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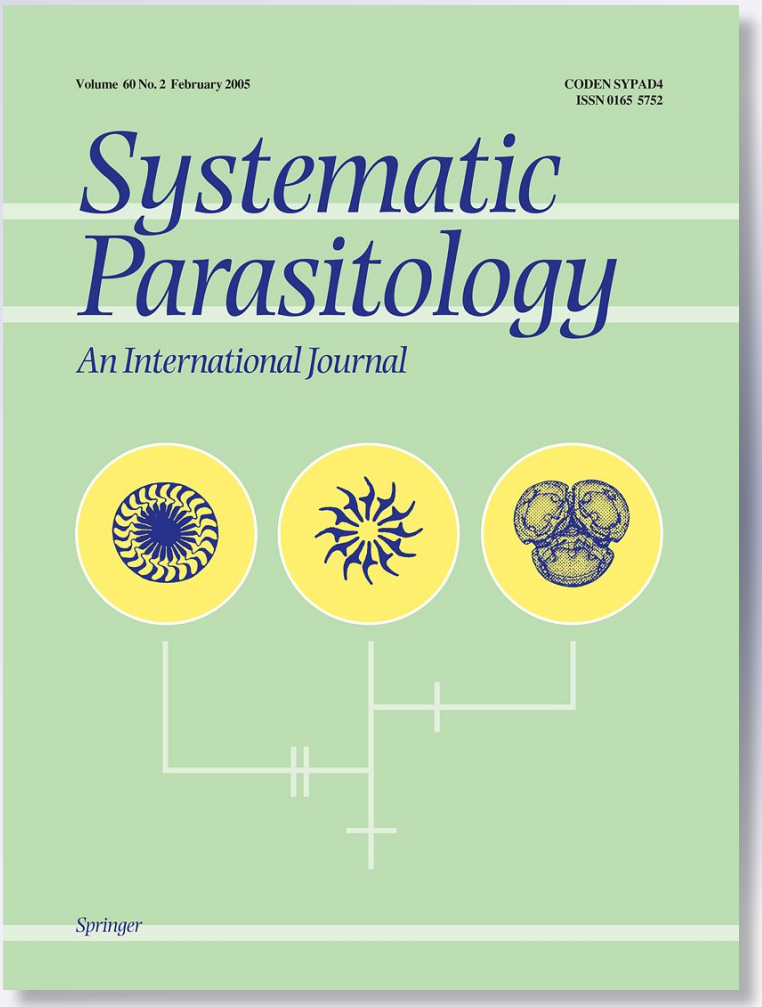

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Sabelliphilidae (Copepoda: Cyclopoida) associated with the tube anemone *Pachycerianthus maua* (Carlgren) and the horseshoe worm *Phoronis australis* Haswell off New Caledonia

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Abstract Examination of washings of the ceriantharian *Pachycerianthus maua* (Carlgren) and its phoronid symbiont *Phoronis australis* Haswell in New Caledonian waters revealed two species of symbiotic copepods belonging to the family Sabelliphilidae (Cyclopoida). *Phoronicola spinulatus* Boxshall & Humes, 1988, the only other copepod known to be associated with a phoronid and originally described from Hong Kong, was found on both the lophophore of *Phoronis australis* and the tentacular crown of *Pachycerianthus maua*. Both sexes of *Phoronicola spinulatus* are redescribed based on the New Caledonian material and re-examination of the type-material revealed some observational errors in the original description. *Myxomolgus hoi* n. sp. was exclusively found on the ceriantharian host and appears most closely related to its only known Pacific congener, *M. invulgus* Kim, 2001, in lacking the strong spines on antennulary segments 1–2, the presence of closely set, fine teeth along the convex margin of the mandibular blade, and the absence of a proximal bulbous protrusion along the inner margin of leg 5 exopod. Differences between both species are found in the rostrum, antennule, antenna, maxillule, leg 4, caudal rami and body size. The relatively low number of specimens of *P. spinulatus* recovered from washings of the lophophores (and its presence on *Pachycerianthus maua*) suggests that its real host is a ceriantharian rather than a phoronid. It is conceivable that both *Phoronicola spinulatus* and *M. hoi* n. sp. live and feed on/inside the mucilaginous ceriantharian tube rather than on the lophophore or tentacular crown of their respective hosts.

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Introduction

Tube-dwelling anemones or ceriantharians are solitary anthozoans, living buried in soft sediments. Tube anemones live and can withdraw into a mucilaginous tube, which is made from secreted mucus and threads of nematocyst-like organelles, known as ptychocysts. The virtually cosmopolitan horseshoe worm *Phoronis australis* Haswell (Phylum Phoronida) lives embedded in the tube-wall of ceriantharians, generally of the genera *Cerianthus* delle Chiaje and *Pachycerianthus* Roule. *Phoronis australis* is the only phoronid so far known to be encountered with ceriantharians. It is found in all warm temperate to tropical coasts from the intertidal to deeper waters. The number of phoronids in a tube-wall may reach 100, but in general there are 20–50 individuals. The association between the phoronid and the ceriantharian is considered as a case

of inquiline commensalism based on their relationships (*cf*. substrate, nutrition and protection) (Emig et al., 1972).

Examination of washings of *Pachycerianthus maua* (Carlgren) and its symbiont *Phoronis australis* collected off New Caledonia by one of us (RH) revealed two copepod associates belonging to the family Sabelliphilidae. *Phoronicola spinulatus* Boxshall & Humes, 1988, the only known copepod symbiont of a phoronid and originally described from *P. australis* associated with the ceriantharian *Cerianthus filiformis* Carlgren off Hong Kong, was found on both the lophophore and mucous tube of *P. australis* and on the tentacular crown of *P. maua*. A second, as yet unknown, sabelliphilid species belonging to the genus *Myxomolgus* Humes & Stock, 1972 was found on the ceriantharian host.

Materials and methods

Immediately after collection, the ceriantharian was kept in seawater in a bucket. Phoronids emerging from the mucilaginous tube wall were extracted by cutting the lophophores with scissors. In the laboratory the tube anemone and phoronids were placed in separate containers with seawater to which sufficient 95% ethanol was added to make an approximately 5% solution. Both were left in this solution at ambient temperature for about 25 minutes. After thorough rinsing the wash water was poured through a fine mesh sieve (38 μm) and the live copepods were picked and subsequently preserved in 95% ethanol. No attempt was made at dissecting the ceriantharian tube.

