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Parasitic copepods from two species of commercial fishes collected off Iraq, with description of *Hatschekia shari* n. sp.

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Abstract Two species of parasitic copepods, including one new species, are described based on specimens collected from off Basrah, Iraq (Arabian Gulf). *Hatschekia shari* n. sp. (Siphonostomatoida: Hatschekiidae) was found from the gill filaments of the spangled emperor *Lethrinus nebulosus* (Forsskål) (Perciformes: Lethrinidae). The new species is characterised by the following characters in the female: a rectangular cephalothorax with dorsal frame composed of two short and one long bifid longitudinal bars, connecting to one short and one long latitudinal bars; elongate, cylindrical trunk without posterolateral processes or lobes; absence of parabasal papillae; and antennae bearing middle segments without narrow median part and with terminal claws without basal conical processes. *Bactrochondria formosana* Ho, Lin & Liu, 2011 (Cyclopoida: Chondracanthidae) was found on the gill filaments of the largescale tonguesole *Cynoglossus arel* (Bloch & Schneider) (Pleuronectiformes: Cynoglossidae). Close comparison of the specimens of *B. formosana* collected from off Iraq with the original description revealed some differences in elements and ornamentations on the body and appendages. Our finding of *B. formosana* represents not only a new record from the Indian Ocean but also from a new host.

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Introduction

The family Hatschekiidae Kabata, 1979 (Copepoda: Siphonostomatoida) is one of the major groups of gill parasites in marine fishes. Kabata (1979) established this family with five genera; subsequently four genera have been added (Boxshall, 1987, 1989; Castro-Romero & Baeza-Kuroki, 1989; Uyeno, 2013). *Hatschekia* Poche 1902 is the largest genus of the family, with 68 valid species recognised by Jones (1985) in his revision of the genus; however three species described by Uma Devi & Shyamasundari (1980) were left out (Jones & Cabral, 1990). Moreover, 47 new species have been described since (Pillai, 1985; Castro-Romero & Baeza-Kuroki, 1986; Villalba, 1986; Jones & Cabral, 1990; Kabata, 1991; Ho & Kim, 2001; Uyeno & Nagasawa, 2009b, 2010a, b, c, 2012a, 2013; El-Rashidy & Boxshall, 2011) and it is likely that the number will increase significantly in the future. On the other hand, the cyclopoid copepod family Chondracanthidae is also one of the major parasites on marine demersal fishes. In this family, 30 genera were recognized in Ho's (1970) revision but 50 genera are currently known (Uyeno & Nagasawa, 2012b). Species of the latter family predominantly attach in the oral or branchial cavities of hosts (Boxshall & Halsey 2004).

Iraq is located in the innermost part of the Arabian Gulf where more than 700 species of fishes have been reported (Froese & Pauly, 2013), but the records of parasitic copepods from marine fishes are scarce. Only two hatschekiid species, *Hatschekia conifera* Yamaguti, 1939 and *H. insolita* Wilson, 1913, have been reported (Al-Daraji, 1995; Bannai et al., 2008) and there is no record of chondracanthid copepods.

The present study provides descriptions of two parasitic copepod species from highly valued commercial fishes in the northwest Arabian Gulf (off Iraq), *Hatschekia shari* n. sp. from *Lethrinus nebulosus* (Forsskål) and *Bactrochondria formosana* from *Cynogrossus arel* (Bloch & Schneider).

Materials and methods

Fishes were captured by bottom trawl off Khor Al-Ummia (29°46′N, 48°48′E) in northwest Arabian Gulf from November 2008 to August 2009. Copepods were removed from fish gills, preserved in 70% ethanol, and soaked in lactophenol for a few hours before dissection. After dissection, the appendages were examined using the method described by Humes & Gooding (1964). Drawings were made with the aid of a drawing tube. Morphological terminology follows Huys & Boxshall (1991) and Uyeno & Nagasawa (2009a). Measurements are in micrometres and are given as ranges, followed by means in parentheses. Type-specimens are deposited in the crustacean collection at the Natural History Museum, London (NHMUK) and the National Museum of Nature and Science, Tsukuba (NSMT). Fish names follow Froese & Pauly (2013).

Family Hatschekiidae Kabata, 1979
Genus *Hatschekia* Poche, 1902

Hatschekia shari n. sp.

Type-host: *Lethrinus nebulosus* (Forsskål) (Perciformes: Lethrinidae).
Type locality: Off Khor Al-Ummia (29°46′N, 48°48′E), northwest Arabian Gulf, Iraq.
Site: Gill filaments.
Type-material: Holotype, adult female (NHMUK 2013.139), November 2008. Paratypes: 2 adult females (NHMUK 2013.140–141), 3 adult females (NSMT-Cr 22388), November 2008. All specimens collected by Atheer H. Ali.
Etymology: The specific name, *shari*, is derived from a local name of the type host, *L. nebulosus*, in Iraq.

Description (Figs. 1, 2)

Female. Adult body (Fig. 1A–C) 1,604 long, excluding caudal rami. Head composed of cephalosome (Fig. 1C). Cephalothorax (Fig. 1B) rectangular, slightly longer than wide, 202 × 192, bearing projecting anterior margin, with greatest width posteriorly; dorsal chitinous frame (Fig. 1B) composed of 2 short slightly curved and 1 long bifid longitudinal bars, connecting to 1 short and 1 long latitudinal simple bars. Trunk (Fig. 1A) elongate, cylindrical, 1,409 × 248, with double constrictions at bases of legs 1 and 2 (Fig. 1A, C). Urosome (Fig. 1D) (excluding caudal rami) conical, shorter than wide, 30 × 63. Caudal ramus (Fig. 1D, E) longer than wide, 14 × 7, fused to urosome, with 6 setae.

