Three new species of Hatschekia Poche, 1902 (Copepoda: Siphonostomatoida: Hatschekiidae) parasitic on Abalistes filamentosus (Pisces: Tetraodontiformes: Balistidae) from off Okinaw...

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Redescription of four species of *Hatschekia* (Copepoda: Siphonostomatoida: Hatschekiidae) parasitic on tetraodontiform fishes from Japan

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Abstract

Four species of the genus *Hatschekia* Poche, 1902 (Copepoda: Siphonostomatoida; Hatschekiidae) are redescribed based on specimens collected from tetraodontiform fishes captured recently in Japanese waters: female *H. iridescens* Wilson, 1913 from *Diodon liturosus* Shaw (representing a new host record), *D. hystrix* L., and *D. holocanthus* L.; female *Hatschekia legouli* Nuñes-Ruivo, 1954 (representing a new parasite record for Japan) from *Chilomycterus reticulatus* L.; female *H. ostracii* Yamaguti, 1953 from *Ostracion immaculatus* Temminck & Schlegel and *O. cubicus* L.; and both sexes of *H. monacanthi* Yamaguti, 1939 from *Thamnaconus modestus* (Günther). Proportions of various parts of the female body and appendages are included as important characters to distinguish morphologically similar species. A key to the 20 species of *Hatschekia* reported from Japanese waters is also included.

Key words: taxonomy, copepods, marine fish, Japanese waters

Introduction

The genus *Hatschekia* Poche, 1902 is one of the major copepod genera parasitic on marine teleosts. Jones (1985) revised this genus and recognized 68 species as valid. Since then, a total of 22 new species have been described from the Indo-Pacific region (Pillai 1985; Castro & Baeza 1986; Villalba 1986; Jones & Cabral 1990; Kabata 1991; Ho & Kim 2001). Of the 90 valid *Hatschekia* species (Boxshall & Halsey 2004), 20 have been reported from Japan (Yamaguti 1939, 1953, 1963; Shiino 1957a, b; Yamaguti & Yamasu 1959; Jones 1985). However, only females were described for most of these Japanese species, and the descriptions were often insufficient. It is fair to point out that describing and identifying members of *Hatschekia* are challenging tasks, as these parasites have comparatively minute and vestigial appendages.

Hewitt (1969) was the first copepodologist to use extensively the length and width ratios of some body parts in his descriptions of *Hatschekia* taxa. However, Jones (1985) considered such ratios were dubious because these features were shown to vary widely within a relatively large collection of *Hatschekia hippoglossi* (Guérin-Méneville, 1837). Nonetheless, Kabata (1991) mentioned that all such variations have their limits, and used the trunk length: cephalothorax length ratio and the cephalothorax length: width ratio as delineating features for some of his new taxa. In this paper, we redescribe four species of *Hatschekia* based on new material collected from tetraodontiform fishes from Japan: *H. iridescens* Wilson, 1913, *H. legouli* Nuñes-Ruivo, 1954, *H. ostracii* Yamaguti, 1953, and *H. monacanthi* Yamaguti, 1939. We also utilize this opportunity to re-evaluate the taxonomic value of using proportional measurements of various parts of the female body and appendages to support the separation of taxa within this parasite group. A key for identification of females of the 20 species of *Hatschekia* in Japan is included.

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Materials and methods

Tetradontiform fishes were collected in temperate to tropical coastal waters of Japan from 2002–2007 using various types of fishing gear (rod and line, gill nets, scoop nets, and bottom trawl). Copepods were removed carefully from the hosts' gills and preserved in 80% ethanol. Specimens were later soaked in lactophenol for 2–3 hours, and dissected and observed using the wooden slide method of Humes & Gooding (1964). Drawings were made with the aid of a drawing tube fitted on an Olympus BX51 compound microscope. Morphological terminology follows Huys & Boxshall (1991).

The following copepod body parts were measured using an ocular micrometer and are given in millimeters as the range followed by the mean and standard deviation in parentheses (Fig. 1; Table 1): body length (= maximum length of body, excluding the caudal rami; A in Fig. 1); cephalothorax length (= maximum length of cephalothoracic shield; B in Fig. 1); cephalothorax width (= maximum width of cephalothoracic shield; C in Fig. 1); trunk length (= maximum length of trunk, excluding the caudal rami; D in Fig. 1); trunk width (= maximum width of trunk; E in Fig. 1); abdomen length (= maximum length of abdomen; F in Fig. 1); abdomen width (= maximum width of abdomen; G in Fig. 1); caudal ramus length (= maximum length of caudal ramus; H in Fig. 1); and caudal ramus width (= maximum width of caudal ramus; I in Fig. 1). In addition, the following parts of the appendages were measured: antennule length (J in Fig. 1); length of proximal antennal segment (K in Fig. 1); length of middle antennal segment (L in Fig. 1); length of terminal antennal segment (M in Fig. 1); antenna length (= length of three segments combined; K + L + M in Fig. 1); leg 1 protopod length (N in Fig. 1); leg 1 exopod length (O in Fig. 1); leg 1 endopod length (P in Fig. 1); leg 1 length (= total length of protopod and exopod combined; N + O in Fig. 1); leg 2 protopod length (Q in Fig. 1); leg 2 exopod length (R in Fig. 1); leg 2 endopod length (S in Fig. 1); and leg 2 length (= length of protopod and exopod combined; Q + R in Fig. 1). Voucher specimens are deposited in the crustacean collection of the National Museum of Nature and Science, Tokyo (NSMT).

Results

Family Hatschekiidae Kabata, 1979

Genus *Hatschekia* Poche, 1902

Hatschekia iridescens Wilson, 1913
(Figs 2–13)

Hatschekia iridescens: Wilson 1913: 248; Jones 1985: 244; Villalba 1986: 160.
Hatschekia diodontis: Yamaguti 1953: 225.

Material examined. 7♀ (NSMT-Cr 20327), ex *Diodon liturosus* Shaw, Aka (26°11′N, 127°16′E), Kerama Islands, Okinawa, East China Sea, Japan, 31 July, 2005; 3♀ (NSMT-Cr 20328), ex *Diodon hystrix* L., Yonashiro (26°20′N, 127°57′E), Kin Bay, Okinawa, North Pacific Ocean, Japan, 14 July, 2007; 2♀ (NSMT-Cr 20329) ex *Diodon holocanthus* L., Nishidomari (32°46′N, 132°43′E), Otsuki, Kochi, North Pacific Ocean, Japan, 8 November, 2006.

Description of female. Body (Fig. 2) 0.96–1.27 (1.13 ± 0.12) long, excluding caudal rami (n = 12). Cephalothorax broadly obovate, shorter than wide [0.29–0.44 (0.35 ± 0.05) × 0.36–0.55 (0.47 ± 0.06)], with dorsal, M-shaped chitinous frame. Trunk longer than wide [0.70–0.99 (0.83 ± 0.11) × 0.32–0.44 (0.39 ± 0.04)], bilobed posteriorly. Abdomen (Fig. 3) shorter than wide [0.04–0.06 (0.05 ± 0.01) × 0.08–0.10 (0.09 ± 0.01)]. Caudal ramus (Fig. 3) slightly longer than wide [0.02–0.04 (0.03 ± 0.01) × 0.01–0.02 (0.02 ± 0)], bears 5 naked setae.

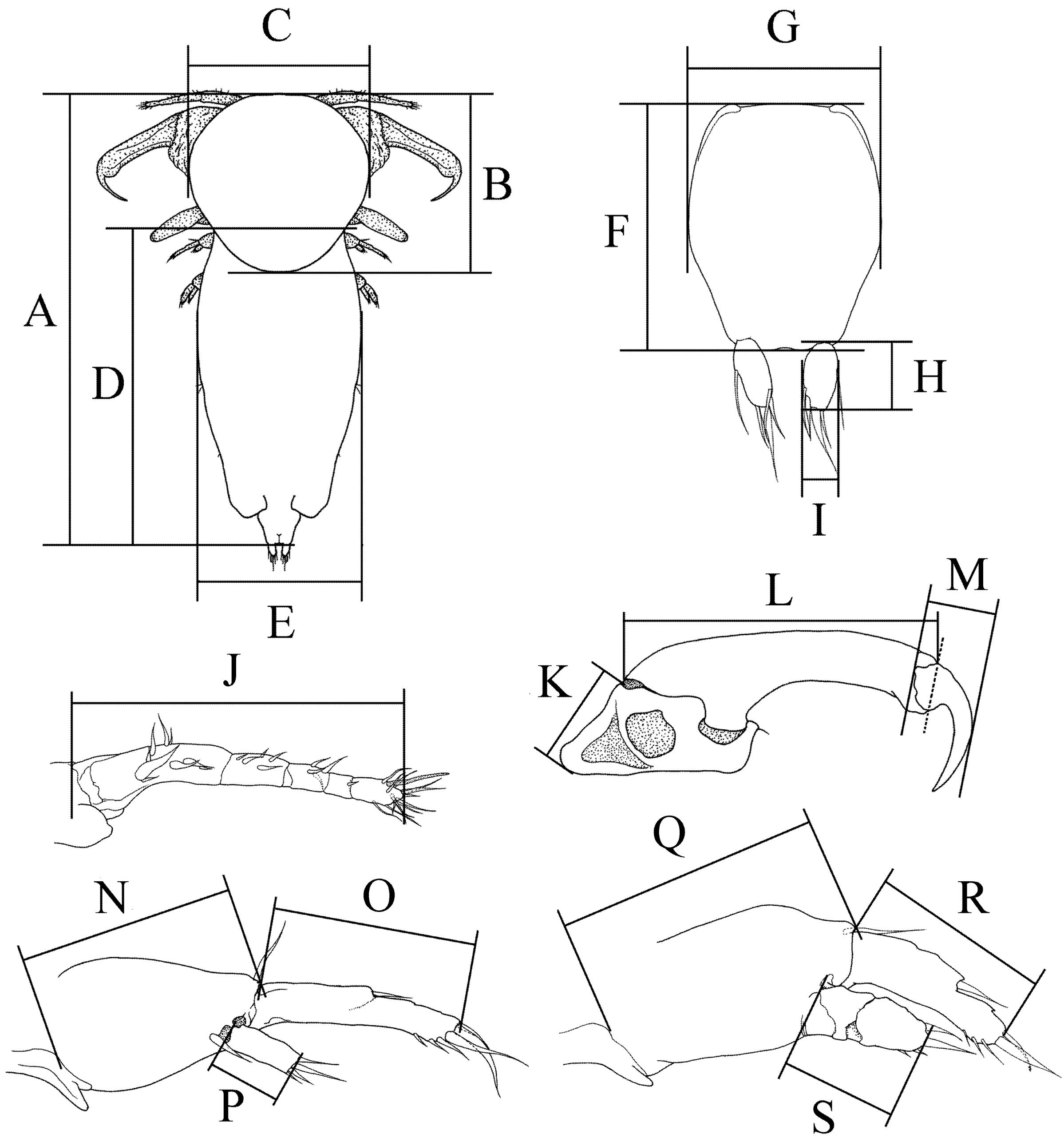


FIGURE 1. Schematic diagrams of various body parts and appendages showing measurements taken of *Hatschekia* specimens. A, body length. B, cephalothorax length. C, cephalothorax width. D, trunk length. E, trunk width. F, abdomen length. G, abdomen width. H, caudal ramus length. I, caudal ramus width. J, antennule length. K, length of proximal segment of antenna. L, length of middle segment of antenna. M, length of terminal segment of antenna. N, length of leg 1 protopod. O, length of leg 1 exopod. P, length of leg 1 endopod. Q, length of leg 2 protopod. R, length of leg 2 exopod. S, length of leg 2 endopod.

