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## New Species belonging to the Family Porcellidiidae (Harpacticoida: Copepoda) from the Southern Coast of New South Wales, Australia

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ABSTRACT. Eight new species belonging to the family Porcellidiidae (Harpacticoida: Copepoda) are described from the southern coast of New South Wales, Australia. All live on the surface of seaweeds in the eulittoral and sublittoral zones. Characteristic features of the family are described and redefined. The genus *Porcellidium* is redefined and subdivided into three groups on the setation of the female caudal ramus and structure of the male antennule. Four of the new species, *Porcellidium hormosirii*, *P. ocellum*, *P. pulchrum* and *P. erythrogastrum* have been assigned to the "Hormosirii" group, and *P. naviculum* and *P. phyllosporum* to the "Naviculum" group. A new genus, *Acutiramus*, is defined and two new species, *A. rufolineatus* and *A. quinquelineatus*, assigned to it. The relationship between the new species and previously described species of *Porcellidium* is discussed. *Porcellidium viride* (Phillipi, 1840) and *P. sarsi* (Claus, 1863) are placed in the 'Naviculum' subgroup, *P. rubrum* Pallares, 1966, *P. hartmannorum* Tiemann, 1978, *P. erythrum* Hicks, 1971 and *P. algoense* Hicks, 1982 are placed in the subgroup 'Hormosirii', and *P. fimbriatum* Claus, 1889 is placed in a subgroup of its own. *Porcellidium acuticaudatum* Thompson & Scott, 1903, *P. brevicaudatum* Thompson & Scott, 1903 and *P. ovale* Geddes, 1968 (not Haller) have been placed in the new genus *Acutiramus*.

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The family Porcellidiidae (Harpacticoida: Copepoda) has a rich assemblage of species in the marine littoral of eastern Australia. Extensive collection by the authors over the past two decades has revealed 30 new forms from New South Wales, Australia. In addition, five new

forms have been found in the subtropical waters of the Great Barrier Reef, Qld. For convenience, the NSW forms will be split into a northern assemblage characteristic of the warm temperate waters north of Sydney, and a southern assemblage characteristic of

waters influenced by the cool currents from the Bass Strait. A small number of species span both northern and southern waters of NSW. In this paper eight of the southern species will be described.

Members of the Porcellidiidae are poor swimmers. With the exception of three species (*Porcellidium echinophylum*, *P. bevicaudatum* and *P. tapui*) living in mutualistic relationship with other animals, all members of the family live on the surface of seaweed to which they adhere with remarkable tenacity. They appear to be confined to the littoral and sublittoral zones, but little is known about their vertical distribution. *Porcellidium hormosirii* is abundant at mean tide level (MTL) and *Acutiramus rufolineatus* is common at mean low water neap tides (MLWN) on NSW rocky shores. All the other species described here have been collected from the infralittoral fringe (accessible region of the sublittoral). At the other extreme, *P. tapui* has been recorded at depths of 200 m living on hermit crab shells (Hicks & Webber, 1983).

Up to the present time the family has been regarded as monotypic with all species being referred to one genus, *Porcellidium*. The reason for this is not difficult to understand. In the first place the family is remarkably conservative in its basic structure. Members are highly specialised for a particularly difficult and demanding ecological niche—dwelling on the surface of seaweed in turbulent waters. Having achieved an efficient body form and structure to exploit this niche, no significant structural changes can take place without being detrimental to this way of life. Thus in their general body form members of this family look remarkably alike.

Secondly, many authors have noted minor differences in structure or shape, most of which show continuous variation between species and are hard to quantify. Hitherto, none have fallen into the category of unique (discontinuous) characters which exist in one or more distinct forms that would allow the erection of new genera. Apart from trivial differences, members look remarkably similar.

Thirdly, the database upon which taxonomy of this group is based is very small. In many of the older descriptions familial characters are given as though they were specific characters. Of the 27 species (Hicks & Webber, 1983) of *Porcellidium* presently recognised, only eight have been completely and adequately described (*P. echinophylum* Humes & Gelerman, 1962; *P. rubrum* Pallares, 1968; *P. bevicaudatum* Thompson & Scott (Humes & Ho, 1969); *P. planum* Tiemann, 1977; *P. hartmannorum* Tiemann, 1978; *P. dilatatum* Hicks, 1971; *P. tristanense* Wiborg (Hicks, 1982) and *P. tapui* Hicks & Webber, 1983. Adequate descriptions of *P. erythrum* and *P. algoense* have been given by Hicks (1971, 1982), thus making a total database of only 10 species. The New South Wales and Great Barrier Reef material studied by the authors has increased this database to over 40 species. Consequently family, generic and specific characters can be defined with far greater confidence.

A number of unique characters have been found

which provide good criteria upon which new genera can be erected, moreover, a better understanding of the range of variation of other characters has led the way to a redefinition of the characteristics of the Porcellidiidae.

Certain features are found in all species and do not vary. Where these differ from related families (Harpacticidae, Peltidae, Tisbidae) they constitute familial characters. Unique characters which appear in two or three distinct forms without any continuous variation between them, appear to be good characters upon which to base generic relationships, while features showing a wide (and sometimes continuous) range of variation can be useful specific characters. Table 1 (Appendix) gives a list of characters that have been used in the present descriptions.

Attempts have been made in the past to devise a key to the species (Nicholls, 1941; Lang, 1948; Wiborg, 1964), but each is based upon female characters alone. However, the list in Table 1 (Appendix) clearly shows that adult males provide valuable taxonomic characters (antennule structure, cephalosome shape, setation of P2 and P5, for example), and these should be incorporated in the list of diagnostic features used to compile taxonomic keys.

The new enlarged database conflicts in many instances with characters of the family as listed by Sars (1904), Lang (1948) and other authors. This necessitates a major revision of the criteria defining the Porcellidiidae and a restatement of the characteristics of the genus *Porcellidium*. As a first step towards the revision of *Porcellidium*, the genus will be divided into three subgroups and a new genus, *Acutiramus*, erected to accommodate two new species which are excluded from *Porcellidium*.

### Type Material

For each species one sample taken from a natural population has been designated the type population, and the station from which it was collected is referred to as the type locality. Type populations were selected to contain ovigerous females, males coupled with juvenile females as well as nauplius and copepodite (copepodite) stages. Samples heavily contaminated with epizoic organisms were avoided. The location of sampling stations on the southern coast of New South Wales from which material was obtained is shown in Figure 1.

At Broulee regular sampling was carried out over a number of years, but for other stations sampling has been less frequent.

From each type population an ovigerous female has been selected as the holotype and the egg mass, which obscures the limbs, detached. A male has been selected as the allotype. The remaining type population (and in some cases other populations from the type locality) is designated paratype material. Dissected specimens were stained in chlorazol black and mounted in polyvynal

lactophenol. Drawings of limbs and body parts were made from dissection of paratype material using a Leitz Ortholux microscope with drawing tube attachment. The numbers on illustrations refer to the respective paratype slide from which they were drawn. Details of surface morphology have been obtained from scanning electron micrographs of gold coated formalin preserved specimens taken on Cambridge Steroscan 180 and Hitachi S-255 ON scanning electron microscopes.

Holotypes, allotypes and a representative selection of paratype material (including slides) have been deposited in the Australian Museum, Sydney (AM). Other paratype material has been deposited at the British Museum of Natural History, London (BM(NH)). Other material (not paratype specimens) has been deposited in the National Museum of New Zealand, Wellington (NMNZ). The remaining paratype material and prepared slides are currently held in the Division of Botany & Zoology, School of Life Sciences, Australian National University, Canberra, Australia (ZANU), by the senior author.

Tables 1 to 4 are listed in the Appendix.

### Measurements and Terminology

Measurements were made on formalin preserved paratype specimens, care being taken not to distort the width of the body by pressure from the coverglass. To avoid error that might be caused by the angle at which the caudal rami are held, body length has been taken

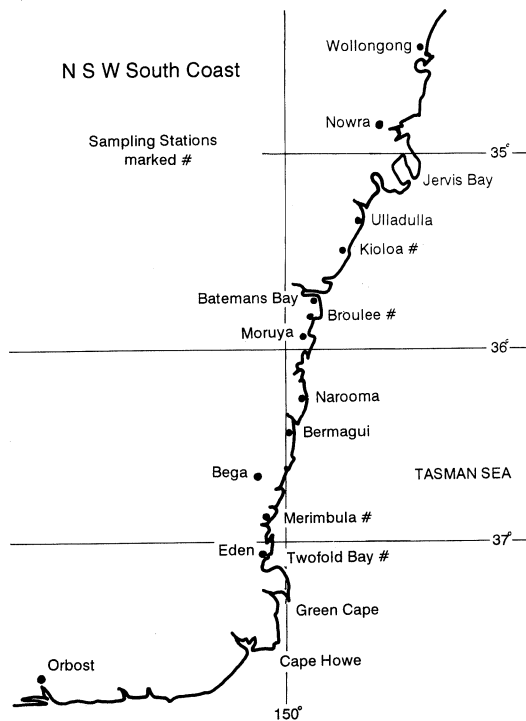


Fig. 1. Map of the New South Wales south coast showing sampling stations and type localities.

as the distance from the anterior edge of the rostrum to the posterior extremity of the urosome (Fig. 2). Terms used to describe the shape of the urosome and caudal ramus as well as setae are also illustrated in Figure 2. The term spinose has been reserved for rigid or spine-like setae; plumose and annulated setae are more flexible. A hyaline fringe round the cephalosome in most species has been omitted from the drawings of the whole animal.

Estimates of abundance are subjective. They relate to a standard procedure in which copepods were washed from about four litres of each seaweed. Identification and matching males with females is greatly facilitated by the fact that adults of most species are distinctively coloured and show a marked preference for a particular species of seaweed.

### Systematics

#### Porcellidiidae Sars 1904

**Diagnosis.** Epimeral lobe of third metasomal segment reduced in female, normal in male, fourth segment without epimeral lobe; urosome comprises genital double segment plus anal segment; setae of plate-like caudal rami never longer than ramus; antennules with 6 articles in female, prehensile in male with articles 3 and 4 fused to form a compound segment; maxilliped not strongly prehensile; first pereopod (P1) with crescent of filiform setules (fimbriate crescent) on anterior aspect of endopod; setal formula (internal) for endopod of natatory limbs (pereopods P1-P4) is characteristic of the family –

Female	Male
P1 1:2	P1 1:2
P2 1:2:s.2.1	P2 1:2:s.2.1 or 1:2:s.2.0 or 1:2:0.2.0
P3 1:s.1:1.s.2.1	P3 1:s.1:1.s.2.1
P4 1:s:s.2.1	P4 1:s:s.2.1

[‘s’ denotes a spinous seta].

All members of the family show strong sexual dimorphism.

**Adult females.** Body oval or shield shape in outline, usually strongly dorsoventrally compressed. Rostrum an inverted triangle, sometimes obscured from dorsal view. Anterior of cephalosome semicircular or truncated. Hyaline border surrounds cephalosome in most species. Epimeral lobes of metasomal segments 1 and 2 with hyaline border, lobe 3 reduced without hyaline border, segment 4 without epimeral lobe.

Urosome comprises genital double segment and anal segment only. Genital segment of urosome expanded laterally by anterior and posterior epimeral lobes in most species, but never as wide as the cephalosome. Urosome plus fifth pereopods completely cover egg mass dorsally and give rounded posterior outline to body.

Caudal rami triangular, rhomboidal or rectangular

plates (never cylindrical). Caudal setae short (never longer than ramus) divisible into a dorsal series –  $\alpha$ ,  $\beta$  and  $\gamma$ , with  $\gamma$  terminal or lateral, and a terminal series of 4 (rarely 3) setae. Ramus ends in terminal fringe of

very fine setules.

Limbs. Antennule reduced to 6 articles with aesthetasc on article 4. Exopod of antenna with single article bearing 6 setae. Mandibular palp with 4 pilose setae on

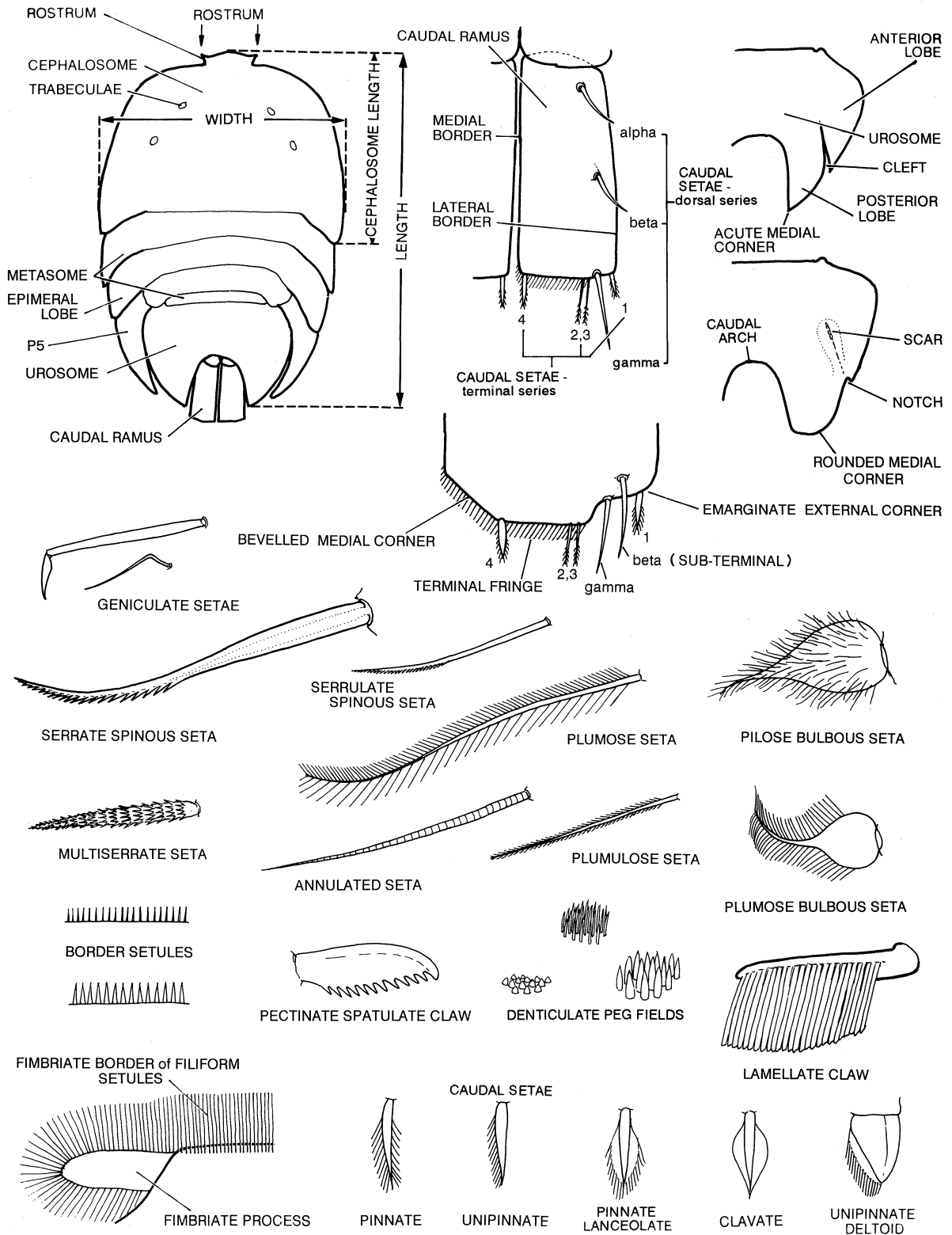


Fig. 2. Diagrams indicating method of measurement and terminology used in describing species. P5 – fifth pereiopod. Numbering on the terminal caudal setae (2,3) should read 3,2.

