

Two new species of branchial parasitic isopods (Crustacea: Isopoda: Bopyridae: Pseudioninae) from hermit crabs collected in Singapore

Jason D. Williams and Lauren M. Schuerlein

Department of Biology, Hofstra University, Hempstead, New York 11549, U.S.A.,
e-mail (JDW): biojdw@hofstra.edu

Abstract.—Branchial bopyrids were investigated from hermit crabs collected in Singapore in August 2000. Two male and female bopyrid pairs belonging to the genus *Asymmetrione* were found on *Diogenes avarus* Heller and described as *A. sallyae*. One pair of bopyrids from the branchial chamber of *Clibanarius infraspinus* Hilgendorf represents a new species of *Pseudione* that is described as *P. kensleyi*. This is the first report of isopod parasites on hermit crabs from Singapore and represents the first records of bopyrids from these hermit crab hosts.

Isopods of the family Bopyridae are obligate parasites of decapod crustaceans. This large family (>575 species) is currently divided into ten subfamilies (but see Bourdon & Boyko 2005) which contain members that primarily inhabit the branchial chamber or attach to the abdomen of their hosts (Markham 2003). Bopyrid isopods found in the branchial chambers of hermit crabs are restricted to the subfamily Pseudioninae (Boyko & Williams 2001). In total, seven genera in the subfamily Pseudioninae contain branchial parasites of hermit crabs and most are restricted to these paguroid hosts (Markham 2003).

One of us (JDW) collected hermit crabs from Singapore in August 2000. Of those collected, three hermit crabs contained female and male pairs of pseudionine bopyrids. Two pairs belonged to the genus *Asymmetrione* Codreanu, Codreanu, & Pike, 1965 and one pair belonged to the genus *Pseudione* Kossman, 1881; comparison of these specimens with type material and species descriptions showed they represented a new species from each genus. Morphology of male and female bopyrids was documented with light microscopy and scanning electron microscopy (SEM) was used to ex-

amine the ultrastructure of a male specimen of the new *Asymmetrione* species.

Methods

Hermit crabs were collected by hand on 8 August 2000 from Noordin Beach, Pulau Ubin, Singapore, from an intertidal area of a sandy beach among roots of mangrove trees, and preserved in 70% ethyl alcohol. In total, 62 hermit crabs were examined, including: 6 specimens of *Clibanarius danai* Rahayu & Forest, 19 *Clibanarius infraspinus* Hilgendorf, and 37 *Diogenes avarus* Heller. Hermit crabs were removed from shells after cracking with a mortar and pestle constructed of galvanized steel pipe (60 mm in diameter) and the shield length (SL) of each crab was measured using a vernier caliper or stage micrometer to the nearest 0.1 mm. Isopod size is given as total body length (anterior margin of head to posterior margin of pleotelson). Drawing tube sketches were made of the specimens and scanned into a Macintosh[™] computer. Final plates were prepared using the programs Adobe Photoshop[™] and Adobe Illustrator[™].

For SEM, fixed specimens were dehydrated in an ascending ethanol series fol-

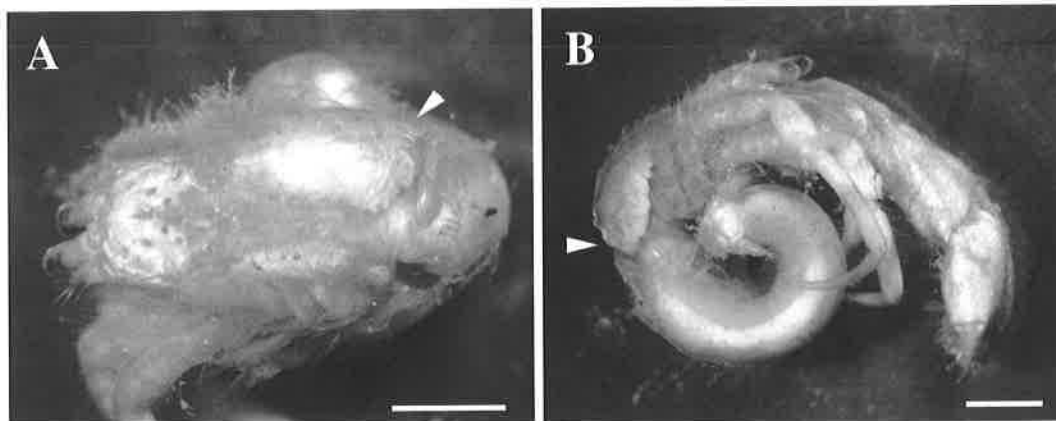


Fig. 1. *Asymmetrione sallyae*. Holotype (ZRC 2004.0648) within branchial chamber of host, *Diogenes avarus* Heller. A, dorsal view of host; B, right lateral view of host. Arrowhead indicates anterior end of isopod extending from the branchial chamber of host. Scale = 2.0 mm.

lowed by four changes of 100% ethanol. Drying was completed with a Samdri 795 Critical Point Drier. Dried specimens were mounted on an aluminum stub, coated with gold (EMS-550 Sputter coater), and viewed with a Hitachi S-2460N SEM. Type specimens are deposited in the Zoological Reference Collection of the Raffles Museum of Biodiversity Research, Singapore (ZRC) and the National Museum of Natural History, Smithsonian Institution, Washington, D.C., U.S.A. (USNM).

Family Bopyridae Rafinesque-Schmaltz,
1815

Subfamily Pseudioninae Codreanu, 1967
Genus *Asymmetrione* Codreanu, Codreanu,
& Pike, 1965

Asymmetrione sallyae, new species
Figs. 1–6

Material examined.—Holotype: dextral female (4.0 mm) infesting right branchial chamber of male *Diogenes avarus* (SL = 2.7; ZRC 2004.0675), Noordin Beach, Pulau Ubin, Singapore, intertidal near mangrove roots, coll. J. D. Williams, 8 August 2000 (ZRC 2004.0648). Allotype: male (1.74 mm), same data as holotype (ZRC 2004.0649). Paratypes: dextral female (damaged anterior end, 3.63 mm), male (1.4 mm; on SEM stub) infesting right branchial

chamber of male *Diogenes avarus* (SL = 2.1), same collection data as holotype (USNM 1024495).

Type locality.—Noordin Beach, Pulau Ubin, Singapore, Johore Strait, South China Sea.