Rostrum with 1 thumb-shaped process on each posterolateral corner (Fig. 4). Antennule (Fig. 4) indistinctly 5-segmented, 0.23–0.34 (0.28 ± 0.04) long, with armature formula: 10, 6, 4, 1, 13 + 1 aesthetasc; base of squat, apically blunt elements fused partially to respective segment. Antenna (Fig. 5) 3-segmented; proximal segment (coxa) unarmed; middle segment (basis) ornamented with large patch of surface pits (the pits appear as 2 small patches in the figure, but are actually fused into a single patch on the lateral surface); terminal segment claw-like, composed of incompletely fused endopodal segment and claw, armed with 1 minute spine and 1 small seta at midlength; proximal segment length 0.07–0.13 (0.10 ± 0.02); middle segment length 0.13–0.17 (0.15 ± 0.01); terminal segment length 0.09–0.14 (0.12 ± 0.02); total length 0.31–0.43 (0.36 ± 0.04). Parabasal papilla not observed. Oral cone robust. Mandible (Fig. 6) slender, with 5 sharp teeth apically. Maxillule (Fig. 7) bilobate; each lobe armed with 2 attenuate elements. Maxilla (Fig. 8) 4-segmented; proximal segment unarmed; second segment rod-like, with 1 basal seta; third segment elongate, with 1 distal seta; terminal segment small, apically with 1 small seta and bifid claw. Maxilliped absent.

Legs 1 and 2 (Figs 9–10) biramous, with indistinctly bimerous exopod and 2-segmented endopod; leg armature formula as follows:

	Protopod	Exopod	Endopod
Leg 1	1–1	1–0; 6	0–0; 6
Leg 2	1–0	1–0; 5	0–1; 5

Intercoxal sclerite of legs 1 and 2 (Fig. 11) elongate, unornamented and unmodified. Protopods of legs 1 and 2 with several semicircular surface wrinkles (it is uncertain whether these wrinkles are spinulate or membranous); rami ornamented with semicircles of spinules; some setae unipinnate. Leg 1 (Fig. 9) 0.12–0.17 (0.15 ± 0.02) long; protopod length 0.06–0.09 (0.08 ± 0.01); exopod length [0.06–0.08 (0.07 ± 0.01)] exceeding endopod length [0.04–0.05 (0.04 ± 0)]. Leg 2 (Fig. 10) 0.12–0.18 (0.16 ± 0.02) long; protopod length 0.06–0.10 (0.09 ± 0.01); exopod length 0.05–0.09 (0.07 ± 0.01); endopod length 0.04–0.06 (0.05 ± 0.01).

Leg 3 (Figs 2, 12) represented by 2 simple setae on mid-lateral surface of trunk. Leg 4 (Figs 2, 13) represented by 1 simple seta on posterior ¾ of trunk.

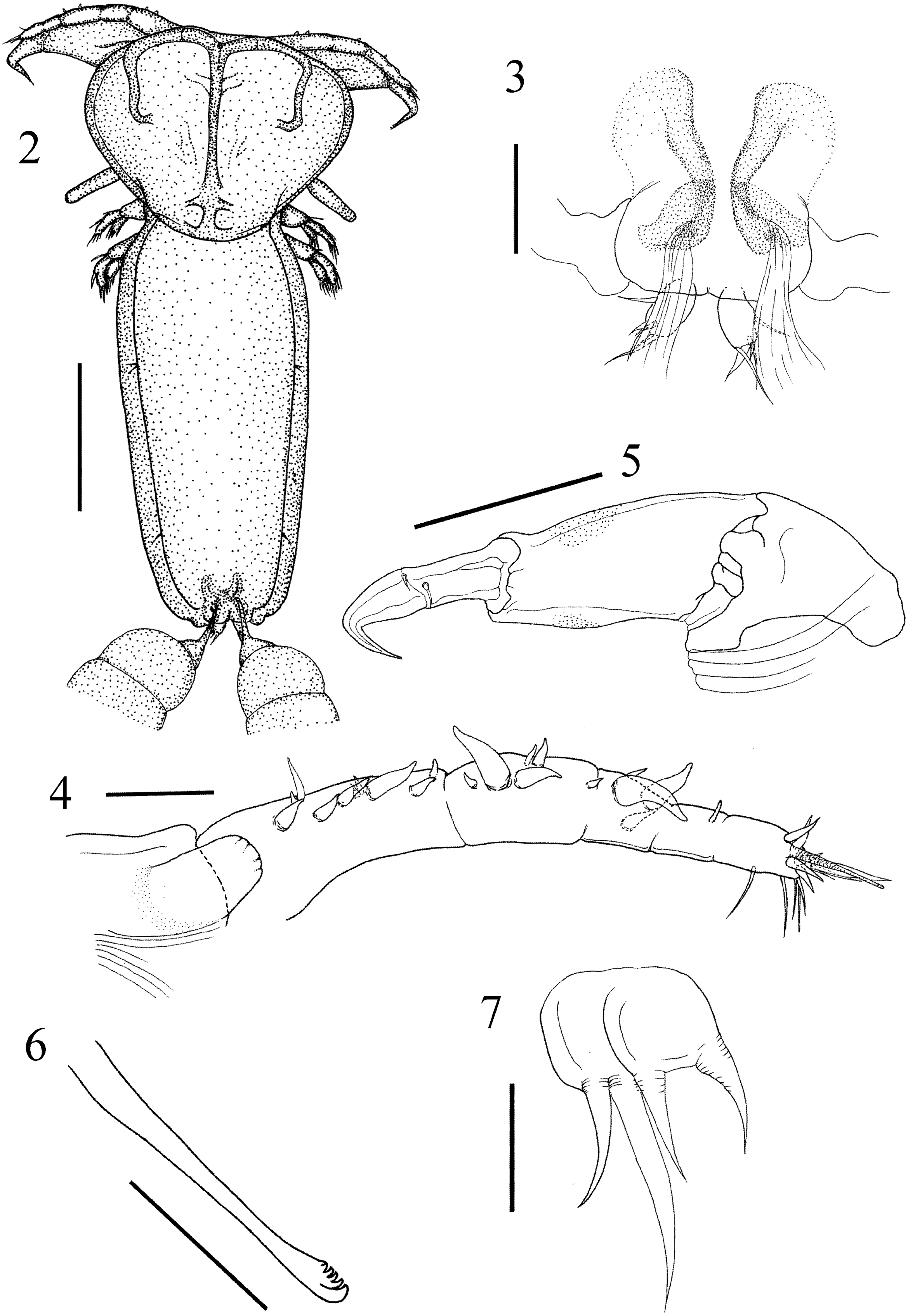
Attachment site. Gill filaments.

Remarks. *Hatschekia iridescens* was described originally by Wilson (1913) based on specimens of both sexes removed from *Diodon hystrix* collected in Montego Bay, Jamaica. This species was later reported from *D. holocanthus* in Okinawa, Japan (Yamaguti 1953). Jones (1985) also redescribed this species using Wilson's type specimens. Villalba (1986) identified 25 ovigerous females from *D. holocanthus* in Isla de Pascua, Chile, as *H. iridescens*. The morphology of his specimens, however, differs from the specimens examined by Wilson (1913), Jones (1985) and the present authors in lacking small posterior lobes on the trunk (Yamaguti (1953) did not mention the presence or absence of posterior lobes). As such, Villalba's specimens may not be conspecific with *H. iridescens*. A re-examination of Villalba's material is needed to clarify this issue.

Several discrepancies exist between our observations and those of previous authors regarding the fine structural details of *H. iridescens*. For instance, an M-shaped chitinous frame, consisting of a conspicuous mid-longitudinal part and two somewhat indistinctive lateral parts, was present in our material. Wilson (1913) and Jones (1985), in contrast, reported the mid-longitudinal frame only. These authors perhaps overlooked the lateral parts of the frame. Yamaguti (1953) described a T-shaped chitinous frame on the dorsal surface of the cephalothorax, but his illustration in fact depicted an M-shaped frame.

Wilson (1913, fig. 249) found 15 (3, 4, 0, 8) setae in total on the four distal antennulary segments. Yamaguti (1953, fig. 30) and Jones (1985, fig. 11A) found a total of 26 (6, 4, 3, 1, 12) and 25 (7, 4, 4, 0, 10) setae, respectively, on the antennule, while our specimens have 35 (10, 6, 4, 1, 13 + 1 aesthetasc) elements. Jones (1985, fig. 11A) did not illustrate the relatively smaller setae on the antennule, which suggests that he overlooked them.

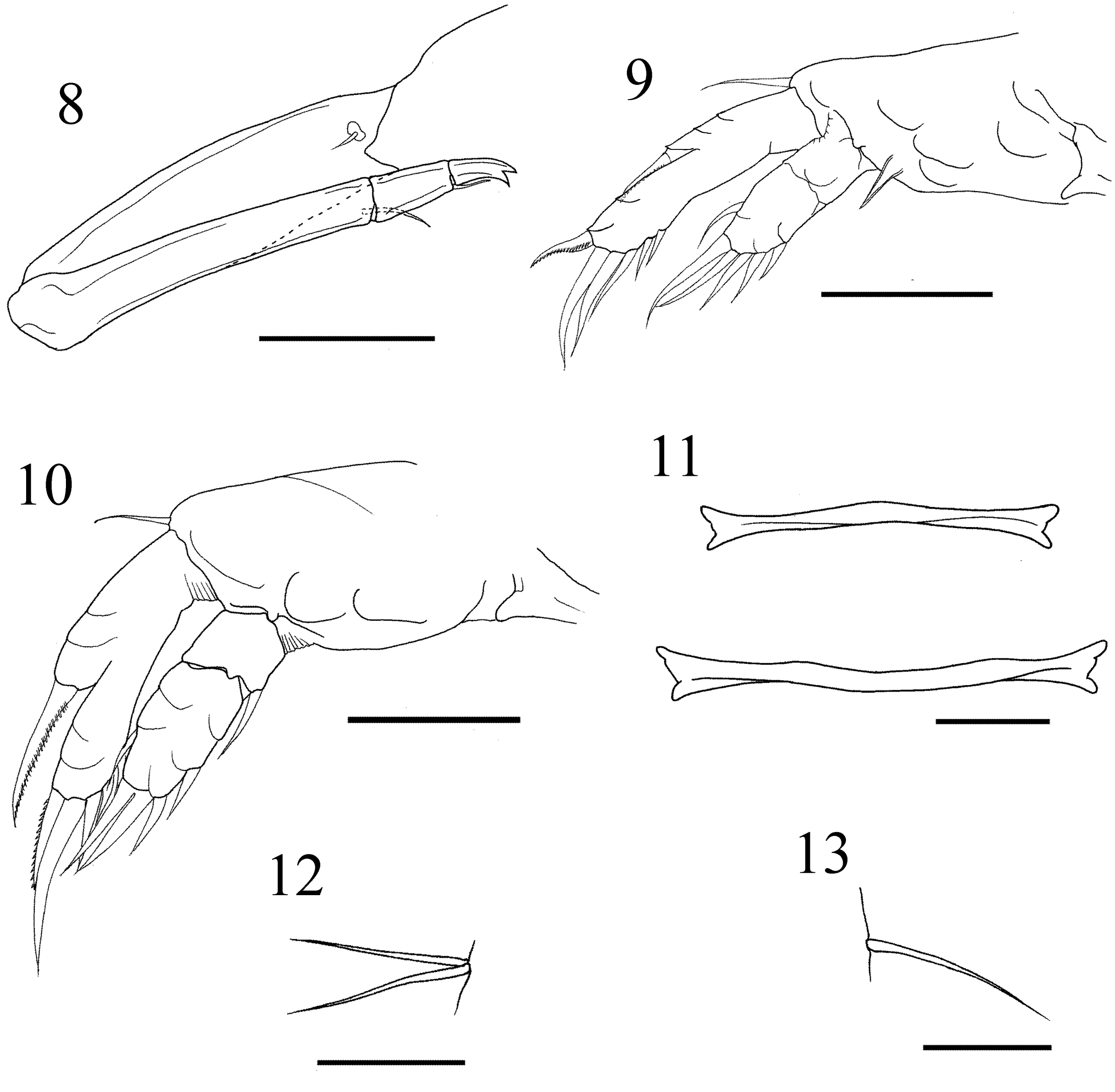
The antennal claw in our specimens bears one minute spine and one simple seta. Further, the claw is incompletely 2-segmented, with the proximal and distal segments separated by a thin transverse line. Wilson (1913) found only a swelling, Jones (1985) illustrated only a small medial process, and Yamaguti (1953) described only a spiniform barb on the antennal claw. The elements observed by us are very small and delicate, and the suture line is extremely weak. It is thus plausible that these fine structures of the antennal claw were overlooked by the past authors.