Rostrum slightly protruded, bearing paired protrusions without processes (Fig. 1B). Antennule (Fig. 1F) indistinctly 5-segmented, 82 long; armature formula: 9, 4, 4, 1, 13 + 1 aesthetasc. Antenna (Fig. 1G) 3-segmented, 111 long; proximal segment (coxa) small, unarmed, 26 long; middle segment (basis) conical, 67 long, ornamented, with surface of cuticle pitted; terminal claw robust, indistinctly 2-segmented near base; proximal segment, 19 long. Parabasal papilla absent. Oral cone robust. Mandible (Fig. 1H) slender, with 2 sharp teeth. Maxillule (Fig. 1I) bilobate; both lobes bearing 2 tapered unequal elements. Maxilla (Fig. 1J) 4-segmented, with typical hatschekiid shape; proximal segment unarmed; second segment fusiform, with 1 basal seta; third segment rod-like, with 1 distal seta; terminal segment short, with bifid claw. Maxilliped absent.

Legs 1 and 2 (Fig. 2A, B) modified, biramous, composed of protopods, exopods, and endopods; both rami indistinctly 2-segmented. Spine and seta formula as follows:

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

Leg 1 (Fig. 2A) 69 long; protopod 45 long; exopod 24 long, exceeding endopod length, 22. Leg

2 (Fig. 2B) 89 long; protopod 56 long; exopod 32 long; endopod 34 long. Protopods and both rami ornamented with semicircular cuticular folds, consisting of blunt spinules. Distal element on proximal exopodal segment of leg 1 robust. Intercoxal sclerites of legs 1 and 2 unarmed. Leg 3 (Figs. 1A, 2C) represented by 2 simple setae originating on anterior third of trunk. Leg 4 (Figs. 1A, 2D) represented by 1 simple seta and vestige of element on posterior quarter of trunk.

Variability

Two paratypes (NHMUK 2013.140–141) have cephalothorax wider than long. Measurement ranges of the body parts and appendages of female paratypes (n = 5) are as follows: body length (excluding caudal rami) 1,339–1,542 (1,477); cephalothorax 185–216 × 174–215 (202 × 200); trunk 1,148–1,492 × 219–261 (1,306 × 236); urosome (excluding caudal rami) 17–46 × 57–89 (28 × 69), caudal ramus 16–17 × 8–9 (16 × 8), antennule length 73–96 (88); antenna total length 103–134 (114), proximal segment length 27–41 (31), middle segment length 61–71 (65), terminal segment length 15–22 (19); leg 1 length 59–65 (63), leg 1 protopod length 39–45 (42), leg 1 exopod length 20–21 (21), leg 1 endopod length 18–22 (20); leg 2 length 71–87 (81), leg 2 protopod length 47–55 (52), leg 2 exopod length 24–32 (29), leg 2 endopod length 27–32 (29).

Length ratios of various body parts based on the type-series (n = 6): cephalothorax length/body length 0.14:1; cephalothorax width/body length 0.14:1; trunk length/body length 0.88:1; trunk width/body length 0.16:1; abdomen length/body length 0.02:1; abdomen width/body length 0.05:1; caudal ramus length/body length 0.01:1; caudal ramus width/body length 0.01:1; cephalothorax width/cephalothorax length 0.99:1; abdomen width/abdomen length 2.67:1; antennule length/body length 0.06:1; antenna length/body length 0.08:1; terminal claw length of antenna (as terminal segment length of antenna in Uyeno & Nagasawa, 2009a, b)/middle segment length of antenna 0.29:1; leg 1 length/body length 0.04:1; leg 1 exopod length/leg 1 endopod length 1.07:1; leg 2 length/body length 0.05:1; leg 2 exopod length/leg 2 endopod length 1.00:1; antennule length/antenna length 0.77:1.

