

Three new species of the genus *Macandrewella* (Copepoda: Calanoida: Scolecitrichidae) from the Pacific Ocean, with notes on distribution and feeding habits

SUSUMU OHTSUKA†, SHUHEI NISHIDA‡ and
KAZUMITSU NAKAGUCHI†

†*Faculty of Applied Biological Science, Hiroshima University,
1-4-4 Kagamiyama, Higashi-Hiroshima 739-8528, Japan;
e-mail: ohtsuka@hiroshima-u.ac.jp*

‡*Ocean Research Institute, University of Tokyo, 1-15-1 Minamidai,
Nakano, Tokyo 164-8639, Japan*

(Accepted 16 October 2000)

Two new species of the little-known scolecitrichid genus *Macandrewella* are described from southern Japan. *Macandrewella chelipes sensu* Wilson (1950) from the southern Pacific is also revealed to be new to science. The generic diagnosis is partly emended. *Macandrewella* seems to be distributed exclusively in the hyperbenthic zone of the tropical/subtropical Indo-Pacific region. A gut content analysis of the two new species from Japan disclosed that *Macandrewella* is a specialized detritivore, feeding mainly on small crustacean carcasses and/or sloughs, whereas other scolecitrichids are general detritivores. This specialization in feeding may be associated with the presence of a single cephalic lens in species of the genus.

KEYWORDS: Calanoida, *Macandrewella*, hyperbenthic, detritivore, lens.

Introduction

Recently, hyperbenthic copepod communities in the world oceans have drawn much attention, partly because several primitive groups such as the Platycopioidea are distributed exclusively in this zone (Huys and Boxshall, 1991; Ohtsuka *et al.*, 1998a), and partly because insufficient systematic and ecological surveys have been carried out there. In the order Calanoida several exclusively benthic taxa are known. In shallow waters, the Arietellidae (the genera *Paramisophira* and *Metacalanus*), Pseudocyclopidae, Pseudocyclopiidae, Ridgewayiidae and Stephidae are common members (e.g. Sars, 1903, 1921; Bowman and González, 1961; Fosshagen, 1968a, 1968b, 1970a, 1970b; Ohtsuka, 1983, 1985, 1992; Ohtsuka and Hiromi, 1987; Othman and Greenwood, 1988, 1989, 1994; Ohtsuka *et al.*, 1991, 1994, 1996, 1999; Barthélémy *et al.*, 1998). On the other hand, deep-water calanoid communities are composed of totally different taxa such as the Aetideidae, Arietellidae (the genera *Campaneria*,

Crassarietellus and *Scutogerulus*), Hyperbionychidae, Phaennidae, Scolecitrichidae and Tharybidae (Bradford, 1969; Grice and Hulsemann, 1970; Grice, 1973; Ohtsuka *et al.*, 1993, 1998b; Nishida *et al.*, 1999).

During our investigation of hyperbenthic copepods in continental waters of the Nansei Islands, southern Japan, two rarely known scolecitrichid genera, *Macandrewella* and *Scolecocalanus* were discovered for the first time in Japan. These genera have hitherto accommodated only eight and three species, respectively. The family Scolecitrichidae is distributed mainly in deep waters, and is characterized by specialized sensory setae on the maxillae and maxillipeds, which are presumed to play an important role in detection of detrital food (Ohtsuka and Kubo, 1991; Nishida and Ohtsuka, 1997). In addition, these two genera possess an optical sensor, i.e., a single cephalic cuticular lens, of unknown function. The present paper describes two new species of *Macandrewella*, with notes on their distribution and feeding habits. As for *Scolecocalanus*, only three species have so far been described, two of which were described on the basis of females only (Farran, 1936; Wilson, 1950). Although two adult males of the genus were captured during the present survey, their descriptions are pending until females are discovered.

Macandrewella chelipes sensu Wilson (1950) from the southern Pacific differed from the original, and additional descriptions of the species from the Indian Ocean. Wilson's (1950) specimens are deposited at the National Museum of Natural History, Washington DC; we carefully re-examined them, and have come to the conclusion that it is new to science.

Materials and methods

Copepods were collected from the hyperbenthic zone in Okinawa, southern Japan (figure 1). Table 1 shows the sampling dates, localities and depths, and collection gears (cf. Ohtsuka *et al.*, 1992). Samples were fixed with 10% neutralized formalin/sea-water immediately after collection.

The fine structure of the fifth legs of both sexes of the two new species described from Okinawa was examined with a scanning electron microscope (SEM, Jeol T-20). Gut content analysis performed with scanning electron microscopy follows Ohtsuka *et al.* (1999).

Type specimens of the two new species from the Nansei Islands, southern Japan, are deposited at the Natural History Museum and Institute, Chiba (CBM-ZC). Types of another new species previously known as *Macandrewella chelipes sensu* Wilson (1950) are deposited at the National Museum of Natural History, Washington, DC (USNM). Terminology follows Huys and Boxshall (1991).

Description

Family SCOLECITRICHIDAE Giesbrecht, 1892 Genus *Macandrewella* Scott, 1909

Diagnosis (emend.). Calanoida. Scolecitrichidae. Cephalosome fused to first pediger. Rostrum bifurcate, bearing pair of long filaments at tip. Single distinct cuticular lens present at base of rostrum. Anteromedial crest-like plate absent on cephalosome. Fourth and fifth pedigers fused. Last prosomal somite carrying one or two pairs of acute or lobate processes in female, and pair of short, pointed prominences in male. Urosome four-segmented, at most one-third as long as prosome

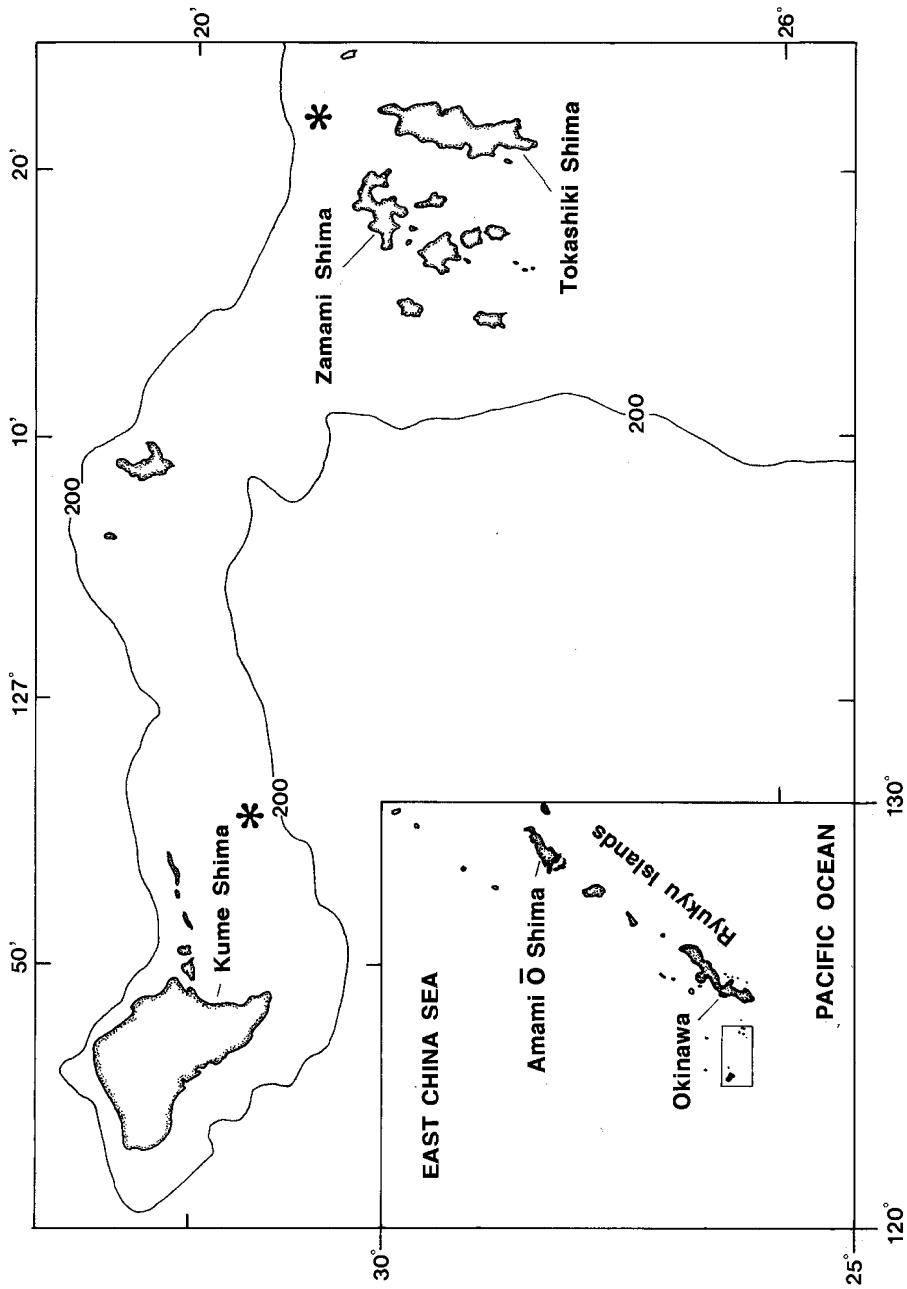


FIG. 1. Location of sampling stations. Asterisks: sampling stations. 200: isobaths of 200 m.

in female, and five-segmented in male, with anal somite almost telescoped into preceding somite. Caudal setae symmetrical or asymmetrical in female. Antennule composed of 23 free segments in female; male antennules asymmetrical, 18-segmented on right side, 19-segmented on left side. Maxillary endopod bearing three worm-like and five brush-like sensory setae. Mouthparts of male similar to those of female, but with some elements on mandibular palp slightly more reduced. Terminal elements of maxillipedal endopod more developed in male than in female. Strong processes present on posterior surface of endopods of legs 2 and 3 in both sexes. Female right/left leg 5 present or absent. Male leg 5 highly developed, both biramous; right exopod three-segmented, left two-segmented; endopods uni-segmented. Second exopodal segment of right leg forming distinct chela with third segment, bearing inner thumb-like process. Third exopodal segment of left leg armed with two membranous elements terminally.

Remarks. Scott (1909) established the genus *Macandrewella* accommodating *M. joanae*, and transferred *Scolecithrix chelipes* Giesbrecht, 1896 into this genus. The genus is clearly distinguishable from other scolecitrichid genera by the combination of the following characters: the presence of a single cephalic lens; the highly developed male leg 5 with the second and third exopodal segments of the right leg forming a chela.

Later, Farran (1936) created a closely related genus *Scolecocalanus* with a single cephalic lens at the rostral base. Main differences between *Macandrewella* and *Scolecocalanus* are as follows (see Campaner, 1989): an anterior crest-like cephalic expansion present in *Scolecocalanus* and absent in *Macandrewella*; the female fifth legs are two-segmented with a common base or absent in *Macandrewella*, whereas in *Scolecocalanus*, the left leg is uni-segmented with a stout terminal spine and the right leg is reduced. In addition, the rostral filaments are long and slender in *Macandrewella* but short and thick in *Scolecocalanus*. The only known male of *Scolecocalanus* is *S. spinifer* Wilson, 1950, in which the two-segmented exopod of the right leg 5 does not form a chela.

The asymmetry of the male antennules of *Macandrewella* was first mentioned by Gopalakrishnan (1973), which is confirmed in the three new species described herein.

Type species. *Macandrewella joanae* Scott, 1909 (monotypy).

***Macandrewella stygiana* new species**
(figures 2, 3A, 4–7, 8A–J, 9)

Material examined. Off Tokashiki Shima Is., 31 May 1999: 8♀♀ and 17♂♂.

Types. HOLOTYPE: 1♀, appendages dissected and mounted on glass slides, body in vial, CBM-ZC 5691. PARATYPES: 1♀ and 2♂♂, appendages dissected

Table 1. Locality, depth, date, time and gear used for collection of two new species of *Macandrewella* from southern Japan.

Locality	Depth (m)	Date	Time	Gears
Off Kume Shima Island (26° 17.9'N, 126° 54.2'E)	167	23 May 1989	0824-0858	Sledge-net ^a
Off Tokashiki Shima Island (26° 15.8'N, 127° 21.9'E)	95–115	31 May 1999	1225-1300	Sledge-net ^a

^a Mouth area: 1450×326 mm; mesh size: 0.33 mm (see Ohtsuka *et al.* 1992).

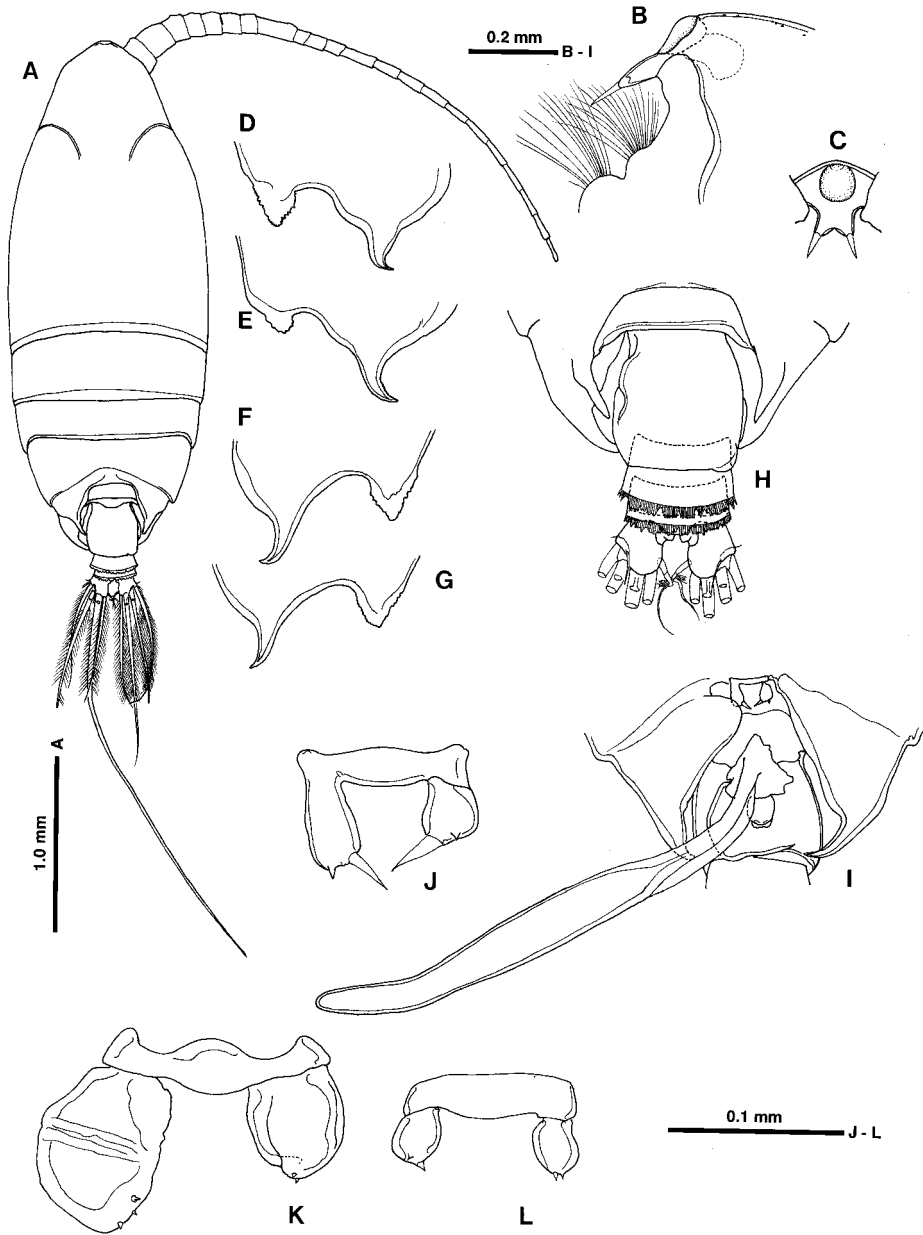


FIG. 2. *Macandrewella stygiana*, n. sp., female (holotype: A–D, F, H–J; paratypes: E, G, K, L). (A) Habitus, dorsal view. (B) Rostrum, lateral view. (C) Rostrum, ventral view. (D, E) Prosomal end, right lateral view. (F, G) Prosomal end, left lateral view. (H) Urosome, dorsal view. (I) Fifth pediger and genital double-somite, ventral view. (J–L) Leg 5, anterior surface.

and mounted on glass slides, body in vials, CBM-ZC 5692–5694; 2♀♀ and 4♂♂, whole specimens, CBM-ZC 5695.

