

Three New Species of *Anthessius* (Copepoda, Cyclopoida, Anthessiidae) Associated with Mollusks

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ABSTRACT

Three new copepod species of *Anthessius* are described as associates of mollusks. *Anthessius tuberculatus* n. sp. associated with the bivalve *Asaphis violascens* (Forsskål in Niebuhr, 1775) in Kosrae, Micronesia bears a pair of dorsal tubercles on the fifth pedigerous somite. *Anthessius rarus* n. sp. is associated with the aplysiid gastropod *Dolabella auricularia* (Lightfoot, 1786) in Bohol, the Philippines and has elongate caudal rami which are about 5.2 times as long as wide. *Anthessius cucullatus* n. sp. associated with the aplysiid gastropod *Aplysia kurodai* Baba, 1937 in Korea has a hood-like dorsal expansion on genital double-somite of the female.

Keywords: copepod associates, bivalve, aplysiid gastropod, Micronesia, the Philippines, Korea

INTRODUCTION

Mollusks are among the most preferred hosts of copepod symbionts. Copepod species of the family Anthessiidae are mostly associated with bivalve and gastropod mollusks (Boxshall and Halsey, 2004). Humes (1986) included five genera in this family, *Anthessius* Della Valle, 1880, *Neanthessius* Izawa, 1976, *Katanthessius* Stock, 1960, *Panaietis* Stebbing, 1900, and *Rhinomolgus* Sars, 1918. One genus *Discanthessius* Kim I.-H., 2009 has since been added to the family (Kim, 2009). *Anthessius* is the most speciose genus in the family, currently comprising 45 valid species, almost all of which inhabiting temperate and warm waters, except for *A. antarcticus* Moles, Avila & Kim I.-H., 2015 discovered in the Antarctic waters (Moles et al., 2015). In the present paper, three new species of *Anthessius* are described from three different geographic regions in the Pacific, Kosrae Island in Micronesia, Bohol Island in the Philippines, and Korea, respectively.

MATERIALS AND METHODS

Copepod samples collected from molluscan hosts were fixed and preserved in 80% ethanol. For microscopic observation,

the copepods were immersed in lactic acid for at least 10 minutes. Specimens were dissected and observed using the reverse slide method of Humes and Gooding (1964). In the armature formula for legs in the descriptions, Roman numerals indicate spines and Arabic numerals represent setae. Measurement of body length is from the anterior margin of the cephalosome to the posterior margin of the caudal rami, excluding the caudal setae. Elements I–V in the description of mandible denote five armature elements (Fig. 1), as follows: element I, the proximal spine on the ventral (convex) margin of gnathobase; element II, the distal spine on the ventral margin of the gnathobase; element III, the distal lash; element IV, the distal element on the dorsal (concave) margin of the gnathobase, which is usually vestigial or absent in *Anthessius*; and element V, the proximal seta on the dorsal margin of the gnathobase. Type specimens have been deposited in the Marine Biodiversity Institute of Korea (MABIK), Seocheon, Korea.

SYSTEMATIC ACCOUNTS

Order Cyclopoida Burmeister, 1834
Family Anthessiidae Humes, 1986

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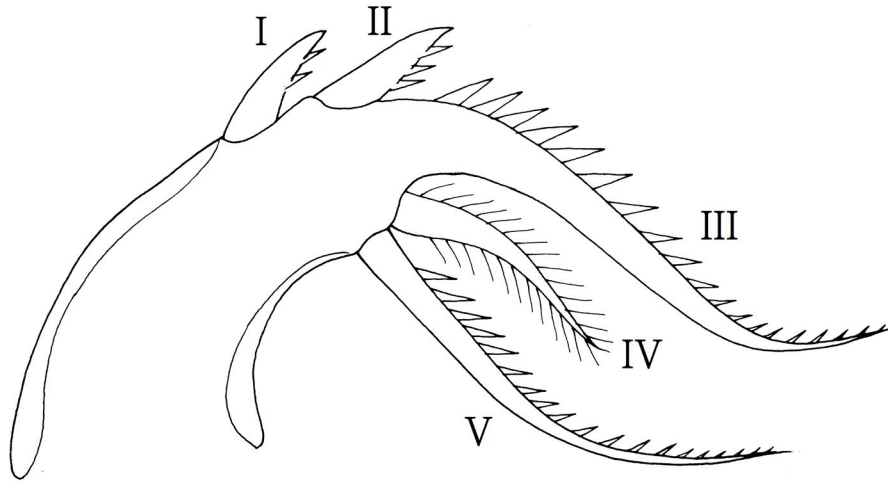


Fig. 1. Schematic structure of primitive mandible of the Anthessiidae, as shown in the genus *Katanthessius* Stock, 1960. Roman numerals I to V represent armature elements I to V.

Genus *Anthessius* Della Valle, 1880

***Anthessius tuberculatus* n. sp. (Figs. 2-4)**

Material examined. 1 ♀ (holotype, MABIK CR00247444) and 1 ♂ (allotype, MABIK CR00247445) from the mantle cavity of the bivalve *Asaphis violascens* (Forsskål in Niebuhr, 1775), intertidal, Mangrove Channel (05°16'31"N, 162°57'52"E), Utwe, Kosrae, 24 Jun 2015, coll. I.-H. Kim. Holotype and allotype, each dissected and mounted on a slide, have been deposited in the MABIK, Seocheon, Korea.

Female. Body (Fig. 2A) rather narrow and 2.04 mm long. Prosome 1.14 mm long, occupying about 56% of body length; greatest width 0.69 mm; length/width ratio of body 1.65 : 1. Dorsal suture line distinct between cephalosome and first pedigerous somite. Posterolateral corners of all prosomal somites rounded. Urosome (Fig. 2B) 5-segmented. Fifth pedigerous somite (= first urosomite) 269 µm wide, with lobate tubercle (indicated by arrowhead in Fig. 2B) on each side of posterodorsal surface; lateral margins of somite parallel. Genital double-somite and first 2 abdominal somites with finely serrate posteroventral fringes (Fig. 2C). Genital double-somite 255 × 287 µm, wider than long, with distinctly convex lateral margins; genital apertures large, positioning dorsolaterally near midlength of double-somite. Three free abdominal somites 124 × 149, 109 × 131, and 127 × 127 µm in length and width, respectively. Anal somite with paired horizontal rows of spinules proximally on ventral surface and minute spinules along posteroventral margin (Fig. 2C). Caudal rami slightly divergent; each ramus (Fig. 2D) gradually narrowing distally, 160 × 57 µm (length/width ratio 2.81 : 1), armed with 6 setae, ornamented with minute

spinules along ventrodorsal margin; outer lateral seta (seta II) stiff, naked, positioning at 53% region of ramus length; outer distal seta (seta III) spiniform, tipped with a setule; two mid-terminal setae (setae IV and V) and inner distal seta (seta VI) pinnate; inner dorsal seta (seta VII) small and naked.

Rostrum (Fig. 2E) broad; posterior margin discernible, broadly rounded. Antennule (Fig. 2F) 417 µm long, 7-segmented; second segment longest, and fourth segment second longest; two terminal segments markedly short; armature formula of segments 4, 14, 6, 3, 4 + aesthetasc, 2 + aesthetasc, and 7 + aesthetasc; several setae on distal 3 segments pinnate, all other setae naked. Antenna (Fig. 2G) 3-segmented, consisting of basis and 2-segmented endopod; these 3 segments similar in length; basis with 1 inner distal spinulose spine; first endopodal segment with 1 seta on inner margin; second endopodal segment 2.10 times longer than wide (88 × 42 µm), with 11 armature elements: 4 setae (including spiniform one) on inner margin, 3 setae on subdistal region, and 4 strong distal claws of unequal lengths.

Labrum (Fig. 2H) with rather elongate, tapering posterior lobes and deep posteromedial incision; posterior lobes with fine spinules at apical region. Mandible (Fig. 2I) armed with 5 armature elements: element I (proximal spine on ventral margin of gnathobase) and element II (distal spine) subequal in size, both simple, unornamented; element III (distal lash) elongate, toothed along its ventral margin, spinulose along distal half of dorsal margin; element IV foliaceous, terminating in 2 spiniform processes, with 9 spinules on distal margin; element V (outer seta) elongate, slender, slightly longer than distal lash (element III), with row of spinules along its ventral margin. Paragnath (Fig. 2H) as flexed, naked lobe. Maxillule (Fig. 2J) lamella-like, distally bilobed; outer lobe

with 2 short, leaf-like setae; inner lobe with row of fine spinules; inner margin with 2 large and 2 small setae. Maxilla (Fig. 3A, B) 2-segmented; proximal segment (syncoxa) unarmed; distal segment (basis) terminating in slender, spiniform process, armed with small conical process and row of several minute spinules at outer proximal region, broad anterior seta (seta II), 4 large spines along convex margin, and 1 minute spinule near base of distal process (Fig. 3B). Maxilliped (Fig. 3C) incompletely 3-segmented; first and second segments unarmed; third segment blunt apically, subdistally with small seta and small setiform process, ornamented with minute spinules on outer side; 1 transparent membrane present along outer margin of second segment and proximal half of third segment.

Legs 1–4 (Figs. 3D–G) with 3-segmented rami; outer seta on basis small, naked; all setae on coxa and rami pinnate. Outer margin of endopodal segments with row of setules. Outer distal corners of first and second segments of endopods with pointed process. Outer margin of exopodal segments with spinules. Inner margin of basis with setules. Leg 3 similar to leg 2, except bearing 4 spines and 2 setae on third endopodal segment. Armature formula of legs 1–4 as follows:

	Coxa	Basis	Exopod	Endopod
Leg 1	0-1	1-0	I-0; I-1; III, I, 4	0-1; 0-1; I, 1, 4
Leg 2	0-1	1-0	I-0; I-1; III, I, 5	0-1; 0-2; II, I, 3
Leg 3	0-1	1-0	I-0; I-1; III, I, 5	0-1; 0-2; II, I, I+2
Leg 4	0-1	1-0	I-0; I-1; III, I, 5	0-1; 0-2; II, I, I+1

Leg 5 (Fig. 3H) consisting of 1 dorsolateral seta on fifth pedigerous somite and free exopod. Exopodal segment slender, gradually broadening distally, $130 \times 41 \mu\text{m}$ (length/width ratio 3.17 : 1); both inner and outer margins spinulose; distal margin armed with 3 spines (61, 42, and $47 \mu\text{m}$ long, respectively, from outer to inner) and 1 small, naked seta ($30 \mu\text{m}$ long). Leg 6 represented by minute spine and small seta on genital operculum (Fig. 3I).

