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ORIGINAL ARTICLE

On two species of *Periclimenaeus* Borradaile, 1915 (Caridea: Palaemonidae) from colonial tunicates in the southwestern Atlantic

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ABSTRACT

Two species of the palaemonid genus *Periclimenaeus* Borradaile, 1915, *P. ascidiarum* Holthuis, 1951 and *P. maxillulidens* (Schmitt, 1936), are reported from the offshore Escalvada Island, Espírito Santo, Brazil. The location represents a new southernmost record for these species in the western Atlantic. Both species were found inside an undescribed tunicate species of *Diplosoma*, dwelling inside the circulatory channels, among the zooid clusters. Although *P. ascidiarum* is known to occur in tunicates, the finding of the rare *P. maxillulidens* inside an ascidian host represents the first record of this association. Illustrations for both species and a taxonomic key for the southwestern Atlantic *Periclimenaeus* are provided based on the present material and literature records.

KEYWORDS

Ascidiacea, biodiversity, caridean shrimps, ecology, South Atlantic

INTRODUCTION

Currently composed of 83 species worldwide, *Periclimenaeus* Borradaile, 1915 is a specious genus within the Palaemonidae (Bruce, 2011; 2012a; 2012b; 2012c; 2013; 2014a; 2014b; 2014c; 2014d; De Grave and Fransen, 2011; Ďuriš *et al.*, 2011; Ramos-Tafur and Lemaitre, 2017). Among the Atlantic palaemonids, the genus is readily recognized by the well-developed, highly asymmetrical second pereopods with snapping mechanism on the

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major chela (molar process on the dactylus and opposing fossa on the fixed finger), presence of an antennal tooth, absence of both hepatic and epigastric teeth, supraorbital tooth usually absent (when present, small), and a well-developed scaphocerite (Bruce, 1995).

Periclimenaeus species are typically found in cryptic habitats, dwelling inside sponge and ascidian hosts, and are most abundant in shallow tropical waters (Bruce, 2013). Out of the 14 species known from the western Atlantic, eight are reported as sponge-associated, one as ascidian-associated and the remaining five species have no host records (see Tab. 1).

In Brazil, the genus was hitherto represented by only seven species: *Periclimenaeus ascidiarum* Holthuis, 1951, *Periclimenaeus atlanticus* (Rathbun, 1901), *Periclimenaeus brucei* Cardoso and Young, 2007, *Periclimenaeus caraibicus* Holthuis, 1951, *Periclimenaeus crosnieri* Cardoso and Young, 2007, *Periclimenaeus pearsei* (Schmitt, 1932), and *Periclimenaeus perlatus* (Boone, 1930), all restricted to the northernmost coast of the country (Cardoso and Young, 2007; Souza *et al.*, 2011; Vieira *et al.*, 2012). Interestingly, *P. atlanticus*, originally reported from Paraíba by Young (1986), was missing in subsequent major checklists (*e.g.*, Ramos-Porto and Coelho, 1998; Coelho *et al.*, 2006; Vieira *et al.*, 2012), and only briefly mentioned by Cardoso and Young (2007: 296). Although Young (1986) did not provide illustrations or a proper taxonomic treatment for his material, the identity of his specimens was confirmed by D. Grangeiro and M.L. Christoffersen (pers. comm.) through the examination of some of Young's (1986) vouchers deposited in the carcinological collection of the Universidade Federal da Paraíba, Paraíba, Brazil.

During ascidian samplings in Escalvada Island (Espírito Santo, Brazil), specimens of *P. ascidiarum* and *P. maxillulidens* (Schmitt, 1936) were retrieved

Table 1. List of hosts for the western Atlantic *Periclimenaeus* Borradaile, 1915 based on literature records. (?) – Host unknown; * – Species previously reported from Brazil

Periclimenaeus species	Host type	Host identification	References
P. ascidiarum Holthuis, 1951*	Ascidiacea	Unknown	Holthuis (1951): 82
P. atlanticus (Rathbun, 1901)	(?) Coral and turtle-grass beds	Unknown	Holthuis (1951): 84; Chace (1972): 26
P. bredini Chace, 1972	(?) Calcareous mudflats and epibiont growth on mangrove roots	Unknown	Chace (1972): 28; Pachelle *et al.* (2018): 131
P. brucei Cardoso and Young, 2007*	Porifera	*Ircinia* sp. (Irciniidae)	Cardoso and Young (2007): 302
P. caraibicus Holthuis, 1951*	(?) Coral reef and turtle-grass beds	Unknown	Holthuis (1951): 113; Chace (1972): 28; Vieira *et al.* (2012): 14
P. chacei Abele, 1971	(?) Coral rubble	Unknown	Abele (1971): 38
P. crosnieri Cardoso and Young, 2007*	Porifera	Unknown	Cardoso and Young (2007): 309
P. maxillulidens (Schmitt, 1936)	(?) Epibiont growth on mangrove roots	Unknown	Santana-Moreno *et al.* (2013): 231; Pachelle *et al.* (2018): 132
P. mcmichaeli Ramos-Tafur and Lemaitre, 2017	Porifera?	Unknown	Ramos-Tafur and Lemaitre (2017): 501
P. pearsei (Schmitt, 1932)*	Porifera	*Spongia officinalis* Linnaeus (Spongiidae) and *Ircinia strobilina* (Lamarck) (Irciniidae)	Chace (1972): 29; Vieira *et al.* (2012): 18; Santana-Moreno *et al.* (2013): 232
P. pectinidactylus Ďuriš, Horká and Sandford, 2009	Porifera	*Smenospongia* sp.? (Thorectidae)	Ďuriš *et al.* (2009): 32
P. perlatus (Boone, 1930)*	Porifera	Unknown	Holthuis (1951): 103; Ramos-Porto and Coelho (1998): 338
P. schmitti Holthuis, 1951	Porifera	*Aplysina fistularis* (Pallas) (Aplysinidae), *Lissodendoryx colombiensis* Zea and van Soest (Coelosphaeridae), *Monanchora arbuscula* (Duchassaing and Micheloti) (Crambeidae) and *Xestospongia rosariensis* Zea and Rützler (Petrosiidae)	De Grave and Anker (2017): 28; Santana-Moreno *et al.* (2013): 232
P. wilsoni (Hay, 1917)	Porifera	Unknown	Holthuis (1951): 106; Ramos-Tafur and Lemaitre (2017): 501

