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The *similis*-Subgroup within *Triconia* (Copepoda: Cyclopoida: Oncaeidae) from Korean Waters (East China Sea), Including a New Species

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Jin-Hee Wi, Kyoung-Soon Shin, and Ho-Young Soh (2011) The *similis*-subgroup within *Triconia* (Copepoda: Cyclopoida: Oncaeidae) from Korean waters (East China Sea), including a new species. *Zoological Studies* **50**(5): 588-604. Two small oncaeid copepods were collected in June 2009 using a conical net of a fine mesh size (100 μm) from off the southern coast of Cheju I., Korea (Northwest Pacific) which is affected by the Tsushima Warm Current. One species is newly recorded from Korean waters, and the other is new to science. The new species, *Triconia denticula* sp. nov., differs from already described *similis*-subgroup species by a "bulging" lateral margin at the midlevel of the female genital double-somite covered by minute scales on the middorsal and lateral surfaces; the anal somite of the species is ornamented with small scales on the dorsal and ventral surfaces; and the exopodal outer seta of P5 is very long and plumose, which is longer than those of other species of the *similis*-subgroup. Males of this species were not found so far. *Triconia umerus* (Böttger-Schnack and Boxshall) which is newly recorded from Korean waters is redescribed with a comparison of its morphological details and differences from published studies. In addition, the zoogeography of the *similis*-subgroup described from the Northwest Pacific is summarized. http://zoolstud.sinica.edu.tw/Journals/50.5/588.pdf

Key words: Taxonomy, Oncaeid copepods, *Triconia*, Tsushima Warm Current, Zoogeography.

Of small-sized copepods, oncaeid copepods play important ecological roles as they have high numerical abundances (Kršinić 1998, Hopcroft et al. 2001) and species diversity (Heron and Bradford-Grieve 1995, Böttger-Schnack 1999 2001 2003, Heron and Frost 2000). Due to identification difficulties caused by their small body size, insufficient taxonomic description, and close morphological similarities among species of this family, a number of sibling species and species groups have sometimes been designated as forms without sufficient definition for subsequent identification (Heron and Frost 2000), and this has often led to erroneous identifications and underestimation of the actual species diversity of oncaeids (Böttger-Schnack et al. 2004). However, recent achievements in the taxonomic study of oncaeid copepods proved that morphological characteristics for identifying and separating species, such as details of the mouthparts, morphometrics, and ornamentation of elements, are of sufficient quality for correct taxonomic identification (Böttger-Schnack 1999 2005, Böttger-Schnack and Schnack 2009, Böttger-Schnack and Machida 2010).

Of over 100 species of oncaeid copepods so far described (http://copepodes.obs-banyuls.fr/en), about 30 species were recorded from several Pacific areas: the Southwest Pacific (18 species: Heron and Bradford-Grieve 1995); the Northeast Pacific (30 species: Heron and Frost 2000); the East China Sea (10 species: Chen and Zhang

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1974; 8 species: Zheng et al. 1982); Japanese waters (13 species: Itoh 1997); and Korean waters (10 species: Wi et al. 2008 2009 2010). However, taxonomical criteria of many oncaeid species from Pacific areas have not yet been established due to insufficient information and erroneous descriptions given in previous taxonomic literature (Chen et al. 1974, Itoh 1997). These problems may be directly linked to incorrect interpretations of various ecological data. Therefore, improved and detailed taxonomic resolution of these species is important with respect to ecological aspects such as indicator species, community analysis, and vertical migration (Böttger-Schnack and Schnack 2009).

The genus *Triconia* is characterized by the presence of a terminal conical process on the distal endopodal segment of P4, and includes 3 subgroups: the *similis*-subgroup, *conifera*-subgroup, and *dentipes*-subgroup (Böttger-Schnack 1999). The *similis*-subgroup of *Triconia* presently includes 7 species, among which morphological differences are subtle, mainly limited to minute characters such as the form of the genital double-somite size and armature of the female P5. Recently, Böttger-Schnack and Machida (2010) newly confirmed that through genetic comparisons among *similis*-subgroup species (all 8 species including a new morphospecies *Triconia* sp. 8), proportional spine lengths on the endopods of the swimming legs are also important characters for identifying and grouping the various morphs/species in the *similis*-subgroup.

Triconia denticula sp. nov. and *T. umerus* from Korean waters are similar in typical morphological characteristics of *similis*-subgroup species, which are marked by the absence of a dorsal projection on the prosome of the female and the presence of integumental pockets on the anterior face of the labrum of both sexes. The purpose of this study was to provide morphological characteristics of 2 small *Triconia* species within the *similis*-subgroup from Korean waters and provide more-expanded insights for identifying diverse sibling species in the Northwest Pacific.

MATERIALS AND METHODS

Zooplankton were taken from the East China Sea, south of Cheju I., Korea on 27 June 2009 (Fig. 1). A conical net (with a mesh size of 100 μm and a mouth diameter of 45 cm) was towed vertically from near the bottom to the surface at a station with a total water depth of 108 m. Vertical profiles of temperature and salinity (T-S) were recorded using SEB 911plus CTD at the station. Specimens were fixed in 99.8% ethanol (not denatured). Oncaeid species were sorted out from the zooplankton samples. Each specimen was dissected under a dissecting microscope (NIKON Stereoscopic Zoom Microscope SMZ645, Japan) in CMC-10 aqueous mounting medium (Masters, Wood Dale, IL, USA), mounted on slides, and sealed with high-quality nail varnish. Drawings were made using a stereo microscope (Nikon AFX-II) equipped with a drawing tube. Scale bars are given in micrometers (μm). The total body length and ratio of the prosome to urosome (excluding the caudal rami) were measured along the lateral aspect, where telescoping of the somite is not considered. However, to calculate the relative lengths of the urosomal segments, the telescoping effect was taken into account. Specimens of *Triconia* were examined with a Hitachi-3000 scanning electron microscope (Japan) to observe the minute surface ornamentations on the exoskeleton in greater detail, before the specimens were described. Specimens were prepared by dehydration through a graded ethanol series, critical point-dried, mounted on stubs, and sputter-coated with palladium.

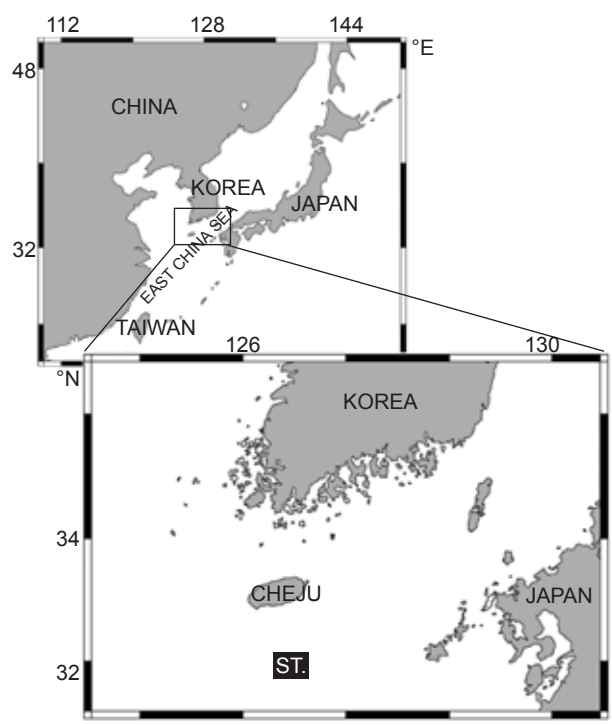

Fig. 1. Location of sampling station of 2 *Triconia* species off the southern coast of Cheju I., Korea (in the East China Sea).

The descriptive terminology follows Huys and Boxshall (1991). Abbreviations used in the text and figures are as follows: ae, aesthetasc; CR, caudal rami; P1-P6, 1st to 6th thoracopods; exp, exopod; enp, endopod; exp(enp)-1, -2, and -3 are used to respectively denote the proximal, middle, and distal segments of a ramus. All type specimens were deposited in the National Institute of Biological Resources (NIBR), Incheon, Korea.

TAXONOMY

Order Cyclopoida Burmeister 1835
Family Oncaeidae Giesbrecht 1893
Genus *Triconia* Böttger-Schnack 1999
Triconia denticula sp. nov.

(Figs. 2-4, 9A, B, F)

Materials examined: Holotype ♀ dissected and mounted on 1 glass slide, NIBRIV0000214676, East China Sea (south of Cheju I.) (126°5'E, 32°00'N) on 27 June 2009; paratypes 2 ♀♀ dissected and mounted on 3 slides, NIBRIV 0000214677 and undissected 2 ♀♀ in 1 vial, NIBRIV0000214678, East China Sea (126°5'E, 32°00'N) on 27 June 2009.