Male. Body (Fig. 4A) similar to that of female. Length 1.88 mm. Prosome 1.03 mm long; greatest width 0.60 mm. Urosome (Fig. 4B) 6-segmented. Fifth pedigerous somite $239 \mu\text{m}$ wide. Genital somite $167 \times 194 \mu\text{m}$, with slightly convex lateral margins. Four abdominal somites 94×155 , 109×139 , 91×121 , and $114 \times 114 \mu\text{m}$, respectively. Caudal ramus $136 \times 52 \mu\text{m}$ (length/width ratio 2.62 : 1).

Rostrum as in female. Antennule with 3 additional aesthetascs (2 on second segment and 1 on fourth, at places indicated by dark spots in Fig. 2F) and 1 additional seta on second segment at place indicated by arrowhead in Fig. 2F. Antenna (Fig. 4C) as in female, but spine on first segment pectinate along inner margin, with 1 spinule on outer margin; seta on second segment pectinate along inner margin.

Labrum, mandible, and maxillule as in female. Maxilla (Fig. 4D) with 2 tubercles on outer side of proximal segment (syncoxa); distal segment (basis) with small digitiform proximal process tipped with several minute spinules at outer proximal region. Maxilliped (Fig. 4E) 4-segmented; first segment (syncoxa) with tubercle-like process on inner margin and patch of spinules at outer distal area; second segment (basis) tapering distally, with 2 setae of similar lengths (distal one of them spiniform), 2 large patches of spinules, and 1 longitudinal row of minute spinules; third segment (endopod) short, with 1 large seta and 1 spine; fourth segment as large, strongly curved hook bearing 1 small seta proximally and fine spinules along concave inner margin.

Leg 1 with same armature formula as that of female, but distal seta on third endopodal segment spiniform, proximally pinnate and distally spinulose (Fig. 4F). Spines on swimming legs 1–4 generally longer than those of female.

Exopodal segment of leg 5 (Fig. 4G) 2.83 times as long as wide ($133 \times 47 \mu\text{m}$), broader than that of female. Leg 6 represented by 2 unequal setae on genital operculum (Fig. 4B).

Etymology. The specific name *tuberculatus* alludes to the presence of the paired tubercles on the dorsal surface of the fifth pedigerous somite in the female.

Remarks. The genus *Anthessius* currently contains 45 valid species. For a comparison of *Anthessius tuberculatus* n. sp. with these congeners, three diagnostic features of the new species are selected as follows: (1) The third exopodal segment of leg 4 with four spines (rather than three) and five setae (shared by 25 congeners); (2) the antenna is armed with four claws distally (shared by 29 congeners); and (3) the caudal ramus is more than twice but less than 3.5 times as long as wide (shared by 22 congeners).

All the above three diagnostic features of *A. tuberculatus* n. sp. are shared only with five congeners, as follows: *A. alatus* Humes and Stock, 1965; *A. groenlandicus* (Hansen, 1923); *A. lighti* Illg, 1960; *A. nosybensis* Kim I.-H., 2009; and *A. stylocheili* Humes and Ho, 1965. These five species can be differentiated from *A. tuberculatus* n. sp. by their features not shared by the new species, as follows:

In *A. alatus* the cephalothorax is, as usual in species of *Anthessius* associated with the clams of the genus *Tridacna*, narrow in anterior half and laterally expanded in posterior half, the proximal four segments of the antennule are distinctly broader than distal three segments, the antenna is markedly robust, with its terminal segment being much wider than long, the basis (second segment) of the maxilla is armed with more than 10 spines, and the exopodal segment of leg 5 is broad, 1.26 times as long as wide (Humes and Stock, 1965).

Anthessius groenlandicus was described by Hansen (1923) as the body is nearly half as broad as long (cf. much nar-

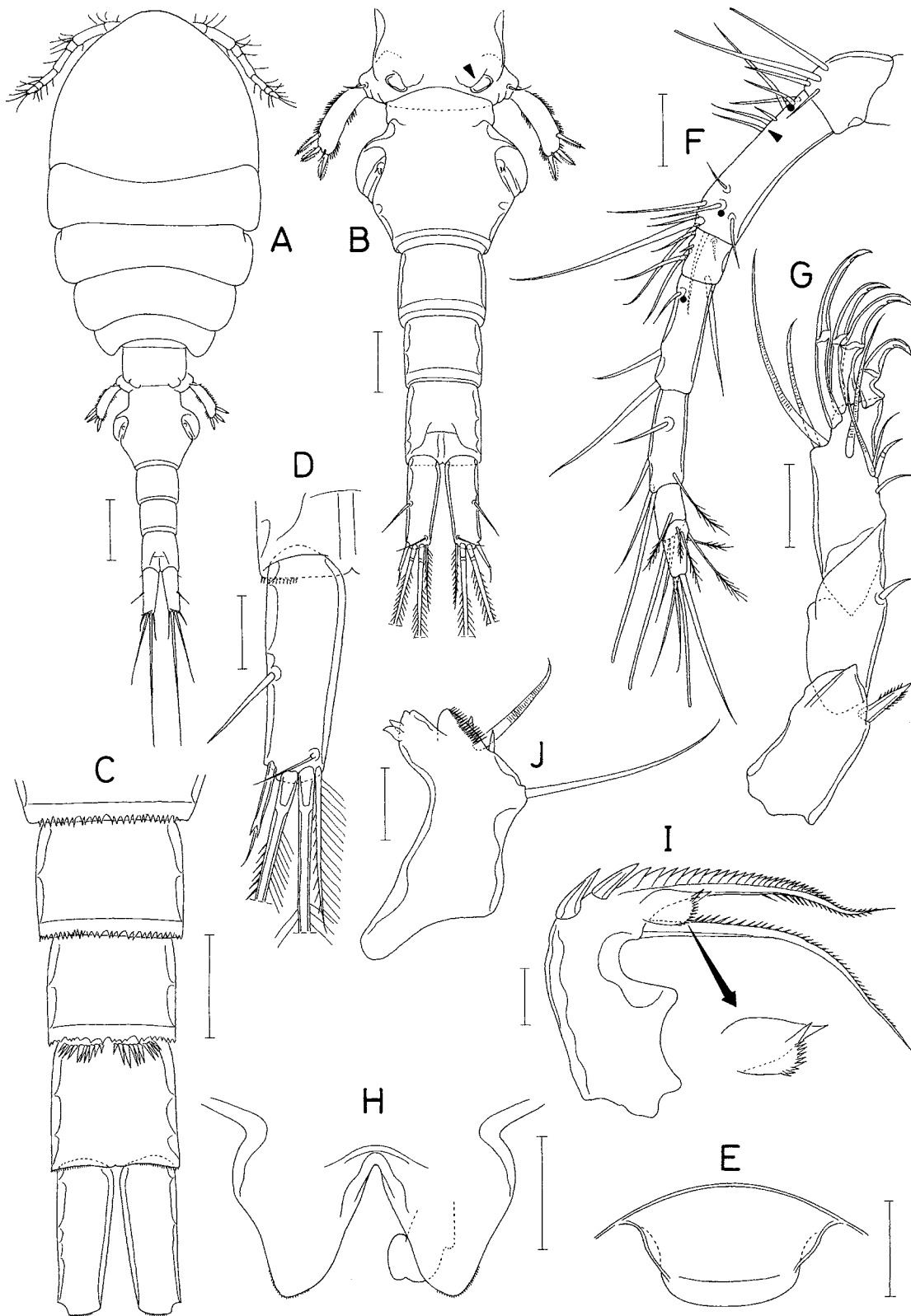


Fig. 2. *Anthessius tuberculatus* n. sp., female. A, Habitus, dorsal; B, Urosome, dorsal; C, Abdomen, ventral; D, Left caudal ramus, dorsal; E, Rostrum; F, Antennule; G, Antenna; H, Labrum and left paragnath; I, Mandible; J, Maxillule. Scale bars: A=0.2 mm, B, C=0.1 mm, D-H=0.05 mm, I, J=0.02 mm.