Body length. ♀: 3.23–3.84 mm (mean \pm SD = 3.45 \pm 0.26 mm, n = 6). ♂: 3.25–3.81 mm (3.55 \pm 0.21, n = 6).

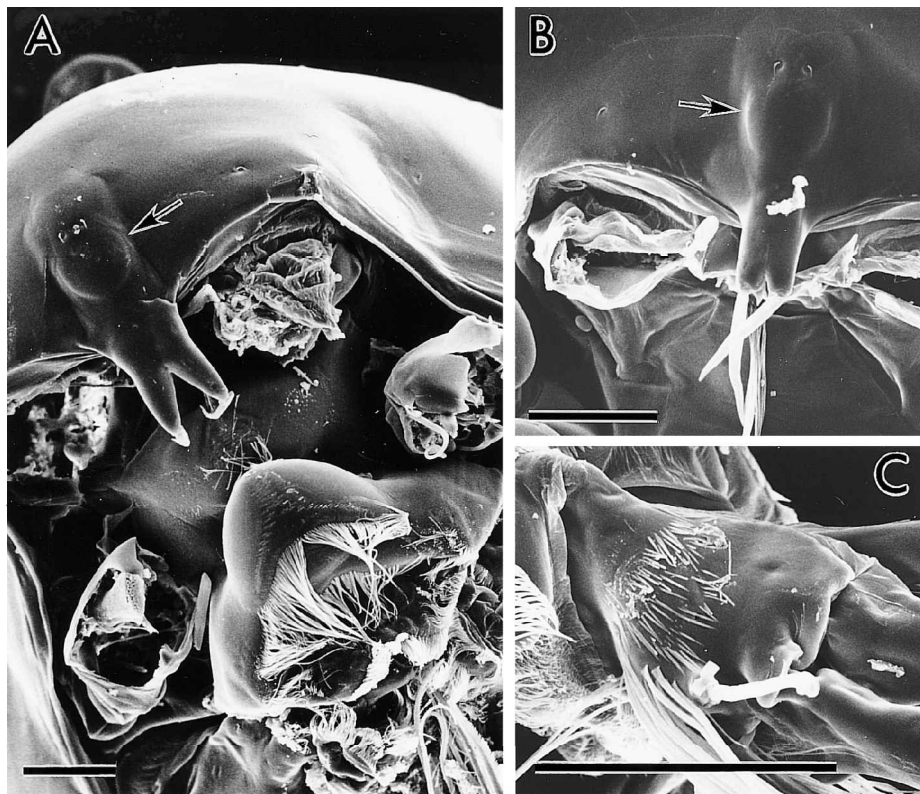


FIG. 3. SEM micrographs of *Macandrewella stygiana*, n. sp., female (A) and *M. omorii* n. sp., male (B, C). (A) Rostrum and labrum, ventral view, cuticular lens indicated by arrow. (B) Rostrum, ventral view, cuticular lens indicated by arrow. (C) Caudal ramus, ventral view. Scales = 0.1 mm.

Description. *Female:* Body (figure 2A) robust. Cephalosome completely fused to first pediger, protruding anteroventrally into bifurcate rostrum; rostrum (figure 2B, C) with pair of slender filaments; single median cuticular convex lens (figure 2B, C) present at base of rostrum (see also figure 3A, arrowed). Fifth pediger almost fused with preceding somite, with suture visible dorsally and ventrolaterally; posterior margin (figure 2A, D–G, H, I) asymmetrical, with two pairs of processes, dorsolateral projections lamellar, with serrate margin, ventrolateral processes curved ventromedially at tip, nearly reaching posterior end of genital double-somite; right ventrolateral margin produced medially into round lobe partially covering leg 5 (figure 2I; see also figure 4A).

Urosome (figure 2H, I) short, approximately one-fifth as long as prosome; genital double-somite over half length of urosome. Genital double-somite asymmetrical, with anterodorsal swelling on left side (figure 2H) and posterodorsal protrusion on right side (figure 2H); genital area covered by attachment disc of simple sausage-like spermatophore (compare with figure 11A, C, D, G in *M. omorii*) in some paratypes (figure 2I); single genital operculum located midway. Second and third urosomites with striated posterior margin; fourth urosomite (anal somite) almost telescoped into preceding somite. Caudal rami (figure 2A, H) almost symmetrical except for setae V in which left seta is much longer and thicker than right seta; seta

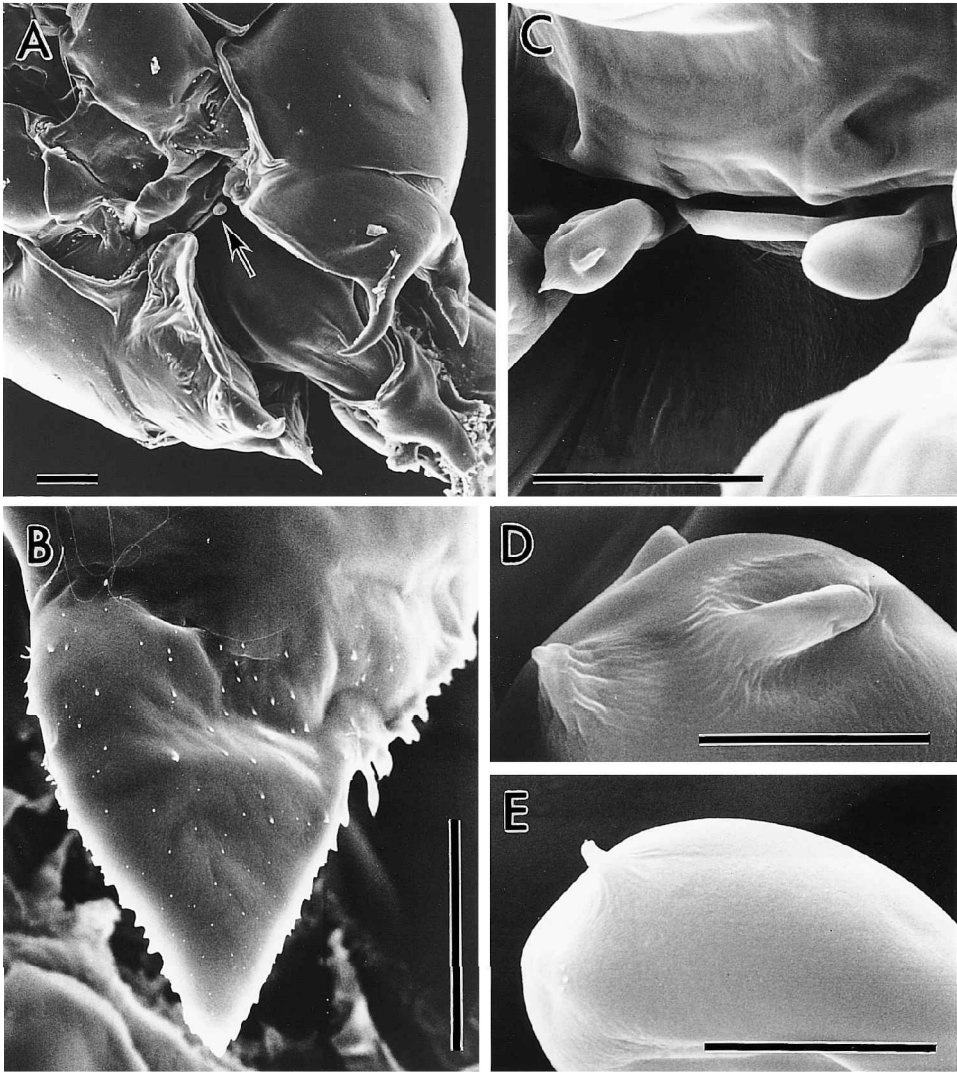


FIG. 4. SEM micrographs of *Macandrewella stygiana*, n. sp., female. (A) Prosomal ends and leg 5, ventral view, leg 5 indicated by arrow. (B) Dorsolateral process of prosomal end, lateral view. (C) Leg 5. (D) Terminal portion of right leg 5. (E) Terminal portion of left leg 5. Scales = 0.1 mm (A); 0.05 mm (B, C); 0.01 mm (D, E).

I minute; seta II located dorsally near base of seta IV; seta VII originating from inner ventrolateral side, bent outward.

Antennule (figure 5A, B) consisting of 23 free segments, reaching nearly to prosomal end. Fusion pattern and armature elements as follows: I-3, II-IV-6+ ae (II-2, III-2+ ae, IV-2; one seta on IV missing in figure 5A), V-2+ ae (one seta missing), VI-2, VII-2+ ae (two setae missing), VIII-2, IX-2+ ae, X-XII-4+ ae, XIII-1, XIV-2+ ae, XV-1 (missing), XVI-2+ ae, XVII-1 (missing), XVIII-1 (missing), XIX-1, XX-2, XXI-1+ ae, XXII-1, XXIII-1, XXIV-1+1, XXV-1+1, XXVI-1+1, XXVII-XXVIII-5+ ae (including two rudimentary setae). Distal seta on tenth segment spiniform; two anterior setae on terminal segment vestigial. Antenna

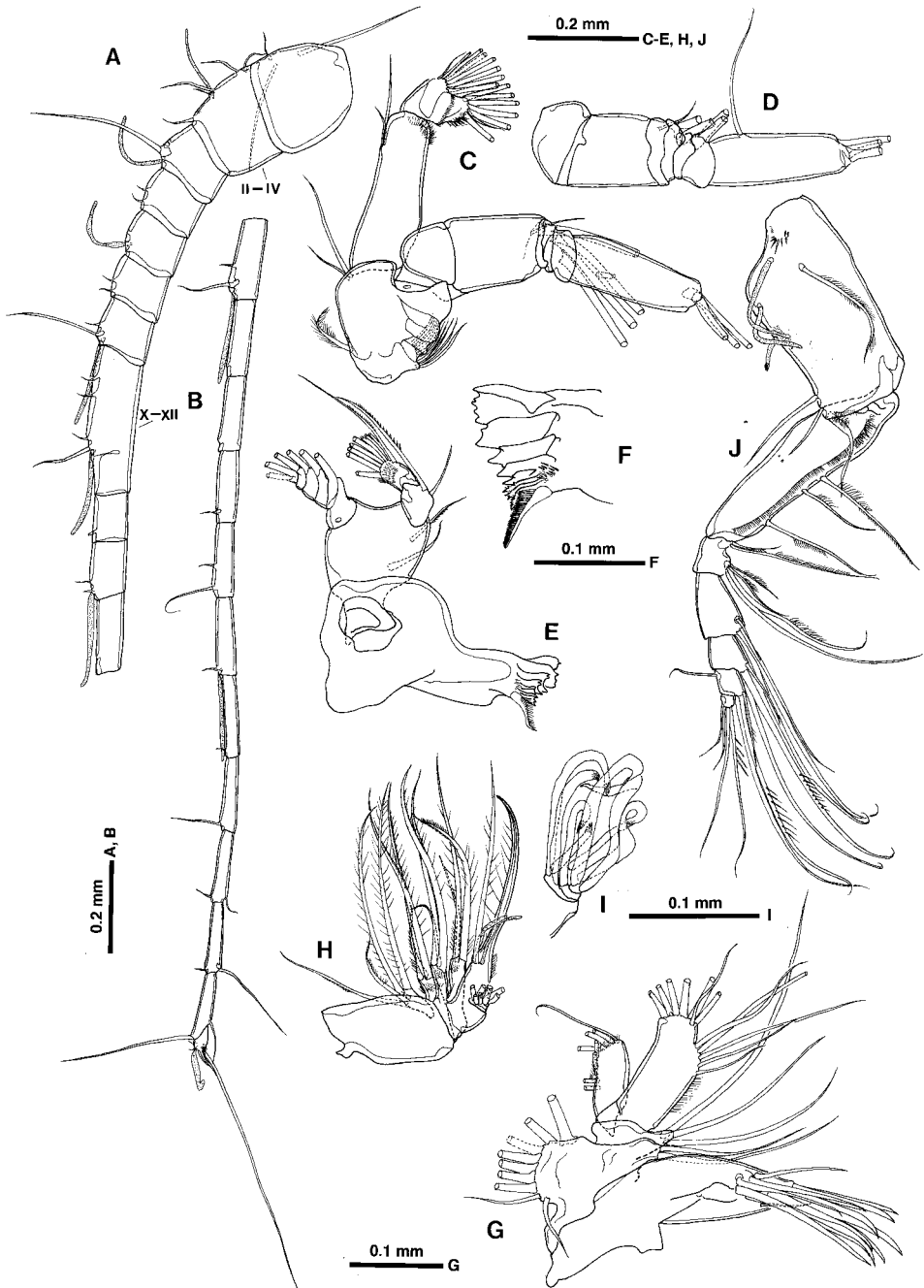


FIG. 5. *Macandrewella stygiana*, n. sp., female (holotype). (A) Antennular segments I to XV. (B) Antennular segments XVI to XXVII-XXVIII. (C) Antenna. (D) Antennary exopod. (E) Mandible. (F) Mandibular cutting edge. (G) Maxillule. (H) Maxilla. (I) Maxillary endopod. (J) Maxilliped.

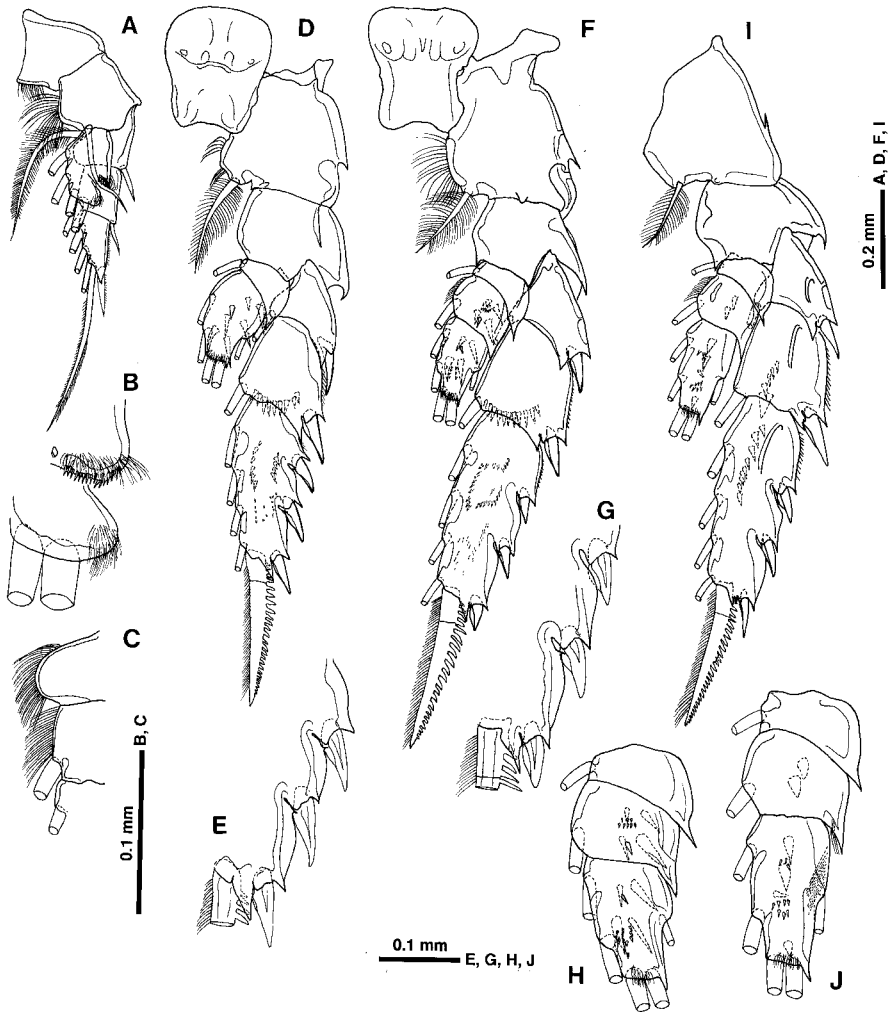


FIG. 6. *Macandrewella stygiana*, n. sp., female (holotype). (A) Leg 1, anterior surface. (B) Outer distal margin of endopod of leg 1, anterior surface. (C) Inner margin of first and second exopodal segments of leg 1. (D) Leg 2, anterior surface. (E) Outer margin of third exopodal segment of leg 2, anterior surface. (F) Leg 3, anterior surface. (G) Outer margin of third exopodal segment of leg 3, anterior surface. (H) Endopod of leg 3, anterior surface. (I) Leg 4, anterior surface. (J) Endopod of leg 4, anterior surface.