Description.—Female (Figs. 1–3), holotype, length 4.0 mm, maximal width 1.92 mm, head length 0.78 mm, head width 0.74 mm, pleon length 1.59 mm. Body distorted ~65° with right side convex (dextrally deflexed). Anterior end of female extending slightly from the posterior margin of branchial chamber of host (Fig. 1). All body regions and segments distinct (Fig. 2A). Irregular patches of pigmentation present medially to coxal plates on pereomeres 1–7 (Fig. 2A).

Head deeply set into pereon, subcircular (Fig. 2A); frontal lamina irregularly four-lobed, covered with scales (Fig. 3A). Two irregularly shaped eyes present at postero-lateral corners of raised lamina (Fig. 2A). Antennule of 3 articles, antenna of 5 articles; all articles with setae and scales. Maxilliped (Fig. 3F) with rounded distal end and subacute spur; without palp. Barbula with 1 pair of rounded lateral projections and 2 pairs of rounded lobes medially (Fig. 3E). Oostegites completely enclosing brood pouch (Fig. 2B); first oostegite proximal

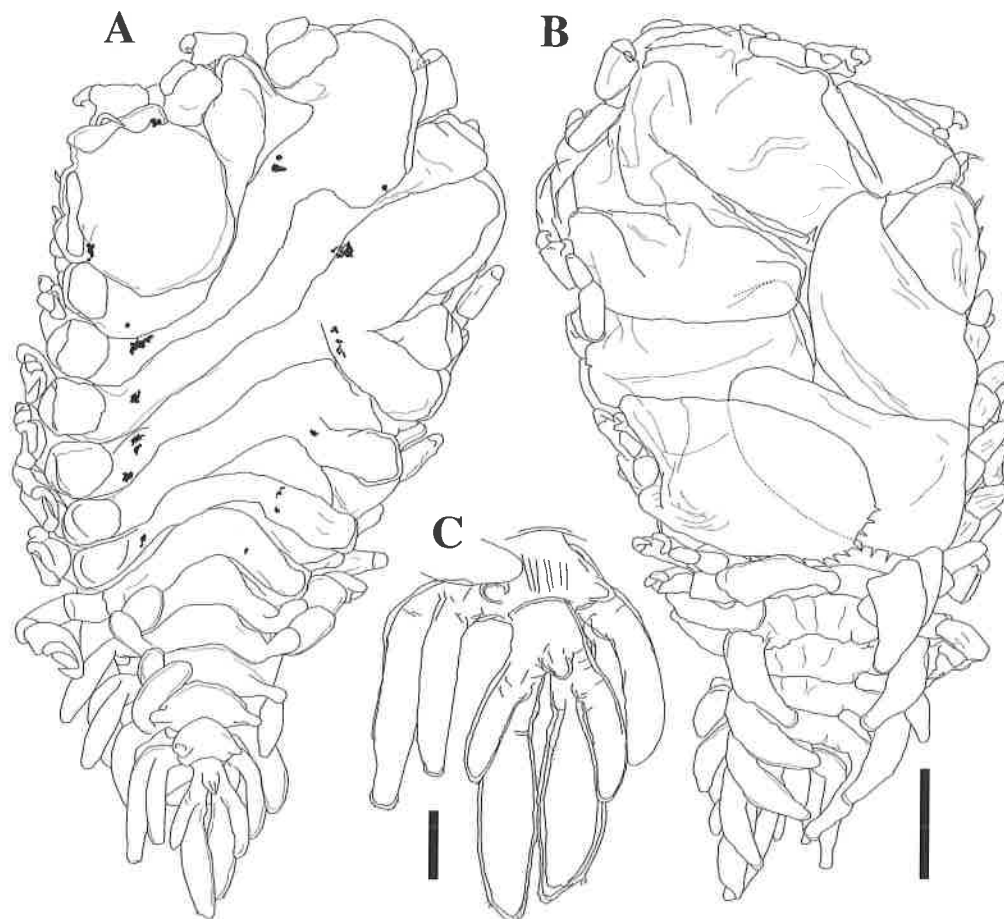


Fig. 2. *Asymmetrione sallyae*. Female, 4.0 mm, ZRC 2004.0648, holotype. A, dorsal view; B, ventral view; C, dorsal view of pleotelson and uropods. Scale = 500 μ m (A, B), 150 μ m (C).

lobe ovate, distal lobe rounded, with digitiform extension covered by setae (Figs. 3G, H).

Pereon of 7 distinct pereomeres; pereomeres 2–4 expanded on right side; pereon broadest at pereomere 4 on convex side, tapering posteriorly (Figs. 2A, B). Coxal plates on all pereomeres (Fig. 2A), largest on pereomeres 1–4, tapering posteriorly, indistinct on pereomere 7. Pereopods 1–5 increasing slightly in size, diminishing in 6 and 7; all with deep propodal sockets curved around dactyli, scales on areas of all pereopodal segments (Figs. 3A–D); ischium with circular protuberance covered by scales (Fig. 3D). First two pereopods surrounding head; pereopods on left side in

straight row, with no gaps between pereopods; pereopods on right (convex) side with large gaps between pereopods 2–4 (Fig. 2A).

Pleon of 6 distinctly segmented pleomeres. First five pleomeres with lateral plates, tapering posteriorly, reduced to a small knob on pleomere 5 (Figs. 2A, C). Pleopods biramous, digitate with weak tubercles; endopods slightly shorter than exopods, all with scales (Figs. 2A, C). Uropods biramous; endopods approximately half the length of exopods, similar in shape to pleopods, exopod with subterminal protuberance with 4 distal setae (Fig. 2C). Sixth pleomere with a small rounded anal cone extending dorsally between uropods.