FIGURES 2–7. *Hatschekia iridescens* Wilson, 1913, female. 2, habitus, dorsal. 3, posterior part of body, dorsal. 4, antennule, ventral. 5, antenna, ventral. 6, mandible. 7, maxillule. Scale bars: 2, 0.25 mm; 3–4, 0.05 mm; 5, 0.1 mm; 6–7, 25 µm.

Wilson (1913) noted that the first two leg pairs had bimerous exopods and unimerous endopods. Yamaguti (1953) stated that the exopods of both legs were 2-segmented and their endopods 1- and 2-segmented, respectively. Jones (1985) also reported that the exopods were 2-segmented but the endopods were obscurely 2-segmented in legs 1 and 2. In our specimens, however, legs 1 and 2 had indistinctly 2-segmented exopods and distinctly 2-segmented endopods. This discrepancy may be due to insufficient observation by the previous authors. We observed wrinkles on the anterior surface of the protopods of legs 1 and 2; however, no such information was provided by the previous authors. As these wrinkles are highly transparent, the previous authors may have overlooked these structures.

Hatschekia iridescens resembles *H. legouli* Nuñes-Ruivo, 1954 in having an M-shaped chitinous frame on the cephalothorax, similar antennulary and swimming leg armature formulae, and squat, apically blunt antennulary elements that lack a complete basal articulation. However, *H. iridescens* differs from *H. legouli* by having a considerably smaller antennule length/antenna length ratio [0.78 ± 0.03 vs. 1.16 ± 0.16 (U-test; $p<0.01$), Table 1], a less planiform cephalothoracic shield, a slightly higher cephalothorax length/body length ratio [0.31 ± 0.03 vs. 0.22 ± 0.02 (U-test; $p<0.001$) Table 1], and relatively smaller posterior lobes on the trunk. A redescription of the male of *H. iridescens* is needed, as it was poorly described by Wilson (1913). Our finding of *H. iridescens* on *D. liturosus* represents a new host record.



FIGURES 8–13. *Hatschekia iridescens* Wilson, 1913, female. 8, maxilla, ventral. 9, leg 1, ventral. 10, leg 2, ventral. 11, intercoxal sclerite of legs 1 and 2, ventral. 12, leg 3, ventral. 13, leg 4, ventral. Scale bars: 8–11, 0.05 mm; 12–13, 17 µm.

TABLE 1. Ratios of body parts and appendages of females of *Hatschekia iridescens*, *H. legouli*, *H. monacanthi*, and *H. ostracii*. Data are shown in millimeters as mean ± standard deviation. Abbreviations are as follows: body length (BL), cephalothorax length (CeL), cephalothorax width (CeW), trunk length (TL), trunk width (TW), abdomen length (AbL), abdomen width (AbW), caudal ramus length (CaL), caudal ramus width (CaW), antennule length (A1L), antenna length (A2L), middle segment length of antenna (A2ML), terminal segment length of antenna (A2TL), leg 1 length (L1L), leg 1 exopod length (L1ExL), leg 1 endopod length (L1EnL), leg 2 length (L2L), leg 2 exopod length (L2ExL), and leg 2 endopod length (L2EnL).

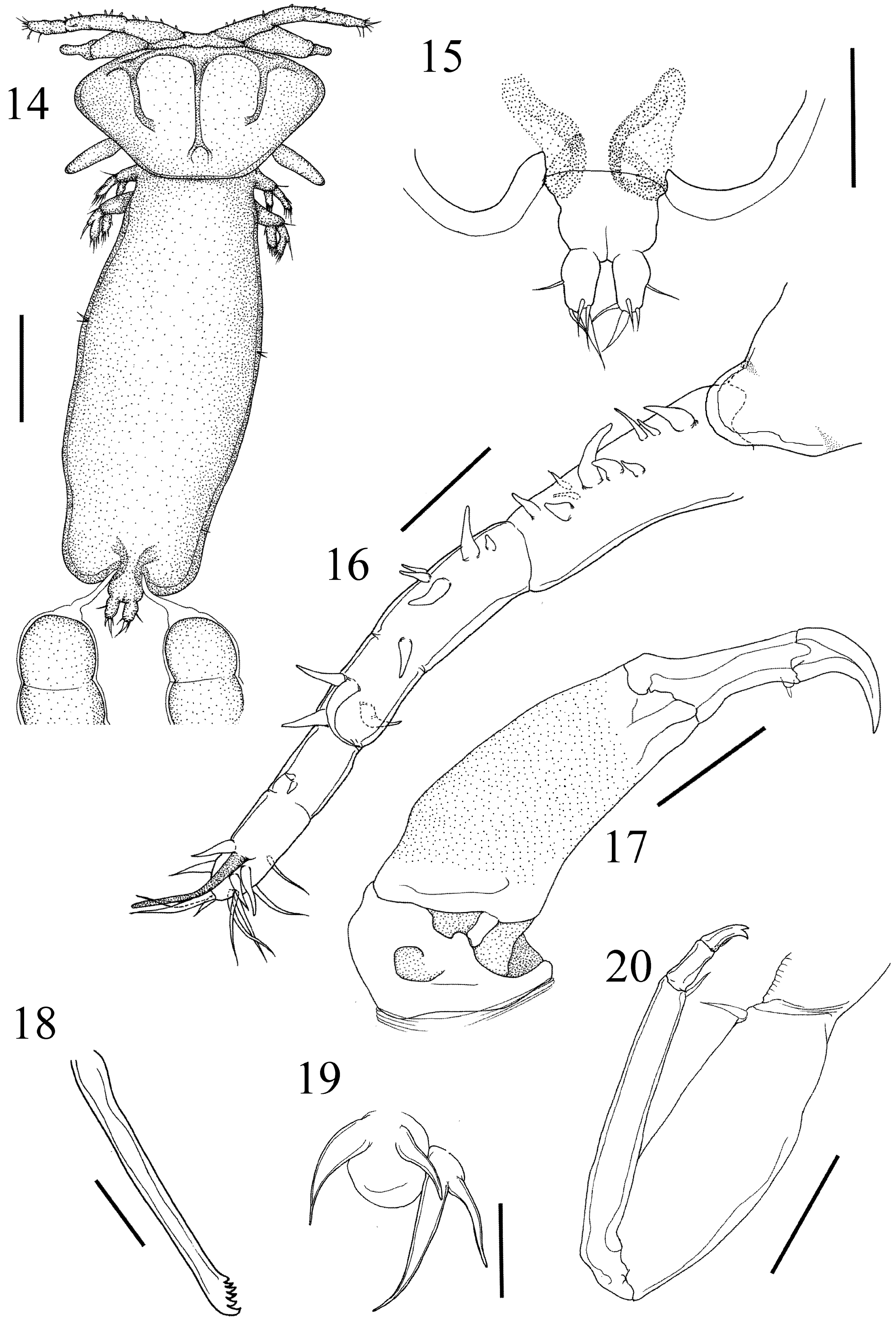
	Copepods			
	H. iridescens (n = 12)	*H. legouli* (n = 7)	*H. monacanthi* (n = 7)	*H. ostracii* (n = 9)
CeL/BL	0.31 ± 0.03	0.22 ± 0.02	0.27 ± 0.03	0.42 ± 0.03
CeW/BL	0.42 ± 0.05	0.39 ± 0.03	0.33 ± 0.01	0.40 ± 0.02
TL/BL	0.73 ± 0.03	0.78 ± 0.02	0.75 ± 0.02	0.65 ± 0.03
TW/BL	0.34 ± 0.03	0.32 ± 0.01	0.33 ± 0.04	0.37 ± 0.03
AbL/BL	0.05 ± 0.01	0.04 ± 0.01	0.03 ± 0.01	0.12 ± 0.01
AbW/BL	0.08 ± 0.01	0.06 ± 0.01	0.09 ± 0.01	0.09 ± 0.00
CaL/BL	0.03 ± 0.00	0.04 ± 0.01	0.02 ± 0.00	0.04 ± 0.01
CaW/BL	0.01 ± 0.00	0.02 ± 0.00	0.01 ± 0.00	0.02 ± 0.00
CeW/CeL	1.35 ± 0.31	1.74 ± 0.15	1.22 ± 0.08	0.95 ± 0.06
AbW/AbL	1.82 ± 0.23	1.62 ± 0.25	2.96 ± 0.60	0.78 ± 0.05
A1L/BL	0.25 ± 0.03	0.24 ± 0.02	0.15 ± 0.02	0.23 ± 0.01
A2L/BL	0.33 ± 0.05	0.21 ± 0.03	0.27 ± 0.03	0.44 ± 0.04
A2TL/A2ML	0.78 ± 0.12	0.59 ± 0.11	0.20 ± 0.04	0.26 ± 0.04
L1L/BL	0.13 ± 0.01	0.11 ± 0.02	0.08 ± 0.01	0.17 ± 0.02
L1ExL/L1EnL	1.67 ± 0.16	1.78 ± 0.07	2.22 ± 0.30	3.24 ± 0.36
L2L/BL	0.14 ± 0.02	0.12 ± 0.02	0.08 ± 0.01	0.15 ± 0.03
L2ExL/L2EnL	1.48 ± 0.21	1.65 ± 0.21	2.20 ± 0.33	1.92 ± 0.32
A1L/A2L	0.78 ± 0.07	1.16 ± 0.16	0.56 ± 0.04	0.54 ± 0.05

Hatschekia legouli **Nuñes-Ruivo, 1954**
(Figs 14–24)