from two colonies of an undescribed species of *Diplosoma* Macdonald (Ascidiacea: Didemnidae) (S. Vieira, pers. comm.). The material represents the southernmost record of both shrimp species in the southwestern Atlantic Ocean and the first host record for *P. maxillulidens* in the literature.

Material and Methods

The shrimps were extracted from two colonies of the ascidian *Diplosoma* sp. associated with coral rubble obtained by scuba diving at approximately 15 m depth on the northernmost part of the Escalvada Island, Espírito Santo, Brazil. The tunicate hosts were preserved in 10% formaldehyde in sea water and deposited in the Ascidiacea collection of the Zoology Department at Universidade Federal do Paraná, Paraná, Brazil (DZUP).

The shrimps were extracted from the ascidian's circulatory channels and preserved in 70% ethanol; subsequently, they were studied and deposited in the carcinological collection of the Museu de Zoologia, Universidade de São Paulo (MZUSP). The shrimps were drawn under a stereomicroscope equipped with a camera lucida to illustrate the most important taxonomic characters. Carapace length (CL, in mm) was used as standard measurement for the shrimps, measured from the level of the posterior orbital margin to the posterior margin in the midline of the carapace.

Systematics

Palaemonidae Rafinesque, 1815

***Periclimenaeus* Borradaile, 1915**

***Periclimenaeus ascidiarum* Holthuis, 1951**
(Figs. 1–3)

Periclimenaeus ascidiarum Holthuis, 1951: 80, pl. 22, figs. g–l, pl. 23, figs. a–i.— Chace, 1972: 25, 26.— Coelho and Ramos, 1972: 146.— Ramos-Porto, 1980: 297.— Abele and Kim, 1986: 11, 89.— Ramos-Porto and Coelho, 1990: 105.— Ramos-Porto and Coelho, 1998: 337.— Coelho *et al.*, 2006: 50, tab. 3.— Souza *et al.*, 2011: 44.— Vieira *et al.*, 2012: 13, fig. 7 (map).— Ramos-Tafur and Lemaitre, 2017: 505 (key).— Pachelle *et al.*, 2018: 130, fig. 2.

Material examined. Brazil, Espírito Santo, off Vitória, Escalvada Island, 20°41'55.3"S 40°24'20.8"W, scuba dive, 15 m depth, coral rubble, inside *Diplosoma* sp. (Fig. 4), coll. Sandra Vieira Paiva, 29 March 2017: 1 ovigerous female, 2.7 mm CL, MZUSP 39106; 1 ovigerous female, 2.7 mm CL, MZUSP 39107.

Distribution. Western Atlantic: USA (Florida), Colombia (Cape de La Vela), Dominica, Cuba (Batabanó Gulf), Panama (Bocas del Toro) and Brazil (Maranhão, Ceará, Pernambuco, Espírito Santo) (Holthuis, 1951; Chace, 1972; Vieira *et al.*, 2012; Pachelle *et al.*, 2018; present study).

Remarks. The morphological characters in our specimens agree well with those described by Holthuis (1951), including (i) shape and armature of the rostrum (Fig. 1A), (ii) first article of antennular peduncle with distolateral angle produced into small tooth (Fig. 1C), (iii) scaphocerite twice as long as broad, with a distinct lateral tooth (Fig. 1D), (iv) proportions of the first pereopod (Fig. 1E); (v) overall shape and armature of the second pereopods (Fig. 2), and (vi) pereopods 3–5 with dactyli distally biunguiculate and bearing an additional proximoventral tooth (Fig. 3B, D, F).

Holthuis (1951) described *P. ascidiarum* based on specimens associated with unidentified ascidians from Florida (USA) and Cape la Vela (Colombia). Since then, the species has been reported from several localities in the Caribbean and Brazil, but with no mention of an ascidian host (Vieira *et al.*, 2012). The new material suggests that *P. ascidiarum* occurs in colonial ascidians of the genus *Diplosoma*; however, the range of host species remains to be investigated. The present material also represents the first record of *P. ascidiarum* in Espírito Santo, extending considerably its known southern distribution in the Atlantic Ocean from Pernambuco (8–9°S) to Escalvada Island (20°S).

