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A New Species of Freshwater Bopyrid, *Probopyrus iriomotensis* (Crustacea: Isopoda), Parasitizing *Macrobrachium* spp. (Crustacea: Decapoda), from Iriomote Island, Ryukyu Islands, Southwestern Japan

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A new species of bopyrid isopod, *Probopyrus iriomotensis* sp. nov. parasitizing palaemonid freshwater shrimps of the genus *Macrobrachium*, is described based on material from Iriomote Island, Ryukyu Islands, southwestern Japan. The new species most commonly infects the branchial chambers of *Macrobrachium shokitai* Fujino and Baba, 1973, but rarely also *M. formosense* (Bate, 1868). The new species is similar to *Probopyrus ascendens* (Semper, 1880), *P. gangeticus* Chopra, 1923, and *P. giardi* Weber, 1892, but can be distinguished from them by a combination of characters of the pleomere and pleotelson, relative body width, and the degree of deflection of the body axis. This is the first species of Bopyridae to be recorded from a freshwater environment in Japan. In addition, the generic assignment of two marine species of *Probopyrus* is questioned, and the date of authorship of *P. marinus* Nierstrasz and Brender à Brandis, 1923 is clarified.

Key Words: Crustacea, Isopoda, Bopyridae, *Probopyrus*, *Macrobrachium*, Iriomote Island, Japan.

Introduction

In Japan, 94 species of bopyrid isopod have been recorded (Shiino 1972; Saito *et al.* 2000; Shimomura *et al.* 2006). Although these species infect various groups of decapod crustaceans inhabiting marine or brackish-water environments, no true freshwater species has been known from Japan. Carcinologists of the University of the Ryukyus recently noticed, however, an unidentified bopyrid species of the genus *Probopyrus* Giard and Bonnier, 1888 infecting the branchial chambers of *Macrobrachium shokitai* Fujino and Baba, 1973, an endemic freshwater shrimp of Iriomote Island, the largest and least disturbed of the Yaeyama Islands in the southern Ryukyu Islands.

The genus *Probopyrus* (type species: *Bopyrus ascendens* Semper, 1880) is represented by 28 species from the Indo-West Pacific, East Pacific, and tropical and subtropical regions of the western Atlantic, which infect mostly brackish- or freshwater palaemonid shrimps, including species of *Macrobrachium*, *Cuapetes*, *Leander*, *Palaemon*, and *Palaemonetes* (Shiino 1973; Markham 1985a; Román-Contreras and Bourdon 2001; Boyko and Schotte 2009; see “Discussion”) (Table 1).

In this report, we describe the new species of *Probopyrus* infecting *Macrobrachium shokitai* under the name of *P. iriomotensis*. The new species is morphologically similar to *P. ascendens* (Semper, 1880), *P. gangeticus* Chopra, 1923, and *P. giardi* Weber, 1892. Distinguishing characters between *P. iriomotensis* sp. nov. and the latter three allied species are discussed. The present new species is the first freshwater bopyrid species known from Japan.

Materials and Methods

Specimens of *Macrobrachium shokitai* and *M. formosense* (Bate, 1868), the host shrimps of the new species of *Probopyrus*, were collected with hand-nets at Iriomote Island, preserved in 70% ethanol, and transported to the laboratory. The branchial chambers and pleons of the *Macrobrachium* shrimps were examined under a binocular microscope (Olympus X-II) to detect and extract bopyrid specimens. Measurements and drawings were made with the aid of a microscope (Olympus BHB-Tr) with an attached drawing tube.

Measurements provided are the body length (BL: measured along the major axis of the body) of the bopyrid specimens and the postorbital carapace length (CL: measured from the posterior margin of the orbit to the midpoint of the posterodorsal margin of the carapace) of the host shrimps. Other measurements and terminology essentially follow those of Markham (1985a) for bopyrids and Baba *et al.* (1986) for shrimps. The examined specimens are deposited in the Toyama Science Museum (TOYA Cr), Toyama, Japan; the Kitakyushu Museum of Natural History and Human History (KMNH IvR), Kitakyushu, Japan; and the Ryukyu University Museum, Fujikan (RUMF-ZC), Nishihara, Okinawa, Japan.