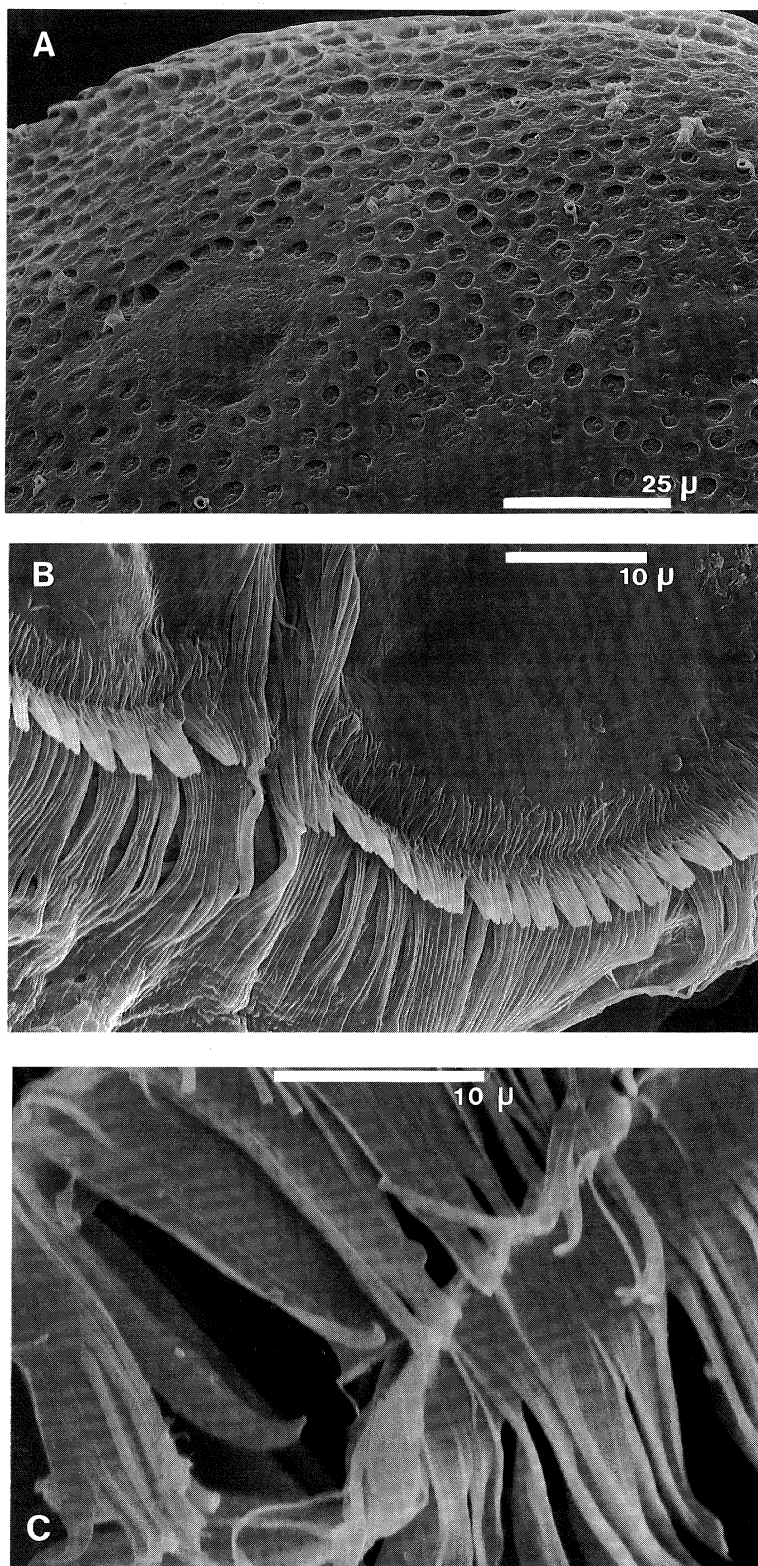


Plate 1. A – *Porcellidium hormosirii*. Dorsal pits on anteriodorsal surface of cephalosome. A few sensory setae with a collar round their base can be seen. The large oval patch to the left of centre without pits marks the position of a trabecula. SEM micrograph. Scale bar = 25  $\mu\text{m}$ . B – *Porcellidium erythrogastrum*. Part of the fimbriate crescent on P1 endopod, showing ribband-like filiform setules and proximal row of denticulate pegs. SEM micrograph. Scale bar = 10  $\mu\text{m}$ . C – terminal claws of P1 endopod showing lamellate structure of setules. SEM micrograph. Scale bar = 10  $\mu\text{m}$ .

large anterior lobe (expanded basis), 9 setae on endopod, 5 pilose and 1 plain seta plus D-shaped medial lobe on posterior lobe (exopod). Maxillule with 3 endites, endopod with 2 or 6 setae, exopod reduced, bearing 2 (occasionally one) short setae. Maxilliped reduced, not subchelate or strongly prehensile, variable, coxa with or without rounded medial plate bordered with filiform setules, basis with or without fimbriate process. Natatory limbs P1-P4 with long intercoxal (sternal) sclerite separating base of limbs, coxa-basis of limb project laterally, not ventrally. P1 exopod shorter than endopod, endopod of 2 articles, article 1 triangular with anterior crescent of filiform setules (fimbriate crescent, Pl. 1B), article 2 with 2 strong lamellate claws in most species (Pl. 1C), denticulate peg fields may be present but never on coxa-basis. Setation of natatory limbs as given in Diagnosis above. P5 exopod of 1 article, expanded, leaf-like with strong falciform ventral ridge, lies lateral to urosome (not ventral to egg mass).

**Males** Rostrum reduced, anterior of cephalosome truncated in most species, hyaline border, if present, as for female. Epimeral lobe of third metasomal segment normal with hyaline fringe, epimere absent on fourth.

Urosome not greatly expanded, narrower than female.

Caudal rami usually quadrate, usually different in shape but similar in setation to female.

**Limbs.** Antennules modified as prehensile organs for clasping urosome of juvenile female, articles 3 and 4 fused to form compound segment bearing coupling structures (coupling denticles); other appendages identical to female except for P2 and P5. P2 endopod setal formula variable - 1:2:0.2.0, 1:2:s.2.0 or 1:2:s.2.1 (s = spinous seta). P5 rhomboidal in most species with 1 or 6 terminal setae.

**Generic composition.** *Acutiramus* n.gen.; *Porcellidium* Claus, 1860.

**Remarks.** The majority of species are coloured and many species show sexual dimorphism in the colour pattern. Colouration and ornamentation of the dorsal surface (pits, ridges, reticulation, honeycomb etc.) are highly specific and provide useful means of identification without dissection. Many species have a specific relationship with certain epizoic organisms (suctorians, thecate ciliate protozoa and diatoms) which are an aid to identification. Nauplii are oval and extremely flattened. Copepodede (copepodite) stages take on the adult body form and pass through five stages. Metamorphosis occurs at the end of the fifth stage. Adults show strong sexual dimorphism, but the gender of juveniles can be determined at the third stage copepodede. Adult males couple with third, fourth and fifth stage juvenile females.

The family has many features in common with certain members of the Harpacticidae (*Zaus*), Peltidae (*Alteutha*, *Dactylopusia*) and Tisbidae (*Aspidiscus*, *Psamathe*), but the diagnostic characters listed above (taken as a whole) are unique and clearly distinguish members of the Porcellidiidae.

### *Porcellidium* Claus 1860

**Diagnosis.** Anterior of female cephalosome semicircular, male truncated; hyaline border and dorsal pits present; urosome broad, with epimeral expansions to form anterior and posterior lobes, posterior lobe broad, caudal rami included in caudal arch of urosome; caudal rami rectangular or quadrate,  $\alpha$  and  $\beta$  setae not close together; maxillule endopod with 6 setae; maxilliped basis with fimbriate process, coxal lobe fimbriate; male P2 endopod with 2 plumose terminal setae; male P5 with 6 terminal setae; female P5s do not extend beyond the caudal rami or touch one another posteriorly.

**Females.** Anterior outline of cephalosome semicircular with prominent rostrum, no medial bulge (convexity) or overhang above rostrum. Hyaline border always present on cephalosome and metasomal epimera. Ducts from marginal glands open dorsal to hyaline border. Dorsal pits usually conspicuous, but may be reduced or absent.

Large lateral epimeral expansions of urosome, forming distinct anterior and posterior lobes. Urosome broad. Posterior lobe rounded, not V-shaped. Marginal setules border lateral edges of urosome. Caudal arch accommodates part, if not most, of the caudal rami.

Caudal rami quadrate or rectangular, external corner may be emarginate (recessed), but posterior border is never oblique.  $\alpha$  and  $\beta$  setae never close together (ie, ratio  $\alpha$  to  $\gamma/\alpha$  to  $\beta < 5$ ),  $\beta$  usually about middle of ramus but may be subterminal (ie, close to  $\gamma$ ). Terminal setae 2 and 3 typically plain, slender and close together.

Maxillule endopod with 6 setae. Maxilliped with filiform setules bordering rounded coxal lobe and edge of basis, fimbriate process present. P1 without conspicuous or extensive denticulate peg fields on endopod. P5 lanceolate or ovate, not rounded or truncated posteriorly. Fifth limbs do not reach beyond the urosome or touch posteriorly.

**Males.** Anterior outline of cephalosome truncated, usually with medial convexity. Hyaline border and dorsal pits as for female.

Urosome without lateral expansions or marginal setules, caudal arch shallow.

Caudal rami quadrate, setation as for female.

First pilose seta on mandibular palp slender. P2 endopod with 2 plumose setae on terminal article, spinous seta absent (P2 = 1:2:0.2.0). P5 rhomboid with 6 terminal setae.

**Species composition.** 'Hormosirii' sub-group: *Porcellidium rubrum* Pallares, 1966; *P. hartmannorum* Tiemann, 1978; *P. algoense* Hicks, 1982; *P. hormosirii* n.sp.; *P. ocellum* n.sp.; *P. pulchrum* n.sp.; *P. erythrogastrum* n.sp.

'Fimbriatum' sub-group: *Porcellidium fimbriatum* Claus, 1889.

'Naviculum' sub-group: *Porcellidium viride* (Philippa, 1840); *P. sarsi* (Claus, 1863); ? *P. erythrum* Hicks, 1971; *P. naviculum* n.sp.; *P. phyllosporum* n.sp.

**Remarks.** There is considerable variation in the shape of the urosome as well as the shape and setation of the caudal rami, moreover, a ventral blade may or may not

be present on the male antennule. Because of this members of this genus will be divided into three subgroups as follows:

1. Ventral blade present on male antennule –
  - Terminal setae 2 and 3 of caudal rami very close together, plain, fine ..... ‘Hormosirii’ subgroup
  - Terminal setae 2 and 3 of caudal rami not very close, resemble 1 and 4, pinnate, thick ..... ‘Fimbriatum’ subgroup
2. No ventral blade on male antennule ..... ‘Naviculum’ subgroup

**‘Hormosirii’ subgroup**

***Porcellidium hormosirii* n.sp.**

Figs 3-6

**Type material.** HOLOTYPE adult female with egg-mass detached, AM P35432; ALLOTYPE adult male, AM P35433; PARATYPES 3 ovigerous females, 3 adult males, 1 coupled stage III, 1 coupled stage IV female copepododes, AM P35434. A second population has been designated paratype material [Cr.16] taken from *Hormosira banksii* at Cronulla, Sydney, NSW, 21 Aug. 1975, V.A.P. Harris, AM P35435. Four females and 3 males [Ki24] paratypes BM(NH) 1992.383-389, (other material [Aw10] BM(NH) 1992.390-399). Dissections from which illustrations were made have been designated paratype material (slides 1159, 1348 male, 1160, 1167 female); these and remaining type population held at ZANU, registration Po.F.[Ki.24] [total type population 164 females (62 carrying eggs), 159 males (106 coupled to juvenile females), 148 uncoupled juveniles]. Taken from *Hormosira banksii* at midtide level on rocky shore, O’Hara Head, Kioloa, NSW (35°32’S 150°24’E), 24 Nov. 1976, V.A.P. Harris.

**Diagnosis. Adult female.** Amber yellow; mean length 0.68 mm, rostrum width 0.1 mm, ratio of cephalosome width to rostrum 4.5; dorsal surface conspicuously pitted; urosome broad, side of anterior lobe almost straight, posterior lobe rounded, medial corner rounded, small notch and scar; caudal rami rectangular, emarginate, medial corner bevelled with seta 4 set in,  $\alpha$  seta short and thick,  $\beta$  closer to  $\gamma$  than  $\alpha$ , terminal setae finely pinnate; small triangular peg field on endopod of P1; apex of P5 pointed.

**Adult male.** Antennule socket obscured, shoulders acutely angular; antennule with bifid ventral blade.

**Dimensions. Females.** Mean length 0.68 mm (SD = 0.011, N = 16), cephalosome length 0.37 mm, width 0.45 mm (SD = 0.018), height 0.11 mm, body length to width ratio 1.55. Rostrum 0.1 mm wide, ratio of body width to rostrum 4.5. Urosome width to length ratio 1.53. Caudal ramus length to width ratio 1.7.

**Males.** Mean length 0.5 mm (SD = 0.02, N = 16), Cephalosome length 0.28 mm, width 0.36 mm, height 0.1 mm, ratio of body length to width 1.38.

**Adult female (Fig. 3A).** Anterior outline of cephalosome semicircular, rostrum prominent, projects about 0.02 mm with hyaline edge (Fig. 3D). Hyaline border of cephalosome and epimeral lobes 7  $\mu$ m wide. Dorsal surface of cephalosome, metasome, and urosome conspicuously pitted (Pl. 1A). Pits 3  $\mu$ m in diameter with distinct crescentic border, in some areas cuticle between pits is raised to form a reticulate pattern. Reticulate pattern on dorsal surface of caudal rami.

Urosome broad (Fig. 4A), lateral edge of anterior lobe almost straight, bordered with fine setules, posterior lobe rounded with medial corner rounded and bordered with stronger setules, small notch and scar between lobes. Caudal arch deep (one-third length of urosome).

Caudal ramus rectangular slightly broader distally (Fig. 4B), medial edge straight, external corner emarginate, medial corner bevelled with seta 4 set in from corner.  $\alpha$  seta thick in comparison with other species,  $\beta$  closer to  $\gamma$  seta, terminal setae 1-4 finely pinnate and similar in size, 2 and 3 close together, terminal fringe of very fine setules ventral to setae extends from seta 2 to medial corner of ramus. In their natural position the rami do not project more than one-third of their length beyond the caudal arch of urosome.

Antennule (Fig. 3B) has the setal formula –

$$\frac{1}{1} : \frac{11}{2} : \frac{7}{3} : \frac{5+(As+1)}{4} : \frac{3}{5} : \frac{10}{6}$$

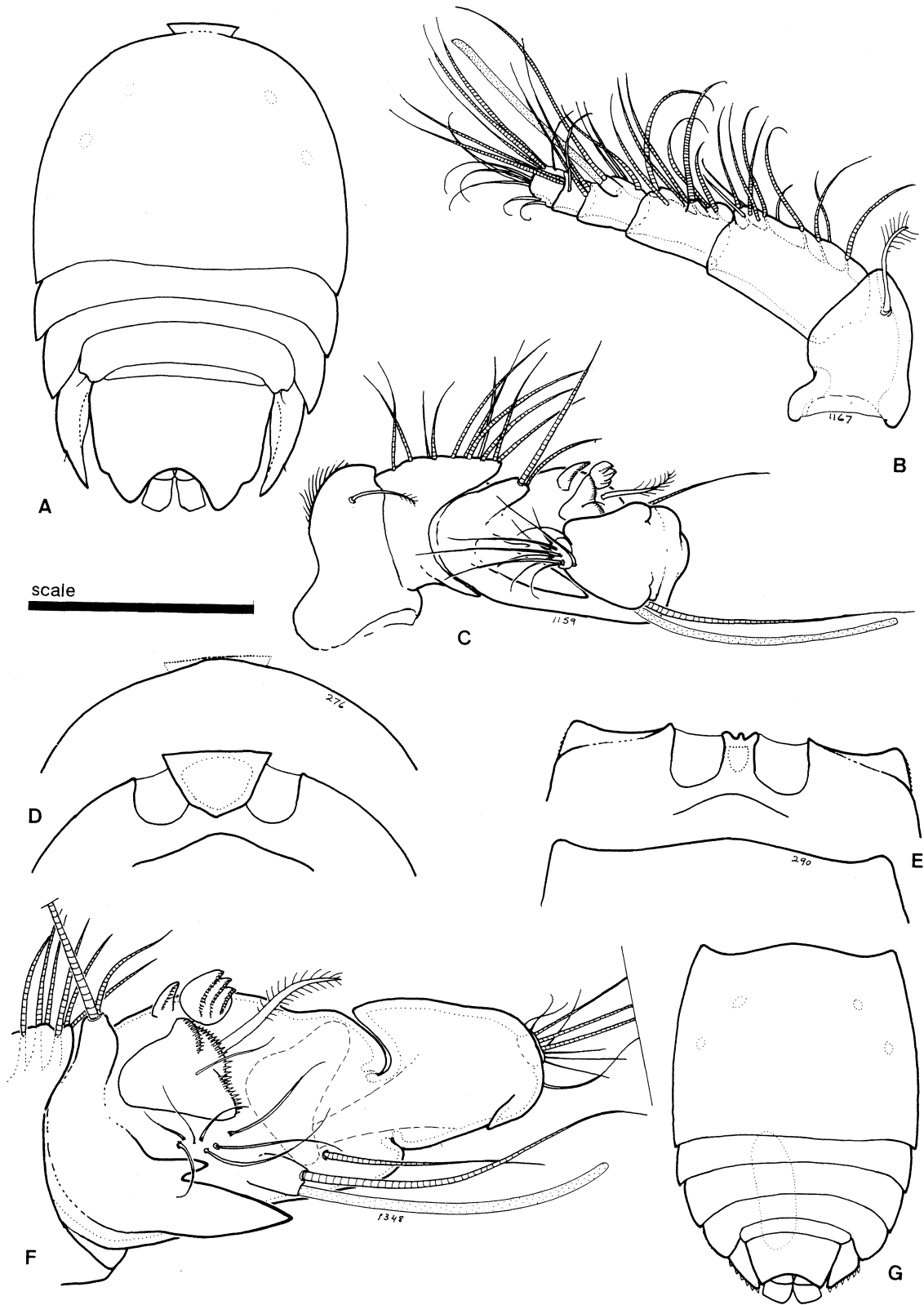
(As = aesthetasc)

Seta on first article plumose, remaining setae annulate. An aesthetasc (As) with accompanying seta is borne on a short lobe on article 4.