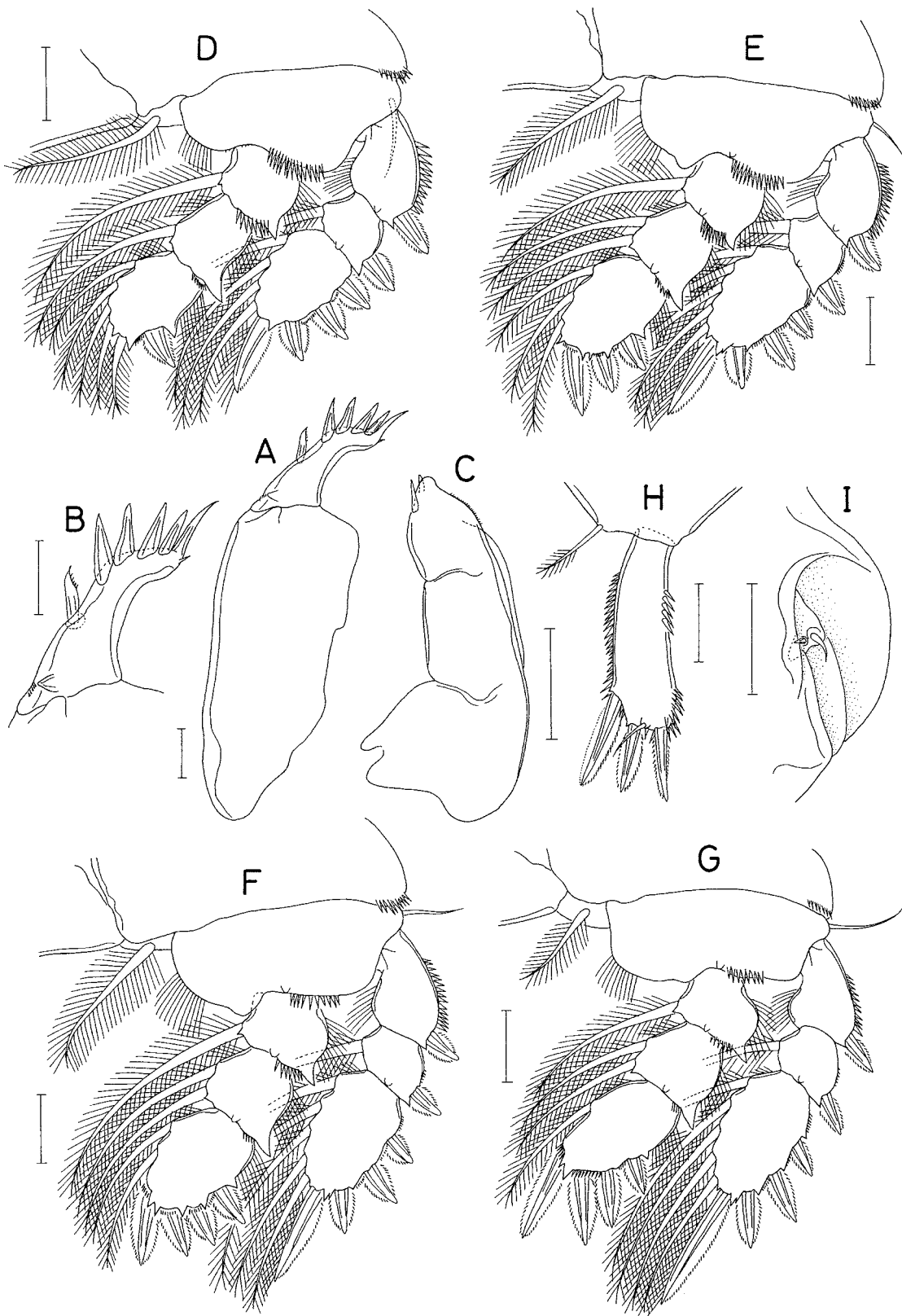


Fig. 3. *Anthesius tuberculatus* n. sp., female. A, Maxilla; B, Distal segment of maxilla; C, Maxilliped; D, Leg 1; E, Leg 2; F, Leg 3; G, Leg 4; H, Leg 5; I, Right genital area, dorsal. Scale bars: A, B=0.02 mm, C-I=0.05 mm.

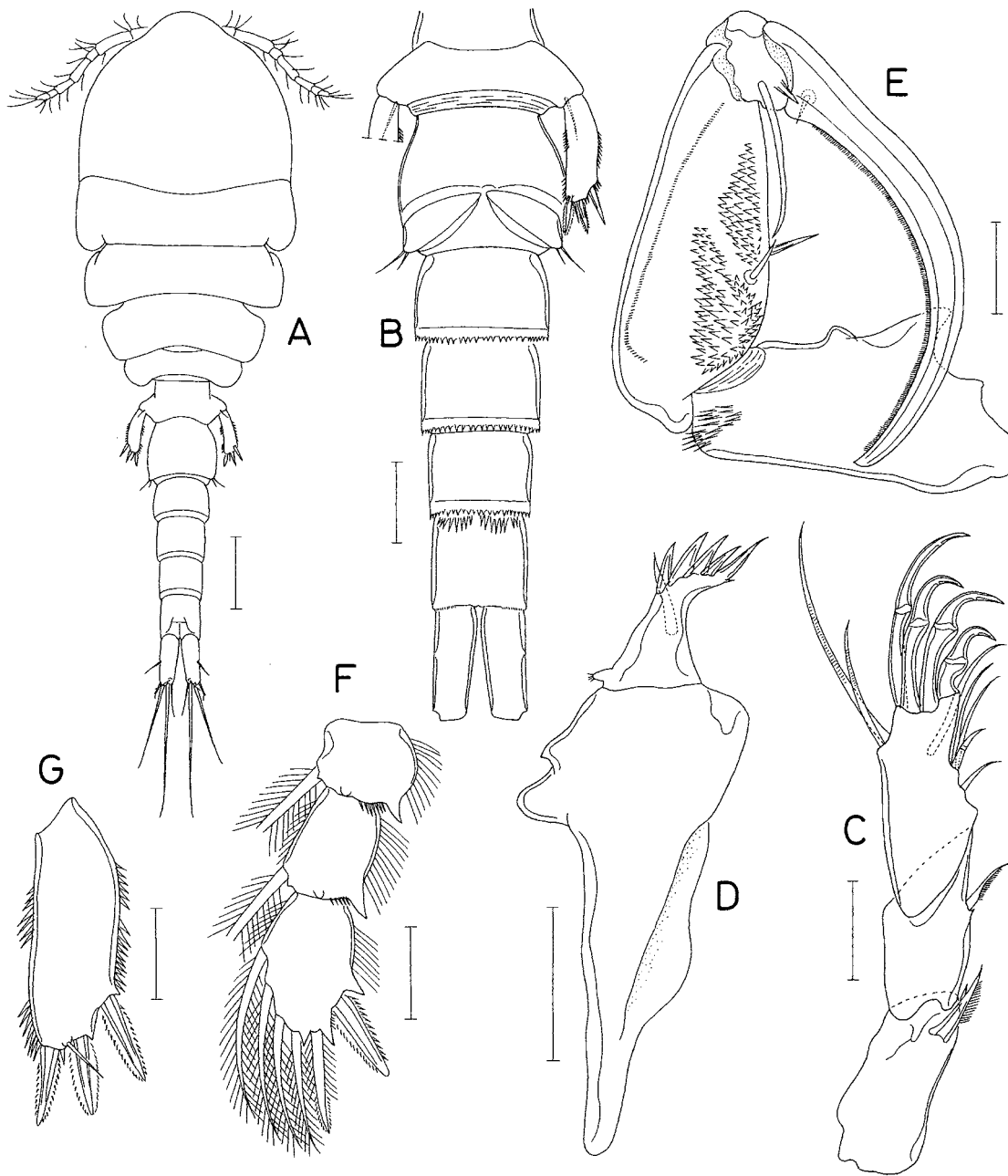


Fig. 4. *Anthessius tuberculatus* n. sp., male. A, Habitus, dorsal; B, Urosome, ventral; C, Antenna; D, Maxilla; E, Maxilliped; F, Endopod of leg 1; G, Exopod of leg 5. Scale bars: A=0.2 mm, B=0.1 mm, C-G=0.05 mm.

rower than half length of body in *A. tuberculatus* n. sp.), the anal somite is longer than two preceding abdominal somites combined (cf. shorter in *A. tuberculatus* n. sp.), and the outer margin of the exopodal segment of leg 5 is unornamented (cf. ornamented with spinules in *A. tuberculatus* n. sp.).

In *A. lighti* the genital double-somite of the female is longer than wide, based on the illustration given by Illg (1960); the exopodal segment of leg 5 possesses no spinules on the

outer margin and is about four times as long as wide in the female (Illg, 1960); and elements I and II (ventral spines) of the mandible are ornamented with subsidiary spinules.

Anthessius nosybensis, an associate of the bivalve *Anadara antiquata* (Linnaeus) in Madagascar, is very similar to *A. tuberculatus* n. sp. in many respects. In this Madagascan species the caudal ramus is 3.41 times as long as wide in the female; the mandible lacks element IV, but with subsidiary

spinules on elements I and II; the maxilla is armed with five spines on the distal concave margin of the basis (second segment); and the exopodal segment of leg 5 is more slender, 3.88 times as long as wide (Kim, 2009).

In *A. stylocheili* the genital double-somite bears a prominent digitiform process on the lateral margin, as illustrated in the original description of Humes and Ho (1965); Humes and Ho (1965) did not record the proximal rows of spinules on the ventral surface of the anal somite certainly because of their absence; and the exopodal segment of leg 5 is smooth along the outer margin, without spinules.

Some of morphological differences between species are summarized in Table 1.

Anthessius rarus n. sp. (Figs. 5–7)

Material examined. 2 ♀♀ and 1 ♂ (along with numerous specimens of *Anthessius dolabellae* Humes & Ho, 1965) from external washings of about 20 *Dolabella auricularia* (Lightfoot, 1786), approximately 09°44'N, 124°34'E, tidal pool, Bohol, the Philippines, 31 Mar 2016, coll. J. Lee & I.-H. Kim. Holotype (♀, MABIK CR00247446) has been deposited in the MABIK, Seocheon, Korea. Dissected paratypes (1 ♀, 1 ♂) are retained in the collection of the junior author.

Female. Body (Fig. 5A) narrow. Body length 2.69 mm. Prosoma fusiform, depressed, 1.35 mm long, half as long as body length. Greatest width of prosoma 0.91 mm. Dorsal suture line distinct between cephalosome and first pedigerous somite. Cephalosome with rounded anterior margin. Urosome (Fig. 5B) 5-segmented, slender, elongate. Fifth pedigerous somite 250 × 268 μm, narrowed proximally, with parallel lateral margins along distal two-thirds. Genital double-somite slightly longer than wide (286 × 268 μm), widest across genital areas; genital aperture positioning at 40% length of double-somite. Three free abdominal somites unornamented, 159 × 168, 102 × 23, and 290 × 159 μm, respectively. Anal somite about 1.8 times as long as wide, about 2.8 times as long as second abdominal somite, lacking spinules on ventral surface. Caudal rami (Fig. 5C) straight backwards, 5.20 times as long as wide (312 × 60 μm), slightly longer than anal somite, armed with 7 small, naked setae; seta I (outer proximal seta) minute, setule-like; seta II (outer seta) positioning at 53% region of ramus length; 2 mid-terminal setae (setae IV and V) 167 and 276 μm long, respectively, shorter than caudal ramus. Egg sac (Fig. 5D) cylindrical, 830 × 320 μm; each egg about 100 μm in diameter.

Rostrum (Fig. 5E) broad; its posterior margin rounded, obscure near apex. Antennule (Fig. 5F) slender, 602 μm long, 7-segmented; armature formula 4, 15, 6, 3, 4 + aesthetasc, 2 + aesthetasc, and 7 + aesthetasc; all setae small and naked;

2 terminal segments short, both shorter than fifth segment. Antenna (Fig. 5G) massive, 3-segmented, consisting of basis and 2-segmented endopod; basis about 1.3 times as long as wide, with 1 seta distally; proximal endopodal segment (second segment) as long as wide, with 1 seta at inner subdistal region; distal endopodal segment (third segment) wider than long (73 × 90 μm), with small tubercle proximally on inner margin, armed with 1 small claw + 3 small setae on inner margin, and 4 claws (1 strong and 3 slender) + 3 setae distally.