Taxonomy

Genus *Probopyrus* Giard and Bonnier, 1888

Probopyrus iriomotensis sp. nov.

[New Japanese name: Shokitatenaga-no-erayadori]

(Figs 1–3)

Material examined. Holotype: female (BL 8.6 mm), TOYA Cr-15308, Kanpire Waterfall, Urauchi River, Iriomote Island, Ryukyu Islands, southwestern Japan, left branchial chamber of host (*Macrobrachium shokitai*, TOYA Cr-15310), 16 March 2002, coll. A. Ito *et al.* Allotype: male (BL 1.8 mm), TOYA Cr-15309, removed from pleon of holotype.

Paratypes: female (BL 4.4 mm), KMNH IvR 500,390, and male (BL 1.4 mm) attached to its pleon, KMNH IvR 500,391, left branchial chamber of host; female (BL

Table 1. List of species belonging to the genus *Probopyrus* in the world.

Species Host	Locality	Reference
1 <i>P. aberrans</i> Nierstrasz and Brender à Brandis, 1932 <i>Spirontocaris</i> sp.	Nemuro, Japan (type locality)	Nierstrasz and Brender à Brandis (1932)
2 <i>P. abhoyai</i> (Chopra, 1923) <i>Palaemon</i> sp.	Ganges Delta, India (type locality)	Chopra (1923)
3 <i>P. alcocki</i> (Chopra, 1923) <i>Palaemon</i> aff. <i>malcolmonsonii</i> H. Milne-Edwards, 1844	Ganges Delta, India (type locality)	Chopra (1923)
4 <i>P. annandalei</i> Chopra, 1923 <i>Macrobrachium australe</i> (Guerin-Méneville, 1838) (?), young	Tale Sap, Siam, Thailand (type locality)	Chopra (1923)
5 <i>P. ascendens</i> (Semper, 1880) <i>Macrobrachium lar</i> (Fabricius, 1798)	Philippines (type locality)	Bonnier (1900)
6 <i>P. bithynis</i> Richardson, 1904 <i>Macrobrachium ohione</i> (Smith, 1874)	Louisiana, USA (type locality)	Richardson (1904, 1905)
7 <i>P. borrei</i> (Giard and Bonnier, 1888) <i>Macrobrachium lar</i> (Fabricius, 1798); <i>M. australe</i> (Guerin-Méneville, 1838)	Amboina (type locality); Flores Is.	Bonnier (1900); Shiino (1973)
8 <i>P. brachysoma</i> (Chopra, 1923) <i>Palaemon mirabilis</i> Kemp, 1917; <i>Macrobrachium</i> aff. <i>australe</i> (Guerin-Méneville, 1838)	Ganges Delta, India (type locality)	Chopra (1923)
9 <i>P. brevipes</i> (Bonnier, 1900) <i>Palaemon endehensis</i> De Man, 1892	Flores Is. (type locality)	Bonnier (1900)
10 <i>P. buitendijki</i> (Horst, 1910) <i>Macrobrachium rosenbergii</i> (De Man, 1879); <i>Palaemon malcolmonsonii</i> H. Milne-Edwards, 1844	Malaysia (type locality); Ganges Delta, India; West Java, Indonesia	Horst (1910); Chopra (1923); Markham (1985b)
11 <i>P. demani</i> (Weber, 1892) <i>Palaemon pilimanus</i> De Man, 1879	Sumatra (type locality); Godavari Delta, India	Bonnier (1900); Chopra (1923)
12 <i>P. floridensis</i> Richardson, 1904 <i>Palaemonetes exilipes</i> Stimpson, 1871	Florida, USA (type locality)	Richardson (1904, 1905)
13 <i>P. fluviatilis</i> (Weber, 1892) <i>Palaemon lampropus</i> De Man, 1892	Celebes (type locality)	Bonnier (1900)

Table 1. Continued.

