Syst Parasitol (2021) 98:155–165
https://doi.org/10.1007/s11230-021-09968-2

Two new species and a new record of Bopyrinae (Isopoda: Bopyridae) infesting Alpheidae and Hippolytidae, with comments on the genus *Bopyrina* Kossmann, 1881

Jianmei An · Qianqian Xi · Gustav Paulay

Received: 19 August 2020 / Accepted: 10 February 2021 / Published online: 8 March 2021

Abstract Two new bopyrids, *Bopyrinina articulata* n. sp. and *Bopyrinella asymmetrica* n. sp. are described from French Polynesia, the Red Sea, and the Philippines. *Bopyrinina articulata* n.sp. infests *Salmoneus* cf. *gracilipes* Miya, and is distinguishable from other species of this genus by the structure of the maxilliped, pleopods and oostegite 1. *Bopyrinella asymmetrica* n. sp. is most similar to *Bopyrinella albida* Shiino, 1958, but females differ from that species because all pereomeres on the short side have round dorsolateral bosses and its pleotelson is greatly distorted. *Bopyrina ocellata* (Czerniavsky, 1868) is newly recorded from the Western Atlantic, from Florida, USA. Review of the species of *Bopyrina* revealed that *B. choprai* Nierstrasz & Brender à Brandis, 1929 and *B. sewelli* Chopra, 1930 are intermediate in morphology between *Bopyrina* and *Schizobopyrina*, the taxonomic assignment of these two species needs further evaluation. Keys to *Bopyrinella* Nierstrasz & Brender à Brandis, 1925 and *Bopyrina* Kossmann, 1881 are presented. Hosts and distributions of the seven species of *Bopyrinella* are summarized.

J. An (✉) · Q. Xi
School of Life Science, Shanxi Normal University, Linfen 041000, People's Republic of China
e-mail: anjianmei@hotmail.com

G. Paulay
Florida Museum of Natural History, University of Florida, Gainesville, FL 32611-7800, USA

Keywords Bopyridae · *Bopyrina* · *Bopyrinella* · *Bopyrinina* · New species · Parasite · Caridea · Alpheidae

Introduction

The Bopyrinae Rafinesque, 1815 (Crustacea: Isopoda) comprise 27 genera and 127 species (Boyko et al., 2008), all parasites of caridean shrimps (Markham 1985a). We present information about new collections of three genera, including two new species.

Shiino (1933) erected *Bopyrinina* for *Bopyrinina dorsimaculata* Shiino, 1933 infesting *Periclimenes* sp. from Japan. This genus can be easily distinguished from similar genera such as *Bopyrina* Kossmann, 1881, *Bopyrinella* Nierstrasz & Brender à Brandis, 1925 and *Bopyrus* Latreille, 1802, by the prominent lateral plates on its pleon, suggestive of the Pseudioninae Codreanu, 1967. However, the widely open brood pouch, uniramous pleopods and medially fused pleon all indicate that this genus belongs in the Bopyrinae. Markham (1990) described a second species, *Bopyrinina paucimaculata* Markham, 1990, infesting *Echinopericlimenes hertwigi* (Balss) in New Caledonia. Here we describe a third species, *B. articulata* n. sp., from French Polynesia and Saudi Arabia, infesting the alpheid shrimp *Salmoneus* cf. *gracilipes* Miya.

Bopyrinella includes six species, all parasitizing different species of Alpheoidea (Boyko et al., 2008): two from Hippolytidae, two from Alpheidae, one from Thoridae, and one from Ogyrididae (Table 1). Monod (1933) described *Bopyrinella stricticauda* Monod, 1933 from the Gulf of Suez infesting Alpheidae. Shiino (1936) described *Bopyrinella nipponica* Shiino, 1936 from Japan infesting *Heptacarpus rectirostris* (Stimpson). Shiino (1958) reported *Bopyrinella albida* Shiino, 1958 from Japan, infesting *Arete indicus* Coutière. Richardson (1904) described *Bopyrina thorii* Richardson 1904 from Florida infesting *Thor floridanus* Kingsley; the species was later transferred to *Bopyrinella* by Markham (1985a). An et al. (2015) reported *Bopyrinella parameces* An, Boyko & Li, 2015 from China infesting Ogyrididae and commented on the status of *B. stricticauda*. Recently Romero-Rodríguez & Álvarez (2020) reported *Bopyrinella hadrocoxalis* Romero-Rodríguez & Álvarez, 2020 infesting *Thor manningi* Chace from Mexico. Here, we describe a seventh species, *B. asymmetrica* n. sp., infesting the alpheid shrimp *Athanas parvus* de Man, from Philippine waters.

Kossmann (1881) erected *Bopyrina* Kossmann, 1881 for *Bopyrina ocellata* (Czerniavsky, 1868). Czerniavsky (1868) described this species as *Bopyrus ocellatus* infesting *Hippolyte leptocerus* (Heller) from the Black Sea. Bourdon (1968) described *B. ocellata* infesting Hippolytidae and Palaemonidae. Czerniavsky (1881), Bonnier (1900), Bourdon & Bruce (1983), and Kazmi & Khatoon (2016) have recorded and provided substantial detail about this species. *B. ocellata* is now recorded as widely distributed in the East Atlantic from Britain thorough the Mediteranean and Black sea, and has also been recorded from the Indo-West Pacific, from India, Japan and Australia

Table 1 Hosts and localities of 7 species of *Bopyrinella*

Species	Type host/family	Type locality	Other hosts	Other localities	References
B. albida Shiino, 1958	*Arete indicus* Coutière/Alpheidae	Japan	*Athanas dimorphus* Ortmann *Arete dorsalis* Stimpson	Thailand Hong Kong	Markham (1985a); Markham (1985b) Markham (1986); Markham (1990); Bruce (1990) Nakashima (1995)
B. nipponica Shiino, 1936	*Heptacarpus rectirostris* (Stimpson)/ Thoridae	Japan	-	-	Shiino, (1936)
B. parameces An, Boyko & Li, 2015	*Ogyrides orientalis* (Stimpson)/ Ogyrididae	Shandong Province	-	-	An, Boyko & Li, (2015)
B. stricticauda Monod, 1933	Alpheidae	Gulf of Suez	-	-	Monod, (1933); Kensley, (2001)
B. thorii (Richardson, 1904)	*Thor floridanus* Kingsley/Thoridae	Florida	-	Caribbean coast of Mexico Curacao	Romero-Rodríguez & Román-Contreras (2008, 2014) Román-Contreras & Martinez-Mayén (2011 Nierstrasz & Brender à Brandis, (1925); Shiino, 1936); Markham, (1985a)
B. hadrocoxalis Romero-Rodríguez & Álvarez, 2020	*Thor manningi* Chace/Thoridae	Quintana Roo	-	-	Romero-Rodríguez & Álvarez, (2020)
B. asymmetrica n.sp.	*Athanas parvus* de Man/Alpheidae	Philippines	-	-	The present paper

