

## Marine Record

**Cite this article:** Romero-Rodríguez J, Álvarez F (2025). First parasitic bopyrid isopod of the genus *Ionella* (Epicaridea: Pseudioninae) in the Atlantic. *Journal of the Marine Biological Association of the United Kingdom* **105**, e2, 1–7. <https://doi.org/10.1017/S002531542400122X>

Received: 17 September 2024

Revised: 4 December 2024

Accepted: 5 December 2024

### Keywords:

Bopyridae; ectoparasite; ghost shrimp; Montepío; *Neocallichirus*; Veracruz

### Corresponding author:

Fernando Álvarez;

Email: [falvarez@ib.unam.mx](mailto:falvarez@ib.unam.mx)

# First parasitic bopyrid isopod of the genus *Ionella* (Epicaridea: Pseudioninae) in the Atlantic

Jesús Romero-Rodríguez  and Fernando Álvarez 

Colección Nacional de Crustáceos, Instituto de Biología, Universidad Nacional Autónoma de México (UNAM), Ciudad de México, México

## Abstract

*Ionella fimbriata* sp. nov. is described from a pair of bopyrid isopods attached to a male specimen of the ghost shrimp *Neocallichirus grandimana* collected in Veracruz, Mexico. This is the fifth species belonging to *Ionella* but the first one recorded from the Atlantic Ocean, which represents an important extension of its distribution range because until now all *Ionella* species were known from the Pacific Ocean. Females of *I. fimbriata* sp. nov. can be differentiated from the others of the genus by a barbula with one stout, acute, falcate projection on each side and medial margin with triangular rounded projections; seven pairs of pereopods with elongate cuticular extensions on bases and ischia, and five pairs of tuberculated biramous pleopods of pinnate shape. Males can be recognized by five pairs of globose biramous pleopods, in which endopods are longer than exopods, and uropods longer than pleopods. Description and illustrations of both the female and male *I. fimbriata* sp. nov. are provided, as well as keys for both sexes of all species in the genus. The fecundity, embryo size and volume of *I. fimbriata* sp. nov. are reported.

## Introduction

Crustaceans commonly known as mud or ghost shrimps belong to the infraorders Axiidea and Gebiidea, both previously treated as thalassinids, have body forms adapted for burrowing in marine, primarily soft-bottom intertidal or subtidal (<200 m) areas (Dworschak, 2005). They show symbiotic associations with organisms that inhabit the burrows, among which are endoparasites, e.g. bacteria of genus *Vibrio* and *Pseudomonas*, cestodes and rhizocephalan barnacles, and ectoparasites such as copepods and bopyrid isopods (Dworschak *et al.*, 2012).

Axiideans and gebiideans are the fourth largest group of decapods, after caridean shrimps, anomurans and brachyurans, parasitized by bopyrid isopods (Boyko *et al.*, 2017). Most bopyrids of axiideans and gebiideans are ectoparasites, i.e. the female and dwarf male dwell in the hosts' branchial chamber, producing a characteristic bulge, or they can be found between the host's pleopods (*Phylloporus* Stimpson, 1857), or in a single species, *Axiophilus mirabilectus* (Markham and Dworschak, 2005), endoparasitically (Markham and Dworschak, 2005). The subfamilies Keponinae and Pseudioninae comprise species that parasitize both shrimp infraorders whereas Phylloporinae is known only from hosts in Gebiidea (Boyko *et al.*, 2017). In Mexico one species of Phylloporinae and five species of Pseudioninae have been recorded parasitizing burrowing shrimps, of them only the pseudionines *Orthione furcata* (Richardson, 1904), *Progebiophilus upogebiae* (Hay, 1917) and *Robinione overstreeti* (Adkison and Heard, 1995) are currently known to occur along the Mexican Atlantic coast (Román-Contreras, 2008; Romero-Rodríguez and Álvarez, 2021).

Examination of a pair of bopyrid isopods found in the branchial chamber of a ghost shrimp from Veracruz, Mexico, revealed that the parasite's characteristics are similar to those of the pseudionine genus *Ionella* Bonnier, 1900 which currently includes four species (Boyko *et al.*, 2023), all of them reported from the Pacific Ocean (Bonnier, 1900; Shiino, 1964a, 1964b; Danforth, 1970; Markham, 1994). The aims of this study are to provide a description of the pair of bopyrids examined and to report for the first time a species of *Ionella* from the Atlantic.

## Materials and methods

A single burrowing shrimp bearing a pair of bopyrid isopods was provided by Dr José Luis Villalobos, it was collected manually using a yabby pump on sandy substrate in the intertidal zone of Montepío beach, Veracruz, Mexico. A map and a general description of this area were provided by Hernández *et al.* (2010).

The specific host identity, size (carapace length, CL), sex (based on the position of the gonopores on the pereopods) and the shape of first pleopods were determined according to Dworschak *et al.* (2012) and Hernández *et al.* (2020). The parasites were gently removed from the host to record their total lengths (TL), measured from the anterior margin of the first pereomere of the longer side to the posterior margin of the pleon (Romero-Rodríguez and Álvarez, 2020). The embryos of the brood mass of the female parasite were counted; ten

© The Author(s), 2025. Published by Cambridge University Press on behalf of Marine Biological Association of the United Kingdom. This is an Open Access article, distributed under the terms of the Creative Commons Attribution-NonCommercial licence (<http://creativecommons.org/licenses/by-nc/4.0/>), which permits non-commercial re-use, distribution, and reproduction in any medium, provided the original article is properly cited. The written permission of Cambridge University Press must be obtained prior to any commercial use.



embryos were randomly selected in order to measure their width ( $d^1$ ), length ( $d^2$ ) and to calculate their volume ( $V$ ) using the formula  $V = \pi(d^1)^2 \times (d^2)/6$  (Cericola and Williams, 2015; Romero-Rodríguez and Álvarez, 2020). Measurements were made to the nearest 0.1 mm using an ocular micrometer attached to a compound microscope. Drawings made with a camera lucida were used to construct figures using Adobe Illustrator. Digital photographs of the parasites were taken with a Leica DFC490 camera mounted on a Leica Z16APOA stereomicroscope provided with the Leica Application Suite version 4.3.0. Both parasites and host are deposited in the Colección Nacional de Crustáceos (CNCR), housed at the Instituto de Biología of the Universidad Nacional Autónoma de México (UNAM).