Copepods were cleared in lactic acid before dissection and subsequently observed using the hanging drop method described by Humes & Gooding (1964). All measurements are given in micrometres, except where indicated. All illustrations were drawn with the aid of a drawing tube mounted on an Olympus BH microscope. The terminology for the caudal ramus setae follows that of Huys & Boxshall (1991) and for the maxillary setae that of Humes & Boxshall (1996). In the armature formula of the swimming legs 1–4, spines are indicated by Roman numerals and setae by Arabic numerals. Abbreviations used: *exp*, exopod; *enp*, endopod. The undissected holotype of *Myxomolgus hoi* n. sp. has been deposited in the Muséum national d'Histoire naturelle (MNHN) in Paris and voucher specimens of *Phoronicola spinulatus* in the MNHN and the Natural History Museum (NHM) in London.

Family Sabelliphilidae Gurney, 1927
Genus *Myxomolgus* Humes & Stock, 1972

Humes & Stock (1972) proposed *Myxomolgus* as one of the four new genera recognised in the family Sabelliphilidae, but a generic diagnosis was not provided until the following year (Humes & Stock, 1973). They satisfied the provisions of ICZN Art. 13.3 by fixing *Paranthessius myxicolae* Bocquet & Stock, 1958 as the type-species. However, to be available from Humes & Stock (1972), the generic name *Myxomolgus* also needs to be accompanied by a description or definition that states in words characters that are purported to differentiate the taxon (ICZN Art. 13.1.1). Humes & Stock (1972) provided a key to the 18 genera included in the Sabelliphilidae at that time. In the absence of a proper generic diagnosis, the characters mentioned in the first four couplets of their key (*Myxomolgus* keys out in couplet 4) are here collectively regarded as a diagnostic statement differentiating *Myxomolgus* from related genera.

Myxomolgus hoi n. sp.

Type-material: Holotype ♀ preserved in ethanol, deposited in MNHN under registration number MNHN-Cp8071; paratype ♀ dissected and mounted on a glass slide and retained in personal collection of senior author; from washings of tentacular crown of one individual of *Pachycerianthus maua* (Carlgren); collected by SCUBA diving at 35 m depth in the Chenal de l'Îsle aux Canards, off Nouméa, New Caledonia (22°19.203′S, 166°26.286′E); 6 October, 2004; collected by P. Laboute & R. Huys. The description below is based on the paratype.

Etymology. The species is named for Prof. Ju-shey Ho (California State University, Long Beach, USA), in recognition of his enormous contribution to the systematics and biology of symbiotic copepods.

Description (Figs. 1–2)

Female. Body (Fig. 1A) cyclopiform, with stout prosome and slender urosome. Length of paratype

(excluding caudal setae) 763 and greatest width 332; length of holotype 750. Length to width ratio of prosome 1.57:1. Ratio of prosome to urosome 2.18:1. Prosome consisting of cephalosome and 4 pedigerous somites. Suture line between cephalosome and first pedigerous somite relatively distinct. Urosome (Fig. 1B) 5-segmented, comprising somite bearing leg 5, genital double-somite, 2 free abdominal somites and anal somite. Somite bearing leg 5 68 wide. Genital double-somite elongate, 124 × 85; pleural areas expanded, greatest width at about halfway along double-somite length. Genital apertures located dorsolaterally at about 3/5 of double-somite length; each closed off by vestigial leg 6 (Fig. 2I) bearing minute spinous process, 1 naked and 1 plumose seta. Free abdominal somites and anal somite 22 × 48, 16 × 46 and 33 × 51, respectively. Ventral posterior margins of genital double-somite and free abdominal somites smooth; that of anal somite with minute spinules (Fig. 1C). Caudal ramus (Fig. 1C) subrectangular, 1.33 times longer than wide (32 × 24), with straight inner margin, bearing 6 setae; setae III–VI plumose.

Rostrum (Fig. 1D) ventrally deflected, triangular, with rounded apex.

Antennule (Fig. 1E) 7-segmented, relatively slender, 210 long; armature formula: 4, 13, 6, 3, 4 + aesthetasc, 2 + aesthetasc, 7 + aesthetasc; all setae naked and setiform (segments 1–2 without spines).

Antenna (Fig. 1F) 4-segmented, comprising coxobasis and 3-segmented endopod; armature formula: 1, 1, 3 + geniculate claw, 4 + 3 geniculate claws; proximal seta of second endopodal segment well developed; 2 of 4 setae on distal endopodal segment characteristically blunt at tip and apical claws unequal in length and longer than segment.

Labrum (Fig. 1G) bilobate, with deep median incision between lobes; no ornamentation discernible.

Mandible (Fig. 1H) short, strongly tapering blade; outer scale largely incorporated and without proximal notch; convex margin with numerous closely set, fine denticles; inner margin with small spinules in distal half.

Paragnath a small tapering lobe, bearing several minute spinules proximally.

Maxillule (Fig. 2A) a small, elongate lobe with 1 short, naked seta along inner margin and 1 short, naked and 2 longer, pinnate setae apically.

Maxilla (Fig. 2B) 2-segmented, consisting of large unarmed syncoxa and distal basis drawn out into long tapering lash. Basis with 3 setae (I–III); seta I located near concave inner margin, spiniform and with 2 rows of spinules; seta II located on anterior surface, slender and with 1 row of spinules; seta III located proximally on outer margin, short, naked and recurved. Lash with 3 large and 3–4 (variability observed between right and left sides) small spinules along outer margin; inner margin with fine spinules; anterior surface with 4 small spinules.

Maxilliped (Fig. 2C) 3-segmented, consisting of elongate syncoxa and basis, and 1-segmented endopod. Syncoxa unarmed and about as long as basis. Basis with 2 short, naked setae along inner margin. Endopod produced into tapering, apically recurved claw; with 2 accessory, naked setae.

Legs 1–4 (Fig. 2D–G) biramous with 3-segmented rami. Inner coxal seta in leg 4 rudimentary and naked (Fig. 2G). Apical spines on distal endopodal segment of leg 4 armed with serrate membrane on both sides; inner spine 55 long, outer one 22. Armature formula of legs 1–4 as follows:

Leg 1	coxa 0–1	basis 1–0	exp I–0; I–1; III,I,4
			enp 0–1; 0–1; I, 5
Leg 2	coxa 0–1	basis 1–0	exp I–0; I–1; III,I,5
			enp 0–1; 0–2; I,II,3
Leg 3	coxa 0–1	basis 1–0	exp I–0; I–1; III,I,5
			enp 0–1; 0–2; I,II,2
Leg 4	coxa 0–1	basis 1–0	exp I–0; I–1; II,I,5
			enp 0–1; 0–1; II

Leg 5 (Fig. 1B) consisting of outer basal seta, arising from dorsolateral surface of fifth pedigerous somite, and free segment representing the exopod. Exopod (Fig. 2H) 13 × 8 (1.62:1); inner margin straight, without bulge; distal margin with one spinous process, 1 serrate spine (22 long) and 1 long, naked seta (43 long).

Egg-sacs not observed.

Male. Unknown.

