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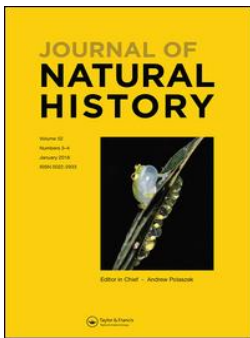
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New occurrences and host records for two species of parasitic isopods (Isopoda, Cymothoidea, Bopyridae) associated with caridean shrimps (Decapoda, Caridea) from Brazil

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ABSTRACT

Two species of bopyrid isopods of the Bopyrinae subfamily are recorded from new localities and hosts in northeastern Brazil. *Parabopyrella lata* (Nierstrasz and Brender à Brandis, 1929) was recorded from the state of Ceará, found for the first time parasitising the caridean shrimp *Alpheus packardii* Kingsley, 1880. In addition, *Probopyrus* cf. *pandalicola* (Packard, 1879) is recorded from the state of Bahia, parasitising the palaemonid shrimp *Palaemon northropi* (Rankin, 1898). Taxonomic comments are provided for each species.

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KEYWORDS

Parabopyrella; *Probopyrus*; Bopyrinae; taxonomy; new records

Introduction

Three of the nine subfamilies within Bopyridae Rafinesque, 1815 are exclusive parasites of caridean shrimps: Argeiinae Markham, 1977, Bopyrinae Rafinesque, 1815 and Hemiarthrinae Markham, 1972 (Markham 1985; An et al. 2015). Bopyrinae is the second largest subfamily, containing 122 described species and 27 genera (Boyko et al. 2008). The genus *Parabopyrella* Markham, 1985 has 28 species and is found parasitising members of the Alpheidae Rafinesque, 1815, Hippolytidae Bate, 1888 and Lysmatidae Dana, 1852 shrimps (Boyko 2006; An et al. 2015). The genus *Probopyrus* Giard and Bonnier, 1888 has 27 described species (Boyko et al. 2008) and parasitizes shrimps of the family Palaemonidae Rafinesque, 1815 (Markham 1985). Here we register a new locality and host record for the species *Parabopyrella lata* (Nierstrasz and Brender à Brandis, 1929) and new locality for the species *Probopyrus* cf. *pandalicola* (Packard, 1879) on the northern coast of Brazil.

Material and methods

The material examined is deposited in the Carcinological Collection of the Departamento de Zoologia, Universidade Federal do Rio Grande do Sul (UFRGS). Specimens were dissected and female pereopods 1 and 7 were mounted on slides. Illustrations were made with the aid of a camera lucida fitted on a stereomicroscope and

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a compound microscope. The parasite specimens were measured for total length (TL), i.e. from the anterior margin of the cephalon to the posterior margin of the pleotelson, and the hosts for carapace length (CL), i.e. from the tip of rostrum to the mid-dorsal posterior margin of carapace. References are provided for taxonomic authorities of all parasitic taxa and hosts.

Systematic account

Order **ISOPODA** Latreille, 1817
Family **BOPYRIDAE** Rafinesque, 1815
Subfamily **BOPYRINAE** Rafinesque, 1815
Genus ***Parabopyrella*** Markham, 1985

Parabopyrella lata (Nierstrasz and Brender à Brandis, 1929)

Figure 1

Bopyrella lata Nierstrasz and Brender à Brandis, 1929: 34, 35, fig. 43 [type locality: between St. Thomas, Virgin Islands, and Saba, Netherlands Antilles; infesting unidentified alpheid]; Chopra 1930: 137 (mention); Lemos de Castro 1965: 283–286 (key), figs. 6–13; Bourdon 1980: 187 (key), 199–201, fig. 6.

Parabopyrella lata – Markham, 1985: 67 (key), 68–71, figs. 29, 30; Markham 1988: 57 (list); Kensley and Schotte 1989: 112 (Table 2); Brasil-Lima 1998: 639 (list); Camp 1998: 133 (list); An et al. 2015: 47, 48 (mention), 61 (key); Baeza et al. 2018: 1–11, figs. 1–4.