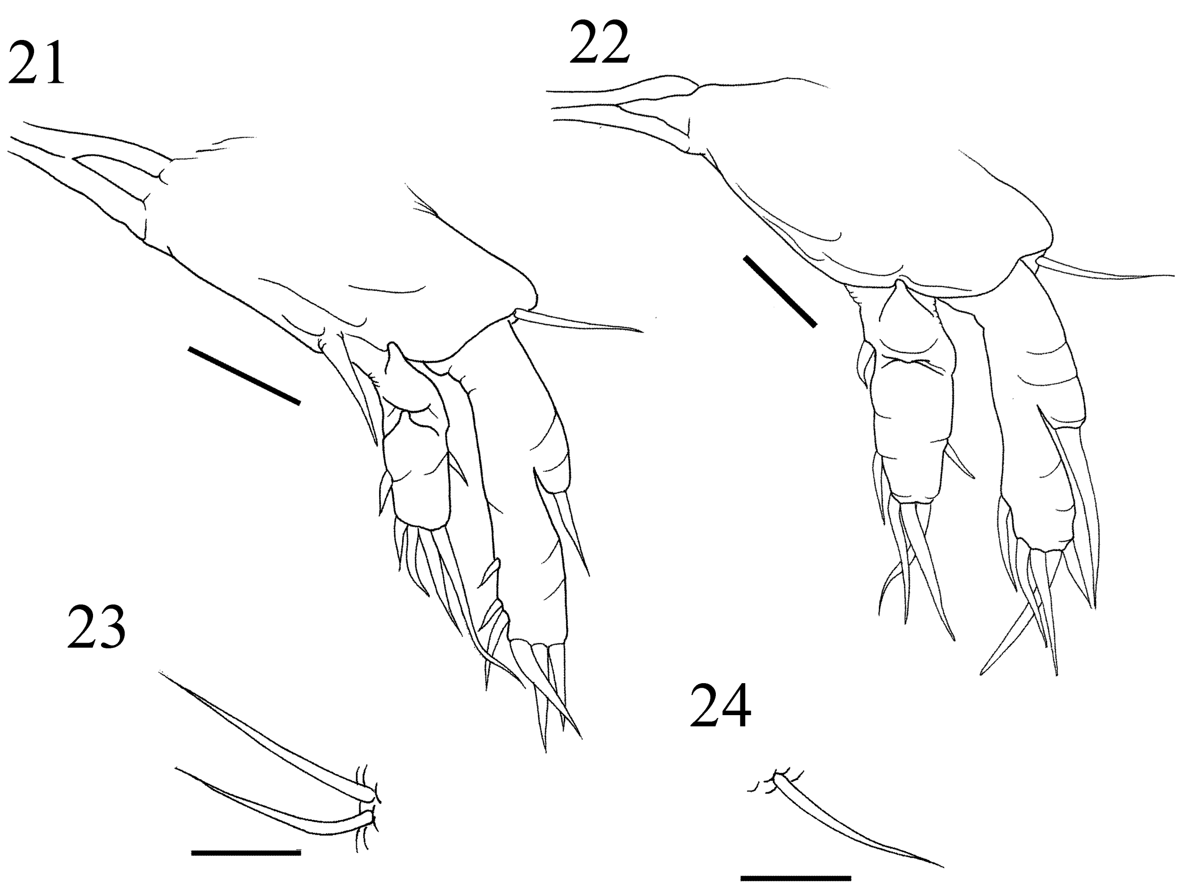
Hatschekia legouli: Nuñes-Ruivo 1954: 500; Jones 1985: 248.

Material examined. 5♀ (NSMT-Cr 20330), ex *Chilomycterus reticulatus* L., Nishidomari (32°46′N, 132°43′E), Ohtsuki, Kochi, North Pacific Ocean, Japan, 8 November, 2005; 2♀ (NSMT-Cr 20331), ex *C. reticulatus*, Nishinoomote (30°49′N, 131°2′E), Tanegashima Island, Kagoshima, East China Sea, Japan, 22 May, 2007.

Description of female. Body (Fig. 14) 1.05–1.43 (1.23 ± 0.12) long, excluding caudal rami (n = 7). Cephalothorax trapezoid, shorter than wide [0.23–0.34 (0.27 ± 0.04) × 0.41–0.51 (0.47 ± 0.04)], with dorsal, M-shaped chitinous frame. Trunk longer than wide [0.79–1.15 (0.96 ± 0.11) × 0.33–0.48 (0.40 ± 0.05)], with pair of posterior lobes. Abdomen (Fig. 15) shorter than wide [0.04–0.06 (0.05 ± 0.01) × 0.07–0.09 (0.07 ± 0.01)]. Caudal ramus (Fig. 15) longer than wide [0.04–0.05 (0.04 ± 0) × 0.02–0.03 (0.02 ± 0)], bears 5 naked setae.



FIGURES 14–20. *Hatschekia legouli* Nuñes-Ruivo, 1954, female. 14, habitus dorsal. 15, posterior part of body, dorsal. 16, antennule, ventral. 17, antenna, ventral. 18, mandible. 19, maxillule. 20, maxilla. Scale bars: 14, 0.4 mm; 15, 0.1 mm; 16–17, 20, 0.05 mm; 18, 12.5 µm; 19, 25 µm.



FIGURES 21–24. *Hatschekia legouli* Nuñes-Ruivo, 1954, female. 21, leg 1, ventral. 22, leg 2, ventral. 23, leg 3, ventral. 24, leg 4, ventral. Scale bars: 21–22, 25 µm; 23–24, 17 µm.

Rostrum with rounded process on each posterolateral corner (Fig. 16). Antennule (Fig. 16) incompletely 5-segmented, 0.26–0.36 (0.30 ± 0.03) long; with armature formula: 10, 6, 4, 1 (only 1 specimen has 2 setae on this segment), 13 + 1 aesthetasc; base of squat, apically blunt elements fused partially to respective segment. Antenna (Fig. 17) 3-segmented; proximal segment (coxa) unarmed; middle segment (basis) ornamented with surface pits; terminal segment claw-like, comprised of incompletely fused endopodal segment and claw, armed with 1 minute inner spine; proximal segment length 0.04–0.07 (0.06 ± 0.01); middle segment length 0.11–0.15 (0.13 ± 0.01); terminal segment length 0.06–0.09 (0.07 ± 0.01); total length 0.22–0.28 (0.26 ± 0.02). Parabasal papilla not observed. Oral cone robust. Mandible (Fig. 18) slender, with 5 sharp apical teeth. Maxillule (Fig. 19) bilobate; both lobes bears 2 acuminate elements. Maxilla (Fig. 20) 4-segmented; proximal segment unarmed; second segment rod-like, with 1 basal seta; third segment elongate, with 1 distal seta; terminal segment small, apically with 1 small seta and bifid claw. Maxilliped absent.

Legs 1 and 2 (Figs 21–22) biramous, with indistinctly bimerous exopod and 2-segmented endopod; leg armature formula as follows:

	Protopod	Exopod	Endopod
Leg 1	1–1	1–0; 6	0–0; 6
Leg 2	1–0	1–0; 5	0–1; 5

Intercoxal sclerite of legs 1 and 2 (not figured) unornamented and unmodified. Protopods with semicircular surface wrinkles (it is uncertain whether these wrinkles are spinulate or membranous); rami ornamented with semicircles of spinules. Leg 1 (Fig. 21) 0.13–0.15 (0.13 ± 0.01) long; protopod length

0.06–0.08 (0.07 ± 0.01); exopod length [0.06–0.07 (0.06 ± 0)] exceeding endopod length [0.03–0.04 (0.04 ± 0)]. Leg 2 (Fig. 22) 0.13–0.15 (0.13 ± 0.01) long; protopod length 0.06–0.10 (0.08 ± 0.01); exopod length 0.06–0.08 (0.07 ± 0.01); endopod length 0.04–0.06 (0.04 ± 0.01).

Leg 3 (Figs 14, 23) represented by 2 simple setae on mid-lateral surface of trunk. Leg 4 (Figs 14, 24) represented by 1 simple lateral seta on posterior ¾ of trunk.

Attachment site. Gill filaments.

Remarks. *Hatschekia legouli* was described originally by Nuñes-Ruivo (1954) based on 49 female specimens from *Chilomycterus reticulatus* caught in Goree, Senegal. Jones (1985) noted, however, that a redescription of *H. legouli* was needed because details of leg 1 were not given in the original description. It is worth nothing here that the other appendages of the female also were incompletely described, and the male of *H. legouli* has not been described yet. We attribute our specimens to *H. legouli* as they share: a) a trapezoid cephalothorax that is twice as wide as long; b) an M–shaped dorsal chitinous frame on the cephalothorax; c) a trunk with relatively well developed posterior lobes; and d) the antennulary bases protruding beyond the anterior margin of the cephalothorax. In addition, we collected our material from the same host species as Nuñes-Ruivo (1954). As discussed in the Remarks section of *H. iridescens* above, *H. legouli* closely resembles *H. iridescens*, as both species share a similar M-shaped chitinous frame on the cephalothorax, armature on the antennule and swimming legs, and squat, apically blunt antennulary elements that lack a complete basal articulation. *Hatschekia legouli*, however, differs from *H. iridescens* in having a trapezoid cephalothorax and the abdomen and caudal rami extending beyond the distal end of the posterior lobes of the trunk. Our finding of *H. legouli* represents the first record of this species from Japan and the North Pacific Ocean.

Hatschekia ostracii **Yamaguti, 1953**

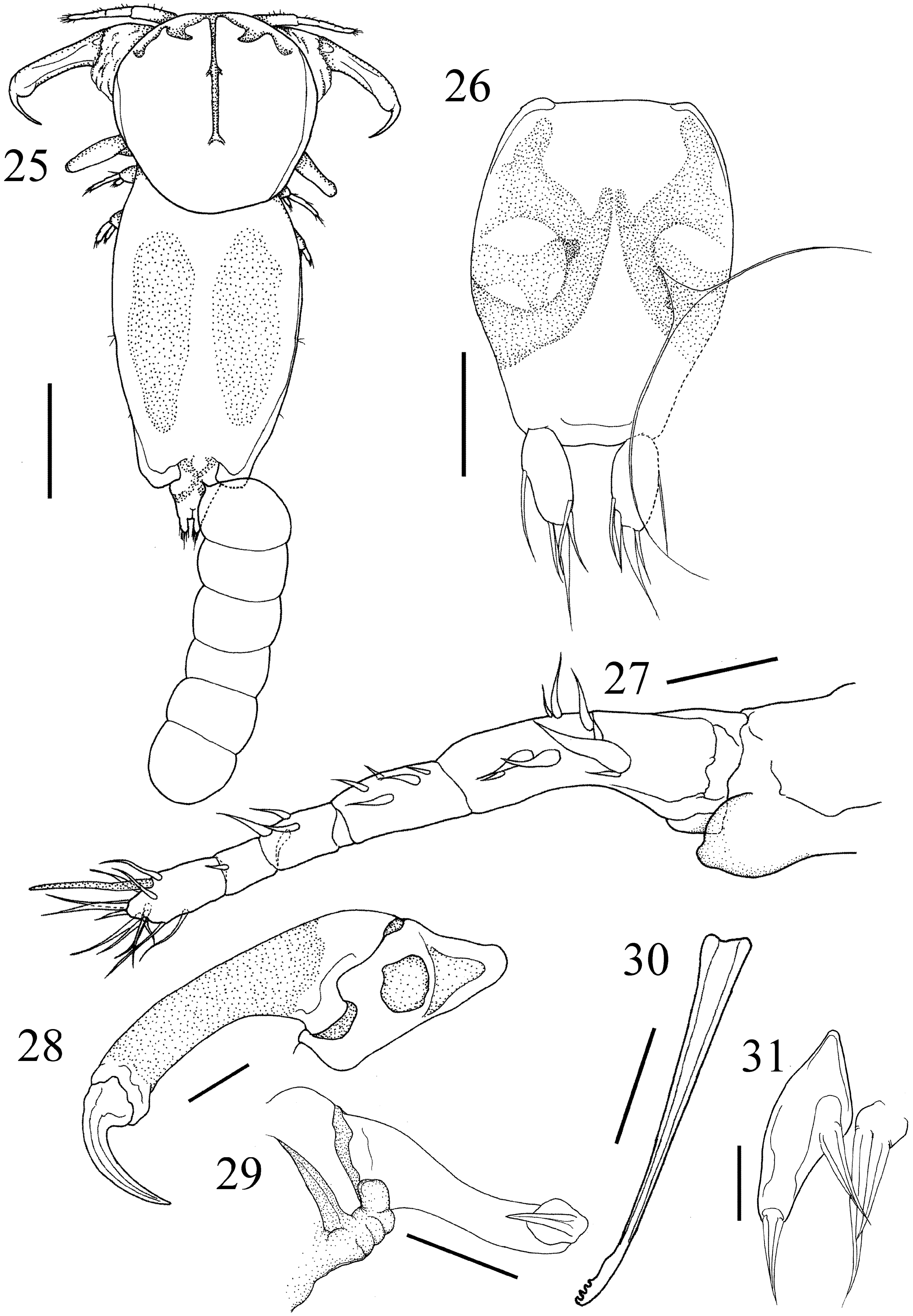
(Figs 25–37)

Hatschekia ostracii: Yamaguti 1953: 228; Jones 1985: 256; Kim 1998: 739.