(figure 5C, D) with coxa bearing plumose inner seta and outer row of setules; basis with two inner setae of unequal length; endopod two-segmented, proximal segment bearing two setae subterminally and patch of fine setules terminally, distal segment with eight setae (one missing in figure 5C) on middle lobe and seven setae on terminal lobe; exopod indistinctly seven-segmented, setal formula 0,1,1,1,1,1,1+3. Mandible (figure 5E, F) with heavily sclerotized gnathobase bearing spinulose seta and eight teeth, five of which are flattened with broad edge, and others with minute, acutely pointed prominences at tip; basis bearing two spinulose inner setae; endopod

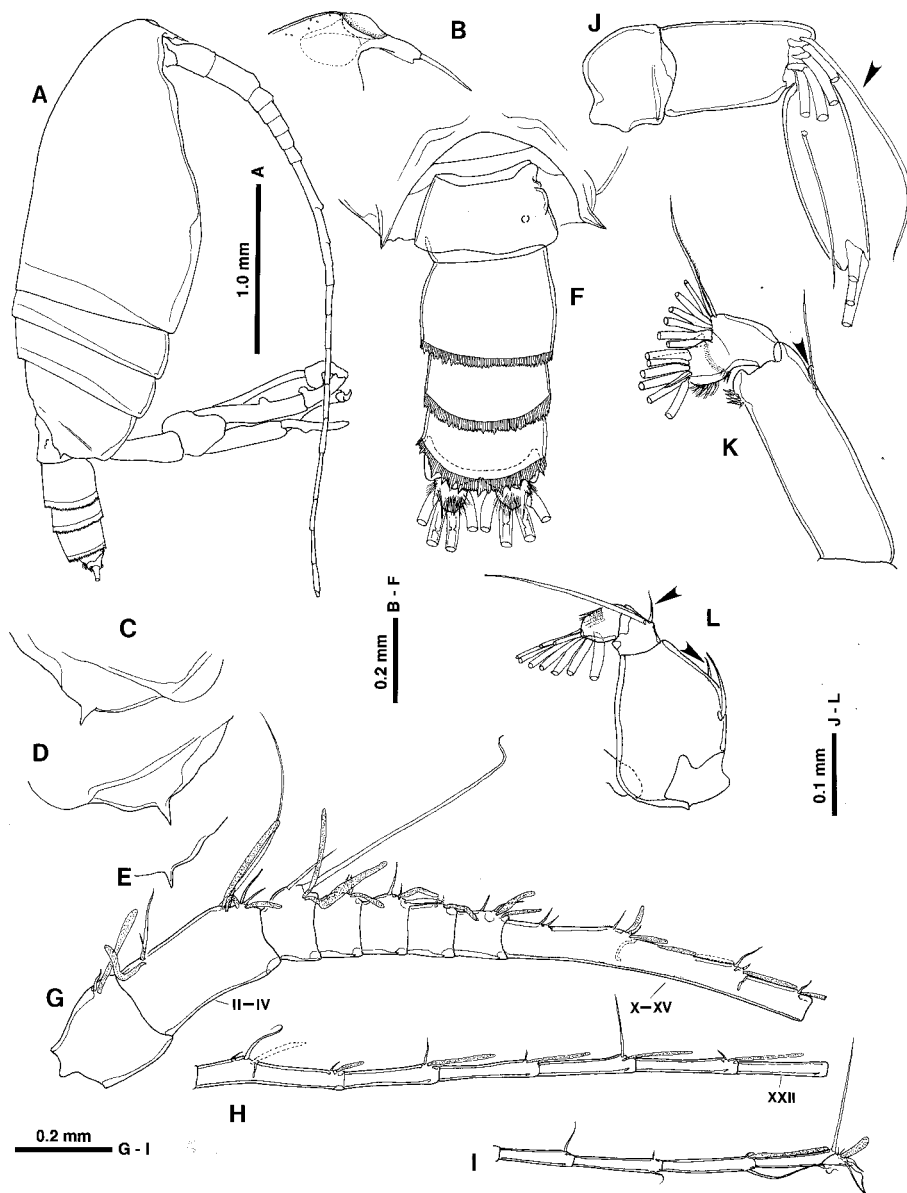


FIG. 7. *Macandrewella stygiana*, n. sp., male (paratypes). (A) Habitus, lateral view. (B) Rostrum, lateral view. (C) Prosomal end, right lateral view. (D, E) Prosomal end, left lateral view. (F) Urosome, dorsal view. (G) Antennular segments I to X-XV. (H) Antennular segments XVI-XVII to XXII. (I) Antennular segments XXIII to XXVII-XXVIII. (J) Antennary exopod, seta indicated by arrow more developed in male than in female. (K) Antennary endopod, seta indicated by arrow shorter in male than in female. (L) Mandibular basis and endopod, setae arrowed shorter in male than in female.

two-segmented, proximal segment with two setae, distal segment with nine setae and patch of fine spinules; exopod five-segmented, setal formula 1,1,1,1,2.

Maxillule (figure 5G) with elongate praecoxal arthrite bearing one minute, seven

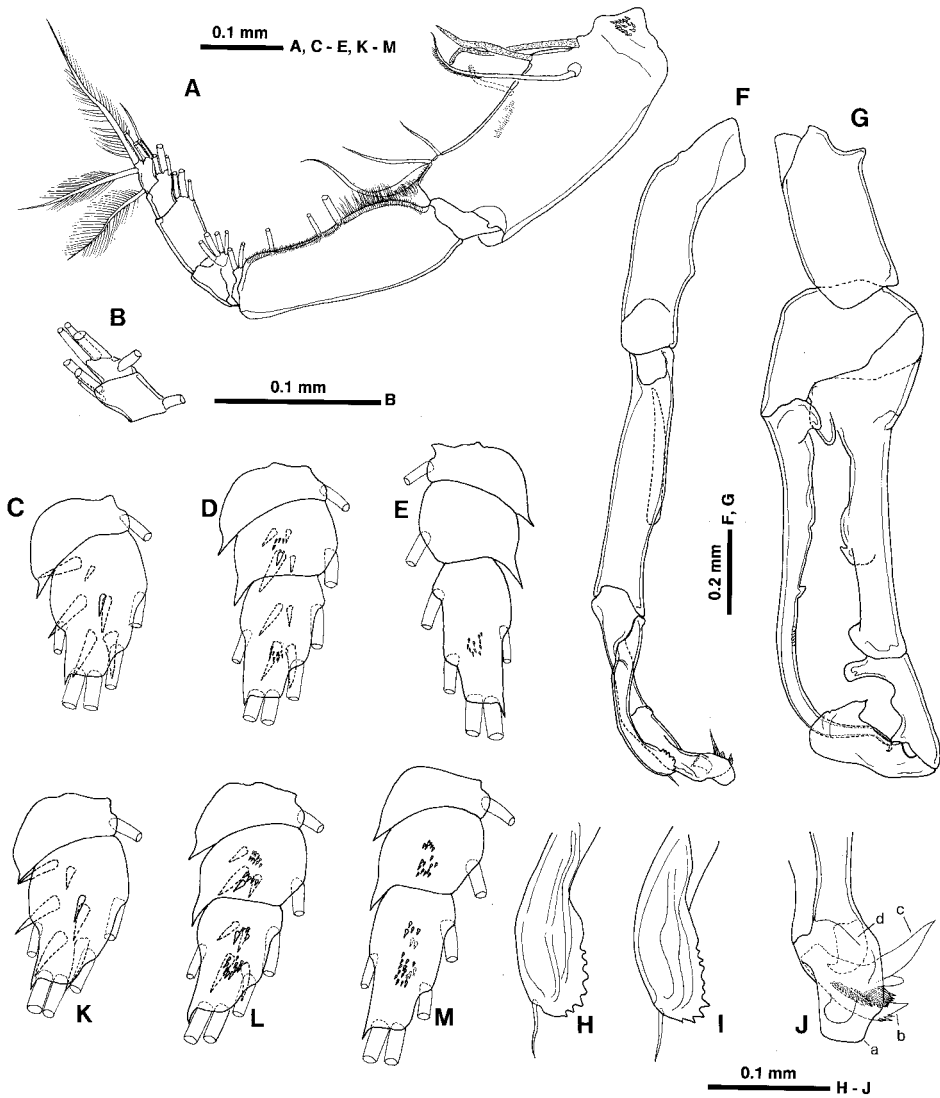


FIG. 8. *Macandrewella stygiana*, n. sp., male (paratypes) (A–J) and *M. omorii*, n. sp., male (paratype) (K–M). (A) Maxilliped with abnormal endopod. (B) Normal terminal endopodal segments of maxilliped. (C, K) Endopod of leg 2, anterior surface. (D, L) Endopod of leg 3, anterior surface. (E, M) Endopod of leg 4, anterior surface. (F) Left leg 5. (G) Right leg 5. (H, I) Terminal portion of left endopod of leg 5. (J) Terminal portion of left exopod of leg 5.

sclerotized spiniform, two hirsute and three serrate setae; coxal endite with two setae; coxal epipodite bearing nine setae (one missing in figure 5G); basis completely fused with endopod; first and second basal endites bearing three and five setae, respectively; baseopod with seven setae terminally; exopod lobate, bearing eight setae and patch of fine setules along outer margin. Maxilla (figure 5H, I) compact; first praecoxal endite bearing four setae plus rudimentary element; second praecoxal to second coxal endites each with three setae and patch of fine spinules; basis

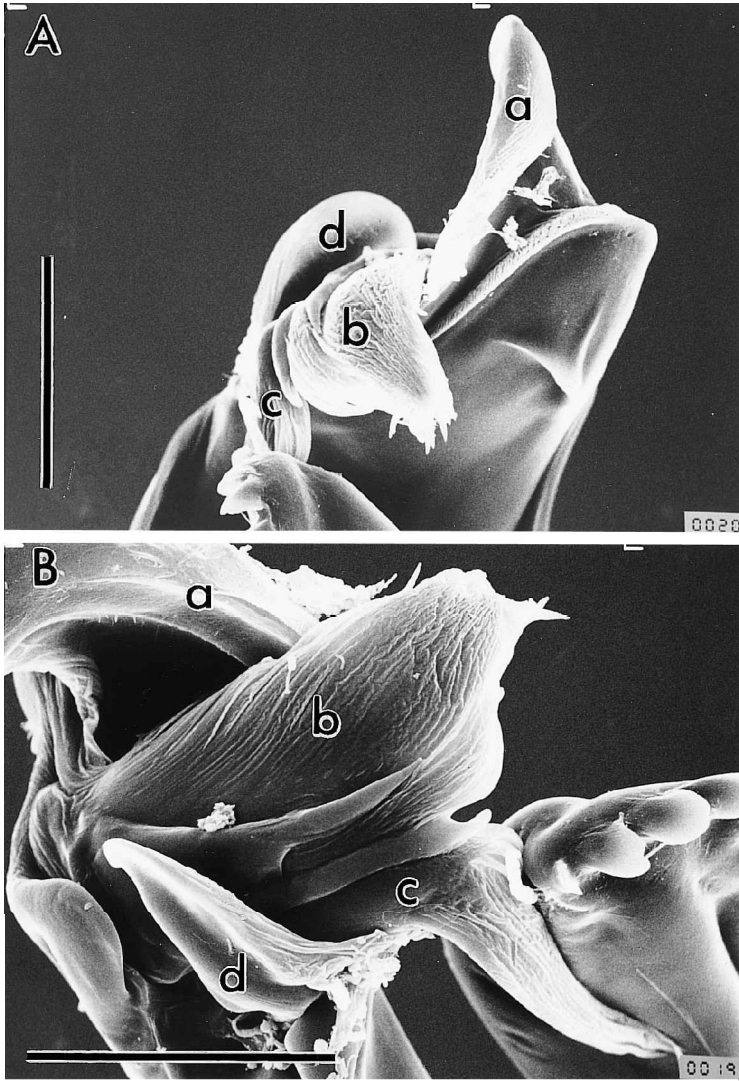


FIG. 9. SEM micrographs of terminal portion of exopod of left leg 5 of male *Macandrewella stygiana*, n. sp. Elements indicated by 'a'–'d'. See also figure 16. Scales = 0.05 mm.

furnished with two worm-like sensory, one spinulose and one heavily sclerotized seta; endopod (figure 5I) indistinctly three-segmented, first to third segments bearing three brush-like, two brush-like and three worm-like sensory setae, respectively. Maxilliped (figure 5J) elongate; syncoxa with two worm-like sensory setae proximally and single brush-like sensory seta at mid-length; other four setae disposed as figured. Basis as long as syncoxa, with submarginal row of minute spinules and three setae along inner margin; first endopodal segment almost incorporated into basis, with two setae; setal formula of second to sixth endopodal segments 4,4,3,3+1,4.

Seta and spine formula of legs 1–4 as shown in table 2. Leg 1 (figure 6A–C) with uni-segmented endopod and three-segmented exopod; endopod bearing middle outer knob with patch of minute spinules, and patch of fine setules terminally (figure 6B);

Table 2. Seta and spine formula of legs 1–4 of *Macandrewella stygiana* n. sp.

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

Note: Roman numeral: spine; Arabic numeral: seta.

first exopodal segment with inner margin expanded (figure 6C); first and second exopodal segments each with naked outer spine; third exopodal segment bearing serrate outer spine and spiniform terminal seta. Leg 2 (figure 6D, E) with two-segmented endopod and three-segmented exopod; coxa and basis each with sharply pointed prominence on lamellar outer margin; first endopodal segment without prominences, second segment with one anterior and six posterior acute prominences; second exopodal segment with posterior row of prominences, third segment with two posterior patches of prominences. Leg 3 (figure 6F–H) with three-segmented rami; inner distal corner of basis produced into pointed process; second and third endopodal segments with one minute anterior and four posterior prominences (figure 6H); second exopodal segment bearing posterior row of prominences along distal margin, third segment with minute prominences on posterior surface. Leg 4 (figure 6I, J) with three-segmented rami; coxal outer margin bearing proximally directed process; second and third exopodal segments with longitudinal row of stout prominences on posterior surface.

Leg 5 of holotype (figure 2I, J) rudimentary, two-segmented with common base; second segment of left leg separate from base; that of right leg fused to it; each segment with spine and pointed process terminally; those of paratypes variable, second segment separate from common base on both rami, variable in size, with two or three minute elements terminally (figures 2K, L, 4A, C–E).

Male: Body (figure 7A) more slender than female. Rostrum (figure 7B) bifurcate, with pair of filaments as in female; cuticular median lens present at base of rostrum as in female. Cephalosome completely coalescent with first pediger; fifth pediger fused to fourth pediger with suture visible laterally; fifth pediger slightly asymmetrical, with right dorsolateral process directed slightly outward and left one posteriorly directed (figure 7C–E). Urosome (figure 7F) approximately one-third as long as prosome; genital somite asymmetrical, with two round dorsolateral and one dorsal knobs on right side; second to fourth urosomites with striated posterior margin; second urosomite slightly asymmetrical viewed dorsally; anal somite small; caudal rami symmetrical, small; caudal seta II located dorsally at base of seta III; seta VII located ventrally at base of seta VI.

Antennule (figure 7G–I) consisting of 19 and 18 free segments on left and right side, respectively. Armature elements and fusion pattern of left antennule as follows: I-1+ ae, II-IV-6+ 4ae (II-2+ ae, III-2+ 2ae, IV-2+ ae), V-2+ 2ae, VI-2+ ae, VII-2+ 2ae, VIII-2+ ae, IX-2+ 2ae, X–XV-7+ 6ae (X-2+ ae, XI-2+ 2ae, XII-ae, XIII-ae, XIV-2+ ae, XV-1+ ae), XVI–XVII-3+ 2ae (XVI-2+ ae, XVII-1+ ae), XVIII-1+ ae, XIX-1+ ae, XX-1+ ae, XXI-1+ ae, XXII-unarmed, XXIII-1, XXIV-1+ 1,

XXV-1+1+ae, XXVI-1+1, XXVII-XXVIII-5+ae (including two rudimentary setae). Right antennule with segments XXII and XXIII completely coalescent.