Labrum (Fig. 5H) with prominent posterior lobes; each lobe tapering, abruptly narrowed along distal third, with 1 dentiform cusp on inner margin, apically tipped with finely serrate membranous lobe. Mandible (Fig. 5I) with 5 discernible elements. Elements I and II similar to each other in size, each bearing 2 denticles on its subdistal margin. Element III (distal lash) elongate, toothed along ventral (concave) margin. Element IV rudimentary, tapering, not articulated at base, pointed at tip, with row of several minute spinules. Element V as elongate seta, toothed along ventral margin, not articulated at base. Maxillule (Fig. 6A) weakly bilobed distally, with 2 small setae on outer lobe, 1 large and 2 small setae plus 2 rows of spinules on inner lobe, and 1 long, thin seta on inner margin. Maxilla (Fig. 6B) consisting of syncoxa and basis; syncoxa large, but unarmed; basis terminating in spiniform process, armed with 1 spinulose lobe proximally, 2 unequal setae (setae I and II) on anterior surface, and 2 large and 3 small spiniform processes at distal region. Maxilliped (Fig. 6C) unsegmented; distal one-fifth tapering, tipped with 1 small seta, ornamented with few spinules on margin.

Legs 1–4 (Fig. 6D–G) biramous, with 3-segmented rami; inner coxal setae large, pinnate; outer setae on basis small, naked. Second endopodal segment of leg 2 armed with 2 inner setae (in holotype and male paratype) but abnormally with 1 inner seta in female paratype (Fig. 6E). In third exopodal segment of legs 1–4, 3 outer spines small, less than half length of distal spine. In third endopodal segment of legs 2–4, proximalmost outer spine distinctly shorter than distal spines. Armature formula for legs 1–4 as follows:

	Coxa	Basis	Exopod	Endopod
Leg 1	0-1	1-0	I-0; I-1; III, I, 4	0-1; 0-1; I, I, 4
Leg 2	0-1	1-0	I-0; I-1; III, I, 5	0-1; 0-2 (or 0-1); I, II, 3
Leg 3	0-1	1-0	I-0; I-1; III, I, 5	0-1; 0-2; I, III, 2
Leg 4	0-1	1-0	I-0; I-1; III, I, 5	0-1; 0-2; I, III, 1

Leg 5 (Fig. 6H) consisting of small, naked dorsolateral seta on fifth pedigerous somite and free exopod; exopodal segment roughly elliptical, 1.89 times longer than wide (106 × 56 μm), armed with 3 small spines and 1 naked seta

Table 1. Diagnostic characters of *Anthessius* species

Species	Characters ^a								
	1	2	3	4	5	6	7	8	9
<i>A. alatus</i>	+	2.2	4	<1	Large, bilobed	12	4	1.26	+
<i>A. alpheusicola</i>	?	3.3	4	?	Large, bilobed	5	3	5.4	+
<i>A. amicalis</i>	+	1.43	4	<1	Large, bilobed	7	4	1.1	+
<i>A. antarcticus</i>	X	2.40	2	2.23	Long seta	4	4	2.83	+
<i>A. arcuatus</i>	?	1.92	3	<1	Serrate lash	17	4	2.3	+
<i>A. arenicolus</i>	+	=4	4	=3	X	4-5	4	=3.7	+
<i>A. atrinae</i>	X	5.2	3	2.2	Serrate lobe	5	3	1.67	X
<i>A. brevicaudis</i>	X	0.54	4	=4	Bifurcate lobe	5	4	1.7	+
<i>A. brevifurca</i>	?	=1.2	0	=3	X	4	4	=3	+
<i>A. concinnus</i>	X	=4	3	=1.5	Serrate lash	10	4	=2.83	+
<i>A. dilatatus</i>	?	=4	3	=1.3	X	5	3	=4	+
<i>A. discipedatus</i>	+	1.74	3	<1	Bifurcate lobe	7	4	0.84	+
<i>A. distensus</i>	X	1	4	<1	Pointed lobe	14	4	1.33	+
<i>A. dolabellae</i>	X	1.55	4	<1	Bilobed	4	3	2.8	+
<i>A. fitchi</i>	+	4.5	4	>1	Bilobed	5	4	2	+
<i>A. graciliunguis</i>	+	3.5	4	3	Small spinule	5	3	2	+
<i>A. groenlandicus</i>	+	>3	4	?	?	5	4	<3	X
<i>A. hawaiiensis</i>	?	2.5	3	=2	Long process	8	4	2.5	X
<i>A. investigatoris</i>	?	1.5	4	=4	?	?	3	=4	+
<i>A. isamusi</i>	X	2.09	2	=1	Bifurcate lobe	3	3	2.62	X
<i>A. kimjensis</i>	+	2.49	3	2.6	Bifurcate lobe	6	3	1.49	+
<i>A. leptostylis</i>	?	=5	4	=2.2	X	4	3	=3.5	+
<i>A. lighti</i>	X	2.6	4	=1.1	Bilobed	5	4	4	X
<i>A. longipedis</i>	X	2.03	4	1.5	Tapering lobe	5	3	4.47	+
<i>A. lophiomi</i>	+	2.90	4	<1	X	4	3	3.16	+
<i>A. minor</i>	+	2	4	=1.5	?	4	4	=2.3	+
<i>A. mytilicolus</i>	X	5.5	4	=3	Bilobed	4	4	3.75	+
<i>A. navanacis</i>	X	2.5	4	=1.5	?	5	3	1.8	+
<i>A. nortoni</i>	+	3	4	<1	Tapering lobe	3	3	3.2	X
<i>A. nosybensis</i>	+	3.41	4	2.18	X	5	4	3.88	+
<i>A. obtusispina</i>	X	3	3	=1.3	Spinulose lash	11	4	2.9	+
<i>A. ovalipes</i>	+	2	3	<2	Spinulose lash	10	4	=2	+
<i>A. pectinis</i>	X	12	3	=1	X	15	4	=1.5	+
<i>A. pinctadae</i>	+	3.55	3	2	Tapering lobe	5	4	1.96	+
<i>A. pinnae</i>	X	3.4	2	=2	X	5	3	1.7	+
<i>A. placunae</i>	?	7.5	4	>1	X	4	3	3	X
<i>A. pleurobranchiae</i>	?	>4	4?	?	?	>10	4	=4	X
<i>A. proximus</i>	X	2.14	4	1.60	Bilobed	4	3	2.9	X
<i>A. saecularis</i>	X	3.5	4	=2.5	Bilobed	6	3	2.9	+
<i>A. sensitivus</i>	+	2.1	4	2	Serrate lobe	3	3	3.5	+
<i>A. solecurti</i>	+	=4	4	=1.5	X	3	4	=3.5	+
<i>A. solidus</i>	+	4.6	4	<1	Bilobed	6	4	2.16	+
<i>A. stylocheili</i>	X	2.8	4	<1	Pointed lobe	4-6	4	4.2	X
<i>A. teissieri</i>	+	=3.5	4	=2	?	?	3	=4.5	+
<i>A. varidens</i>	X	1.83	4	=1.2	Minute setule	4	3	2.59	X
<i>A. tuberculatus</i> n. sp.	+	2.81	4	2.10	Serrate lobe	5	4	3.17	+
<i>A. rarus</i> n. sp.	X	5.20	4	0.8	Tapering lobe	4	4	1.89	X
<i>A. cucullatus</i> n. sp.	X	2.06	4	1.28	Serrate lobe	4	3	2.71	X

+, present; X, absent; ?, missing data; =, approximately; >, more than; <, less than.

^a1, denticles on proximal ventral surface of anal somite; 2, length/width ratio of ♀ caudal ramus; 3, terminal claws of antenna; 4, length/width ratio of terminal antennary segment; 5, shape of element IV of mandible; 6, spines on concave margin of maxillary basis (excluding distal lash); 7, spines on third exopodal segment of leg 4; 8, length/width ratio of exopodal segment of ♀ leg 5; 9, spinules on outer margin of ♀ leg 5.

along oblique distal margin, ornamented with spinules on distal part of inner margin. Leg 6 (Fig. 6I) represented by 2

minute setiform elements on genital operculum.