Description: Body length in lateral view 660-710 μm (average, 655 μm, *n* = 5 individuals), most surfaces of body densely covered with minute refractile granulations (not figured). Prosome length 1.7-times as long as urosome including caudal rami, 1.9-times as long as urosome excluding caudal rami (Fig. 2A, B). Second pedigerous somite without conspicuous dorsoposterior projection in lateral view (Fig. 2B). Fourth pedigerous somite with rounded posterolateral corners (Fig. 2B). Proportional lengths (%) of urosomites 12.3: 56.9: 9.9: 8.7: 12.3. Proportional lengths (%) of urosomites and caudal rami 11.2: 51.9: 9.0: 7.8: 11.2: 8.9.

Genital double-somite (Figs. 2C, 9A, B) about 1.5-times as long as maximum width (in dorsal view) and 1.8-times as long as postgenital somites combined, maximum width measured at 3/5 distance of posterior margin, "bulgy" part from area of genital apertures to 3/4 distance from anterior margin (Fig. 2C), tapering posteriorly; paired genital apertures approximately 1/3 distance from anterior margin of dorsal surface, armed with a single long spine, short process (Figs. 2D, 9A); dorsolateral and ventral surfaces covered with minute denticles (Figs. 2C, 9B). Secretory pores on dorsal surface as indicated in figure 2C.

Anal somite (Figs. 2A, C, 9F) about 1.3-times wider than long, almost same length as caudal rami, with wide anal opening, with linear row of small denticles on it; dorsal and ventral surfaces covered with small scales; 2 secretory pores located on either side of anal opening and 4 on mid-posterior region (Figs. 2C, E, 9F); posterior margin finely serrated ventrolaterally (Fig. 2E).

Caudal rami (Fig. 2C) about 1.75-times as long as wide, with 6 elements, secretory pore located near insertion of seta II, fringed with serrations (Fig. 2F): antero- and posterolateral setae II + III long, spiniform, and unipinnate along medial margin; outer terminal seta IV long and plumose; inner terminal seta V longest and plumose, 1.5-times longer than seta IV and 2.1-times longer than seta VI; terminal accessory seta VI long and plumose; dorsal seta VII much shorter than seta VI, plumose and bi-articulate at base.

Antennule 6-segmented (Fig. 3A), relative lengths (%) of segments measured along posterior non-setiferous margin 8.1: 20.3: 44.6: 10.8: 4.1: 12.1. Armature formula 1-[3], 2-[8], 3-[5], 4-[3+ae], 5-[2+ae], 6-[6+(1+ae)].

Antenna 3-segmented, slightly reflexed (Fig. 3B); coxobasis ornamented with row of long spinules on outer margin, with bipinnate seta at inner distal corner. Endopod 2-segmented, 1st segment 1.7-times as long as 2nd one; proximal endopodal segment subtriangular, forming outer lobate bearing spinular patch, with row of denticles along posterior inner margin; distal endopodal segment about 1/2 length of proximal endopodal segment, articulating with narrow base, with row of short spinules along outer margin, lateral armature armed with 1 pectinate, strong spiniform seta (III) and 3 naked setae (I, II, and IV), setae II and III slightly longer than setae I and IV, distal armature consisting of 5 long curved setae, ornamented with row of fine spinules unilaterally, and 2 slender naked setae on distal margin.

Labrum (Fig. 3C, D) distinctly bilobed, forming paired rounded distal lobes, with marginal denticles along outer distal margin, and with dentiform processes along inner distal margin, processes increasing in length distally; mid-outer margin swollen laterally; posterior wall of medial concavity with 4 strong, sclerotized teeth; 2 large secretory pores on inner margin of lobe (indicated by small arrows in Fig. 3D); anterior surface (Fig. 3C) with paired row of long setules on either side, and paired integumental pockets lateroposteriorly.

Mandible (Fig. 3E) with 5 elements on gnathobase: 3 setae and 2 blades; outer seta

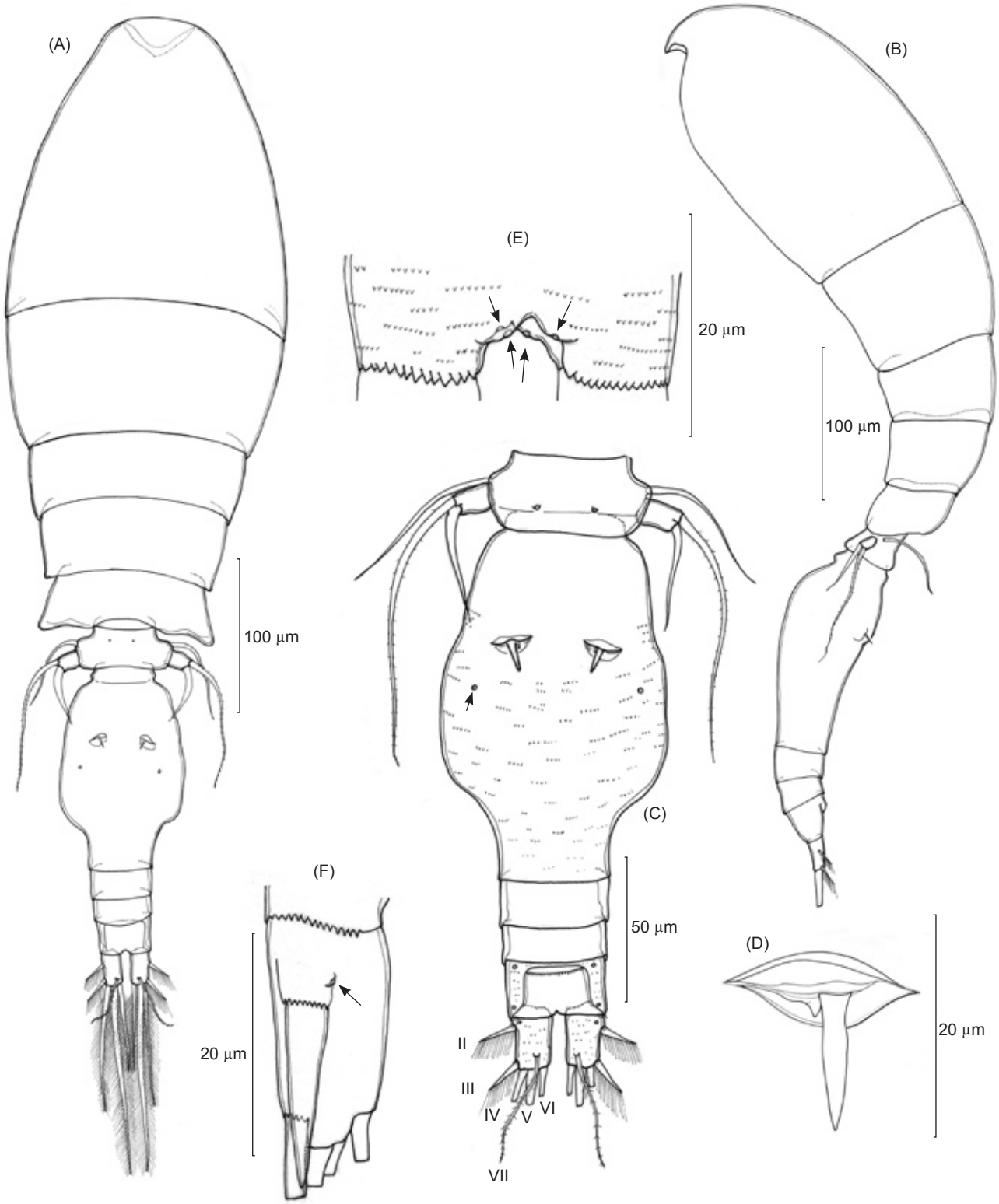

Fig. 2. *Triconia denticula* sp. nov. Female (holotype): (A) habitus, dorsal view; (B) habitus, lateral view; (C) urosome, dorsal view, caudal setae numbered using Roman numerals; (D) genital aperture, right side (arrow indicating a small process); (E) posteromedial part of anal somite, ventral view, secretory pores indicated by an arrow; (F) left caudal rami, lateral view, serration near insertion of setae II and III, and secretory pore indicated by an arrow.