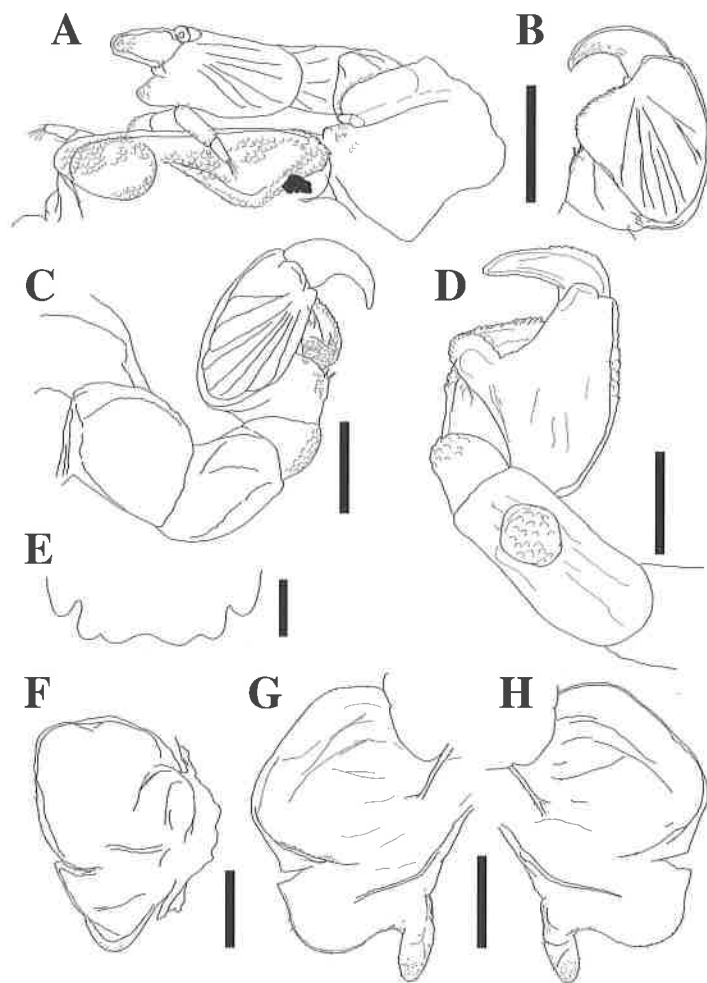


Fig. 3. *Asymmetrione sallyae*. Female, 4.0 mm, ZRC 2004.0648, holotype (A, D); Female, 3.63 mm (damaged anterior end), USNM 1024495, paratype (B, C; E–H). A, right side of head showing frontal lamina, antennae, and first pereopod, dorsal view; B, right pereopod 1, external view; C, right pereopod 1, internal view; D, left pereopod 7, internal view; E, barbula; F, right maxilliped, external view; G, right oostegite 1, external view; H, right oostegite 1, internal view. Scale = 150 μ m (A–C), 120 μ m (D, E), 200 μ m (F), 300 μ m (G, H).

Male (Figs. 4–6), allotype, length 1.74 mm, maximal width 0.48 mm on third segment. Body long and slender, pleon slightly narrower than pereon (Figs. 4A, B, 6A, B). Head oval, fused with pereomere 1, all other segments distinct (Fig. 4A). Two large, suboval eyes near posterolateral margin of head. Irregular pigmentation on dorsal surface of pereon and pleon (Fig. 4A). Antennule of 3 articles, antenna of 5 articles; each article with distal setae (Figs. 5A, 6D). Pereon widest across pereomeres 3 and 4. Per-

comeres only slightly separated anteriorly, more separated between pereomeres 4–7. Pereopods 3 and 4 largest, slightly decreasing in size anteriorly and posteriorly (Figs. 4B, 6A), all propodi with two ridges of stout scales accepting distal tip of dactyli (Figs. 5A, B, 6C, E), setae along ridge and distal margin of carpus, scales on ischium, merus, and carpus.

Pleon of 6 pleomeres, first narrower than pereomere 7, pleomeres tapering posteriorly, posterolateral borders extending beyond

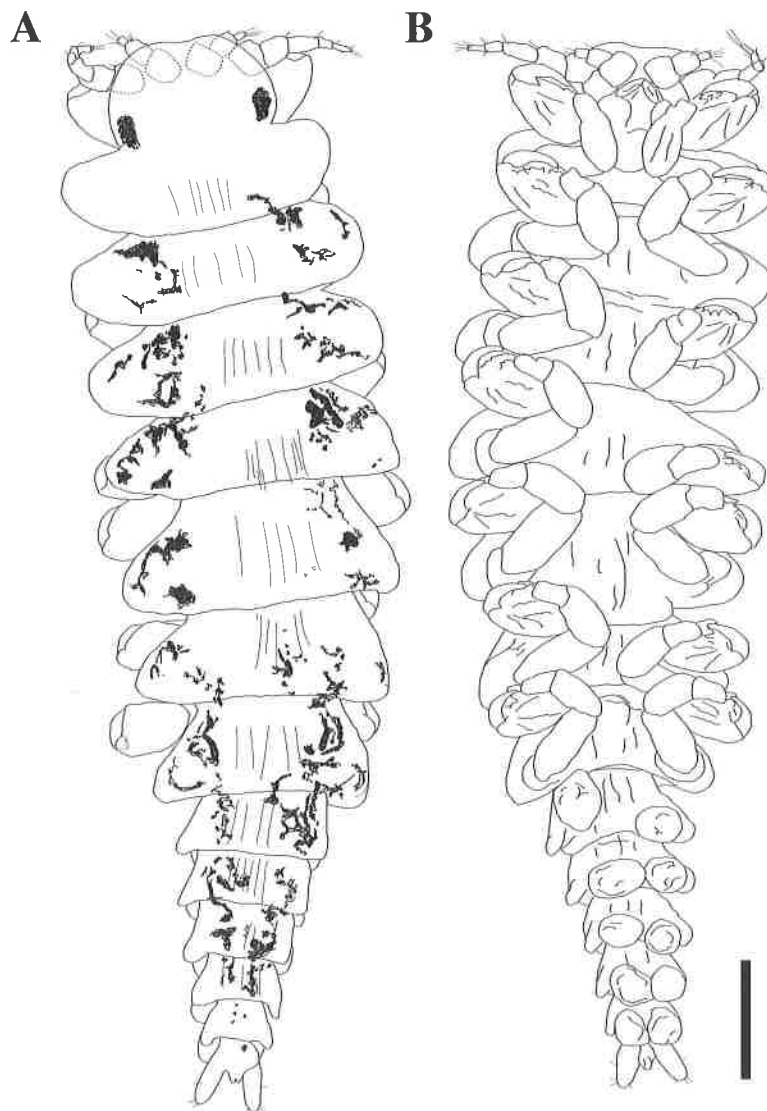


Fig. 4. *Asymmetrione sallyae*. Male, 1.74 mm, ZRC 2004.0649, allotype. A, dorsal view; B, ventral view. Scale = 200 μ m.

succeeding pleomere (Figs. 4A, B, 6A). Five pairs of rounded pleopods (Figs. 4B, 5C, 6A, B). Final pleomere lacking uropods, with posterior border produced into 2 long lateral lobes each bearing setae; anal cone with slight notch, positioned between lateral lobes, less than a third as long as lobes (Fig. 5C).