Genus *Phoronicola* Boxshall & Humes, 1988

Phoronicola spinulatus Boxshall & Humes, 1988

Material examined: (1) NHM: holotype ♀ (reg. no. 1987.416; dissected on slide) and 2 paratype ♂♂ (reg.

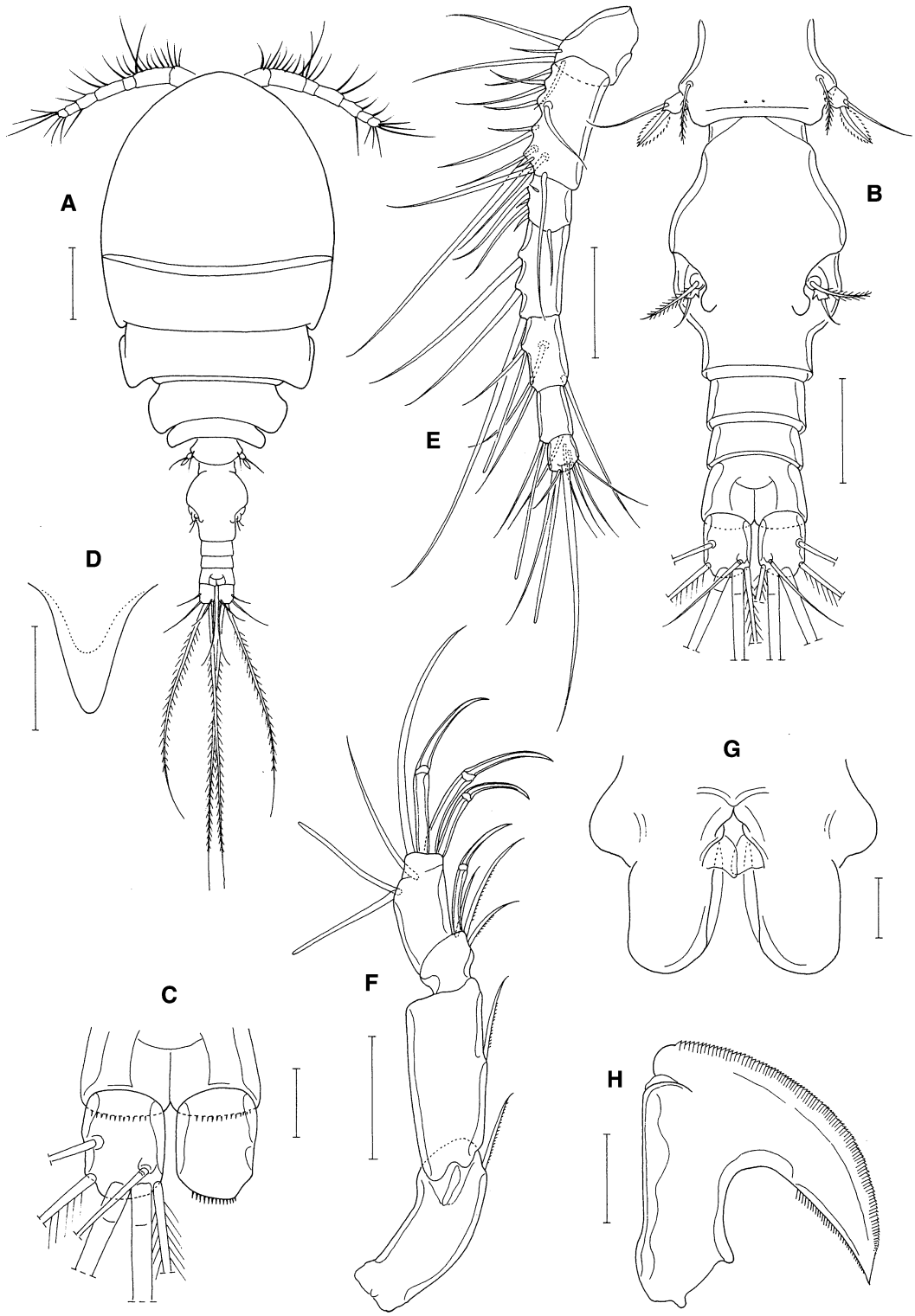


Fig. 1 *Myxomolgus hoi* n. sp. Female (paratype). A, habitus, dorsal; B, urosome, dorsal; C, caudal rami, dorsal; D, rostrum; E, antennule; F, antenna; G, labrum; H, mandible. *Scale-bars*: 100 μm (A); 50 μm (B, D–F); 20 μm (C, G, H)