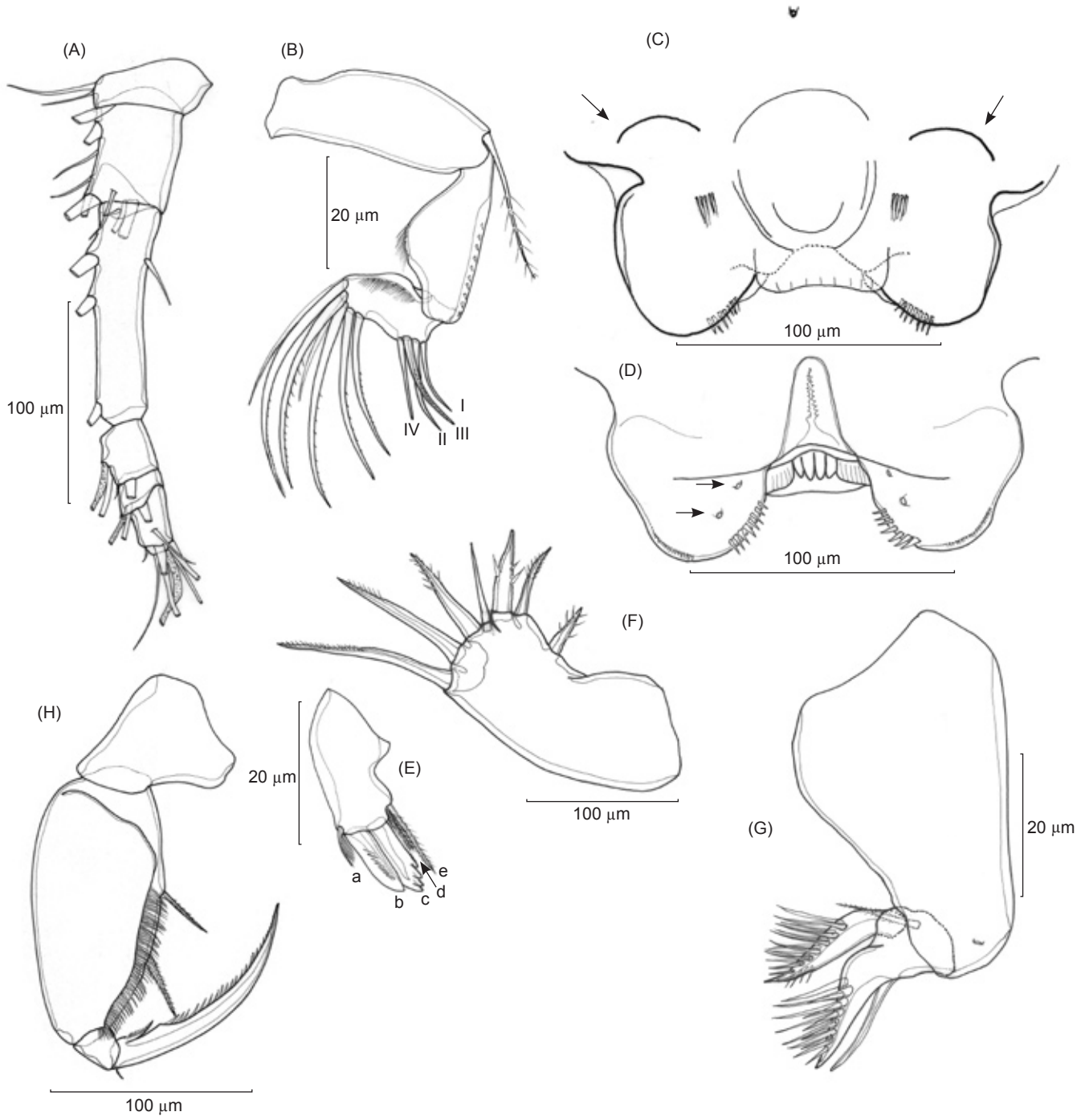

Fig. 3. *Triconia denticula* sp. nov. Female (holotype): (A) antennule; (B) antenna, individual elements on lateral margin of 2nd endopodal segment numbered using Roman numerals; (C) labrum, anterior, bold arrows indicating integumental pockets; (D) labrum, posterior, small arrows indicating secretory pores on lobes; (E) mandible, individual setae designated using small letters; (F) maxillule; (G) maxilla; (H) maxilliped.

a shortest, with row of long fine setules along dorsal side; ventral blade b strong and spiniform, ornamented with row of spinules on posterior surface; dorsal blade c strong and broad, with 4 or 5 dentiform processes along distal margin; seta d short and pectinate; seta e almost as long as blade c and multipinnate.

Maxillule (Fig. 3F) weakly bilobed, surface ornamentation not discernible: inner lobe (praecoxal arthrite) with 3 elements, outermost element spiniform, slightly swollen at base, ornamented with 3 thick spinules; middle element setiform, bipinnate; innermost element located along concave inner margin at some distance from other elements, sparsely bipinnate; outer lobe consisting of 4 elements, outermost element setiform, with row of minute spinules unilaterally, longest, innermost element unornamented.

Maxilla (Fig. 3G) 2-segmented, allobasis shorter than syncoxa: syncoxa unarmed, with 1 large secretory pore; allobasis produced distally into slightly curved claw bearing 2 rows of very strong spinules along medial margin, outer margin with strong naked seta extending to tip of allobasal claw, inner margin with slender naked seta and strong curved spine with 2 rows of strong spinules along medial margin and single row of shorter spinules along outer margin.

Maxilliped (Fig. 3H) 4-segmented, comprising syncoxa, basis, and 2-segmented endopod: syncoxa distally tapered, without ornamentation; basis robust and expanded, with 2 bipinnate setae on inner margin, distal one about 1.2-times longer than proximal one, with row of spinules along palmar margin between proximal seta and articulation with endopod; proximal endopodal segment unarmed; distal endopodal segment drawn out into long curved claw ornamented with strong spinules along entire concave margin, accessory armature consisting of slender naked seta on outer proximal margin, and unipectinate spine basally fused to inner proximal corner of claw.

Swimming legs 1-4 biramous (Fig. 4), with 4-segmented exopods and endopods: intercoxal sclerites well developed, without ornamentation; basis of P1 with inner and outer setae, basis of P2 to P4 with short inner distal process and outer seta, respectively, of which outer seta of P3 longest and that of P2 shortest. Armature formula of P1-P4 as follows (Roman numerals indicate spines, Arabic numerals indicate setae):

Leg	Coxa	Basis	Exopod	Endopod
P1	0-0	1-I	I-0;I-1;III,I,4	0-1;0-1;0,I,5
P2	0-0	1-0	I-0;I-1;III,I,5	0-1;0-2;I,II,3
P3	0-0	1-0	I-0;I-1;II,I,5	0-1;0-2;I,II,2
P4	0-0	1-0	I-0;I-1;II,I,5	0-1;0-2;I,II,1

Exopods of P1 to P4: outer margin of exopodal segments with well-developed serrated hyaline lamella, inner margin of proximal exopodal segments with long setules, proximal-most spine of P1 exp-3 shortest and exp-1 proximal-most spine shortest in P3+P4; terminal spine almost equal in length to (P1+P4) or shorter than (P2-P3) distal exopodal segment.

Endopods of P1 to P4: outer margin of endopodal segments with fringe of long setules; distal endopodal segments of P2-P4 with conical process (expressed as a “cone”) between outer distal and terminal spines, with apical pore, other ornamentation not discerned; cone size gradually reduced from P2 to P4; outer margin of distal segment of P1 formed into short arrowhead-shaped process close to distal-most inner seta; outer subdistal spine almost equal in length to outer distal spine (P2-P3) or slightly longer than (P4) outer distal spine; terminal spines increasing in length from P2 to P4.

P5 (Figs. 2A, C, 9B) consisting of long plumose seta on lateral surface of 1st urosomal somite and 1-segmented exopod with 2 unequal setae; exopod 1.5-times longer than wide, bearing stout naked seta and longer slender seta (Fig. 9B), ornamented with pinnules bilaterally.

P6 (Figs. 2D, 9A) represented by operculum closing off each genital aperture; armed with long spine and a small process on inner side of it.

Etymology: The specific name is derived from the Latin *denticulus*, meaning denticle, and refers to numerous small denticles on the surface of the genital double-somite in the female.