Mouthparts and legs 1-4 similar to those of female except: antennary endopod with shorter seta on proximal segment more reduced than in female (figure 7K, arrowed); antennary exopod with proximal-most seta longer than in female, reaching to exopod tip (figure 7J, arrowed); mandible palp with distal seta on basis and proximal seta on first endopodal segment shorter than those in female (figure 7L, arrowed); maxilliped (figure 8A, B) with basis bearing row of fine setules along proximal one-third; outer setae on fifth and sixth endopodal segments thicker and longer than those in female. Terminal two endopodal segments fused, with only three terminal setae on one side (figure 8A), which is considered to be aberrant, but separate, with 3+1 and four setae on fifth and sixth segments on other side (figure 8B). Distribution of prominences on surfaces of legs similar to those in female except for lack of large prominences on posterior surface of leg 4 (figure 8C-E).

Leg 5 elongate, about half length of prosome (figure 7A). Right leg (figure 8G) chelate; coxa with triangular swelling proximally; basis expanded laterally; first exopodal segment with three processes along inner margin, proximal directed distally, middle irregular and distal triangular; second exopodal segment short, with three protuberances along inner margin, proximal process largest, truncate at tip; third exopodal segment lamellar, as long as preceding segment, curved inward distally; endopod uni-segmented, smoothly curved outward and recurved at tip, bearing one large proximal and one short middle process along outer margin. Left leg 5 (figure 8F, H-J) with coxa as long as basis; basis with longitudinal keel-like structure along proximal half; exopod two-segmented, second segment with lamellar plate ('a' in figures 8J, 9A, B), and three elements ('b', 'c', 'd' in figures 8J, 9A, B) terminally; endopod uni-segmented, shorter than exopod, bearing inner serrated margin and one small seta terminally.

Variation. The dorsolateral projections of the fifth pediger of the female more or less vary in shape, size and serration (figure 2D-G). The fifth leg of the female is also variable in fusion between the first and the second segments, the size of the second segment, and the number and development of elements on the second segment (figure 2J, K, L). The terminal serration on the left endopod of the male leg 5 also varies (figure 8H, I).

Remarks. The new species is closely related to *Macandrewella cochinesis* Gopalakrishnan, 1973 from off Cochin, Indian Ocean, on the basis of the structure of the male leg 5. However, it is readily distinguishable from the latter in the following characters: (1) the dorsolateral processes on the prosomal ends of the female are serrated along the margin in *M. stygiana* (smooth in *M. cochinesis*); (2) the right ventrolateral process of the prosomal end of the female reaches nearly to the posterior margin of the genital double-somite in *M. stygiana* (only to mid-length of the compound somite in *M. cochinesis*); (3) the female leg 5 is present in *M. stygiana* (absent in *M. cochinesis*); (4) the outer middle process of the right endopod of the male leg 5 is smaller in *M. stygiana* than in *M. cochinesis*; (5) the inner distal process of the penultimate exopodal segment of the male right leg 5 is present in *M. stygiana* (absent in *M. cochinesis*); (6) the distal exopodal segment of the male right leg 5 is relatively larger in *M. stygiana* than in *M. cochinesis*, compared with the inner proximal process of its penultimate segment.

The female of the present new species is also similar to that of *M. joanae*, but distinguished from it by: (1) the ventrolateral processes of the prosomal end reaching

nearly to the posterior margin of the genital double-somite; (2) the absence of a linguiform genital operculum; (3) elements on the terminal segment of leg 5 are variable, but tend to become more reduced than in *M. joanae*.

Distribution. The new species is so far known only from off Tokashiki Shima Is., southern Japan (see figure 21).

Feeding habits. Gut contents of three adult males were examined with SEM. Small crustacean, mainly copepod, fragments were most frequently detected. Some fragments were evidently identified as Oncaeidae and calanoids (figure 10A, B). Tintinnids (figure 10C), radiolarians (figure 10D) and diatoms (figure 10E) were less frequently found in the guts.

Etymology. The specific name, *stygiانا* (Latin *stygianus*, meaning underworld) alludes to the hyperbenthic habitat of the new species.

Macandrewella omorii new species
(figures 3B, C, 8K–M, 11–16)

Material examined. Off Kume Shima Is. (23 May 1989): 24♀♀ and 30♂♂; off Tokashiki Shima Is. (31 May 1999): 22♂♂.

Types. HOLOTYPE: 1♀, appendages dissected and mounted on glass slides, body in vial, collected from off Kume Shima Is., 23 May 1989, CBM-ZC 5696. PARATYPES: off Kume Shima Is., 23 May 1989: 1♀ and 1♂, appendages dissected and mounted on glass slides, body in vials, CBM-ZC 5697, 5698; 14♀♀ and 22♂♂, whole specimens, CBM-ZC 5699. Off Tokashiki Shima Is., 31 May 1999: 1♂, appendages dissected and mounted on glass slides, body in vials, CBM-ZC 5700; 8♂♂, whole specimens, CBM-ZC 5701.

Body length. ♀: 3.32–3.54 mm (3.39 ± 0.07 mm, $n = 16$). ♂ (off Kume Shima Is., 23 May 1989): 3.38–3.62 mm (3.48 ± 0.07 , $n = 21$); (off Tokashiki Shima Is., 31 May 1999): 3.53–4.05 mm (3.74 ± 0.19 mm, $n = 9$).

Description. *Female:* Body (figure 11A) robust, similar to that of female of *Macandrewella stygiانا*. Cuticular lens (figure 11B) present at base of bifurcate rostrum (see figure 12A, arrowed). Posterior ends of prosome slightly asymmetrical, right lateral process straight, directed posteriorly and curved ventrally at tip (figure 11D) and left lateral process directed slightly outwards, reaching beyond posterior margin of genital double-somite (figure 11A, C). Urosome (figure 11A, C, D) short, less than one-third length of prosome; genital double-somite covered by complex spermatophore in all specimens examined (see figures 11A, G, 13A, C); spermatophore proper located on right dorsolateral side (see figure 13C), bulbous spherical structure on left ventrolateral side (see figures 11A, C, G, 13A, C), droplet-like structure on right ventrolateral side (see figure 13A, C); genital operculum (figure 11E) linguiform, located near ventroposterior margin, reaching nearly half-way along second urosomite (see figure 13B, D); seminal receptacles (figure 11E) paired; second and third urosomites with striated posterior margin; anal somite small; caudal rami (figure 11A) as in female of *M. stygiانا*, but setae V almost symmetrical.

Antennule reaching to anal operculum, 23-segmented; armature elements and fusion pattern as in *M. stygiانا*. Antenna to leg 4 resembling those of *M. stygiانا*. Maxillule with praecoxal arthrite bearing patch of setules terminally. Maxillary endopod bearing three worm-like and five brush-like sensory setae (see figure 12C–E). Maxilliped (figure 11F) with syncoxa having patch of long setules

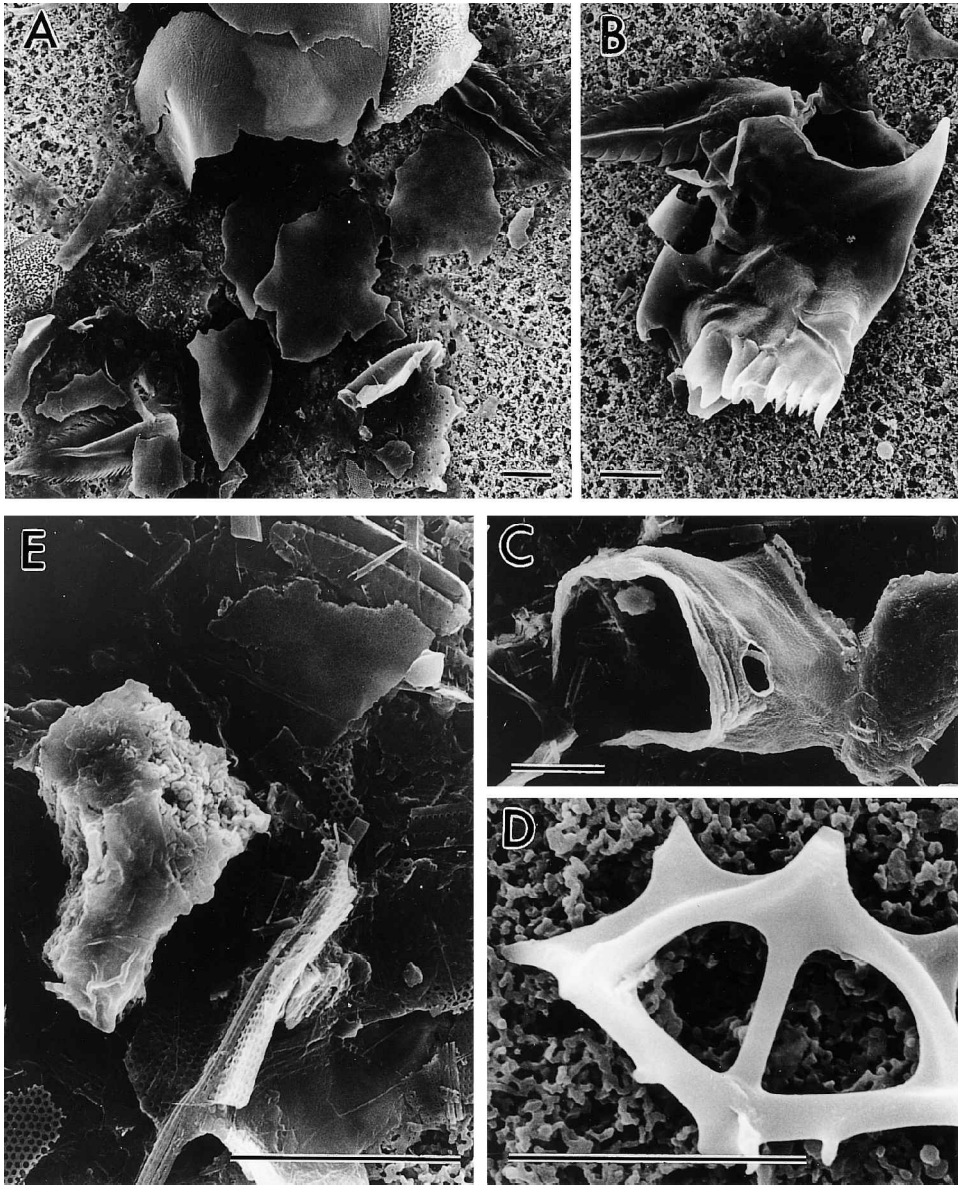


FIG. 10. Gut contents of *Macandrewella stygiana*, n. sp., male. (A) Fragments of presumably copepod *Oncaea* sp. (B) Mandibular cutting edge of calanoid copepod. (C) Tintinnid lorica. (D) Radiolarian fragment. (E) Diatom fragments. Scales = 0.01 mm.

proximally. Differences in size and distribution pattern of prominences on surfaces between *M. omorii* and *M. stygiana* slight in legs 2 (figure 14A, B) and 3 (figure 14C), and remarkable in leg 4 (figure 14D): large prominences on posterior surface of rami lacking in *M. omorii*. Leg 5 absent (see figure 12B).

Male: Body (figures 3B, 14E, F) similar to that of *M. stygiana*; differences as follows: fifth pediger asymmetrical, with right process slightly larger than left (figure 14G, H); genital somite (figure 15A) slightly asymmetrical; second urosomite

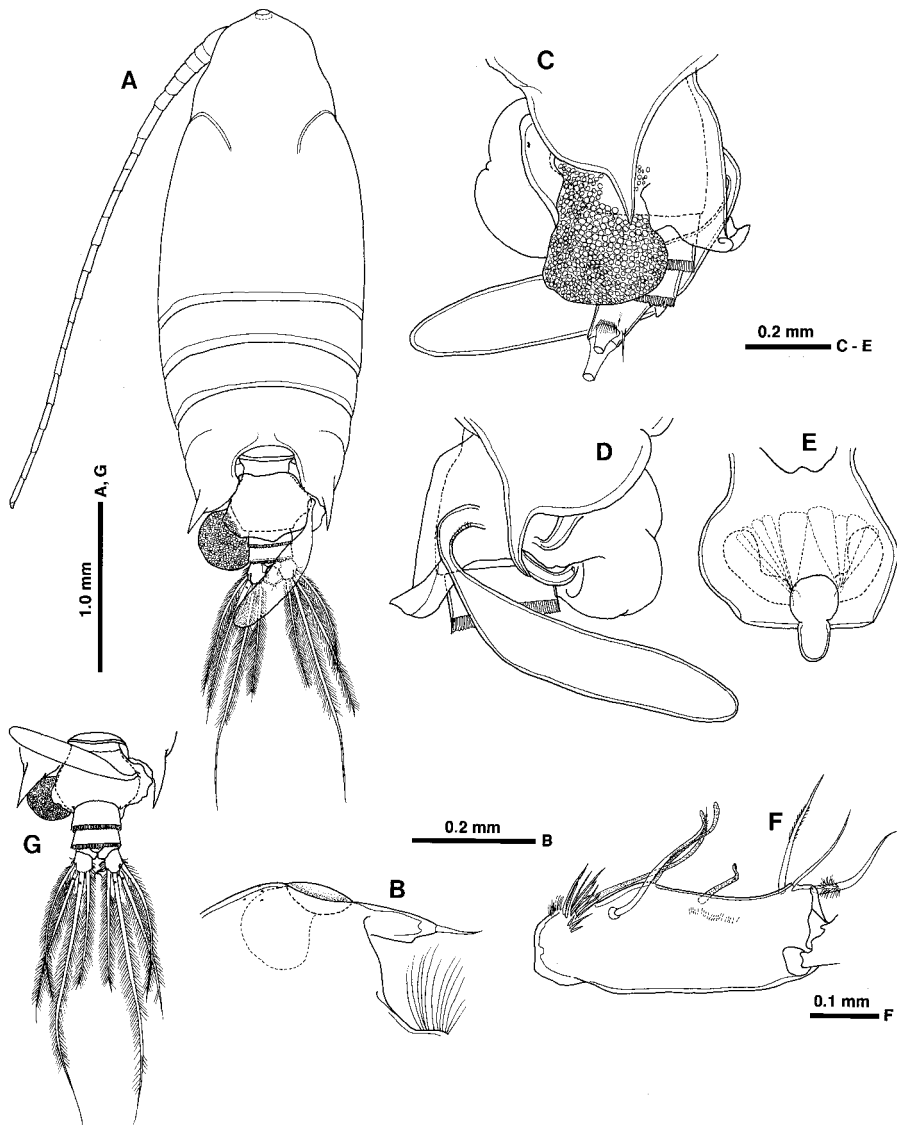


FIG. 11. *Macandrewella omorii*, n. sp., female (holotype: A–E; paratype: F, G). (A) Habitus, dorsal view. (B) Rostrum and cuticular lens, lateral view. (C) Prosomal end and urosome, left lateral view. (D) Prosomal end and urosome, right lateral view. (E) Genital double-somite, ventral view. (F) Syncoxa of maxilliped. (G) Prosomal ends and urosome, dorsal view.

with left side more swollen laterally than right side. Caudal rami (figures 3C, 15A, B) symmetrical.

Both antennules (figure 15C–F) similar to those of *M. stygiana* except in having the second compound segment (II–IV) relatively shorter (see figure 7G). Mouthparts similar to *M. stygiana* except for presence of patch of setules terminally on praecoxal arthrite of maxillule and patch of long setules proximally on maxillipedal syncoxa.