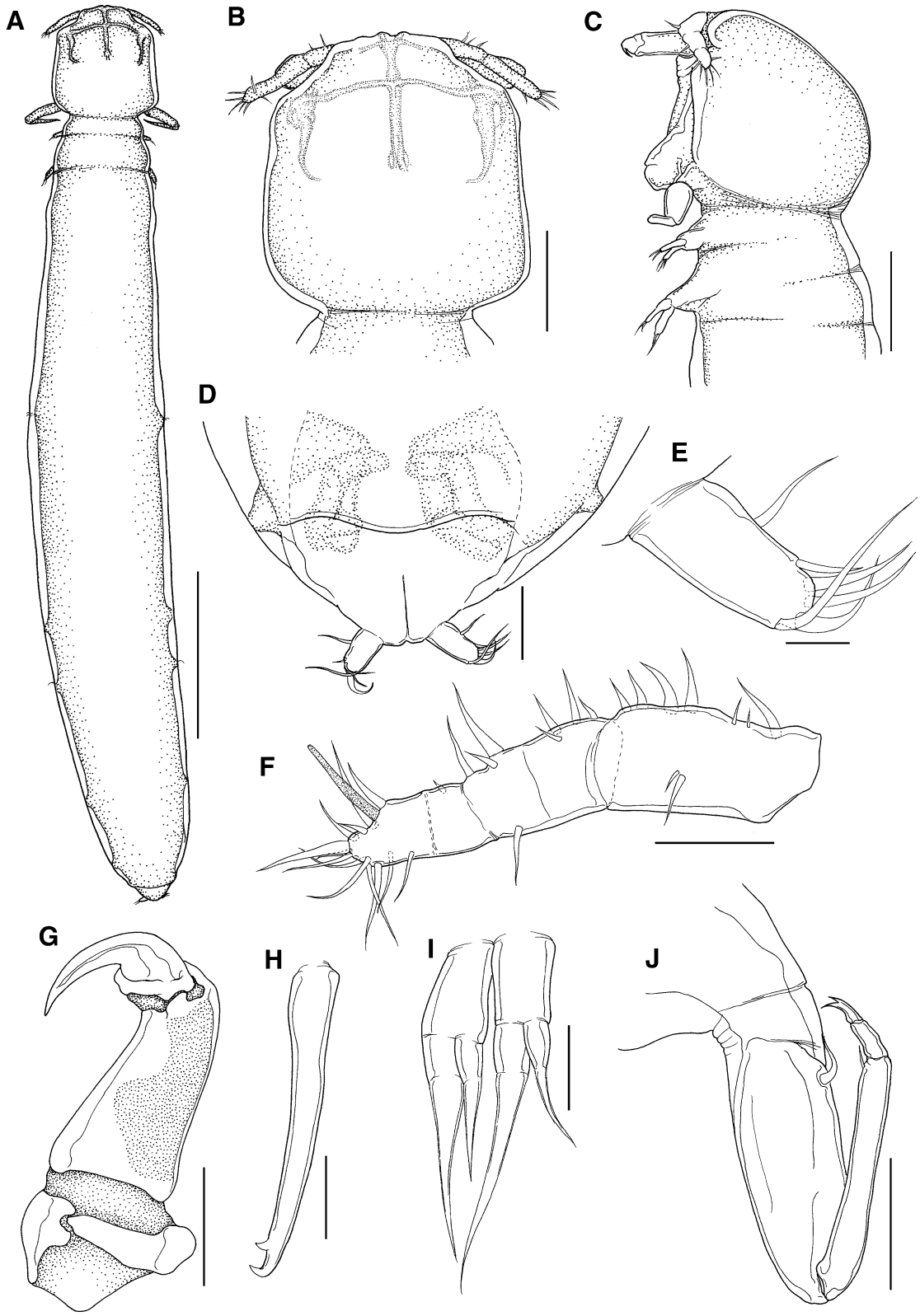
Male. Unknown.

Remarks

Hatschekia shari n. sp. has a rectangular cephalothorax which is almost as long as wide and lacks lateral processes or lobes. The trunk is elongate and slender, without posterolateral lobes or processes. These features are shared with eight congeneric species (out of 118 species), namely *Hatschekia argyrops* Uma Devi & Shyamasundari, 1980, *H. gracilis* Yamaguti, 1954, *H. manea* Jones & Cabral, 1990, *H. pagelliboguerave*i (Hesse, 1878), *H. pagrosomi* Yamaguti, 1939, *H. tenuis* (Heller, 1865), *H. sigani* Uma Devi & Shyamasundari, 1980, and *H. siganicola* El-Rashidy & Boxshall, 2011 (see Kabata, 1979; Uma Devi & Shyamasundari, 1980; Jones, 1985; Jones & Cabral, 1990; El-Rashidy & Boxshall, 2011). Of these species, four are clearly distinguishable from the new species by the morphology of the cephalothorax: with a dorsal chitinous frame composed of three latitudinal bars and X-shaped accessory pieces in *H. gracilis*; with rounded lateral margins and convex posterior margin in *H. manea*; with a pointed conical protuberance on the posterior margin in *H. pagelliboguerave*i; and being expanded laterally with concave lateral margins in *H. sigani* (see Yamaguti, 1954; Uma Devi & Shyamasundari, 1980; Jones & Cabral, 1990). *Hatschekia pagrosomi* and *H. siganicola* can be easily separated from the new species by the presence of parabasal papillae (see Yamaguti, 1939a; Roubal et al., 1983; Kim, 1998; El-Rashidy & Boxshall, 2011). *Hatschekia tenuis* is distinguishable from *H. shari* n. sp. by having the trunk swollen posteriorly into spindle and antennae with terminal claws and basal conical processes (see Yamaguti & Yamasu, 1959; Jones, 1985). The original description of *H. argyrops* is cursory and includes doubtful parts, but the circular cephalothorax and the antenna bearing highly curved middle segment with the narrow median part (see figure 1c in Uma Devi & Shyamasundari, 1980) represent features departing from the morphology of *H. shari* n. sp.