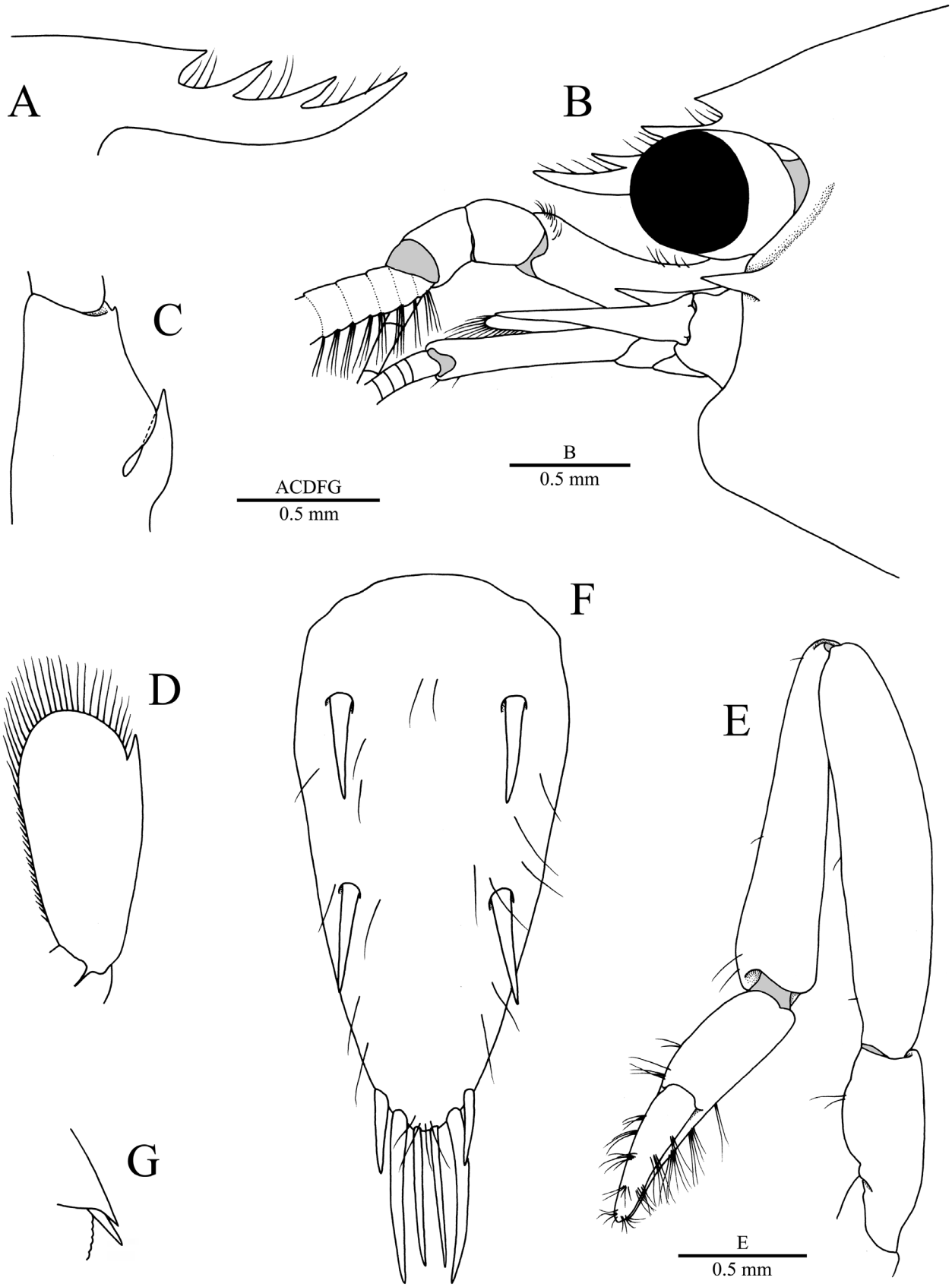

Figure 1. *Periclimenaeus ascidiarum* Holthuis, 1951, ovigerous female, 2.7 mm CL, MZUSP 39106: (**A**) rostrum, lateral view; (**B**) frontal margin and cephalic appendages, lateral view; (**C**) right antennule, first article of peduncle, dorsal view; (**D**) right scaphocerite, dorsal view; (**E**) left first pereopod, lateral view; (**F**) telson, dorsal view; (**G**) right uropod, diaeresis, dorsal view.