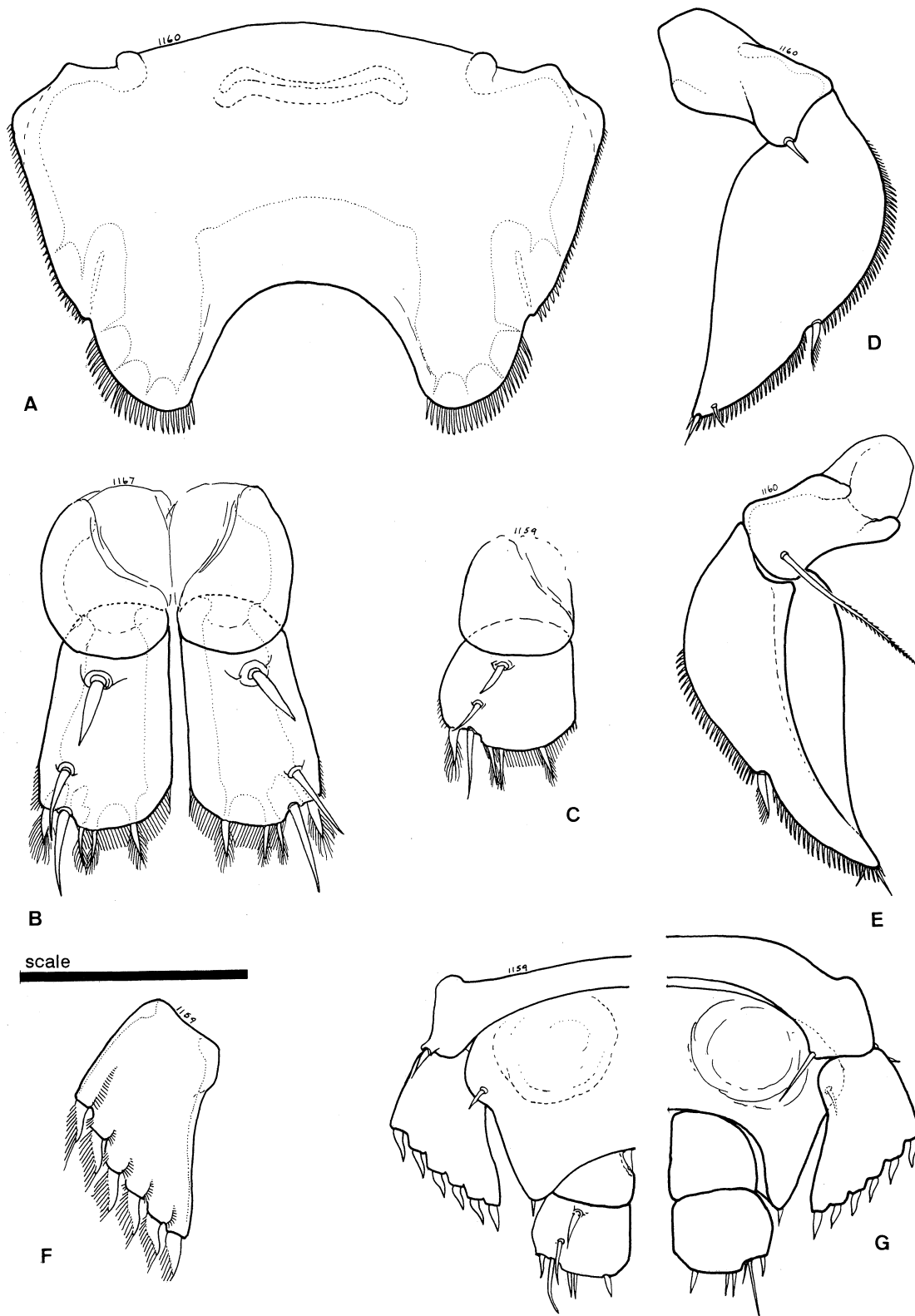
Antenna (Fig. 5B) with diagonal row of setules on basis, exopod with 6 plumulose setae, article 2 of endopod with pair of plain setae plus 6 terminal setae comprising terminal pectinate spatulate claw, 3 geniculate setae with serrulate terminal portion, 2 plumulose flexible setae and a small aesthetasc.

Mandible (Fig. 5A) with strong triangular pars molaris (praecoxa) tapering to the tooth-bearing incisor process with a fine seta on its anterior surface and a lacinia that is bilobed on one mandible and single lobed on the other (Fig. 5D). Coxa-basis of palp expanded anteriorly with 4 swollen pilose setae along its border and a circular

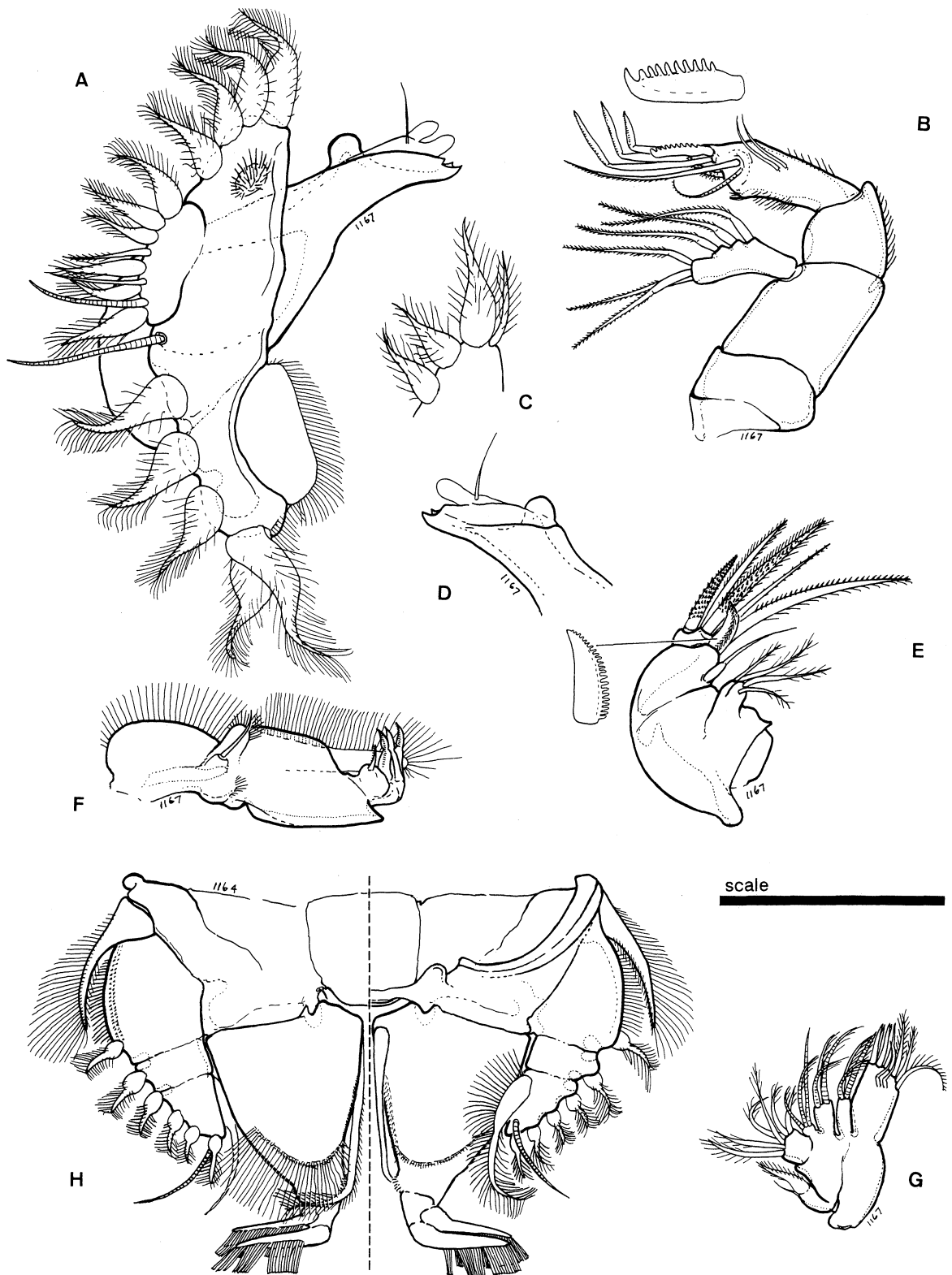




**Fig. 3.** *Porcellidium hormosirii*. A – adult female, dorsal view; B – female antennule; C – left male antennule (ventral view) with terminal segment in clapping position; D – anterior edge of female cephalosome (dorsal and ventral focus); E – anterior edge of male cephalosome (ventral and dorsal focus); F – antennule with ‘palm’ open to show coupling denticles and ventral blade; G – adult male, dorsal view. Scale bar: A,G = 0.315 mm; B,C = 0.075 mm; D,E = 0.2 mm; F = 0.045 mm.



**Fig. 4.** *Porcellidium hormosirii*. A – female urosome; B – female caudal rami; C – male caudal ramus; D,E – female P5 (dorsal and ventral); F – male P5; G – male urosome (dorsal and ventral). Scale bar: A,D,E,G = 0.1 mm; B,C,F = 0.075 mm.

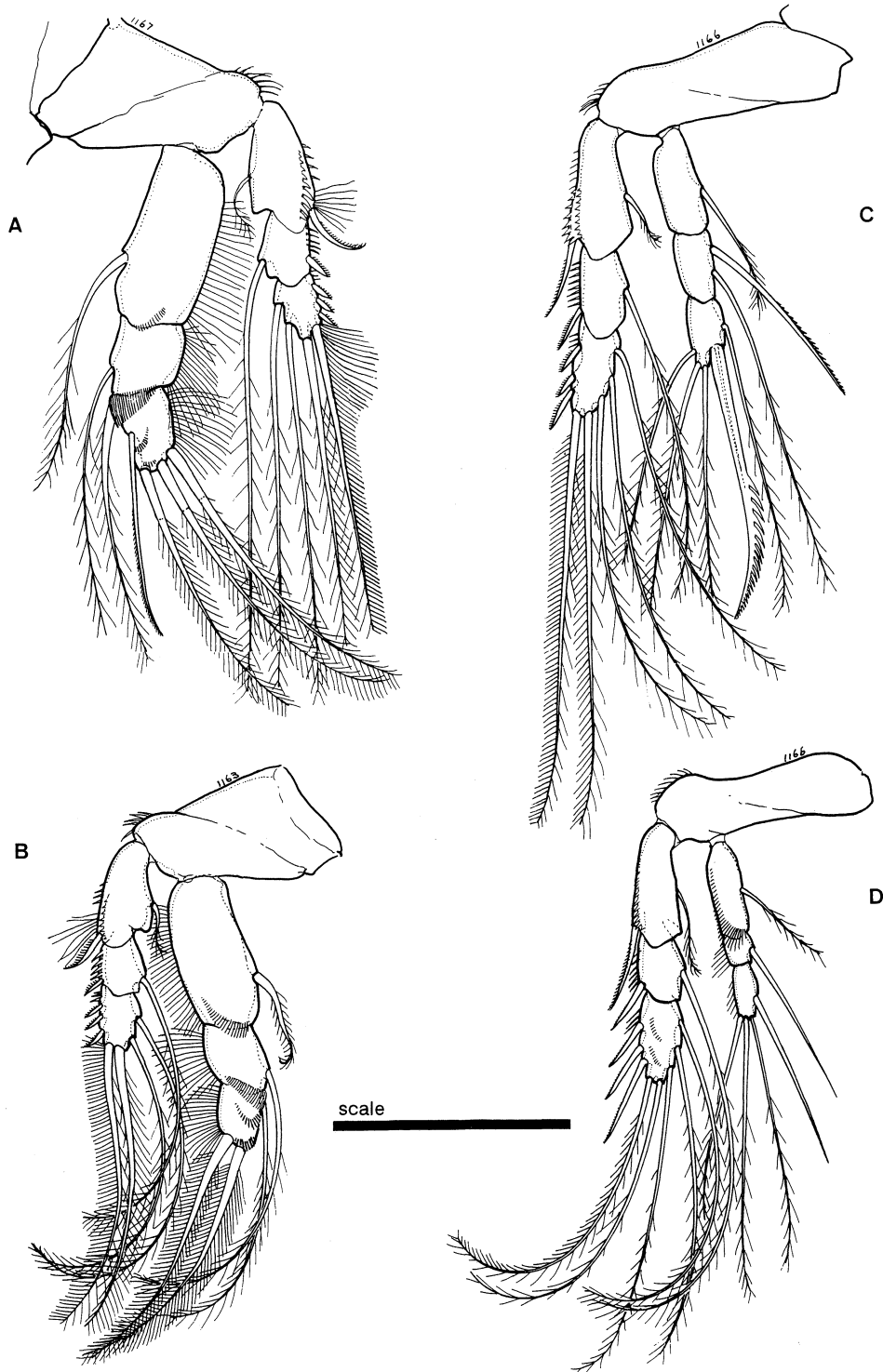


**Fig. 5.** *Porcellidium hormosirii*. A – left female mandible; B – antenna, inset – spatulate claw; C – male mandibular palp; D – right incisor process; E – maxilla, inset – spatulate claw; F – maxilliped; G – maxillule; H – P1, anterior – left, posterior – right. Scale bar: A-G = 0.075 mm; H = 0.1 mm.

patch of setules on ventral surface. An annulated coxal seta is located posterior to the endopod. Endopod with 9 setae (6 swollen pilose setae, 1 annulated seta, 2 plain setae). Posterior lobe of palp (exopod) with 5 swollen pilose setae along border and medial plate

bordered with filiform (hairlike) setules.

Maxillule (Fig. 5G) with prominent gnathobase to praecoxa armed medially with 5 short stout setae plus 3 plumulose setae, 2 fine geniculate setae laterally. Coxa-basis bears 3 endites each armed with 3 setae, endopod



**Fig. 6.** *Porcellidium hormosirii*. A – female P2; B – male P2; C – P3; D – P4. Scale bar: A-D = 0.1 mm.

with 6 plumulose setae, small exopod with swollen pilose seta plus small plain seta.

Maxilla (Fig. 5E), proximal endite of praecoxa bearing 4 setae, distal endite with single seta; coxa-basis bears one short spatulate claw with pectinate edge and 1 large serrulate spinous seta, terminal endopod with 2 multiserrate and 2 serrulate spinous setae.

Maxilliped (Fig. 5F), medial coxal lobe rounded with fimbriate edge (ie, fringed with long filiform setules), single small coxal seta, ventral edge of elongate basis fimbriate, continued distally as flat oblong fimbriate process, short geniculate claw plus seta on basis, 2 geniculate claws on reduced endopod.

First peraeopod (P1) characteristic of family (Fig. 5H). Intercoxal plate quadrate with small medial coxal seta, basis with small lateral tubercle and strong pilose claw-like lateral seta. Exopod proximal article bordered with filiform setules and crescent of fine denticulate pegs parallel to edge, single bulbous pilose seta on articles 1 and 2, article 3 with 4 bulbous pilose setae, annulate terminal seta and plumose internal seta lying dorsal to the endopod (Fig. 5H, right-hand side, anatomically posterior). Endopod of 2 articles; proximal article broadly triangular with strap-like plumose internal seta and band of very fine setules down internal edge, ventral surface (anterior) with fimbriate crescent comprising a double row of denticulate pegs and long ribbon-like filiform setae (Fig. 5H, left-hand side and Pl. 1B), distal article with 2 lamellate claws (Pl. 1C).

Endopod of P2 (Fig. 6A) broad and about one and a half times length of exopod; terminal article of endopod with serrulate spinous seta plus 3 plumose setae. A triangular incised subulate fringe lies at the distal end of article 2. Endopod of P3 (Fig. 6C) with serrulate spinous seta on article 2, large (sabre like) serrate spinous seta on article 3 longer than endopod (1.3:1), remaining setae plumose. Proximal article of P4 endopod with ventral band of setules (Fig. 6D), seta of article 2 and first seta of article 3 plain spinous, remaining setae plumose.

Fifth peraeopod (P5) (Fig. 4D,E), coxa-basis with short dorsal seta and longer ventral serrulate seta. Distal article (exopod) broadly lanceolate with strongly sclerotised falciform ventral ridge, lateral edge bordered with strong setules, 1 lateral unipinnate seta halfway along edge and 2 apical setae. Apex of P5 does not reach beyond middle of posterior lobe of urosome.

**Adult male** (Fig. 3G). Anterior outline of cephalosome a truncated ellipse, slightly convex in midline obscuring lateral angle of antennule socket, shoulders acutely angular (Fig. 3E). Hyaline border and dorsal pits as in female.

Urosome without extensive lateral expansions (Fig. 4G), not divided into distinct anterior and posterior lobes, dorsolateral seta present, single apical setule.

Caudal ramus short, almost quadrate (Fig. 4C), setation as for female.

Antennule (Fig. 3C,F) modified as prehensile organ. Coupling apparatus on compound segment (3+4)

comprises 3 coupling denticles located on the anterioventral face; 1 triangular medial denticle with serrulate distal edge and central seta, 1 small flat proximal denticle with pectinate edge and 1 spherical distal denticle with 3 serrated ridges, a strap-like plumose seta projects from among the denticles. A blade-like sclerite (the ventral blade) projects from the joint between article 2 and the compound segment, and it is associated with an anterior protuberance bearing 2 setae (Fig. 3F). The ventral blade of *P. hormosirii* is unique in being bifid. A small lobe bearing an aesthetasc plus attendant seta originates from the ventral surface of the compound segment. The distal portion of the antennule bears 2 + 9 terminal setae and forms a prehensile digit with which to clasp the urosome region of a juvenile female.

Anterior lobe of mandible with 1 slender and 3 swollen pilose setae (Fig. 5C), other setae as for female.

P1, P3 and P4 as for female. Terminal article of P2 endopod with 2 plumose setae (Fig. 6B). P5 (Fig. 4F) rhomboid with 6 unipinnate setae along posteriolateral border; base of each seta associated with short row of setules on ventral surface.

**Remarks.** *Porcellidium hormosirii* occurs higher in the eulittoral than any other known species of *Porcellidium*. It is found as high as Mean Tide Level on *Hormosira banksii*, which dominates the midlittoral zone on rocky NSW shores, and has been named after this seaweed. It is also found in the infralittoral fringe on low level *Hormosira*, and less frequently on *Ecklonia*, *Colpomenia*, *Lobophora* and *Sargassum*.

**Distribution and abundance.** This species has the widest known range for any species in NSW; it is equally abundant from Ballina in the north to Eden in the south. It has also been recorded from Victoria (H. Robertson). High population densities (100+) are found at all seasons of the year.

### *Porcellidium ocellum* n.sp.

Figs 7-10

**Type material.** HOLOTYPE adult female with egg-mass detached, AM P35436; ALLOTYPE adult male without spermatophore, AM P35437; PARATYPES 3 ovigerous females, 2 males and 1 male coupled to juvenile female, AM P35438; 4 female and 4 male paratypes [Br 82] BM(NH) 1992.400-407 (other material [Br71] BM (NH) 1992.408-417). Dissections from which illustrations were made have been designated paratype material (slides 1128 1233 1234 male, 1143 female); these and remaining type population held at ZANU, registration Po.R.[Br.82] [type population 104 females (88 carrying eggs), 117 males (17 coupled to juvenile females)]. Taken from *Ecklonia radiata* in the infralittoral fringe at edge of Broulee rock platform, NSW (35°52'S 150°11'E), 14 Sept. 1982, V.A.P. Harris.