## Results

Suborder Epicaridea Latreille, 1825

Family Bopyridae Rafinesque, 1815

Subfamily Pseudioninae Codreanu, 1967

Genus *Ionella* Bonnier, 1900

*Ionella fimbriata* sp. nov.

(Figures 1–3; Tables 1–3)

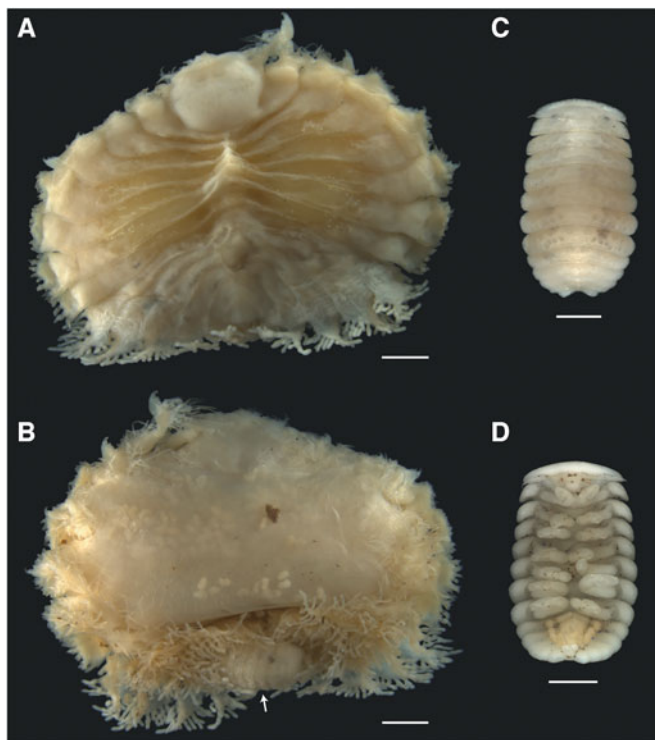
[urn:lsid:zoobank.org:pub:

D8265FC1-EC63-4021-B8DA-BD98D25E4693]

## Material examined

### Holotype

One ovigerous female 7.0 mm TL, within the right branchial chamber of *Neocallichirus grandimana* (Gibbes, 1850) male of 16.68 mm CL, J.L. Villalobos det. host, Montepío beach, San Andrés Tuxtla, Veracruz, Mexico (18°38'41.04"N 95°05'50.02"W), 18 August 2022, J.L. Villalobos *et al.* coll., CNCR-37084.



**Figure 1.** *Ionella fimbriata* sp. nov. (CNCR-37084) parasite of *Neocallichirus grandimana* in Veracruz, Mexico: (A) ovigerous female, holotype, dorsal view, pleomeres 2–4 medially damaged; (B) same, ventral view, white arrow indicating male attached on pleopods; (C) male, allotype, dorsal view; (D) same, ventral view, left pereopod 5 damaged. Scale bars: A–B 1.0 mm, C–D 0.5 mm.

### Allotype

One male 3.08 mm TL, same collection data as for holotype, CNCR-37084.

### Etymology

The name is from the Latin *fimbriatus* (fringed), alluding to the appearance of the female pereopods with intricate elongate cuticular extensions on margins of bases and ischia, resembling fringes.

### Diagnosis

Female: body white in colour, lacking pigmentation and eyes, oval in shape, nearly symmetrical, seven pereomeres distinct and laterally wider in medial region, seven pairs of pereopods increasing in size posteriorly with elongate cuticular extensions on upper margin of bases and lower margin of ischia, marsupium tightly closed, six pleomeres distinct dorsally but 1–5 fused laterally, five pairs of triangular lateral plates with tuberculate margins, five pairs of pinnate biramous pleopods bearing tuberculate projections, uropods uniramous. Male: whitish in colour with minute setae scattered on dorsal and ventral surfaces of pereomeres. Head semicircular, distinct from pereon, pereomeres larger posteriorly; pleomeres narrower than pereomere 7, recurved posteriorly, final pleomere small, semicircular; five pairs of biramous globose pleopods, one pair of uniramous uropods.