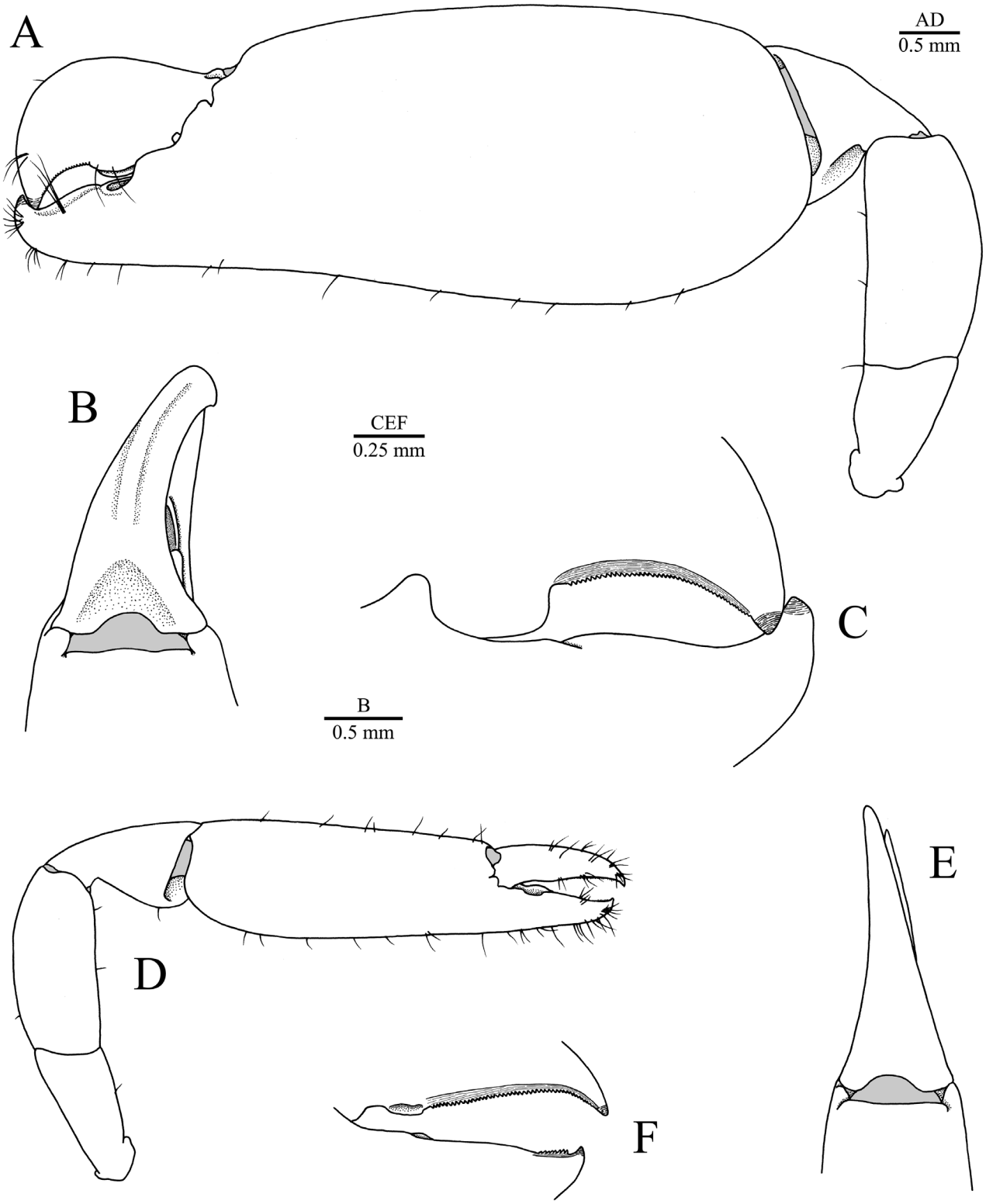

Figure 2. *Periclimenaeus ascidiarum* Holthuis, 1951, ovigerous female, 2.7 mm CL, MZUSP 39106: (**A**) major (left) second pereopod, lateral view; (**B**) same, fingers, dorsal view; (**C**) same, cutting edges, mesial view; (**D**) minor (right) second pereopod, lateral view; (**E**) same, fingers, dorsal view; (**F**) same, cutting edges, lateral view.