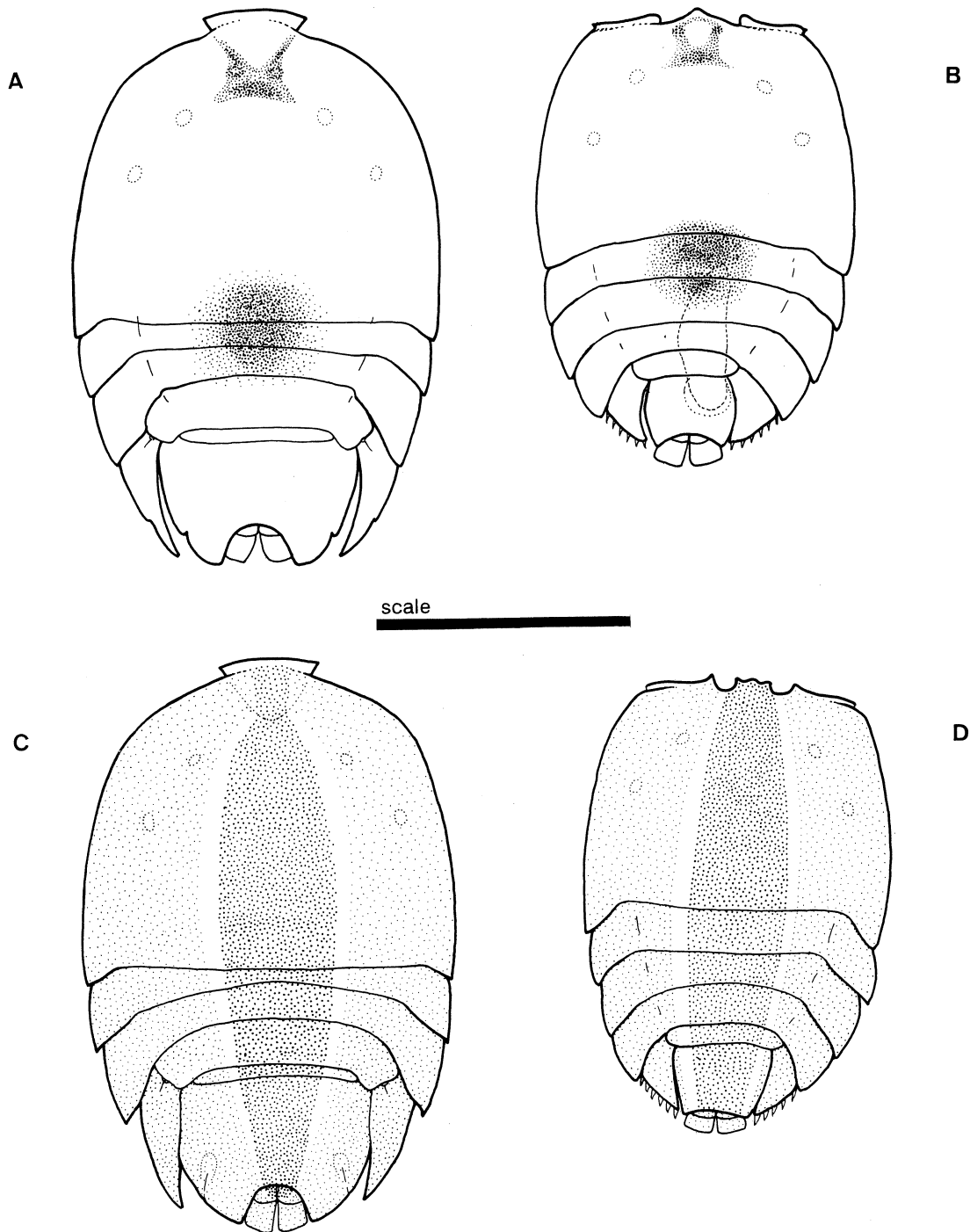
**Diagnosis.** *Adult female.* Almost colourless, antennule

socket red, typically dorsal red patch on metasomes 1 and 2; mean length 0.67 mm, rostrum width 0.12 mm, ratio of cephalosome width to rostrum 3.6; dorsal surface inconspicuously pitted; urosome edge of anterior lobe slightly concave, lateral notch present, medial corners not rounded; caudal rami divergent, rectangular, medial corner not bevelled, lateral corner emarginate; setae 1 and 4 pinnate,  $\beta$  midway between  $\alpha$  and  $\gamma$  seta; no peg field on article 1 of P1 endopod:

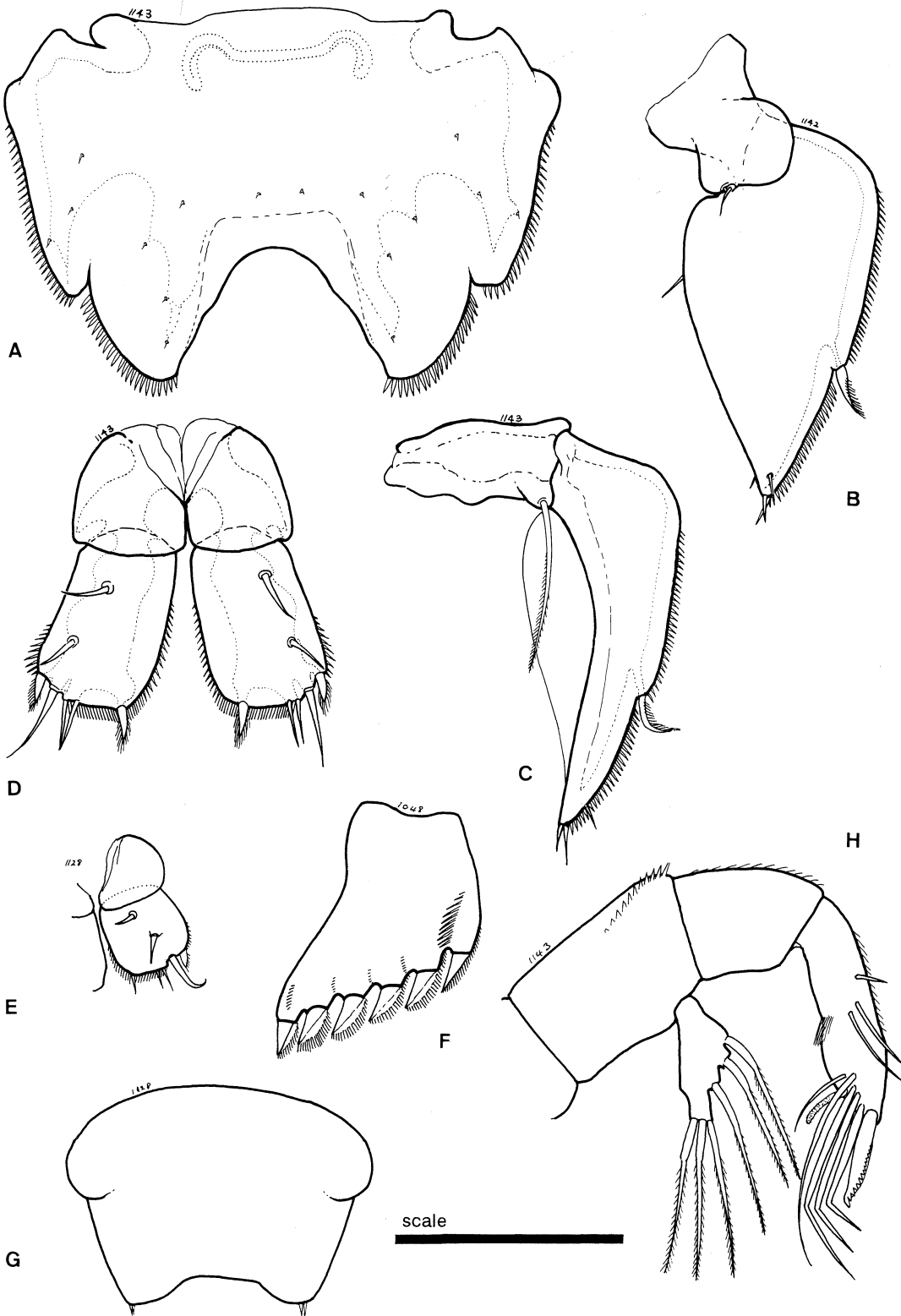
apex of P5 pointed.

*Adult male.* Distal corner of antennule socket prominent, shoulder rounded; ventral blade and anterior spine present on antennule.

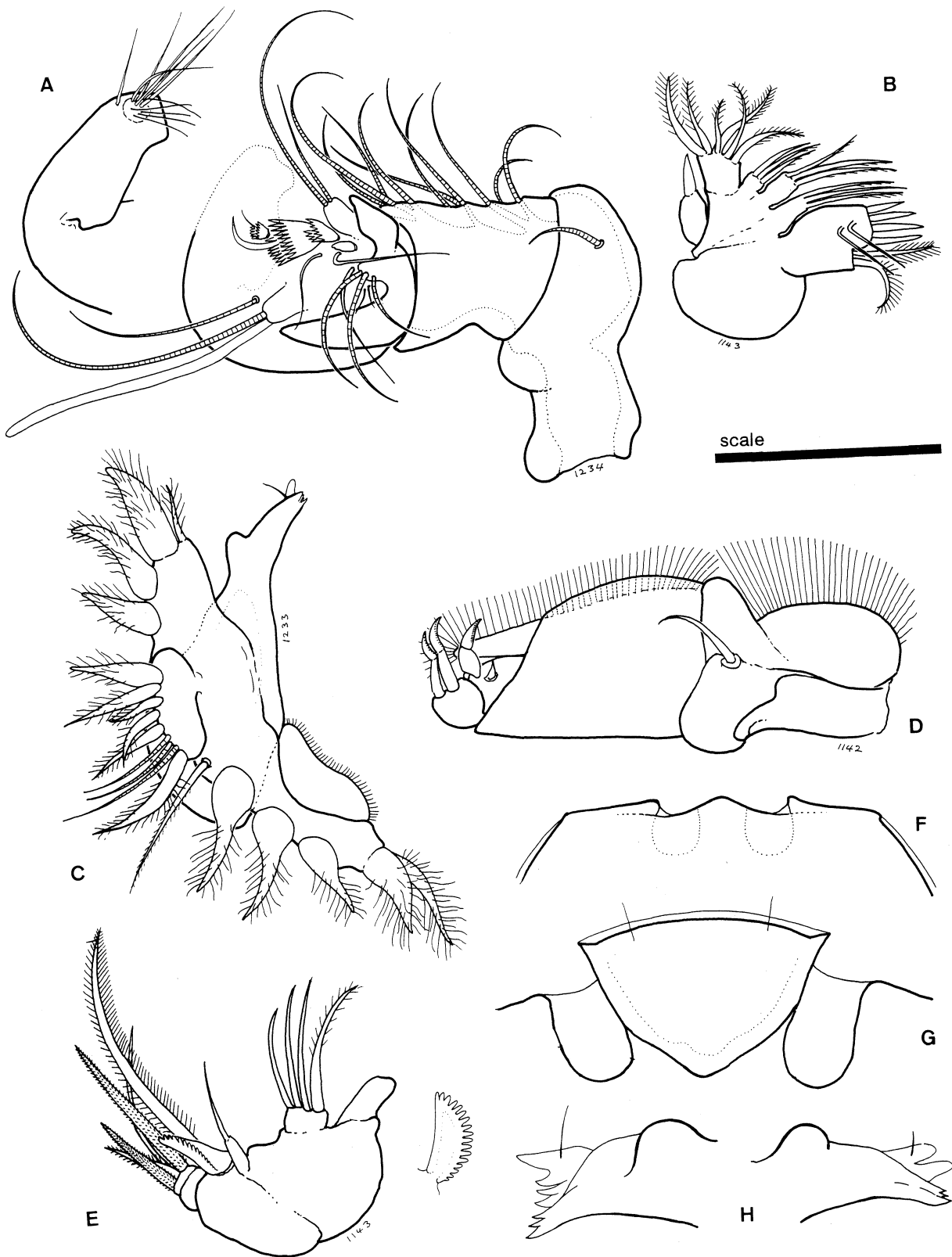
**Dimensions. Females.** Mean length 0.67 mm (SD = 0.021, N = 12), cephalosome length 0.39 mm, width 0.43 mm (SD = 0.014), height 0.1 mm, body length to width ratio 1.5. Rostrum 0.12 mm wide, projects about 0.03



**Fig. 7.** *Porcellidium ocellum*. A – adult female, dorsal view; B – adult male, dorsal view. *Porcellidium pulchrum*; C – adult female, dorsal view; D – adult male, dorsal view. Scale bar: A-D = 0.315 mm.

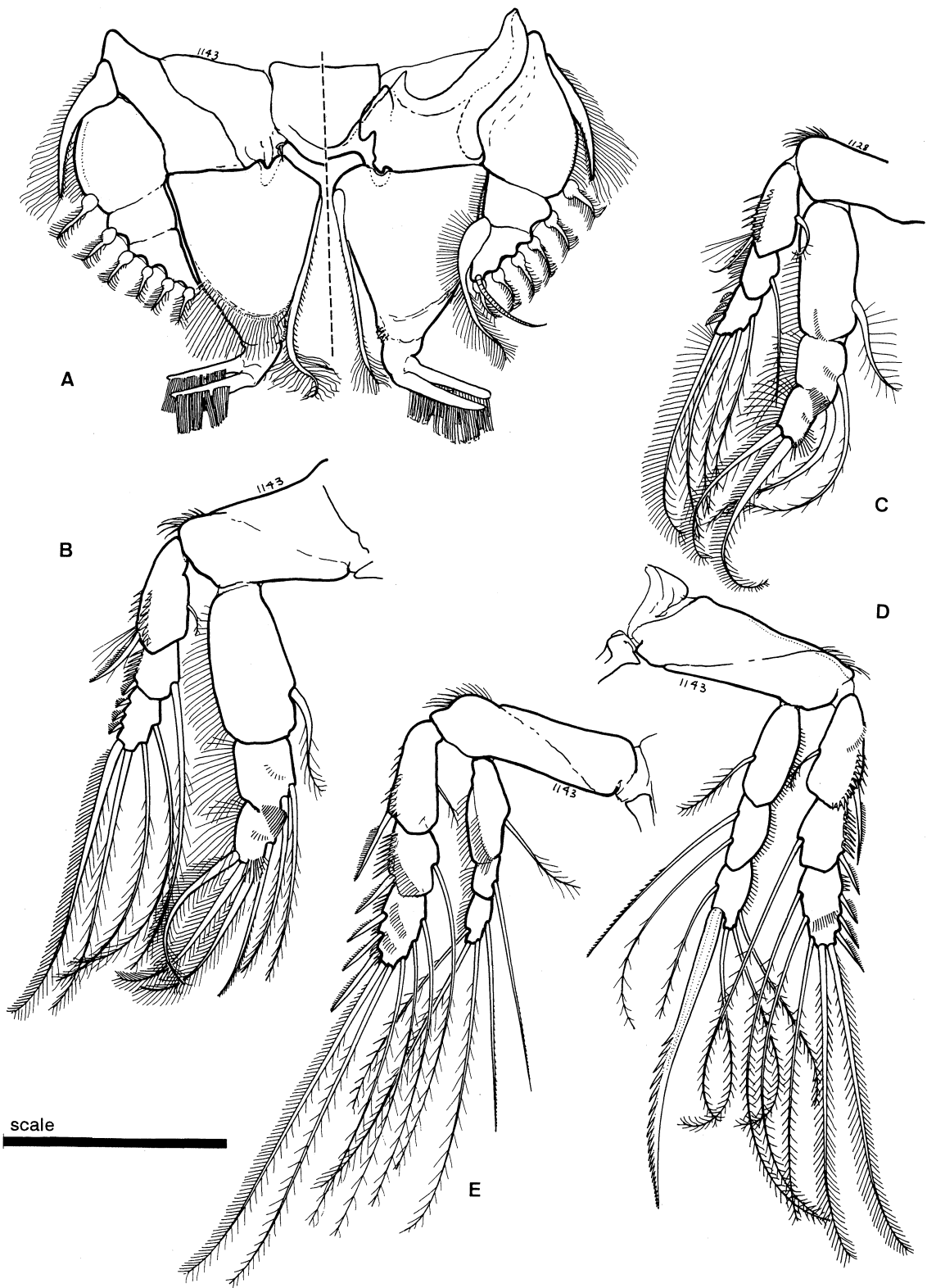


**Fig. 8.** *Porcellidium ocellum*. A – female urosome; B,C – female P5 (dorsal and ventral); D – female caudal rami; E – male caudal ramus; F – male P5; G – male urosome (dorsal); H – antenna. Scale bar: A,B,C,E,G = 0.1 mm; D,F = 0.075 mm; H = 0.055 mm.



**Fig. 9.** *Porcellidium ocellum*. A – male antennule, terminal section displaced to show coupling denticles; B – maxillule; C – male mandible; D – maxilliped; E – maxilla; F – anterior of male cephalosome; G – female rostrum (ventral); H – detail of incisor process. Scale bar: A,E = 0.065 mm; B = 0.055 mm; C,G = 0.1 mm; D,H = 0.05 mm; F = 0.2 mm.





**Fig. 10.** *Porcellidium ocellum*. A – P1, anterior - left, posterior - right; B – female P2; C – male P2; D – P3; E – P4. Scale bar: A-E = 0.1 mm.

mm, ratio of body width to rostrum 3.6. Urosome width to length ratio 1.54. Caudal ramus length to width ratio 1.6.

**Males.** Mean length 0.56 mm (SD = 0.012, N = 7), Cephalosome length 0.32 mm, width 0.38 mm, body length to width ratio 1.47.