Remarks: *Triconia denticula* sp. nov. from south of Cheju I. of Korea (the East China Sea) can be misidentified as *T. rufa* (Boxshall and Böttger 1987) in dorsal view, because of the similar shape of the genital double-somite characterized by a “bulgy” lateral margin at the midlevel of the female genital double-somite and the proportional lengths of the outer basal seta and exopodal setae of P5. However, the former species is included in the *similis*-subgroup due to the absence of a dorsal projection on the 2nd pedigerous somite that exists in *T. rufa*, which belongs to the *conifera*-subgroup (Böttger-Schnack 1999). Furthermore,

T. rufa from the Red Sea (Böttger-Schnack 1999) differs from *T. denticula* sp. nov. by the following morphological characteristics: P5 exopod 2.8-times longer than wide (Böttger-Schnack 2001), while that of *T. denticula* sp. nov. is 1.5-times longer; surface of the genital double-somite ornamented with numerous small scales dorsolaterally at the limited area of the maximum width, but that of *T. denticula* sp. nov. ornamented with numerous denticles on most of the surface; anterolateral margin of the genital double-somite is nearly perpendicular shaped, while it is slightly rounded in *T. denticula* sp. nov.; and caudal dorsal seta VII about same length as seta VI, but in *T. denticula*

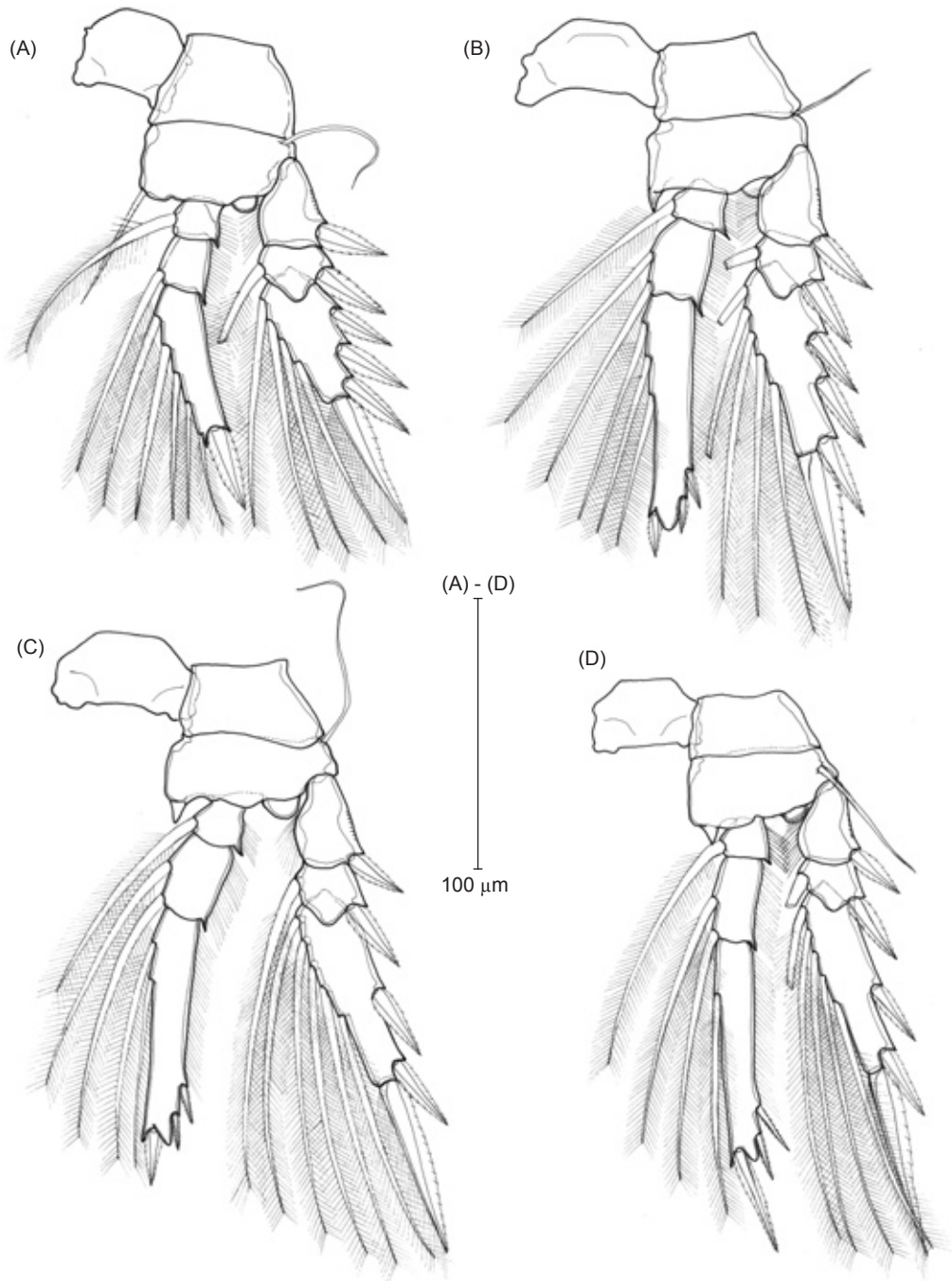

Fig. 4. *Triconia denticula* sp. nov. Female (holotype): (A) P1, posterior view; (B) P2, posterior view; (C) P3, posterior view; (D) P4, posterior view.

sp. nov., caudal seta VII much shorter than seta VI. *Triconia denticula* sp. nov. represents typical morphological characteristics of *similis*-subgroup species within the genus *Triconia*, which is defined by the presence of a conical process on the distal endopodal segment of P4, the lack of a dorsal projection on the 2nd pedigerous somite, and the presence of integumental pockets on the anterior face of the labrum (Böttger-Schnack 1999). However, *T. denticula* sp. nov. differs from other species of the *similis*-subgroup by a combination of following points: (1) the genital double somite is covered by numerous scales on the mid-dorsal and lateral surfaces; (2) the lateral margin of the genital double-somite forms a unique bulgy shape; (3) in P5, the exopod is 1.5-times longer than wide; and (4) the exopodal outer seta of P5 is longest among other *similis*-subgroup species, and plumose; 1.7-times longer than the outer basal seta. Additionally, we observed a form of the genital aperture that was armed with a long spine and minute process (Figs. 2D, 9A), in which spine length and morphological nature of armature near the base of the spine differed compared to other *similis*-subgroup species. Böttger-Schnack (1999) described the genital aperture of each species within the *similis*-subgroup in detail, mentioning 2 species (*T. gonopleura* and *T. parasimilis*), which differed in the morphological nature of the genital apertures: most species "*T. similis* (Sars 1918), *T. minuta* (Giesbrecht 1891), *T. umerus*, *T. hawii* (Böttger-Schnack and Boxshall 1990), and *T. recta* (Böttger-Schnack 1999)" are armed with spinules and spines on the genital apertures; *T. gonopleura* has a conspicuously raised structure and spines of different lengths on both sides of the genital aperture; while *T. parasimilis* is armed with a long spine on each genital aperture.

These facts also indicate that *T. denticula* sp. nov. can be regarded as a new species separate from other species in the *similis*-subgroup, and that ornamentation of the genital aperture can be an important taxonomic key factor in this group.

Triconia umerus (Böttger-Schnack and Boxshall 1990)

(Figs. 5-8, 9C-E, G)

Oncaea umerus Böttger-Schnack and Boxshall 1990: 861-865, figs. 1A-H, 2A-F (female only).
Triconia umerus, Böttger-Schnack 1999: 81-97, figs. 24-26.

Material examined: 129 ♀♀ and 79 ♂♂ collected from the East China Sea (south of Cheju I.) (126°5'E, 32°00'N) on 17 June 2009, of which 5 females and 5 males were dissected and closely examined. Two females and 2 males are deposited in the National Institute of Biological Resources (NIBR), Incheon, Korea (NIBRIV0000214672).

Female: Body length in lateral view 650-705 μm (average, 677.5 μm, *n* = 5 individuals), exoskeleton well chitinized. Prosome length 1.6-times that of urosome including caudal rami, 1.8-times urosome length excluding caudal rami (Fig. 5A, B). Second pedigerous somite without conspicuous dorsoposterior projection in lateral view (Fig. 5B). Proportional lengths (%) of urosomites 12.6: 58.9: 8.9: 8.9: 10.7. Proportional lengths (%) of urosomites and caudal rami 11.1: 52.5: 7.9: 7.9: 9.5: 11.1.

Genital double-somite (Figs. 5A, C, 9C, D) about 1.7-times as long as maximum width (in dorsal view) and 2.1-times as long as postgenital somites combined, maximum width measured at 1/2 distance of posterior margin, becoming slightly broader from anterior to medial part, with conspicuous sunken edge at 2/3 distance from anterior margin, posterior part gradually tapering; paired genital apertures approximately 2/5 distance from anterior margin of dorsal surface, armed with long spine, protrusion and small spinule near base of spine (Figs. 5A, 9D, E); lateral surface covered with rows of minute denticles, particularly concentrated on lateromedial surface and beneath genital aperture, sunken edges of lateral surface with curvilinear row of spinules (Fig. 5B, C). Secretory pores on dorsal surface as indicated in figure 9D.

Anal somite about 1.7-times wider than long and slightly shorter than caudal rami; ornamentation on surface as for *T. denticula* (Figs. 5A, 9C), except for dorsal and ventral surfaces which are not covered in scales.

Caudal ramus (Fig. 5A) about 1.75-times as long as wide, with armature as for *T. denticula*: seta V 1.4-times as long as seta IV, twice as long as seta VI, and 5.1-times as long as caudal ramus; seta VI about 2.6-times as long as caudal ramus.