Male. Body (Fig. 7A) similar in form to female. Body

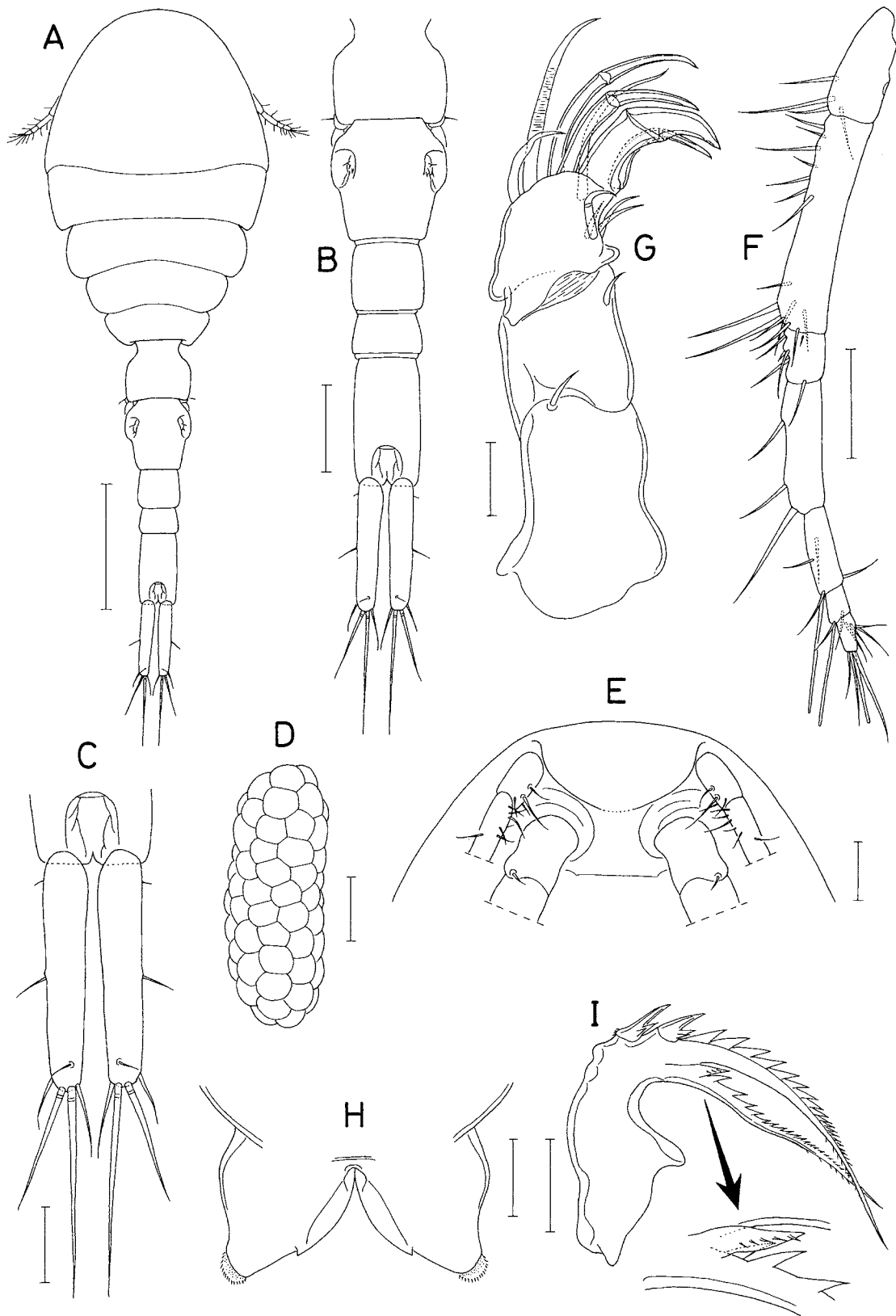


Fig. 5. *Anthesius rarus* n. sp., female. A, Habitus, dorsal; B, Urosome, dorsal; C, Caudal rami, dorsal; D, Egg sac; E, Rostral area, ventral; F, Antennule; G, Antenna; H, Labrum; I, Mandible. Scale bars: A=0.5 mm, B, D=0.2 mm, C, E, F=0.1 mm, G-I=0.05 mm.

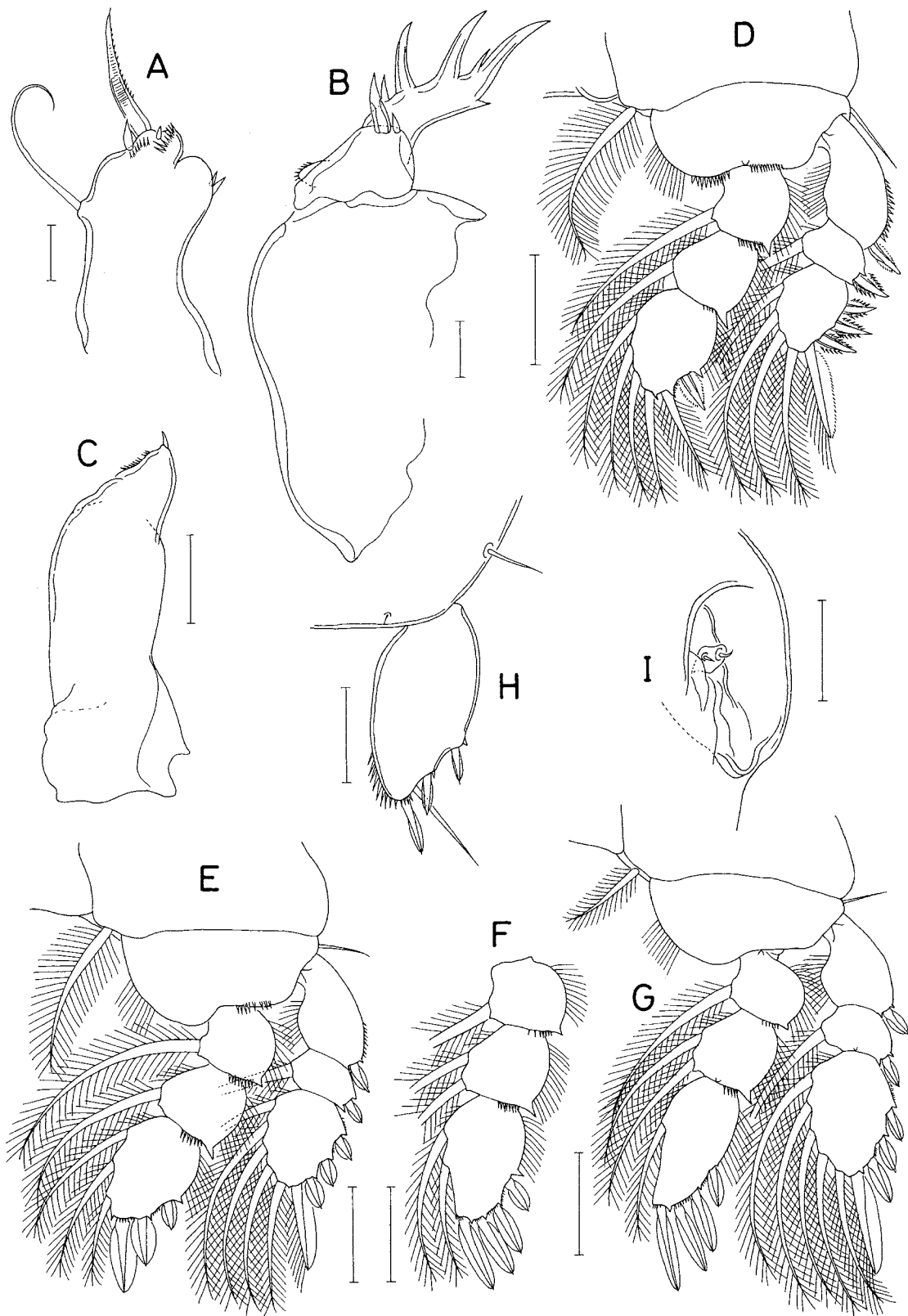


Fig. 6. *Anthessius rarus* n. sp., female. A, Maxillule; B, Maxilla; C, Maxilliped; D, Leg 1; E, Leg 2; F, Endopod of leg 3; G, Leg 4; H, Leg 5; I, Right genital aperture. Scale bars: A, B=0.02 mm, C, H, I=0.05 mm, D-G=0.1 mm.

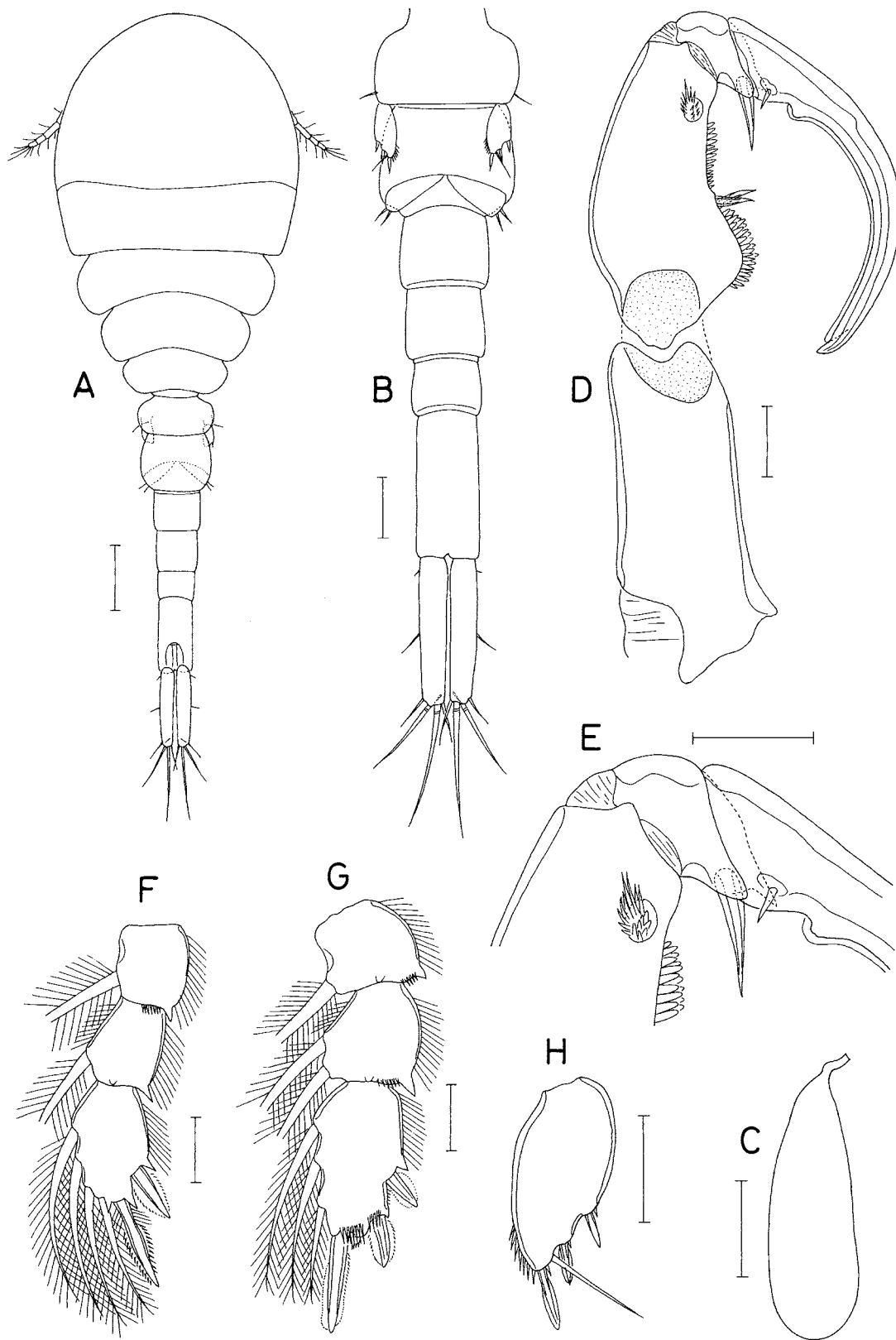


Fig. 7. *Anthessius rarus* n. sp., male. A, Habitus, dorsal; B, Urosome, ventral; C, Spermatophore; D, Maxilliped; E, Endopod of maxilliped; F, Endopod of leg 1; G, Endopod of leg 2; H, Exopod of leg 5. Scale bars: A=0.2 mm, B, C=0.1 mm, D-H=0.05 mm.

length 2.25 mm. Prosome 1.17 mm long. Greatest width of prosome 756 μm across cephalosome. Urosome (Fig. 7B) 6-segmented. Fifth pedigerous somite 244 μm wide. Genital somite wider than long (185 \times 225 μm). Four abdominal somites 124 \times 149, 120 \times 131, 90 \times 116, and 233 \times 105 μm , respectively. Anal somite more than twice longer than wide. Caudal ramus 5.25 times longer than wide (247 \times 47 μm), armed as in female. Spermatophore (Fig. 7C) detached from male 282 \times 94 μm , elongate sac-like.