**Adult female** (Fig. 7A). Anterior outline of cephalosome semicircular. Rostrum prominent, anterior almost straight with narrow hyaline edge (Fig. 9G). Hyaline border of cephalosome and epimeral lobes 6-7  $\mu\text{m}$  wide. Dorsal surface inconspicuously pitted.

Urosome broad, fringed with marginal setules (Fig. 8A), sides of anterior lobe straight or slightly concave, posterior lobe rounded, medial corner not rounded, conspicuous lateral notch between anterior and posterior lobes. Caudal arch deep, one-third of urosome length.

Caudal ramus rectangular (Fig. 8D), medial edge slightly convex giving rami a divergent appearance, medial edge bordered with fine setules, similar setules on external edge towards extremity, external corner emarginate.  $\alpha$  seta about quarter of the way down ramus,  $\beta$  midway between  $\alpha$  and  $\gamma$ , terminal seta 1 pinnate, setae 2 and 3 plain, closely set, seta 4 at medial corner, pinnate, terminal fringe of fine setules present.

Limbs with typical setation. Antenna (Fig. 8H), spatulate claw on endopod finely serrulate, terminal portion of geniculate setae plain. Mandibles without patch of setules on anterior lobe, first pilose seta on palp large, swollen. Maxillule (Fig. 9B) and maxilla (Fig. 9E) similar to *P. hormosirii*. Rounded medial lobe of coxa and basis of maxilliped with fimbriate border, fimbriate process on basis (Fig. 9D). First pereopod (P1, Fig. 10A) with single crescent of fine denticulate pegs on article 1 of exopod, peg fields absent from proximal article of endopod. P2 and P4 as shown in Figure 10B,E. Sabre-like spinous seta on article 3 of P3 endopod (Fig. 10D) longer than endopod (1.3:1). Distal article of P5 (Fig. 8B,C) broadly lanceolate, apex pointed, does not reach beyond middle of posterior lobe of urosome.

**Adult male** (Fig. 7B). Anterior outline of cephalosome a truncated ellipse, obtusely pointed in midline; lateral angle of antennule socket prominent (Fig. 9F), with low 'epaulet' to rounded shoulder. Hyaline border and dorsal pits as for female.

Urosome (Fig. 8G), anterior lobe rounded, posterior lobe with two apical setules, caudal arch very shallow. Caudal ramus quadrate, setation as for female (Fig. 8E).

Antennule typically modified (Fig. 9A). Proximal, middle and distal coupling denticles flat, folded with serrate distal edge, middle denticle large with associated plumose seta. Ventral blade present plus large anterior blade-like spine about half length of ventral blade, small conical peg at base of spine. Terminal segments nearly as long as compound segment.

Mandible (Fig. 9C) with first pilose seta on palp slender. First pereopod (P1), P3 and P4 as for female. P2 with 2 plumose setae on distal article of endopod (Fig.

10C). Terminal setae of P5 lanceolate with pinnate lateral border (Fig. 8F).

**Remarks.** The trivial name, *ocellum*, refers to a conspicuous red spot behind the rostrum which gives the appearance of a cyclopean eye (L. *ocellus* = a little eye). The body is almost transparent with a slight amber tint. A dorsal red patch of variable intensity appears on metasomal segments 1 and 2. Skeletal structures supporting the rostrum and antennules are red giving the characteristic 'eye-spot' (Fig. 7A,B).

Spirit specimens lose their colour and might be confused with *P. hormosirii* as they are about the same size. *Porcellidium ocellum* is easily distinguished by the male's rounded shoulders and prominent antennular socket and the urosome of the female which has a distinct notch but no scar between anterior and posterior lobes. The caudal rami are slightly divergent with the alpha seta slender (see Figs 9F; 8A,D).

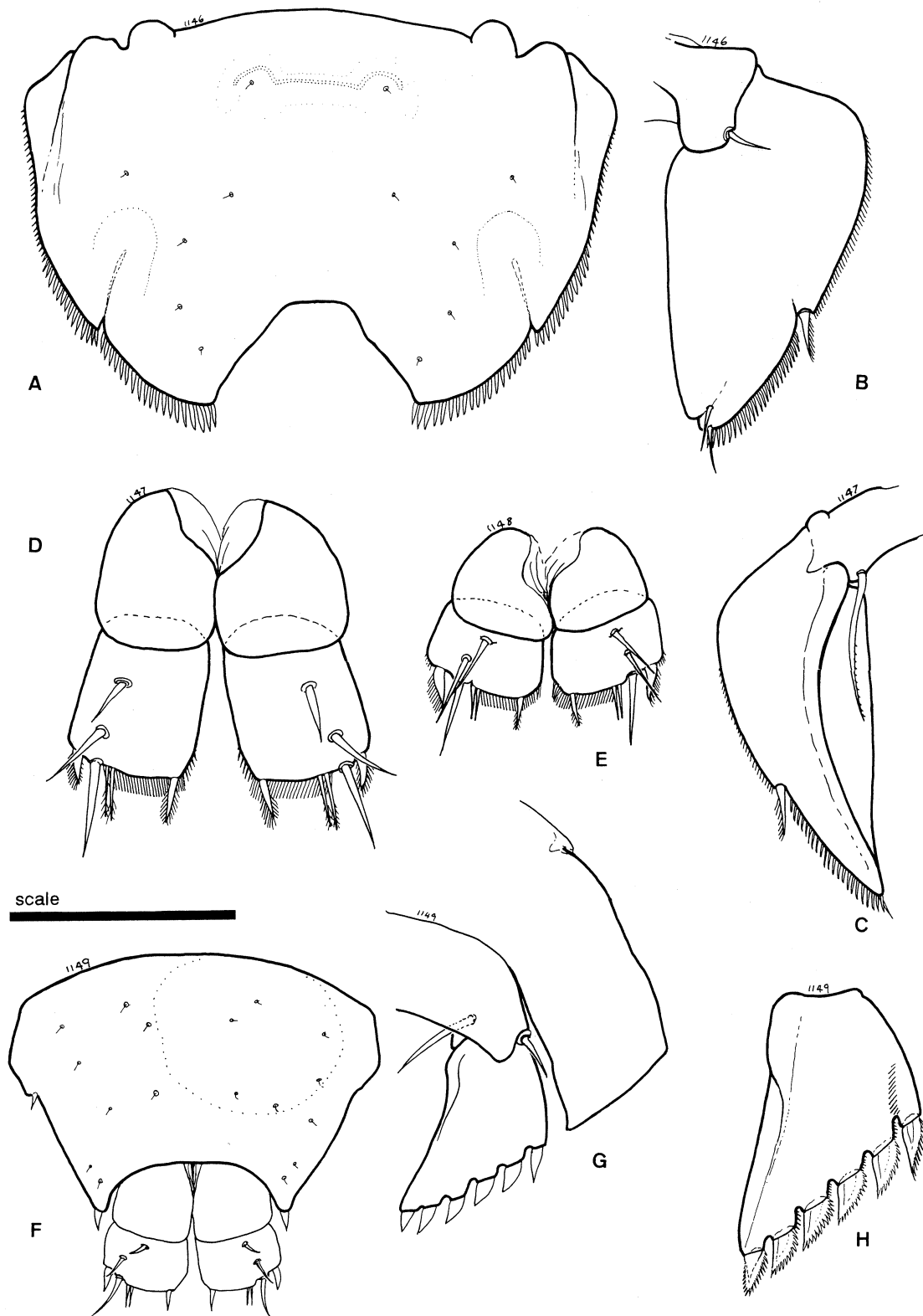
**Distribution and abundance.** *Porcellidium ocellum* is a southern species; it is common at Broulee and Twofold Bay, but has not been recorded north of Batemans Bay. Next to *P. hormosirii* it is the most abundant species on the south coast. Population densities of over 100 per plant are frequently encountered on *Ecklonia radiata*. Occasionally small numbers are found on *Phyllospora*, *Caulerpa*, *Cystophora*, *Sargassum*, and on encrusted stones in the infralittoral fringe and sublittoral zone.

### *Porcellidium pulchrum* n.sp.

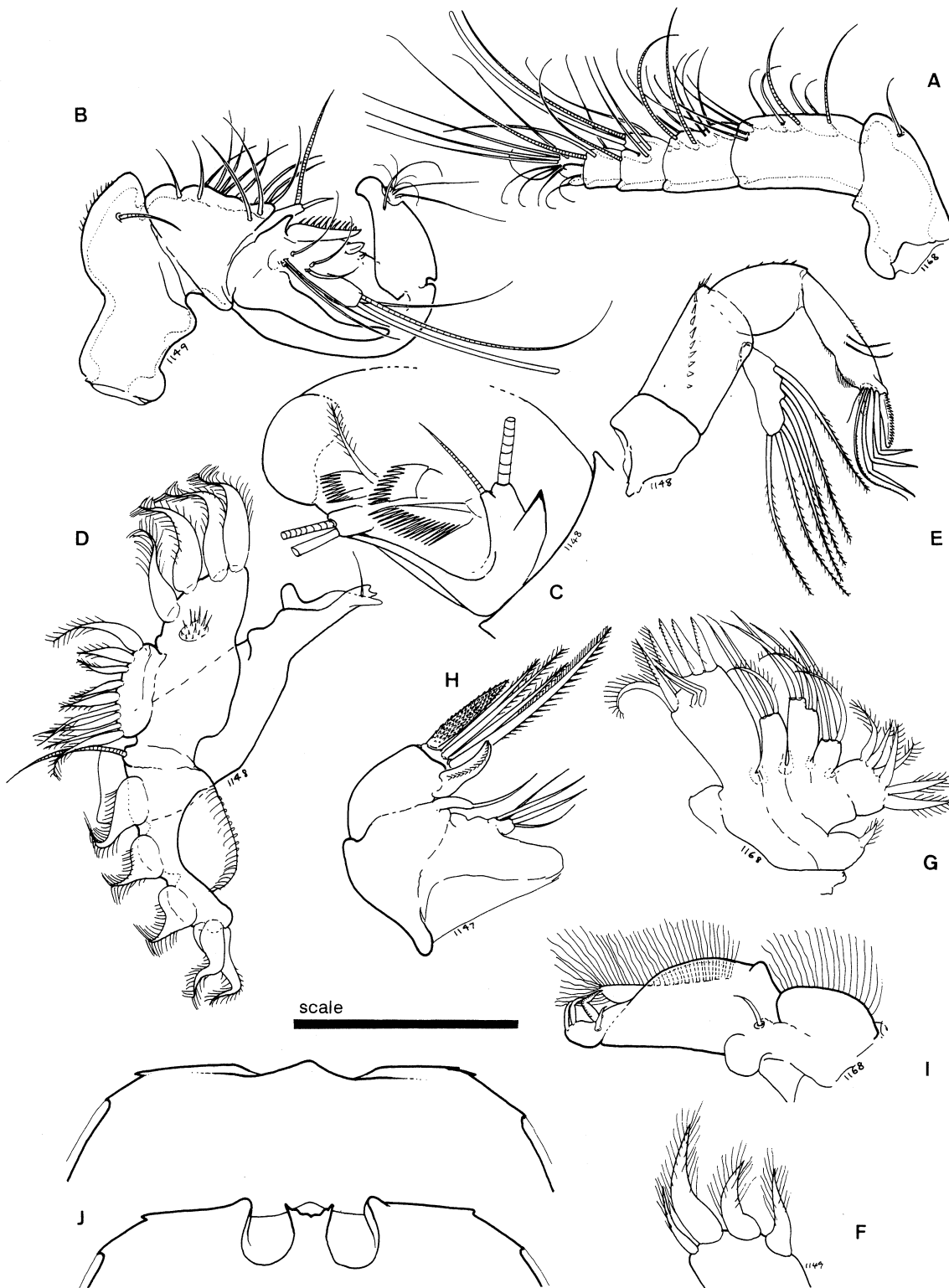
Figs 7, 11-13

**Type material.** HOLOTYPE adult female with egg-mass detached, AM P35442; ALLOTYPE adult male, AM P35443; PARATYPES 3 ovigerous females, 2 males and 1 male coupled to juvenile female, AM P35444; 4 female + 4 male paratypes [Br 82] BM(NH) 1992.418-425, (other material [Br15] BM(NH) 1992.426-435. Dissections from which illustrations were made have been designated paratype material (slides 1146, 1147 female, 1148 male); these and remaining type population held at ZANU, registration Po.RR.[Br.82] [total type population 146 females (66 carrying eggs), 116 males (28 coupled to juvenile females)]. Taken from *Ecklonia radiata* in the infralittoral fringe at edge of Broulee rock platform, Broulee, NSW (35°52'S 150°11'E), 14 Sept. 1982, V.A.P. Harris.

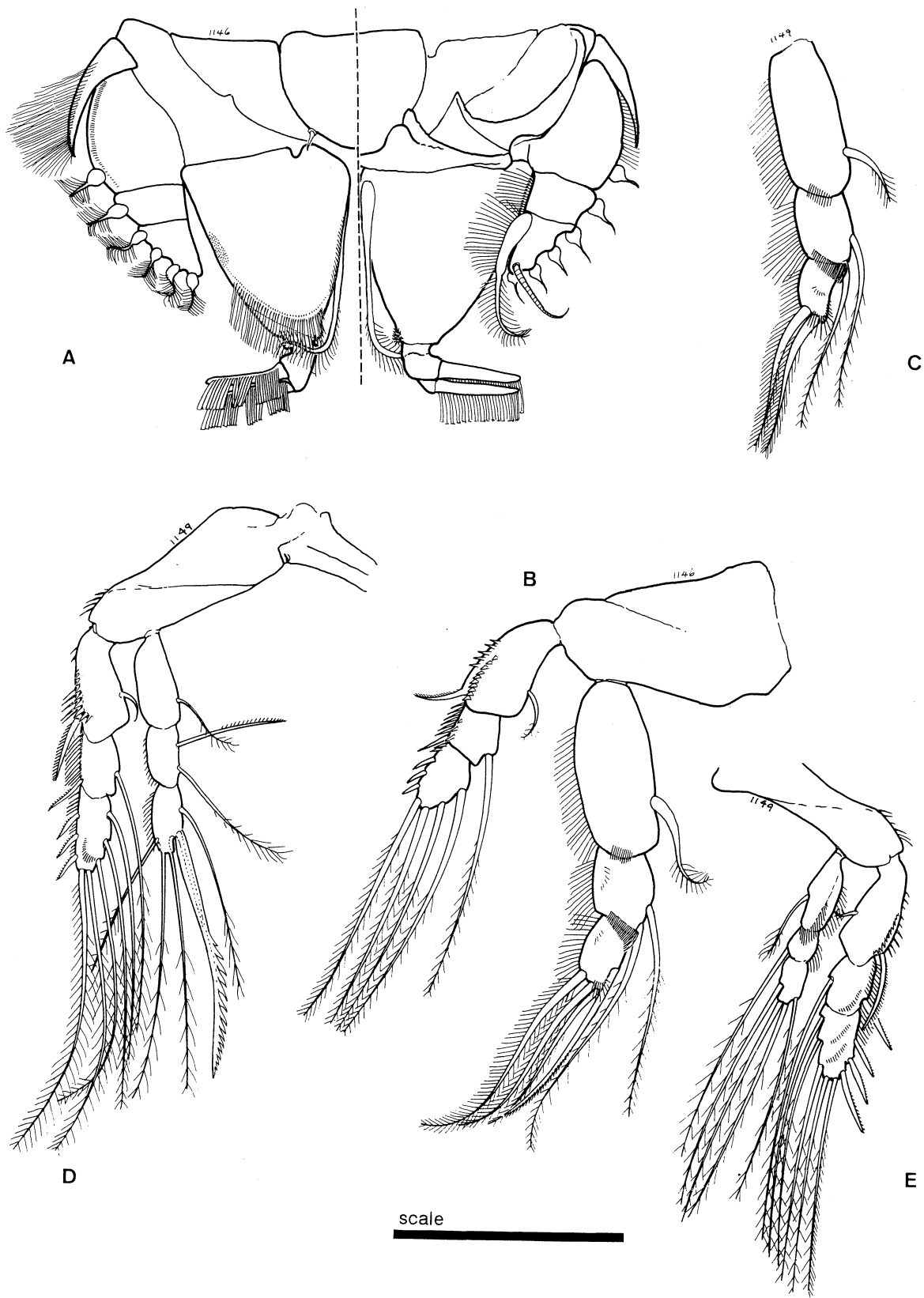
**Diagnosis.** *Adult female.* Typically lemon yellow with broad red stripe down back; mean length 0.71 mm, rostrum width 0.13 mm, ratio of cephalosome width to rostrum 3.6; dorsal surface inconspicuously pitted; urosome broad, almost semicircular, medial corners not rounded, slight lateral notch and scar; caudal rami rectangular, medial corner not bevelled, lateral corner not emarginate, setae 1 and 4 pinnate, seta 4 set at medial corner,  $\alpha$  seta about halfway down ramus,  $\beta$  close to posterior border; peg field on first article of P1 endopod



**Fig. 11.** *Porcellidium pulchrum*. A – female urosome; B,C – female P5 (dorsal and ventral); D – female caudal ramus; E – male caudal ramus; F – male urosome; G – male P5 plus third and fourth epimeral lobes; H – male P5. Scale bar: A,B,C,F,G = 0.1 mm; D,E,H = 0.065 mm.



**Fig. 12.** *Porcellidium pulchrum*. A – female antennule; B – male antennule, showing long ventral blade; C – coupling denticles; D – female mandible; E – antenna; F – male mandibular palp; G – maxillule; H – maxilla; I – maxilliped; J – anterior edge of male cephalosome (dorsal and ventral focus). Scale bar: A,B,D,E,F,H,I = 0.075 mm; C,G = 0.045 mm; J = 0.165 mm.



**Fig. 13.** *Porcellidium pulchrum*. A – P1, anterior - left, posterior - right; B – female P2; C – male P2 endopod; D – P3; E – P4. Scale bar: A-E = 0.1 mm.

very small or absent; apex of P5 not pointed.

**Adult male.** Lateral corner of antennule socket conspicuous, shoulders rounded; antennule with prominent ventral blade.