Distribution pattern of prominences on surfaces of legs 2–4 (figure 8K–M) with

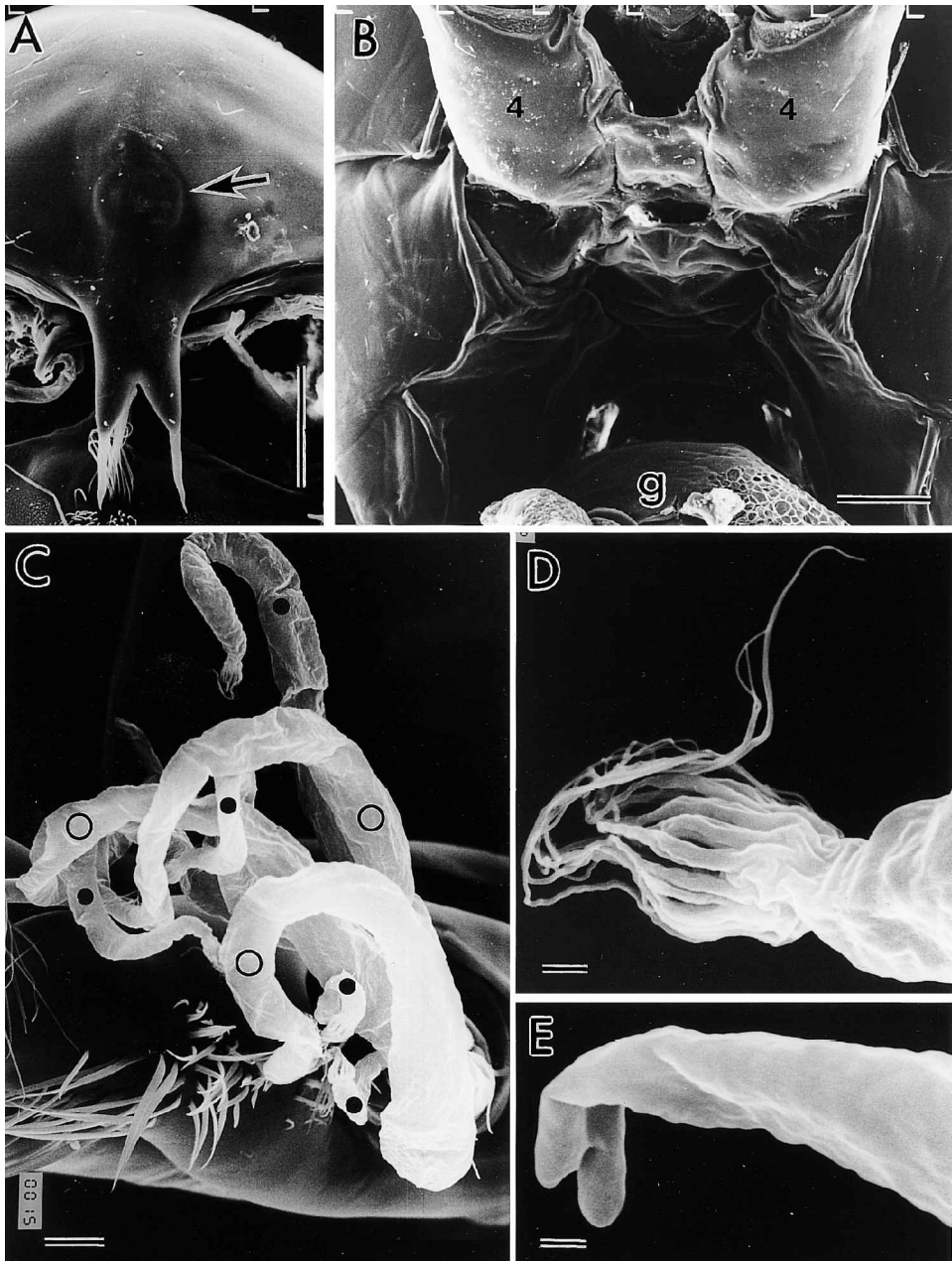


FIG. 12. SEM micrographs of *Macandrewella omorii*, n. sp., female. (A) Rostrum, ventral view, cuticular lens indicated by arrow. (B) Parts posterior to legs 4 ('4'), 'g' meaning genital double-somite, note absence of leg 5. (C–E) Maxillary endopod, brush-like (D) and worm-like (E) sensory setae indicated by closed and open circles, respectively. Scales=0.1 mm (A, B); 0.01 mm (C); 0.001 mm (D, E).

minor differences from those of *M. stygiana* (compare with figure 8C–E). Large process wanting on posterior surface of rami of leg 4, as in female.

Leg 5 (figure 14E) large, over half as long as prosome. Right leg (figure 15H) with

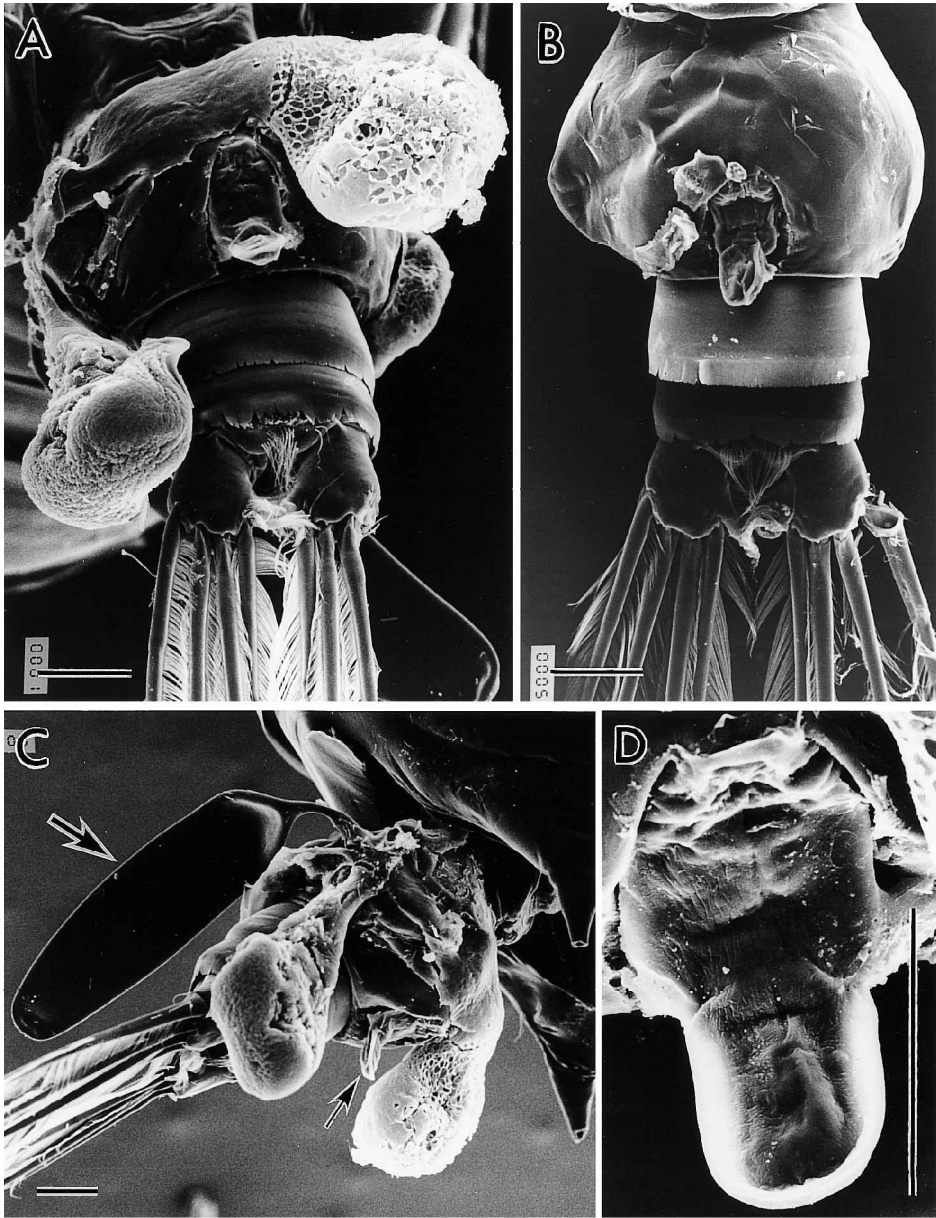


FIG. 13. SEM micrographs of *Macandrewella omorii*, n. sp., female. (A) Urosome with spermatophore, ventral view. (B) Urosome, ventral view, spermatophore removed. (C) Urosome, right lateral view, spermatophore proper and linguiform genital operculum indicated by large and small arrows, respectively. (D) Genital operculum. Scales = 0.1 mm.

protopod and endopod similar to *M. stygiana* except for two large contiguous protuberances between proximal and middle swellings of endopod; exopod three-segmented, first segment robust with inner thumb-like swelling proximally, second segment with inner hook-like projection originating from segmental base and triangular process at

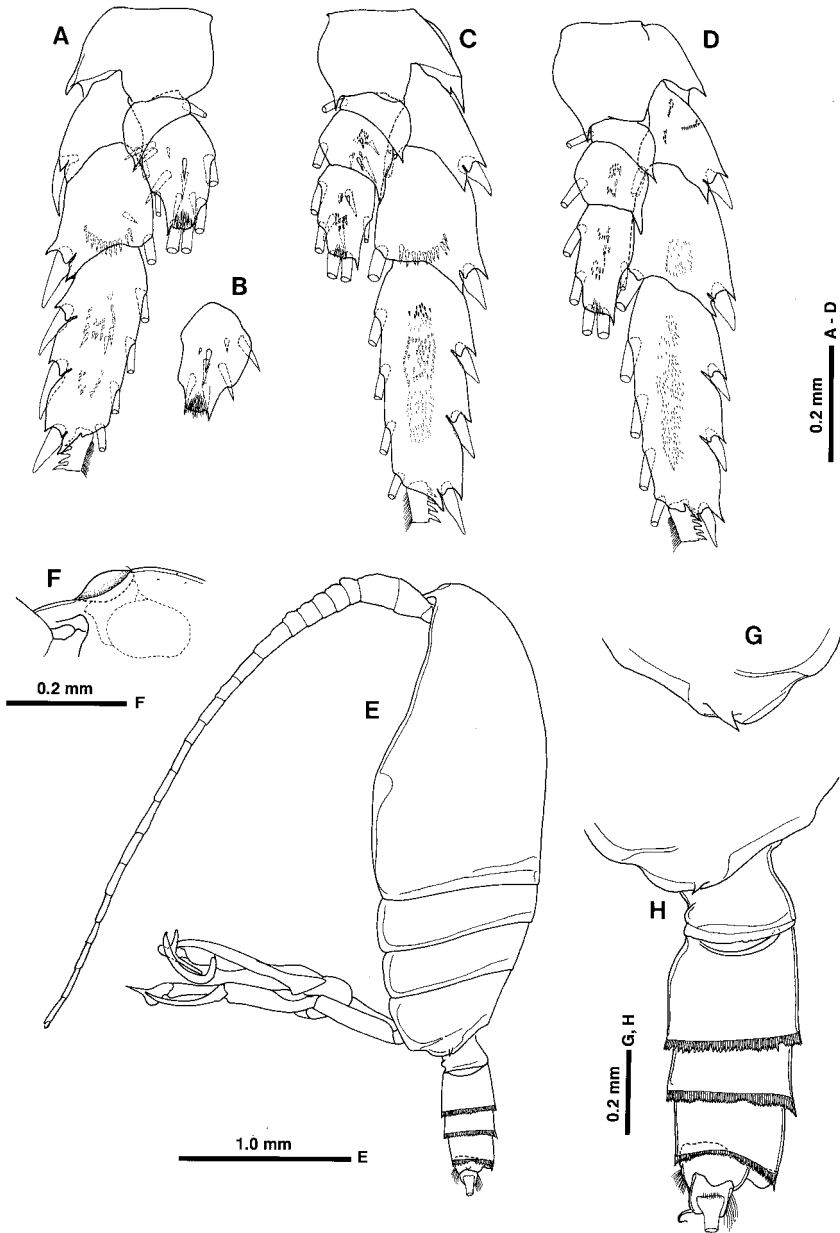


FIG. 14. *Macandrewella omorii*, n. sp., female (paratype: A–D), male (paratype: E–H). (A) Right leg 2, anterior surface, coxa omitted. (B) Second endopod segment of left leg 2, anterior surface. (C) Leg 3, anterior surface, coxa omitted. (D) Leg 4, anterior surface, coxa omitted. (E) Habitus, lateral view. (F) Cuticular lens, lateral view. (G) Right posterior corner of prosome, lateral view. (H) Prosomal end and urosome, left lateral view.

midlength, third segment Y-shaped at tip. Left leg 5 (figure 15G, I, J) with coxa as long as basis; basis with longitudinal keel-like structure along proximal half; exopod two-segmented, second segment with acutely produced triangular process subterminally

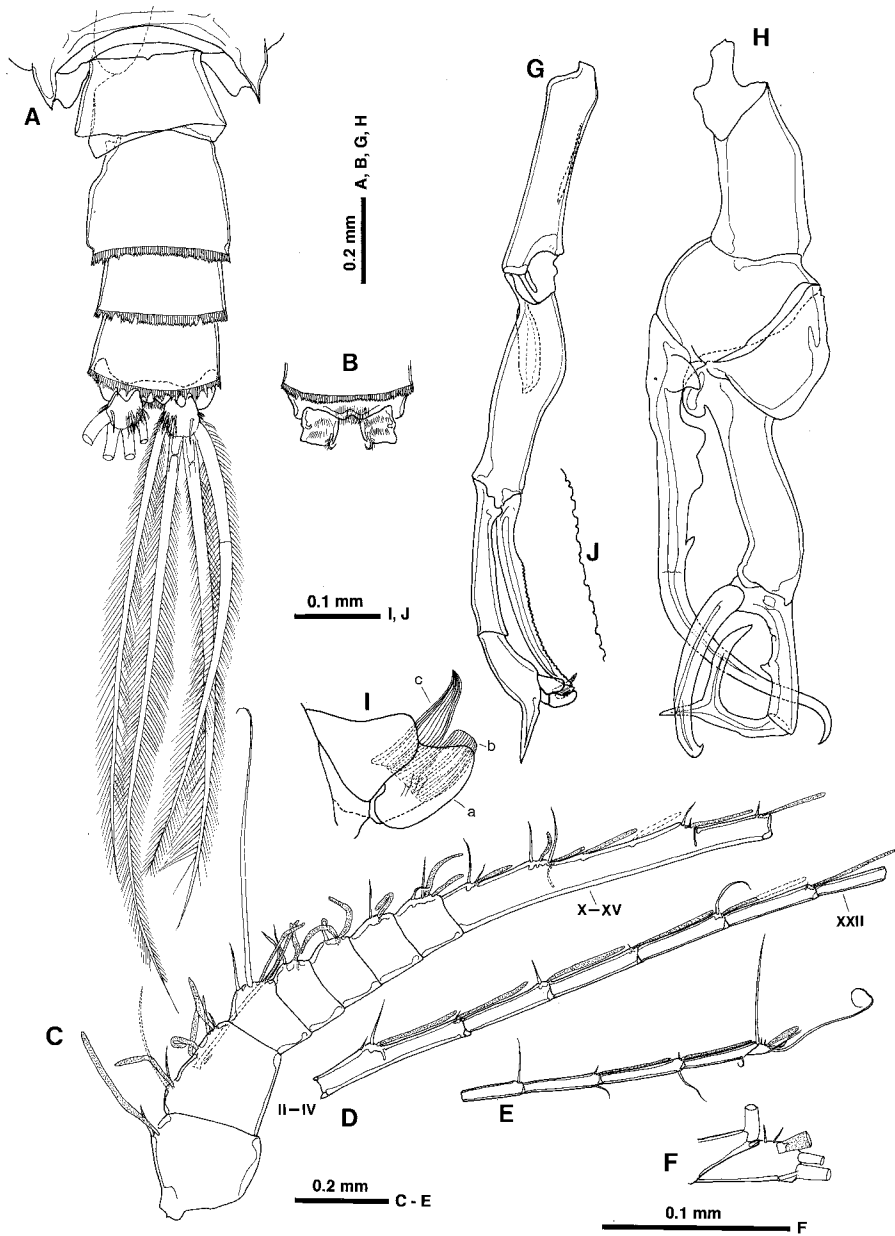


FIG. 15. *Macandrewella omorii*, n. sp., male (paratype). (A) Prosomal ends and urosome, dorsal view. (B) Anal somite and caudal rami, ventral view. (C) Antennular segments I to X–XV. (D) Antennular segments XVI–XVII to XXII. (E) Antennular segments XXIII to XXVII–XXVIII. (F) Antennular compound segment XXVII–XXVIII. (G) Left leg 5. (H) Right leg 5. (I) Terminal portion of left exopod of leg 5. (J) Inner margin of left endopod of leg 5.

and two striated elements (see 'b' and 'c' in figures 15I and 16) sandwiched by two plate-like structures terminally (see 'a' and 'd' in figures 15I and 16); endopod uni-segmented, furnished with serration almost entirely along inner margin (figure 15J).