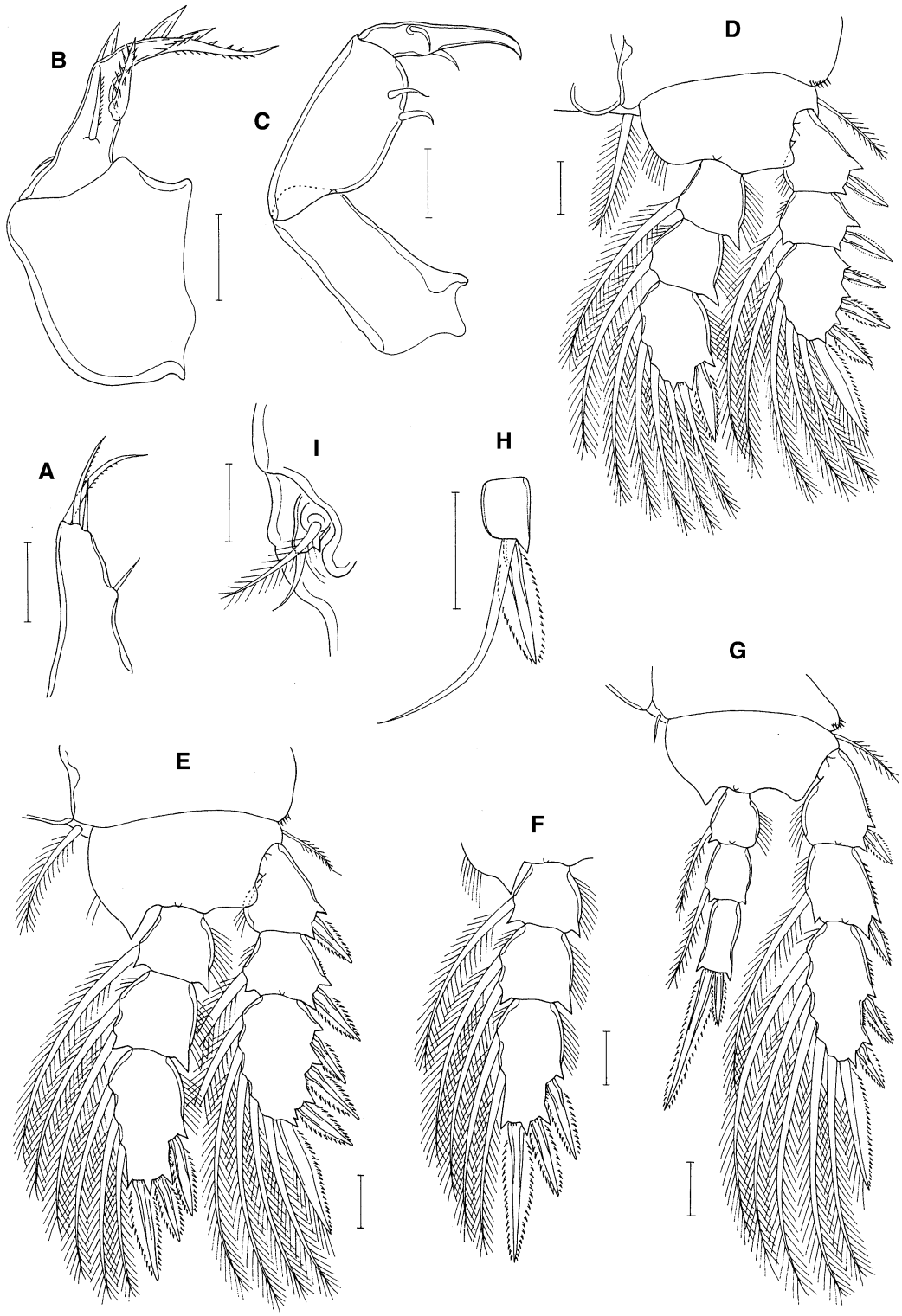
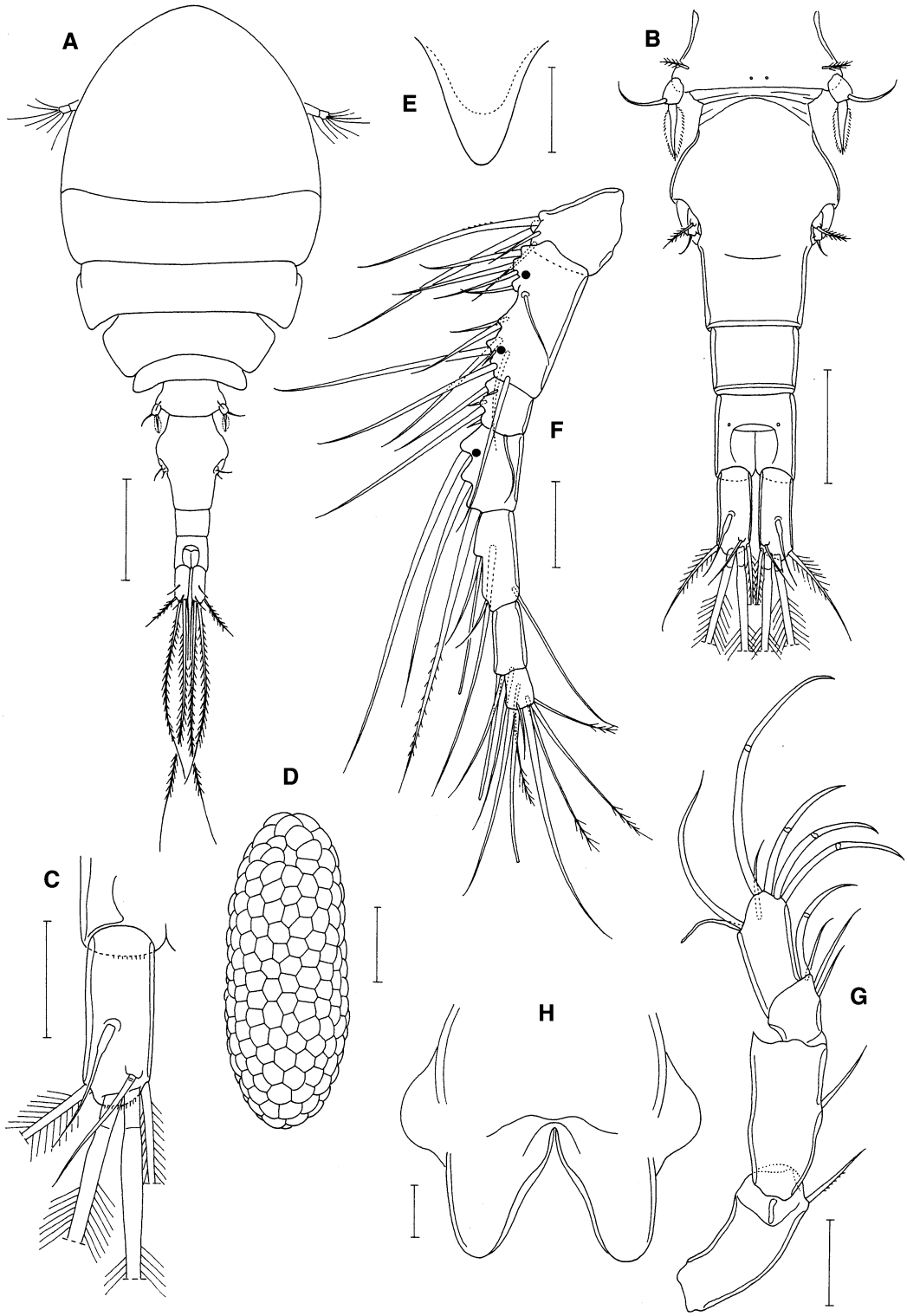


Fig. 2 *Myxomolgus hoi* n. sp. Female (paratype). A, maxillule; B, maxilla; C, maxilliped; D, leg 1; E, leg 2; F, endopod of leg 3; G, leg 4; H, exopod of leg 5; I, genital area. *Scale-bar*: 20 μm



◀ **Fig. 3** *Phoronicola spinulatus* Boxshall & Humes, 1988. Female (New Caledonia). A, habitus, dorsal; B, urosome, dorsal; C, left caudal ramus, dorsal; D, egg-sac; E, rostrum; F, antennule (black dots indicate position of additional aesthetascs in male); G, antenna; H, labrum. *Scale-bars*: 200 μm (A, D); 100 μm (B); 50 μm (C, E–G); 20 μm (H)

nos 1987.417–418; one dissected on slide, one in alcohol); from one *Phoronis australis* Haswell collected at 3–5 m depth in Hoi Sing Wan (Starfish Bay) on the southern shore of Tolo Harbour, New Territories, Hong Kong; 3 April, 1986; collected by P. G. Oliver.