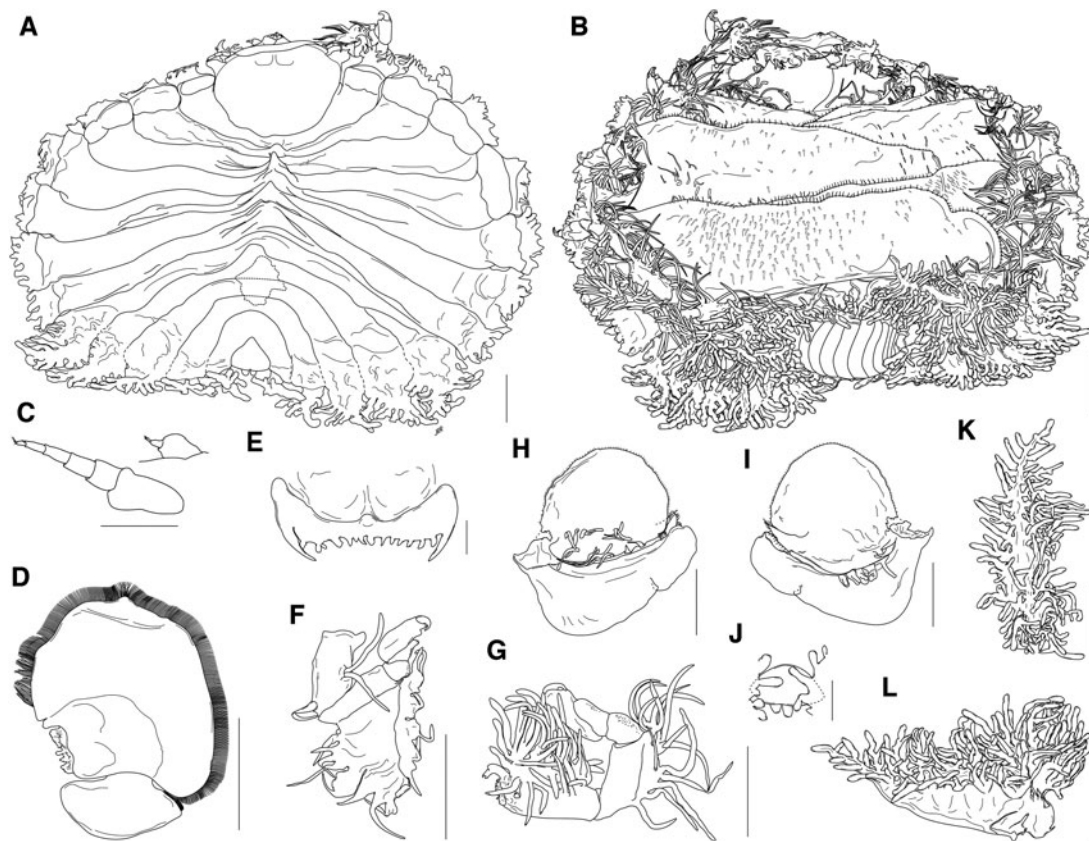
### Type locality

Montepío beach (18°38'41.04"N 95°05'50.02"W), intertidal zone, San Andrés Tuxtla, Veracruz, Mexico.

### Description

Holotype. Ovigerous female (Figures 1A, B & 2A–L), body length 7.0 mm, maximal width 11.54 mm at pereomere 5, head length 1.96 mm, head width 2.66 mm, pereon length 2.0 mm, pleon length 2.56 mm, pleon width 9.80 mm. Head rounded with semi-triangular anterolateral projections, two slight semi-square anterodorsal depressions. Anterior margin nearly straight, frontal lamina recurved backwards. Oral cone protruding on anteromedial margin. Posterior margin rounded, distinct from first pereomere. Eyes absent (Figures 1A & 2A). Antennae separated from each other. Antennule short, three-segmented, basal segment largest and rounded, second segment tapering, distal one smaller, bearing fine distal setae (Figure 2C). Antenna long, six-segmented, exceeding lateral margins of head, basal segment largest, subsequent segments gradually decreasing in size, distal segment tiny, bearing fine apical setae (Figure 2C). Maxilliped lacking palp, surface smooth, anterior segment large, suboval, margin densely lined with setae; posterior segment smaller, rounded triangular in shape, plectron truncated, bearing setae on upper distal margin (Figure 2D). Barbula with one stout, acute, falcate projection on each side, medial margin bearing short rounded projections of variable sizes, dorsomedial region protruding as conspicuous rounded bulge (Figure 2E).

Pereon broadly rounded, of seven distinct pereomeres, all wider laterally than in central region. Pereomeres 2–5 folded up producing dorsomedial semi-triangular knob (Figures 1A & 2A). All pereomeres bearing conspicuous crenate coxal plates (Figure 2A). Pereomeres 1–4 with semi-rectangular dorsolateral bosses (Figure 2A). Seven pairs of pereopods, increasing in size posteriorly but of similar form. Basis elongate with cuticular extensions on upper margin, ischium elongate with lower margin extended, merus short and rectangular in shape, carpus triangular with tiny scales at distal margin, propodus oblong with minute setae on dactylus insertion, dactylus curved, stout and acute (Figure 2F, G). Pereopod 1 with two long and slender branches on upper margin of basis (Figure 2F), ischium lower margin



**Figure 2.** Ovigerous female of *Lonella fimbriata* sp. nov., holotype (CNCR-37084), parasite of *Neocallichirus grandimana* in Veracruz, Mexico. (A) habitus, dorsal view, pleomeres 2–4 medially damaged; (B) same, ventral view; (C) antennule and antenna; (D) maxilliped; (E) barbula; (F) right pereopod 1; (G) right pereopod 7; (H) right oostegite 1, dorsal view; (I) same, ventral view; (J) detail of pleomere 6 and uropods; (K) left pleopod 1; (L) same, lateral view. Scale bars: A, B, D, F–I, K–L 1.0 mm, C, E, J 0.5 mm.

extended as thin whole plate bounded by slender projections (Figure 2F). Pereopods 1 and 2 with a single tapering projection near distal part of lower margin of basis (Figure 2B, F). Pereopods 2–7 with elongate cuticular extensions on upper margin of basis increasing in number and thickness posteriorly (Figure 2B, G) and lower margin of ischium extending as long and intricate cuticular extensions (Figure 2G). Marsupium tightly closed by five pairs of oostegites (Figures 1B & 2B). First pair of oostegite surfaces smooth, divided by deep groove, anterior section large, ovoid, bearing small setae along margin, with 14 long, slender cuticular extensions on posterior margin; posterior section triangular, shorter but wider than anterior one, lacking posterolateral point (Figure 2H); inner ridge with curved, smooth, protruding lobule on proximal portion, distal portion bearing eight thick projections, first four bifurcated distally (Figure 2I). Oostegites 2–5 increasing in size posteriorly, imbricated from back to front, rectangular, with margins lined by conspicuous setae, dorsally with setae of variable sizes clearly more numerous on pairs 4 and 5 (Figure 2B).

