923) wrote that the host of *P. alphei* was "an Alpheid closely resembling, but apparently distinct from *Synalpheus hululensis* Coutière", leaving the identity of the host uncertain but highly likely to be another species of *Synalpheus*.

All the specimens of Synalpheus herricki and S. ruetzleri parasitized by Parapleurocrypta duofratres sp. nov. from Fernando de Noronha were collected inhabiting sponges. This is not surprising, as both species are classified as obligate sponge canal symbionts with a monogamous sociobiology (Anker et al. 2012). Synalpheus herricki has been found inhabiting five different species of sponges along its distribution, whereas S. ruetzleri is known only from the sponge Hymeniacidon cf. caerulea Pulitzer-Finali, 1986 in Belize and Panama (Anker et al. 2012). According to Duffy (1992), sponge-dwelling species of Synalpheus have higher rates of parasitism by bopyrids than "free living" species. The author suggested that this might be due to the higher densities of shrimps within a sponge, as opposed to the lower densities found in non spongedwelling species (Duffy 1992). In contrast, McGrew and Hultgren (2011) compared different sponge-dwelling species and found that the number of snapping-shrimps living within a sponge did not influence prevalence of bopyrids, and larger groups of Synalpheus did not lead to more parasitized individuals. The presence of unidentified species of both branchial and pleonal bopyrids has also been reported in a eusocial colony of S. neptunus neptunus (Dana, 1852) in Indonesia (Didderen et al. 2006), showing that these isopods can parasitize "free living", sponge-dwelling monogamous species and sponge-dwelling social species of snappingshrimps. More studies regarding the parasitic bopyrids of *Synalpheus* are needed to better understand how the natural history of these hosts can influence their rates of parasitism. Furthermore, the study of bopyrid host choice within *Synalpheus* could broaden our understanding of the coevolution of parasitic isopods and alpheid shrimps (Boyko and Williams 2009).

CONCLUSIONS

The present study describes a new species of bopyrid isopod, *Parapleurocrypta duofratres* sp. nov., parasitizing the branchial chamber of two species of *Synalpheus* shrimps from the Fernando de Noronha archipelago, Brazil. This is the first species of parasitic isopod described for the archipelago and the first record of the genus *Parapleurocrypta* in the Atlantic Ocean, bringing the number of bopyrid species in the genus to three and from Brazil to 29. In this study, SEM is used for the first time to show details of some structures, like the long setae on the maxilliped palp. We suggest that future studies use this technique when possible, especially on females.

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