**Dimensions. Females.** Mean length 0.71 mm (SD = 0.028, N = 17), cephalosome length 0.4 mm, width 0.47 mm (SD = 0.017), height 0.11 mm, body length to width ratio 1.5. Rostrum 0.13 mm wide, ratio of body width to rostrum 3.6. Urosome width to length ratio 1.5. Caudal ramus length to width ratio 1.2.

**Males.** Mean length 0.55 mm (SD = 0.018, N = 20), Cephalosome length 0.31 mm, width 0.39 mm, body length to width ratio 1.4.

**Adult female** (Fig. 7C). Anterior outline of cephalosome semicircular. Rostrum slightly convex with hyaline edge; projects about one-quarter of width. Hyaline border of cephalosome and epimeral lobes 5  $\mu$ m wide. Indistinct shallow pits (2  $\mu$ m in diameter) cover dorsal surface, occasional sensory setules present.

Urosome broad, semicircular (Fig. 11A), edge of anterior lobe with fine setules anteriorly and larger setules posteriorly, laterodorsal ridge, posterior lobe curved, fringed with larger setules, medial corners not rounded; slight lateral notch and scar between anterior and posterior lobes. Caudal arch one-quarter length of urosome.

Caudal ramus almost quadrate (Fig. 11D), medial edge straight, lateral corner not emarginate.  $\alpha$  seta short, located about halfway down ramus,  $\beta$  seta halfway between  $\alpha$  and  $\gamma$ , terminal setae pinnate, 2 and 3 slender and set close together, 4 at medial corner, terminal fringe of very fine oblique setules. In their natural position the rami do not project beyond urosome.

Limbs with typical setation. Antenna (Fig. 12E), terminal portion of geniculate setae on endopod plain, spatulate claw with serrulate border. Mandible (Fig. 12D) with patch of setules on anterior lobe. Maxillule (Fig. 12G) and maxilla (Fig. 12H) similar to *P. hormosirii*. Maxilliped (Fig. 12I) with rounded medial coxal lobe, fimbriate border to coxa and basis, fimbriate process on basis. First peraeopod (P1) endopod with peg field at lateral end of fimbriate crescent very small or absent (Fig. 13A). P2 and P4 as shown in Figure 13B,E. Sabre-like spinous seta on endopod of P3 slightly longer (1.2:1) than endopod (Fig. 13D). Distal article of P5 ovate, apex not pointed; reaches lateral notch of urosome (Fig. 11B,C).

**Adult male** (Fig. 7B). Anterior outline of cephalosome a truncated ellipse, convex in midline, lateral angle to antennule socket not prominent, shoulders rounded (Fig. 12J). Hyaline border and dorsal pits as in female.

Urosome (Fig. 11F) with stout setule at apex of posterior lobe.

Caudal ramus quadrate (Fig. 11E), setation as for female.

Antennule (Fig. 12B) typically modified. Proximal coupling denticle a long triangular pectinate comb,

medial and distal denticles thin plates with serrate edge (Fig. 12C). Ventral blade present, narrow, almost as long as compound segment, anterior spine present. Terminal segment half length of compound segment.

Mandible with first pilose seta on palp slender. P1, P3 and P4 as for female. P2 with 2 plumose setae on distal article of endopod (Fig. 13C). Terminal setae of P5 all similar, flat triangular with serrated lateral edge (Fig. 11H).

**Remarks.** The trivial name refers to the colour of living animals (*L. pulcher* = beautiful). This is lemon yellow with a broad red stripe down the middle of the back, however, a small proportion of animals taken from Twofold Bay, Eden, lack the red stripe or it is broken into a series of red dots. No other morphological differences have been noticed between these two colour forms.

Living specimens of *Porcellidium pulchrum* could be confused with *Acutiramus rufolineatus* which has a dorsal red stripe, but their size and other differences listed under *A. rufolineatus* (see below) readily distinguish them. Populations of *P. pulchrum* have been found only on *Ecklonia radiata*, although occasionally isolated individuals have been found on *Phyllospora* and *Sargassum*.

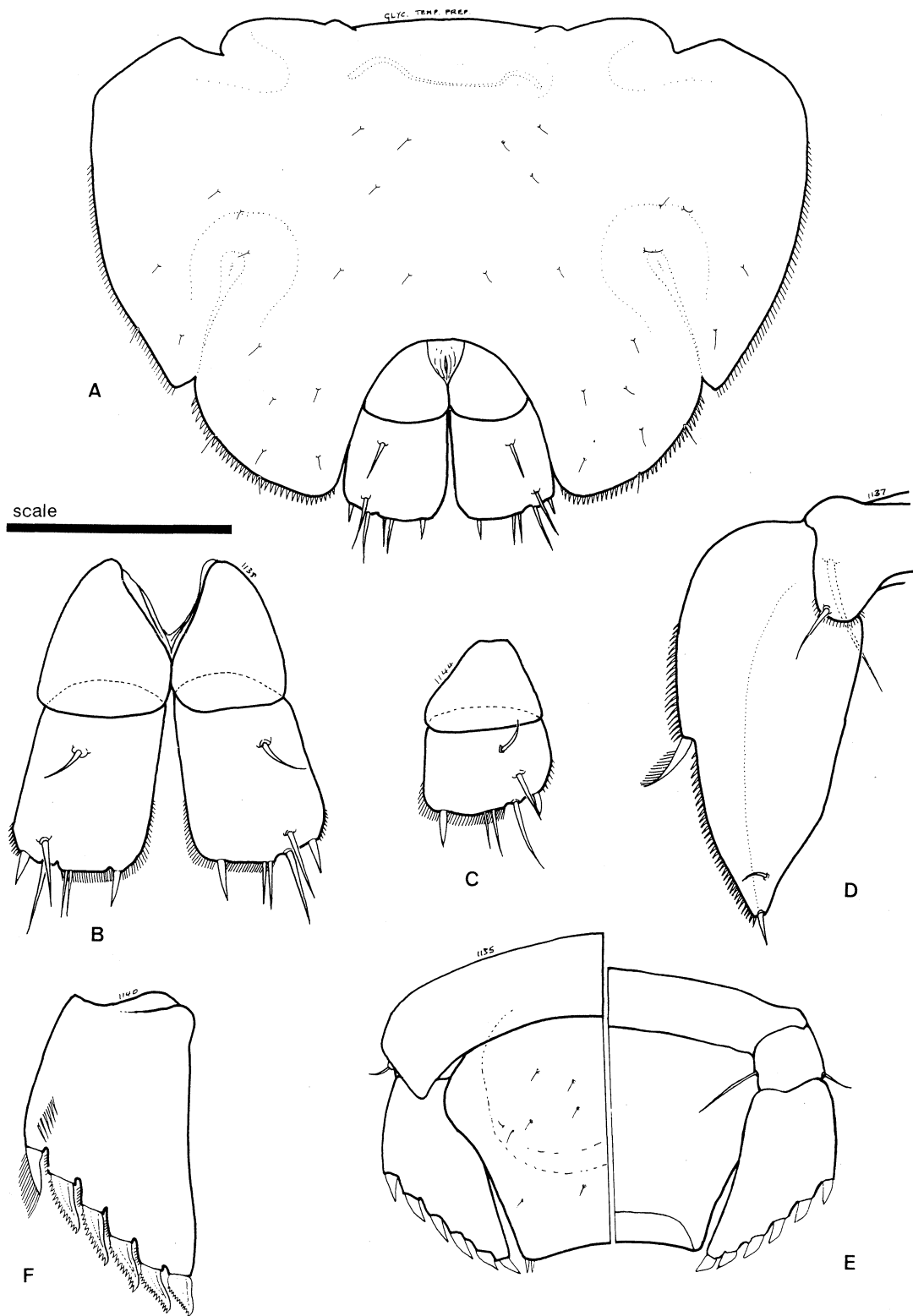
**Distribution and abundance.** This species has been recorded only from Kioloa, Broulee and Twofold Bay stations. Large populations (greater than 100) are sometimes encountered. On *Ecklonia* it is second in abundance to *P. ocellum* with which it is invariably associated.

### *Porcellidium erythrogastrum* n.sp.

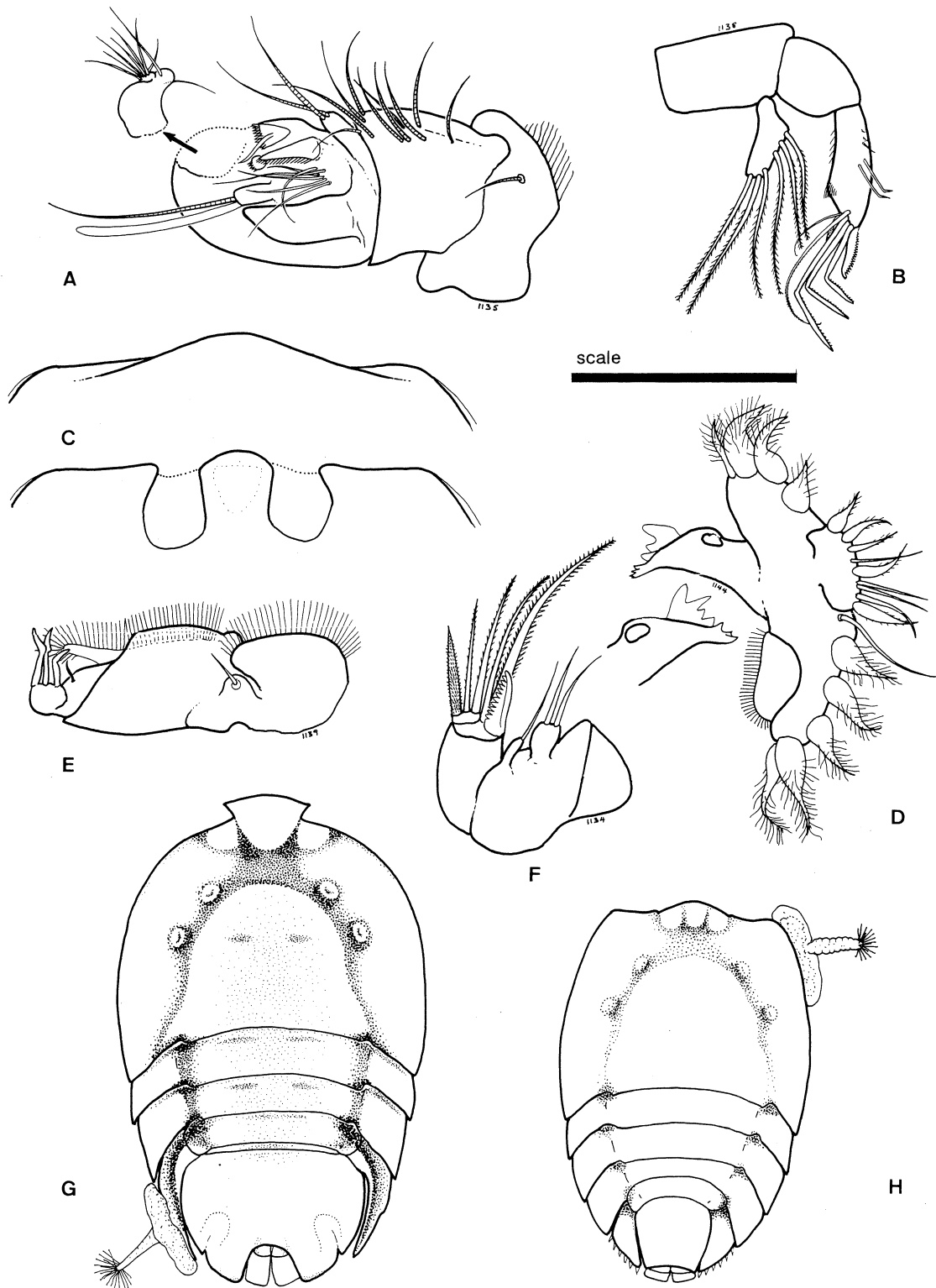
Figs 14-16

**Type material.** HOLOTYPE adult female with egg-mass detached, AM P35439; ALLOTYPE adult male, AM P35440; PARATYPES 3 ovigerous females, 2 males and 1 male coupled to juvenile female, AM P35441; 4 female and 3 male paratypes [Mb 6] BM(NH) 1992.436-442, (other material [Ki21] BM(NH) 1992.443-452. Dissections from which illustrations were made have been designated paratype material (slides 1138 female, 1135, 1144 male); these and remaining type population material held at ZANU, registration Po.I.[Mm.6] [total type population 208 females (158 carrying eggs), 125 males (42 coupled to juvenile females)]. Taken from *Phyllospora comosa* in the infralittoral fringe at Mullamarang Reef, Kioloa, NSW (35°33'S 150°23'E), 3 Nov. 1975, V.A.P. Harris.

**Diagnosis. Adult female.** Almost colourless with ventral internal edge of cephalosome red; mean length 0.83 mm, rostrum width 0.14 mm, ratio of cephalosome width to rostrum 3.7; dorsal surface smooth, no pits; urosome broad with lateral notch and scar, medial corners rounded; caudal rami rectangular, slightly emarginate,  $\beta$  seta near posterior border, terminal setae

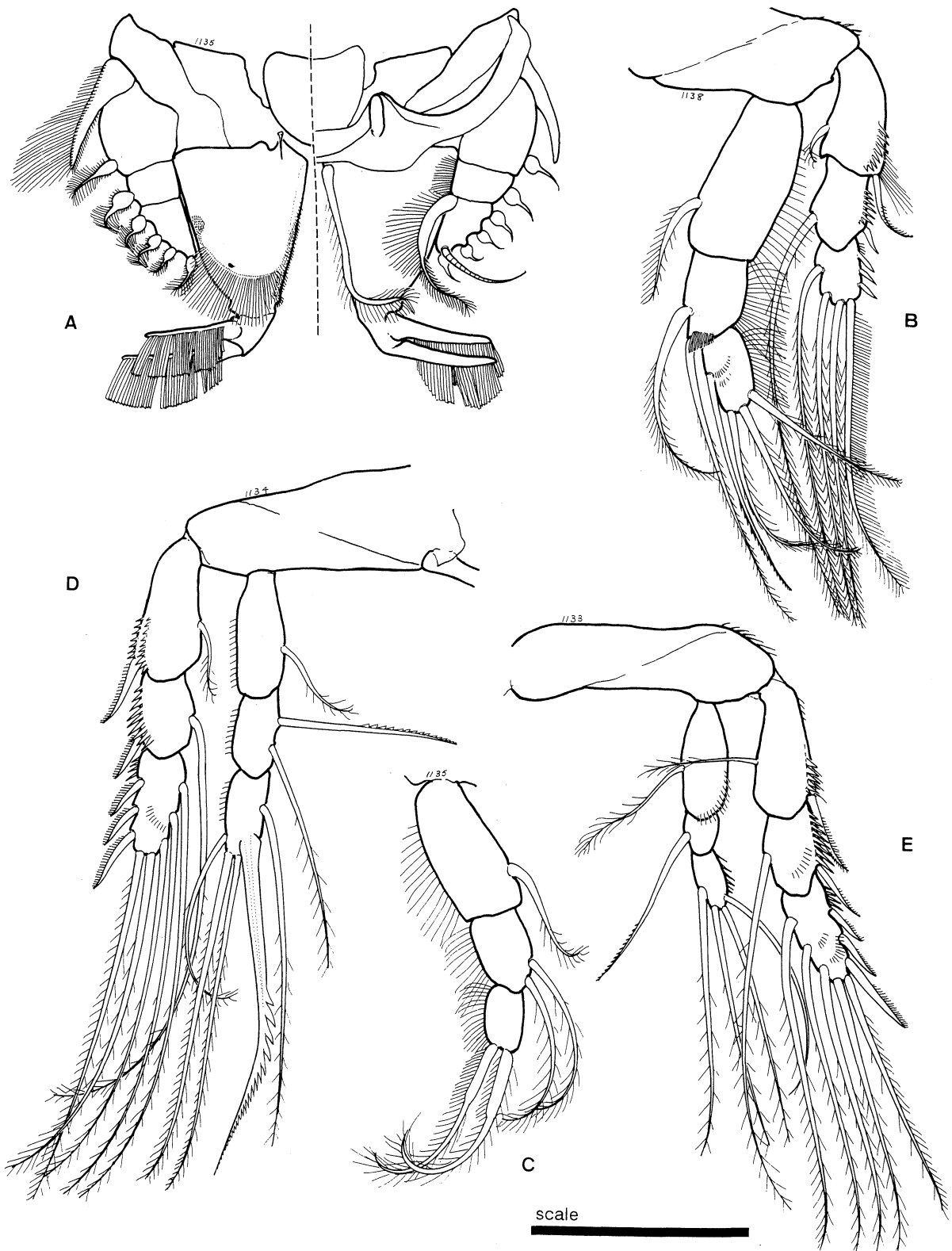


**Fig. 14.** *Porcellidium erythrogastrum*. A – female urosome; B – female caudal rami; C – male caudal ramus; D – female P5; E – male urosome (dorsal and ventral); F – male P5. Scale bar: A, D, E = 0.1 mm; B, C, F = 0.065 mm.



**Fig. 15.** *Porcellidium erythrogastrum*. A – male antennule, terminal segment displaced to show coupling denticles; B – antenna; C – anterior edge of male cephalosome (dorsal and ventral focus); D – male mandible and incisor process; E – maxilliped; F – maxilla; G – adult female, stippling indicates red colouration. A suctorian, *Ophryodendron*, is shown attached to P5; H – adult male with suctorian attached. Scale bar: A,E,F = 0.075 mm; B,D = 0.1 mm; C = 0.165 mm; G,H = 0.38 mm.





**Fig. 16.** *Porcellidium erythrogastrum*. A – P1, anterior - left, posterior - right; B – female P2; C – male P2 endopod; D – P3; E – P4. Scale bar: A-E = 0.1 mm.

plain; small lateral peg field on endopod of P1; apex of P5 pointed.