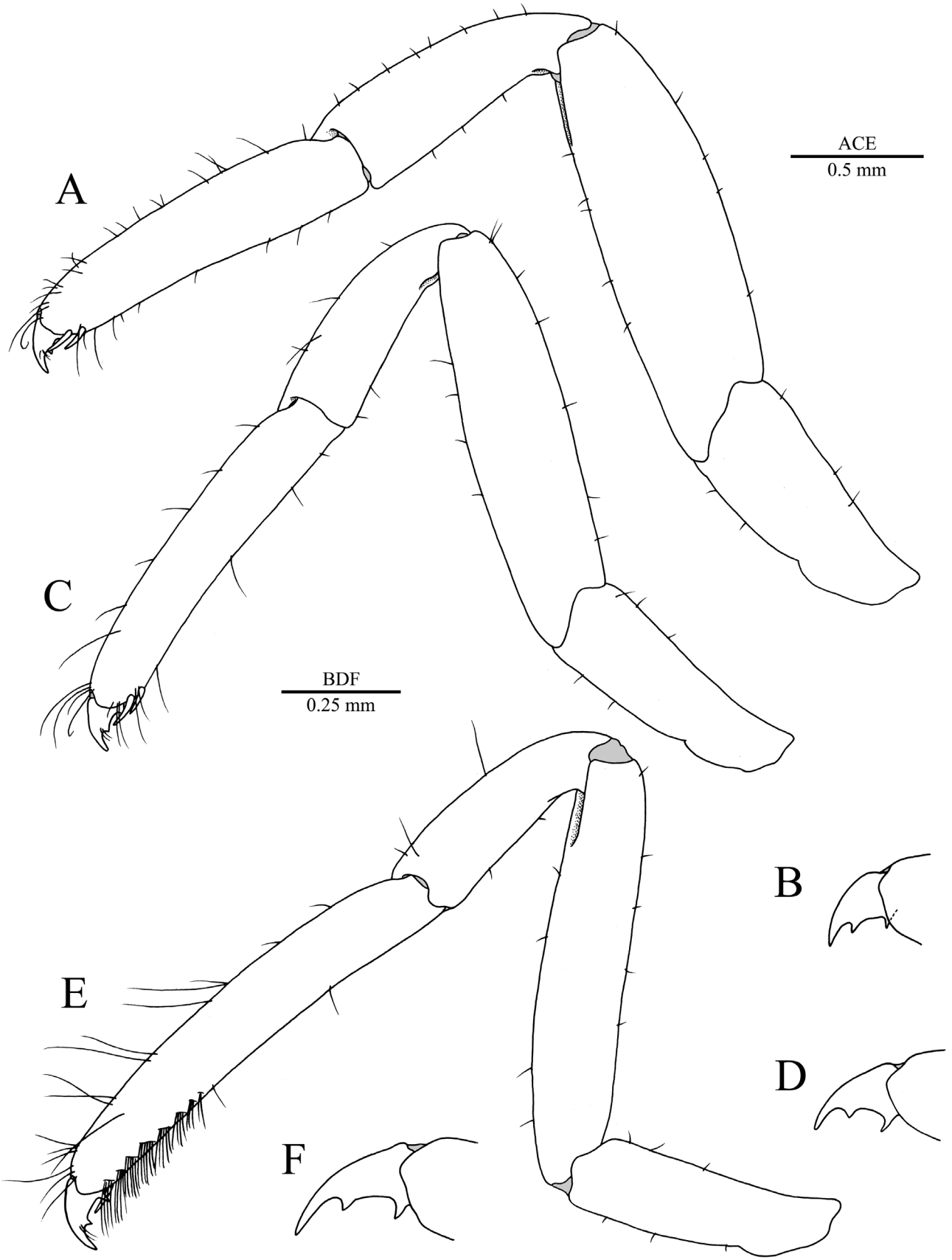

Figure 3. *Periclimenaeus ascidiarum* Holthuis, 1951, ovigerous female, 2.7 mm CL, MZUSP 39106: (A) left third pereopod, lateral view; (B) same, dactylus, lateral view; (C) left fourth pereopod, lateral view; (D) same, dactylus, lateral view; (E) left fifth pereopod, lateral view; (F) same, dactylus, lateral view.

Figure 4. The ascidian host, *Diplosoma* sp. (Didemnidae), at Ilha Escalvada, Espírito Santo (Brazil), photographed *in situ*. Note the spaces between the zooid clusters where the shrimps were dwelling.

***Periclimenaeus maxillulidens* (Schmitt, 1936)**
(Figs. 5–7)

Periclimenes maxillulidens Schmitt, 1936: 371, pl. 13, fig. 3a–o.

Periclimenaeus maxillulidens.— Holthuis, 1951: 87, pl. 26.— Abele and Kim, 1986: 11, 90.— Chace, 1972: 28.— Cardoso and Young, 2007: 295 (key), 296.— Santana-Moreno *et al.*, 2013: 231, fig. 2G.— Ramos-Tafur and Lemaitre, 2017: 505 (key) .— Pachelle *et al.*, 2018: 132.

Material examined. Brazil, Espírito Santo, off Vitória, Escalvada Island, 20°41'55.3"S 40°24'20.8"W, scuba dive, 15 m depth, coral rubble, inside *Diplosoma* sp. (Fig. 4), coll. Sandra Vieira Paiva, 29 March 2017: 1 ovigerous female, 3.7 mm CL, MZUSP 39108.

Distribution. Western Atlantic: USA (Florida), Mexico (Yucatan), Bonaire, Panama (Bocas del Toro) and Brazil (Espírito Santo) (Schmitt, 1936; Holthuis, 1951; Santana-Moreno *et al.*, 2013; Pachelle *et al.*, 2018; present study).

Remarks. Schmitt (1936) described *P. maxillulidens* (as *Periclimenes maxillulidens*) based on one male collected in Bonaire. Afterwards, the species was only reported from USA (Florida), Mexico (Yucatan) and Panama (Bocas del Toro) (Holthuis, 1951; Santana-Moreno *et al.*, 2013; Pachelle *et al.*, 2018). The present female from Escalvada Island represents the fourth record of this rare species and its first record in Brazil and the southwestern Atlantic Ocean.

Our specimen agrees well with the specimens described and illustrated in Schmitt (1936: pl. 13) and Holthuis (1951: pl. 26), including (i) shape and armature of the rostrum (Fig. 5A), (ii) first article of antennular peduncle with distolateral angle blunt, lacking a tooth (Fig. 5C), (iii) scaphocerite wider distally, with a small lateral tooth (Fig. 5D), (iv) proportions of the first pereopod (Fig. 5E), (v) overall shape and armature of the major second pereopod (Fig. 6A–C), and (vi) pereopods 3–5 with dactyli simple, lacking both subdistal and proximoventral teeth (Fig. 7B, D, F).