Family Chondracanthidae Milne Edwards, 1840

Genus *Bactrochondria* Ho, Kim & Biju Kumar, 2000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◀**Fig. 1** *Hatschekia shari* n. sp., adult female, holotype. A, habitus, dorsal view; B, cephalothorax, dorsal view; C, anterior part of body, lateral view; D, posterior part of trunk, dorsal view; E, right caudal ramus, dorsal view; F, left antennule, anterior; G, left antenna, posterior; H, right mandible, anterior; I, left maxillule, anterior; J, left maxilla, posterior. *Scale-bars*: A, 300 μm; B, 70 μm; C, 100 μm; D, F, 20 μm; E, 5 μm; G, J, 30 μm; H, I, 7 μm

Bactrochondria formosana Ho, Lin & Liu, 2011

Host: *Cynoglossus arel* (Bloch & Schneider) (Pleuronectiformes: Cynoglossidae).
Locality: Off Khor Al-Ummia (29°46′N, 48°48′E), northwest Arabian Gulf, Iraq.
Site: Females attaching to gill filaments. Males attaching to nuptial organs of females.
Material studied: 2 adult females and 2 adult males (NHMUK 2013.142–145), 2 adult females and 2 adult males (NSMT-Cr 22389), August 2009. Materials collected by Atheer H. Ali.

Description (Figs. 3–5)

Female. Adult body (Fig. 3A, B) 1,908–2,539 (2,185) long, excluding caudal rami. Head composed of cephalosome (Fig. 3A–C), longer than wide, 389–495 × 332–395 (437 × 352), with paired globular cephalic processes on anterolateral corners and oral region swollen. Neck region formed by first

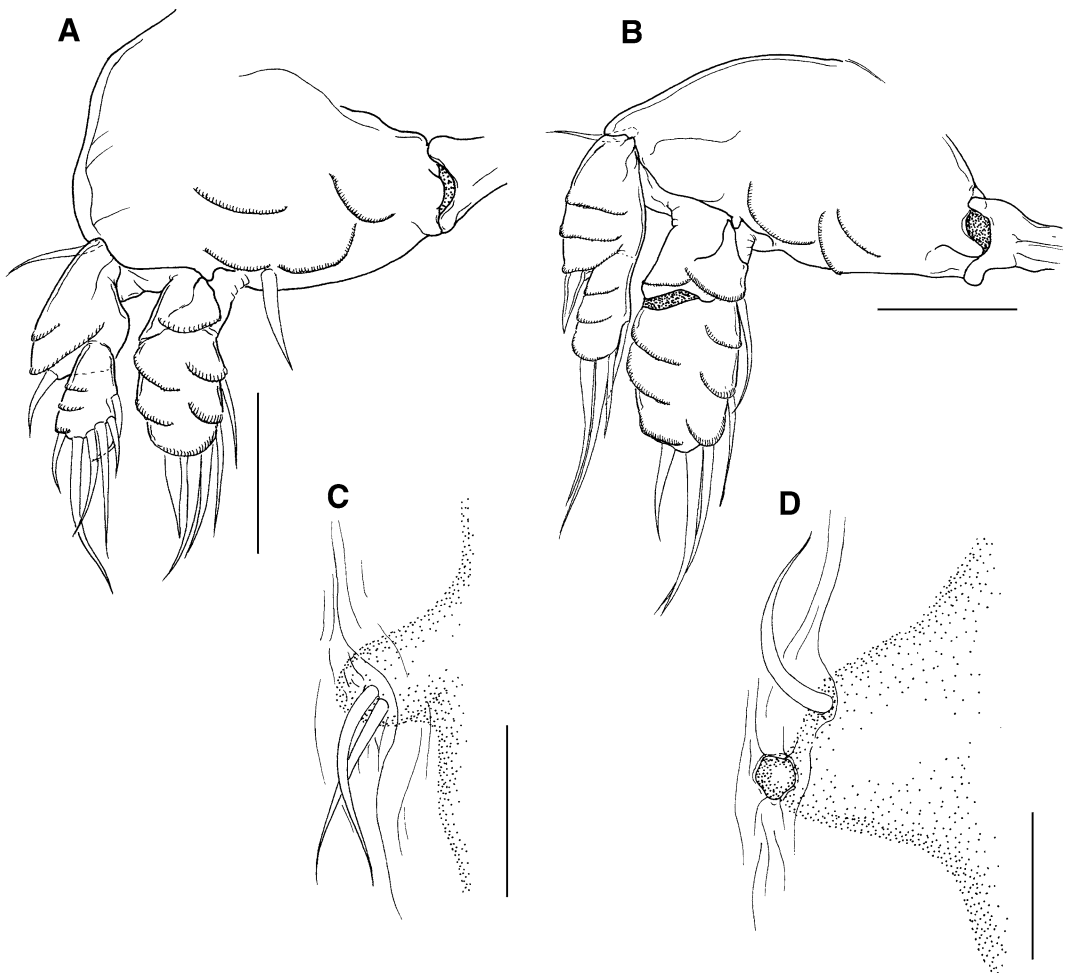


Fig. 2 *Hatschekia shari* n. sp., adult female, holotype. A, right leg 1, anterior; B, right leg 2, anterior; C, left leg 3; D, left leg 4. *Scale-bars*: A, B, 20 μm; C, D, 10 μm

pediger. Trunk (Fig. 3A, B) elongate, 1,365–1,901 × 313–380 (1,598 × 342), cylindrical, slightly constricted at border between first and second pedigers; nuptial organ reaches posterior third of genital double somite (Fig. 3D). Genital somite double (Fig. 3D), wider than long 86–105 × 132–203 (93 × 160). Abdomen (Fig. 3D) wider than long, 29–41 × 56–70 (63 × 33), bearing paired papillae, tipped with setule on dorsal surface. Caudal ramus (Fig. 3D) tapering into pointed tip with 3 setae and 1 tubercle. Egg-sacs (Fig. 3E) elongate, multiseriate.