Species Host	Locality	Reference
14 <i>P. gangeticus</i> Chopra, 1923 <i>Palaemon</i> sp.	Ganges Delta, India (type locality)	Chopra (1923)
15 <i>P. giardi</i> Weber, 1892 <i>Macrobrachium placidum</i> (De Man, 1892); <i>M. sintangense</i> (De Man, 1898)	Sumatra (type locality); Lumpun Lake, Thailand	Bonnier (1900); Markham (1991)
16 <i>P. godavertiensis</i> (Chopra, 1923) <i>Palaemon</i> aff. <i>scabriculus</i> Heller, 1862	Godaveri Delta, India (type locality)	Chopra (1923)
17 <i>P. incertus</i> (Bonnier, 1900) <i>Palaemon bartensis</i> de Man, 1892	Flores Is. (type locality)	Bonnier (1900)
18 <i>P. instularis</i> Román-Contreras and Bourdon, 2001 <i>Macrobrachium faustinum</i> (de Saussure, 1857)	St. Mary Parish, Jamaica (type locality)	Román-Contreras and Bourdon (2001)
19 <i>P. iriomotensis</i> sp. nov. <i>Macrobrachium shokitai</i> (Fujino and Baba, 1973); <i>M. formosense</i> (Bate, 1868)	Iriomote Island, Japan (type locality)	Present study
20 <i>P. marinus</i> (Nierstrasz and Brender à Brandis, 1923) Unknown	Indonesia (type locality)	Nierstrasz and Brender à Brandis (1923)
21 <i>P. markhami</i> Román-Contreras, 1996 <i>Macrobrachium americanum</i> Bate, 1868	Mexico (type locality)	Román-Contreras (1996)
22 <i>P. pacificensis</i> Román-Contreras, 1993 <i>Macrobrachium tenellum</i> (Smith, 1871)	Guerrero, Mexico (type locality)	Román-Contreras (1993)
23 <i>P. palaemoni</i> Lemos de Castro and Brasil Lima, 1974 <i>Palaemon pandaliformis</i> (Stimpson, 1871)	Brazil (type locality)	Lemos de Castro and Brasil Lima (1974)

Table 1. Continued.

Species Host	Locality	Reference
24 <i>P. pandalicola</i> (Packard, 1879) <i>Macrobrachium acanthurus</i> (Wiegmann, 1836); <i>M. amazonicum</i> (Heller, 1862); <i>M. digueti</i> (Bouvier, 1895) (?); <i>M. ohione</i> (Smith, 1874); <i>M.</i> <i>olfersii</i> (Wiegmann, 1836); <i>Palaemon (Palaeander)</i> <i>northropi</i> (Rankin, 1898); <i>Palaemonetes</i> (<i>Palaemonetes</i>) <i>intermedius</i> Holthuis, 1949; <i>P. (P.)</i> <i>paludosus</i> (Gibbes, 1850); <i>P. (P.) pugio</i> Holthuis, 1949; <i>P. (P.) vulgaris</i> (Say, 1818); <i>Cuapetes americanus</i> (Kingsley, 1878)	Atlantic coast of USA (type locality); Panama; Virgin Is.; New Hampshire to Brazil; Pacific drainage of Panama	Richardson (1905); Markham (1985a, 1988)
25 <i>P. pica</i> (Chopra, 1923) <i>Leander potamiscus</i> Kemp, 1917	Sanguem River, India (type locality)	Chopra (1923)
26 <i>P. plesionikae</i> (Barnard, 1920) <i>Plesionika martia</i> (A. Milne-Edwards, 1883)	South Africa (type locality)	Barnard (1920)
27 <i>P. prashadi</i> (Chopra, 1923) <i>Palaemon lamarrei</i> H. Milne-Edwards, 1837	Ganges Delta, India (type locality)	Chopra (1923)
28 <i>P. ringueleti</i> Verdi and Schuldt, 1988 <i>Palaemonetes argentinus</i> Nobili, 1901	Buenos Aires, Argentina (type locality)	Verdi and Schuldt (1988)
29 <i>P. semper</i> Nierstrasz and Brender à Brandis, 1929 <i>Palaemon</i> sp.	Amboina Is. (type locality); Shanghai	Nierstrasz and Brender à Brandis (1929, 1932)