Distribution and host.—From Pulau Ubin, Singapore on *Diogenes avarus*. Two

Diogenes avarus were infested by specimens of *Asymmetrione sallyae* in the right branchial chamber (37 total *D. avarus* examined; prevalence = 5.4%).

Etymology.—This species is named in memory of Sally Schuerlein, mother of the second author (LMS).

Remarks.—This is the first species of *Asymmetrione* found on hermit crabs from Singapore and is the first occurrence of any

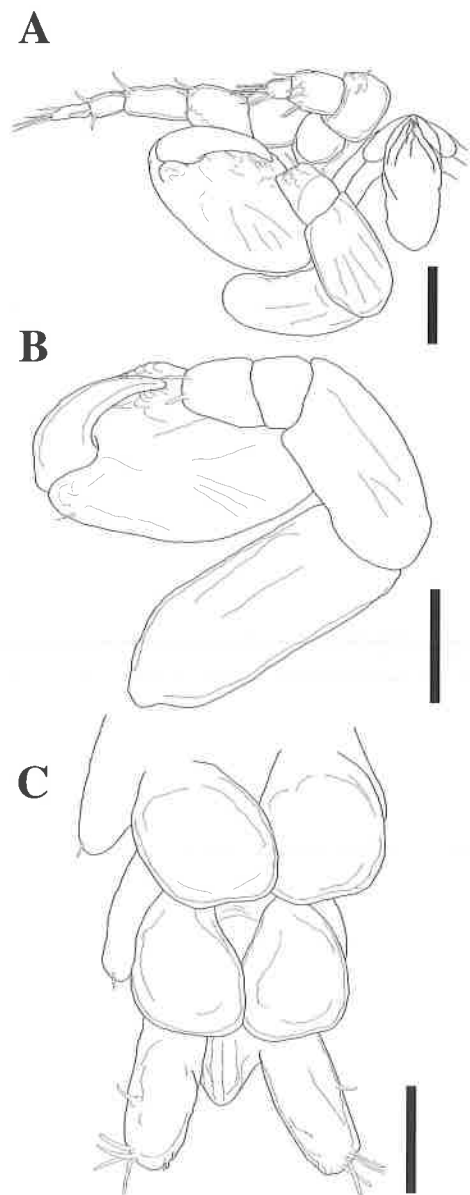


Fig. 5. *Asymmetrione sallyae*. Male, 1.74 mm, ZRC 2004.0649, allotype. A, left antennae, pereopod 1, and mouthparts; B, left pereopod 7; C, ventral view of posterior pleomeres and pleotelson. Scale = 60 μ m (A, B), 50 μ m (C).

Asymmetrione infesting crabs of the genus *Diogenes*. The only other known *Asymmetrione* from this region of the Indo-West Pacific is *A. asymmetrica* (Shiino, 1933), first described from *Clibanarius bimaculatus*

(de Haan) collected in Japan and subsequently found on *Clibanarius merguiensis* de Man from Phuket, Thailand (Shiino 1933, Markham 1985a). Although males of these two species are very similar, females can be easily distinguished by the uniramous uropods and greatly expanded tergal projections on pereomeres 5–7 of the right side of *A. asymmetrica*. *A. sallyae* lacks such tergal projections and has biramous uropods. In addition, *A. asymmetrica* varies in having uniramous or biramous fourth and fifth pleopods (Shiino 1933). *Asymmetrione shiinoi* Codreanu, Codreanu, & Pike, 1965 is found in the Red Sea and displays expanded tergal projections on the right side and uniramous uropods as observed in *A. asymmetrica*.

Of the eight previously described *Asymmetrione* species, *A. foresti* (Bourdon, 1968) and *A. desultor* Markham, 1975 have sinistral body distortion (Bourdon 1968, Markham 1975). *Asymmetrione desultor* is differentiated by being found only on pagurids while the rest of the species are found on diogenid hosts (the host of *A. nossibensis* Bourdon, 1976 is unknown). *Asymmetrione ambodistorta* Markham, 1985 is unique in the genus in exhibiting both dextral and sinistral distortion (Markham 1985b). Thus, *A. sallyae* belongs in the group of six strictly dextral species (*A. asymmetrica*, *A. clibanarii* Markham, 1975, *A. dardani* Bourdon, 1968, *A. nossibensis*, and *A. shiinoi*) found on diogenid hosts. *Asymmetrione clibanarii* has a wide distribution in the western Atlantic and females of this species are distinguished from the Singapore specimens by the broad triangular shaped pleopods and uniramous uropods (although some specimens of *A. clibanarii* have biramous uropods; fide Markham 1975). The males of *A. clibanarii* also have reduced lateral lobes, compared to the long lateral lobes in the males of *A. sallyae*. *Asymmetrione dardani* is found in the eastern Atlantic (Agadir, Morocco); the species has pronounced tubercles on the pereopods, pleopods, and uropods of the females