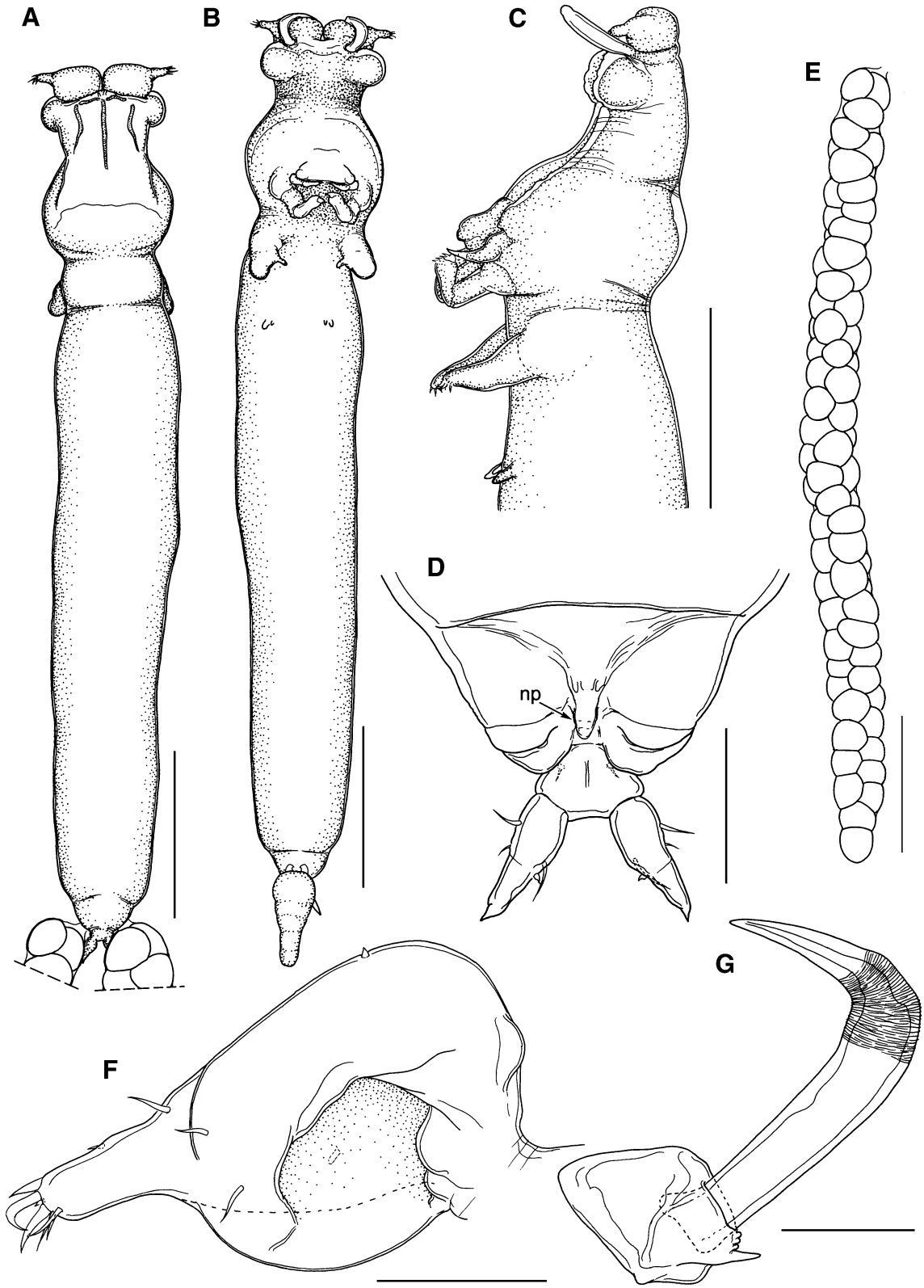
Antennule (Fig. 3F) unsegmented, composed of inflated basal part and rod-like distal part; basal part depressed on posterior surface with inner lobe and 4 elements; distal part bearing 2 setae on anterior surface and 7 setae at tip. Antenna (Fig. 3G) 2-segmented; proximal segment small, bearing pointed process on outer margin; terminal claw incurved and striated at anterior third. Labrum (Fig. 4A) trapezium-shaped, with rounded posterolateral corners. Mandible (Fig. 4B) composed of unarmed coxa and gnathobase with more than 30 teeth on convex margin and about 70 teeth on concave margin. Maxillule (Fig. 4C) bilobate, composed of conical outer lobe tipped with 1 apical process, and inner lobe tipped with 2 blunt papillary elements. Maxilla (Fig. 4D) 2-segmented; proximal segment broad, unarmed; terminal segment tapering into blunt process, bearing 1 basal seta, 1 blunt element with small tip, 1 subterminal tooth, and row of fine, marginal teeth. Maxilliped (Fig. 4E) 3-segmented; proximal segment rod-like, unarmed; middle segment rod-like, enlarged distally with swollen inner margin covered with 2 patches of spinules; terminal claw robust, incurved. Leg 1 (Fig. 4F) composed of greatly enlarged, conical protopod with outer median seta and reduced papilliform exopod and endopod each bearing 6 and 1 small blunt elements. Leg 2 (Fig. 4G) bilobate; protopod small, bearing outer seta; exopod rod-like, bearing 4 elements; endopod rod-like, bearing single apical element. Legs 3 and 4 not observed.