Fig. 1. *Probopyrus iriomotensis* sp. nov., holotype, female (BL 8.6 mm), TOYA Cr-15308. A, Entire animal, dorsal view; B, same, ventral view, showing attached dwarf male (allotype) on ventral side of pleon (arrowhead); C, right antenna 1, ventral view; D, right antenna 2, ventral view; E, left maxilliped, ventral view; F, palp of maxilliped; G, barbula, ventral view; H, left oostegite 1, ventral view; I, same, dorsal view; J, left pereopod 1, medial view; K, left pereopod 7, medial view.

Fig. 2. *Probopyrus iriomotensis* sp. nov., allotype, male (BL 1.8 mm), TOYA Cr-15309 (A–E) and paratype, male (BL 1.8 mm), KMNH IvR 500,393 (F, G). A, Entire animal, dorsal view; B, same, ventral view; C, anteroventral view of head with right antennae 1 and 2; D, left pereopod 1, medial view; E, left pereopod 7, medial view; F, head and pereomere 1, dorsal view; G, pleon, dorsal view.

5.7 mm), KMNH IvR 500,392, and male (BL 1.8 mm) removed from its pleon, KMNH IvR 500,393, right branchial chamber of host, same data as holotype. Ovigerous female (BL 5.5 mm), RUMF-ZC-900, and male (BL 1.5 mm) attached to its pleon, RUMF-ZC-901, left branchial chamber of host; ovigerous female (BL 7.6 mm), RUMF-ZC-903, and male (BL 1.9 mm) removed from its pleon, RUMF-ZC-904, right branchial chamber of host, Nishifunatsuki, tributary of Nakama River, Iriomote Island, Ryukyu Islands, southwestern Japan, 23 January 2004, coll. T. Naruse. Female (BL 9.8 mm), with attached male on pleon, RUMF-ZC-01045, right branchial chamber of host; ovigerous female (BL 10.3 mm), RUMF-ZC-01047, with no attached male, right branchial chamber of host; ovigerous female (BL 11.1 mm), RUMF-ZC-01043, with no attached male, right branchial chamber of host, Kanpire Waterfall,

Fig. 3. *Macrobrachium shokitai* Fujino and Baba, 1973, male (CL 7.6 mm), KMNH IvR 500,394, infected by *Probopyrus iriomotensis* sp. nov. in the left branchial chamber.

Urauchi River, Iriomote Island, Ryukyu Islands, southwestern Japan, 11 July 2009, coll. T. Naruse.

Host specimens. *Macrobrachium shokitai* (all specimens immature): male (CL 12.8 mm), TOYA Cr-15310, infected by holotype female (TOYA Cr-15308) and allotype male (TOYA Cr-15309); male (CL 7.6 mm), KMNH IvR 500,394, infected by paratype female and male (KMNH IvR 500,390 and 500,391); male (CL 8.9 mm), KMNH IvR 500,395, infected by paratype female and male (KMNH IvR 500,392 and 500,393), Kanpire Waterfall, Urauchi River, Iriomote Island, Ryukyu Islands, southwestern Japan, 16 March 2002, coll. A. Ito *et al.* Male (CL 8.7 mm), RUMF-ZC-902, infected by paratype female and male (RUMF-ZC-900 and -901); male (CL 10.0 mm), RUMF-ZC-905, infected by paratype female and male (RUMF-ZC-903 and -904), Nishifunatsuki, tributary of Nakama River, Iriomote Island, Ryukyu slands, southwestern Japan, 23 January 2004, coll. T. Naruse. Male (CL 11.4 mm), RUMF-ZC-01044, infected by paratype female and male (RUMF-ZC-01045); male (CL 11.5 mm), RUMF-ZC-01046, infected by paratype female (RUMF-ZC-01047), Kanpire Waterfall, Urauchi River, Iriomote Island, Ryukyu Islands, southwestern Japan, 11 July 2009, coll. T. Naruse.