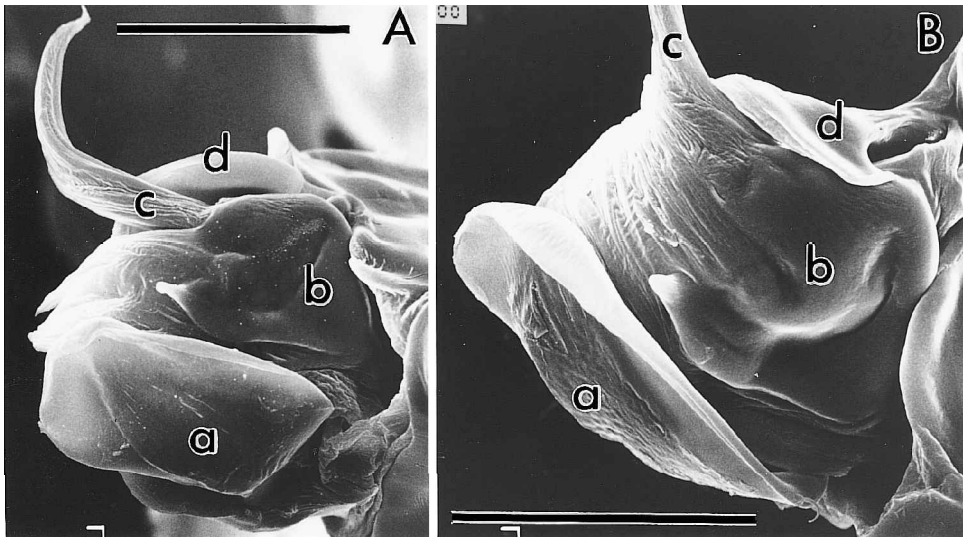


FIG. 16. SEM micrographs of *Macandrewella omorii*, n. sp., male. (A, B) Terminal portion of left exopod of leg 5. Elements indicated by 'a'–'d'. Scales = 0.05 mm.

Variation. The number and distribution of prominences and processes on legs 2–4 more or less vary among individuals. An outer proximal-most process on the posterior surface of the second endopodal segment of leg 2 is bifurcate only on the left side in a paratype (figure 14A, B) but uni-cuspidate on both sides of the holotype.

Remarks. The new species is similar to *Macandrewella joanae* Scott, 1909 and *M. asymmetrica* Farran, 1936 in sharing the following characters: (1) the elongate linguiform genital operculum of the female; (2) the terminal segment of the right exopod of the male leg 5 with a stout outer middle process; (3) the large subterminal outer process on the second exopodal segment of the male left leg 5. The female of *M. joanae* bears a distinct leg 5, whereas it is lacking in the new species and in *M. asymmetrica*. In addition, the symmetrical caudal setae V and only one pair of lateral processes on the prosomal ends are shared only by *M. asymmetrica* and the new species. The female of the new species is distinguishable from that of *M. asymmetrica* by: (1) the lateral processes on the prosomal ends nearly reaching or extending slightly beyond the posterior margin of the genital double-somite (reaching at most mid-length of somite in *M. asymmetrica*); (2) the rostrum with paired knobs subterminally (knobs absent in *M. asymmetrica*); (3) the antennule reaching the anal operculum (extending only to the posterior margin of the genital double-somite in *M. asymmetrica*); (4) the presence of minute prominences on the surface of the exopod of leg 4 (prominences absent in *M. asymmetrica*). Since the male of *M. asymmetrica* was only briefly described by Farran (1936) and there is no additional re-description, there are potentially minor differences between these two species, as follows: (1) the inner proximal process on the second exopodal segment of the right leg 5 is directed outward in *M. omorii* whereas inward (folded accidentally in making preparation?) in *M. asymmetrica*; (2) the inner margin of the endopod of the left leg 5 is almost entirely serrated in *M. omorii* while it is only serrated at the tip in *M. asymmetrica*.

Distribution. The new species was captured only off Kume Shima and Tokashiki Shima Is., southern Japan (see figure 21).

Feeding habits. Gut contents of three adult females and two adult males were examined with SEM. A wide variety of crustacean fragments was the remains more frequently found in the guts (figure 17). Some fragments were identified as belonging

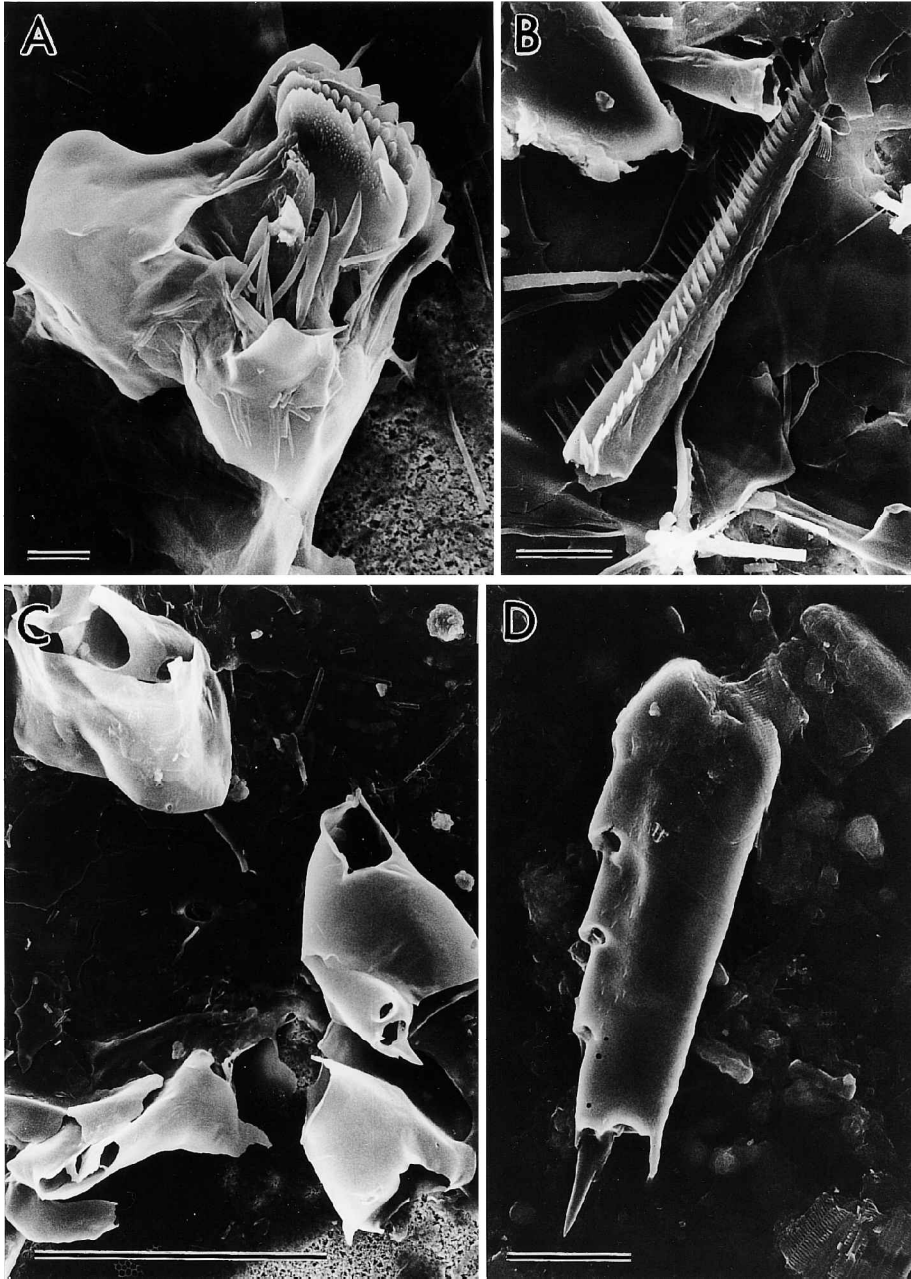


FIG. 17. Gut contents of *Macandrewella omorii*, n. sp., female. (A, B) Crustacean fragments. (C) Copepod fragments. (D) Leg of *Oncaea* sp. Scales = 0.01 mm (A, B, D); 0.1 mm (C).

to Oncaeidae spp. (figure 17D). Radiolarians (figure 18) and diatoms were less frequently discovered in the guts.

Etymology. The specific name, '*omorii*' is dedicated to Prof. M. Omori of the Tokyo University of Fisheries.

***Macandrewella serratipes* new species**
(figures 19, 20)

Synonym. *Macandrewella chelipes sensu* Wilson, 1950.

Material examined. Fiji Is. (16°32'S, 119°59'W), 40 fathoms, 21 January 1905 (Wilson leg.): 7♀♀ and 6♂♂. Note: the ledger book for the USNM numbers says only Fiji, and the latitude/longitude of the locality described in the vial plots out to the South Pacific near Tuamotu Is. but not in Fiji. Hence the type locality is in question (Walter, personal communication).

Types. HOLOTYPE: 1♀, appendages dissected and mounted on glass slides, body in vial, USNM 67242. PARATYPES: 1♀ and 3♂♂, appendages dissected and mounted on glass slides, body in vial; 5♀♀ and 3♂♂, whole specimens, USNM 232823.

Body length. ♀: 2.91–3.23 mm (3.04 ± 0.11 mm, $n=7$). ♂: 3.16–3.74 mm (3.45 ± 0.23 , $n=6$).

Description. The new species was briefly described as *Macandrewella chelipes* by Wilson (1950), but several characters were overlooked or misunderstood. These are newly or precisely described in the present study.

Female: Prosome (figure 19A) with fourth and fifth pedigers almost completely coalescent; prosomal ends (figure 19A–D) slightly asymmetrical, with dorsolateral processes reaching posterior end of genital double-somite. Urosome (figure 19A, D) less than one-third length of prosome; genital double-somite asymmetrical, with two

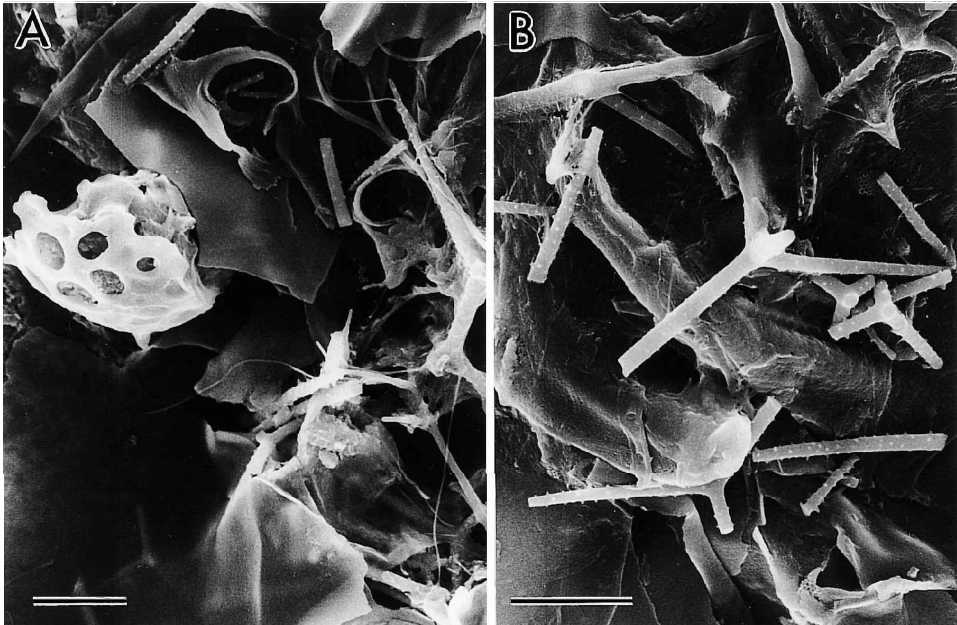


FIG. 18. Gut contents of *Macandrewella omorii*, n. sp., female. (A) Fragments of radiolarians and crustaceans. (B) Radiolarian fragments. Scales=0.01 mm.

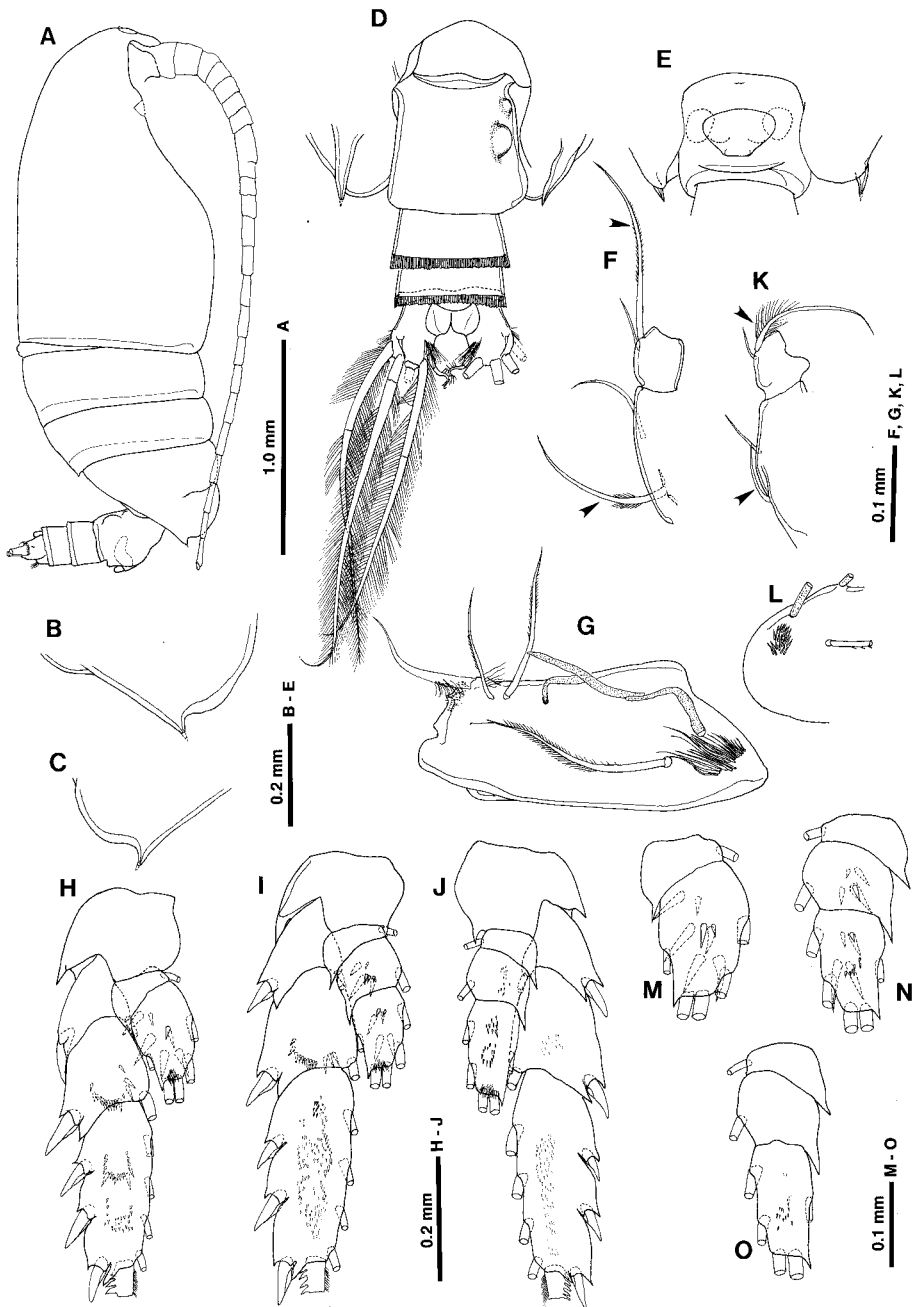


FIG. 19. *Macandrewella serratipes*, n. sp., female (holotype: A–C, F, G, H–J; paratype: D, E), male (paratypes: K–O). (A) Habitus, lateral view. (B) Prosomal end, right lateral view. (C) Prosomal end, left lateral view. (D) Prosomal ends and urosome, dorsal view. (E) Genital double-somite, ventral view. (F, K) Mandibular basis and first endopodal segment, setae showing sexual dimorphism indicated by arrows. (G) Maxillipedal syncoxa. (H) Leg 2, anterior surface, coxa omitted. (I) Leg 3, anterior surface, coxa omitted. (J) Leg 4, anterior surface, coxa omitted. (L) Tuft of short setules on maxillipedal syncoxa. (M) Endopod of leg 2, anterior surface. (N) Endopod of leg 3, anterior surface. (O) Endopod of leg 4, anterior surface.