(Markham 2010). *Bopyrina* species parasitize mainly caridean shrimp of the family Hippolytidae (Bourdon, 1968; Markham 1985a). This genus is most similar to *Schizobopyrina* Markham 1985, sharing with that genus an asymmetrical oostegite 1, head fused with pereomere 1 and uniramous pleopods. According to Markham (1985a), females of *Schizobopyrina* can be distinguished from those of *Bopyrina* by the presence (vs. absence) of a maxilliped palp, elongate (vs. very small) oostegites 2–5, and at least a lateral separation of the pleomeres on both sides (vs. complete fusion of pleomeres on short side). *Bopyrina choprai* Nierstrasz & Brender à Brandis, 1929 and *Bopyrina sewelli* Chopra, 1930 have distinct pleomeres on the short side of the body as in *Schizobopyrina*. *B. choprai* is only known from the original simple description (Nierstrasz and Brender à Brandis, 1929), where the maxilliped and oostegites are not described. *B. sewelli* has an obscure maxilliped palp, represented by a slight extension along the anterior margin of the maxilliped that bears a single short seta, and oostegites 2-5 are greatly reduced and transparent, making it difficult to discern their exact shape. Thus *B. choprai* fits *Schizobopyrina* in the one character known, while *B. sewelli* mixes characters from the two genera. Additional information, ideally molecular phylogenetic data are needed to resolve the placement of these species. Here we record *B. ocellata* from Florida, the first occurrence of this species in the West Atlantic.

Materials and methods

The present specimens are deposited in the Invertebrate Zoology collections of the Florida Museum of Natural History, University of Florida (UF) and preserved in 75–95% ethanol. Type of *Bopyrinella asymmetrica* was repatriated to the National Museum of the Philippines, Manila (NMCR). Specimen were viewed and drawn using a LEICA-MZ16 stereomicroscope, the figures were scanned using a CanonScan 9900F, and finalized with a drawing tablet and Adobe Illustrator. A male studied by scanning electron microscope was postfixed in 2.5% glutaraldehyde in 0.2 M Millonig's phosphate buffer at pH 7.4 for 1.5h, then in 1% osmium tetroxide in 0.2M Millonig's buffer for 1h, and dehydrated through a graded series of ethanol, followed by critical point drying. After sputter coating with colloidal gold, it was examined with a KYKY2800B scanning electron microscope.

Bopyridae Rafinesque, 1815
Bopyrinae Rafinesque, 1815
***Bopyrinina* Shiino, 1933**
***Bopyrinina articulata* n. sp.**

Type-host: Salmoneus cf. *gracilipes* Miya (Alpheidae, UF Arthropoda 16483) male.
Type-locality: French Polynesia, Society Islands, Moorea Island, Gump reef, in front of waterfront bungalows, silty fringing reef in bay, under rocks 0–1 meter; 17.4902°S; 149.826°W; 19 Nov 2008, coll. A. Anker.
Type-specimens: Holotype female, paratype male (UF Arthropoda 16484), from right branchial chamber of host.
Other material paratype female (UF Arthropoda 47905), infesting right branchial chamber of *Salmoneus* cf. *gracilipes* Miya (UF Arthropoda 23899) female, without eggs, French Polynesia, Society Islands, Moorea Island, Papetoai lagoon, 0.5–1meters 17.491°S, 149.883°W, 3 Nov. 2009, coll. A. Anker, T. Lotufo. Non-type female and male (UF Arthropoda 47904), infesting left branchial chamber of *Salmoneus* cf. *gracilipes* Miya (UF Arthropoda 36070), male, Saudi Arabia, off Thuwal, Shib Nazar east offshore reef, 22.322°N, 38.855°E, 0-20 m, 16 Mar 2013, A. Anker, P. Norby, J. Moore, J. Bouwmeester.

Description

Holotype female [UF Arthropoda 16484; Fig. 1]. Body length 2.25 mm, width (across third pereomere) 1.63mm, head length 0.38 mm, head width 0.58 mm, pleon length 0.63 mm. All pereomeres except first distinct, pleomeres medially indistinct, body with about 40° sinistral distortion (Fig. 1A, B).

Head wider than long, with bilobate posterior margin, fused with pereomere 1 medially, with well-developed frontal lamina (Fig. 1A). Irregular black eyes at border of anterior margin and frontal lamina (Fig. 1A). Antennula and antenna of three and four articles, respectively, both with stout basal article and terminally setose (Fig. 1C). Barbula with a pair of short, falcate lateral projections on each side (Fig. 1D). Maxilliped approximately triangular, with