Pleon of six pleomeres, dorsally distinct. Pleomeres 1–5 curved backwards, fused laterally to each other and to triangular lateral plate with tuberculated margins, edges barely indicated by slight intersegmental lines (Figures 1A & 2A), pleomere 6 smaller, triangular, almost enclosed by pleomere 5 (Figure 2A, J). Ventrally, almost entirely covered by five pairs of biramous pleopods decreasing in size posteriorly, directed inwards, slightly overlapping in medial region of pleon (Figure 2B), both rami of pinnate shape with tuberculated projections (Figure 2K, L). Pleopods 1–3 with endopods longer than exopods (Figure 2K, L), 4 and 5 with both rami of similar sizes. Uropods uniramous, short, rectangular (Figure 2J).

Male, allotype (Figures 1C, D & 3A–G): length 3.08 mm, maximal width 1.53 mm (at pereomere 7), head length 0.35 mm, head width 1.18 mm, pereon length 1.76 mm, pleon length 0.91 mm, pleon width 1.35 mm.

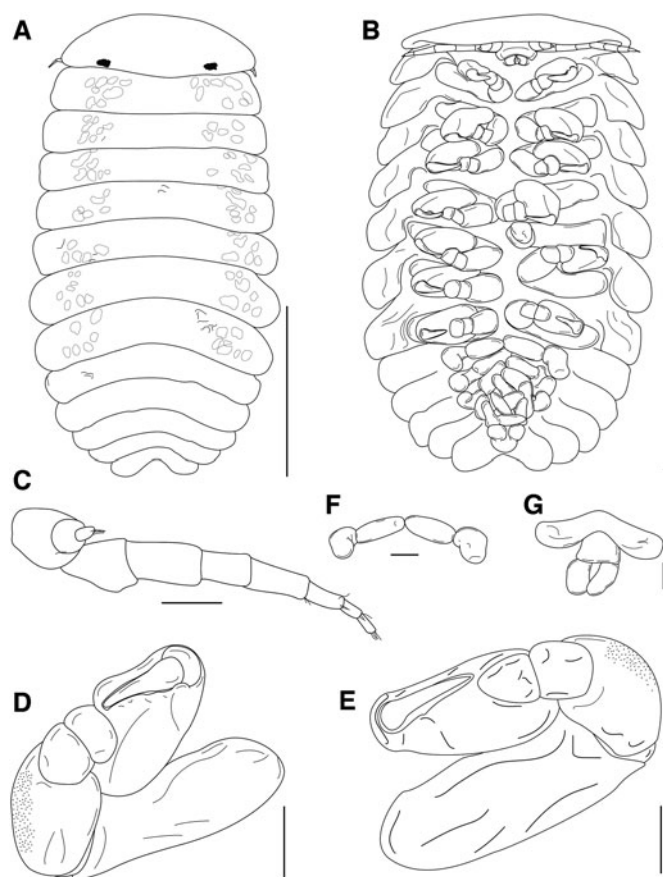
Head semicircular, wider than long, surface smooth, posterior margin slightly curved, distinct from first pereomere, eyes on posterolateral margins (Figures 1C & 3A). Antennule short, three-segmented, first segment larger, third segment tiny, tipped with small setae (Figure 3C). Antennae long, seven-segmented, slightly exceeding lateral margin of head, first four segments large and similar in size, latter three ones decreasing in size progressively, last three segments bearing fine setae (Figure 3C).

Pereon of seven distinct pereomeres, slightly enlarged posteriorly, posterior margin overlapping adjoining anterior margin, rounded lateral margins directed downwards (Figures 1C & 3A). Midventral tubercles absent. Seven pairs of pereopods of similar shape, increasing in size posteriorly (Figures 1D & 3B). Basis elongate, ischium approximately half size of basis, meri and carpi distinct, small, rounded, propodi ovoid, dactyli acute (Figure 3D, E).

Pleon of five pleomeres plus small semicircular pleotelson. First pleomere narrower than final pereomere, others progressively recurved, narrower posteriorly. All segments distinctly separated dorsally and laterally, lateral margins rounded (Figures 1C & 3A). Five pairs of globose biramous pleopods, slightly decreasing in size posteriorly (Figures 1D & 3B). Endopods longer than exopods, directed medially (Figures 1D & 3B, F). One pair of globose uniramous uropods, longer than last pair of pleopods (Figure 3B, G).

#### Distribution

Currently known only from southern Veracruz, Mexico, in the southwest Gulf of Mexico.



**Figure 3.** Male of *Ionella fimbriata* sp. nov., allotype (CNCR-37084), parasite of *Neocallichirus grandimana* in Veracruz, Mexico. (A) habitus, flattened under a cover slip, dorsal view; (B) same, not flattened, ventral view, left pereopod 5 damaged; (C) antennule and antenna; (D) right pereopod 1; (E) left pereopod 7; (F) pleopod 1 pair; (G) detail of pleomere 5, pleotelson and uropods. Scale bars: A–B 0.5 mm, C–G 0.1 mm.

### Remarks

Several characteristics of the pair of bopyrid isopods examined, such as female with body broadly oval, barely distorted, suboval maxilliped lacking palp and densely fringed by setae, first pair of oostegites without posterolateral point, biramous pleopods and uniramous uropods; male with extended head, all body regions distinct, lacking midventral tubercles, biramous pleopods and uniramous uropods, show their affinity with *Ionella* (Bonnier, 1900; Markham, 1994). Currently, this genus is comprised of four species (Boyko *et al.*, 2023): *Ionella agassizii* Bonnier, 1900, *I. compressa* (Shiino, 1964a, 1964b), *I. maculata* Markham, 1994 and *I. murchisoni* Danforth, 1970.