Antennule 6-segmented (Fig. 6A), relative lengths (%) of segments measured along posterior non-setiferous margin 13.1: 19: 42.9: 11.9: 4.8: 8.3. Armature formula as for *T. denticula* sp. nov.

Antenna 3-segmented (Fig. 6B); coxobasis with row of long setules on inner margin, with bipinnate seta at inner distal corner; distal enopodal segment less than 1/2 length of proximal one, lateral and distal armatures similar to those of *T. denticula* sp. nov.

Labrum (Fig. 6C, D) similar to that of *T. denticula* sp. nov., except for mid-lateral margin of lobe almost rounded (indicated by arrow in Fig. 6D).

Mandible (Fig. 6E, F) similar to that of *T. denticula* sp. nov., except for dentiform processes on dorsal blade (Fig. 6F) reaching mid-region of distal margin.

Maxillule (Fig. 6G) similar to that of *T. denticula* sp. nov., except for innermost seta of inner lobe slightly longer than that of *T. denticula* sp. nov.

Maxilla (not figured) as in *T. denticula* sp. nov.

Maxilliped (Fig. 6H, I) similar to that of *T. denticula* sp. nov.; basis with 2 bipinnate setae unequal in length, distal one about 1.5-times longer and much stronger than proximal one, with row of spinules along palmar margin between proximal

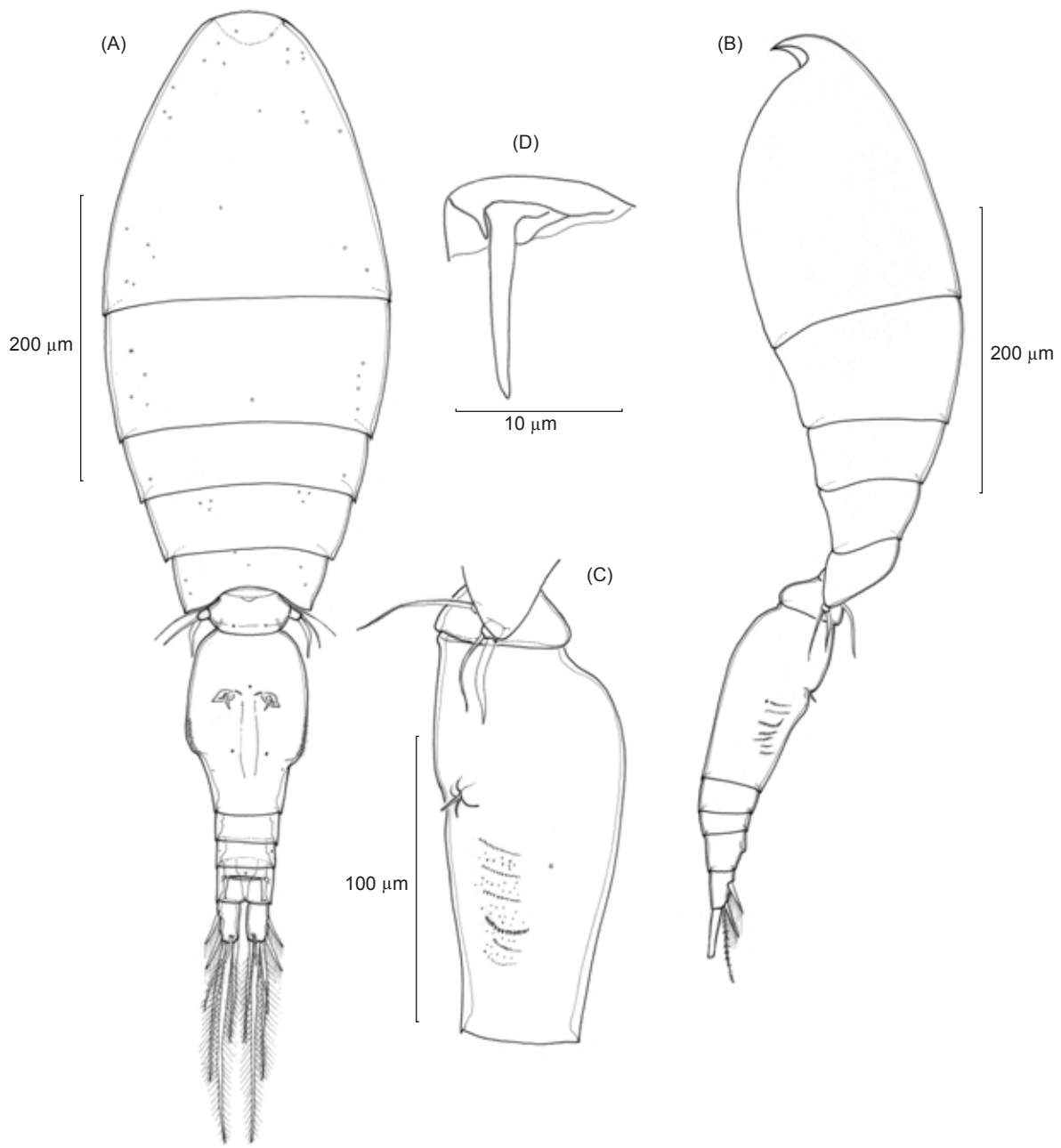

Fig. 5. *Triconia denticula* sp. nov. Female (holotype): (A) P1, posterior view; (B) P2, posterior view; (C) P3, posterior view; (D) P4, posterior view.

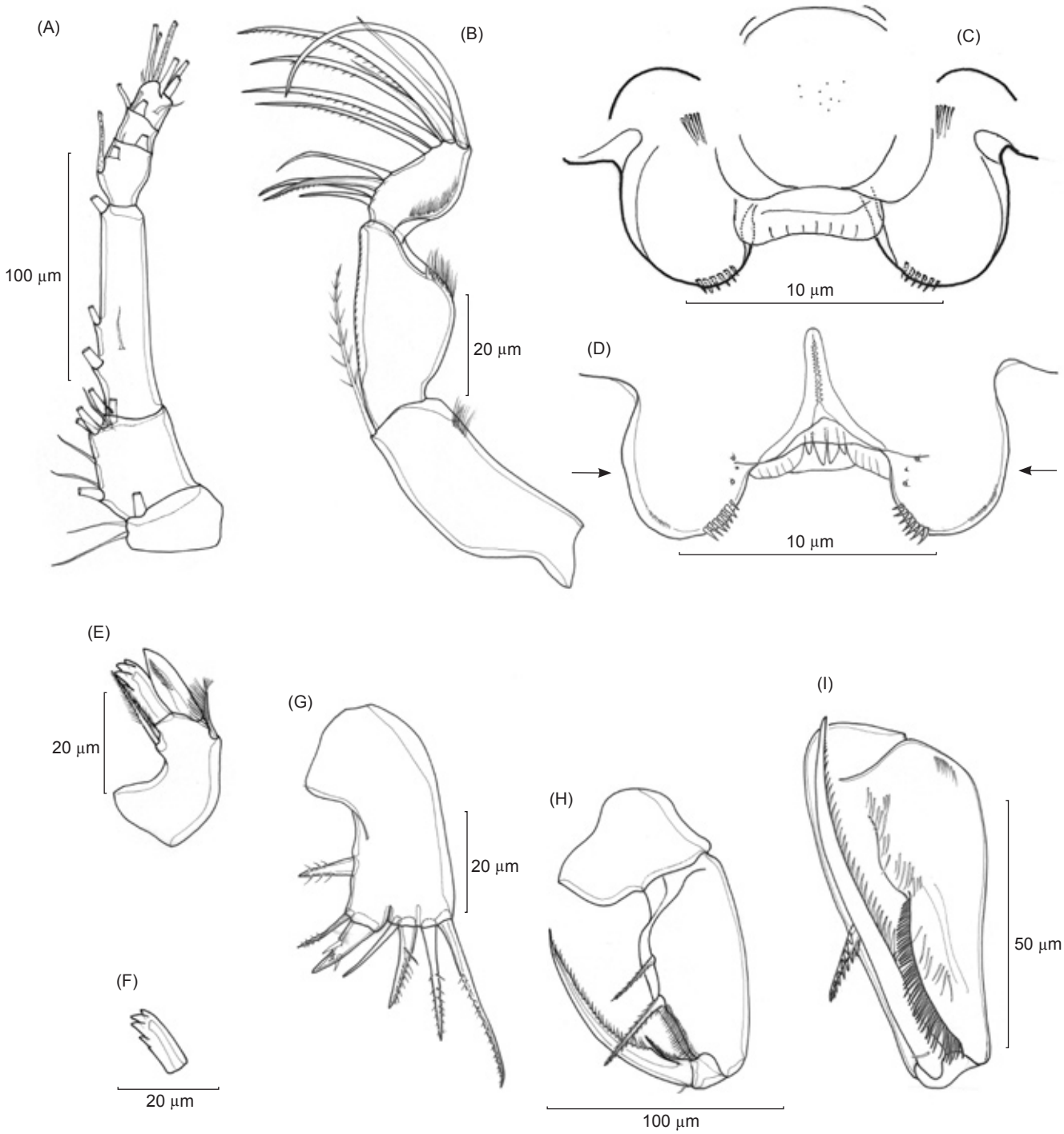

Fig. 6. *Triconia umerus*. Female: (A) antennule; (B) antenna; (C) labrum, anterior; (D) labrum, posterior, arrows indicating round shape of the mid-outer margins of the lobes; (E) mandible; (F) dorsal blade on gnathobase of mandible; (G) maxillule; (H) maxilliped; (I) basis of maxilliped, lacking proximal seta.

seta and articulation with proximal endopodal segment, rows of long setules on anterior surface and row of setules on outer margin; distal endopodal segment bearing row of strong pinnules on entire length of concave margin; unipectinate spine extending over protruding edge on 2nd endopodal segment.