Material examined

Brazil: mature female (3.85 mm TL), Praia do Pacheco, Ceará, 15/V/2003, Colls. Victor Torres, Daniel Malledo & Daniel Laovo, infesting right branchial chamber of ovigerous female *Alpheus packardii* Kingsley, 1880 (5.4 mm CL) (UFRGS 6629).

Remarks

Based on the redescription by Markham (1985) and key of An et al. (2015), the present specimens are closest in morphology to *P. lata* (Nierstrasz and Brender à Brandis, 1929) (Figure 1(a,b)). Within *Parabopyrella*, *P. lata* is considered to be part of the 'C3' group which has a deeply medially incised pleotelson and long, divergent posterolateral lobes (An et al. 2015). According to Markham (1988), *P. lata* has a known range in the north-west Atlantic (Florida from Cape Canaveral to Homosassa Springs, including Bahamas) and the Caribbean Sea (between St. Thomas, Virgin Islands and Saba, Lesser Antilles) where it has been reported parasitising *Alpheus normanni* Kingsley, 1878 and unidentified alpheids (Markham 1985; Boyko 2006; Baeza et al. 2018). The range of hosts for *P. lata* has expanded to include the shrimp *Lysmata boggessi* Rhyne and Lin, 2006 (Boyko 2006; Baeza et al. 2018). In addition, Lemos de Castro (1965) recorded the species in Brazil (Rio de Janeiro and São Paulo) infesting *Alpheus* sp. and the gebiid *Upogebia affinis* (Say, 1818). This last record was considered questionable by Markham (1985) and Boyko (2006) due to it being the only record of a Bopyrinae isopod parasitising a species outside of the infraorder Caridea. In the present study, a female specimen found parasitising a new host, *Alpheus packardii* Kingsley, 1880, has been preliminarily assigned to *P. lata*. It is also the first record of the species for the state of Ceará, Brazil.