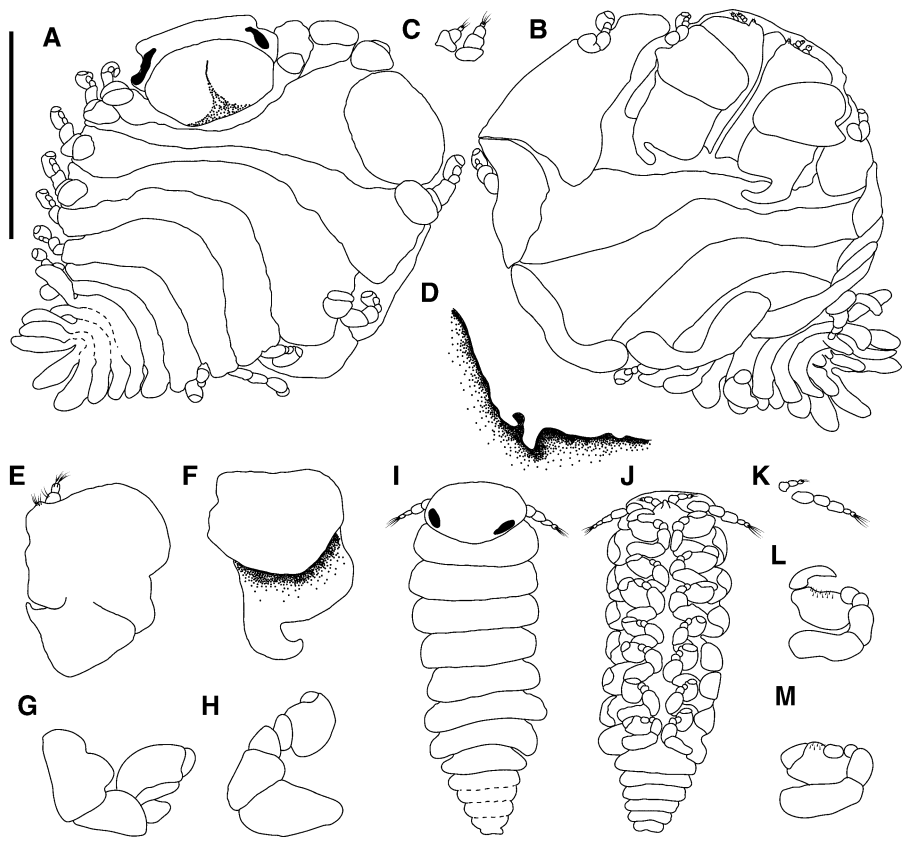

Fig. 1 *Bopyrinina articulata* n. sp., female (A–H). A, Dorsal view; B, Ventral view; C, Right antenna and antennula; D, Right side of barbula; E, Left maxilliped, external view; F, Right oostegite 1, internal view; G, Right pereopod 1; H, Left pereopod 7. Male (I–M). I, Dorsal view; J, Ventral view; K, Left antenna and antennula; L, Right pereopod 1; M, Right pereopod 7. Scales, 1 mm (A, B); 0.79 mm (C, F); 0.55 mm (D, E, I, J, K); 0.32 mm (G, H, L, M)

setose, articulated palp, plectron sharp, anterior segment twice as long as posterior one (Fig. 1E).

Pereon broadest across third pereomere (Fig. 1A, B). First four pereomeres with dorsolateral bosses, those on the long side slightly larger than those on the short side. Small coxal plates present on pereomeres 1–4 of short side and pereomeres 2–4 of long side; that on first pereomere of long side much larger than others. Tergal projections indistinct on short side, but distinct on long side, especially that on pereomere 2 much larger than others (Fig. 1A). Brood pouch widely open. Oostegite 1 visible in ventral view (Fig. 1B), with slightly concave anterior margin, curved posterior margin, internal ridge entire, and large, blunt-tipped, hook-like posterolateral extension directed medially (Fig. 1F). Pereopods similar in shape, posterior pereopods larger than anterior, with blunt dactyli (Fig. 1G, H).

Pleon distorted, medially fused, pleomeres 1–5 and pleotelson with lamellar lateral plates, first pleopod biramous with small globose endopodite, pleopods 2–5 uniramous and smaller than corresponding lateral plates. Pleotelson with uniramous uropods (Fig. 1A, B).

Paratype male (UF Arthropoda 16484): Body length 0.97 mm, maximal width (across second pereomere) 0.31 mm, head length 0.17 mm, head width 0.24 mm. All pereomeres distinct (Fig. 1I).

Head subovate with curved posterior margin (Fig. 1I). Irregular black eyes near posterolateral corners (Fig. 1I). Antennula with three articles, antenna with five articles, both terminally setose, antenna extending beyond head (Fig. 1J, K).

Pereomeres distinct, of subequal width, lacking midventral tubercles (Fig. 1J). All pereopods with six articles, with slender bases; pereopod 1 much larger

than others, with especially sharp, pointed dactyli (Fig. 1J, L, M).

Pleon of six pleomeres, first pleomere distinct, narrower than pereomere 7. Pleomeres 2–5 medially indistinct dorsally, pleomere 5 and pleotelson completely fused, but indicated by lateral indentations. All pleomeres distinct ventrally (Fig. 1J). Pleopods and uropods lacking (Fig. 1J).

Etymology: The specific name, *articulata* refers to the articulated palp of maxilliped in females and the ventral separation of pleomeres in males.

Remarks

The new species is placed *Bopyrinina* because of the distorted pleon, well-developed frontal lamina, widely open brood pouch, and medially fused pleomeres of females, and lack of pleopods and uropods in males. It is distinguished from both of the other two known species of the genus, *B. dorsimaculata* and *B. paucimaculata,* by the following characters of the female: articulated maxilliped palp (vs. unarticulated), biramous pleopod 1 and uniramous pleopods 2–5 (vs. four pairs of uniramous pleopods), oostegite 1 with curved posterior margin and hook-like posterolateral extension (vs. straight posterior margin and without posterolateral extension). Males differ from these two species in their pleomeres being distinct ventrally (vs. completely fused). This the first record of a parasitic isopod from the alpheid genus *Salmoneus*.

Bopyrinella Nierstrasz & Brender à Brandis, 1925

Bopyrinella asymmetrica n. sp.

Type-host: Athanas parvus de Man (UF Arthropoda 43254), male.

Type-locality: Philippines, Mindoro Island, Puerto Galera, SW of Paniquian Island, slope with sand and rhodoliths, patch reefs, lots of algae, 10-12m, 13.51369°N, 120.9404°E; 25 April 2015, coll. G. Paulay.

Type specimens: Holotype female, paratype male NMCR 50789, (ex UF Arthropoda 42809), from right branchial chamber of *Athanas parvus* de Man.

Description

Holotype female [ex UF Arthropoda 42809; Figs. 2, 3]. Body length 2.39 mm, maximal width (across second pereomere) 1.43 mm, head length 0.36 mm, head width 0.57 mm, pleon length 0.73 mm. Body highly asymmetrical, with about 40° dextral distortion (Fig. 2A, B).

Head wider than long, roughly trapezoidal, deeply embedded into pereomere 1. Head with well-developed frontal lamina, with small black eyes at border between frontal lamina and head (Fig. 2A). Antennula with three articles, terminal article much smaller than other two articles, terminally setose; antenna lacking (Fig. 2C). Barbula without any projections, posterior margin entire (Fig. 2D). Maxilliped subquadrate, without palp, plectron short and blunt (Fig. 2E).

Pereon broadest across pereomere 2, all pereomeres distinct (Fig. 2A). First four pereomeres of long side with round dorsolateral bosses and slender coxal plates. All pereomeres of short side with round dorsolateral bosses, but only first pereomere with small coxal plate. Brood pouch completely open, first five pairs of oostegites well-developed and lamellar, oostegites 6, 7 small, restricted to near bases of pereopods 6, 7 (Fig. 3B). Oostegite 1 of two sides asymmetrical, right one subquadrate, with blunt posterolateral point, smooth internal ridge and serrated posterior margin (Fig. 2F, G), left one with substantial posterolateral extension, almost smooth internal ridge, and entire posterior margin (Fig. 2H, I). Pereopods all similar, with blunt dactyli (Fig. 2J).

Pleon of six pleomeres, with marked medial depression. Pleomere 1 distinct, 2–5 separated on long side, but fused in middle and on short side (Fig. 2A, B). Five pairs of uniramous pleopods. Pleotelson greatly distorted, without uropods (Fig. 2B).