Swimming legs 1-4 biramous (Fig. 7), with armature and ornamentation as in *T. denticula* sp. nov.

In exopods of P3 and P4, relative lengths of spines on 2nd and distal segments when compared

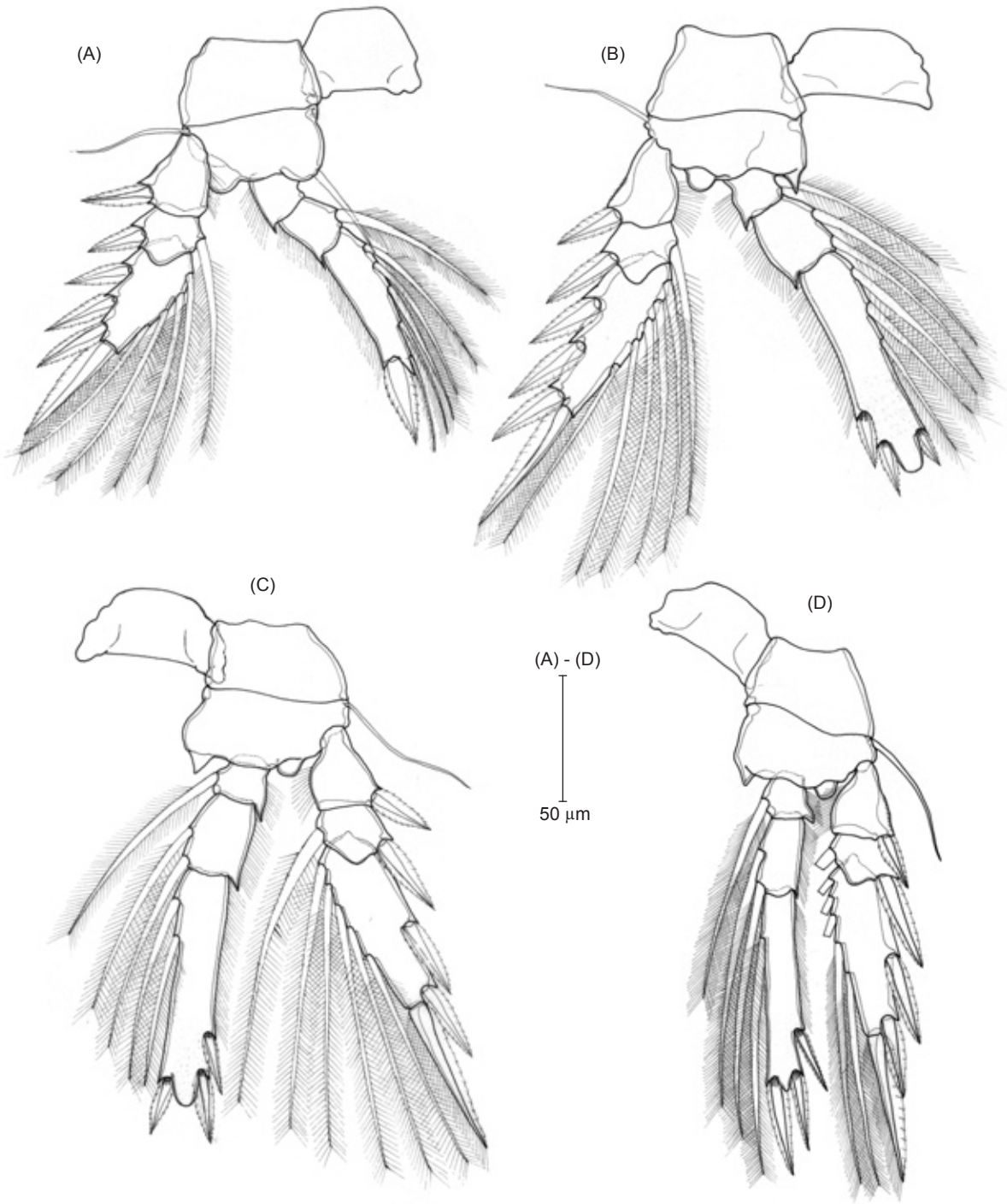

Fig. 7. *Triconia umerus*. Female: (A) P1, posterior view; (B) P2, posterior view; (C) P3, posterior view; (D) P4, posterior view.

to each terminal spine on distal segments longer than those of *T. denticula* sp. nov.

In endopods, outer distal spine almost equal in length to outer subdistal spine (P2) or slightly longer than outer subdistal spine (P3, P4); terminal spine slightly longer (P2) than cone, and that of P3 much longer than cone and almost as long as outer subdistal spine.

P5 (Fig. 5A, C) consisting of long naked outer basal seta and small 1-segmented exopod; exopod slightly longer than wide, bearing stout naked spine and slender seta.

P6 (Figs. 5A-D, 9D, E) represented by operculum closing off each genital aperture; armed with long spine, short spinule, and blunt process.

Male: Body length in lateral aspect 515-565 μm (average, 540 μm, *n* = 5 individuals). Sexual dimorphism in antennules, antenna, maxilliped, P5 and P6, caudal ramus, and genital segmentation. Prosome 1.7-times as long as urosome including caudal rami, 1.9-times as long as urosome excluding caudal rami (Fig. 8A, B). Caudal rami (Fig. 8A, C) 1.6-times larger than wide, shorter than in female (1.75-times); seta V 1.6-times as long as seta IV, 2.2-times as long as seta VI, and 6.2-times as long as caudal ramus; seta VI about 2.8-times as long as caudal ramus; length ratio of seta IV to seta VI as in female. Proportional lengths (%) of urosomites (excluding caudal rami) 11.3: 67.7: 4.8: 3.2: 3.2: 9.8. Proportional lengths (%) of urosomites (including caudal rami) 10.3: 61.3: 4.4: 2.9: 2.9: 8.8: 9.4.

Antennule (Fig. 8E) 4-segmented, distal segment corresponding to fused 4th to 6th segments of female. Armature formula: 1-[3], 2-[8], 3-[4], 4-[11+2ae+ (1+ae)]. Relative lengths (%) of segments measured along posterior non-setiferous margin 9.4: 21.9: 40.6: 28.1.

Antenna (Fig. 8F) similar to that of female, except for relative lengths of lateral armature on distal endopodal segment, with 2 pectinate spiniform elements and 2 naked setae almost equal in length.

Maxilliped (Fig. 8G, H) 3-segmented, consisting of syncoxa, basis, and 1-segmented endopodal segment; syncoxa unarmed; basis robust, inflated in proximal 1/2 forming bulbous swelling, anterior surface with semicircular groove filled with small spinules, several scales distally (Fig. 8H), and small expanded flap ornamented with row of very short spatulate spinules along palmar margin, with 2 naked setae of equal length inserted within longitudinal cleft. Endopodal segment drawn out into long curved claw, concave margin unornamented, with short, unipectinate spine basally fused to inner proximal corner of claw; claw with minute hyaline apex.

P1-P4 with armature and ornamentation as in female, except for slightly shorter length of terminal spine on P2 enp-3. Distal endopodal segments of P2-P4 ornamented with small denticles on anterior part (Figs. 8I, 9G).

P5 (Fig. 8A-C) exopod not delimited from somite, armature as in female, except for outer basal seta being slightly longer.

P6 (Fig. 8C, D) represented by posterolateral flap closing off genital aperture on either side, covered with rows of denticles (Fig. 8D); posterolateral corners acutely protruding laterally.