(2) 3 ♀♀ and 2 ♂♂ (1 ♀ and 1 ♂ deposited in MNHN; the remaining specimens are kept in the personal collection of the senior author) from washings of the tentacular crown and mucilaginous tube of one individual of *Pachycerianthus maua* (Carlgren); 2 ♀♀ and 2 ♂♂ (1 ♀ and 1 ♂ dissected and measured; 1 ♀ and 1 ♂ deposited in NHM under Reg. No. 2012.1049–1050) in washings of lophophores of approximately 15 individuals of *Phoronis australis*; both hosts collected by SCUBA diving at 35 m depth in the Chenal de l'Îsle aux Canards, off Nouméa, New Caledonia (22°19.203′S, 166°26.286′E); 06 October 2004; collected by P. Laboute & R. Huys. The redescription below is based on the largest female and male found among the four specimens extracted from *Phoronis australis*.

Redescription (Figs. 3–5)

Female. Body (Fig. 3A) cyclopiform. Length (excluding caudal setae) 1.28 mm and greatest width 553. Length to width ratio of prosome 1.45:1. Ratio of prosome to urosome 1.68:1. Prosome consisting of cephalosome and 4 pedigerous somites. Suture line between cephalosome and first pedigerous somite faint. Urosome (Fig. 3B) 4-segmented, comprising somite bearing leg 5, genital double-somite, free abdominal somite and anal somite. Leg 5 bearing somite 151 wide. Genital double-somite longer than wide, 198 × 149; pleural areas expanded, with greatest width measured at about 2/5 of double-somite length. Genital apertures located dorsolaterally at halfway along double-somite length; each closed off by vestigial leg 6 (Fig. 5B) bearing minute spinous process, 1 naked and 1 plumose seta. Free abdominal and anal somites 61 × 77 and 74 × 71, respectively. Ventral posterior margins of genital double-somite and free abdominal somite smooth, that of anal somite (Fig. 3C) with minute spinules. Caudal ramus (Fig. 3C) subrectangular, 2.62 times longer than wide (76 × 29), with minute spinules on ventral posterior margin and 6 setae; seta II smooth and broadened in proximal part; seta VII smooth with annulations at base; setae III–VI plumose.

Rostrum (Fig. 3E) ventrally deflected and as long as its proximal width.

Antennule (Fig. 3F) 7-segmented, 308 long; armature formula 4, 13, 6, 3, 4 + aesthetasc, 2 + aesthetasc, 7 + aesthetasc; anterodistal seta on fourth segment weakly plumose in distal half; 4 of 7 setae on terminal segment distally plumose.

Antenna (Fig. 3G) 4-segmented, comprising coxobasis and 3-segmented endopod; armature formula: 1, 1, 3 + geniculate claw, 3 + 4 geniculate claws; outer distal angle of first endopodal segment produced and sharply pointed; proximal outer seta on distal endopodal segment weak and blunt at tip; apical claws unequal in length and at least as long as segment.

Labrum (Fig. 3H) bilobate, with deep median incision between lobes; lateral margins produced into round expansions; no ornamentation discernible.

Mandible (Fig. 4A) with tapering blade and moderately short distal lash; proximal notch absent; outer scale represented by acutely pointed hyaline element; convex margin with numerous denticles; inner margin with setules.

Paragnath (Fig. 4B) digitiform with fine setules on 1 side.

Maxillule (Fig. 4C) a small, elongate lobe with 1 short, naked seta along inner margin and 1 minute, naked and 2 longer, pinnate setae apically.

Maxilla (Fig. 4D) 2-segmented, consisting of unarmed syncoxa and distal basis drawn out into long lash. Basis with 3 setae (I–III); seta I slightly longer than half the length of distal lash, with row of fine spinules along both margins; seta II located on anterior surface, with minute spinules along medial margin; seta III small and located proximally on outer margin. Lash with large spinules along outer margin and fine spinules along inner margin.

Maxilliped (Fig. 4E) 3-segmented, consisting of syncoxa, basis and 1-segmented endopod. Syncoxa large, unarmed. Basis expanded, with uneven inner and outer margins and 2 inner setae of equal lengths; proximal seta naked; distal seta spiniform, with minute spinules along both margins. Endopod produced into