The female examined differs from the other species of the genus in several characters (Table 1). In *I. agassizii*, both segments of the maxilliped are fused, the barbula has one large oblique and pointed projection on each side and bears a series of numerous very small secondary lamellae on the medial margin, the digitations on the inner margin of the first pair of oostegites are small and not distally bifurcated, the margins expanded at bases and ischia extend as a single thin sharp-edged blade and the five pairs of biramous pleopods are foliaceous in shape (Bonnier, 1900; Shiino, 1964a). In *I. compressa*, the coxal plates are distinct on the first four segments but only on the longer side of the body, all pereopods are relatively long, the two last pleomeres and pleotelson are short, narrow and crowded together and the uropods are very small and tuberculate (Shiino, 1964b). In *I. maculata*, the antennae are minute, the barbula bears two short broad projections on each side, pereomeres 6 and 7 are produced

**Table 1.** Comparison of some morphological characteristics of bopyrid isopod females belonging to the genus *Ionella* Bonnier, 1900

Species	Segments of				Barbula		Projection	Lateral Plates	Reference		
	Head	DLB	Cox Pls	Ant 1	Ant 2	Max				Inner ridge	Pleopods Shape
<i>I. agassizii</i>	Rounded	1–4	1–4 Ls 1–2 Ss	3	6	Rounded	1 large, oblique	With very small lamellae	Oval lamellae	Expanded	1, 4
<i>I. compressa</i>	Pentagonal	–	1–4 Ls	–	–	–	–	–	Finger-like processes	Short, hardly noticeable	5
<i>I. fimbriata</i> sp. nov.	Rounded	1–4	1–7	3	6	Rounded	1 stout, acute, falcate	With triangular rounded projections	Pinnate	Triangular with tubercles on margin	6
<i>I. maculata</i>	Subtrapezoidal	–	1–5?	2	3? <sup>a</sup>	Suboval	2 short, broad	notched	Foliate	Lacking	3
<i>I. murchisoni</i>	Square	1–4	1–4	–	Large	–	–	–	Exopod pinnate and endopod as 2 basal bulbs	Knob-like peripheral projections	2

<sup>a</sup>Based on the illustrations and descriptions; DLB, dorsolateral bosses on pereomeres; Cox Pls, coxal plates; Ls, long side of body; Ss, short side of body; Ant 1, antennule; Ant 2, antenna; Max, maxilliped; Lp, lateral plate. (1) Bonnier, 1900; (2) Danforth, 1970; (3) Markham, 1994; (4) Shiino, 1964a; (5) Shiino, 1964b; (6) this study.

**Table 2.** Comparison of some morphological characteristics of bopyrid isopod males belonging to the genus *Ionella* Bonnier, 1900

Species	Head	Segments of		Pereon	Pereomeres margins	Pleopods	Uropods	References
		Ant 1	Ant 2					
<i>I. agassizii</i>	Rounded to trapezoidal	3	8	Wider in 5, SRBF	Rounded	Biramous, rod-like, endopod longer than exopod	Small, oval in shape with small rigid setae	1, 4
<i>I. compressa</i>	Semicircular	–	Long <sup>a</sup>	Wider in 4–5, SRBF <sup>a</sup>	Truncated	Uniramous, as pointed conical lobes	Oval	5
<i>I. fimbriata</i> sp. nov.	Semicircular	3	7	Wider in 4–5, slightly enlarged posteriorly	Rounded	Biramous, of bulb shape, exopods longer than endopods	Longer than pleopods, of bulb shape	6
<i>I. maculata</i>	Semicircular	3	5	Nearly parallel, 1 and 7 slightly narrower	Rounded	1, 2 Biramous, as flaps; 3–5 uniramous, of variable form between knobs and flaps	As flaps, distally setose	3
<i>I. murchisoni</i>	Semicircular	2	Long	Wider in 6, SRBF <sup>a</sup>	Rounded	Biramous, endopods longer than exopods	Extremely tiny, as short rod or slight swelling	2

<sup>a</sup>Based on the illustrations and descriptions; Ant 1 = antennule; Ant 2 = antenna; SRBF = slightly reduced anteriorly and posteriorly. (1) Bonnier, 1900; (2) Danforth, 1970; (3) Markham, 1994; (4) Shiino, 1964a; (5) Shiino, 1964b; (6) this study.

**Table 3.** Hosts and geographic distribution of *Ionella* Bonnier, 1900 species

Species	Host(s)	Distribution (*type locality)	Reference
<i>I. agassizii</i>	<i>Neotrypaea uncinata</i> (Milne Edwards, 1837) (as <i>Callianassa uncinata</i> )	Talcahuano*, Puerto Montt, Dichato, Bahía Coliuma, Bahía Coliumo, Bahía San Vicente and Valdivia, Chile, southeast Pacific. Beach across road from NOAA/STRI lab, Panama, northeast Pacific.	1 6 2
<i>I. compressa</i>	<i>Neocallichirus jousseaumei</i> (Nobili, 1904) (as <i>Callianassa jousseaumei</i> ) <i>Paratrypaea bouvieri</i> (Nobili, 1904) (as <i>Callianassa bouvieri</i> )	Honohoshi, Amamiooshima*, Japan, northwest Pacific Nansei islands, Japan, northwest Pacific.	7 4
<i>I. fimbriata</i> sp. nov.	<i>Neocallichirus grandimana</i>	San Andrés Tuxtla*, Veracruz, Mexico, northwest Atlantic.	8
<i>I. maculata</i>	' <i>Callianassa</i> ' sp.	New Caledonia*, southwest Pacific.	5
<i>I. murchisoni</i>	' <i>Callianassa</i> ' sp.	Sand Island, Kaneohe Bay*, Hawaii, USA, north central Pacific.	3