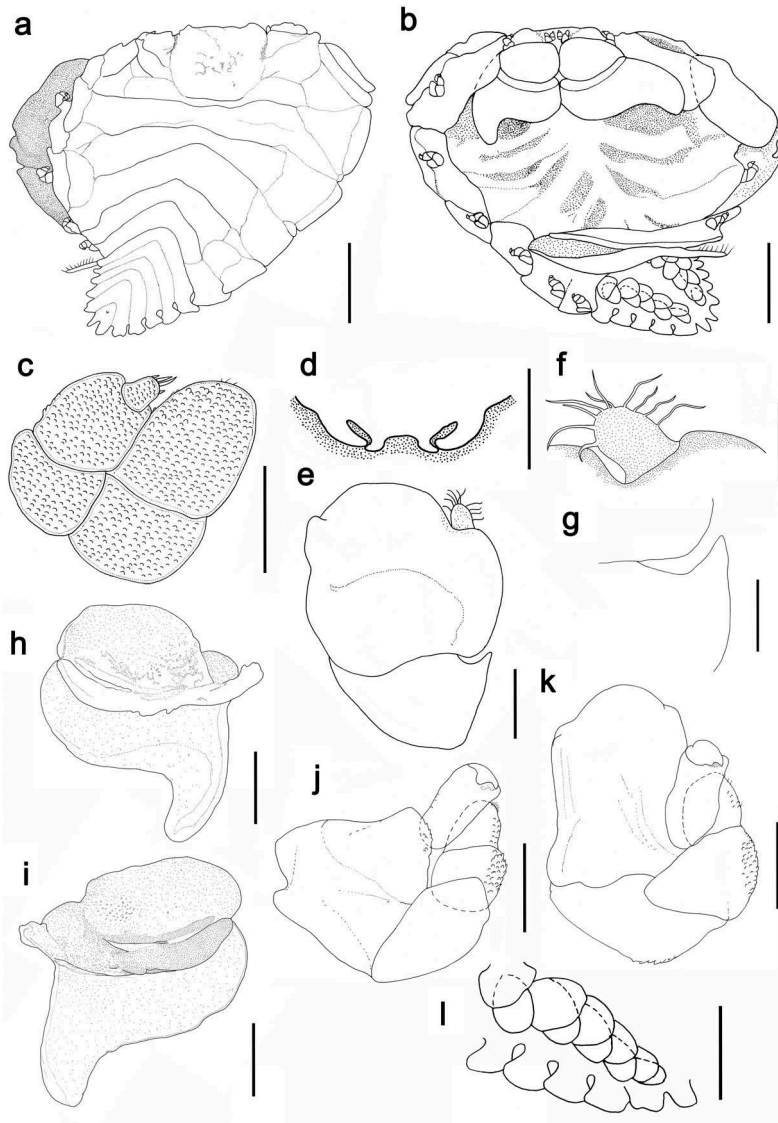


Figure 1. *Parabopyrella lata* (Nierstrasz and Brender à Brandis, 1929), female (UFRGS 6629): (a), habitus dorsal view; (b), habitus ventral view; (c), antennule (left) and antenna (right); (d), barbula; (e), maxilliped; (f), maxilliped palp; (g), maxilliped spur; (h), oostegite 1, outer view; (i), oostegite 1, inner view; (j), right pereopod 1; (k), right pereopod 7; (l), left pleopods. Scale bars: (a) and (b) = 1.0 mm; (c) = 0.1 mm; (d) = 0.5 mm; (e) = 0.35 mm; (f) and (g) = 0.1 mm; (h–k) and l = 0.5 mm.

The present material differs from Markham's (1985) Florida specimens in the following: the posterior article of oostegite 1 is more elongate and broadly rounded (Figure 1(h,i)) (versus more acute in the Florida specimens) and the inner lobes of the barbula are oriented laterally (Figure 1(d)) (versus inner lobes of the barbula oriented medially in the Florida specimens). Boyko (2006) analysed one bopyrid female (9.6 mm TL) parasitising the left branchial chamber of a female *L. boggei*

(14.7 mm CL) and identified it as *P. lata*. The author also pointed out the differences between *P. lata* and *P. mortenseni* (Nierstrasz and Brender à Brandis, 1929). The specimen was characterised by the broad shape of the anterior body in dorsal view, the irregular and asymmetrical development of the dorsolateral bosses and coxal plate on the first pereomere, the pleotelson medially indented, the posterior article of oostegite 1 broadly rounded and weakly curved and the maxilliped palp as an elongated spur with few setae (Boyko 2006). Nevertheless, the pleotelson with acute projections (Figure 1(a,b)) (versus quadrangular projections in Boyko's specimen) and the presence of ten of setae in the maxilliped palp (Figure 1(e,f)) (versus four in Boyko's specimen) distinguish the present material from that identified by Boyko (2006). The absence of illustrations for other appendages make more accurate comparisons between these two specimens difficult, but these morphological differences along with the hippolytid host raise the possibility that the material analysed by Boyko (2006) could be a different species than reported by Markham (1985) and that of our study. However, based on the fact that only one female was collected from Brazil and lack of a male specimen for comparison, there is not enough data to show that the specimen analysed here constitutes a new species. Additional material is needed to elucidate this question.

Genus *Probopyrus* Giard and Bonnier, 1888

Probopyrus cf. pandalicola (Packard, 1879)

Figures 2, 3

Abbreviated synonymy (see Markham 1985; the synonymy list below includes only taxonomic resources since 1985, see discussion for taxonomic notes and non-taxonomic references).

Bopyrus pandalicola Packard, 1879: 308–310, fig. 262 [type locality: unspecified, east coast of the United States].