Macrobrachium formosense: male (CL 14.2 mm), RUMF-ZC-01042, infected by paratype female (RUMF-ZC-01043), Kanpire Waterfall, Urauchi River, Iriomote Island, Ryukyu Islands, southwestern Japan, 11 July 2009, coll. T. Naruse.

Description of female holotype. Body compressed dorsoventrally, semioval in general outline, distinctly asymmetrical, with anterior margin nearly straight;

body axis deflection 26°; maximal width at pereomere 3, equal to 77% of body length.

Head (Fig. 1A) distinctly demarcated from pereon, but deeply embraced in pereomere 1 dorsally, head length 20% of body length; anterior margin slightly extending beyond that of pereomere 1, lacking frontal lamina; eyes absent. Both antennae 1 and 2 (Fig. 1C, D) 2-segmented. Maxillipeds (Fig. 1E, F) with short, non-articulated, setose palp and prominent spur. Barbula (Fig. 1G) with 2 pairs of lateral projections, outer one broad and blunt, inner one long and slender, and with medial “v”-shaped tiny notch.

Pereomeres (Fig. 1A) distinctly separated dorsally and laterally; anterior boundary of pereomere 3 nearly straight; posterior margins of pereomeres 1 and 2 convex, “U”-shaped; posterior margins of pereomeres 4 to 7 concave, inverted “U”-shaped. Dorsolateral bosses and coxal plates present on both sides of pereomeres 1 to 4. Oostegites (Fig. 1B) surrounding ventral side of margin of pereomeres, but incompletely enclosing brood pouch; oostegite 1 (Fig. 1H, I) prominently produced into rounded posterolateral point, with internal ridge dentate. Pereopods (Fig. 1J, K) all subequal, relatively small, with all articles distinct; basis stout, with inner margins forming expanded carina; ischium rectangular; merus and carpus triangular; propodus trapezoidal; dactylus stout.

Pleon (Fig. 1A) length 32% of body length; pleomeres 1 and 2 clearly demarcated, pleomeres 2 to 5 and pleotelson with medial portions fused, notched laterally; each pleomere with pair of well-developed, flap-like, biramous pleopods, these reaching beyond lateral margins of pleon in concave side *in situ*, last pair smallest; uropods absent. Pleotelson sub-triangular, posterior margin rounded, smooth, without cleft or anal cone.

Description of male allotype. Body small, about 20% of that of female in length; elliptical in general outline; body width 46% of body length.

Head (Fig. 2A) fused with pereomere 1, semicircular, subequal in length to pereomere 1. Eyes small but conspicuous. Antennae (Fig. 2C) subequal in length; antenna 1 with 3 articles, and with short setae on anterior parts of distal 2 articles. Antenna 2 with 2 articles, proximal one having short setae.

All pereomeres (Fig. 2A) distinctly demarcated dorsally, no tubercles ventrally; lateral margins convex. Pereopods (Fig. 2D, E) all subequal, rather small; all articles distinct; palm of propodus with granules; distoventral tip of carpus with a few distal setae.

Pleon (Fig. 2A) length 25% of whole body length; pleomeres 1 and 2 clearly demarcated, pleomere 3 and following pleomeres completely fused; lateral margins of each pleon produced laterally, semicircular. Terminal pleomere short, with posterolateral margins and center of distal margin weakly expanded, forming “W”-shape; uropods absent. Pleopods situated on posterolateral parts of pleomeres 1 to 4, sessile, tuberculiform (Fig. 2B).

Variation in male. One male paratype (KMNH IvR 500,393, BL 1.8 mm: Fig. 2F, G) differing from other males in having slightly concave frontal cephalic margin, with head demarcated laterally from pereomere 1, and pleomere 3 and following pleomeres also being demarcated laterally.

Coloration. *Female in preservative.* Ground color light yellowish brown. Head and dorsolateral bosses whitish in dorsal view; lateral parts of pereomeres 1–7 and coxal plates 2–4 with scattered dark pigment on concave side. Each side of oostegites 1, 2, and 5, and concave side of oostegites 3 and 4 black in ventral view; con-

vex side of oostegite 4 with dark pigment spots. Ventral side of body (Fig. 3) with “C”-shaped marking corresponding to black parts of brood pouch.