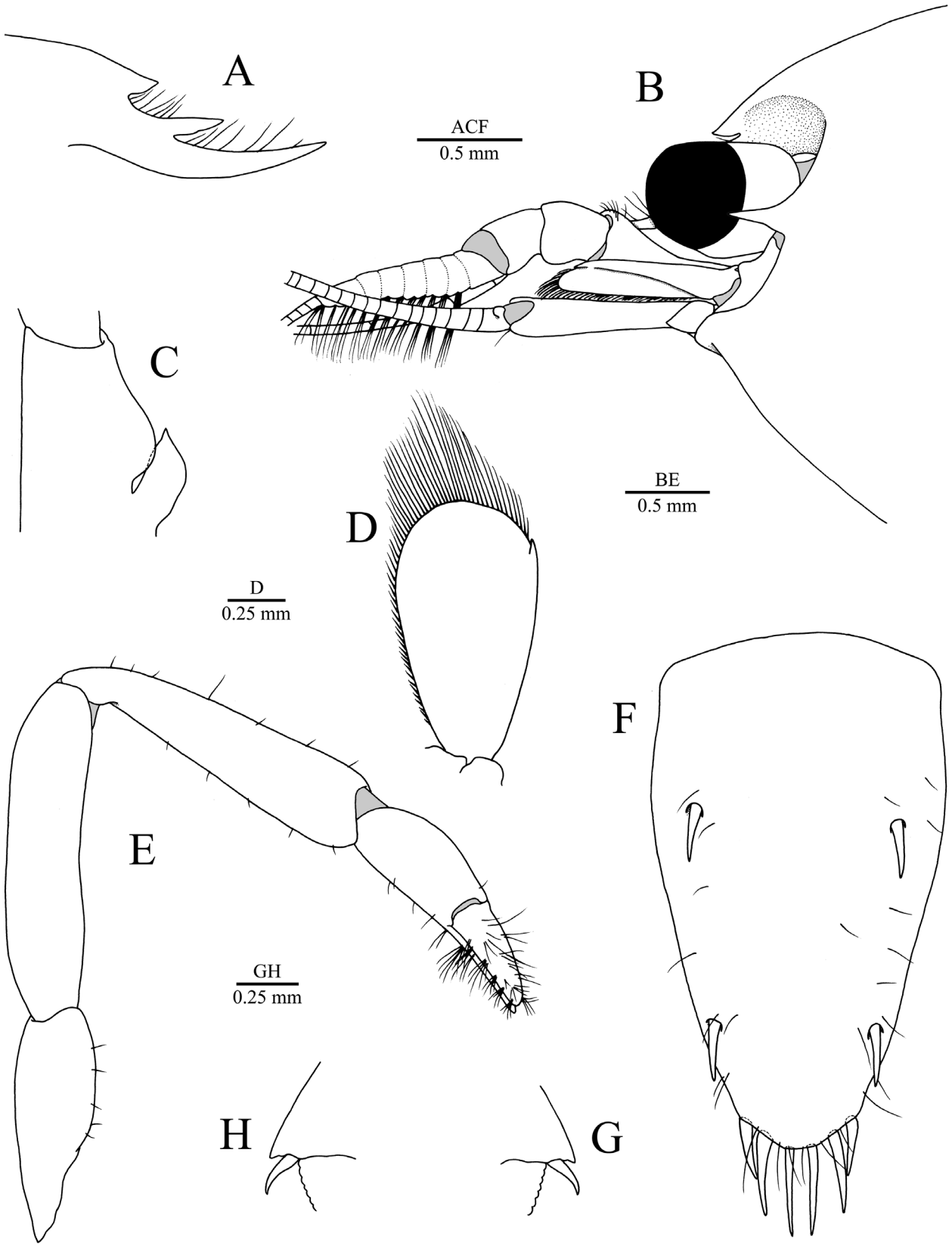

Figure 5. *Periclimenaeus maxillulidens* (Schmitt, 1936), ovigerous female, 3.7 mm CL, MZUSP 39108: (**A**) rostrum, lateral view; (**B**) frontal margin and cephalic appendages, lateral view; (**C**) right antennule, first article of peduncle, dorsal view; (**D**) right scaphocerite, dorsal view; (**E**) right first pereopod, lateral view; (**F**) telson, dorsal view; (**G, H**) right and left uropods, respectively, diaeresis, dorsal view.