(1) Bonnier, 1900; (2) Boyko et al., 2017; (3) Danforth, 1970; (4) Itani, 2004; (5) Markham, 1994; (6) Shiino, 1964a; (7) Shiino, 1964b; (8) this study.

laterally into slender falcate posterolateral projections and the biramous pleopods are foliate (Markham, 1994). In *I. murchisoni*, pereomeres 2–7 are fused medially into a slightly elevated margin, the dorsolateral bosses on pereomeres 1–4 are triangular in outline, the swelled margins on the bases and ischia of pereopods 2–7 are a single rounded blade, based on the illustration and description (Danforth, 1970, Figure 1B), and the pleon is flat and triangular in shape with no dorsal evidence of segmentation (Danforth, 1970).

Differences between males of the new species and all others of *Ionella* species are also recognized (Table 2). In *I. agassizii*, the pleopods are rod-like with the endopod longer than the exopod and the oval uropods bear small rigid setae. Males of *I. compressa* have pereomeres with truncated margins and uniramous pleopods. In *I. murchisoni*, the pleopods are biramous with the endopod longer than the exopod, both finger-shaped and arising from a common peduncle, and the uropods are 'extremely tiny' (Danforth, 1970). Males of *I. maculata* can be recognized by their minute antennae and pleopods varying from biramous in pairs 1 and 2 to uniramous in pairs 3–5 (Markham, 1994).

The females of *I. fimbriata* sp. nov. can be distinguished by a barbula with one stout, acute and falcate projection on each side, a medial margin bearing triangular rounded projections of variable size; seven pairs of pereopods that increase in size posteriorly and bear semicylindrical elongate cuticular extensions on the upper margins of bases and flatter and thinner cuticular extensions on

the lower margins of ischia; five pleomeres curved backwards, fused laterally to each other and to a triangular lateral plate of tuberculated margins, as well as five pairs of biramous pleopods of pinnate shape with tuberculated projections. Likewise, males of this species can be recognized by seven pairs of pereopods that increase in size posteriorly but are of similar shape; five pairs of globose biramous pleopods, in which the endopods are longer than the exopods, and uniramous uropods of similar shape to the pleopods but larger in size than last pair of pleopods.

#### Reproductive remarks

The ovigerous female examined had 2194 embryos in the brood chamber, which were classified as stage II because they were oblong in shape and with no traces of developing appendages or ocular line pigments (Beck, 1980). The embryos' length and width varied from 0.309 to 0.364 mm and from 0.182 to 0.236 mm, respectively; the mean length ( $0.336 \pm 0.018$  mm) and width ( $0.215 \pm 0.017$  mm) were also estimated. The mean volume calculated was  $0.008 \pm 0.001$  mm<sup>3</sup>, with a range that varied between 0.006 and 0.011 mm<sup>3</sup>.

#### Discussion

Currently, most species included in *Ionella* do not fulfil the three characters used to define the genus by Bonnier (1900): females with pleomeres lacking lateral plates, uropods uniramous and

biramous pleopods in both females and males. *Ionella maculata* is the only species reported as not having lateral plates on the pleomeres (Markham, 1994) while the type-species of the genus, *I. agassizii*, has lateral plates on the pleomeres (Shiino, 1964a). Likewise, the pleopods of *I. compressa* males are uniramous and those of *I. maculata* males are not entirely biramous (Table 2). Based on a wider list of generic characters provided by Markham (1994), we suggest that the following could improve the characterization of this genus: females with oval body, barely distorted; maxilliped rounded or suboval in shape, lacking palp and anterior segment densely fringed by setae; first pair of oostegites with subcircular anterior segment, inner ridge ornamented only laterally, posterior segment shorter without posterolateral point; bases and ischia of pereopods with wide margins, and biramous pleopods. Males with rounded extended head, midventral tubercles absent, at least the first two pairs of pleopods biramous, and uniramous uropods. However, some of these characters are not described for *I. compressa* and *I. purchisoni* (Table 1) which remain poorly known (Markham, 1994). Examination of specimens is therefore needed to confirm the morphological details of these species in order to complete the characterization of *Ionella*. Based on the current taxonomic information available, keys are provided herein for both females and males of species in this genus.

All hosts of *Ionella* species are axiidean ghost shrimps belonging to Callianassidae and Callichiridae (Table 3). To our knowledge, *N. grandimana* had not been recognized as a host of *Ionella* species, or any other bopyrid species. The record of

*I. fimbriata* sp. nov. in the northwest Atlantic represents a significant distribution range extension for *Ionella*, because this genus was previously restricted to the Pacific Ocean (Table 3). Similarly, the record of *I. fimbriata* sp. nov. increases to 14 the number of bopyrid species in Veracruz, Mexico, where until 2005 only three bopyrid had been recorded. Recent studies reported nine more bopyrid species in the region, three of them new species (Romero-Rodríguez and Álvarez, 2023; this study), which makes to Veracruz one of the regions with the greatest diversity of bopyrid parasites in Mexico.