Male in preservative. Ground color light yellowish brown; pereomeres more brownish. Eyes conspicuously blackish.

Ecological note. Most of the examined specimens of *Probopyrus iriomotensis* were found on specimens of *Macrobrachium shokitai*, the sole land-locked species of *Macrobrachium* in the Ryukyus, from the upper reaches of the Urauchi River and Nakama River (Fig. 3). The infected part of the carapace of the host shrimp, either the right or left branchial chamber, was strongly expanded, and it is very easy to recognize the infection even in the field. Female bopyrids were attached by their ventral side to the branchial chamber of the host, and were facing backward. The brood pouch of the isopod is closed by the cuticular membrane of the inner side of the host's carapace. Six females were found with one male each attached to the ventral side of the pleon (Fig. 1B; the arrowhead indicates the posterior end of a male). Two female bopyrids collected in January (RUMF-ZC-900 and RUMF-ZC-903) and two of three collected in July (RUMF-ZC-01043 and RUMF-ZC-01047) had spawned, but three collected in March (TOYA Cr-15308, KMNH IvR 500,390, and KMNH IvR 500,392) were not carrying eggs or larvae. All the infected *M. shokitai* examined in the present study were immature males (CL 7.6–12.8 mm).

One individual of *Macrobrachium formosense* was infected by *Probopyrus iriomotensis* at the latter's type locality. This finding suggests that *P. iriomotensis* may infect other species of *Macrobrachium* as well, including amphidromous species, although the present observations indicate that this isopod most commonly infects the land-locked *M. shokitai*.

Distribution. Known only from Iriomote Island, Ryukyu Islands, Japan: upper reaches of Urauchi River and Nakama River, and Kanpire Waterfall.

Etymology. Named after the type locality, Iriomote Island, Ryukyu Islands, Japan.

Discussion

Species differentiation

The diagnostic characters of *Probopyrus* pertain to the female: semi-oval body shape; head demarcated distinctly from pereon but deeply embedded into dorsal surface of first pereomere; presence of unarticulated palp on maxilliped; presence of two pairs of lateral projections on barbula; distinctly demarcated pereomeres; presence of small pereopods on all pereomeres; oostegites ventrally surrounding margins of pereomeres but not fully enclosing brood pouch; oostegite 1 produced into prominent posterolateral point; six distinctly demarcated pleomeres (with medial parts of some pleomeres fused) (Shiino 1973; Markham 1985a, b). The present new species agrees well with *Probopyrus* in every diagnostic respect. Females of *Probopyrus iriomotensis* lack any cleft or notch on the posterior margin of the pleotelson, and pleomere 1 is clearly differentiated from the more posterior pleomeres. They are thus similar to females of *P. ascendens* (Semper, 1880), *P. gangeticus* Chopra, 1923, and *P. giardi* Weber, 1892. These three species, however, lack clear demarcations of the pleomere 2 and the following segments (cf. Bonnier 1900, pl. 32, figs 1, 7; Chopra 1923, pl. 19, fig. 1). Furthermore, the new species can be separated

from *P. ascendens* and *P. giardi* by its narrower body shape (body width 77% of body length in *P. iriomotensis* vs 102% in *P. ascendens* and 87% in *P. giardi*), and from *P. gangeticus* by the greater deflection of the body axis (26° vs 16°).

The pigmentation of females of *Probopyrus iriomotensis* is similar to that of *P. borrei* (Giard and Bonnier, 1888), but the new species can be differentiated easily by the rounded and smooth posterior margin of the pleotelson (vs a deeply concave posterior margin in *P. borrei*), the undemarcated medial parts of pleomere 2 and the following segments (vs pleomere 2 and sometimes the following segments being demarcated even medially in *P. borrei*), and the blunt shape of the two lateral projections on the barbula (vs hook-shaped in *P. borrei*) (cf. Shiino 1973, figs 1–4).