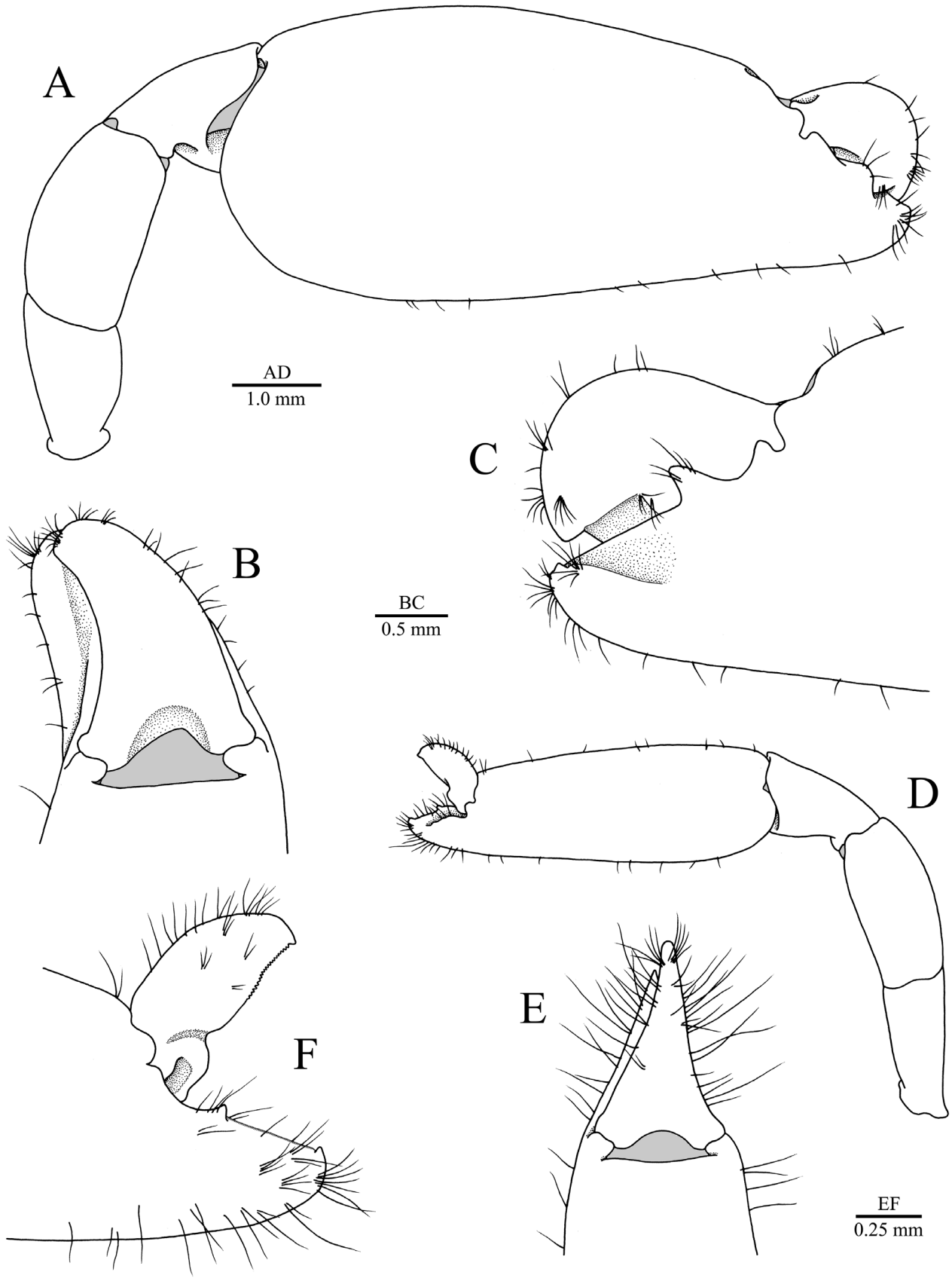

Figure 6. *Periclimenaeus maxillulidens* (Schmitt, 1936), ovigerous female, 3.7 mm CL, MZUSP 39108: (**A**) major (right) second pereopod, lateral view; (**B**) same, fingers, dorsal view; (**C**) same, mesial view; (**D**) minor (left) second pereopod, lateral view; (**E**) same, fingers, dorsal view; (**F**) same, mesial view.

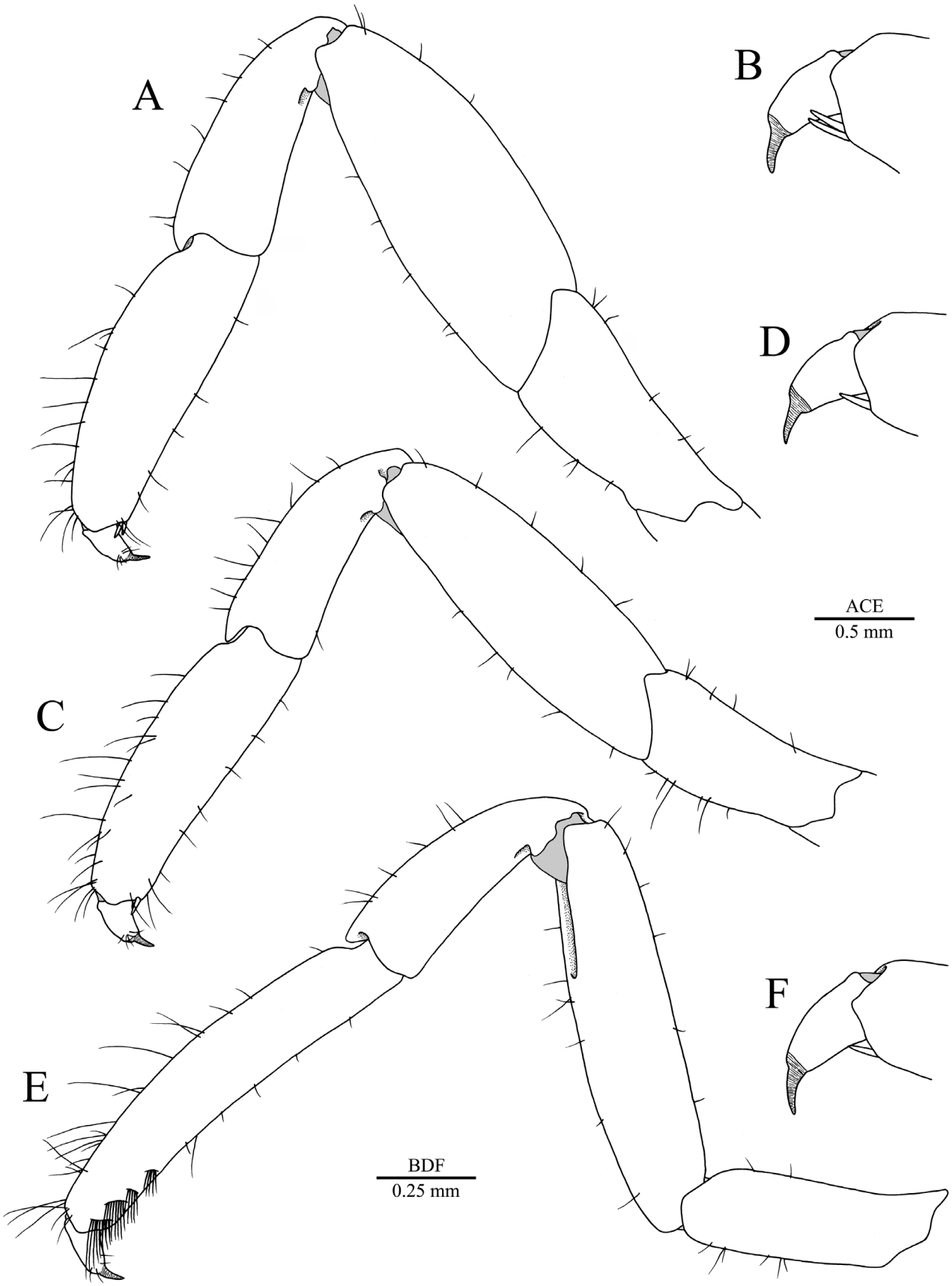

Figure 7. *Periclimenaeus maxillulidens* (Schmitt, 1936), ovigerous female, 3.7 mm CL, MZUSP 39108: (**A**) left third pereopod, lateral view; (**B**) same, dactylus, lateral view; (**C**) left fourth pereopod, lateral view; (**D**) same, dactylus, lateral view; (**E**) left fifth pereopod, lateral view; (**F**) same, dactylus, lateral view.