Rostrum, antenna, mandible, maxillule, and maxilla as in female. Antennule with same armature formula as in female. Maxilliped (Fig. 7D) consisting of 3 segments and terminal hook; first segment (syncoxa) large but unarmed; second segment (basis) with convexly protruded proximal inner margin, 2 equal setae and densely arranged spinules on inner margin, 1 patch of spinules subdistally; third segment (endopod) short, with 1 large spine at inner distal region (Fig. 7E); terminal hook large, strongly arched, bearing 1 small seta proximally.

Leg 1 different from that of female in having 2 spines and 4 setae (formula I, I, 4) on third endopodal segment (Fig. 7F). Third endopodal segment of leg 2 slightly different from that of female in having elongated distalmost spine and 2 patches of spinules on distal margin (Fig. 7G). Legs 3 and 4 as in female.

Exopodal segment of leg 5 1.94 times longer than wide (91 \times 47 μm), armed and ornamented as in female. Leg 6 represented by 2 small equal setae on genital operculum (Fig. 7B).

Etymology. The name of the new species is from Latin *rarus* (= rare), depicting its rare occurrence on the host.

Remarks. As a significant feature of *Anthessius rarus* n. sp., its caudal rami are elongate, 5.20 times as long as wide in the female. Similarly elongate caudal rami, with the ratio of the length to the width being four or more, are observable in 11 species in the genus. Of these 11, four species, *A. atrinae* Suh & Choe, 1991, *A. dilatatus* (Sars, 1918), *A. leptostylis* (Sars, 1916), and *A. placunae* Devi, 1984 may easily be separated from the new and other seven species, because the four species have three spines (armature formula II, I, 5, rather than III, I, 5) on the third exopodal segment of leg 4.

Of the remaining seven species, *A. concinnus* (A. Scott, 1909) and *A. pleurobranchiae* Della Valle, 1880 are also clearly distinguished from other 10 congeners, because their maxillary basis bears 10 or more spines (or teeth) on its concave margin, in contrast to at most six spines in other eight species.

In *Anthessius*, the presence or absence of transverse rows of spinules on the proximal ventral surface of the anal somite is considered as a diagnostic taxonomic character. Within the group of the above 10 species, four are known

to have the rows of the spinules on the anal somite and are, therefore, not necessary to compare further with *A. rarus* n. sp. which has a smooth anal somite. These four species are *A. arenicolus* (Brady, 1872), *A. fitchi* Illg, 1960, *A. colecurti* Della Valle, 1880, and *A. solidus* Humes & Stock, 1965.

The remaining species *A. mytilicolus* Reddiah, 1966 was originally poorly described, but Humes and Lee (1985) and Lin and Ho (1999) completely redescribed it, based on the specimens collected newly from the bivalve *Perna viridis* (Linnaeus) in Hong Kong and Taiwan, respectively. As distinct differences of *A. rarus* n. sp. from *A. mytilicolus*, (1) the antenna is robust, with its terminal segment being wider than long, compared to about three times as long as wide in *A. mytilicolus* as figured by Humes and Lee (1985) and Lin and Ho (1999), (2) the anal somite of the female is more than twice as long as the penultimate abdominal somite, compared to 1.60 times as long as wide in *A. mytilicolus*, as measured by Humes and Lee (1985), (3) the exopodal segment of leg 5 is broader, 1.89 times as long as wide in the female, compared to the elongate condition in *A. mytilicolus* in which the exopodal segment of the female is 3.55 times (Humes and Lee, 1985) or 3.75 times as long as wide (Lin and Ho, 1999); and (4) the male antennule of *A. rarus* n. sp. unusually has no aesthetasc on the proximal segments, in contrast to the addition of four aesthetascs in *A. mytilicolus*, three on the second segment and one on the fourth (Lin and Ho, 1999).

Anthessius cucullatus n. sp. (Figs. 8–11)

Material examined. 13 ♀♀ and 7 ♂♂ from external washings of the aplysiid gastropod *Aplysia kurodai* Baba, 1937, in the Sea of Japan, Wolpo, Pohang, Korea (36°12'28"N, 129°22'30"E), 11 Sep 2013, coll. H. Hwang. Holotype (♀, MABIK CR00247447) and paratypes (10 ♀♀, 5 ♂♂, MABIK CR00247448) have been deposited in the MABIK, Seocheon, Korea. Dissected paratypes (2 ♀♀, 2 ♂♂) are retained in the collection of the junior author.

Female. Body (Fig. 8A) with weak exoskeleton. Body length 2.46 mm. Prosome flattened, elliptical, 1.36 \times 1.03 μm . Cephalothorax divided into cephalosome and first pedigerous somite by faint dorsal suture line. Urosome (Fig. 8B) 5-segmented. Fifth pedigerous somite 246 μm wide, distinctly narrower than genital double-somite. Genital double-somite 1.34 times wider than long (288 \times 385 μm), consisting of broad anterior part and narrower posterior part (Fig. 8C); anterior part bearing hood-like posterodorsal expansion covering most of narrower posterior part of double-somite; genital apertures large, positioning dorsally, at a third of double-somite length; broad anterior part of double-somite bearing paired digitiform process at each ventrolateral region (Fig. 8C); these digiti-

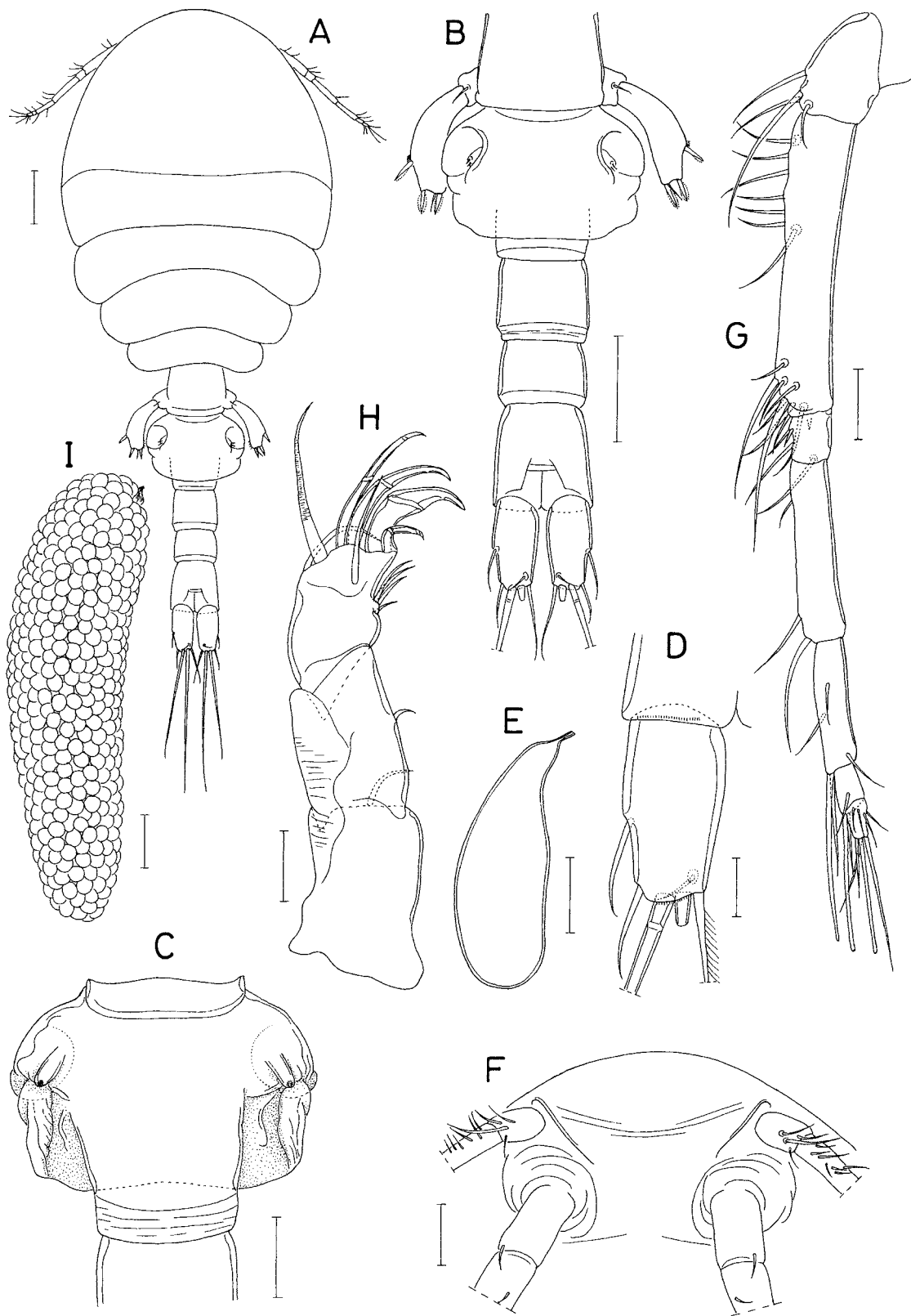


Fig. 8. *Anthesius cucullatus* n. sp., female. A, Habitus, dorsal; B, Urosome, dorsal; C, Genital double somite, ventral; D, Right caudal ramus, ventral; E, Spermatophore; F, Rostral area, ventral; G, Antennule; H, Antenna; I, Egg sac. Scale bars: A, B, I=0.2 mm, C, E, F=0.1 mm, D, G, H=0.05 mm.