Material examined. 7♀ (NSMT-Cr 20332), ex *Ostracion immaculatus* Temminck & Schlegel, Tatsukushi (32°47′N, 132°51′E), Kochi, North Pacific Ocean, Japan, 9 May, 2006; 1♀ (NSMT-Cr 20333), ex *Ostracion cubicus* L., Ama (26°13′N, 127°17′E), Kerama Islands, Okinawa, East China Sea, Japan, 26 May, 2007; 1♀ (NSMT-Cr 20334), ex *O. cubicus* L., Sakimotobu (26°38′N, 127°52′E), Okinawa, East China Sea, Japan, 25 July, 2007.

Description of female. Body (Fig. 25) 0.66–1.02 (0.87 ± 0.10) long, excluding caudal rami (n = 9). Cephalothorax suborbicular, longer than wide [0.30–0.46 (0.37 ± 0.04) × 0.28–0.39 (0.35 ± 0.04)], with dorsal, T-shaped chitinous frame. Trunk longer than wide [0.41–0.69 (0.57 ± 0.09) × 0.21–0.39 (0.32 ± 0.06)], with pair of posterior lobes. Abdomen (Fig. 26) length 0.07–0.11 (0.10 ± 0.01); width 0.06–0.09 (0.08 ± 0.01). Caudal ramus (Fig. 26) longer than wide [0.03–0.04 (0.03 ± 0) × 0.01–0.02 (0.01 ± 0)] and bears 5 naked setae.

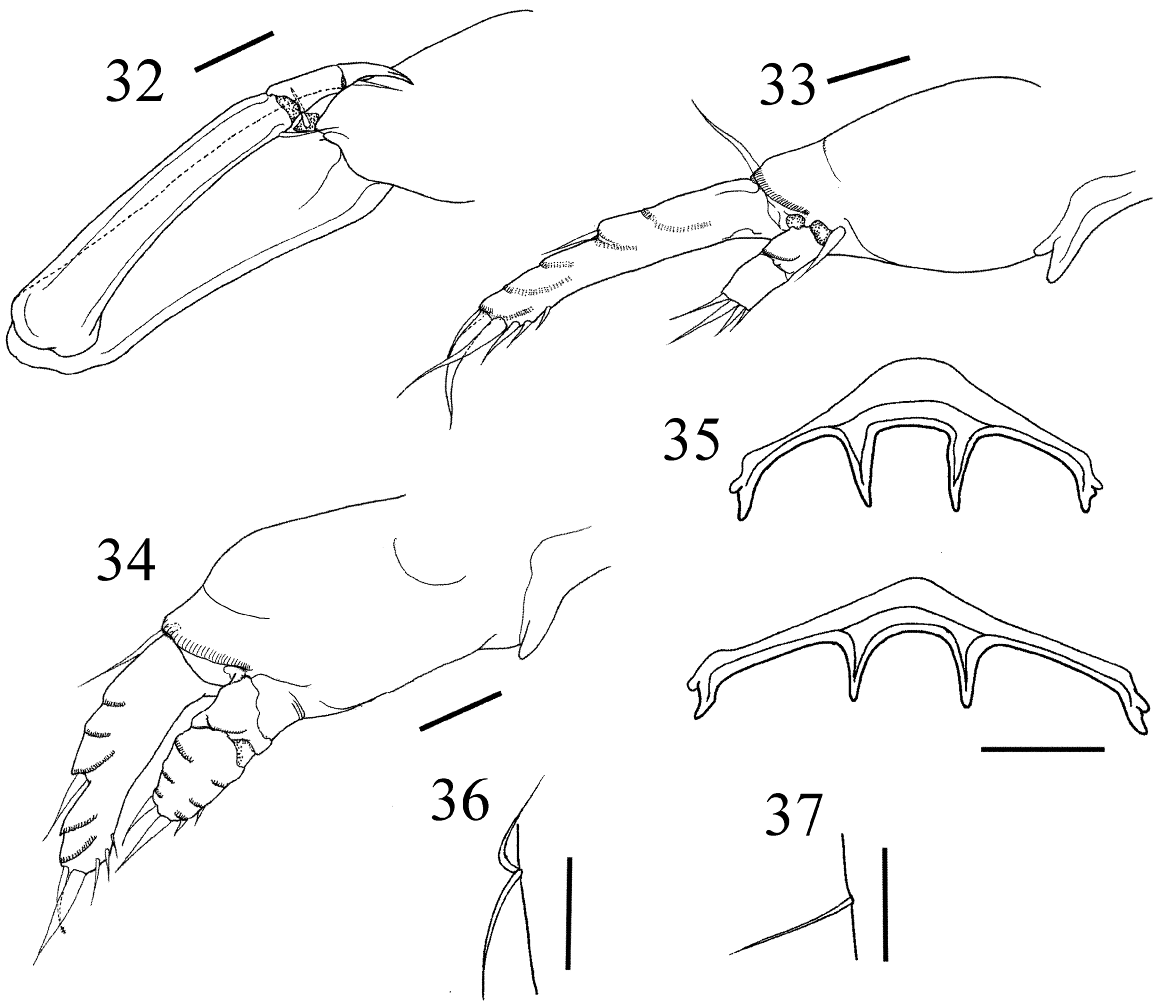
Rostrum with 1 ovoid process on each posterolateral corner (Fig. 27). Antennule (Fig. 27) 5-segmented, 0.17–0.25 (0.21 ± 0.02) long; armature formula: 9, 5, 4, 1, 13 + 1 aesthetasc. Antenna (Fig. 28) 3-segmented; proximal segment (coxa) unarmed; middle segment (basis) covered with surface pits; terminal segment claw-like, unarmed; proximal segment length 0.06–0.11 (0.08 ± 0.02); middle segment length 0.20–0.28 (0.24 ± 0.03); terminal segment length 0.06–0.07 (0.06 ± 0.01); total length 0.32–0.43 (0.38 ± 0.04). Parabasal papilla (Fig. 29) thumb-shaped, ventrally-directed. Oral cone robust. Mandible (Fig. 30) slender, with 4 sharp apical teeth. Maxillule (Fig. 31) bilobate; inner lobe sclerotized, bears 1 proximal and 1 apical elements; outer lobe with 2 attenuate elements. Maxilla (Fig. 32) 4-segmented; proximal segment unarmed; second segment rod-like, with 1 basal seta; third segment elongate, with 1 distal seta; terminal segment small, with 1 small seta and bifid claw. Maxilliped absent.



FIGURES 25–31. *Hatschekia ostracii* Yamaguti, 1953, female. 25, habitus, dorsal. 26, abdomen and caudal rami, dorsal. 27, antennule, ventral. 28, antenna, ventral. 29, antenna and parabasal papilla, medial. 30, mandible, ventral. 31, maxillule, ventral. Scale bars: 25, 0.2 mm; 26–27, 0.04 mm; 28, 0.05 mm; 29, 0.1 mm; 30–31, 20 µm.

Legs 1 and 2 (Figs 33–34) biramous, with incompletely bimerous exopod and 2-segmented endopod; leg armature formula as follows (armature on terminal segment of rami represented by the mode followed by the range in parentheses):

	Protopod	Exopod	Endopod
Leg 1	1–1	1–0; 5 (4–6)	0–0; 4 (3–5)
Leg 2	1–0	1–0; 5 (4–5)	0–0; 3 (2–4)



FIGURES 32–37. *Hatschekia ostracii* Yamaguti, 1953, female. 32, maxilla, ventral. 33, leg 1, ventral. 34, leg 2, ventral. 35, intercoxal sclerite of leg 1 and 2, ventral. 36, leg 3, ventral. 37, leg 4, ventral. Scale bars: 32–34, 36–37, 20 µm; 35, 0.05 mm.

Intercoxal sclerite of legs 1 and 2 (Fig. 35) bears 2 short and 2 long processes. Protopods bear row of blunt spinules along distal margin and semicircular wrinkles on anterior surface (it is uncertain whether these wrinkles consist of spinules or not). Rami bear small, spinulate, hyaline sculptures on anterior surface. Leg 1 (Fig. 33) 0.14–0.16 (0.15 ± 0.01) long; protopod length 0.06–0.08 (0.07 ± 0.01); exopod length [0.07–0.08 (0.08 ± 0.01)] exceeding endopod length [0.02–0.03 (0.02 ± 0)]. Leg 2 (Fig. 34) length 0.10–0.17 (0.13 ± 0.02); protopod length 0.05–0.09 (0.07 ± 0.01); exopod length 0.05–0.07 (0.06 ± 0.01); endopod length 0.03–0.04 (0.03 ± 0).

Leg 3 (Figs 25, 36) represented by 2 simple setae on mid-lateral surface of trunk. Leg 4 (Figs 25, 37) represented by 1 simple lateral seta on posterior ⅔ of trunk.

Attachment site. Gill filaments.

Remarks. *Hatschekia ostracii* was described originally by Yamaguti (1953) based on several gravid female specimens collected from *Ostracion cubicus* captured in Komatsushima (as Komatusima), Tokushima, Japan. This species was later redescribed by Kim (1998) from female specimens removed from *O. immaculatus* collected in Korea. *Hatschekia ostracii* has 4 processes on the intercoxal sclerite of legs 1 and 2 in common with *H. balistae* Nuñes-Ruivo, 1954 and *H. monacanthi* Yamaguti, 1939. However, *H. balistae* is distinguishable from *H. ostracii* by the presence of an anteromedian pointed apex on the cephalothorax and absence of posterior lobes on the trunk. *Hatschekia ostracii* differs from *H. monacanthi* by lacking a chitinous ring on the cephalothorax and having a significantly longer exopod relative to the endopod in leg 1 [L1ExL/L1EnL ratio 3.24 ± 0.36 vs. 2.22 ± 0.30 (U-test; $p<0.01$), Table 1] and a considerably longer abdomen relative to the body length [AbL/BL ratio 0.12 ± 0.01 vs. 0.03 ± 0.01 (U-test; $p<0.001$), Table 1].