Probopyrus pandalicola – Markham 1985: 26–35, 127–128 (Table 2; in part), 134, figs. 7–8; Verdi and Schuldt 1988: 22–24; Kensley and Schotte 1989: 112, 266 (lists; in part); Jiménez and Vargas 1990: 457–462, figs. 1–11; Román-Contreras 1993: 689, 690, 694, 695; Brasil-Lima 1998: 209; Alvarez-León et al. 1999: 17–21, 19 (Table 1; in part), fig. 1; Rocha and Bueno 2000: 134, 137, 138; Román-Contreras and Bourdon 2001: 918, 920 (Table 1), 922 (Table 2); Román-Contreras 2004: 153, 154 (Table 1), 156, 157 (Table 2), 161, figs. 1, 2; Román-Contreras and Martínez-Mayén 2011: 1145, 1149, 1150; Pralon et al. 2018: 6, 7; Saito et al. 2010: 173 (Table 1; in part), 179.

not *Probopyrus pandalicola*: Campos and de Campos 1989: 29–34, 33 (Table 1); Alvarez-León 1993: 307–308; Alvarez-León et al. 1999: 17–21, 19 (Table 1; in part); Bunkley-Williams and Williams 1998: 149, 150 (Table 1; in part).

Material examined

Brazil: mature female (4.4 mm TL), Olivença, Ilhéus, Bahia (14°56'28.4"S, 39°00'39.3"W), 06/V/2015, Coll. J. T. Lisboa, infesting left branchial chamber of male *Palaemon northropi* (Rankin, 1898) (9.8 mm CL) (UFRGS 6630); Mature male (1.09 mm TL), same data; mature