Paratype male (ex UF Arthropoda 42809): length 0.78 mm, maximal width (across fourth pereomere) 0.30 mm, head length 0.13 mm, head width 0.19 mm. All body regions and segments distinct, with scattered irregular black pigment spots on dorsal surface (Fig. 2K).

Head subovate with curved posterior margin (Fig. 2K). Black eyes in posterolateral corners (Fig. 2K). Antennula with three articles, antenna with four articles, both terminally setose (Fig. 3A, B).

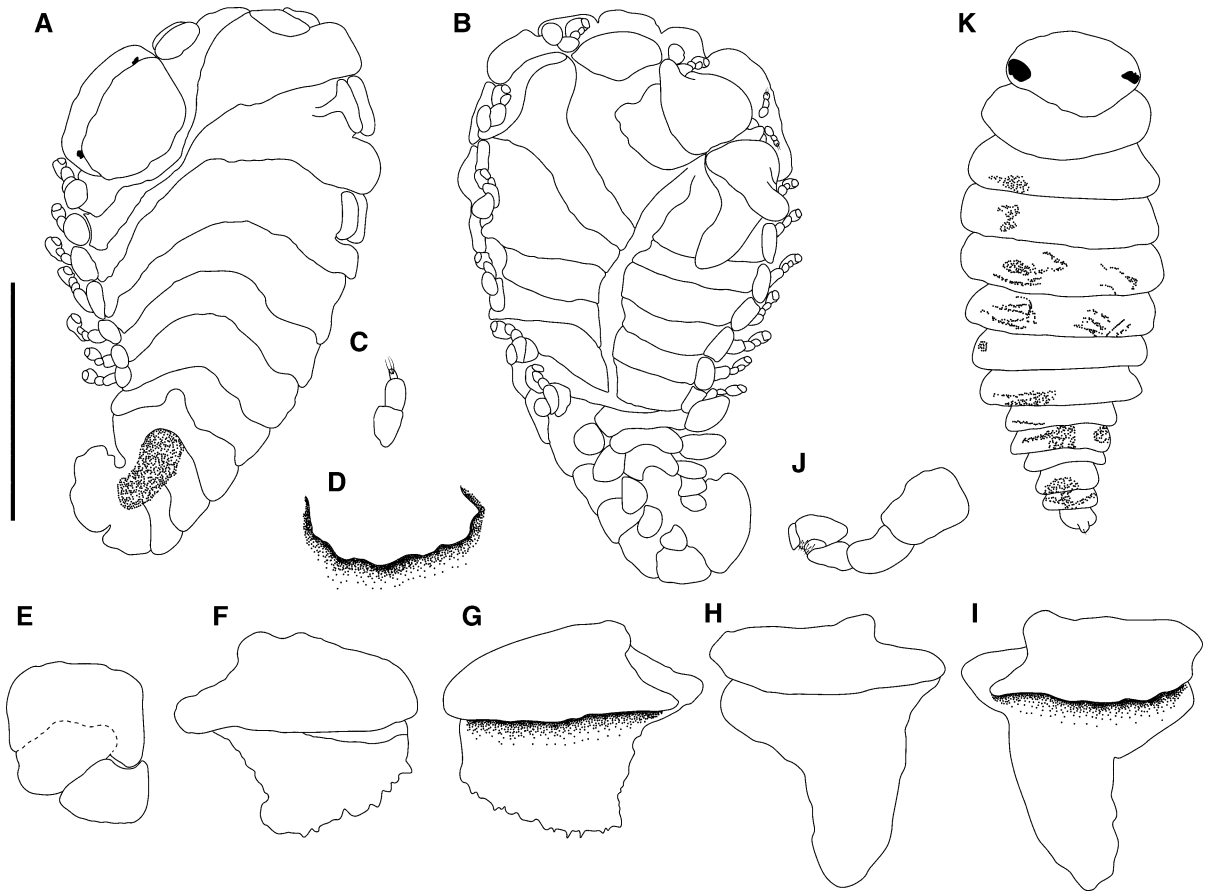

Fig. 2 *Bopyrinella asymmetrica* n. sp., female (A–J). A, Dorsal view; B, Ventral view; C, Right antennula; D, Barbula; E, Right maxilliped, external view; F, Right oostegite 1, external view; G, Right oostegite 1, internal view; H, Left oostegite 1, external view; I, Left oostegite 1, internal view; J, Right pereopod 6. Male. K, Dorsal view. Scale, 1 mm (A, B); 0.50 mm (C, E, F, G, H, I, J); 0.80 mm (D); 0.35 mm (K)

Pereon subparallel, slightly narrowing toward anterior and posterior, pereomeres of subequal width (Fig. 2K,3A). Pereopods all of similar size and structure (Fig. 3C, D), with scales on the ventral surface of meri, carpi and propodi.

Pleon of six pleomeres, abruptly narrower than pereon (Fig. 2K, 3A). Five pairs of tuberculate pleopods (Fig. 3E, F). Pleotelson round, anal cone discernible (Fig. 2K, 3E), with setae adjacent to anal cone (Fig. 3G).

Etymology: The specific name, *asymmetrica* refers to the highly asymmetrical body, including the markedly distorted pleotelson in the female.

Remarks

The new species is assigned to *Bopyrinella* because the female has an elongated, distorted body, oostegite 1 is well developed and asymmetrical, the brood pouch is widely open, and there are five pairs of uniramous pleopods (An et al., 2015; Nierstrasz and Brender à Brandis, 1925). There are six recognized species in this genus. An, Boyko and Li (2015) reviewed *Bopyrinella* when they described the fifth species. The present species is most similar to *B. albida*, but females differ in having black eyes (vs. without eyes), all pereomeres of short side with round dorsolateral bosses (vs. only first four pereomeres with dorsolateral bosses), a sharply distorted pleotelson (vs.