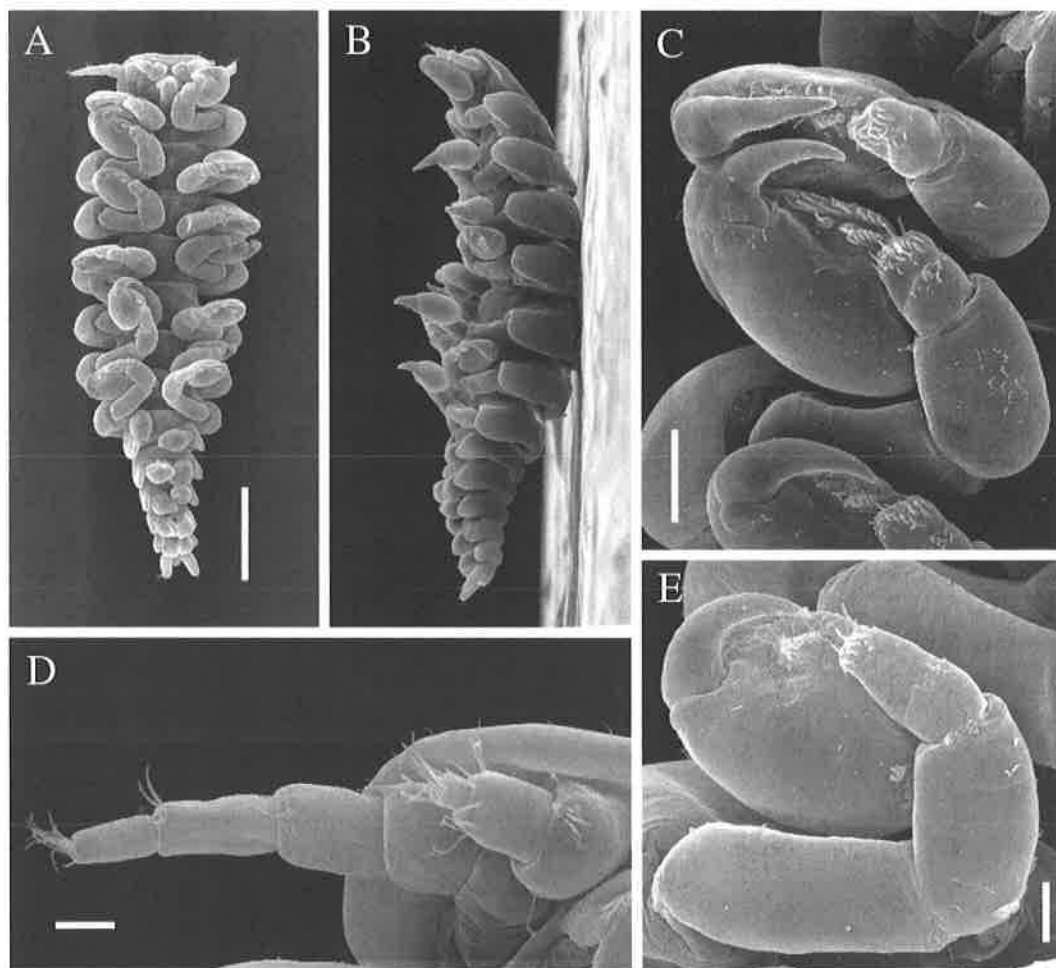


Fig. 6. *Asymmetrione sallyae*. Male, 1.40 mm, USNM 1024495, paratype. A, ventral view; B, lateral view; C, left pereopods 1 and 2; D, left antennule and antenna; E, left pereopod 7. Scale = 250 μ m (A, B), 50 μ m (C), 25 μ m (D, E).

and expanded tergal projections on pereomeres 6–7 of the left side whereas *A. sallyae* lacks such structures. *Asymmetrione nossibensis* was described from Madagascar. In contrast to *A. sallyae*, females of *A. nossibensis* have broad and lanceolate lateral plates, pleopods, and uropods with large tubercles. The species are further distinguished in that the males of *A. nossibensis* have a head that is not fused with pereomere 1 whereas the males of *A. sallyae* have a head that is fused with pereomere 1; however, this character has been

shown to be variable in other species of bopyrids (see Boyko & Williams 2004).

The extension of the body of *A. sallyae* from the branchial chamber of hosts (see Fig. 1) is similar to that found in the species *Bopyrophryxus branchi abdominalis* Codreanu, 1965. The convex (right) sides of mature females of *A. sallyae* and *B. branchi abdominalis* extend from the posterior margin of the branchial chamber of hosts, in the latter species the great elongation of the body (especially pereomeres 2 and 3 due to the expansion of the brood chamber)

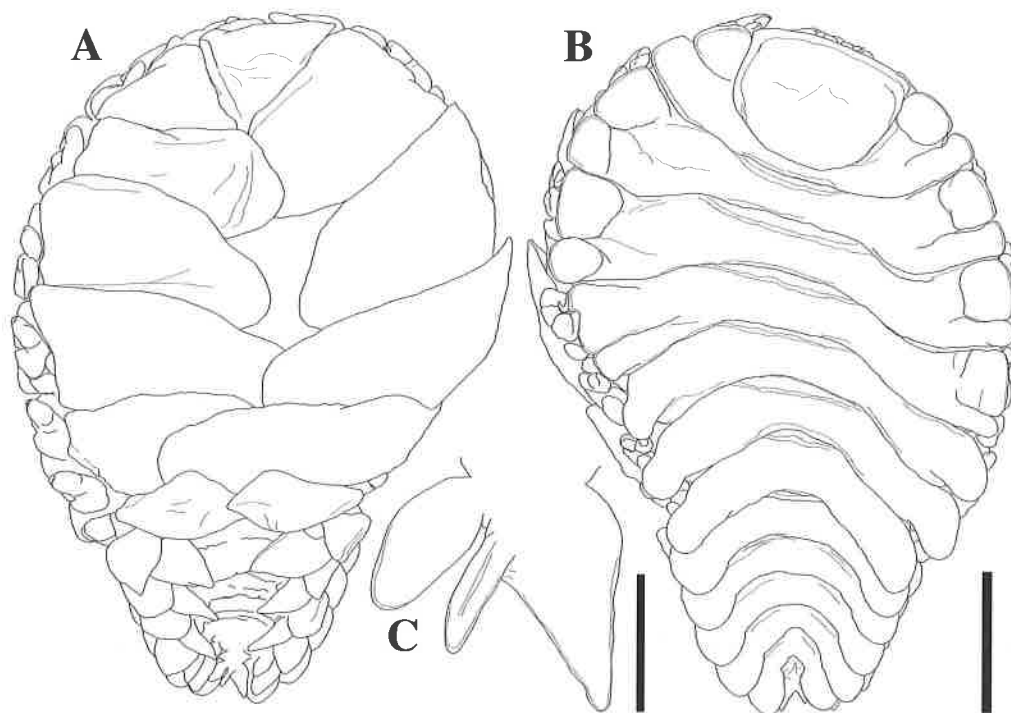


Fig. 7. *Pseudione kensleyi*. Female, 4.95 mm, ZRC 2004.0650, holotype. A, ventral view; B, dorsal view; C, ventral view of pleotelson and uropods. Scale = 1.0 mm (A, B), 150 μ m (C).

overlaps with the abdomen of the host (see Bourdon & Boyko 2005).