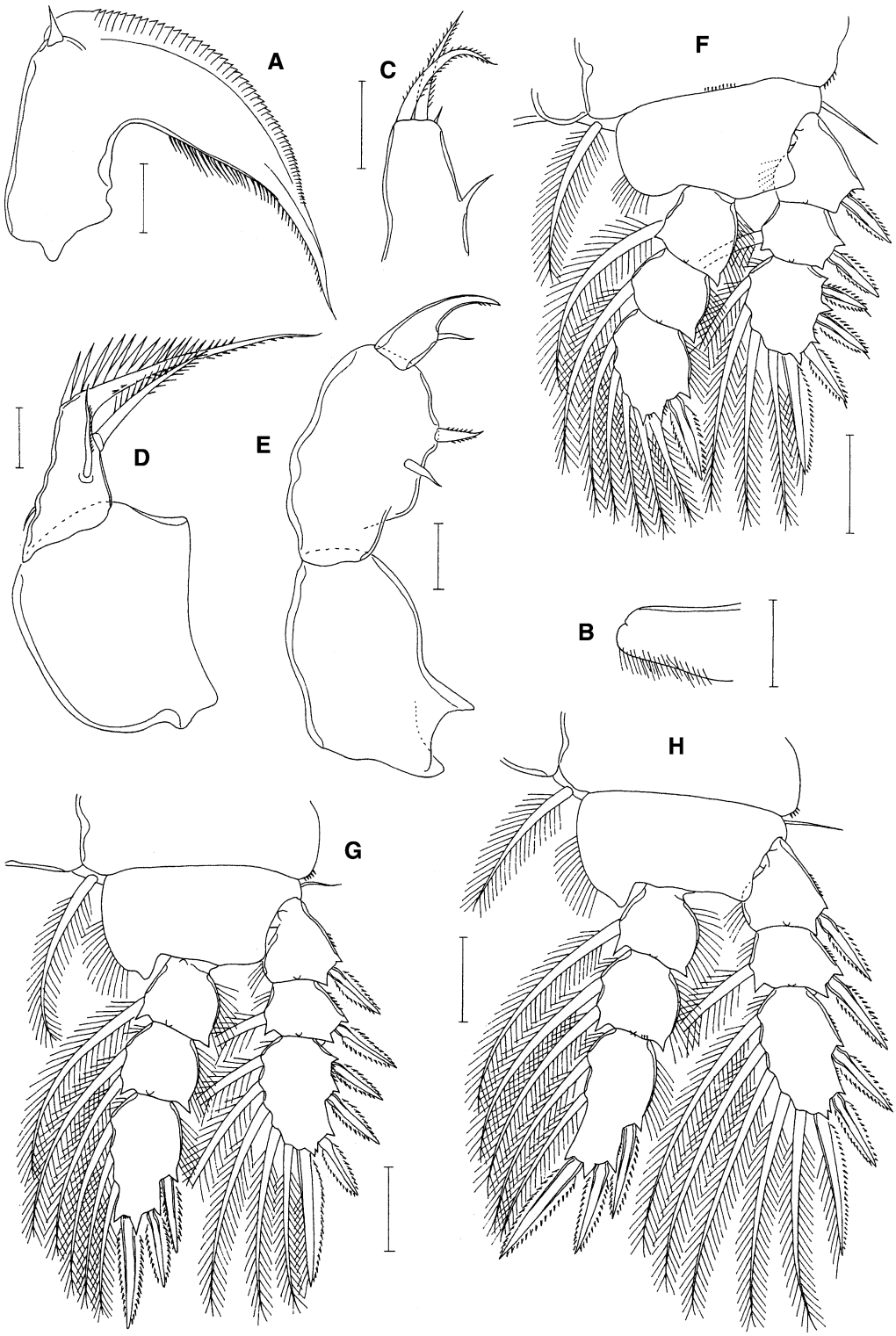


Fig. 4 *Phoronicola spinulatus* Boxshall & Humes, 1988. Female (New Caledonia). A, mandible; B, paragnath; C, maxillule; D, maxilla; E, maxilliped; F, leg 1; G, leg 2; H, leg 3. *Scale-bars*: 20 μm (A–E); 50 μm (F–H)

weakly curved claw bearing about 3 minute subapical spinules; with 1 naked seta along inner margin.

Legs 1–3 (Fig. 4F–H) with 3-segmented rami. Leg 4 (Fig. 5A) with 3-segmented exopod and 1-segmented endopod. Legs 1–3 with large plumose inner coxal seta. Leg 4 without inner coxal seta. Outer seta on basis of legs 1–4 small and naked. Leg 4 endopod 63 × 22; apical spine 86 long. Distal exopodal segment of leg 4 with small notch on outer margin. Armature formula of legs 1–4 as follows:

Leg 1	coxa 0–1	basis 1–0	exp I–0; I–1; III,I,4
			enp 0–1; 0–1; I,5
Leg 2	coxa 0–1	basis 1–0	exp I–0; I–1; III,I,5
			enp 0–1; 0–2; I,II,3
Leg 3	coxa 0–1	basis 1–0	exp I–0; I–1; II,I,5
			enp 0–1; 0–2; I,II,2
Leg 4	coxa 0–0	basis 1–0	exp I–0; I–1; I,I,5
			enp I

Leg 5 (Fig. 5B) consisting of outer basal seta, arising from dorsolateral surface of fifth pedigerous somite, and free exopod. Exopod 26 × 18 (1.44:1), apical margin with dentiform process, 1 serrate spine (46 long) and 1 naked seta.

Egg-sac (Fig. 3D) 866 × 336, containing numerous small eggs.

Male. Body (Fig. 5C) more slender than that of female. Length (excluding caudal setae) 915 and greatest width 342. Length to width ratio of prosome 1.57:1. Urosome 5-segmented; comprising somite bearing leg 5, genital somite, 2 free abdominal somites and anal somite. Genital somite swollen, 211 × 173, with rounded anterior and posterior corners; genital operculum with 2 plumose setae and 1 triangular process, representing leg 6 (Fig. 5H). Two free abdominal somites and anal somite 25 × 54, 31 × 50 and 38 × 54, respectively. Caudal ramus (Fig. 5D) slightly shorter than in female, 55 × 23 (2.39:1).

Rostrum as in female.

Antennule with 3 additional aesthetascs, 2 on second and 1 on fourth segments (position indicated by black dots in Fig. 3F).

Antenna with additional minute spinules on proximal half of inner margin of first endopodal segment.

Labrum (Fig. 5E) with strongly tapering posterior lobes, each terminating in nipple-shaped apex.

Mandible, paragnath, maxillule and maxilla as in female.

Maxilliped (Fig. 5F) consisting of syncoxa, basis and 2-segmented endopod. Syncoxa large, unarmed. Basis with pointed process at about halfway along inner margin; with 2 short, naked setae, 1 long longitudinal row of strong spinules and additional short longitudinal row of smaller spinules. First endopodal segment short and unarmed. Second endopodal segment forming large and strongly curved claw, bearing row of spinules along proximal 2/3 of concave margin; basal part with 1 large, pinnate seta and 1 small, naked seta.

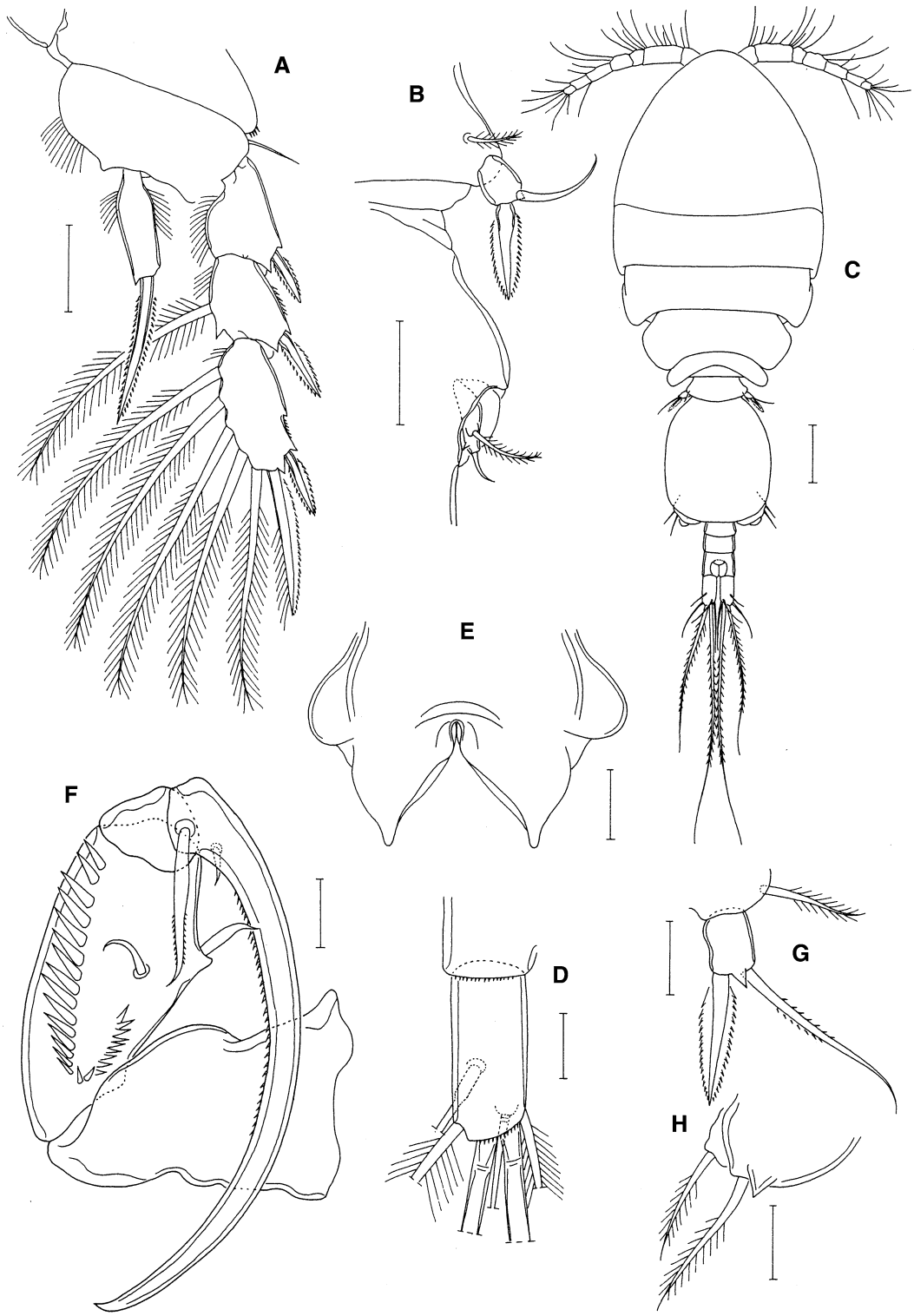
Legs 1–4 as in female.