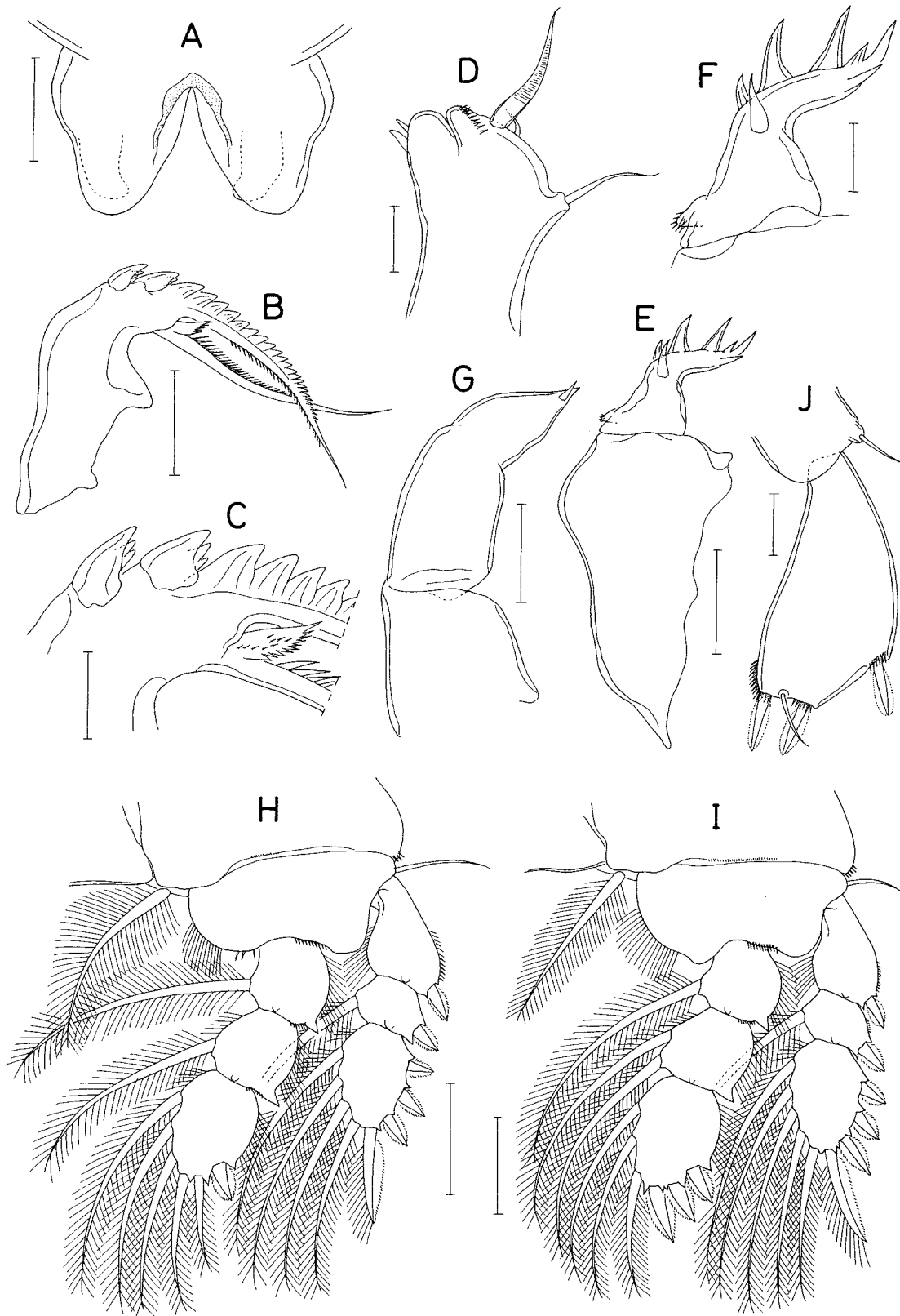


Fig. 9. *Anthessius cucullatus* n. sp., female. A, Labrum; B, Mandible; C, Distal part of mandible; D, Maxillule; E, Maxilla; F, Basis of maxilla; G, Maxilliped; H, Leg 1; I, Leg 2; J, Leg 5. Scale bars: A, B, E, G=0.05 mm, C, D, F=0.02 mm, H, I=0.1 mm.

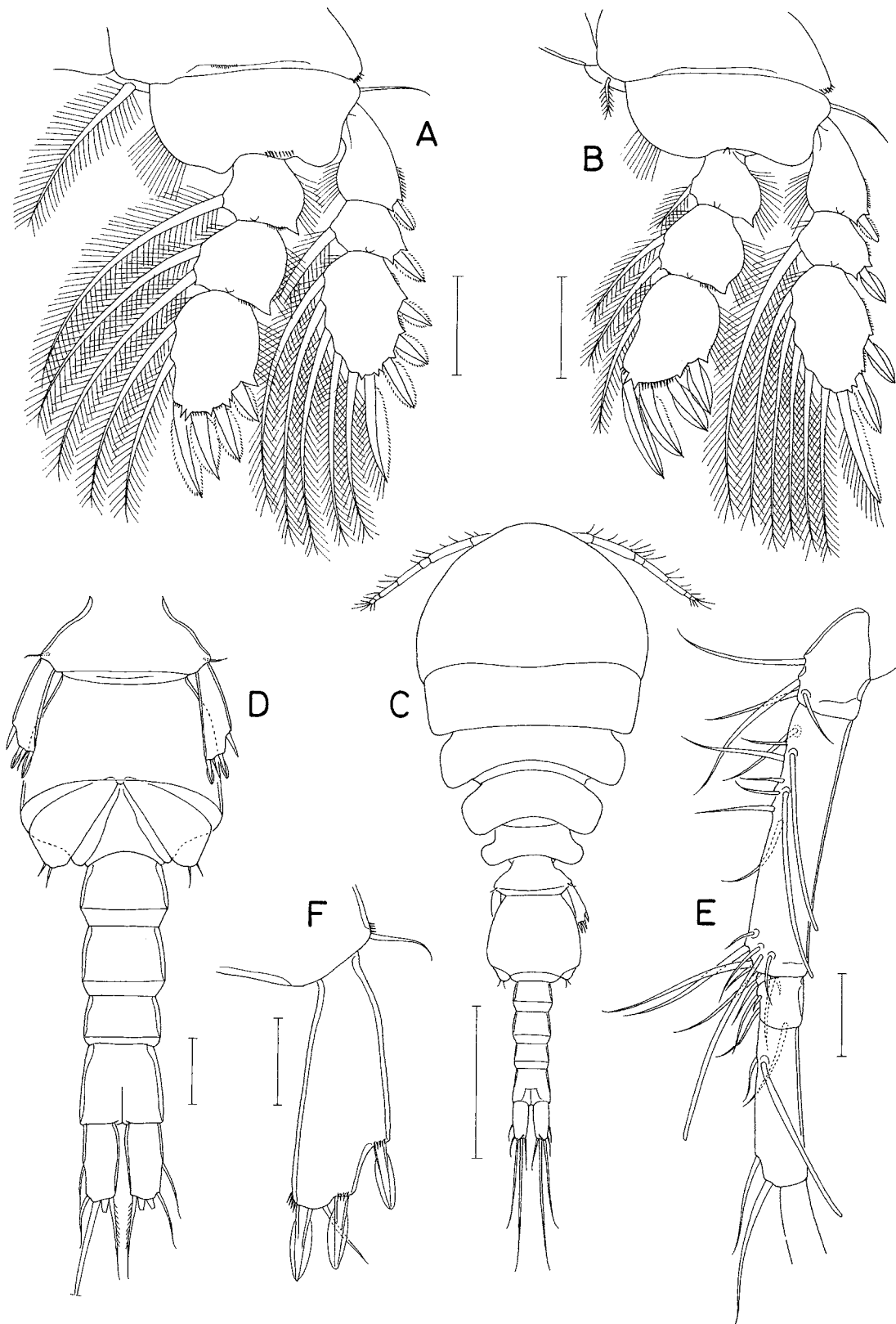


Fig. 10. *Anthessius cucullatus* n. sp. Female: A, Leg 3; B, Leg 4. Male: C, Habitus, dorsal; D, Urosome, ventral; E, First to fourth segments of antennule; F, Leg 5. Scale bars: A, B, E, F=0.05 mm, C=0.5 mm, D=0.1 mm.

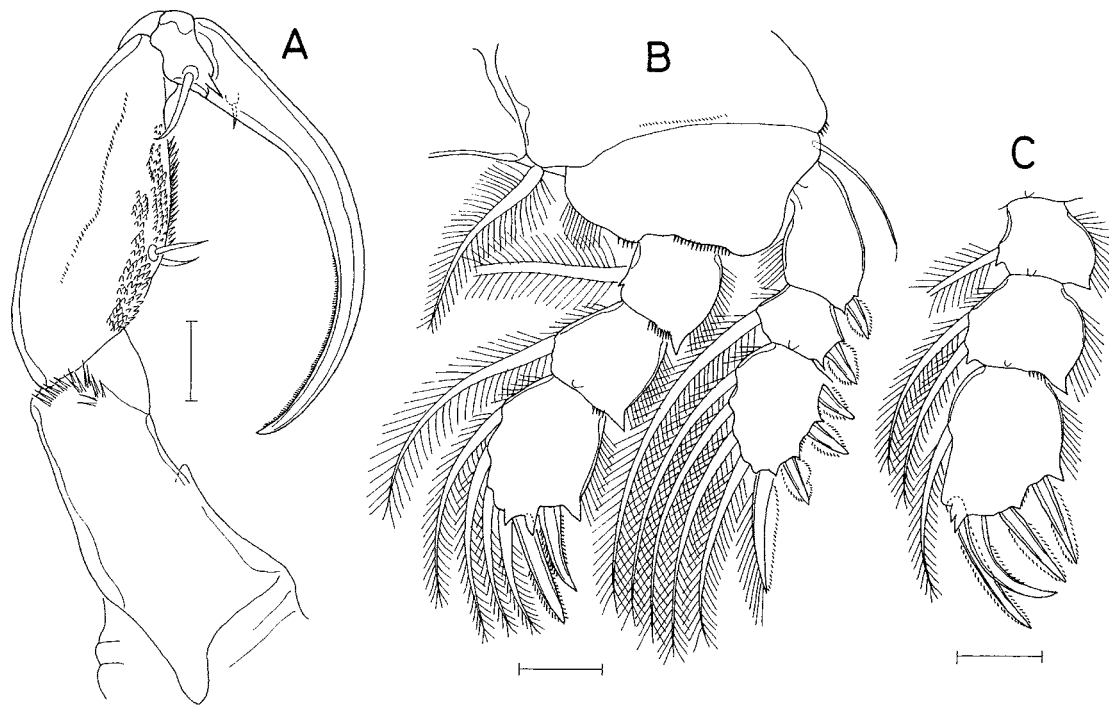


Fig. 11. *Anthessius cucullatus* n. sp., male. A, Maxilliped; B, Leg 1; C, Endopod of leg 4. Scale bars: 0.05 mm.