Genus *Pseudione* Kossman, 1881

Pseudione kensleyi, new species

Figs. 7–9

Material examined.—Holotype: female (4.95 mm) infesting left branchial chamber of female *Clibanarius infraspinus* (SL = 3.7; ZRC 2004.0676), Noordin Beach, Pulau Ubin, Singapore, intertidal near mangrove roots, coll. J. D. Williams, 8 August 2000 (ZRC 2004.0650). Allotype: male (1.47 mm), same data as holotype (ZRC 2004.0651).

Type locality.—Noordin Beach, Pulau Ubin, Singapore, Johore Strait, South China Sea.

Description.—Female (Figs. 7, 8), body length 4.95 mm, maximal width 3.28 mm, head length 0.90 mm, head width 1.14 mm. No body pigmentation. Pereon weakly sinistral with coxal plates and pereomeres of

left side slightly larger on segments 1–3 (Fig. 7B).

Head wider than long, with thin frontal lamina (Fig. 7B), deeply embedded medially in segment 1; minute eyes obscured by frontal lamina. Antennules of two articles, covered by scales; basal article rounded, meeting medially; second article short with setae at distal end (Fig. 8A). Antennae of two articles with large, U-shaped basal article; terminal article elongate with setae at distal end (Fig. 8B). Maxilliped with rounded distal end and subacute spur; without palp (Fig. 8G). Barbula with 1 pair of lanceolate lateral projections and 2 pairs of rounded lobes medially (Fig. 8D). First oostegite proximal lobe rounded, with distal lobe subtriangular (Fig. 8E); fifth oostegite with setae along posterior edge.

Pereon composed of 7 pereomeres, broadest across pereomere 3, gradually tapering anteriorly and posteriorly; pereomere 1 with approximately straight poste-

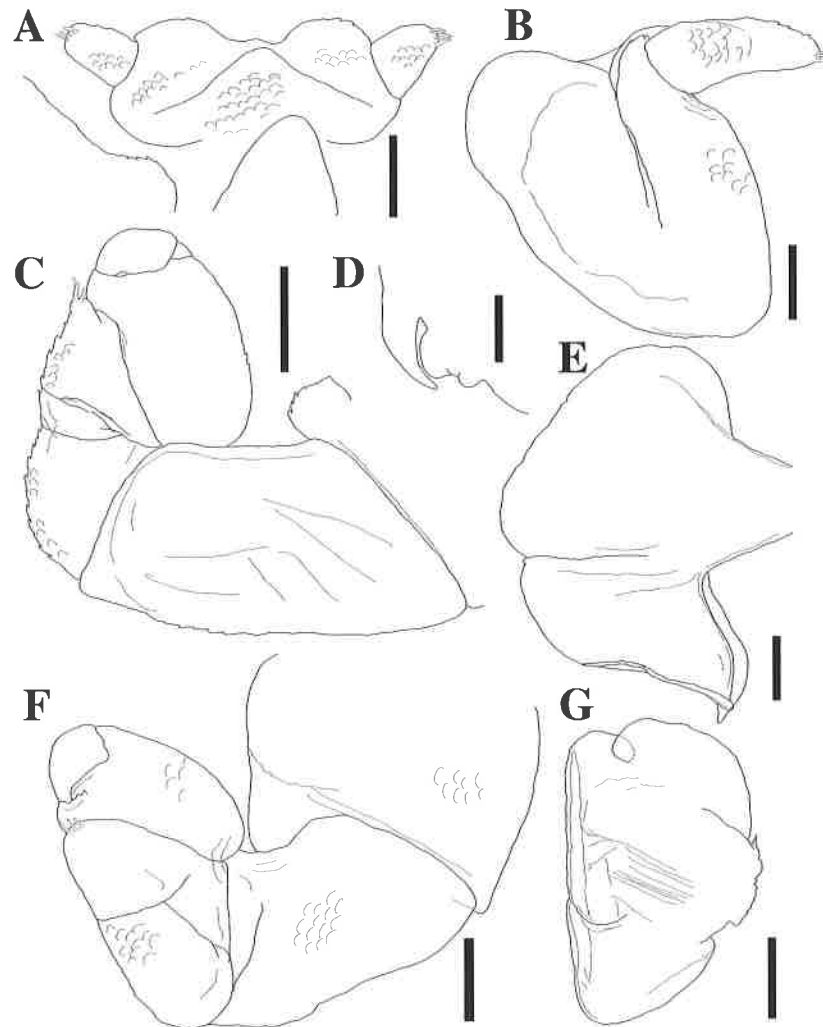


Fig. 8. *Pseudione kensleyi*. Female, 4.95 mm, ZRC 2004.0650, holotype. A, antennules; B, right antenna; C, right pereopod 1; D, right side of barbula; E, right oostegite 1, external view; F, right pereopod 7; G, right maxilliped, external view. Scale = 75 μ m (A, C, F), 50 μ m (B), 200 μ m (D), 25 μ m (E, G).

rior margin. Margins of pereomeres 2–4 with increasingly concave posterior margins (Fig. 7B). Pereomeres 1–4 strongly bilobed laterally, pereomere 5 weakly bilobed, pereomeres 6–7 entire, produced into rounded lobes, similar in morphology to lateral plates of pleon. Pereomeres 1–4 with rounded coxal plates and dorsolateral bosses. Oostegites nearly enclosing marsupium, lacking pronounced tubercles. First pair of pereopods at anterolateral margin of head;

pereopods evenly spaced. All pereopods with scales scattered in some regions of segments, distal end of carpus typically with 3 stout setae; posterior pereopods larger (Figs. 8C, F).

Pleon with 5 distinct pleomeres plus pleotelson (Fig. 7A, B). Pleomeres with extended foliaceous, biramous pleopods (Fig. 7A), and uniramous overlapping, rounded lateral plates (Fig. 7B); lateral plates and pleopods diminishing in size from anterior