The minor second pereopod, herein illustrated for the first time for the species (Fig. 6D–F), lacks granules on its surface, but is furnished with setae, which are more abundant on the chela fingers. The fingers are slightly curved inwards; the cutting edge of the fixed finger has a small triangular tooth on its proximal half and a series of tiny teeth on the distal half; the dactylus has a wide, laterally excavated process proximally, separated from the rest of the cutting edge by a sinus; cutting edge distally serrated (Fig. 6F).

According to Holthuis (1951), *P. maxillulidens* is morphologically very similar to two other Atlantic species, *P. atlanticus* and *P. schmitti* Holthuis, 1951. *Periclimenaeus maxillulidens*, however, can be readily separated from both species by the combination of three morphological characters: (i) shape and armature of rostrum (1–2 dorsal teeth in *P. maxillulidens* and *P. schmitti*, 4 teeth in *P. atlanticus*; *cf.* Holthuis, 1951: pl. 24, fig. b; Fig. 5A), (ii) armature of the scaphocerite (blunt in *P. schmitti*, with small tooth in *P. maxillulidens*, with distinct tooth in *P. atlanticus*; *cf.* Holthuis, 1951: pl. 24, fig. e; pl. 27, fig. c; Fig. 5D), and (iii) the shape of pereopods 3–5 dactyli (simple in *P. maxillulidens* and *P. atlanticus*, biunguiculate in *P. schmitti*; *cf.* Holthuis, 1951: pl. 24, fig. o; pl. 27, fig. m; Fig. 7B, D, F).

Although most species of *Periclimenaeus* are known to associate with sponges and ascidians, the hosts for several species are either unknown or reported as unidentified sponges or ascidians (Holthuis, 1951; Bruce, 2006; Fransen, 2006; Dobson *et al.*, 2016). *Periclimenaeus maxillulidens* has been reported from sandy debris (Schmitt, 1936), broken shells, gravel, sand and coral (Holthuis, 1951; Santana-Moreno *et al.*, 2013). Pachelle *et al.* (2018) reported a single ovigerous female of *P. maxillulidens* in epibiotic growth on mangrove roots, but without specifying whether the specimen was collected inside sponges or ascidians. Therefore, the present study confirms that the species is, at least, associated with colonial ascidians of the genus *Diplosoma* (Fig. 4).

Identification key for the species of Periclimenaeus from the southwestern Atlantic

1a. Pereopods 3–5 with dactyli simple. 2

1b. Pereopods 3–5 with dactyli biunguiculate. . . . 3

2a. Rostrum straight, dorsal margin with 4 teeth; scaphocerite with lateral tooth distinct, strong. . . . . *P. atlanticus*
[Brazil: Paraíba]

2b. Rostrum sinuous, dorsal margin with 2–3 teeth; scaphocerite with lateral tooth subtle, weak. . . . . *P. maxillulidens*
[Brazil: Espírito Santo (Escalvada Island)]

3a. Rostrum with a ventral tooth; carapace with small supraorbital tooth or acute tubercle; scaphocerite with lateral tooth distinct, clearly overreaching blade; dactyli of pereopods 3–5 with unguis ventrally serrulate. . . . . *P. caraibicus*
[Brazil: Rio Grande do Norte (Atol das Rocas)]

3b. Rostrum with ventral margin unarmed; orbital region of carapace smooth; scaphocerite with lateral tooth not as distinct, at most reaching the distal margin of the blade; dactyli of pereopods 3–5 with unguis ventrally smooth. 4

4a. Telson with both pairs of dorsal spines inserted in the anterior half of telson; outer pair of distal spines of telson removed from the distal margin, inserted more proximally than the remaining two distal pairs of spines 5

4b. Telson with posterior pair of dorsal spines inserted in the posterior half of telson; outer pair of distal spines of telson placed in the distal margin, in line with the remaining two distal pairs of spines. 7

5a. Rostrum very high, dorsal teeth large; pereopod 1 carpus long, almost twice as long as chela. . . . . *P. perlatus*
[Brazil: Ceará, Paraíba, Pernambuco]

5b. Rostrum not very high, dorsal teeth medium-sized; pereopod 1 carpus short, slightly longer than chela. 6

6a. Carapace not inflated; second pereopods with palm furnished with numerous granules. . . . . .*P. brucei*
[Brazil: Rio Grande do Norte (Atol das Rocas)]

6b. Carapace inflated; second pereopods chelae smooth, without granules. . . . . .*P. crosnieri*
[Brazil: Rio Grande do Norte (Atol das Rocas)]

7a. Rostrum long, distinctly overreaching the corneas; stylocerite slender, tip acute; dactylus of both second pereopods with cutting edge serrated near apex; minor second pereopod fingers serrated near apex; propodus of pereopod 3 with ventral spines restricted to the distoventral angle. . . . . .*P. ascidiarum*
[Brazil: Maranhão, Ceará, Pernambuco, Espírito Santo (Escalvada Island)]

7b. Rostrum short, not reaching the distal margin of the corneas; stylocerite broad, tip triangular; dactylus of both second pereopods with cutting edge smooth near apex; minor second pereopod fingers smooth near apex; propodus of pereopod 3 with ventral spines distributed along the margin. . . . . .*P. pearsei*
[Brazil: Maranhão]

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