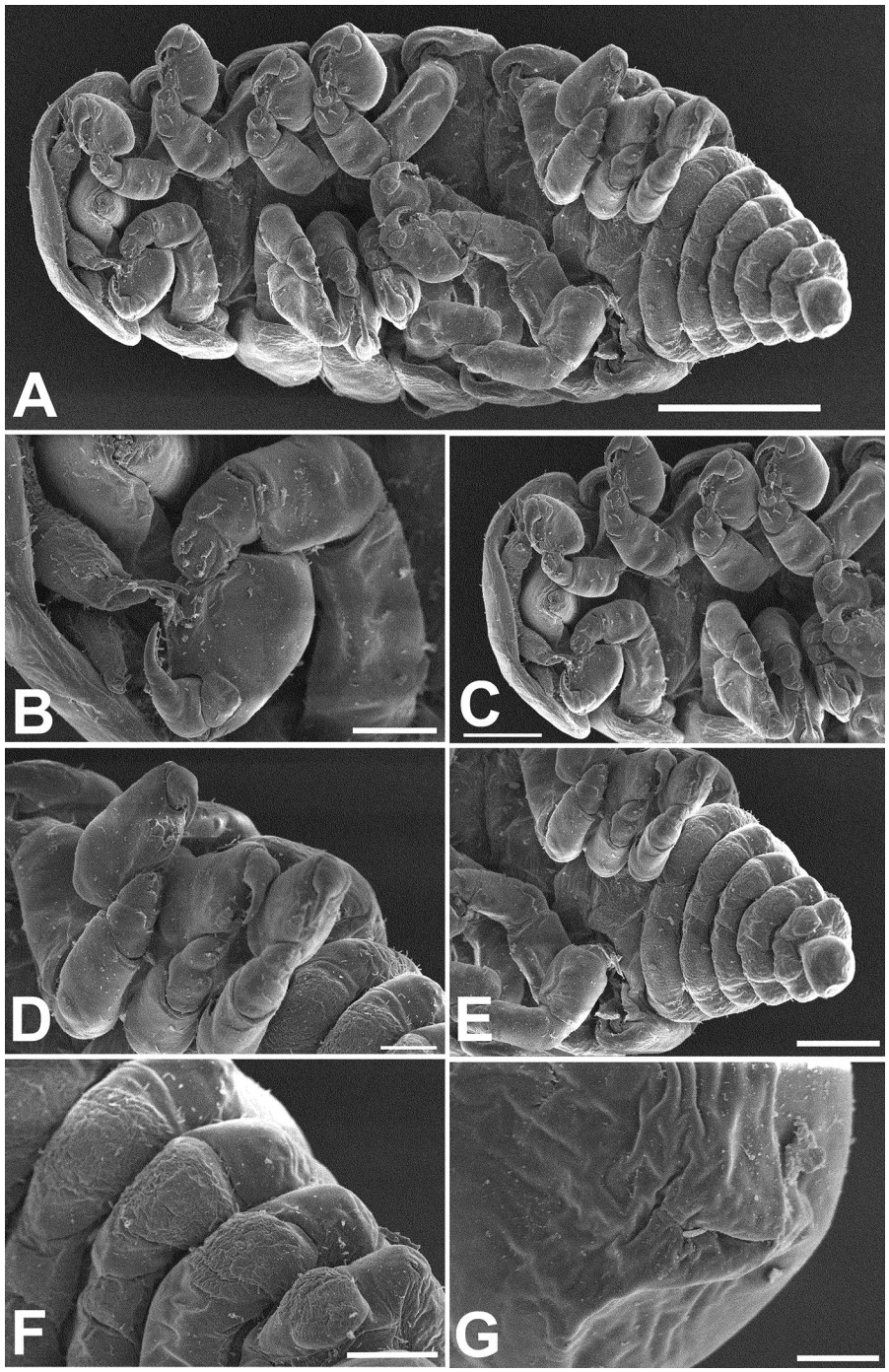

Fig. 3 *Bopyrinella asymmetrica* n. sp., Scanning Electron Micrograph of paratype male (A–G): A, Ventral view; B, Right antennae and pereopod 1; C, First four pereopods; D, Left pereopods 5–7; E, Ventral view of pleon; F, Left tuberculated pleopods 2–5; G, Terminal point of the pleon. Scales, 100 um (A); 20 um (B, D, F); 50 um (C, E); 5 um (G)

straight, undistorted), distinct pleomere 1 (vs. medially fused), and pleomeres of short side completely fused (vs. separated by lateral indentation). The present species also differs from the recently reported species *B. hadrocoxalis* in having a distinct frontal lamina on the head (vs. without frontal lamina),

maxilliped without palp (vs. maxilliped with a non-articulated palp), barbula without any projection (vs. barbula with single smooth and small projection on each side), clearly uniramous pleopods (vs. pleopods 1–4 with thick rounded bulges produced by deep division giving appearance of biramous pleopods).

Key to six species of genus *Bopyrinella* (based on females).

1 Four pairs of pleopods … *B. thorii* (Richardson, 1904)
- Five pairs of pleopods … 2
2 Maxilliped with palp … 3
- Maxilliped without palp … 4
3 All pleomeres fused on short side of the body … *B. hadrocoxalis* Romero-Rodríguez & Álvarez, 2020
- All pleomeres separated on short side of the body… *B. nipponica* Shiino, 1936
4 Head with frontal lamina, seven pairs of oostegites …5
- Head without frontal lamina, five pairs of oostegites … 6
5 Pleotelson straight, in line with rest of pleon… *B. albida* Shiino, 1958
- Pleotelson curved, sharply distorted … *B. asymmetrica* n. sp.
6 With black eyes, terminal margin of pleotelson entire … *B. stricticauda* Monod, 1933
- Without eyes, terminal margin of pleotelson indentated … *B. parameces* An, Boyko & Li, 2015

Bopyrina Kossmann, 1881

Bopyrina ocellata (Czerniavsky, 1868)

Bopyrus ocellatus Czerniavsky, 1868: 79; pl. VI, figs 1–3.
Bopyrus virbii Walz, 1881: 159–164; Kossmann, 1881: 667; Walz, 1882: 200.
Bopyrina ocellata Czerniavsky,1881: 529; Bourdon, 1968: 388; Giard & Bonnier, 1890: 383; Bonnier, 1900: 48,61, 221, 369–370, 381, fig. 60; Bourdon, 1968: 188, 388–409, figs 183–190, tables 64–68, graphs 27–30; Bourdon & Bruce, 1983: 99; Lester & Sewell, 1989: 120,125; Humphrey, 1995: table 48; Poore *et al.*, 2002: 117; Shimomura *et al.*, 2006: 1, 4–7, figs 3, 4; Markham, 2010: 9–10, figs 10. Kazmi & Khatoon, 2016: 152–154, figs 153, 154.
Bopyrina ocellata var. (sic) *mediterranea* -Giard & Bonnier, 1890: 383 [synonymised with *Bopyrina virbii*].
? *Bopyrina nitescens* Giard & Bonnier, 1890: 383 [nomen nudum].
Bopyrina hippolytes Giard & Bonnier, 1890: 384 [nomen nudum].
Bopyrina giardi Bonnier, 1900: 14, 18, 24–27, 48, 61, 83, 165, 365–368, 372, 382, 471–476; pls XXXIX, XL.
Bopyrina sullata [sic]; Bonnier, 1900: 382 [list of hosts and localities known].
Bopyrina giardi -Tattersall, 1911: 268, fig. 203; Chopra, 1923: 417, 418, 523–527, 532–534; text fig. 31; Motaş & Bãleanu, 1937: 164–172, figs 1–6; Bourdon, 1968: 388, 396–397.
Bopyrina ocellatus [sic] — Chopra, 1923: 542.
Bopyrella [sic] *ocellata* — Restivo, 1971: 153.
? *Bopyrella* (?) *nitescens* — Bourdon, 1980: 233.
? *Bopyrina ocellata* — Tsukamoto, 1981: 394–401, figs 1–21, table 1.