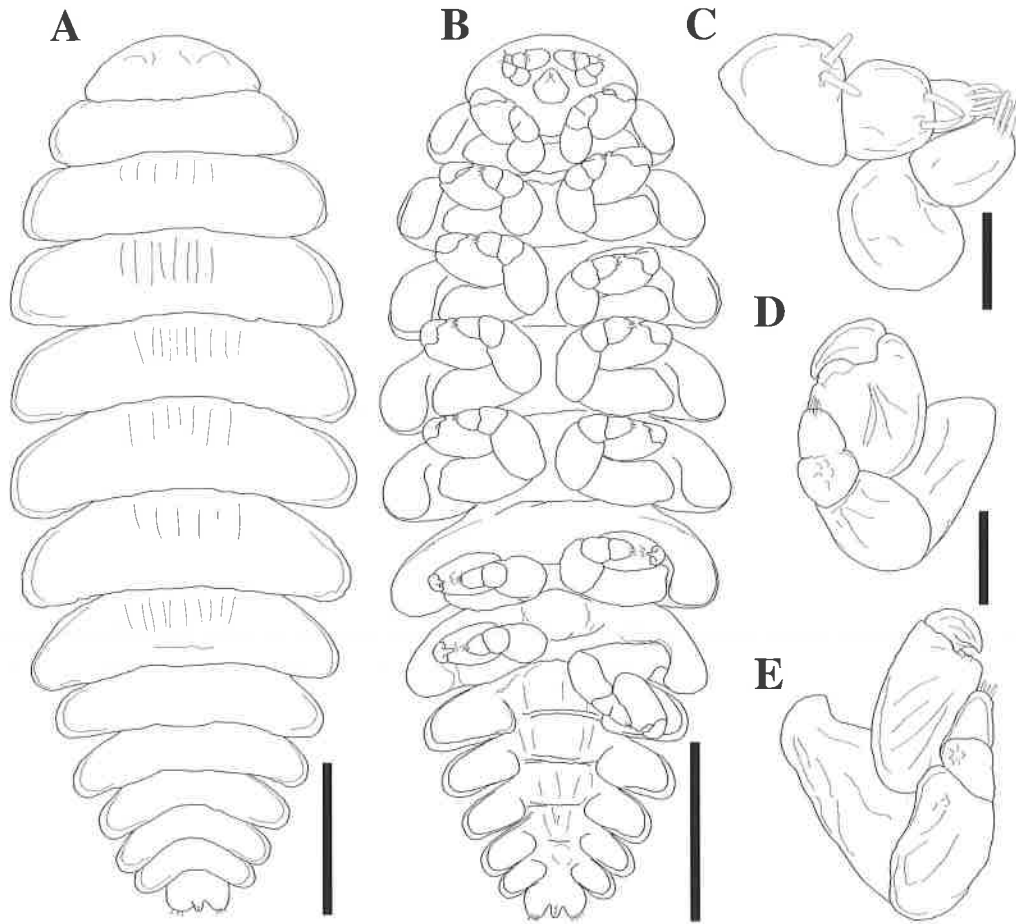


Fig. 9. *Pseudione kensleyi*. Male, 1.47 mm, ZRC 2004.0651, allotype. A, dorsal view; B, ventral view; C, left antennule and antenna; D, right pereopod 1; E, right pereopod 7. Scale = 250 μ m (A, B), 25 μ m (C), 60 μ m (D, E).

to posterior. Pleotelson (Fig. 7C) trifold with pair of uniramous uropods surrounding a digitiform middle extension (possible anal cone); uropods asymmetrical, right uropod distally rounded, left uropod with wider base, tapering to rounded point (Fig. 7C).

Male (Fig. 9), allotype, length 1.47 mm, maximal width 0.57 mm, head length 0.10 mm, head width 0.29 mm, pleon length 0.31 mm.

Head suboval, widest posteriorly, distinct from first segment of pereon (Figs. 9A, B). Eyes absent. Antennule of two articles, article 2 with 3 stout setae; antenna of three

articles, two stout setae on articles 1 and 2, article 3 with 5 stout setae (Fig. 9C).

Pereomeres 4–5 broadest, tapering anteriorly and posteriorly. All pereomeres directed laterally, distolateral margins rounded. Pereopods 2–5 subequal (Figs. 9D, E); 1, 6, and 7 smaller, all articles distinctly separated, carpus with few stout setae on distal margin, scales scattered in some regions on merus and ischium.

Pleon with five segments plus pleotelson; segments tapering posteriorly, pleomeres directed posterolaterally. All pleomeres distinctly segmented, not markedly narrower

than pereomeres, rounded distolateral margins. Five pairs of low rounded pleopods (Fig. 9B); no midventral tubercles. Pleotelson (Fig. 9A, B) notched medially with anal cone, with distolateral rounded lobes extending as far as anal cone, distal margins of lobes with setae; uropods absent.

Distribution and host.—From Pulau Ubin, Singapore on *Clibanarius infraspinatus*. One *C. infraspinatus* was infested by *Pseudione kensleyi* in the left branchial chamber (19 total *C. infraspinatus* examined; prevalence = 5.2%).

Etymology.—This species is named in honor of the late Brian Kensley in recognition of his extensive work on isopods.

Remarks.—The holotype of *Pseudione kensleyi* has a trifold pleotelson, a feature unknown in members of the genus *Pseudione* that infect hermit crabs. The asymmetrical nature of the uropods in this specimen suggest that a developmental abnormality occurred, with enlargement of the anal cone into a digitiform extension between the uropods. It is suspected that the normal morphology of *P. kensleyi* is similar to that found in other *Pseudione* parasites of hermit crabs (i.e., symmetrical uropods) but additional specimens are required to determine the typical morphology of this structure. Boyko & Williams (2004) recently reviewed the ten described species of *Pseudione* that are parasites of hermit crabs. Among these species, females can be separated into two groups based on body shape; those species with faint-to-pronounced S-shaped curvature (*P. calcinii* Shiino, 1958, *P. clibanaricola* Shiino, 1933, *P. novaeguineensis* Danforth, 1971) and those with a nearly straight anteroposterior alignment (*P. biacuta* Bourdon, 1979, *P. brandaoi* Brian & Darteville, 1941, *P. giardi* Calman, 1898, *P. hyndmanni* (Bate & Westwood, 1868), *P. intermedia* Nierstrasz & Brender à Brandis, 1932, *P. nobilii* Nierstrasz & Brender à Brandis, 1923, and *Pseudione quasimodo* Boyko & Williams, 2004). *Pseudione kensleyi* exhibits a slight S-shaped curve similar to *P. calcinii*, with