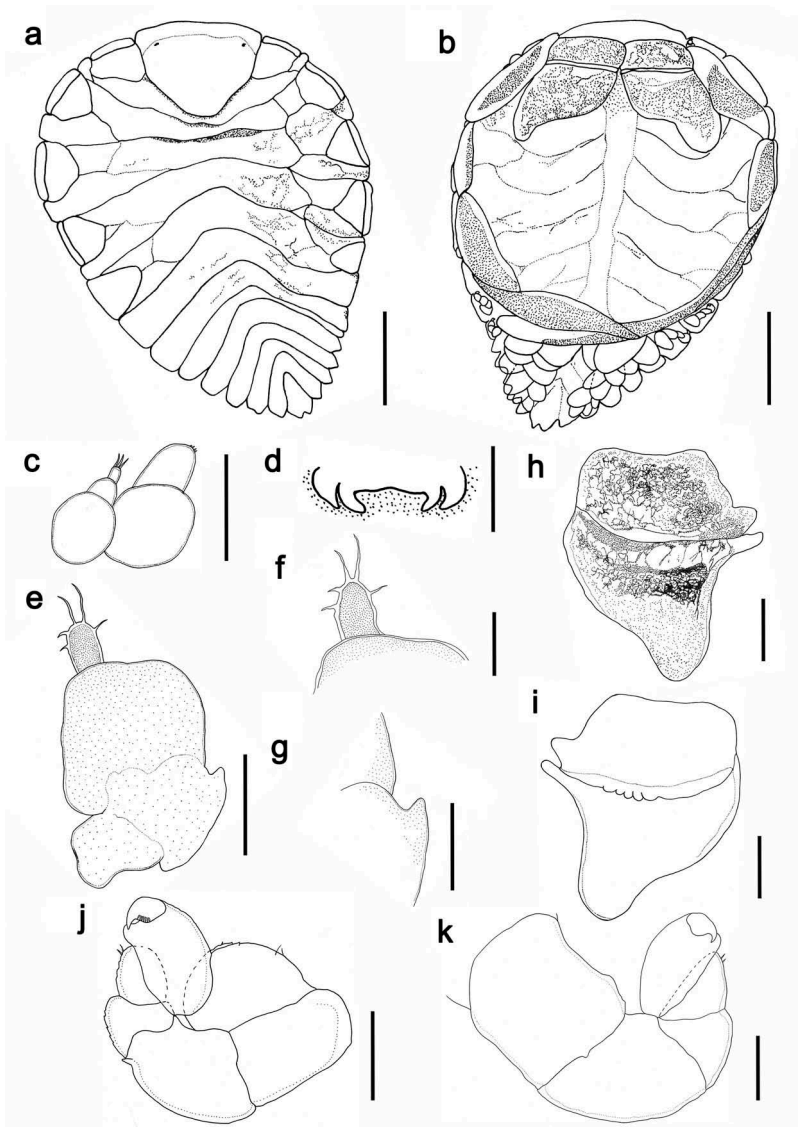


Figure 2. *Probopyrus* cf. *pandalicola* (Packard, 1879), females (UFRGS 6630): (a), habitus dorsal view (4.4 mm TL); (b), habitus ventral view (4.4 mm TL); (c), antennule (left) and antenna (right) (3.45 mm TL); (d), barbula (2.6 mm TL); (e), maxilliped (2.6 mm TL); (f), maxilliped palp (2.6 mm TL); (g), maxilliped spur (2.6 mm TL); (h), oostegite 1, outer view (3.45 mm TL); (i), oostegite 1, inner view (3.45 mm TL); (j), right pereopod 1 (3.45 mm TL); (k), right pereopod 7 (3.45 mm TL). Scale bars: (a) and (b) = 1.0 mm; (c) = 0.1 mm; (d) = 0.37 mm; (e) = 0.2 mm; (f) and (g) = 0.1 mm; (h) and (i) = 0.25 mm; (j) and (k) = 0.1 mm.

female (3.45 mm TL) and mature male (0.9 mm TL), infesting right branchial chamber of male *P. northropi* (4.5 mm CL), same data; mature female (2.6 mm TL), infesting left branchial chamber of female *P. northropi* (3.0 mm CL), same data; mature female (1.9 mm TL), infesting left branchial chamber of female *P. northropi* (3.0 mm CL), same data; mature female (1.5 mm TL), infesting left branchial chamber of female *P. northropi*