Hatschekia monacanthi Yamaguti, 1939

(Figs 38–64)

Hatschekia monacanthi: Yamaguti 1939: 468; Jones 1985: 250.

Material examined. 6♀ and 4♂ (NSMT-Cr 20335), ex *Thamnaconus modestus* (Günther), Sakaiminato (35°32′N, 133°15′E), Tottori, Sea of Japan, Japan, 19 June, 2002; 1♀ (NSMT-Cr 20336), ex *T. modestus*, Osakikamishima (34°12′N, 132°53′E), Hiroshima, Seto Island Sea, Japan, 20 July, 2006.

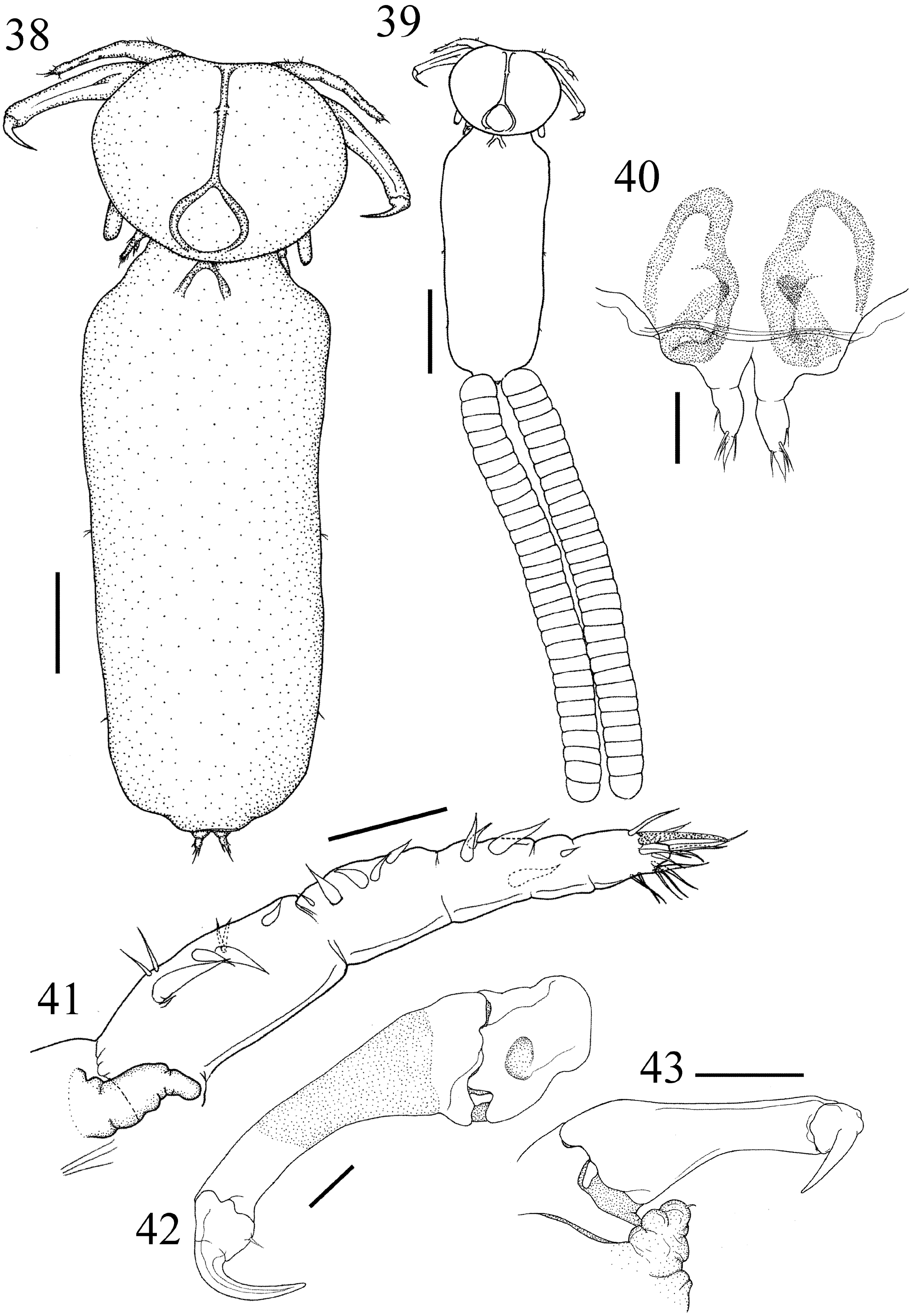
Description of female. Body (Figs 38–39) 1.44–1.66 (1.54 ± 0.09) long, excluding caudal rami (n = 7). Cephalothorax nearly elliptical, shorter than wide [0.39–0.45 (0.42 ± 0.03) × 0.48–0.54 (0.52 ± 0.02)], bears dorsal, T-shaped chitinous frame with complete ring at its posterior end. Trunk with posterior end being slightly swollen along the midline, longer than wide [1.05–1.27 (1.16 ± 0.09) × 0.44–0.58 (0.51 ± 0.06)]. Abdomen (Fig. 40) shorter than wide [0.04–0.07 (0.05 ± 0.01) × 0.12–0.15 (0.13 ± 0.01)]. Caudal ramus (Fig. 40) length 0.03–0.04 (0.03 ± 0); width 0.02–0.03 (0.02 ± 0); bears 5 naked setae.

Rostrum with 1 digitiform process on posterolateral corners (Fig. 41). Antennule (Fig. 41) indistinctly 5-segmented, 0.20–0.27 (0.23 ± 0.03) long; armature formula: 9, 5, 4, 1, 13 + 1 aesthetasc. Antenna (Fig. 42) 3-segmented; proximal segment (coxa) unarmed; middle segment (basis) ornamented with surface pits; terminal segment, usually unarmed (1 specimen with 1 basal seta); proximal segment length 0.09–0.12 (0.10 ± 0.01); middle segment length 0.23–0.29 (0.26 ± 0.03); terminal segment length 0.04–0.08 (0.05 ± 0.01); total length 0.37–0.46 (0.42 ± 0.04). Parabasal papilla (Fig. 43) shriveled, carrying apical process. Oral cone robust. Mandible (Fig. 44) slender, with 4 sharp apical teeth. Maxillule (Fig. 45) bilobate; both lobes armed with 2 tapering elements. Maxilla (Fig. 46) 4-segmented; proximal segment unarmed; second segment rod-like, with 1 basal seta; third segment elongate, with 1 distal seta; terminal segment small, with 1 small seta and bifid claw. Maxilliped absent.

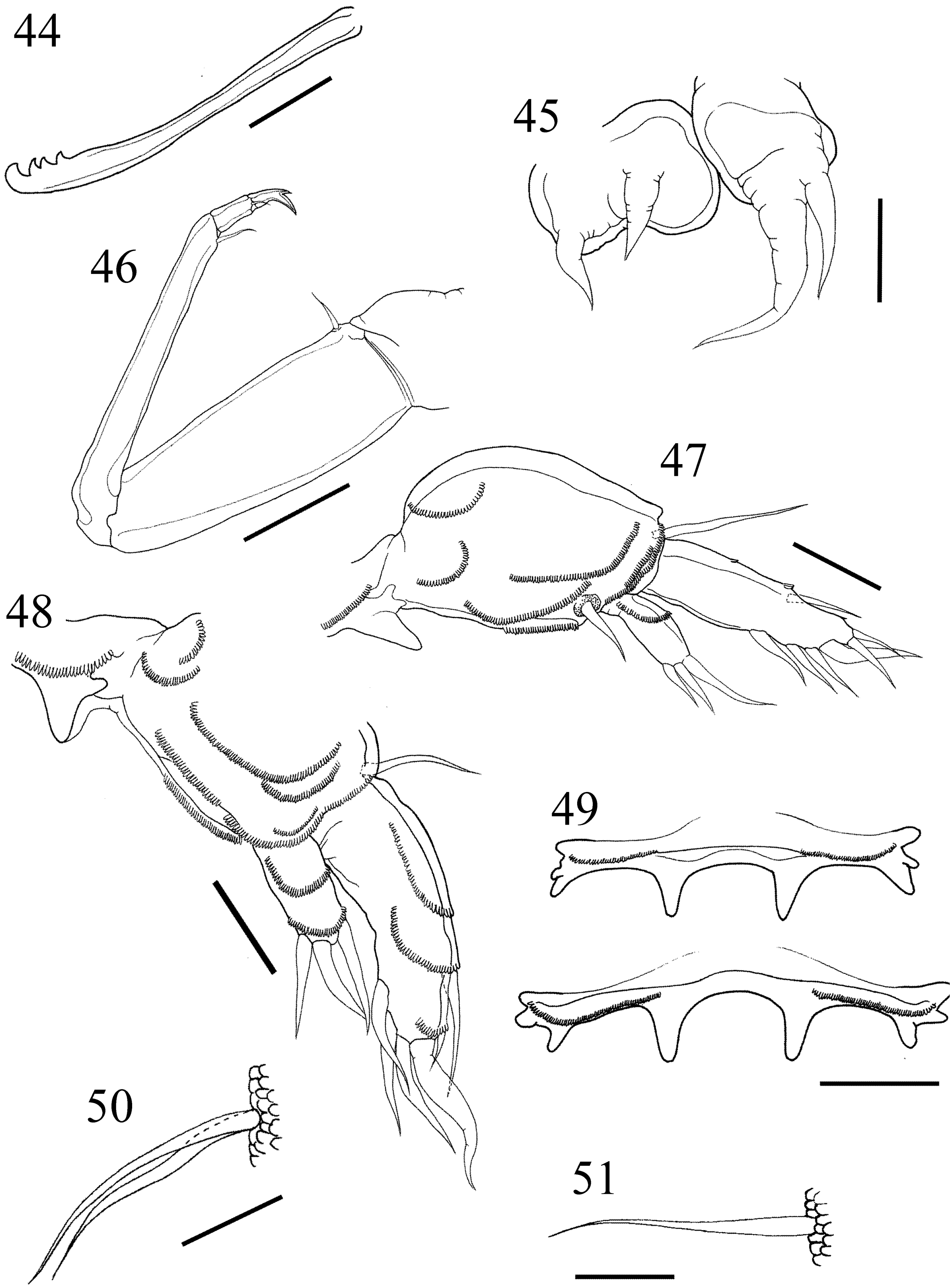
Legs 1 and 2 (Figs 47–48) biramous, with 1-segmented rami; armature formula as follows:

	Protopod	Exopod	Endopod
Leg 1	1–1	7	3
Leg 2	1–0	6	3

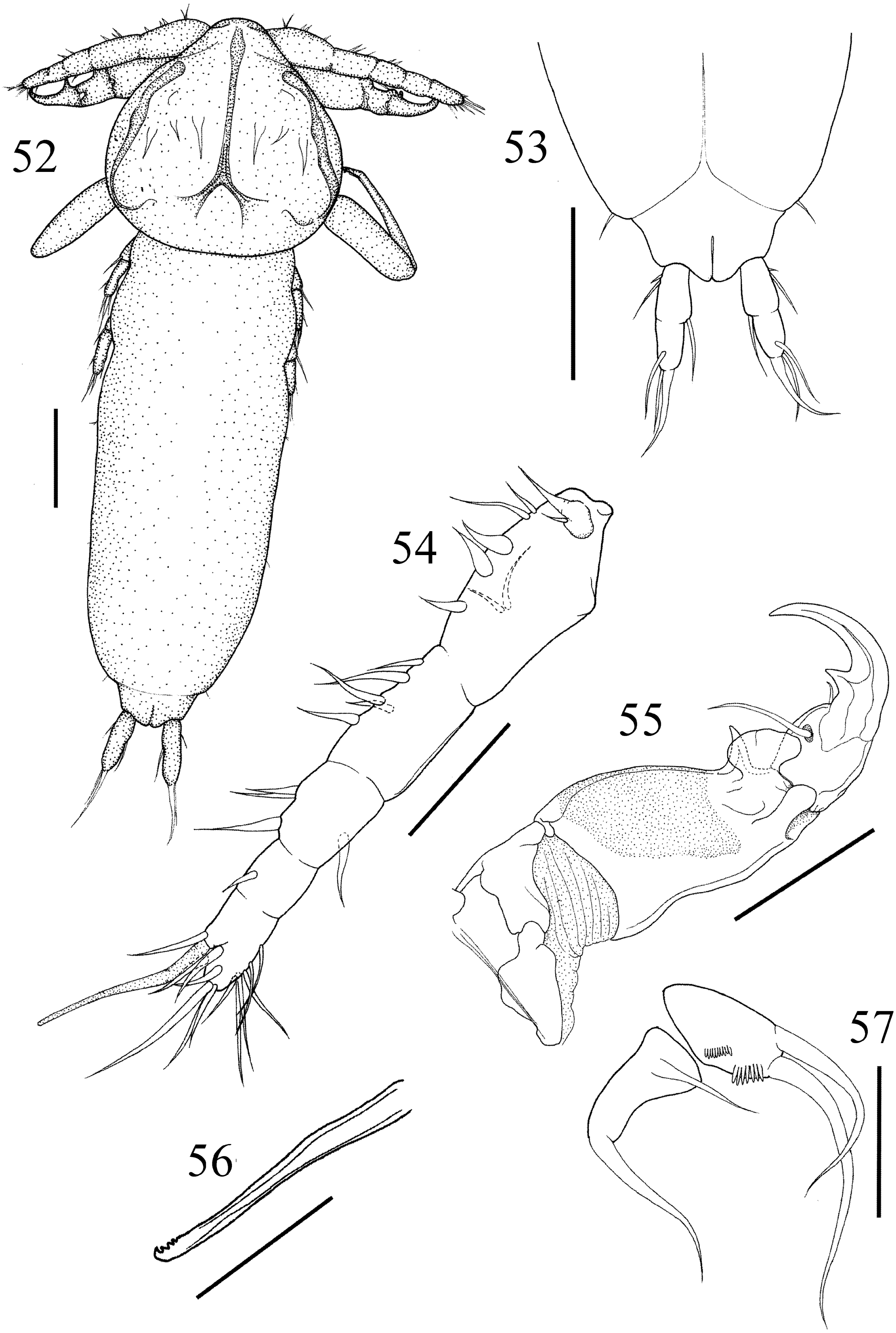
Intercoxal sclerite of legs 1 and 2 (Fig. 49) bears 2 short and 2 long processes plus 2 spinular rows. Protopods and rami, except leg 1 exopod, ornamented with rows of blunt spinules on anterior surface. Leg 1 (Fig. 47) 0.12–0.14 (0.13 ± 0.01) long; protopod length 0.06–0.08 (0.07 ± 0.01); exopod length [0.05–0.06 (0.06 ± 0)] exceeding endopod length [0.02–0.03 (0.03 ± 0)]. Leg 2 (Fig. 48) length 0.11–0.13 (0.12 ± 0.01); protopod length 0.05–0.07 (0.07 ± 0.01); exopod length 0.04–0.06 (0.05 ± 0.01); endopod length 0.02–0.03 (0.02 ± 0.01).



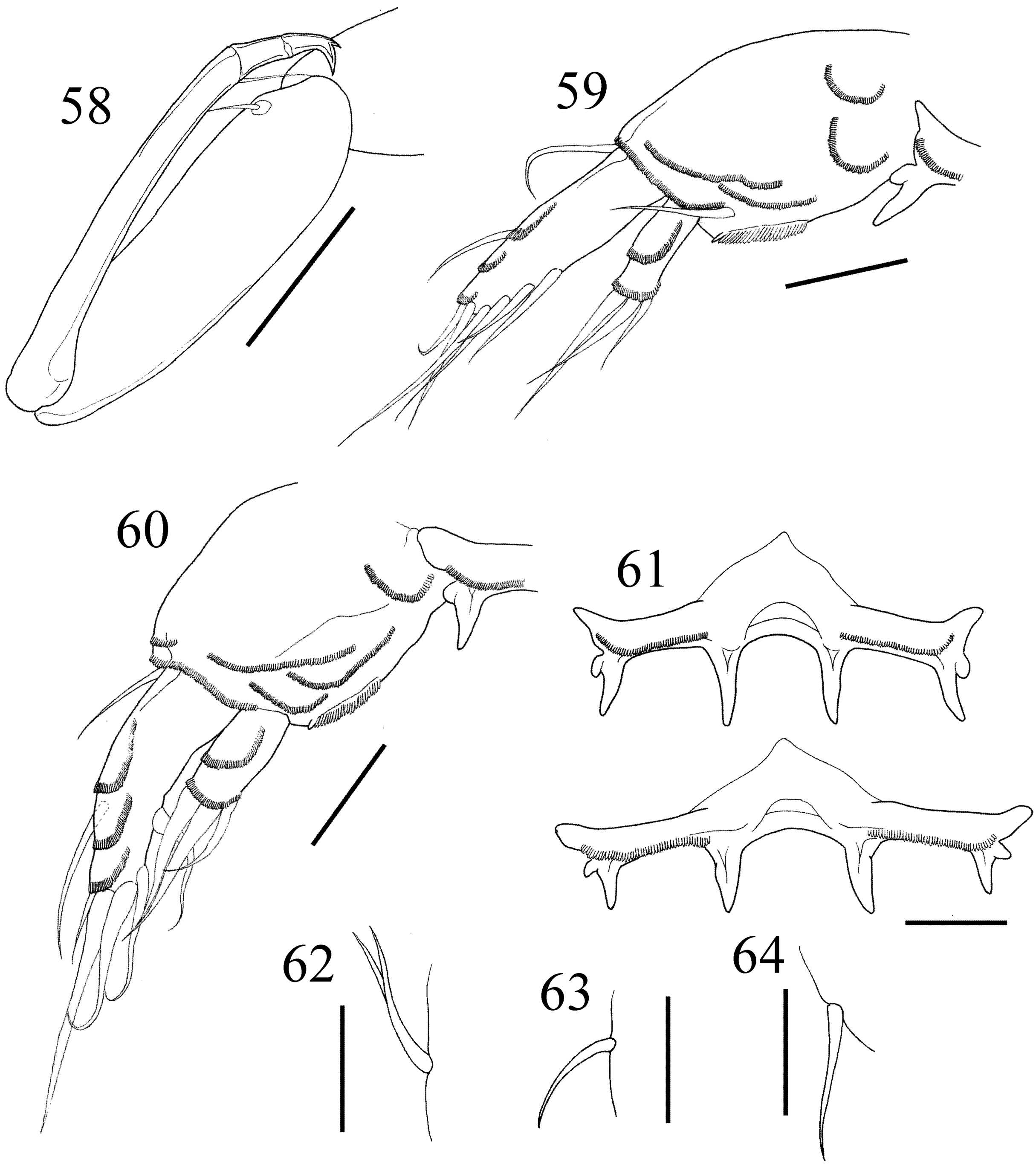
FIGURES 38–43. *Hatschekia monacanthi* Yamaguti, 1939, female. 38, habitus, dorsal. 39, habitus with egg sacs, dorsal. 40, posterior part of body, dorsal. 41, antennule, ventral. 42, antenna, ventral. 43, antenna and parabasal papilla, medial. Scale bars: 38, 0.2 mm; 39, 0.4 mm; 40–42, 0.05 mm; 43, 0.1 mm.



FIGURES 44–51. *Hatschekia monacanthi* Yamaguti, 1939, female. 44, mandible, ventral. 45, maxillule, ventral. 46, maxilla, ventral. 47, leg 1, ventral. 48, leg 2, ventral. 49, intercoxal sclerite of leg 1 and 2, ventral. 50, leg 3, ventral. 51, leg 4, ventral. Scale bars: 44, 12.5 µm; 45, 47–48, 25 µm; 46, 49, 0.05 mm; 50–51, 13 µm.



FIGURES 52–57. *Hatschekia monacanthi* Yamaguti, 1939, male. 52, habitus, dorsal. 53, posterior part of body, ventral. 54, antennule, ventral. 55, antenna, ventral. 56, mandible, ventral. 57, maxillule, ventral. Scale bars: 52–53, 0.1 mm; 54–55, 0.05 mm; 56, 17 µm; 57, 25 µm.



FIGURES 58–64. *Hatschekia monacanthi* Yamaguti, 1939, male. 58, maxilla, ventral. 59, leg 1, ventral. 60, leg 2, ventral. 61, intercoxal sclerite of leg 1 and 2, ventral. 62, leg 3, ventral. 63, leg 4, ventral. 64, leg 5, ventral. Scale bars: 58, 0.05 mm; 59–61, 25 µm; 62–64, 13 µm.

Leg 3 (Figs 38, 50) represented by 2 simple setae on mid-lateral surface of trunk. Leg 4 (Figs 38, 51) represented by 1 simple lateral seta on posterior ¾ of trunk.

Description of male. Body (Fig. 52) 0.71–0.81 (0.77 ± 0.04) long, excluding caudal rami (n = 4). Cephalothorax subtriangular, 0.24–0.27 (0.25 ± 0.01) × 0.23–0.27 (0.25 ± 0.02), with 6 dorsal spines and dorsal chitinous frame constructed of 1 central, straight bar flanked by 2 curved bars. Trunk length longer than wide [0.50–0.55 (0.54 ± 0.02) × 0.19–0.22 (0.21 ± 0.01)]. Abdomen (Fig. 53) shorter than wide [0.04–0.06 (0.05 ± 0.01) × 0.07–0.09 (0.08 ± 0.01)]. Caudal ramus (Fig. 53) longer than wide [0.05–0.07 (0.06 ± 0.01) × 0.02–0.03 (0.02 ± 0)], bears 6 naked setae.

Rostral process absent. Antennule (Fig. 54) incompletely 5-segmented, 0.19–0.22 (0.21 ± 0.01) long; armature formula: 9, 5, 4, 1, 13 + 1 aesthetasc. Antenna (Fig. 55) 3-segmented; proximal segment (coxa) unarmed; middle segment (basis) robust, distally with 1 pointed and 1 globular processes, ornamented with surface pits; terminal segment pointed, claw-like, with 2 basal setae and 1 medial pointed process; proximal segment length 0.05–0.06 (0.06 ± 0.01); middle segment length 0.08–0.12 (0.10 ± 0.01); terminal segment length 0.05–0.08 (0.07 ± 0.01); total length 0.18–0.24 (0.22 ± 0.03). Parabasal papilla absent. Oral cone robust. Mandible (Fig. 56) slender, with 4 sharp apical teeth. Maxillule (Fig. 57) bilobate; both lobes armed with 2 tapering elements; outer lobe with 2 short rows of blunt spinules. Maxilla (Fig. 58) 4-segmented; proximal segment unarmed; second segment rod-like, with 1 basal seta; third segment elongate, with 1 distal seta; terminal segment small, with 1 small seta and bifid claw. Maxilliped absent.