Although 15 atyid and 13 palaemonid species of freshwater shrimp have been recorded from Iriomote Island (Shokita 2003a, b; Fujita 2005; Cai and Shokita 2006), *Probopyrus iriomotensis* has been recorded only from *M. shokitai* and *M. formosense*. *Macrobrachium shokitai* is the only species of the genus known from the Ryukyus that has a land-locked life history and abbreviated larval development (Shokita 1973), and it has been categorized as “Vulnerable” or “Near Threatened” in three red data books issued by the Fisheries Agency, the Ministry of the Environment, and Okinawa Prefecture (Baba 1998; Shokita and Naruse 2005; Shokita 2006). It is interesting that all the infected specimens of *M. shokitai* were immature males. There is no information as to whether *P. iriomotensis* affects sex determination or growth of the host. As for other species of *Probopyrus*, Beck (1979, 1980) reported that *P. floridensis* Richardson, 1904 (as *P. pandalicola* (Packard, 1879)) infected females of *Palaemonetes paludosus* (Gibbes, 1850) in higher percentage than in males, but that only female hosts less than 31 mm in body length had a higher frequency of infection. Furthermore, the chelae of the infected male hosts were shorter than those of uninfected males, and most infected mature females were not ovigerous. Similarly, *Probopyrus bithynis* Richardson, 1904 was thought to have a detrimental effect on the reproductive capacity of female *Macrobrachium ohione* (Smith, 1874) (Truesdale and Mermilliod 1977). There are also a large number of freshwater palaemonid shrimps, including *M. formosense*, in Taiwan and China, but no bopyrid infections have been reported nor observed in them (J.-Y. Shy, Y. Cai, personal communications); however, Bonnier (1900) recorded *Probopyrus ascendens* (Semper, 1880) from *Macrobrachium lar* (Fabricius, 1798) in the Philippines. One of us (TN) also observed an infected *Macrobrachium* specimen in the RUMF collection (T. Naruse, unpublished data). Future study may reveal the presence of more bopyrid species infecting freshwater shrimps.

Notes on species of *Probopyrus*

According to Shiino (1973), Markham (1985a), Román-Contreras and Bourdon (2001), and Boyko and Schotte (2009), 26 previously described species are recognized in the genus *Probopyrus*. We would like to suggest that two more species should be recognized. Dale and Anderson (1982) showed that *P. bithynis* and *P. floridensis* are both distinct from *P. pandalicola*, being differentiated by larval characters. However, Markham (1985a: 27) considered all of them to be conspecific, commenting, “If they are distinct only as larvae, however, the separation into different species (or subspecies, or whatever) remains impossible and of little practical value for anyone working only with adults.” Even though the separation may not be practical for taxonomists, the evidence from larval characters strongly sug-

gests that *P. bithynis* and *P. floridensis* are valid species.

It is worth mentioning that *Probopyrus aberrans* Nierstrasz and Brender à Brandis, 1932 and *P. plesionikae* (Barnard, 1920) are substantially different from other species of *Probopyrus* in their morphological and ecological traits. *Probopyrus aberrans* is characterized by a rectangular body shape and fairly reduced pleopods in females (vs semi-oval body shape and better developed pleopods in other species). *Probopyrus plesionikae* is unique in its elliptical body shape, complete (vs incomplete) enclosure of the brood pouch by oostegites, and 7-segmented antenna 2 (vs 2- or 3-segmented). Furthermore, these two species infect truly marine shrimps: *P. aberrans* can be found on *Spirontocaris* sp. (Hippolytidae), while *P. plesionikae* infects *Plesionika martia* (A. Milne-Edwards, 1883) (Pandalidae). As was noted above, species of *Probopyrus* usually infect fresh- or brackish-water shrimps. It will require careful reexamination to confirm the generic position of these two species. Since this issue is well outside of the scope of the present study, we tentatively leave them in *Probopyrus* for now.

Finally, although many authors have attributed the authorship of *Probopyrus marinus* to Nierstrasz and Brender à Brandis (1932), this species was originally described by them in 1923, not in 1932, as a species of *Palaegyge* Carus, 1888 (Nierstrasz and Brender à Brandis 1923).

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