Male. Adult body (Fig. 5A) indistinctly segmented, 314–412 (344) long, excluding caudal rami. Genital somite (Fig. 5B) bearing paired opercula, covering genital apertures. Abdomen (Fig. 5B) indistinctly fused to both genital segment and caudal rami, bearing paired papillae with setule and simple setules. Caudal ramus (Fig. 5B) tapering into pointed tip, with 2 setae. Antennule (Fig. 5C) elongate, incompletely 4-segmented, bent backward; armature formula 1-2-2-2-1-8. Antenna (Fig. 5D) 2-segmented, stocky, incurved, unarmed hook. Labrum unarmed. Mandible (Fig. 5E) bearing more than 10 teeth on both convex and concave side of gnathobase. Maxillule (Fig. 5F) lobe with 3 terminal blunt elements. Maxilla (Fig. 5G) as in female except distal process without subterminal tooth. Maxilliped (Fig. 5H) as in female except much small terminal claw. Leg 1 (Fig. 5I) reduced, composed of small knob with 1 outer seta and lobe with 2 blunt elements. Leg 2 (Fig. 5J) conical lobe, with single basal seta and 2 apical elements.

Fig. 3 *Bactrochondria formosana* Ho, Lin & Liu, 2011, adult female. A, habitus, dorsal view; B, habitus, ventral view; C, anterior part of body, lateral view; D, posterior part of trunk, ventral view (np, nuptial organ); E, egg-sac; F, right antennule, posterior; G, right antenna, anterior. *Scale-bars*: A, B, E, 500 μm; C, 400 μm; D, 100 μm; F, G, 70 μm

Remarks

Five nominal species of the genus are known (Ho et al., 2011). *Bactrochondria formosana* Ho, Lin & Liu, 2011 is easily distinguished from *B. hoi* (Pillai, 1985), *B. longitruncus* (Yamaguti, 1939) and *B. tuase* Ho, Lin & Liu, 2011, by the possession of a terminal claw on the male maxilliped (see Ho et al., 2011). Based on the female specimen, *B. papilla* Ho, Kim & Biju Kumar, 2004 differs from *B. formosana* by having the cephalic process with a swollen base and a nipple-like protrusion and lacking striation on the terminal claw (see Ho et al., 2011). *Bactrochondria formosana* was originally described based on specimens collected from Taiwan (Ho et al., 2011); our finding of the copepod from off Iraq represents the second record. There are small differences in the morphology of the body and appendages between the original description and our specimens (Table 1). The differences of element numbers on legs of the male and antennules in both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sexes may be due to damages or overlooking because of their fragile nature, but the ornamentation on antennae and maxillules of female and mandibles of both sexes are stable and clearly differentiated. However, the differences in the ornamentations are quite small and we consider that the specimens from Iraq are *B. formosana* with some morphological variations.

So far *B. formosana* is known only from *Paraplagusia bilineata* (Bloch) (Pleuronectiformes: Cynoglossidae) (Ho et al., 2011). *Cynoglossus arel* therefore, represents a new host record.