The fecundity of *I. fimbriata* sp. nov. is similar to the ~2000 embryos reported from females of *I. agassizii* of 6–8 mm TL (Muñoz and George-Nascimento, 1999, Figure 3), but is lower than that reported for other bopyrid females of similar size (Cericola and Williams, 2015). The latter could be related to the mean embryo size and volume calculated for *I. fimbriata* sp. nov. which is higher than those calculated for other bopyrid species (Cericola and Williams, 2015; Romero-Rodríguez and Álvarez, 2023) because in other decapod crustacean groups it has been observed that fecundity is related to egg size, i.e. species with reduced fecundity produce eggs large in size while those species with small eggs have a high fecundity (Ramírez-Llodra, 2002), as was observed in *Pseudostegias atlantica* Lemos de Castro, 1965 (Romero-Rodríguez and Álvarez, 2023). However, it is important to highlight that all the reproductive information of *I. fimbriata* sp. nov. comes from a single individual. This shows the need to enhance the knowledge on the reproductive biology of this species and other bopyrid isopods.

#### Key to females of species of *Ionella* Bonnier.

- 1a Pereon of seven pereomeres clearly distinct dorsally.....2
- 1b Pereon of seven pereomeres weakly indicated by demarcations, only first pereomere distinct side to side, all others fused dorsomedially.....*Ionella purchisoni*
- 2a Coxal plates on both sides of the body, at least on pereomeres 1 and 2.....3
- 2b Coxal plates only on pereomeres 1–4 of long side of body.....*Ionella compressa*
- 3a Short antennule and long antenna; barbula with one acute projection on each side.....4
- 3b Antennae minute, barbula with two broad projections on each side.....*Ionella maculata*
- 4a Pereopods with upper margin of bases and lower margin of ischia expanded as thin plates; pleopods of foliate shape with irregular margins.....*Ionella agassizii*
- 4b Pereopods with upper margin of bases and lower margin of ischia with elongate cuticular extensions; pleopods of pinnate shape with tuberculated projections.....*Ionella fimbriata* sp. nov.

#### Key to males of species of *Ionella* Bonnier.

- 1a Pereomeres of rounded margins, at least first two pairs of pleopods biramous.....2
- 1b Pereomeres with truncated margins, five pairs of uniramous pleopods.....*Ionella compressa*
- 2a Five pairs of biramous pleopods .....3
- 2b Pleopods 1 and 2 biramous, 3–5 uniramous.....*Ionella maculata*
- 3a Uropods uniramous, resembling pleopods in appearance.....4
- 3b Uropods uniramous, extremely tiny, appearing as short rods or swelling.....*Ionella purchisoni*
- 4a Uropods small, oval-shaped bearing small rigid setae.....*Ionella agassizii*
- 4b Uropods longer than last pleopods, globose in shape.....*Ionella fimbriata* sp. nov.

**Acknowledgments.** We thank S. Guzmán-Gómez (LANABIO/IB/UNAM) for her assistance in taking the photographs for Figure 1, and J. L. Villalobos-Hiriart (Colección Nacional de Crustáceos/IB/UNAM) for providing the specimens examined and for his support with the laboratory work. We also thank the reviewers for their helpful comments on the manuscript.

**Author contributions.** J. R.-R.: conceptualization, specimen identification, writing original draft preparation and editing. F. A.: conceptualization, original draft reviewing and editing. All authors reviewed and accepted the latest version of the manuscript.

**Financial support.** This work was supported by a scholarship granted to the first author by the Consejo Nacional de Humanidades, Ciencia y Tecnología (CONAHCyT) through the program ‘Becas Posdoctorales por México’.

**Competing interest.** None.

**Data availability.** The authors confirm that the data supporting the findings of this study are available within the article.