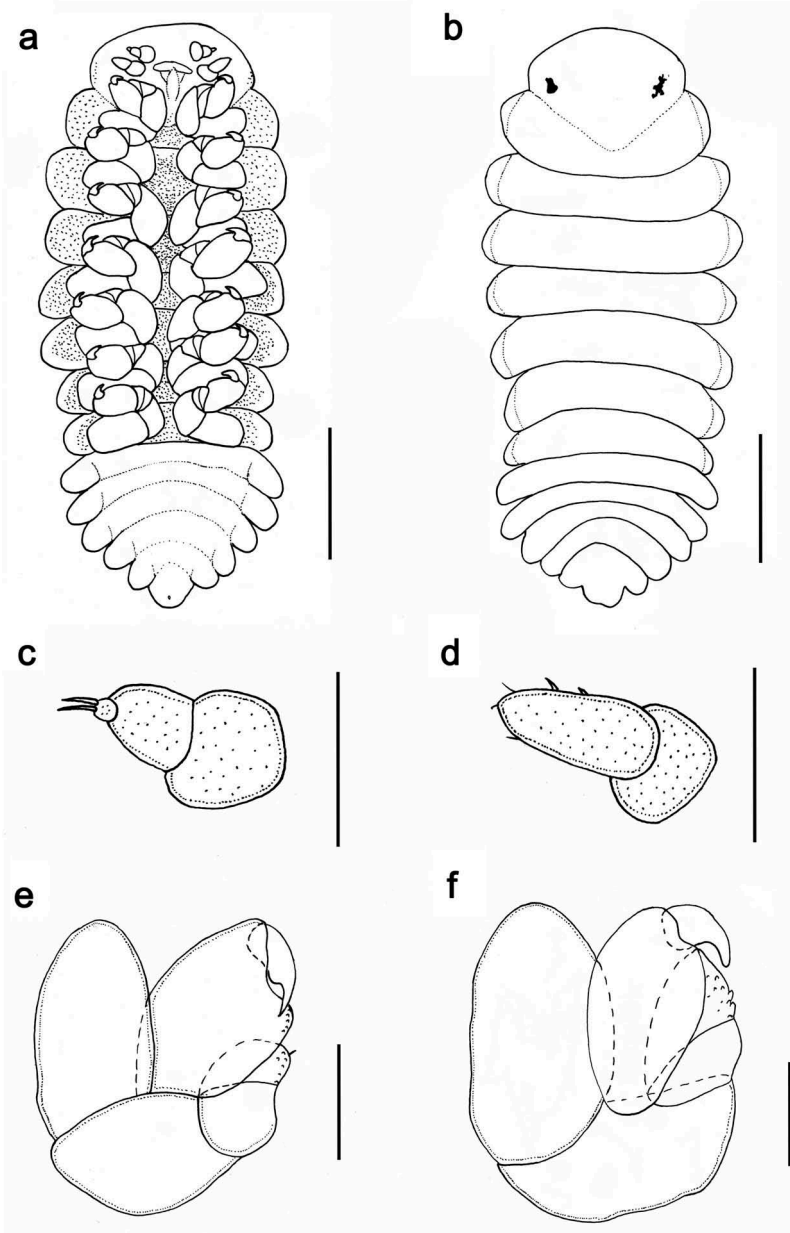


Figure 3. *Probopyrus* cf. *pandalicola* (Packard, 1879), male (1.09 mm TL) (UFRGS 6630): (a), habitus ventral view; (b), habitus dorsal view; (c), antennule; (d), antenna; (e), left pereopod 1; (f), left pereopod 7. Scale bars: (a) and (b) = 0.25 mm; (c–f) = 0.05 mm.

(3.4 mm CL), same data; mature female (1.2 mm TL), infesting left branchial chamber of female *P. northropi* (3.5 mm CL), same data; mature female (2.7 mm TL) and mature male (0.9 mm TL), infesting right branchial chamber of female *P. northropi* (3.9 mm CL), same data.