Remarks: *Triconia umerus* from Korean waters (the East China Sea) agrees with typical morphological characteristics of *T. umerus* from the Red Sea (Böttger-Schnack and Boxshall 1990, Böttger-Schnack 1999). However, several form variations exist in the following points: in the female from Korean waters, (1) the length ratio of the prosome to the urosome (including and excluding caudal rami) is smaller (1.6: 1 and 1.8: 1) compared to Red Sea specimens (2.1: 1 and 2.3: 1); (2) the length to the maximum width ratio of the genital double-somite is larger (1.7: 1) than in Red Sea specimens (1.3: 1); (3) in the caudal ramus, the relative length of seta V to seta VI is longer (2.6-times), compared to Red Sea specimens (1.8-times); and (4) the maxilliped is ornamented with rows of long setules on the anterior surface and rows of setules on the outer margin, not figured in previous descriptions (Böttger-Schnack and Boxshall 1990, Böttger- Schnack 1999). In the male from Korean waters, (1) the distal endopodal segments of P2-P4 are ornamented with small denticles on the entire surface, but this is not mentioned in Red Sea specimens; (2) the length to width ratio of the caudal ramus is larger (1.6-times) than in Red Sea specimens (1.4-times), as in the female; (3) the proportional length of CR setae IV and VI is as in the female, but Böttger-Schnack (1999) reported that Red Sea specimens present a different ratio; and (4) the basis of the maxilliped is ornamented with several scales distally, and with grooves filled with small spinules on the anterior surface, which were not noted, or erroneously described in previous figures (in Böttger- Schnack 1999, fig. 26C): the basis of maxilliped lacks scales and grooves (as mentioned above) expressed as a patch of spinules. Also, *T. umerus* from Korean waters is larger for females (650-710 μm) and males (515-565 μm), compared to Red Sea

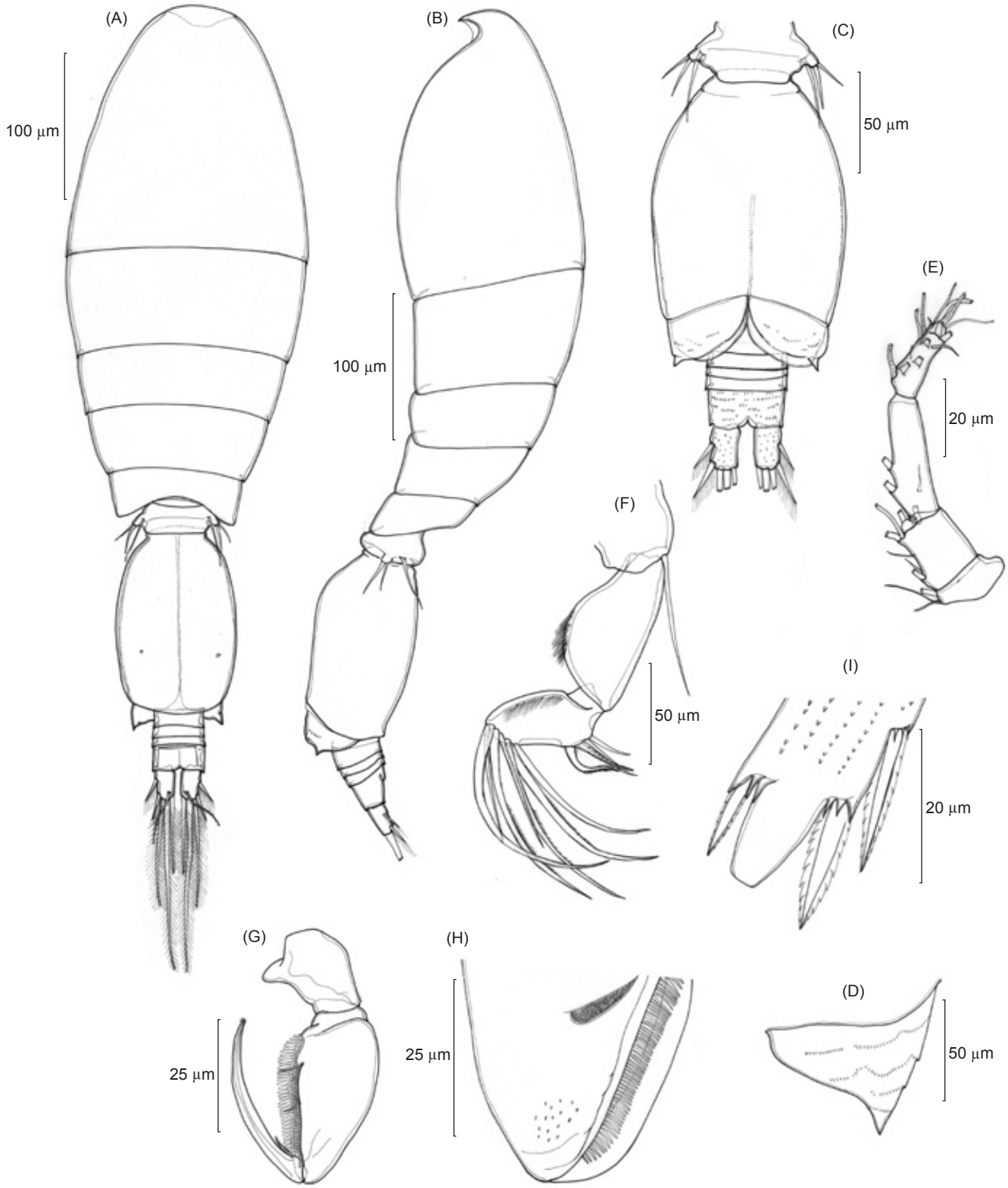

Fig. 8. *Triconia umerus*. Male: (A) habitus, dorsal view; (B) habitus, lateral view; (C) urosome, ventral view; (D) P6, genital flap, right lateral view; (E) antennule; (F) antenna, proximal and distal endopodal segments; (G) maxilliped; (H) posterior part of basis of maxilliped; (I) P2, enp-3, distal part.

specimens (570-620 μm in females and 520 μm in males), which were measured by traditional methods, where the telescoping somites are not considered in length measurements (Böttger-Schnack 1999).

DISCUSSION

Taxonomy: Böttger-Schnack and Huys (1998) carried out a preliminary phylogenetic analysis of the Oncaeidae based on a total of 52 morphological characteristics, ultimately recognizing 20 species groups within the family. Most of the branches represented robust groupings, which may deserve generic status. The 3rd and 4th clades included 14 oncaeid species characterized by a conical process on the distal endopodal segment of P2 to P4 (Böttger-Schnack 1999). Böttger-Schnack (1999) established these 2 clades as a new genus, *Triconia,* and included 3 subgroups within the genus: the *conifera*-subgroup, *similis*-subgroup, and *dentipes*-subgroup. The *similis*-subgroup is distinguished from the other subgroups by a combination of the absence of a dorsoposterior projection on the 2nd pedigerous somite and the presence of integumental pockets on the anterior surface of the labrum. The new species *T. denticula* sp. nov. which shows all of these characteristics is also located in the *similis*-subgroup, but it differs from other species of the *similis*-subgroup by its morphological nature, such as the longest P5 exopodal outer seta among other *similis*-subgroup species, numerous small denticles on the dorsolateral and ventral surfaces of the genital double-somite, a "bulgy" lateral margin at the midlevel of the female genital double-somite, and the form of armature near the base of the spine on the genital apertures. On the other hand, Böttger-Schnack and Boxshall (1990) pointed out that specimens of *T. similis* (as *Oncaea similis*) described by Olson (1949) and Ferrari (1975) are different species within the *similis*-subgroup based on comparisons of the shape and measurements of the genital-complex. These erroneous identifications were also discovered in descriptions by Chen et al. (1974) from the East China Sea and Itoh (1997) from Japanese waters, in which the genital double-somite of their *T. similis* (as *O. similis*) formed shoulder-like edges between the anterior and posterior parts, presenting a similar shape to those of *T. umerus* or *T. hawii*. These subtle morphological differences of oncaeid species might have caused misidentification of this subgroup in marine ecological studies and an underestimation of the diversity of species within the *similis*-subgroup (Hsieh and Chiu 2002, Hsieh et al. 2004). Therefore the construction of accurate identification keys can be used for adequate consideration of the numerous microcopepod species in the world's oceans, including the Oncaeidae (Böttger-Schnack and Schnack 2009), and the results may recognize the existence of a greater diversity of species of the *similis*-subgroup. Due to their morphological similarities and difficulties of handling these small-size copepods (Böttger-Schnack 1999), several oncaeid copepods might have been confused with their sibling species. To resolve inaccuracies due to insufficient and equivocal taxonomic descriptions of the oncaeids, Böttger-Schnack and Machida (2010) used a combination of traditional morphological methods and genetic analyses and provided a list of oncaeid morphospecies, including the *similis*-subgroup of *Triconia*. With this new taxonomic information, the morphologies of all 7 described species of the *similis*-subgroup in the world's oceans (Heron 1977, Boxshall and Böttger 1987, Böttger-Schnack and Boxshall 1990, Böttger-Schnack 1999) were reexamined, and it was newly discovered that this subgroup appears to include 2 groups, which can be distinguished by the proportional spine lengths on the endopods of swimming leg 2: the 1st group, containing *T. minuta*, *T. umerus*, *T. gonopleura* and *T. parasimilis*, presents a relatively short distal endopodal spine, while those of the 2nd group, including *T. similis*, *T. hawii*, and *T. recta*, are relatively long. Based on this new information, the new species, *T. denticula* sp. nov. should be assigned to the latter group.