## References

- Adkison DL and Heard RW (1995) *Pseudione overstreeti*, new species (Isopoda: Epicaridea: Bopyridae), a parasite of *Callinectes islagrande* (Decapoda: Anomura: Callinassidae) from the Gulf of Mexico. *Gulf Research Reports* **9**, 105–110.
- Beck JT (1980) Life history relationships between the bopyrid isopod *Probopyrus pandalicola* and one of its freshwater shrimp hosts *Palaemonetes paludosus*. *American Midland Naturalist* **104**, 135–154.
- Bonnier J (1900) Contribution à l'étude des Epicarides. Les Bopyridae. *Travaux de la Station Zoologique de Wimereux* **8**, 1–476.
- Boyko CB, Bruce NL, Hadfield KA, Merrin KL, Ota Y, Poore GCB and Taiti S (2023) World marine, freshwater and terrestrial isopod crustaceans database. *Jonella* Bonnier, 1900. Available at <https://www.marinespecies.org/aphia.php?p=taxdetails&id=248852> (Accessed online 27 September 2023).
- Boyko CB, Williams JD and Shields JD (2017) Parasites (Isopoda: Epicaridea and Nematoda) from ghost and mud shrimp (Decapoda: Axiidea and Gebiidea) with descriptions of a new genus and a new species of bopyrid isopod and clarification of *Pseudione* Kossmann, 1881. *Zootaxa* **4365**, 251–301.
- Cericola MJ and Williams JD (2015) Prevalence, reproduction and morphology of the parasitic isopod *Athelges takanoshimensis* Ishii, 1914 (Isopoda: Bopyridae) from Hong Kong hermit crabs. *Marine Biology Research* **11**, 236–252.
- Codreanu R (1967) Clasificarea evolutivă a bopirienilor, isopode parazite ale crustaceelor decapode și impotanța lor biologică generală. *Studii și Cercetări de Biologie Seria Zoologie* **19**, 203–211.
- Danforth CG (1970) Epicaridea (Isopoda) of Hawaii. *Bulletin of the Southern California Academy of Sciences* **69**, 27–31.
- Dworschak PC (2005) Global diversity in the Thalassinidea (Decapoda): an update (1998–2004). *Nauplius* **13**, 57–63. Available at <http://crustacea.org/wp-content/uploads/2014/02/nauplius-v13n1a04.Dworschak.pdf>
- Dworschak PC, Felder DL and Tudge CC (2012) Infraorders Axiidea de Saint Laurent, 1979 and Gebiidea de Saint Laurent, 1979 (formerly known collectively as Thalassinidea). In Schram FR and von Vaupel KJC (eds), *Treatise on Zoology-Anatomy, Taxonomy, Biology. The Crustacea, Vol. 9 Part B*. Boston, MA: Brill Press, pp. 109–219.
- Gibbes LR (1850) On the carcinological collections of the United States, and an enumeration of species contained in them, with notes on the most remarkable, and descriptions of new species. *Proceedings of the American Association for the Advancement of Science* **3**, 165–201.
- Hay WP (1917) A new genus and three new species of parasitic isopod crustaceans. *Proceedings of the United States National Museum* **51**, 569–574.
- Hernández P, Windsor AM, Paula CA and Santana W (2020) A new species of the ghost shrimp genus *Neocallichirus* Sakai, 1988 (Decapoda: Axiidea: Callianassidae) from the southwestern Atlantic. *Marine Biology Research* **16**, 50–60.
- Hernández C, Álvarez F and Villalobos JL (2010) Crustáceos asociados a sustrato duro en la zona intermareal de Montepío, Veracruz, México. *Revista Mexicana de Biodiversidad* **81**, S141–S151.
- Itani G (2004) Host specialization in symbiotic animals associated with thalassinidean shrimps in Japan. In Tamaki A. (ed.) *Proceedings of the symposium on 'Ecology of large bioturbators in tidal flats and shallow sublittoral sediments – from individual behavior to their role as ecosystem engineers'* 1–2 November 2003. Nagasaki University, pp. 33–43.
- Latreille PA (1825) *Familles Naturelles du Règne Animal, Exposé Succinctement et Dans un Ordre Analytique Avec L'indication de Leurs Genres*. Paris: J.B. Baillière.
- Lemos de Castro A (1965) Crustaceos Isopodos Epicarideos do Brasil. I: Descrição de uma espécie do genero 'Pseudostegias' Shiino (Isopoda, Bopyridae). *Revista Brasileira de Biologia* **25**, 105–108.
- Markham JC (1994) Crustacea Isopoda: Bopyridae in the MUSORSTOM collections from the tropical Indo-Pacific I. Subfamilies Pseudioninae (in part), Argeiinae, Orbioninae, Athelginae and Entophilinae. Chapter 6. In Crosnier A (ed.), *Résultats des Campagnes MUSORSTOM 12*. Mémoires du Muséum National d'Histoire Naturelle, vol. **161**. Paris, FR: Éditions du Muséum national d'Histoire naturelle, pp. 225–253.
- Markham JC and Dworschak PC (2005) A new species of *Entophilus* Richardson, 1903 (Isopoda: Bopyridae: Entophilinae) from the Gulf of Aqaba, Jordan. *Journal of Crustacean Biology* **25**, 413–419.
- Milne Edwards H (1834–1840) *Histoire Naturelle des Crustacés, Comprenant l'Anatomie, la Physiologie et la Classification de ces Animaux*. Paris: Encyclopédique Roret.
- Muñoz G and George-Nascimento M (1999) Efectos reproductivos recíprocos en la simbiosis entre napes (Decapoda: Thalassinidea) e isópodos bopíridos (Isopoda: Epicaridea) en Lenga, Chile. *Revista Chilena de Historia Natural* **72**, 49–56.
- Nobili G (1904) Diagnoses préliminaires de vingt-huit espèces nouvelles de stomatopodes et décapodes macroures de la Mer Rouge. *Bulletin du Muséum d'Histoire naturelle* **10**, 228–238.
- Rafinesque CS (1815) *Analyse de la Nature ou Tableau de l'Univers et des Corps organisés*. Palermo Published by the author.
- Ramírez-Llodra E (2002) Fecundity and life-history strategies in marine invertebrates. *Advances in Marine Biology* **43**, 87–170.
- Richardson J (1904) Contributions to the natural history of the Isopoda. *Proceedings of the United States National Museum* **27**, 1–89.
- Román-Contreras R (2008) Estudios y registros de isópodos epicarideos de México: 1897–2005. In Álvarez F and Rodríguez-Almaraz GA (eds), *Crustáceos de México: Estado actual de su conocimiento*. Nuevo León, MX: Dirección de Publicaciones Universidad Autónoma de Nuevo León, pp. 81–114.
- Romero-Rodríguez J and Álvarez F (2020) New hosts and distribution records for bopyrid isopods parasitising alpheid shrimps (Decapoda, Alpheidae) in the SW Gulf of Mexico and Mexican Caribbean. *Journal of Natural History* **54**, 2219–2248.
- Romero-Rodríguez J and Álvarez F (2021) *Probynia ramirromani*, new species (Isopoda: Bopyridae) and new occurrences of bopyrid isopods parasitizing decapod crustaceans from Mexican Atlantic waters. *Proceedings of the Biological Society of Washington* **134**, 318–338.
- Romero-Rodríguez J and Álvarez F (2023) Parasitic bopyrid isopods of the hermit crabs (Anomura, Paguridae) from the Atlantic coast of Mexico, with notes on their reproduction and distribution. *European Journal of Taxonomy* **861**, 132–167.
- Shiino SM (1964a) On two species of bopyrid isopods parasitic on *Callianassa uncinata* Milne-Edwards [sic] from Chile. *Report of Faculty of Fisheries, Prefectural University of Mie* **5**, 27–32.
- Shiino SM (1964b) Results of Amami Expedition. 5. Bopyridae. *Report of Faculty of Fisheries, Prefectural University of Mie* **5**, 237–242.
- Stimpson W (1857) On the Crustacea and Echinodermata of the Pacific shores of North America. *Boston Journal of Natural History* **6**, 444–532.