form processes tipped with copulatory pore; narrower posterior or part of double-somite $181\ \mu\text{m}$ wide. Three free abdominal somites 154×177 , 123×169 , and $192 \times 188\ \mu\text{m}$, respectively; all these abdominal somites unornamented. Caudal ramus (Fig. 8D) 2.06 times longer than wide ($179 \times 87\ \mu\text{m}$), shorter than anal somite, armed with 6 setae (setae II to VII); inner distal seta (seta VI) pinnate along its inner margin, other setae naked; outer margin seta (seta II) positioning at 60% region of ramus length. Spermatophore (Fig. 8E) detached from female elongate sac-like. Egg sac (Fig. 8I) slightly narrowing distally, $1.55 \times 0.42\ \text{mm}$, containing numerous small eggs; each egg about $60\ \mu\text{m}$ in diameter.

Rostrum (Fig. 8F) broad, but posterior region fused with ventral surface of cephalosome, without defined posterior margin. Antennule (Fig. 8G) $600\ \mu\text{m}$ long, 7-segmented; armature formula 4, 16 (7 proximal + 9 distal), 5, 3, 4 + aesthetasc, 2 + aesthetasc, and 7 + aesthetasc; setae small and naked; 2 terminal segments short, these segments together 0.56 times as long as fifth segment. Antenna (Fig. 8H) stout, 3-segmented; first segment (basis) about $133 \times 83\ \mu\text{m}$, with 1 seta distally; second segment (proximal endopodal segment) $115 \times 77\ \mu\text{m}$, with 1 small seta on inner margin; third segment (distal endopodal segment) $86 \times 67\ \mu\text{m}$, with 4 small setae on inner margin, and 4 unequal claws and 3 setae distally and subdistally; innermost claw much smaller than other claws; second inner claw distinctly thicker than

other claws.

Labrum (Fig. 9A) bearing large, tapering posterior lobes. Mandible (Fig. 9B, C) with 5 elements on gnathobase; elements I and II as stout spines, similar to each other in size, each bearing bilobed process on distal margin; element III as elongate distal lash, with toothed ventral margin and fine spinules along dorsal margin; element IV as small, tapering lobe bearing serrate dorsal margin; element V as long as element III, as elongate seta bearing fine spinules along its ventral margin. Paragnath (Fig. 9A) as slightly curved, smooth lobe. Maxillule (Fig. 9D) distally bilobed, with 1 slender seta on inner margin; outer lobe with 2 small, transparent setae; inner lobe with 1 large and 1 small setae and 1 row of minute spinules. Maxilla (Fig. 9E) with unarmed syncoxa; basis (Fig. 9F) terminating in spiniform process, with small, spinulose lobe proximally, 1 seta (seta II) on anterior surface, and 2 large and 3 small spines. Maxilliped (Fig. 9G) digitiform, unsegmented, but divisible into 3 parts by 2 constrictions; terminal part tapering pointed at tip, with 1 small, transparent seta near tip.

Legs 1–4 (Figs. 9H, I, 10A, B) biramous, with 3-segmented rami. Inner coxal seta large in legs 1–3, but small in leg 4, all of them pinnate. Outer seta on basis naked in all swimming legs. Distal margin of basis unornamented or with few spinules. Distal end of exopodal and endopodal segments of legs 2–4 bicuspid. Inner seta on first endopodal segment of

leg 4 markedly small. Armature formula for legs 1–4 as follows:

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

Leg 5 (Fig. 9J) 2-segmented, consisting of protopod and exopod; protopod short, not articulated from somite, with 1 small seta dorsolaterally; exopodal segment narrow proximally but gradually broadening distally, 1.93 times longer than wide ($210 \times 109 \mu\text{m}$), armed with 3 equal spines and 1 small seta, and ornamented with short row of spinules at distal part of inner margin and at base of spines. Leg 6 (Fig. 8B) represented by 2 small setae and 1 small process.

Male. Body (Fig. 10C) 2.04 mm long. Prosome gradually narrowing posteriorly, 1.10 mm long. Greatest width 0.77 mm. Urosome (Fig. 10D) 6-segmented. Fifth pedigerous somite $262 \mu\text{m}$ wide, strongly tapering anteriorly. Genital somite wider than long ($292 \times 312 \mu\text{m}$), broadening posteriorly. Four abdominal somites 96×135 , 107×129 , 77×119 , and $119 \times 130 \mu\text{m}$, respectively. Caudal ramus 2.12 times as long as wide ($123 \times 8 \mu\text{m}$), not shorter than anal somite.

Rostrum as in female. Antennule (Fig. 10E) different from that of female in having armature for second to fourth segments as $15 + 3$ aesthetascs, 6, and $3 +$ aesthetasc. Antenna as in female.

Labrum, mandible, maxillule, and maxilla as in female. Maxilliped (Fig. 11A) consisting of 3 segments and terminal hook; first segment (syncoxa) armed with 1 small process on inner margin and patch of spinules distally; second segment (basis) with 2 small setae and numerous spinules on inner surface; small third segment (endopod) bearing 1 seta and 1 spinule; terminal hook large, strongly arched with 1 small seta proximally and row of minute spinules along distal half of concave margin.

Leg 1 (Fig. 11B) different from that of female in having 2 spines and 4 setae (formula I, I, 4) on third endopodal segment. Legs 2 and 3 as in female. Leg 4 (Fig. 11C) with same armature formula with that of female, but third inner spine on third endopodal segment curved, hook-like.

Leg 5 (Fig. 10F) consisting of lateral seta on fifth pedigerous somite and free exopod; exopodal segment 2.71 times longer than wide ($149 \times 55 \mu\text{m}$), narrower than that of female. Leg 6 (Fig. 10D) represented by 2 small setae on distal apex of genital operculum.

Etymology. The specific name *cucullatus* is from Latin *cucull* (= a hood), referring to the hood-like posterior expansion of the genital double-somite in the female.

Remarks. In having a hood-like dorsal expansion on the genital double-somite in the female *A. cucullatus* n. sp. can readily be differentiated from all congeners. The following is another way to differentiate the new species from its congeners.

Within the genus *Anthessius*, 20 species have three spines and five setae (armature formula II, I, 5) on the third exopodal segment of leg 4 and a half (10 species) of which have, as *A. cucullatus* n. sp., relatively short caudal rami with their length/width ratio less than 3 : 1. These 10 species to be compared with *A. cucullatus* n. sp. are *A. dolabellae* Humes & Ho, 1965, *A. investigatoris* Sewell, 1949, *A. isamusi* Uyeno & Nagasawa, 2012, *A. kimjensis* Suh, 1993, *A. longipedis* Ho & Kim, 1992, *A. lophiomi* Avdeev & Kazachenko, 1985, *A. navanacis* (Wilson, 1935), *A. proximus* Stock, Humes & Gooding, 1963, *A. sensitivus* Stock, Humes & Gooding, 1963, and *A. varidens* Stock, Humes & Gooding, 1963.

Anthessius cucullatus n. sp. may be differentiated from five of the above 10 species by the form of the antenna. The terminal segment (a compound segment derived by the fusion of the original second and third endopodal segments) of the antenna of *A. cucullatus* n. sp. is slightly longer than wide (1.29 times as long as wide). In contrast, in *A. investigatoris*, *A. longipedis* and *A. sensitivus* the antenna is significantly narrower, with the terminal segment being twice or more times as long as wide, and in *A. dolabellae* and *A. lophiomi* the antenna is very robust, with its terminal segment being wider than long. In addition, the outer margin of the exopodal segment of leg 5 in these five species is ornamented with spinules, in contrast to the naked condition in *A. cucullatus* n. sp. The remaining five species can be distinguished from *A. cucullatus* n. sp. by their prominent differences from the new species, as follows:

In *A. longipedis* the genital double somite of the female is distinctly longer than wide, the distal margin of the maxillary basis is armed with five spines (vs. four spines in *A. cucullatus* n. sp.), and the exopodal segment of leg 5 of the female is elongate, 4.47 times as long as wide (Ho and Kim, 1992).

In *A. navanacis* the caudal ramus of the female is about 2.5 times as long as wide, narrower than that of *A. cucullatus* n. sp., the distal margin of the maxillary basis is armed with five spines, and the exopodal segment of female leg 5 is oval and ornamented with spinules along its outer margin (Illg, 1960).

In *A. isamusi* the seta II (outer margin seta) of the caudal ramus is positioned subdistally, the antenna possesses only two terminal claws (in contrast to four claws in general in the genus), element IV of the mandible is bifurcate, the distal margin of the maxillary basis is armed with three spines (Uyeno and Nagasawa, 2012).

In *A. proximus* the body is remarkably smaller than that of *A. cucullatus* n. sp., 1.32–1.51 mm in the female, element

IV of the mandible is bilobed, the spermatophore is oval, the exopodal segment of leg 5 is narrow, 2.9 times as long as wide in the female, and the third endopodal segment of male leg 1 bears two transformed distal spines (Stock et al., 1963).

In *A. varidens* the body is distinctly smaller than that of *A. cucullatus* n. sp., 1.60–1.79 mm long in the female, element IV of the mandible is represented by a minute setule, and the exopodal segment of leg 5 is narrow, 2.59 times as long as wide in the female, and the third endopodal segment of male leg 1 bears two transformed distal spines (Stock et al., 1963).

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CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

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