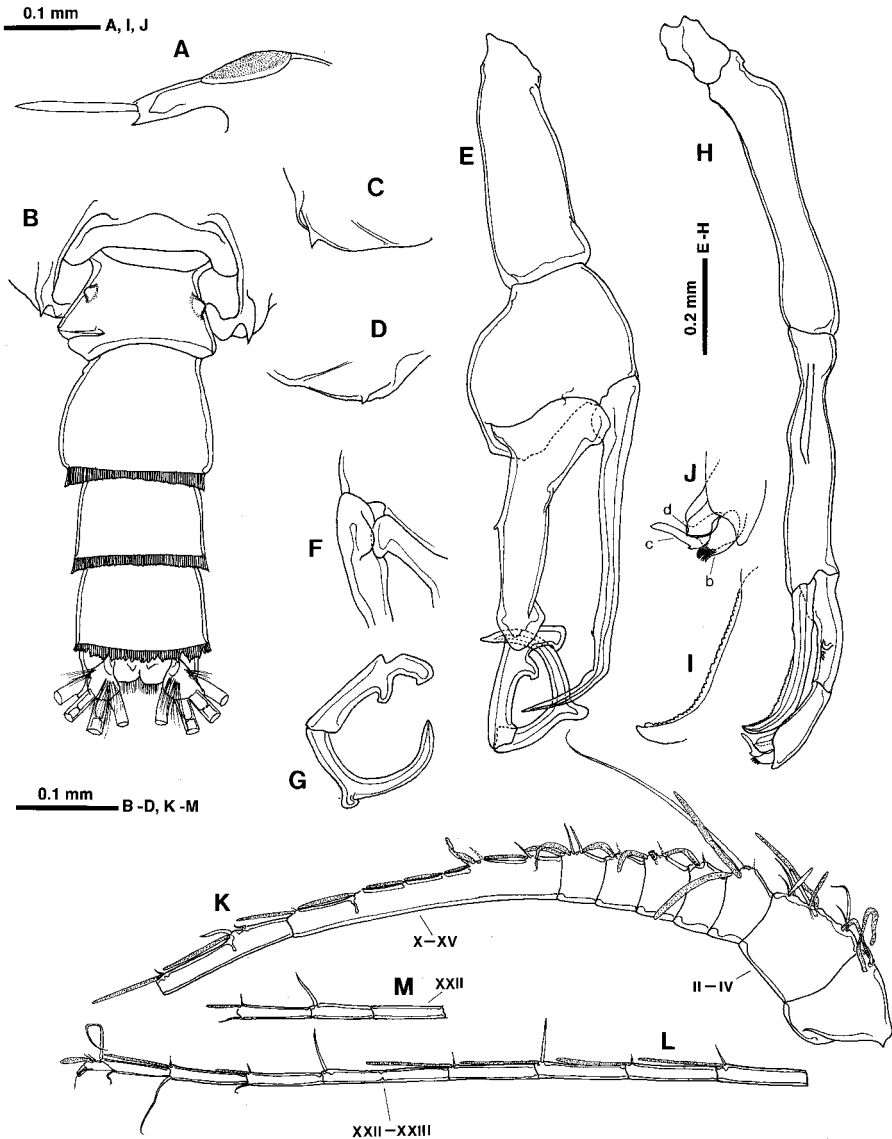


FIG. 20. *Macandrewella serratipes*, n. sp., male (paratypes). (A) Rostrum, lateral view. (B) Prosomal ends and urosome, dorsal view. (C) Prosomal end, right lateral view. (D) Prosomal end, left lateral view. (E) Right leg 5, anterior surface. (F) Base of right endopod of leg 5, posterior surface. (G) Second and third exopodal segments of right leg 5, anterior surface. (H) Left leg 5, anterior surface. (I) Inner serration along distal half of left endopod of leg 5. (J) Terminal portion of left exopod of leg 5. (K) Right antennular segments I to XVI-XVII. (L) Right antennular segments XVIII to XXVII-XXVIII. (M) Left antennular segments XXII to XXIV.

anterior round knobs and posterior swollen corner on right side; genital operculum (figure 19E) wider than long; seminal receptacles extending laterally (figure 19A); second and third urosomites with striated frill along posterior margin; anal somite small, almost telescoped into preceding somite; anal operculum rounded posteriorly;

caudal rami symmetrical in original description, but not confirmed in present description, as in all specimens examined caudal seta V was missing.

Antennule exceeding beyond prosomal ends by last two segments (figure 19A); armature and fusion pattern of segments as in *M. stygiana*. Antenna, mandible (figure 19F), maxillule and maxilla similar to those of *M. stygiana*. Maxilliped (figure 19G) with proximal patch of long setules on syncoxa.

Legs 1–4 (figure 19H–J) basically resembling those of *M. stygiana* (see figure 6), but differing in number of minute prominences. Leg 4 (figure 19J) lacking large prominences on both surfaces of rami. Leg 5 absent.

Male: Habitus similar to two new species described above; rostrum (figure 20A) with pair of sharply pointed prominences beneath bases of filaments; prosomal ends (figure 20B–D) slightly asymmetrical, with right dorsolateral prominence larger than left. Urosome (figure 20B) with first two somites asymmetrical; genital somite with small round dorsal knob on both sides; second urosomite swollen on left side.

Antennules (figure 20K–M) reaching posterior margin of third urosomite; armature and fusion pattern of segments of both antennules similar to two new species described above. Antenna with proximal-most seta on endopod longer than in female, as in *M. stygiana*. Mandible with two basal setae shorter than in female (figure 19K, arrowed); second seta on first endopodal segment differing from female in being plumose, instead of spinulose. Maxillule and maxilla similar to female. Maxilliped (figure 19L) bearing proximal tuft of short setules on syncoxa.

Legs 1–4 similar to female. Number of large processes on posterior surface of endopods of legs 2 and 3 (figure 19M, N) as in female. Leg 4 (figure 19O) furnished only with minute prominences on both surfaces, as in *M. omorii*.

Leg 5 (figure 20E–J) similar to that of *M. omorii*, except for: right leg (figure 20E–G) with relatively long protopod; endopod abruptly curved outward at distal quarter; first exopodal segment bearing minute outer prominence midway, without inner irregular knobs except proximal swelling; second exopodal segment with two inner proximal processes, first process longer and thicker, second process with truncate tip; third exopodal segment evenly curved inward, with outer middle process. Left leg (figure 20H–J) with endopod bearing serration along posterior half of inner margin; first exopodal segment with two low round protuberances at mid-length; second exopodal segment slightly produced into round projection at outer distal corner; distal processes as in figure 20J.

Variation. The number and position of minute prominences on the anterior and posterior surfaces of rami of legs 2–4 vary among individuals, and even between the right and left legs of the same individual. The outer middle process on the third exopodal segment of the male right leg 5 is round at the tip in one paratype but curved distally in another paratype.

Remarks. Giesbrecht (1896) described *Scolecithrix chelipes* from the Red Sea, on the basis of a single male. Later, Scott (1909) transferred this species to the genus *Macandrewella* when he established it with the description of a new species, *M. joanae*. The male of *M. chelipes* was subsequently recorded from the Nicobar Islands in the Indian Ocean (Sewell, 1929). The female was first described from the southern Pacific by Wilson (1950); however the corresponding male is rather different from those previously recorded from the Indian Ocean. Recently, both sexes of the species have been redescribed from the Gulf of Elat, Red Sea, by Campaner (1989). Unfortunately Campaner (1989) described only the lens, rostrum, parts of the mouthparts, and legs 1–3 of the female of *M. chelipes*, but not the habitus, which

makes detailed comparison between the females of *M. chelipes* and *M. serratipes* difficult. Although other congeners have a restricted distribution (see figure 21), *M. chelipes* apparently had a broad distribution in the Red Sea, the Indian Ocean, and the southern Pacific. Hence we suspected that Wilson's (1950) specimens of the southern Pacific *M. chelipes* might correspond to a new species.

The male of the new species is similar to those of *M. sewelli* Farran, 1936, *M. joanae*, *M. omorii* n. sp. and, possibly, *M. asymmetrica*, all of which share a serration along the distal half of the inner margin of the left endopod of leg 5. However, the new species is distinguishable from the latter three species by the following characters: (1) the second exopodal segment of left leg 5 without a large triangular process at the outer distal corner; (2) the second exopodal segment of right leg 5 has a proximal inner process much shorter than the segment proper. Although *M. sewelli* bears also a relatively short inner proximal process on the second exopodal segment of the right leg, it has a large outer digitiform process at the outer distal corner of the first exopodal segment of the right leg, and a truncate tip on the left endopod.

Wilson (1950) erroneously assigned the male of the new species to *M. chelipes* Giesbrecht, 1896, but the latter is distinctly different as follows: (1) the second exopodal segment of right leg 5 has a single proximal inner process, which is directed proximally and tapers distally (two processes, the tips of which are truncate, are

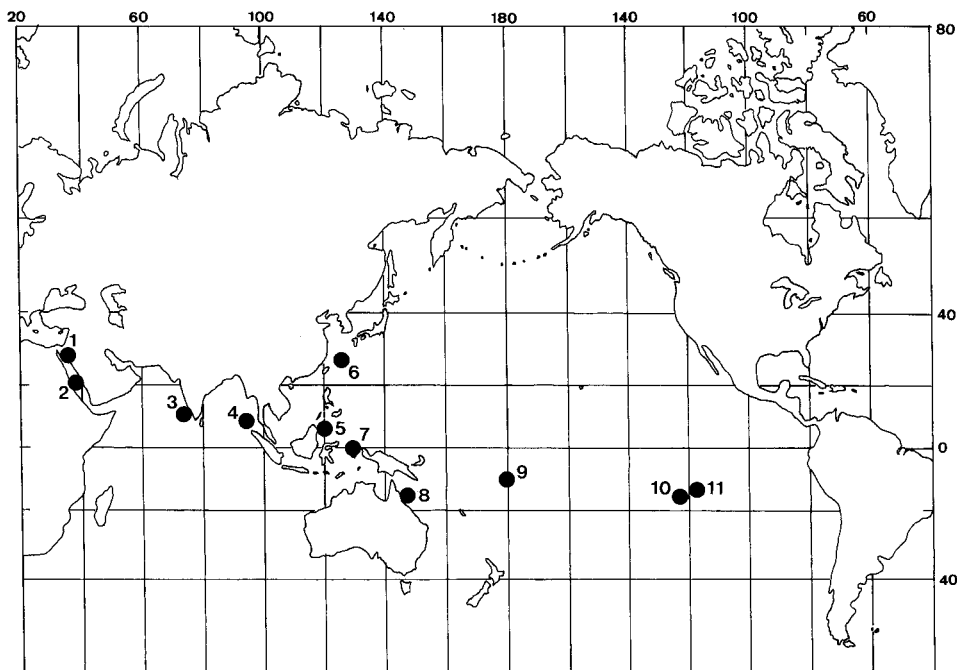


FIG. 21. Distribution of *Macandrewella*. Note that their distribution is restricted between 30°N and 20°S in the Indo-Pacific. (1) *M. chelipes* (Campaner, 1989). (2) *M. chelipes* (Giesbrecht, 1896). (3) *M. cochinesis* (Gopalakrishnan, 1973). (4) *M. scotti* and *M. chelipes* (Sewell, 1929). (5) *M. sewelli* (Wilson, 1950). (6) *M. stygiana* and *M. omorii* (present study). (7) *M. joanae* (Scott, 1909). (8) *M. asymmetrica*, *M. mera* and *M. sewelli* (Farran, 1936). (9) *M. agassizi* (Wilson, 1950). (10) *M. sewelli* (Wilson, 1950). (11) *M. serratipes* (as *M. chelipes*, Wilson, 1950; see material examined of *M. serratipes*).

displayed in *M. serratipes*); (2) the third exopodal segment of right leg 5 with an outer process half as long as the segment (one-tenth as long as the segment in *M. serratipes*).

The new species exhibits sexual dimorphism in the antenna and mandible like *M. stygiana*. In addition, the maxillipedal syncoxa bears proximally a patch of long setules in the female, but of short setules in the male.

Distribution. According to Wilson (1950, note in vials), the new species was collected at a depth of 40 fathoms off Fiji (see figure 21).

Etymology. The specific name, 'serratipes' is derived from the inner serration along the distal half of the left endopod of male leg 5 (Latin *serratus*, serrated, and *pes*, leg).

Discussion

Distribution

The genus *Macandrewella* has hitherto been recorded exclusively from tropical and subtropical waters between 30°N and 20°S in the Indo-Pacific where the average water temperature is more than 20°C (figure 21). This distributional pattern is quite similar to that of coral reefs in the Indo-Pacific region (cf. Barnes, 1987). Eleven species including the present three new ones were reported from the Red Sea (Giesbrecht, 1896), the Nicobar Islands (Sewell, 1929), and off Cochin (Gopalakrishnan, 1973) in the Indian Ocean, and Halmahera Sea (Scott, 1909), the Great Barrier Reef (Farran, 1936), the Ellice Islands, the Fiji Islands (Wilson, 1950), the Philippines (Wilson, 1950), off Tuamotu Archipelago (Wilson, 1950), and the Nansei Islands (present study) in the Pacific Ocean. Some members of *Macandrewella* seem to be constituents of hyperbenthic communities on the continental shelves and slopes. The present two new species from southern Japan were discovered from the near-bottom at depths of 95–167 m. Farran (1936) also discovered three species from the Great Barrier Reef, which were captured in numbers only when the plankton net touched the bottom at approximately 200 m depth. Since other congeners were collected by vertical or surface hauls of plankton nets, no exact depths of collections were specified.

The calanoid families with specialized sensory setae on the maxillae and/or maxillipeds are Diaixidae, Parkiidae, Phaennidae, Scolecitrichidae and Tharybidae (Nishida and Ohtsuka, 1997). Hyperbenthic taxa are rare within the family Scolecitrichidae, in contrast to the families Diaixidae, Phaennidae and Tharybidae, which accommodate many hyperbenthic taxa (Bradford, 1969; Grice and Hulsemann, 1970; Grice, 1973; Campaner, 1978; Othman and Greenwood, 1994; Ohtsuka *et al.*, 1998b).

Feeding

In general, copepods of the family Scolecitrichidae are regarded as detritivores (Nishida *et al.*, 1991; Ohtsuka and Kubo, 1991; Steinberg, 1995; Nishida and Ohtsuka, 1997). An epipelagic species *Scolecithrix danae* Lubbock, 1856 and a mesopelagic species *Scopalatum vorax* (Esterly, 1911) preferentially feed on appendicularian houses and phyto- and microzooplankters aggregated on the houses (Ohtsuka and Kubo, 1991; Steinberg, 1995). Other mesopelagic species, *Lophothrix frontalis* Giesbrecht, 1895 and *Scottocalanus securifrons* (Scott, 1894), consume crustacean fragments, appendicularian houses and other detrital matter (Nishida

et al., 1991; Ohtsuka, unpublished data). The present study has revealed that species of the hyperbenthic genus *Macandrewella* feed voraciously on small crustacean carcasses and/or sloughs. These differences in food items may be related to habitats. In addition, the presence of the single cuticular lens on the cephalosome is likely to be related to the special feeding habit of *Macandrewella*. In a related calanoid family, Phaennidae, specialized detritivory is found in one genus: the deep-sea *Cephalophanes* which has well-developed paired, cephalic mirrors, selectively consumes crustacean carcasses and/or sloughs, whereas species of other genera in the family seem to be general detritivores (Gowing and Wishner, 1986, 1992; Nishida and Ohtsuka, unpublished data). Therefore these optical receptors seem to play an important role in the detection of crustacean carcasses and/or sloughs associated with bioluminescent bacteria (Wada *et al.*, 1995). The optical and chemical sensory systems may be supplemental in these bizarre scolecitrichids and phaennids.

Other cephalic lens-bearing planktonic copepods such as Centropagidae, Pontellidae (Calanoida), Miraciidae (Harpacticoida), Corycaeidae and Sapphirinidae (Poecilostomatoida) are distributed mainly in epipelagic zones (Grice and Hulsemann, 1965; Böttger-Schnack, 1990; Huys and Böttger-Schnack, 1994; Chae and Nishida, 1995). Among these taxa, the lenses of Pontellidae, Corycaeidae and Sapphirinidae presumably function in orientation or mating (Land, 1988; Boxshall, 1992; Chae and Nishida, 1994). The optical sensory organs of the deep-sea calanoid copepods seem to be related to feeding rather than to these functions. This may be supported by the fact that copepodid stages of *Cephalophanes* and *Macandrewella* bear also the same well-developed optical sensor as the adults exhibiting no sexual dimorphism (Nishida and Ohtsuka, unpublished data).

Key to species of *Macandrewella*

Female

The female of *Macandrewella chelipes* Giesbrecht, 1896 was first described by Campaner (1989), but is not included in this key, because species-specific characters of the prosome, urosome, and leg 5 are not mentioned in his description.