*Adult male.* Corner of antennule socket obscured, shoulders rounded; antennule with ventral blade.

**Dimensions. Females.** Mean length 0.83 mm (SD = 0.022, N = 12), cephalosome length 0.47 mm, width 0.52 mm (SD = 0.015), height 0.11 mm, body length to width ratio 1.6. Rostrum 0.14 mm wide, projects about 0.05 mm, ratio of body width to rostrum 3.7. Urosome width to length ratio 1.5. Caudal ramus length to width ratio 1.45.

*Males.* Mean length 0.61 mm (SD = 0.011, N = 8), cephalosome length 0.36 mm, width 0.41 mm (SD = 0.007), body length to width ratio 1.45.

**Adult female** (Fig. 15G). Anterior outline of cephalosome semicircular. Rostrum prominent, anterior slightly convex with hyaline edge. Hyaline border of cephalosome and epimeral lobes 5-8  $\mu$ m wide. Dorsal surface of body and urosome smooth, without pits, numerous collared setae present arranged in characteristic pattern.

Urosome broad, semicircular (Fig. 14A), bordered with marginal setules, deep lateral notch and conspicuous scar between anterior and posterior lobes, both lobes convex, medial corners rounded. Caudal arch deep, one-third urosome length.

Caudal ramus rectangular (Fig. 14B), rounded at medial corner, slightly emarginate at lateral corner. Alpha seta about one-third of way down ramus,  $\beta$  seta near posterior border, terminal setae plain, 4 set in slightly, 2 and 3 slender set close together, terminal fringe of very fine setules present.

Limbs with typical setation. Antenna (Fig. 15B) with spatulate claw of endopod strongly serrated, geniculate setae with finely serrulate terminal portion. Mandible with first pilose seta on palp large, swollen. Maxillule as for *P. ocellum*, maxilla as shown in Figure 15F. Maxilliped (Fig. 15E) with rounded medial coxal lobe, coxa and basis with fimbriate edge, fimbriate process on basis. First pereopod (P1, Fig. 16A) with fine setules along medial edge of article 1 of endopod, small pear shaped denticulate peg field at lateral end of fimbriate crescent. P2 and P4 as shown in Figure 16B,E. Sabre-like spinous seta on article 3 of P3 endopod (Fig. 16D) slightly longer than endopod (1.2:1). Distal end of P5 basis with fringe of setules near dorsal seta (Fig. 14D), ventral seta plain, distal article broadly lanceolate, apex pointed, barely reaching lateral notch of urosome.

**Adult male** (Fig. 15H). Anterior outline of cephalosome a truncated ellipse, slightly convex in midline, lateral angle of antennule socket obscured, shoulders rounded (Fig. 15C). Hyaline border and smooth surface as for female.

Urosome (Fig. 14E) with boundary between anterior and posterior lobes indistinct, no dorsolateral seta.

Caudal rami quadrate (Fig. 14C), setation as for female.

Antennule (Fig. 15A) typically modified. Proximal coupling denticle long, triangular with finely pectinate edge, medial denticle serrulate distally, associated with plumose seta, distal denticle very small. Ventral blade present about half length of compound segment. Terminal segment short (less than quarter length of compound segment).

Mandible (Fig. 15D) with first pilose seta on palp slender. P1, P3 and P4 as for female. P2 with 2 plumose setae on distal article of endopod (Fig. 16C). First terminal seta of P5 unipinnate, remainder with serrulate lateral edge (Fig. 14F).

**Remarks.** The trivial name *erythrogastrum* refers to the red ventral (sternal) border of the cephalosome (*G. erythros* = red + *gastra* = belly).

The ventral internal edge of the cephalosome, trabeculae, apodemes at the base of the limbs and falciform ventral ridge of P5 is red, the rest of the body is opalescent white or colourless. Spirit specimens lose their colour, but may be distinguished from other species by their size, semicircular urosome with deep lateral notch and prominent scar, and the position of the beta seta on the caudal ramus (Fig. 14A,B).

*Porcellidium erythrogastrum* is commonly parasitised by an epizotic suctorian, *Ophryodendron* (Fig. 15G,H), which attaches to the edge of the cephalosome or, more usually, the fifth limb (P5). The association between copepod and protozoan appears to be specific for this suctorian is never found on other species of *Porcellidium* living on the same piece of seaweed.

As many as six of these protozoans have been found on the same individual, but one or two is more usual. A marked disparity has been noted between the sexes; female copepods have a higher percentage parasitism than males (Table 1, Appendix). The type population has an incidence of 7% parasitism, although most populations have a much higher figure (51% has been recorded in one population).

**Distribution and abundance.** This species has only been recorded from the Broulee and Kioloa stations. Large populations (100+) have been found on *Phyllospora comosa* and *Cystophora* sp. Isolated individuals are occasionally found on *Ecklonia*, *Sargassum* and *Colpomenia*.

### 'Naviculum' subgroup

#### *Porcellidium naviculum* n.sp.

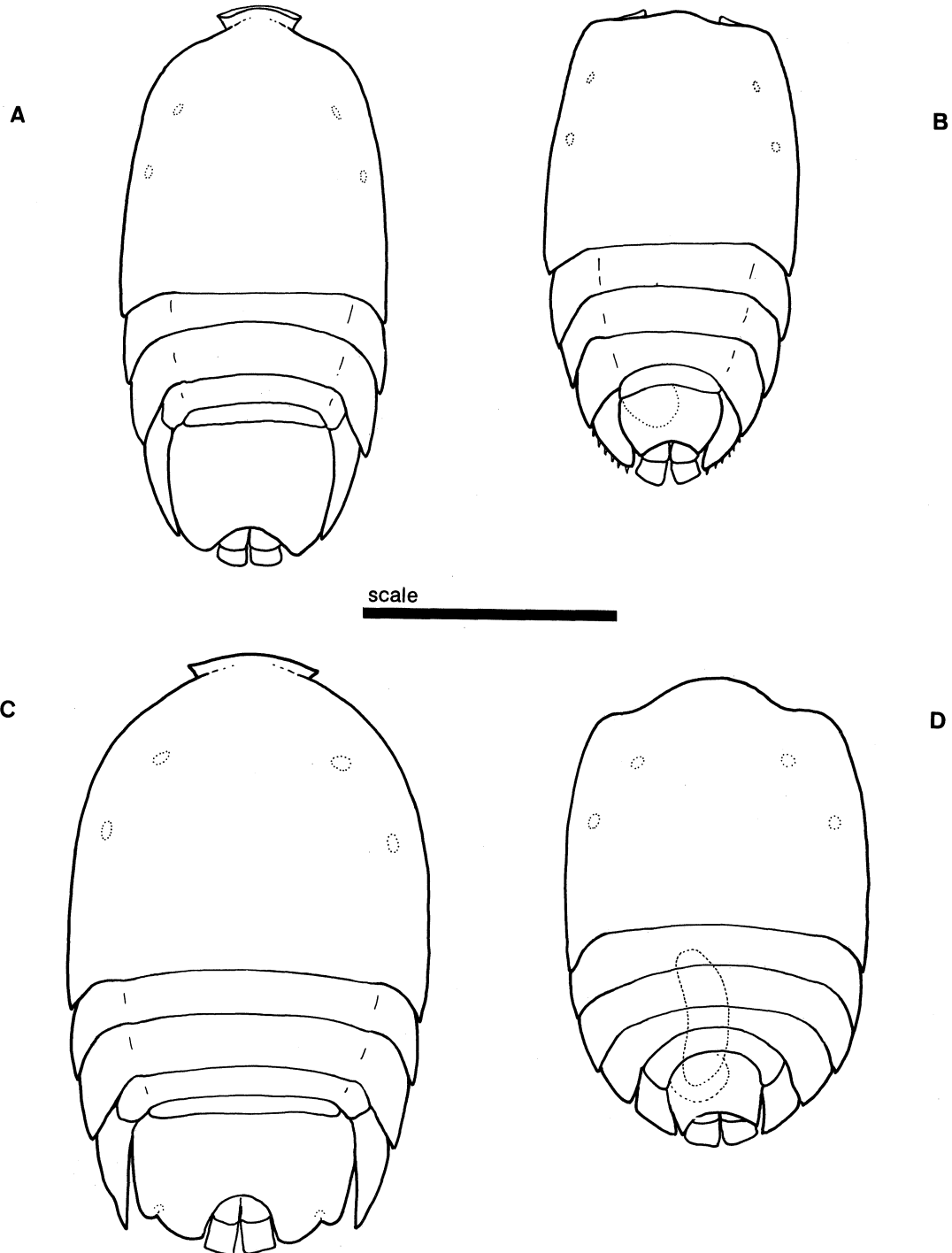
Figs 17-19

**Type material.** HOLOTYPE adult female with egg-mass detached, AM P35454; ALLOTYPE adult male, AM P35455; PARATYPES 3 ovigerous females, 2 males and 1 male coupled to juvenile female, AM P35456; 4 female and 3 male paratypes [Mb.6] BM(NH) 1992.453-459, (other material [Br46,58] BM(NH) 1992.460-469). Dissections from which illustrations were made have been designated paratype material

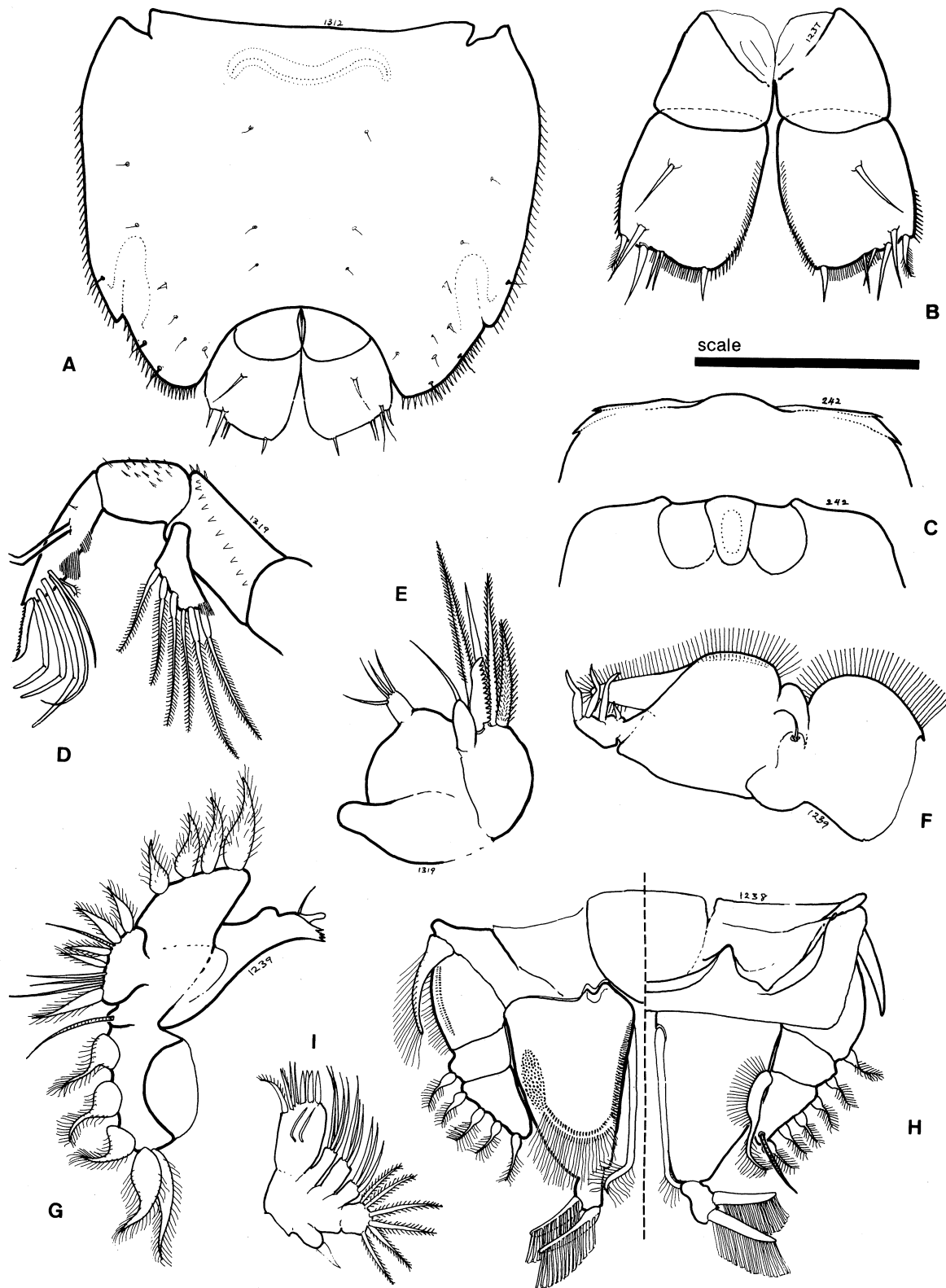
(slides 1238 female, 1239 male); these and remaining type population material held at ZANU, registration Po.T.[Mb.6] [total type population 44 females (34 carrying eggs), 36 males (8 coupled to juvenile females)]. Taken from *Cystophora* sp., in the infralittoral fringe, Merimbula Headland, Merimbula, NSW (36°53'S 149°56'E), 2 Dec. 1982, V.A.P. Harris.

**Diagnosis.** *Adult female.* Amber yellow; mean length

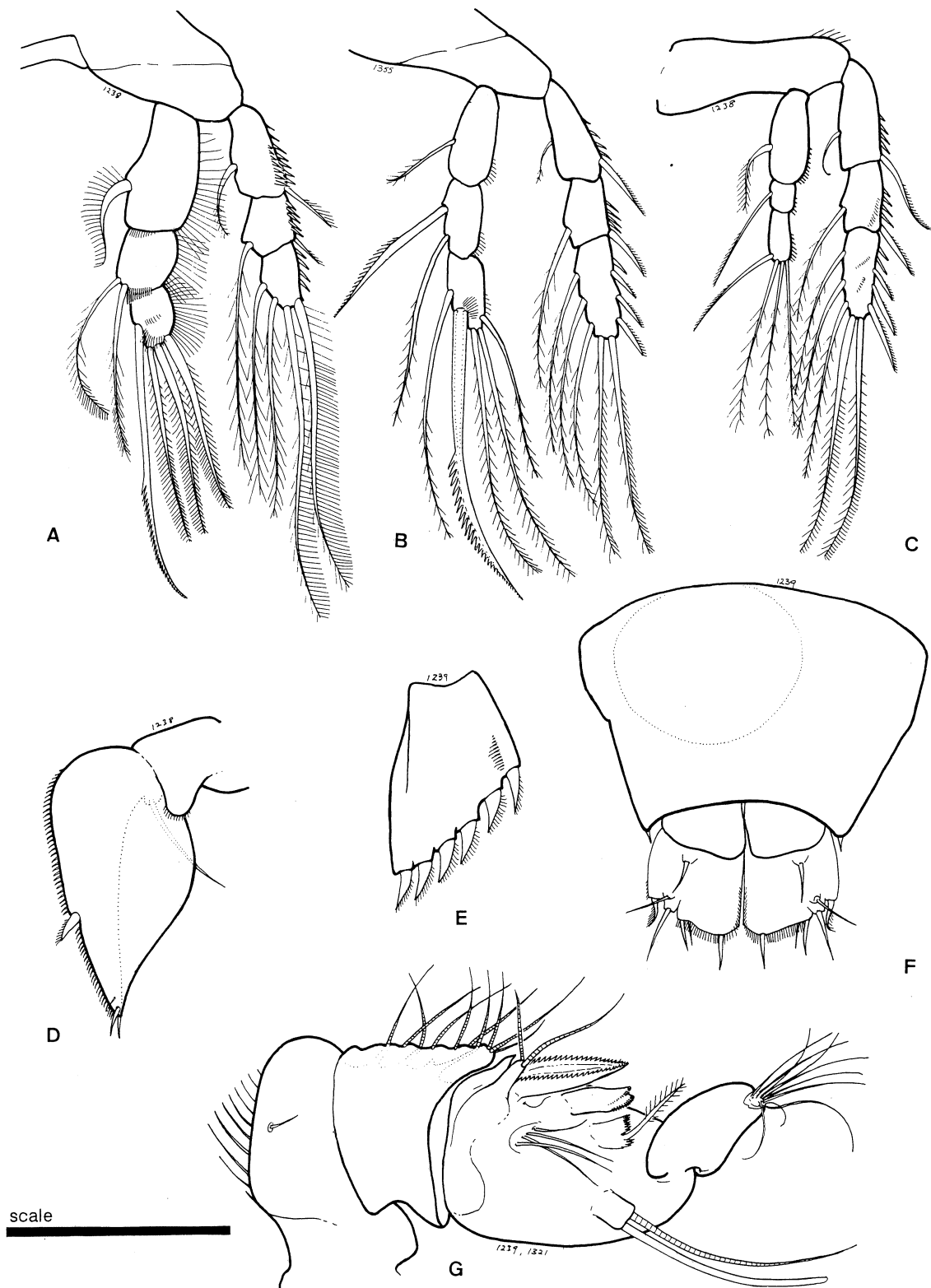
0.72 mm, body narrow (length/width ratio greater than 2); rostrum width 0.1 mm, ratio of cephalosome width to rostrum 3.3; dorsal surface inconspicuously pitted; urosome narrow, U-shaped in outline, anterior and posterior lobes indistinct, no notch; caudal rami rectangular, slightly emarginate, medial corner rounded with terminal seta 4 set in,  $\beta$  seta close to  $\gamma$ ; peg field down medial border of P1 endopod, larger peg field



**Fig. 17.** *Porcellidium naviculum*: A – adult female, dorsal view; B – adult male, dorsal view. *Porcellidium phyllosporum*: C – adult female, dorsal view; D – adult male, dorsal view. Scale bar: A,B = 0.315 mm; C,D = 0.4 mm.