Leg 5 similar to that of female; exopod 22 × 13 (1.69:1); distal spine 35 long.

Discussion

Myxomolgus currently contains three species, all of which are associates of sabellid polychaetes belonging to *Myxicola* Koch in Renier. The type-species, *Myxomolgus myxicolae* (Bocquet & Stock, 1958), has been recorded from Plymouth (UK), Brittany (France) and Lough Hyne, Co. Cork (Ireland), and is associated with *Myxicola infundibulum* (Montagu) (Bocquet & Stock, 1958; Bocquet et al., 1963; Holmes & Gotto, 1992). *Myxomolgus proximus* Humes & Stock, 1973 was described from a single female obtained from the mucous tube of *Myxicola aesthetica* (Claparède) and collected off Brittany; it has not been recorded again since its original description by Humes & Stock (1973). Kim (2001) described a third species, *Myxomolgus invulgus* Kim, 2001, from Daechon beach along the Yellow Sea coast of Korea; its host was an unidentified *Myxicola* species.

The swimming leg armature is remarkably conservative within the genus, the only notable exception being the variation observed in the number of outer spines on the distal exopodal segment of leg 4 (Table 1). Kim's (2001) claim that legs 2–3 display an identical armature formula in *Myxomolgus invulgus* is an inadvertent slip of the pen; in reality, the distal endopod segment of leg 3 has only two inner setae (I,II,2), as in the other species of the genus. It should also be noted that Bocquet & Stock (1958) had originally used an aberrant female for the armature formula of the leg 1 exopod of *M. myxicolae*. Bocquet



◀**Fig. 5** *Phoronicola spinulatus* Boxshall & Humes, 1988. A–B, Female (New Caledonia). A, leg 4; B, right leg 5 and genital aperture, dorsal. C–H, Male (New Caledonia). C, habitus, dorsal; D, right caudal ramus, ventral; E, labrum; F, maxilliped; G, left leg 5; H, right leg 6. *Scale-bars*: 50 μm (A–B); 100 μm (C); 20 μm (D–H)

et al. (1963) pointed out that the normal condition for the distal segment is III,I,4 rather than III,I,3; this is also the pattern found in all other sabelliphilid genera. Humes & Stock (1973) caused confusion by stating "Instead of I-0;I-1;II,I,3 for the exopod, one usually finds I-0;I-1;II,I,4, as has been corrected by Bocquet, Stock, and Kleeton (1963: 31)". The new species, *M. hoi* n. sp. shares with *M. proximus* and *M. invulgus* the armature formula (II,I,5) of the distal exopodal segment of leg 4 but can readily be distinguished from these congeners by the markedly longer terminal geniculate claws on the antenna, the presence of four setae on the maxillule, the vestigial inner coxal seta of leg 4, the different shape of the female genital double-somite and the significantly shorter caudal rami (Table 1). *Myxomolgus hoi* n. sp. appears most closely related to its only known Pacific congener, *M. invulgus*, in lacking the strong denticulate spines on antennulary segments 1–2, the presence of closely set, fine teeth along the convex margin of the mandibular blade, and the absence of a proximal bulbous protrusion along the inner margin of leg 5 exopod. However, *M. invulgus* differs from the New Caledonian species in the following characters: (1) the rostrum is directed anteriorly and discernible in dorsal aspect; (2) the posterior margin of the genital double-somite and first two abdominal somites have crenate, membranous extensions; (3) the anterolateral extensions of the genital double-somite are much more pronounced; (4) the caudal rami are distinctly longer (L:W ratio 2.3 *vs*

Table 1 Morphological characters differentiating *Myxomolgus* spp.

	M. myxicolae	*M. proximus*	*M. invulgus*	*M. hoi* n. sp.
Rostrum	Ventrally deflected	Ventrally deflected	Anteriorly directed	Ventrally deflected
Strong denticulate spines on antennulary segments 1–2	Present	Present	Absent	Absent
Aesthetascs on antennulary segment 2 ♀	Absent	Absent	Present (2)	Absent
Proximal seta on middle endopodal segment of antenna	Vestigial	Vestigial	Vestigial	Well developed
Antenna terminal geniculate claws *vs* length enp-3	Shorter	Shorter	Shorter	Longer
Mandible convex margin	With widely separated, strong teeth	With widely separated, strong teeth	With closely set, fine teeth	With closely set, fine teeth
Maxillule armature	2 setae	3 setae	3 setae	4 setae
Leg 4 exp-3 armature	II,I,4	II,I,5	II,I,5	II,I,5
Leg 4 inner coxal seta	Well developed	Well developed	Well developed	Vestigial
Leg 5 exopod ♀ L:W ratio	2.2	1.6	1.5	1.6
Leg 5 exopod ♀ inner bulge	Present	Present	Absent	Absent
Ventral posterior margin of GDS and Abd 1–2	With 4–6 weak, sclerotised teeth	With 5–7 strong, sclerotised teeth	With crenate, membranous extensions	Smooth
Caudal ramus L:W ratio	2.4	2.5	2.3	1.3
Body size ♀ (μm)	1300	1160	1270	750–763
Distribution	NW France, England, Ireland	NW France	Korea (Yellow Sea)	New Caledonia
Host(s)	*Myxicola infundibulum*	*Myxicola aesthetica*	*Myxicola* sp.	*Phoronis australis* and/or *Pachycerianthus maua*