Host:Hippolyte zostericola (Smith) (UF Arthropoda 43847), female, without eggs.
Locality: USA, Florida, Monroe County, Florida Keys, Tennessee Reef, 6 m, exposed octocoral-dominated reef, with sand and rubble, extracted from rubble breaking; 24.7651°N; 80.7542°W, 3 May 2010, coll. F. Michonneau, G. Paulay, S. McPherson, M. Bemis, H. Lin, J. Moore, N. Evans.
Specimens: Female, male (UF Arthropoda 26172), from right branchial chamber of *Hippolyte zostericola* (Smith).

Re-Description

Female [UF Arthropoda 26172; Fig. 4.] Body length 1.45 mm, maximal width (across third pereomere) 0.90 mm, head length 0.37 mm, head width 0.52 mm, pleon length 0.39 mm. Body pyriform, with about 40° sinistral distortion, most marked at head (Fig. 4A).

Head wider than long, widest at front, trapezoidal, without frontal lamina, with irregular black eyes near anterior margin, separated from first pereomere (Fig. 4A). Antennula and antenna not discernible (Fig. 4B). Barbula with a pair of tiny projections (Fig. 4B). Maxilliped triangular, anterior article much bigger than posterior one, without palp, plectron blunt (Fig. 4C).

Pereon broadest across pereomere 3, all pereomeres fused across middle and on short side, but demarcated on long side (Fig. 4A). Coxal plates and dorsolateral bosses absent, but the first three pereomeres of right

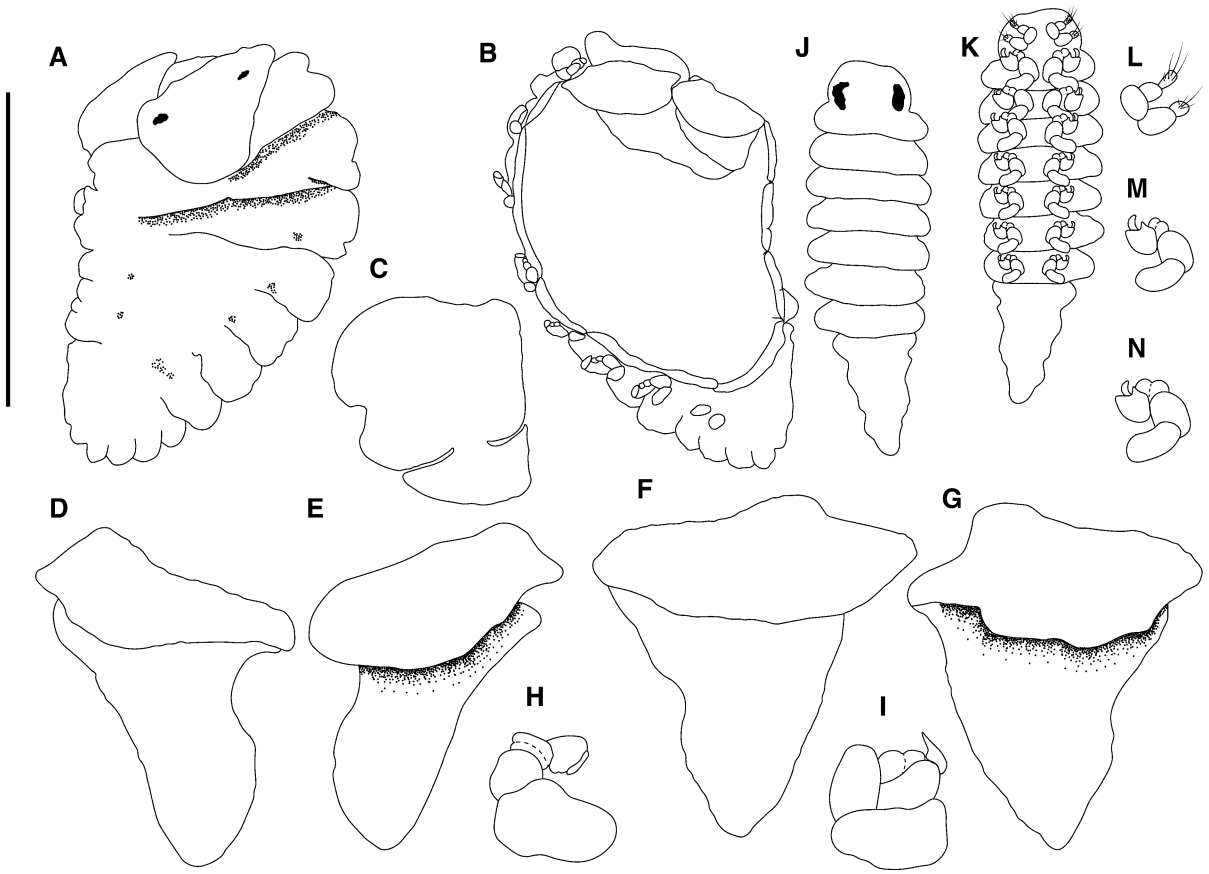

Fig. 4 *Bopyrina ocellata* (Czerniavsky, 1868), female (A–I). A, Dorsal view; B, Ventral view; C, Right maxilliped, external view; D, Right oostegite 1, external view; E, Right oostegite 1, internal view; F, Left oostegite 1, external view; G, Left oostegite 1, internal view; H, Left pereopod 1; I, Left pereopod 7. Male (J–N): J, Dorsal view; K, Ventral view; L, Left antenna and antennula; M, Right pereopod 1; N, Right pereopod 7. Scales, 1 mm (A, B); 0.43 mm (C, D, E, F, G, J, K); 0.2 mm (H, I, L, M, N)

side with bilobate margins, especially pronounced in second pereomere, where it is almost produced into a tergal projection. Boundaries between the first three pereomeres marked with a pigmented band on the long side. Brood pouch widely open, oostegite 1 visible from ventral view (Fig. 4B). First oostegite asymmetrical, right slightly smaller than left, both with smooth internal ridge (Fig. 4D, E, F, G). Other oostegites greatly reduced into small, narrow plates (Fig. 4B). Pereopods similar in size and morphology, carpi and meri fused, with small and blunt dactyli (Fig. 4H, I).

Pleomeres indistinct, pleomeres 1–4 discernable by marginal indentations on right side only, not on left (Fig. 4A, B). Only two small uniramous pleopods present on right side, pleopods absent on left. Uropod lacking (Fig. 4B).