Specimens of Korean and Red Sea *T. umerus* showed some form variations such as body length, relative length of the prosome, the maximum width to length ratio of the genital double-somite, proportional lengths of the caudal ramus setae, and ornamentation of the surface of the distal endopodal segment. In earlier studies, morphological characteristics of *T. conifera* (Giesbrecht 1893) between the Red Sea and Korean waters were compared, and these 2 specimens represented several clear differences in the forms of the female genital double-somite and proportional lengths of the urosomites (Wi et al. 2010). Likewise, morphological and size variations for oncaeids between different oceanic areas can be shown for *T. borealis* (Sars 1918) between the Arctic Ocean (Heron et al. 1984)

and Korean waters (Wi et al. 2010), which differ in spine lengths of P3 exp-1 in the female and the length ratio of the caudal seta in the male. Even though very small morphological details (e.g., the shape of the genital double-somite, location of ornamentation, and relative lengths of P5 setae) including proportional characters were verified to be significant for identification of the Oncaeidae (Böttger-Schnack and Machida 2010), whether differences found mainly in body size

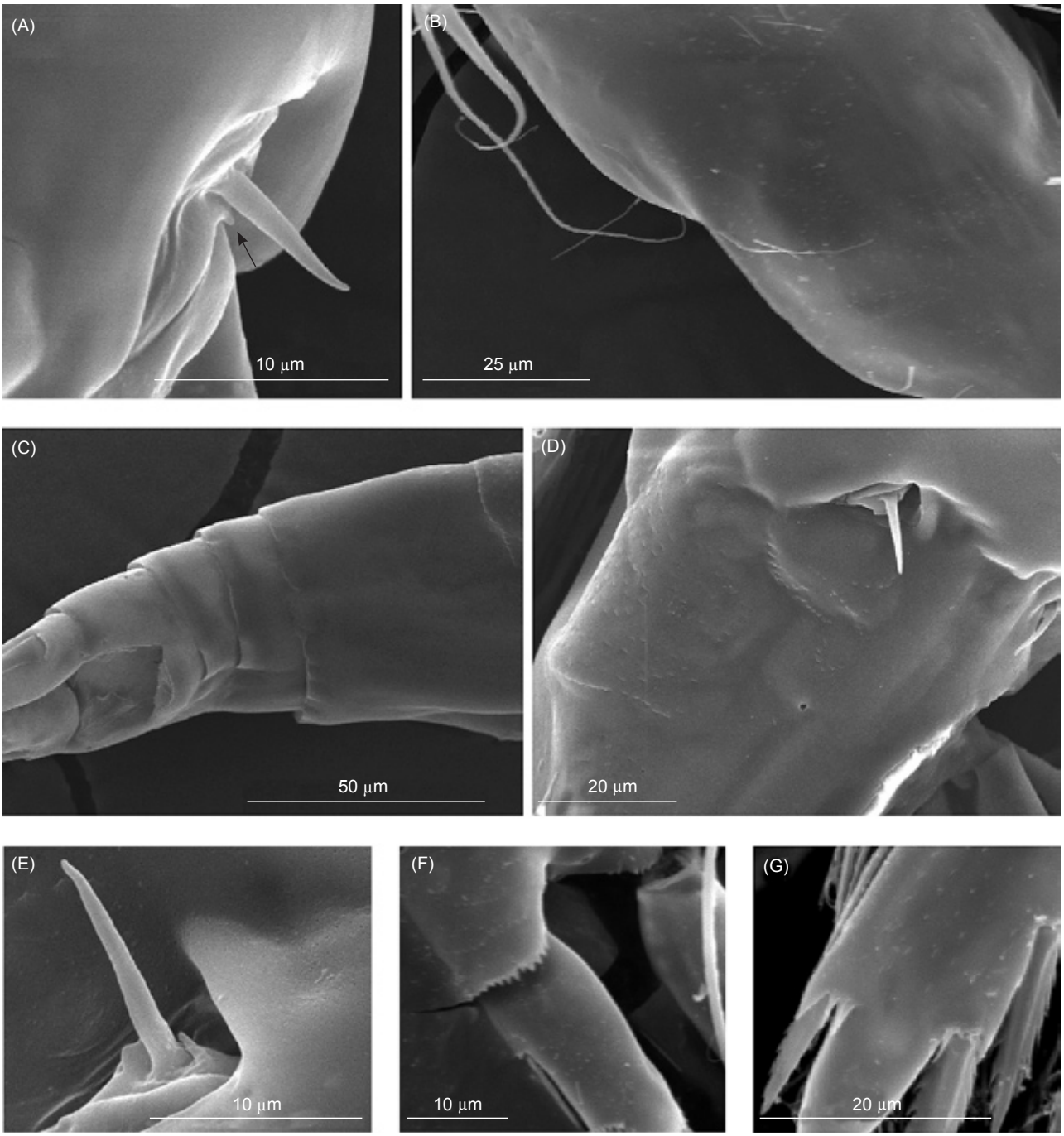

Fig. 9. SEM photographs of *Triconia denticula* sp. nov. and *T. umerus*. *Triconia denticula* sp. nov., female (A, B, F): (A) genital aperture (right side), arrow indicating small process; (B) genital double-somite in lateroventral view, arrow indicating exopodal outer seta of P5; (F) anal somite in ventral view, pores indicated by arrows. *Triconia umerus*, female (C-E): (C) posterior part of genital double-somite and anal somite in dorsolateral view; (D) middle and lateral part of genital double-somite with denticles; (E) genital aperture (left side), arrow indicating a small spinule at the base of the spine; *T. umerus* male: (G) P2, distal endopodal segment ornamented with denticles.

and proportional characters of *Triconia* species between Korean waters and other oceanic regions are distinct taxonomic key factors which can be used to separate these specimens remains ambiguous to this point. Therefore, more-improved taxonomic examinations like genetic comparisons of different regional specimens should be carried out in the future, and as the result, more-updated taxonomic information for *Triconia* species of the East China Sea can be constructed.

Geographical distribution: Some species of the *similis*-subgroup were found in the Northwest Pacific (e.g., Korean waters, Japanese waters, East China Sea, and Yellow Sea). In particular, Hsieh and Chiu (2002) and Hsieh et al. (2004) reported that *T. similis* and *T. minuta* from the East China Sea were indicators of an intrusion of the Kuroshio Current. Zuo et al. (2006) also showed that *T. similis* occurs on the continental shelf of the Yellow Sea and East China Sea at periods affected by the Kuroshio Branch Current. On the other hand, in monitoring data of the marine planktonic copepod fauna to verify seasonal movements of the Kuroshio Current in Ilan Bay and adjacent waters off northeastern Taiwan, 3 oncaeid species were found, of which only *T. minuta* (as *Oncaea minuta*) belongs to the *similis*-subgroup (Lee et al. 2009).

However, Nishibe and Ikeda (2004) suggested that *T. umerus* and *T. minuta* were found from the epipelagic zone of Kuroshio Current waters, while *T. similis* was a cold-water species. Because most identifications of copepods in the East China Sea and Yellow Sea (as stated above) were mainly performed based on deficient and ambiguous descriptions by Chen et al. (1974), the species identified as *T. similis* may be closely related to *T. umerus*.

During the present study period, *T. umerus* and *T. denticula* sp. nov. co-occurred south of Cheju I. (Fig. 1), where the Kuroshio Current provides the main inflow into the East China Sea and Sea of Japan via the Tsushima Warm Current and Cheju Warm Current (Teague et al. 2003). Additionally, most oncaeid species (*T. conifera*, *T. dentipes*, *O. scottodicarloi*, *O. media*, *O. mediterranea*, *O. clevei*, *O. venusta*, and *O. venella*) recorded as warm-water species in the Oyashio region (Nishibe and Ikeda 2004, in their table 5), appeared in this area (Fig. 1). Therefore, *T. denticula* sp. nov. is also considered to be closely related to the Tsushima Warm Current.

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