Legs 1 and 2 (Figs 59–60) biramous, with 1-segmented rami; armature formula as follows:

	Protopod	Exopod	Endopod
Leg 1	1–1	7	3
Leg 2	1–0	6	3

Intercoxal sclerite of legs 1 and 2 (Fig. 61) similar to those of female. Protopods and rami ornamented with rows of blunt spinules on anterior surface. General shape of legs 1 and 2 similar to those of female. Leg 1 (Fig. 59) 0.09–0.11 (0.10 ± 0.01) long; protopod length 0.05–0.06 (0.06 ± 0.01); exopod length [0.04–0.05 (0.04 ± 0)] exceeding endopod length [0.02–0.03 (0.03 ± 0)]. Leg 2 (Fig. 60) 0.09–0.11 (0.10 ± 0.01) long; protopod length 0.05–0.06 (0.05 ± 0.01); exopod length 0.04–0.05 (0.04 ± 0.01); endopod length 0.02–0.03 (0.02 ± 0).

Leg 3 (Figs 52, 62) represented by 2 simple lateral setae inserted slightly beyond anterior ⅓ of trunk. Leg 4 (Figs 52, 63) and leg 5 (Figs 52, 64) each represented by 1 simple seta (former inserted laterally on posterior ⅔ of trunk; latter inserted on posterior end of trunk).

Attachment site. Gill filaments.

Remarks. *Hatschekia monacanthi* was described originally by Yamaguti (1939) based on five female specimens removed from *Stephanolepis cirrhifer* (Temminck & Schlegel) collected in Toyama Bay, Japan, and was also reported in the same paper from *Sebastiscus marmoratus* (Cuvier) captured in Obama, Fukui (as Hukui), Japan. Jones (1985) subsequently redescribed the females of *H. monacanthi* that were collected from *Thamnaconus modestus* (Günther) [as *Navodon modestus*] captured in Ogi, Ishikawa, Japan. As mentioned in the Remarks section of *H. ostracii* above, *H. monacanthi*, *H. balistae* and *H. ostracii* all have 4 processes on the intercoxal sclerite of legs 1 and 2. *Hatschekia monacanthi* can be differentiated easily from these other two species by having, as observed in our specimens, a complete ring at the posterior end of the dorsal chitinous frame on the cephalothorax (Jones 1985).

Our female specimens of *H. monacanthi* collected from *T. modestus* vary slightly from those of Yamaguti (1939) and Jones (1985) with regard to the armature of the antennule and swimming legs 1 and 2. For example, there are four more setae on segments 1 and 5, as well as one more seta on segments 2 and 3, on the antennules of our specimens as compared to those of Jones' specimens. The exopods of legs 1 and 2 bear seven and six setae, respectively, in our specimens as opposed to six and five in Yamaguti's and Jones' material. Although Jones (1985) illustrated a mid-lateral seta on the exopod of both legs 1 and 2, as shown in this paper, no such illustrations were made by Yamaguti (1939). Even in our specimens, it was difficult to observe these setae because they were each positioned immediately behind the outer margin of the exopod. It is thus probable that Yamaguti (1939) overlooked these setae. In the same vein, Jones may have overlooked the small, outer apical seta on the exopod of both legs, but other explanations are possible, such as geographical variation and abnormality of specimens. Yamaguti (1939, fig. 120) illustrated, but did not describe in the text, a protrusion near the insertion of the antennule. This protrusion was reconfirmed in our material (Fig. 41). In addition, as reported by Jones (1985), we also found a parabasal papilla near the base of the antenna.

Males have been hitherto described for only seven species of the genus *Hatschekia*: *H. conifera* Yamaguti 1939, *H. hippoglossi*, *H. harkema* Pearse, 1948, *H. iridescens*, *H. petiti* Nuñes-Ruivo, 1954, *H. pinguis* Wilson, 1908, and *H. prionoti* Pearse, 1947 (see Schram & Aspholm 1997). This paper represents the first description of males of *H. monacanthi*, which demonstrated that females and males of this species differ in the shape of the cephalothorax, structure of the dorsal chitinous frame on the cephalothoracic shield, ornamentation of the maxillule and number of atrophied legs on the trunk surface.

Discussion

Hatschekia iridescens is host specific to porcupinefishes of the genus *Diodon* L. and is found worldwide from tropical to temperate seas (Wilson 1913; Yamaguti 1939), which parallels the circumtropical distribution of their hosts (Leis 2001; Froese & Pauly 2008). *Hatschekia legouli* has been reported from only Senegal (the eastern North Atlantic) and Japan (the western North Pacific) (Nuñes-Ruivo 1954; present paper). Although this distribution pattern is patchy, its porcupinefish host (*Chilomycterus reticulatus*) is found worldwide in tropical seas (Leis 2001; Froese & Pauly 2008), which suggests that *H. legouli* may be also widely distributed in tropical seas. *Hatschekia ostracii* appears to be restricted to Japan and Korea (Yamaguti 1953; Kim 1998; present paper). However, since its boxfish hosts (*Ostracion cubicus* and *O. immaculatus*) are widely distributed (Smith 1986; Froese & Pauly 2008), it is possible that *H. ostracii* may occur in other waters as well.

Hatschekia monacanthi was described originally from the filefish *Stephanolepis cirrhifer* in Toyama Bay and from the kelpfish *Sebastiscus marmoratus* in Obama, Japan (Yamaguti 1939). Both hosts were taken from the Sea of Japan. In the present study, we examined a total of 34 *S. cirrhifer* specimens from nine localities in the Sea of Japan, North Pacific Ocean, and Seto Inland Sea (i.e., Sakaiminato in Tottori; Muroto, Otsuki, and Tatsukushi in Kochi; Imabari and Uwajima in Ehime; Itsukaichi, Osakikamishima, and Takehara in Hiroshima), but could not find any *Hatschekia* specimens. As our *H. monacanthi* material was found on the filefish *Thamnaconus modestus* only, we hypothesize that this copepod species is host specific to *T. modestus*. Yamaguti's (1939) identification of his filefish host as *S. cirrhifer* may have been incorrect, and the single *H. monacanthi* specimen found on *S. marmoratus* by Yamaguti (1939) may be due to the accidental transfer of this parasite from a filefish host to this kelpfish species during handling or processing at the fish market.

In his description of *Hatschekia* species from Australia, Hewitt (1969) included various length and width ratios of body parts and appendages to facilitate species comparisons. However, Jones (1985) advocated that body proportions could not be used as reliable features to distinguish between species because they were too variable intraspecifically. Later, Kabata (1991) mentioned that all those proportional variations have their limits and used two ratios, trunk length/cephalothorax length and cephalothorax length/width, for species identification. In our study, the cephalothorax length/body length ratio and antennule length/antenna length ratio were used to discriminate between *H. iridescens* and *H. legouli*, while the leg 1 exopod length/endopod length ratio and abdomen length/body length ratio were useful to distinguish *H. monacanthi* from *H. ostracii*, because the standard deviations of each of these ratios are small and the range of each of these ratios did not overlap between the two pairs of species (see Table 1). We, therefore, consider that certain body and appendage ratios can serve as useful characters to distinguish between morphologically similar *Hatschekia* species, particularly for those that possess few meristic characters, and recommend that these ratios should be included in future descriptions of *Hatschekia*.

The presence of a parabasal papilla near the base of the antenna was reported by Kabata (1979, 1991), Jones (1985), Castro & Baeza (1986), Jones & Cabral (1990), Schram & Aspholm (1997), and Ho & Kim (2001). In our study, this structure was also observed in *H. ostracii* and *H. monacanthi*. In addition, a process on the posterolateral corners of the rostrum was found in the females of all four species examined in this study. This structure, termed the rostral process, varies typically in shape and size between these four species and may, therefore, be taxonomically important. There are no previous reports regarding the presence of a rostral process on those four taxa or on any other species of this genus. Even Schram & Aspholm (1997, figs. 2A & 6C) did not find any rostral process in their SEM-based morphological study of both sexes of *H. hippoglossi*. Further studies are needed to determine whether a rostral process is a unique synapomorphy of the group of *Hatschekia* species parasitizing tetraodontiform fishes.

A key to the 20 *Hatschekia* species known from Japan is provided below. Since both sexes are known for only a few species, the following key is essentially for the identification of female material.

Key to females of the species of *Hatschekia* from Japan

1 Intercoxal sclerite of legs 1 and 2 with 2 spatulate processes . ... *H. quadrabdominalis* Yü, 1933
- Intercoxal sclerite of legs 1 and 2 with 4 spiniform processes 2
- Such processes absent 3
2 Dorsal surface of cephalothoracic shield bears T-shaped chitinous frame with a complete ring on posterior end .... *H. monacanthi* Yamaguti, 1939
- Dorsal surface of cephalothoracic shield bears T-shaped chitinous frame only .... *H. ostracii* Yamaguti, 1953
3 Trunk elliptical or rounded, considerably wider than cephalothorax 4
- Trunk not as above 5
4 Trunk elliptical; legs 1 and 2 with 6 setae on endopod... *H. cepolae* Yamaguti, 1939
- Trunk round; legs 1 and 2 with 5 setae on endopod .... *H. rotundigenitalis* Yamaguti, 1939
5 Cephalothorax and trunk subequal in width, not separated by transverse constriction; integument separated from body proper by intervening space .... *H. cernae* Goggio, 1905
- Not as above.. 6
6 Antennule with digitiform process near distal end .... *H. bifurcata* Yamaguti & Yamasu, 1959
- Antennule with swelling on proximal segment .... *H. nahaensis* Yamaguti, 1953
- Antennule with prominent spine on proximal segment.. *H. labracis* (Beneden, 1870)
- Not as above 7
7 Antennule armed with squat, apically blunt elements that lack a complete basal articulation.................................. 8
- Not as above.. 9
8 Antennule longer than antenna; trunk with relatively large posterior lobes................. *H. legouli* Nuñes-Ruivo, 1954
- Antennule shorter than antenna; trunk with relatively small posterior lobes .... *H. iridescens* Wilson, 1913
9 Posterior end of trunk with pair of conical processes.. *H. conifera* Yamaguti, 1939
- Not as above 10
10 Legs 1 and 2 with 2 setae on endopod 11
- Legs 1 and 2 with more than 4 setae on endopod 12
11 Trunk tapered at posterior end, nearly twice as wide as cephalothorax ....*H. pseudolabri* Yamaguti, 1953
- Trunk sausage-shaped, nearly equal in width to cephalothorax ....*H. branchiostegi* Yamaguti, 1939
12 Cephalothoracic shield with dorsal T-shaped chitinous frame; trunk with lateral swelling at anterior end.................. ....*H. fusiformis* Shiino, 1957
- Cephalothoracic shield with M-shaped chitinous frame; trunk without lateral swelling at anterior end 13
13 Body length about 3.5 times longer than cephalothorax .... *H. longibrachium* Yamaguti, 1939
- Body length nearly 6–7 times longer than cephalothorax 14
- Body length at least 8 times longer than cephalothorax 15
14 Anterior trunk region bearing legs 1 and 2 narrow.. *H. japonica* Jones, 1985
- Not as above...*H. leptoscari* Yamaguti, 1939
15 Trunk club-shaped, with posterior half wider than anterior half .... *H. tenuis* (Heller, 1865)
- Trunk sausage-shaped ....*H. pagrosomi* Yamaguti, 1939

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