- | | | |
|---|---|------------------------------|
| 1 | Genital double-somite with large dorsal or dorsolateral projection(s) | 2 |
| | Genital double-somite without such projection(s) | 4 |
| 2 | Genital double-somite with large, pointed, mid-dorsal process near posterior margin | |
| | <i>M. agassizi</i> Wilson, 1950 | |
| | Genital double-somite with swelling(s) on right dorsolateral side | 3 |
| 3 | Genital double-somite with single dorsolateral swelling present on right posterior corner | |
| | <i>M. sewelli</i> Farran, 1936 | |
| | Genital double-somite with two dorsolateral swellings on right anterior portion | |
| | <i>M. serratipes</i> n. sp. | |
| 4 | Leg 5 present | 5 |
| | Leg 5 absent | 6 |
| 5 | Two distinct spines on terminal segment of leg 5 | <i>M. joanae</i> Scott, 1909 |
| | One to three elements on terminal segment of leg 5, some or all of which rudimentary | <i>M. stygiana</i> n. sp. |
| 6 | Caudal setae on right and left sides asymmetrical (left seta V much longer than right) | |
| | <i>M. cochinensis</i> Gopalakrishnan, 1973 | |
| | Caudal setae on right and left sides symmetrical | 7 |

- 7 Genital double-somite symmetrical; linguiform genital operculum absent
 *M. scotti* Sewell, 1929
 Genital double-somite asymmetrical, swollen on right lateral side; linguiform genital
 operculum present 8
- 8 Prosome with one lateral and one dorsolateral process terminally on right side
 *M. mera* Farran, 1936
 Prosome ending in single point 9
- 9 Prosomal ends reaching to midway of genital double-somite
 *M. asymmetrica* Farran, 1936
 Prosomal ends reaching nearly to or beyond posterior margin of genital double-somite
 *M. omorii* n. sp.

Male

- 1 Second exopodal segment of right leg 5 with strongly curved proximal process longer
 than second segment proper; second exopodal segment of left leg 5 with strong
 triangular outer process terminally 2
 Second exopodal segment of right leg 5 without such long process proximally; second
 exopodal segment of left leg 5 without outer process 4
- 2 Second exopodal segment of right leg 5 with strong triangular process midway of inner
 margin; left endopod serrate along distal half or two-thirds of segments 3
 Second exopodal segment of right leg 5 lacking inner middle process; left endopod
 serrate only near tip *M. asymmetrica* Farran, 1936
- 3 Right endopod of leg 5 with two distinct round swellings distal to proximal-most
 thumb-like process *M. omorii* n. sp.
 Right endopod of leg 5 with single round swelling distal to proximal-most thumb-
 like process. *M. joanae* Scott, 1909
- 4 Third exopodal segment of right leg 5 strongly curved inward midway or at two-thirds
 of distance, distal and proximal parts connected by membranous structure 5
 Third exopodal segment of right leg 5 without such structure 6
- 5 Third exopodal segment of right leg 5 curved midway; right endopod bearing strong
 triangular process midway *M. cochinensis* Gopalakrishnan, 1973
 Third exopodal segment of right leg 5 curved at two-thirds of distance; right endopod
 bearing small rounded process midway *M. stygiana* n. sp.
- 6 Third exopodal segment of right leg 5 with outer process about midway 7
 Third exopodal segment of right leg 5 without outer process 9
- 7 First exopodal segment of right leg 5 with outer finger-like process terminally
 *M. sewelli* Farran, 1936
 First exopodal segment of right leg 5 without outer process 8
- 8 Second exopodal segment of right leg 5 with two inner processes proximally
 *M. serratipes* n. sp.
 Second exopodal segment of right leg 5 with one proximal inner process
 *M. chelipes* (Giesbrecht, 1896)
- 9 Inner proximal process on second exopodal segment of right leg 5 blunt, as long as
 second segment *M. scotti* Sewell, 1929
 Inner proximal process on second exopodal segment of right leg 5 small, curved
 outward subterminally. *M. agassizi* Wilson, 1950

Acknowledgements

Thanks are extended to Dr M. Madhupratap for providing us with important literature. This study was partially supported by grants from the Ministry of Education, Science, Culture and Sports of Japan (Nos 10660180, 12NP0201).

References

- BARNES, R. D., 1987, *Invertebrate Zoology*, 5th edn (Philadelphia: Saunders College Publishing), 893 pp.
- BARTHÉLÉMY, R., OHTSUKA, S. and CUOC, C., 1998, Description and female genital structure of a new species of the demersal calanoid copepod *Ridgewayia* from southern Japan, *Journal of Natural History*, **32**, 1303–1318.
- BÖTTGER-SCHNACK, R., 1990, Community structure and vertical distribution of cyclopoid copepods in the Red Sea. I. Central Red Sea, autumn 1980, *Marine Biology*, **106**, 473–485.
- BOWMAN, T. E. and GONZÁLEZ, J. G., 1961, Four new species of *Pseudocyclops* (Copepoda: Calanoida) from Puerto Rico, *Proceedings of the United States National Museum*, **113**(3452), 37–39.
- BOXSHALL, G. A., 1992, Copepoda, in F. W. Harrison and A. G. Humes (eds) *Microscopic Anatomy of Invertebrates*, Vol. 9 (New York: Wiley-Liss), pp. 347–384.
- BRADFORD, J., 1969, New genera and species of benthic calanoid copepods from the New Zealand slope, *The New Zealand Journal of Marine and Freshwater Research*, **3**, 473–505.
- CAMPANER, A. F., 1978, On some new planktobenthic Aetideidae and Phaennidae (Copepoda, Calanoida) from Brazilian continental shelf. II. Phaennidae, *Ciência e Cultura*, **30**, 966–982.
- CAMPANER, A. F., 1989, Supplementary description of *Macandrewella chelipes* (Giesbrecht, 1896) from the Gulf of Elat (Copepoda: Calanoida: Scolecithricidae), and comments on its relationships with *Scottocalanus* Sars and *Scolecocalanus* Farran, *Israel Journal of Zoology*, **35**, 229–235.
- CHAE, J. and NISHIDA, S., 1994, Integumental ultrastructure and color patterns in the iridescent copepods of the family Sapphirinidae (Copepoda: Poecilostomatoida), *Marine Biology*, **119**, 205–210.
- CHAE, J. and NISHIDA, S., 1995, Vertical distribution and diel migration in the iridescent copepods of the family Sapphirinidae: a unique example of reverse migration?, *Marine Ecology Progress Series*, **119**, 111–124.
- ESTERLY, C. O., 1911, Third report on the Copepoda of the San Diego region, *University of California Publications in Zoology*, **6**, 313–352.
- FARRAN, G. P., 1936, Copepoda, *Great Barrier Reef Expedition, 1928–1929, Scientific Reports*, **5**, 73–142.
- FOSSHAGEN, A., 1968a, Marine biological investigations in the Bahamas. 4. Pseudocyclopidae (Copepoda, Calanoida) from the Bahamas, *Sarsia*, **32**, 39–62.
- FOSSHAGEN, A., 1968b, Marine biological investigations in the Bahamas. 8. Bottom-living Arietellidae (Copepoda, Calanoida) from the Bahamas with remarks on *Paramisophria cluthae* T. Scott, *Sarsia*, **35**, 57–64.
- FOSSHAGEN, A., 1970a, Marine biological investigations in the Bahamas. 12. Stephidae (Copepoda, Calanoida) from the Bahamas, with remarks on *Stephos sinuatus* Willey and *S. arcticus* Sars, *Sarsia*, **41**, 37–48.
- FOSSHAGEN, A., 1970b, Marine biological investigations in the Bahamas. 15. *Ridgewayia* (Copepoda, Calanoida) and two new genera of calanoids from the Bahamas, *Sarsia*, **44**, 25–58.
- GIESBRECHT, W., 1895, Report of the dredging operations off the west coast of central America to the Galapagos, to the west coast of Mexico, and in the Gulf of California, in charge of Alexander Agassiz, carried out by the U. S. Fish Commission steamer 'Albatross', during 1891, Lieut. Commander Z. L. Tanner, U. S. N. commanding XVI, Die pelagischen Copepoden, *Bulletin of the Museum of Comparative Zoology at Harvard College*, **25**, 243–263.
- GIESBRECHT, W., 1896, Über pelagische Copepoden des Rothen Meeres, gesammelt vom Marinestabsarzt Dr. Augustin Kramer, *Zoologische Jahrbucher. Abteilung für Systematik, Geographie und Biologie*, **9**, 315–328.
- GRICE, G. D., 1973, The existence of a bottom-living calanoid copepod fauna in deep water with descriptions of five new species, *Crustaceana*, **23**, 219–242.
- GRICE, G. D. and HULSEMAN, K., 1965, Abundance, vertical distribution and taxonomy of calanoid copepods at selected stations in the northeast Atlantic, *Journal of Zoology, London*, **146**, 213–262.

- GRICE, G. D. and HULSEMANN, K., 1970, New species of bottom-living calanoid copepods collected in deep water by the DSRV Alvin, *Bulletin Museum of Comparative Zoology*, **139**, 185–230.
- GOPALAKRISHNAN, T. C., 1973, A new species of *Macandrewella* (Copepoda: Calanoida) from off Cochin, south west coast of India, *Handbook to International Zooplankton Collections, Indian Ocean Biological Centre*, **5**, 180–189.
- GOWING, M. M. and WISHNER, K. F., 1986, Trophic relationships of deep-sea calanoid copepods from the benthic boundary layer of the Santa Catalina Basin, California, *Deep-Sea Research*, **33**, 939–961.
- GOWING, M. M. and WISHNER, K. F., 1992, Feeding ecology of benthopelagic zooplankton on an eastern tropical Pacific seamount, *Marine Biology*, **112**, 451–467.
- HUYS, R. and BÖTTGER-SCHNACK, R., 1994, Taxonomy, biology and phylogeny of Miraciidae (Copepoda: Harpacticoida), *Sarsia*, **79**, 207–283.
- HUYS, R. and BOXSHALL, G. A., 1991, *Copepod Evolution* (London: The Ray Society), 468 pp.
- LAND, M. F., 1988, The functions of eye and body movements in *Labidocera* and other copepods, *Journal of Experimental Biology*, **140**, 381–391.
- LUBBOCK, J., 1856, On some Entomostraca collected by Dr Sutherland in the Atlantic Ocean, *Transactions of the Royal Entomological Society of London, N. S.*, **4**, 8–37.
- NISHIDA, S. and OHTSUKA, S., 1997, Ultrastructure of the mouthpart sensory setae in mesopelagic copepods of the family Scolecitrichidae, *Plankton Biology and Ecology*, **44**, 81–90.
- NISHIDA, S., KIKUCHI, T. and TODA, T., 1999, Efficient capture of deep-sea hyperbenthic calanoid copepods with baited traps, *Plankton Biology and Ecology*, **46**, 165–168.
- NISHIDA, S., OH, B.-C. and NEMOTO, T., 1991, Midgut structure and food habits of the mesopelagic copepods *Lophothrix frontalis* and *Scottocalanus securifrons*, *Bulletin of Plankton Society of Japan, Special Volume*, 527–534.
- OHTSUKA, S., 1983, Calanoid copepods collected from the near-bottom in Tanabe Bay on the Pacific coast of the Middle Honshu, Japan. I. Arietellidae, *Publications of the Seto Marine Biological Laboratory*, **29**, 359–365.
- OHTSUKA, S., 1985, Calanoid copepods collected from the near-bottom in Tanabe Bay on the Pacific coast of the Middle Honshu, Japan. II. Arietellidae (cont.), *Publications of the Seto Marine Biological Laboratory*, **30**, 287–306.
- OHTSUKA, S., 1992, Calanoid copepods collected from the near-bottom in Tanabe Bay on the Pacific coast of the Middle Honshu, Japan. IV. Pseudocyclopiidae, *Publications of the Seto Marine Biological Laboratory*, **35**, 295–301.
- OHTSUKA, S. and HIROMI, J., 1987, Calanoid copepods collected from the near-bottom in Tanabe Bay on the Pacific coast of the Middle Honshu, Japan. III. Stephidae, *Publications of the Seto Marine Biological Laboratory*, **35**, 295–301.
- OHTSUKA, S. and KUBO, N., 1991, Larvaceans and their houses as important food for some pelagic copepods, *Bulletin of Plankton Society of Japan, Special Volume*, 535–551.
- OHTSUKA, S., BOXSHALL, G. A. and ROE, H. S. J., 1994, Phylogenetic relationships between arietellid genera (Copepoda, Calanoida), with the establishment of three new genera, *Bulletin of the Natural History Museum (Zoology)*, **60**, 105–172.
- OHTSUKA, S., FOSSHAGEN, A. and GO, A., 1991, The hyperbenthic calanoid copepod *Paramisophria* from Okinawa, South Japan, *Zoological Science*, **8**, 793–804.
- OHTSUKA, S., FOSSHAGEN, A. and PUTCHAKARN, S., 1999, Three new species of the demersal calanoid copepod *Pseudocyclops* from Phuket, Thailand, *Plankton Biology and Ecology*, **46**, 132–147.
- OHTSUKA, S., FOSSHAGEN, A. and SOH, H. Y., 1996, Three new species of the demersal calanoid copepod *Placocalanus* (Ridgewayiidae) from Okinawa, southern Japan, *Sarsia*, **81**, 247–263.
- OHTSUKA, S., ROE, H. S. J. and BOXSHALL, G. A., 1993, A new family of calanoid copepods, the Hyperbionycidae, collected from the deep-sea community in the northeastern Atlantic, *Sarsia*, **78**, 69–82.
- OHTSUKA, S., SOH, H. Y. and UEDA, H., 1998a, *Platycopia compacta* n. sp., the second species of Platycopioida (Crustacea: Copepoda) in the Indo-Pacific region, with remarks on development, feeding, swimming and zoogeography, *Zoological Science*, **15**, 415–424.
- OHTSUKA, S., TAKEUCHI, I. and TANIMURA, A., 1998b, *Xanthocalanus gracilis* and *Tharybis magna* (Copepoda: Calanoida) rediscovered from the Antarctic Ocean with baited traps, *Journal of Natural History*, **32**, 785–804.

- OHTSUKA, S., HUYS, R., BOXSHALL, G. A. and ITÔ, T., 1992, *Misophriopsis okinawensis* sp. nov. (Crustacea: Copepoda) from hyperbenthic waters off Okinawa, South Japan, with definitions of related genera *Misophria* Boeck, 1864 and *Stygomisophria* gen. nov., *Zoological Science*, **9**, 859–874.
- OTHMAN, B. H. R. and GREENWOOD, J. G., 1988, A new species of *Ridgewayia* (Copepoda, Calanoida) from the Gulf of Carpentaria, *Memoirs of the Queensland Museum*, **25**, 465–469.
- OTHMAN, B. H. R. and GREENWOOD, J. G., 1989, Two new species of copepods from the family Pseudocyclopidae (Copepoda, Calanoida), *Crustaceana*, **56**, 63–77.
- OTHMAN, B. H. R. and GREENWOOD, J. G., 1994, A new genus with three new species of copepods from the family Diaixidae (Crustacea: Calanoida), and a redefinition of the family, *Journal of Natural History*, **28**, 987–1005.
- SARS, G. O., 1903, Copepoda. Calanoida, *An Account of the Crustacea of Norway*, **4**, 1–171.
- SARS, G. O., 1921, Copepoda. Supplement, *An Account of the Crustacea of Norway*, **7**, 1–115.
- SCOTT, A., 1909, The Copepoda of the Siboga Expedition. Part 1. Free-swimming, littoral and semi-parasitic Copepoda, *Siboga-Expeditie, Monograph*, **29a**, 1–408.
- SCOTT, T., 1894, Report on Entomostraca from the Gulf of Guinea, collected by John Rattray, B.Sc., *Transactions of the Linnean Society*, **6**, 1–161.
- SEWELL, R. B. S., 1929, The Copepoda of Indian Seas, *Memoirs of the Indian Museum*, **10**, 1–221.
- STEINBERG, D. K., 1995, Diets of copepods (*Scopalatum vorax*) associated with mesopelagic detritus (giant larvacean houses) in Monterey Bay, California, *Marine Biology*, **122**, 571–584.
- WADA, M., YAMAMOTO, I., NAKAGAWA, M., KOGURE, K. and OHWADA, K., 1995, Photon emission from dead marine organisms monitored using a video recording system, *Journal of Marine Biotechnology*, **2**, 205–209.
- WILSON, C. B., 1950, Copepods gathered by the United States Fisheries Steamer 'Albatross' from 1887 to 1909, chiefly in the Pacific Ocean. *Bulletin of the United States National Museum*, **100**(14), 141–441.