the left side swollen at the anterior end. In overall appearance, females of *P. kensleyi* most closely resemble those of *P. calcinii* known from *Calcinus latens* (Randall) collected in Japan (Shiino 1958). However, *P. calcinii* has lateral plates that are narrowly rounded at the distal ends and a maxilliped with a finger-like palp with setae whereas *P. kensleyi* has large, rounded, overlapping pleopods and a simple maxilliped lacking a palp. In addition, *P. calcinii* has long thin uniramous uropods. Unfortunately, males of *P. calcinii* have not been described. Males of *P. kensleyi* and *P. clibanaricola* (a parasite of *Clibanarius bimaculatus* from Japan; see Shiino 1933) are similar in overall body-shape; however, they differ in that the base of the pleotelson is wider in *P. kensleyi* than *P. clibanaricola* and the pleomeres gradually reduce in size from the seventh pereomere whereas in *P. clibanaricola* the first pleomere is longer and thinner than the seventh pereomere. Females of *P. clibanaricola* have a much stronger S-shaped curvature and, as in *P. calcinii*, they possess lateral plates that are narrowly rounded at the distal end. In addition, the distal lobe of the maxilliped of *P. clibanaricola* is narrower and more curved than in *P. kensleyi*. Thus, despite the questionable morphology of the uropods, *P. kensleyi* can be distinguished from all other described *Pseudione* parasites of hermit crabs.

Acknowledgments

We thank Dr. Patsy McLaughlin (Western Washington University) for identification of the hermit crab hosts. Dr. Christopher B. Boyko (American Museum of Natural History) kindly read a draft of the manuscript and discussed the similarities between *Asymmetrione sallyae* and *Bopyrophryxus branchiabdrominalis*. The manuscript was improved by the comments of Dr. Ramiro Román Contreras (Universidad Nacional Autónoma de México) and an anonymous reviewer. The support of Hofstra University is greatly appreciated. This material is

based on work supported by the National Science Foundation under grant No. DEB-00118693.

Literature Cited

- Bate, C. S., & J. O. Westwood. 1868. A history of the British sessile-eyed Crustacea. London: John Van Voorst. Volume II. lvi + 536 pp.
- Bourdon, R. 1968. Les Bopyridae des mers Europeenne.—Memoires du Museum National d'Histoire Naturelle de Paris, Nouvel Serie (A) 50:77–424.
- . 1976. Epicarides de Madagascar. I.—Bulletin du Museum National d'Histoire Naturelle, Paris, (3) no. 371, Zoologie 259:353–392.
- . 1979. Sur la taxonomie et l'ethologie de quelques Orbionines (Isopoda Epicaridea).—International Revue der Gesamte Hydrobiologie 64(3):425–435.
- , & C. B. Boyko. 2005. Redescription of *Bopyrophryxus branchiabdominalis* Codreanu, 1965 (Crustacea: Isopoda: Bopyridae) with a reappraisal of the subfamily Bopyrophryxinae Codreanu, 1965.—Proceedings of the Biological Society of Washington 118:108–116.
- Boyko, C. B., & J. D. Williams. 2001. A review of *Pseudionella* Shiino, 1949 (Crustacea: Isopoda: Bopyridae), with the description of a new species parasitic on *Calcinus* hermit crabs from Easter Island.—Proceedings of the Biological Society of Washington 114:649–659.
- . 2004. New records of marine isopods (Crustacea: Peracarida) from the Bahamas, with descriptions of two new species of epicarideans.—Bulletin of Marine Science 74:353–383.
- Brian, A., & E. Darteville. 1941. Sur un epicaride nouveau du Congo: *Pseudione Brandaoi* nv. sp.—Revue de Zoologie et Botanique d'Afrique (Tervuren) 34:348–352.
- Calman, W. T. 1898. On a collection of Crustacea from Puget Sound (Puget Sound Zoology, Columbia University Contributions no. 9).—Annals of the New York Academy of Science 11(13):259–292, pls. XXXI–XXXIV.
- Codreanu, R. 1965. Sur un bopyride nouveau, *Bopyrophryxus branchiabdominalis* nov. gen. nov. sp., parasite de *Parapagurus monstrosus* des les Kei et type de la sous-famille nouvelle des Bopyrophryxinae nov.—Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences de Paris 261(Groupe 12):1895–1897.
- . 1967. Clasificarea evolutiva a bopirienilor, isopode parazite ale crustaceelor decapode si importanta lor biologica generala.—Studii Cercetari Biologie 19:203–211.
- , M. Codreanu, & R. B. Pike. 1965. Sur deux bopyriens parasites de pagures recueillis par M. A. Horridge dans la mer Rouge et sur leur asymétrie.—Crustaceana 9:225–244.
- Danforth, C. G. 1971. Two bopyrids (Isopoda) from New Guinea.—Bulletin of the Southern California Academy of Sciences 70:99–102.
- Kossman, R. 1881. Studien über Bopyriden. I. *Gigantione moebii* und Allgemeines über die Mundwerkzeuge der Bopyriden. II. *Bopyrina virbii*, beiträge zur Kenntnis der Anatomie und Metamorphose der Bopyriden.—Zeitschrift der Wissenschaftlichen Zoologie 35:652–680, pls. 32–35.
- Markham, J. C. 1975. Two new species of *Asymmetrione* (Isopoda, Bopyridae) from the Western Atlantic.—Crustaceana 29:255–265.
- . 1985a. Additions to the bopyrid isopod fauna of Thailand.—Zoologische Verhandlungen 224:1–63.
- . 1985b. A new species of *Asymmetrione* (Isopoda: Bopyridae) infesting the hermit crab *Ischocheles pilosus* (Holmes) in Southern California.—Bulletin of the Southern California Academy of Science 84:104–108.
- . 2003. A worldwide list of hermit crabs and their relatives (Anomura: Paguroidea) reported as hosts of Isopoda Bopyridae.—Memoirs of Museum Victoria 60:71–77.
- Nierstrasz, H. F., & G. A. Brender à Brandis. 1923. Die Isopoden der Siboga-Expedition. II. Isopoda Genuina. I. Epicaridea.—Siboga-Expedition 32b:57–121; plates IV–IX.
- . 1932. Alte und neue Epicaridea.—Zoologischer Anzeiger 101:90–100.
- Rafinesque-Schmaltz, C. S. 1815. Analyse de la nature ou tableau de l'univers et des corps organisés. Palermo, 224 pp.
- Shiino, S. M. 1933. Bopyrids from Tanabe Bay.—Memoirs of the College of Science, Kyoto Imperial University (B) 8(3, Article 8):249–300.
- . 1958. Note on the bopyrid fauna of Japan.—Report of Faculty of Fisheries, Prefectural University of Mie 3:29–73.

Associate Editor: Christopher B. Boyko