Male (UF Arthropoda 26172): Length 0.56 mm, maximal width (across third pereomere) 0.18 mm, head length 0.06 mm, head width 0.08 mm. Pereomeres distinct (Fig. 4J).

Head subovate, fused with, but much narrower then, first pereomere (Fig. 4J). Black eyes in posterolateral corners (Fig. 4J). Antennula and antenna of three and two articles, respectively, terminally setose (Fig. 4K, L).

Pereomeres of subequal width, sides of pereon nearly parallel (Fig. 4J, K). Pereopods all of similar shape, but decrease in size posteriorly, dactyli short, hook-like (Fig. 4M, N).

Pleon fused into single piece, with marginal indentations vaguely demarcating pleomeres, abruptly narrower than pereon (Fig. 4J, K). Pleopods and uropods lacking (Fig. 4J, K).

Remarks

Czerniavsky (1868) described this species as *Bopyus ocellatus* infesting *Hippolyte leptocerus* (Heller) from the Black Sea. This species has since been redescribed many times and recorded widely in the East Atlantic from Britain thorough the Mediteranean and Black sea, and the Indo-West Pacific from India, Japan and Australia (Markham, 2010). Here we add Florida, in the West Atlantic, as a new region for this species. The broad range spanning the Atlantic and Indo-West Pacific raises the possibility that *B. ocellatus* as presently defined may be a species complex, a possibility supported by observed morphological variation, and best tested through genetic study. The present range extension between the East and West Atlantic is a more typical species distribution. Bourdon (1968) provided a thorough description, with detailed figures. The present specimens match those described by Bourdon (1968) well, but show some differences: the female lacks a frontal lamina and has only two pleopods on the right side. Shimomura et al. (2006) described a *Bopyrina ocellata* female with an obscure frontal lamina and three pairs pleopods, not four pairs as found by Bourdon (1968). These characters are known to vary with maturity, see Bourdon (1968: fig. 189 a-c) showing variation in pleopods with different stages. Nevertheless, these differences may indicate that the West Atlantic specimens represent a cryptic species.

Key to species of *Bopyrina* (based on females).

1 Coxal plates present on pereomeres 2–4 on long side … *B. gigas* Nierstrasz & Brender à Brandis, 1923

- Coxal plates absent … 2

2 Head separated from pereomere 1 … *B. abbreviata* Richardson, 1904

- Head fused with pereomere 1 … *B. ocellata* (Czerniavsky, 1868)

Acknowledgements We are indebted to reviewers and all collectors (A. Anker, T. Lotufo; P. Norby, J. Moore, J. Bouwmeester. F. Michonneau, S. McPherson, M. Bemis, H. Lin, N. Evans) of specimens in the Florida Museum of Natural History and NSF (DEB 1856245) for support. Field work in French Polynesia was supported by the Gordon and Betty Moore Foundation (Moorea Biocode project), in the Philippines by NSF (DEB 1257630, PI: Terrence Gosliner), and in Saudi Arabia by KAUST (URF/1/1389-01-01 to M.L. Berumen).

Authors' contributions Jianmei An conceived the study and identified all specimens; Qianqian Xi prepared the figures and wrote the manuscript; Gustav Paulay identified all hosts and provided all the specimens for identification and revised the manuscript.

Funding This work was supported by the National Natural Science Foundation of China (No. 31471970; No. 32070512) (Jianmei An) and a Program of Ministry of Science and Technology of the People's Republic of China (2015FY210300) (Jianmei An) and Natural Science Foundation of Shanxi Province (No. 201901D111274) (Jianmei An).

Compliance with ethical standards

Conflict of interest The authors declare that they have no competing interest.

Ethical approval These specimens, housed in the Florida Museum collections, were collected under permits of the respective projects listed in the acknowledgements.

References

An, J., Boyko, C. B., & Li, X. (2015). A review of bopyrids (Crustacea: Isopoda: Bopyridae) parasitic on Caridean Shrimps (Crustacea: Decapoda: Caridea) from China. *Bulletin of the American Museum of Natural History, 399,* 1–85.

Bonnier, J. (1900). Contribution à l'étude des épicarides. Les Bopyridae. *Travaux de l'lnstitut Zoologique de Lille et du Laboratoire de Zoologie Maritime de Wimereux, 8,* 1–478.

Bourdon, R. (1968). Les Bopyridae des mers européennes. *Mémoires du Muséum National d'Histoire Naturelle, Série A, Zoologie, 50,* 77–424.

Bourdon, R. (1980). Les espèces du genre *Bopyrella* J. Bonnier (Crustacea, Isopoda, Bopyridae). *Bulletin du Muséum national d'Histoire naturelle, Section A, Zoologie, Biologie et Ecologie Animales, Paris, 4e série,* 185–236.

Bourdon, R., & Bruce, A. J. (1983). Six bopyrid shrimp parasites (Isopoda, Epicaridea) new to the Australian fauna. *Crustaceana, 45,* 96–106.

Boyko, C. B., Bruce, N. L., Hadfield, K. A., Merrin, K. L., Ota, Y., Poore, G. C. B., et al. (2008). *World Marine, Freshwater and Terrestrial Isopod Crustaceans database, Bopyrinae Rafinesque, 1815.* World Register of Marine Species. Accessed 16 September 2020, from http://www.marinespecies.org.

Bruce, A. J. (1990). Redescriptions of five Hong Kong carideans first described by William Stimpson, 1860. In: Morton, B. (Ed.), Proceedings of the Second International Marine Biological Workshop: *The Marine Flora and Fauna of Hong Kong and Southern China* (pp. 569–610). Hong Kong: Hong Kong University Press.

Chopra, B. (1923). Bopyrid isopods parasitic on Indian Decapoda Macrura. *Records of the Indian Museum, 25,* 411–550.

Czerniavsky, V. (1868). Materialia a d Zoographiam Ponticam Comparatam. *Transactions of the First Meeting of the Russian Naturalists in Saint Petersburg, 1868,* 1–136.

Czerniavsky, V. (1881). Wissenschaftliche Mittheilhungen. 6. Berichtigung. *Zoologischer Anzeiger, 4*(94), 528–529.

Giard, A., & Bonnier, J. (1890). Prodrome d'une monographie des épicarides du Golfe de Naples. *Bulletin Scientifique de la France et de la Belgique, 22,* 367–391.

Humphrey, J. D. (1995). Australian quarantine policies and practices for aquatic animals and their products: a review for the Scientific Working Party on Aquatic Animal Quarantine. Part 1. Review and annexes. Part 2, Appendixes. Parkes, Australian Capital Territory.