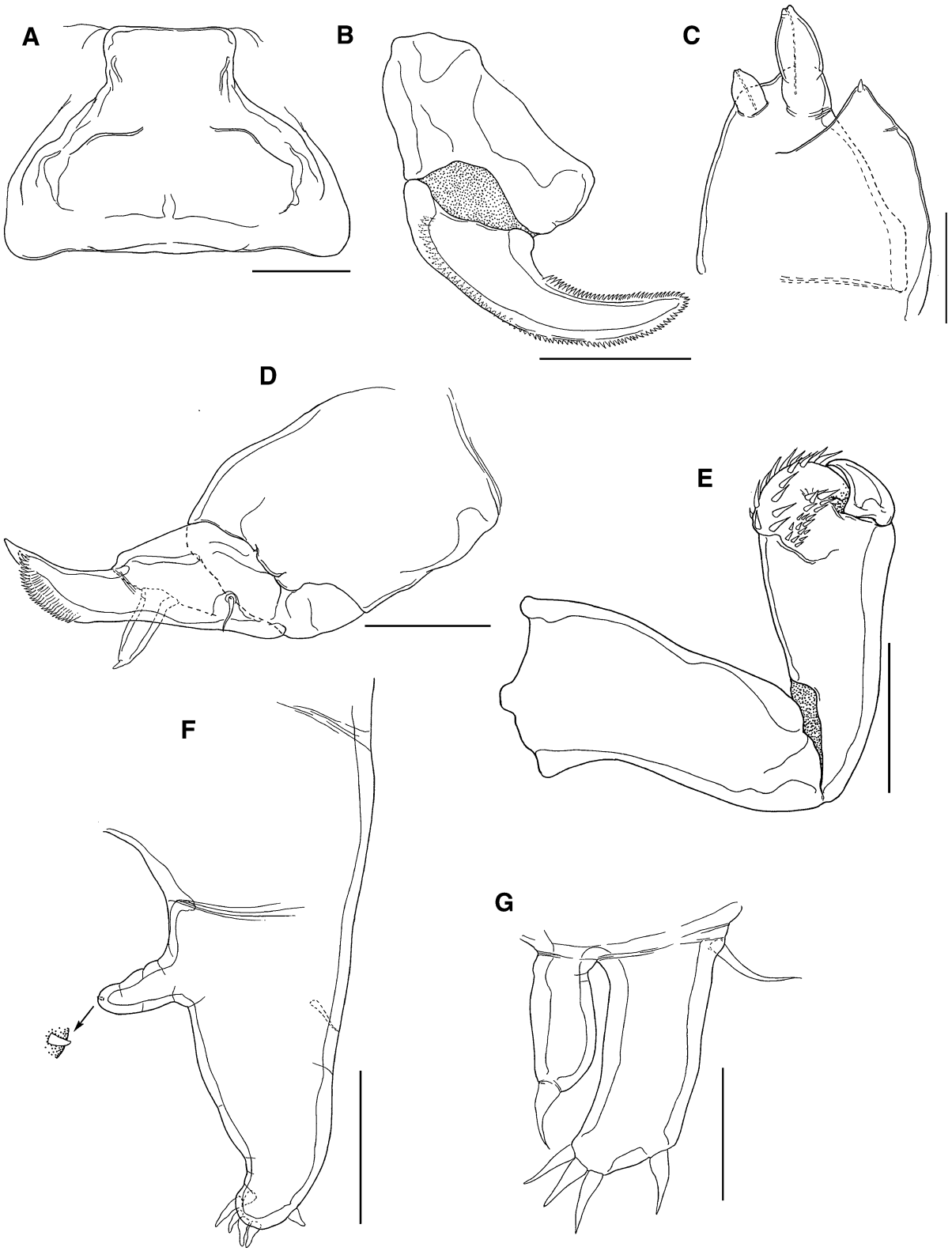
Discussion

Of the 119 valid species of *Hatschekia*, including the new species described above, six species (*H. elegans* Kabata, 1991, *H. gracilis, H. megacephala* Kabata, 1991, *H. pagrosomi*, *H. rotundigenitalis* Yamaguti, 1939, and *H. shari* n. sp.) have been recorded from fishes of the family Lethrinidae (Perciformes) (Jones, 1985; Kabata, 1991; present study). Among these six species, *H. pagrosomi* is unusual since it has been reported from the families Sparidae, Lethrinidae and Carangidae (see Jones, 1985; Kabata, 1991). Since most species of *Hatschekia* are parasitic on fishes of the same family, species which utilise fish hosts from more than two families are rather rare (Uma Devi & Shyamasundari, 1980; Jones, 1985; Pillai, 1985; Castro-Romero & Baeza-Kuroki, 1986; Villalba, 1986; Jones & Cabral, 1990; Kabata, 1991; Kim, 1998; Ho & Kim, 2001; Uyeno & Nagasawa, 2009a, b, 2010a, b, c, 2012a, 2013; El-Rashidy & Boxshall, 2011). This may imply that host specificity in the species of *Hatschekia* is usually high. For instance, Yamaguti (1939a) described *H. pagrosomi* based on female specimens taken from *Pagrus major* (Temminck & Schlegel) (as *Pagrosomus unicolor*) (Perciformes: Sparidae) and *Lethrinus haematopterus* Temminck & Schlegel (Perciformes: Lethrinidae), despite important character differences (e.g. the dorsal chitinous frame, mandibles) between the parasites taken from the two different fish hosts. Under these circumstances, it is doubtful whether the specimens of *H. pagrosomi* collected from *L. haematopterus* are really conspecific with those collected from *P. major*. Actually, *H. pagrosomi* is similar in general body shape with *H. shari* n. sp., which was found on a lethrinid host. A distinctive difference between the two species is the presence of a parabasal papilla in *H. pagrosomi* which, although not mentioned in the text, is illustrated in the original description (figure 77 in Yamaguti, 1939a). On the other hand, Jones (1985) relegated *H. trachuri* Yamaguti & Yamasu, 1960, found on *Trachurus japonicus* (Temminck & Schlegel) (as *Trachurus trachuri*) (Perciformes: Carangidae), as a junior synonym of *H. pagrosomi* because of a few differences between them (details of leg armature). However, Yamaguti & Yamasu (1960) did not mention any appendages and details of the body parts in the original description of *H. trachuri*. Apparently, more detailed comparative studies of *H. pagrosomi* and *H. trachuri* are required.

Fig. 4 *Bactrochondria formosana* Ho, Lin & Liu, 2011, adult ▶ female. A, labrum; B, right mandible, anterior; C, right maxillule, anterior; D, left maxilla, anterior; E, left maxilliped, posterior; F, left leg 1, anterior; G, left leg 2, anterior. *Scale-bars*: A, E, 50 μm; B, D, G, 30 μm; C, 20 μm; F, 70 μm

Since the host of *H. shari* n. sp., the spangled emperor *Lethrinus nebulosus*, is widely distributed from temperate to tropical regions around the world (Froese & Pauly, 2013), the distribution area of *H. shari* n. sp. may be extensive, not only in the Arabian Gulf but also in the Indian Ocean.