Remarks

We have provisionally identified these specimens as *Probopyrus* cf. *pandalicola* which has been reported from *P. northropi* in Mexico, Venezuela, and Brazil (Markham 1985). The new record from Ilhéus, Bahia, Brazil is approximately 1200 km south of previous collections of *P. pandalicola* from Vila Velha, Pernambuco. The adult female specimens of *P.* cf. *pandalicola* analysed here (Figure 2) are characterised by a pyriform body, subtriangular cephalon with anterior margin slightly extending beyond pereion, subrectangular maxilliped with palp on anterior lobe bearing five setae and prominent spur, oostegite 1 internal ridge with five digitiform projections, dactyli of pereopods 1 and 7 deeply inset in propodi, and pleomeres separated laterally and pleotelson deeply bilobed. This combination of characters, as well as those of the male (Figure 3), are closest morphologically to *P. pandalicola* (versus *P. floridensis* Richardson, 1904) but without larval morphology or molecular data it is presently not possible to be more definitive in identification (see below). However, the present female specimens differ from Markham's (1985) material in having a broad frontal lamina (Figure 2(a)) (lacking frontal lamina in Markham's specimens), antenna 2 with two articles (Figure 2(c)) (antenna 2 with three articles in Markham's specimens) and maxilliped palp large and not inset in the distal margin of the anterior maxilliped article (Figure 2(e,f)) (maxilliped palp small and inset in the distal margin of the anterior maxilliped article in Markham's specimens). *Probopyrus pandalicola* has a complex taxonomic history with multiple species being synonymised by Markham (1985) and purportedly recorded from over 15 species of freshwater and marine palaemonid shrimp (Kensley and Schotte 1989). However, Román-Contreras (1993) concluded that three species synonymised by Markham (1985) are distinct from *P. pandalicola*: *P. bithynis* Richardson, 1904 [Louisiana, USA infesting *Macrobrachium ohione* (Smith, 1874) and *M. olfersii* (Wiegmann, 1836)], *P. floridensis* [Florida, USA infesting *Palaemon paludosus* (Gibbes, 1850)], and *P. panamensis* Richardson, 1912 [Paraiso, Panama infesting *M. acanthurus* (Wiegmann, 1836)]. A fourth species *P. palaemoneticola* (Packard, 1881) [Atlantic coast, USA from *Palaemon* Weber, 1795] was later synonymised with *P. pandalicola* by Román-Contreras and Martínez-Mayén (2011), in agreement with Markham's (1985) assessment. Adult female specimens of *P. bithynis* can be distinguished from *P. pandalicola* by horn-shaped anterolateral processes on the head and the presence of a large, subtriangular high carina on the seventh pereopod, both of which are lacking in the material examined from Brazil. In addition, the epicaridium and cryptoniscus larvae of *P. bithynis* are distinct from *P. floridensis* and *P. pandalicola* (Dale and Anderson 1982). Unfortunately, adult specimens of *P. floridensis* and *P. pandalicola* are difficult to distinguish based on morphology (see Table 1 in Román-Contreras and Bourdon 2001); however, the larvae can be distinguished by morphometric analysis (Dale and Anderson 1982). Jiménez and Vargas (1990) were in error when stating 'it is impossible to separate the larvae of *P. pandalicola* and *P. floridensis*'; these authors presumably were only considering epicaridium larvae and did not take into consideration the morphometric data of Dale and Anderson (1982) that showed significant differences between both the epicaridium and cryptoniscus larval stages of *P. floridensis* and *P. pandalicola* (as well as differences in swimming speed and pigmentation of the cryptoniscus larvae). Thus, although almost morphologically indistinguishable as adults, *P. floridensis* and *P. pandalicola* appear to represent reproductively isolated species and we accept the conclusion of others that they are valid species (Román-Contreras 1993; Rocha and Bueno 2000; Saito et al. 2010).

Presently there are four species of *Probopyrus* recognised in Brazil: *P. bithynis*, *P. floridensis*, *P. palaemoni* Lemos de Castro and Brasil-Lima, 1974 [from *Palaemon pandaliformis* (Stimpson, 1871)], and *P. pandalicola*.

It is important to note that much work remains to be done in testing species boundaries in this group. Although *P. pandalicola* has been considered by some to be on both sides of the isthmus of Panama (Kensley and Schotte 1989; Vargas-Ceballos et al. 2016), the presence of the species in the eastern Pacific has been questioned (Román-Contreras 2004). These debates are amenable to testing with new collections and molecular data to determine if the species truly has such a wide geographic and host use pattern (known in some other bopyrids; see *Athelges* Gerstaecker, 1862 in McDermott et al. 2010; *Argeia* Dana, 1853 in An et al. 2015) or represents an even more diverse cryptic species complex than currently recognised. Specimens of *P. pandalicola* collected from the Rhode River, Chesapeake Bay, MD have been sequenced for cytochrome oxidase subunit 1 (COI) and vouchered (USNM 1463140), thus can serve as a starting point for such work. Members of the genus *Probopyrus* are some of the best studied bopyrids in terms of morphology and development (e.g. Dale and Anderson 1982), ecology (e.g. Beck 1979, 1980; Chaplin-Ebanks and Curran 2007; Conner and Bauer 2010), and impacts on host physiology and/or behaviour (reviewed in Brinton and Curran 2015a, 2015b). We urge researchers to appropriately preserve and voucher the parasites during future studies in order to allow for accurate identification, particularly because some of the results on their interactions with hosts are potentially confounded by lack of taxonomic knowledge (Conner and Bauer 2010).

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Disclosure statement

No potential conflict of interest was reported by the authors.

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