Abbreviations: exp(enp)-2, 3, middle, distal segment of exopod (endopod); GDS, genital double-somite ♀; Abd 1–2, first two abdominal somites ♀

Table 2 Morphometric differences between the type-specimens and the New Caledonian material of *Phoronicola spinulatus*

	Hong Kong population (Boxshall & Humes, 1988)	New Caledonian population (Present study)
Body length	♀: 1.17 mm	♀: 1.28 mm
	♂: 1.04 mm	♂: 0.92 mm
Caudal ramus L × W	♀: 84 × 28 μm (3.0:1)	♀: 76 × 29 μm (2.62:1)
	♂: 56 × 20 μm (2.8:1)	♂: 55 × 23 μm (2.39:1)
Endopod of leg 4 ♀ L	42 μm (spine L: 62 μm)	63 μm (spine L: 86 μm)
Exopod of leg 5 ♀ L × W	21 × 18 μm (1.20:1) (spine L: 49 μm)	26 × 18 μm (1.44:1) (spine L: 46 μm)
Exopod of leg 5 ♂ L × W	17 × 10 μm (1.70:1) (spine L: 49 μm)	22 × 13 μm (1.69:1) (spine L: 35 μm)

Abbreviations: L, length; W, width

1.3); (5) the antennule is shorter and more condensed (a trend also observed in the antenna), with segment 2 displaying two aesthetascs and a strong spiniform element in both sexes; (6) the proximal seta of the middle endopodal segment of the antenna is vestigial; (7) the maxillule has three elements; (8) leg 4 has a well-developed, plumose inner coxal seta (instead of naked and vestigial); (9) the inner setae of the proximal and middle endopodal segments are distinctly longer; (10) the inner distal spine of the distal endopodal segment is 2.1 times the length of the outer distal spine (2.5 in *M. hoi* n. sp.); and (11) its large body size (1,270 *vs* 763 μm).

Comparison of the New Caledonian specimens of *Phoronicola spinulatus* with the type-material from Hong Kong revealed a number of differences, some of which can be attributed to observational errors in the original description: (1) the formula of the second antennulary segment in the male is 13 + 2 aesthetascs and not 12 + 1 aesthetasc, as described by Boxshall & Humes (1988); the distal aesthetasc is missing from their figure 1D; (2) the second endopodal segment of the antenna has three setae and one geniculate claw; Boxshall & Humes (1988) figured four setae in addition to the claw but this is an error, since no poecilostomatoid copepod has more than four elements on this segment (Huys & Boxshall, 1991); (3) the observed disparity in the mandibular morphology appears to be unreal; in the New Caledonian material the convex margin carries a spiniform outer scale which is also present in the dissected male paratype (NHM reg. no. 1987.416); the short row of fine spinules figured by Boxshall & Humes (1988) could not be observed; (4) the maxillule has four elements instead of three and the two long apical setae are pinnate instead of smooth; the vestigial apical seta was overlooked in the original description; and (5) the male leg 6 has two setae and one dentiform process; Boxshall & Humes (1988) illustrated only a single seta on this leg. A few morphometric differences exist between the two populations (summarised in Table 2), but we consider these as insufficient to attribute separate specific status to the New Caledonian material.

Members of the nine sabelliphilid genera are typically associated with tubicolous polychaetes belonging to the families Sabellidae (*Myxomolgoides* Humes, 1975; *Myxomolgus*; *Nasomolgus* Sewell, 1949; *Sabelliphilus* M. Sars, 1862), Serpulidae (*Serpuliphilus* Humes & Stock, 1972; *Acaenomolgus* Humes & Stock, 1972) and Terebellidae (*Eupolymniphilus* Humes & Boxshall, 1996; *Terebelliphilus* Kim, 2001). Some species of *Eupolumniphilus* have been recorded from invertebrate burrows (mostly of polychaetes and decapods) off Korea (Kim, 2006), from washings of sponges and compound ascidians off Jamaica (Kim, 2009) and from the stoloniferan coral *Tubipora musica* Linn. off Madagascar (Kim, 2009). Unlike *Sabelliphilus elongatus* M. Sars, 1862, which attaches itself to the radioles or filaments of the host's pseudobranchial fan (Gotto, 1970; Bocquet & Stock, 1964a,b), representatives of *Myxomolgus* typically live embedded in the successive layers of the mucous tube secreted by their sabellid hosts. Bocquet & Stock (1958) suggested that the mucoproteins of the tube probably constitute the most significant part of the copepod's nutrition. The precise microhabitat of the sabelliphilid copepods reported here has not yet been determined. Emig et al. (1972) made a detailed study of the tube wall of *Pachycerianthus maua* and found that it consists of five distinct layers. Its symbiont, *Phoronis australis*, makes its own tube and invariably has its ampulla situated in the stratified fourth mucus layer of the cerianthid tube wall and the lophophore projecting externally. The phoronid tube is of a different nature and consists of acid mucopolysaccharides

as in other phoronids. The relatively low number of specimens of *Phoronicola spinulatus* recovered from washings of the lophophores (and its presence on *Pachycerianthus maua*) suggests that its real host is a ceriantharian rather than a phoronid. It is conceivable that both *P spinulatus* and *Myxomolgus hoi* n. sp. live and feed on/inside the mucilaginous cerianthid tube rather than on the lophophore or tentacular crown of their respective hosts. The only other copepod recorded from a ceriantharian host is the large-sized (4 mm) *Boholia cerianthiphila* Kossmann, 1877, which was described from an unidentified tube anemone off Bohol Island in the Philippines. Unlike *M. hoi*, *B. cerianthiphila* does not live embedded in the tube wall but attaches itself to the mesenteries of the host (Kossmann, 1877). The position of *Boholia* within the Lichomolgoidea is uncertain (Humes & Stock, 1973) and the genus is currently classified as a *genus inquirendum* (Boxshall & Halsey, 2004).

The identification of the ceriantharian host has to be considered provisional. Laboute & Richer de Forges (2004) had previously documented the presence of *Pachycerianthus maua* (as *Cerianthus maua*) in New Caledonian waters; however, Molodtsova (2007) regarded all records of this species in the Western Indo-Pacific as doubtful, since none of them was supported by morphological or anatomical evidence. *Pachycerianthus maua* was originally described from off Zanzibar (Carlgren, 1900) and appears to be restricted to the western part of the Indian Ocean, from the Red Sea to Madagascar. It is possible that the New Caledonian records in reality refer to *P. nobilis* (Haddon & Shackelton, 1894), which assumes a wide distribution in the Pacific and is also known to serve as a host to *Phoronis australis* (see Molodtsova, 2007).

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