Kazmi, Q. B., & Khatoon, N. (2016). *A Compendium of Crustaceans of Pakistani Waters Living in Partnership, Concise compilation of symbiotic crustaceans of Pakistan with all necessary information (with a chapter on IIOE samples).* Germany: LAP LAMBERT Academic Publishing.

Kensley, B. (2001). Biogeography of the marine Isopoda of the Indian Ocean, with a check-list of species and records. *Crustacean Issues, 13,* 205–264.

Kossmann, R. (1881). Studien über Bopyriden. *Zeitschrift für Wissenschaftliche Zoologie, 35,* 652–665.

Lester, R. J. G., & Sewell, K. B. (1989). Checklist of parasites from Heron Island, Great Barrier Reef. *Australian Journal of Zoology, 37,* 101–128.

Markham, J. C. (1985a). A review of the bopyrid isopods infesting caridean shrimps in the northwestern Atlantic Ocean, with special reference to those collected during the Hourglass Cruises in the Gulf of Mexico. *Memoirs of the Hourglass Cruises, 8,* 1–156.

Markham, J. C. (1985b). Additions to the bopyrid isopod fauna of Thailand. *Zoologische Verhandelingen, 224,* 1–63.

Markham, J. C. (1986). Evolution and zoogeography of the Isopoda Bopyridae, parasites of Crustacea Decapoda. In R. H. Gore & K. L. Heck (Eds.), *Crustacean biogeography* (pp. 143–164). London: Routledge.

Markham, J. C. (1990). Further notes on the Isopoda Bopyridae of Hong Kong. In: Morton, B. (Ed.), *Proceedings of the Second International Marine Biological Workshop: the marine flora and fauna of Hong Kong and Southern China* (pp. 555–568). Hong Kong: Hong Kong University Press.

Markham, J. C. (2010). The isopod parasites (Crustacea: Isopoda: Bopyridae) of decapod Crustacea of Queensland, Australia, with descriptions of three new species. In: Davie, P. J. F., Phillips, J. A. (Eds), *Proceedings of the 13th International Marine Biological Workshop, Marine Fauna and Flora of Moreton Bay, Queensland. Memoirs of the Queensland Museum, Nature, 54,* 151–197.

Monod, T. (1933). Tanaidacea et Isopoda. Mission Robert-Ph. Dollfus en Égypte. *Mémoires del´Institut d´Égypte, 21,* 162–264.

MotaÕ, C., & Bãleanu, A. (1937). Notes sur *Bopyrina giardi* Bonnier, épicaride parasite d'*Hippolyte varians* Leach, suives de quelques observations sur son hôte. *Annales de la Universitć de Iassy, 23,* 164–172.

Nakashima, Y. (1995). Can small male shrimps achieve copulation in the presence of larger ones? *Journal of Ethology, 13,* 9–16.

Nierstrasz, H. F., & Brender à Brandis, G. A. (1925). Bijdragen tot de kennis der fauna van Curaçao. Resultaten eener reis van Dr. C.J. van der Horst in 1920, Epicaridea. *Bijdragen tot de Dierkunde, 24,* 1–8.

Nierstrasz, H. F., & Brender à Brandis, G. A. (1929). Papers from Dr. Th. Mortensen's Pacific Expedition 1914–16. XLVIII. Epicaridea. I. *Videnskabelige Meddedelser fra den Dansk Naturhistoriske Forening i København, 87,* 1–44.

Poore, G. C. B., Markham, J. C., & Lew Tan, H. M. (2002). Crustacea: Malacostraca: Syncarida, Peracarida: Isopoda, Tanaidacea, Mictacea, Thermosbaenacea, Spelaeogriphacea. In W. W. K. Houston & P. L. Beesley (Eds.), *Zoological catalogue of Australia* (pp. 111–137). Melbourne: CSIRO Publishing.

Restivo, F. (1971). Su di una nuova specie di *Cabirops* parassita di *Pseudione*. *Pubblicazioni della Stazione Zoologica di Napoli, 39,* 70–86.

Richardson, H. (1904). Contributions to the Natural History of the Isopoda. *Proceedings of the United States National Museum, 27,* 1–89.

Román-Contreras, R., & Martinez-Mayén, M. (2011). Registros nuevos de parásitos epicarideos (Crustacea: Isopoda) en México y suroeste de México. *Revista Mexicana de Biodiversidad, 82,* 1145–1153.

Romero-Rodríguez, J., & Álvarez, F. (2020). *Bopyrinella hadrocoxalis* sp. nov. and *Loki circumsaltanus* Markham (Isopoda: Bopyridae) parasitizing shrimps of the genus *Thor* (Decapoda: T-horidae) in Mexican waters. *Zootaxa, 4808*(3), 560–570.

Romero-Rodríguez, J., & Román-Contreras, R. (2008). Aspects of the reproduction of *Bopyrinella thorii* (Richardson, 1904) (Isopoda, Bopyridae), a branchial parasite of *Thor floridanus* Kingsley, 1878 (Decapoda, Hippolytidae) in Bahía de la Ascensión, Mexican Caribbean. *Crustaceana, 81,* 1201–1210.

Romero-Rodríguez, J., & Román-Conteras, R. (2014). Relationships of the branchial parasite *Bopyrinella thorii* (Isopoda, Bopyridae) and its host *Thor floridanus* (Decapoda, Hippolytidae). *Crustaceana, 87,* 463–475.

Shiino, S. M. (1933). Bopyrids from Tanabe Bay. *Memoirs of the College of Science, Kyoto Imperial University, 8,* 249–300.

Shiino, S. M. (1936). Bopyrids from Tanabe Bay, III. *Memoirs of the College of Science, Kyoto Imperial University (B), 11*(3), 157–174.

Shiino, S. M. (1958). Note on the bopyrid fauna of Japan. *Report Faculty of Fisheries. Prefectural University of Mie, 3,* 29–73.

Shimomura, M., Ohtsuka, S., & Sakakihara, T. (2006). Two bopyrid isopods infesting caridean shrimp *Hippolyte* sp. in the Seto Inland Sea, western Japan (Crustacea: Peracarida). *Bulletin of the Kitakyushu Museum of Natural History and Human History, 4,* 1–7.

Tattersall, W. M. (1911). Die nordischen Isopoden. *Nordisches Plankton VI,* 181–313.

Tsukamoto, R. Y. (1981). *Bopyrina ocellata* (Czerniavsky,1868), isópode parasita assinalada pelaprimeira vez no Atlântico sul. (Epicaridea, Bopyridae). Morfologia, desenvolvimento e distribuição geográfica. *Ciencia e Cultura São Paulo, 33*(3), 394–401.

Walz, R. (1881). Über den Organismus der Bopyriden. *Vorläufige Mittheilung. Zoologischer Anzeiger, 4*(79), 159–164.