Bactrochondria formosana was originally described from the south-western region of Taiwan, and the finding of this copepod from off Iraq represents a second record. Although there are some differences between the original description by Ho et al. (2011) and the present description, similar minor morphological differences were also found between the descriptions by Yamaguti (1939b) and Ho et al. (2011) of the congener *B. longitruncus* (Yamaguti, 1939). In both species, these differences may represent geographical variations. Such morphological differences have also been recorded in parasitic copepods distributed in wide areas, e.g. *Orbitacolax hapalogenyos* (Yamaguti & Yamasu, 1959) (Cyclopoida: Bomolochidae) (see Ho & Dojiri, 1976; Cressey & Cressey, 1989).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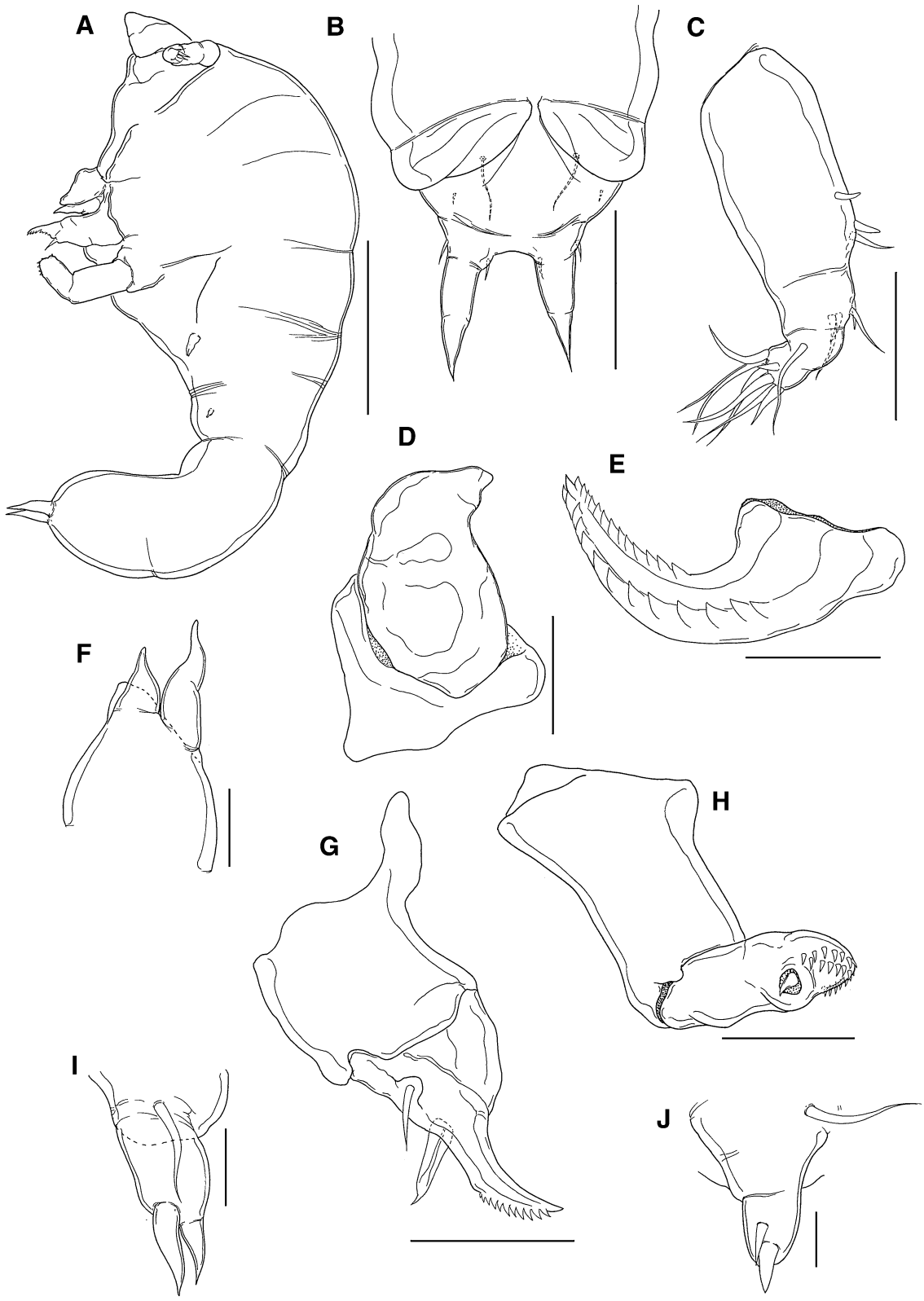
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◀ **Fig. 5** *Bactrochondria formosana* Ho, Lin & Liu, 2011, adult male. A, habitus, lateral view; B, posterior part of trunk, ventral view; C, right antennule, anterior; D, left antenna, anterior. E, right mandible, posterior; F, right maxillule, anterior; G, right maxilla, anterior; H, right maxilliped, anterior; I, left leg 1; J, left leg 2. *Scale-bars*: A, 100 μm; B, 30 μm; C, D, G, H, 20 μm; E, 10 μm; F, I, 5 μm; J, 2 μm

Table 1 Morphological differences in *Bactrochondria formosana* Ho, Lin & Liu, 2011 between the original description by Ho et al. (2011) and the present study

Character	Ho et al. (2011)	Present study
Female		
Element number on basal part of antennule	5	4
Proximal segment of antenna	unarmed	with 1 process
Striated part on terminal hook of antenna	narrow	broad
Teeth number on convex margin of mandible	18–22	more than 30
Teeth number on concave margin of mandible	60–64	*c.*70
Outer lobe of maxillule	covered with denticles	with 1 apical process
Male		
Genital segment	1 paired papilla with 1 seta	1 paired papilla with 1 seta and 1 paired seta
Elements number of antennule	2-1-1-2-5	1-2-2-2-1-8
Teeth number on convex margin of mandible	7–9	more than 10
Teeth number on concave margin of mandible	20–25	more than 10
Protopod of leg 1	unarmed	1 outer seta
Leg 2	with 1 process	with 2 processes

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