**Fig. 18.** *Porcellidium naviculum*. A – female urosome; B – female caudal rami; C – anterior edge of male cephalosome (dorsal and ventral focus); D – antenna; E – maxilla; F – maxilliped; G – female mandible; H – P1, anterior - left, posterior - right; I – maxillule. Scale bar: A = 0.1 mm; B,D = 0.065 mm; C = 0.165 mm; E,F,I = 0.05 mm; G,H = 0.075 mm.



**Fig. 19.** *Porcellidium naviculum*. A – female P2; B – P3; C – P4; D – female P5; E – male P5; F – male urosome and caudal rami; G – male antennule showing coupling denticles. Scale bar: A,B,C,E,F = 0.1 mm; D = 0.125 mm; G = 0.06 mm.

laterally; P5 apex pointed.

**Adult male.** Antennule socket obscured, shoulders rounded; no ventral blade on antennule.

**Dimensions. Females.** Mean length 0.72 mm (SD = 0.019, N = 12), cephalosome length 0.37 mm, width 0.33 mm (SD = 0.017), height 0.22 mm, body length to width ratio 2.18. Rostrum 0.1 mm wide, ratio of body width to rostrum 3.3. Urosome width to length ratio 1.2. Caudal ramus length to width ratio 1.3.

**Males.** Mean length 0.57 mm (N = 7), cephalosome length 0.31 mm, width 0.30 mm, height 0.18 mm, body length to width ratio 1.9.

**Adult female** (Fig. 17A). Body outline an elongate ellipse, lacks typical dorsoventral flattening of other *Porcellidium* species. Rostrum projects about one-third its width, anterior edge slightly bowed with acute corners and hyaline border. Hyaline border of cephalosome 6  $\mu$ m wide. Dorsal surface finely pitted (pits 2  $\mu$ m in diameter).

Urosome narrow (Fig. 18A), together with caudal rami it gives a smooth semicircular posterior outline, anterior lobe long, slight indentation marks boundary with posterior lobe which is short, bordered with setules, medial corner rounded. Caudal arch about one-fifth length of urosome.

Caudal ramus (Fig. 18B) short rectangular with setules on medial and lateral edges, slightly emarginate, medial corner rounded with seta 4 set in from corner.  $\alpha$  seta one-third way down ramus,  $\beta$  seta close to  $\gamma$ , terminal seta 1 pinnate, 2 and 3 fine, close together, terminal fringe of very fine setules present.

Limbs with typical setation. Antenna endopod with serrulate spatulate claw, geniculate setae plain (Fig. 18D). Mandible as shown in Figure 18G. Maxillule (Fig. 18I) and maxilla (Fig. 18E) similar to *P. hormosirii*. Maxilliped (Fig. 18F) with rounded medial coxal lobe, coxa and basis with fimbriate edge, fimbriate process on basis. First pereopod (Fig. 18H) with crescentic double row of pegs on article 1 of exopod; endopod with denticulate peg field along medial border and oval peg field at lateral extremity of fimbriate crescent. P2 (Fig. 19A) with unusually long serrulate spinous internal seta on distal article of endopod (seta:endopod ratio = 1.2:1). Sabre-like spinous seta of P3 (Fig. 19B) slightly longer than endopod (1.2:1). P4 as shown in Figure 19C. Distal article of P5 broadly lanceolate or ovate with one terminal and 2 dorsal setae at its extremity (Fig. 19D); P5 does not extend beyond anterior lobe of urosome.

**Adult male** (Fig. 17B). Anterior outline strongly truncated with tightly rounded shoulders, slightly convex in midline, lateral angle of antennule socket not visible from above (Fig. 18C). Hyaline border and dorsal pits as for female.

Urosome (Fig. 19F) with no division between anterior and posterior lobes or seta on anterior lobe, apical setule present.

Caudal rami quadrate (Fig. 19F), lateral corner emarginate, posterior border slightly oblique, setation similar to female.

Antennule typically modified (Fig. 19G). Proximal coupling denticle elongate triangle serrated along both edges, middle denticle tooth-like with double row of very fine serrations, distal denticle small with pectinate distal edge, associated with plumose seta. No ventral blade. Terminal segments about half length of compound segment.

First pilose seta on mandibular palp slender. P1, P3 and P4 as for female. Distal article of P2 endopod with 2 plumose setae. Terminal setae of P5 unipinnate.

**Remarks.** *Porcellidium naviculum* has been found only on *Cystophora*, particularly *C. moniliformis*. Its yellow brown colour closely matches this seaweed.

The body shape is unusual; when viewed from the side individuals resemble a small boat or gondola (*L. navicula* = a small boat). Females are more than twice as long as they are broad (l/w greater than 2), and their width is only about 1.5 times their height. In all other described species of *Porcellidium* the l/w ratio is less than 2 and body width is at least three and a half times height. It is possible that the narrow body is an adaptation to living on the narrow cylindrical thallus of *Cystophora*.

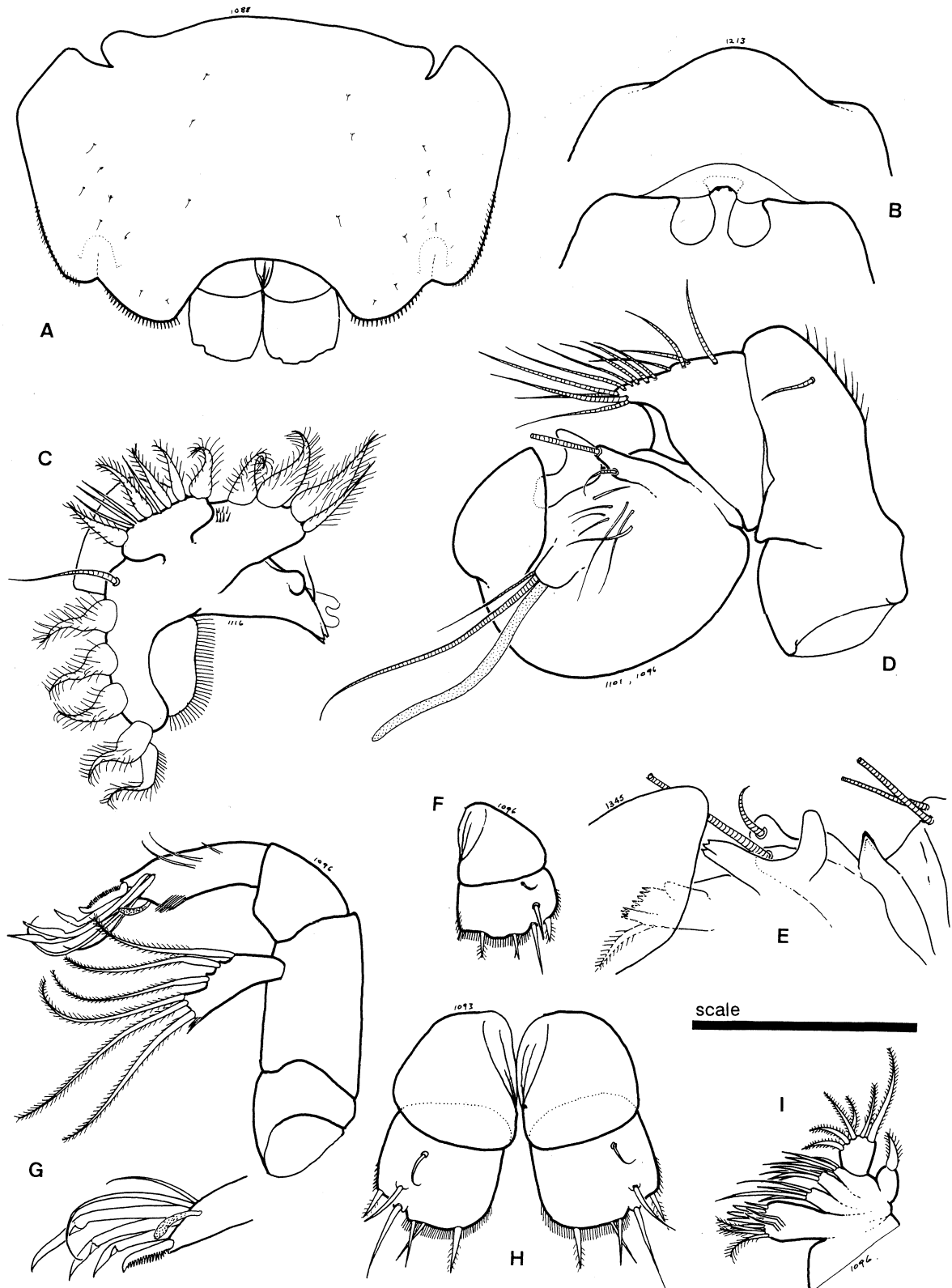
**Distribution and abundance.** This species has been recorded from Kioloa, Broulee and Merimbula, NSW. It is noticeably more abundant further south and must be regarded as a southern species.

### *Porcellidium phylloporum* n.sp.

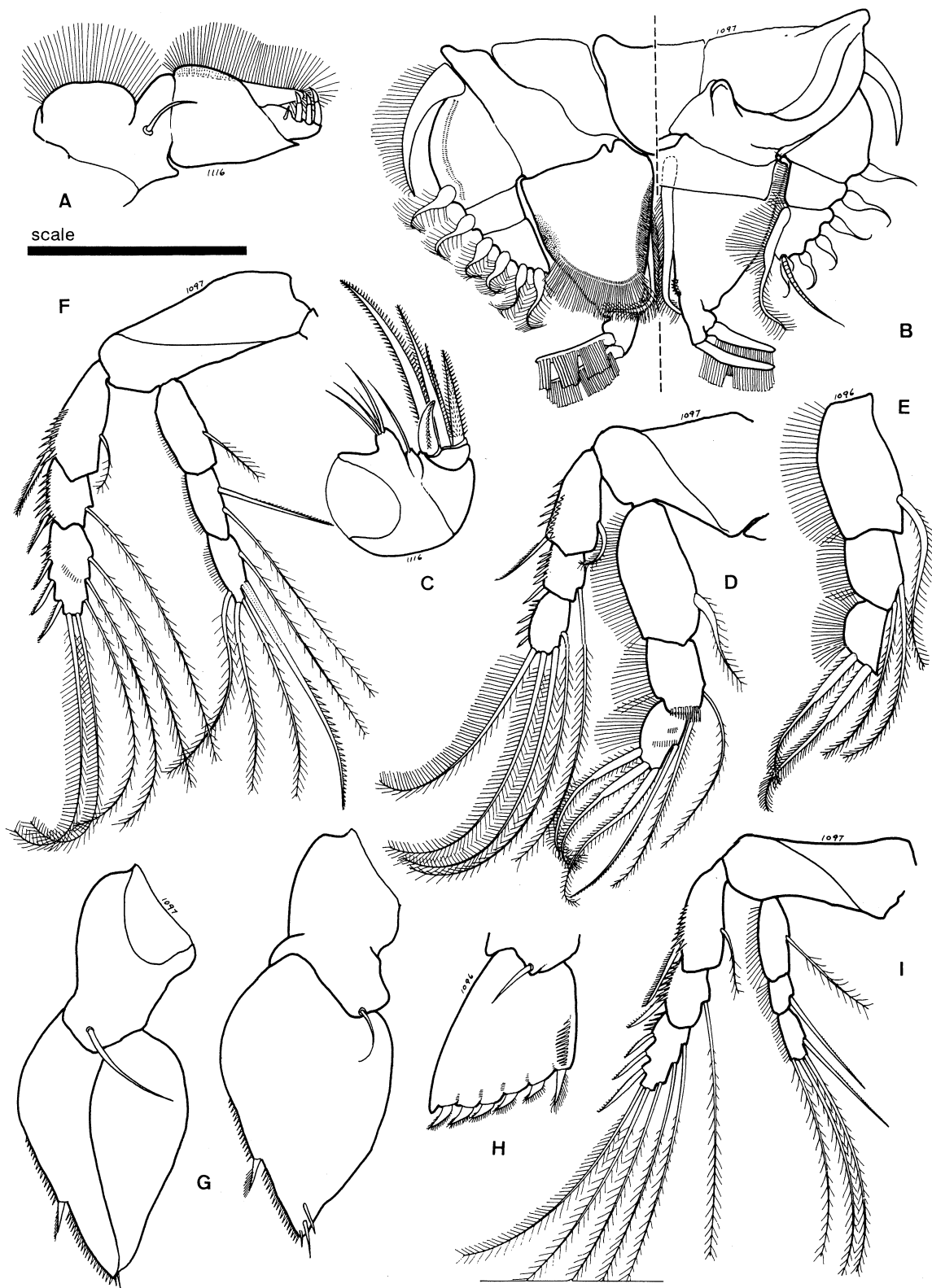
Figs 17, 20, 21

**Type material.** HOLOTYPE adult female with egg-mass detached, AM P35445; ALLOTYPE adult male, AM P35446; PARATYPES 3 ovigerous females, 2 males and 1 male coupled to juvenile female, AM P35447; 3 females and 1 male paratypes [Tb.2] BM(NH) 1992.470-473 (other material [Br 10] BM(NH) 1992.474-483). Dissections from which illustrations were made have been designated paratype material (slides 1088, 1097 female, 1096 male); these and remaining type population held at ZANU, registration Po.P.[Tb.2] [total type population 28 females (6 carrying eggs), 14 males (6 coupled to juvenile females)]. Taken from *Phyllospora comosa* in the infralittoral fringe, Lookout Point, Twofold Bay, Eden, NSW (37°06'S 149°54'E), 3 Dec. 1982, V.A.P. Harris.

**Diagnosis. Adult female.** Orange-brown; mean length 0.93 mm, rostrum width 0.22 mm, ratio of cephalosome width to rostrum 2.6; dorsal surface inconspicuously pitted; urosome very broad, almost rectangular, posterior lobe short, concave notch and faint scar between anterior and posterior lobes, medial corner rounded; caudal rami quadrate, medial corner rounded with seta 4 set in from corner; peg fields on P1 endopod conspicuous (oval lateral field, broad field down medial



**Fig. 20.** *Porcellidium phylloporum*. A – male urosome; B – anterior edge of male cephalosome (dorsal and ventral focus); C – male mandible; D – male antennule (ventral), setae of terminal segment omitted; E – detail of coupling denticles (dorsal); F – male caudal ramus; G – antenna, inset - terminal setae; H – female caudal rami; I – maxillule. Scale bar: A = 0.2 mm; B = 0.3 mm; C, F = 0.125 mm; D, G, I = 0.09 mm; E = 0.055 mm; H = 0.1 mm.



**Fig. 21.** *Porcellidium phyllosporum*. A – maxilliped; B – P1, anterior - left, posterior - right; C – maxilla; D – female P2; E – male P2 endopod; F – P3; G – female P5 (ventral and dorsal); H – male P5; I – P4. Scale bar: A,C = 0.09 mm; B,D,F,G,H,I = 0.165 mm; E = 0.125 mm.



edge); apex of P5 pointed.

**Adult male.** Cephalosome truncated, humped and bowed forward in mid-line to form deep overhang, antennal socket obscured, shoulders rounded; no ventral blade to antennule.

**Dimensions.** *Females.* Mean length 0.93 mm (SD = 0.024, N = 12), cephalosome length 0.6 mm, width 0.58 mm (SD = 0.016), height 0.15 mm, length to width ratio 1.6. Rostrum 0.22 mm wide, projects slightly, ratio of cephalosome width to rostrum 2.6. Urosome width to length ratio 1.7. Caudal ramus length to width ratio 1.1.

*Males.* Mean length 0.73 mm (N = 7), cephalosome length 0.45 mm, width 0.47 mm, ratio of length to width 1.55.

**Adult female** (Fig. 17C). Anterior of cephalosome hemi-elliptical, slightly humped in midline partly obscuring rostrum; antennule notch not visible from above. Rostrum very wide, anterior border curved with narrow hyaline edge, lateral corners acute. Hyaline border of cephalosome 8-11  $\mu\text{m}$  wide. Dorsal surface inconspicuously pitted, scattered sensory setae present.

Urosome short, very broad (almost rectangular, Fig. 20A), anterior lobe bordered with fine setules, rounded posteriorly, posterior lobe short, curved, bordered with stronger setules, rounded medial corner to caudal arch. Concave notch between anterior and posterior lobes. Caudal arch less than one-fifth of urosome length.

Caudal ramus very short, quadrate (Fig. 20H), medial corner rounded, lateral corner slightly emarginate with a few lateral setules.  $\alpha$  seta about halfway down ramus,  $\beta$  seta close to  $\gamma$ , terminal setae finely pinnate, 4 set in from medial corner, 2 and 3 set close together, terminal fringe of very fine setules present.

Limbs with typical setation. Antenna (Fig. 20G) with spatulate claw on endopod finely serrated, terminal portion of geniculate setae plain, articulate. Pars molaris of mandible short, solidly built, first pilose seta of palp large, swollen. Maxillule endites each with 4 setae (Fig. 20I). Maxilla as shown in Figure 21C. Maxilliped with rounded medial coxal lobe, coxa and basis with fimbriate border, fimbriate process to basis (Fig. 21A). First paraeopod (P1, Fig. 21B) basis with prominent anteriolateral tubercle, double row of pegs on article 1 of exopod, article 1 of endopod with conspicuous denticulate peg field along medial border, oval peg field at lateral extremity of fimbriate crescent. P2 (Fig. 21D) with serrulate spinous internal seta on distal article of endopod. Sabre-like spinous seta on endopod of P3 (Fig. 21F) slightly longer than endopod (1.1:1). P4 as shown in Figure 21I. Distal article of P5 (Fig. 21G) short and broad (ovate when flat), apex pointed with terminal and 2 dorsal setae, does not reach beyond anterior lobe of urosome.

**Adult male** (Fig. 17D). Anterior outline of cephalosome a truncated ellipse with medial hump which extends forward as a conspicuous overhang obscuring the

antennule socket, shoulders rounded (Fig. 20B). Hyaline border and dorsal pits as for female.

Urosome with lateral seta to anterior lobe, caudal arch shallow.

Length of caudal ramus less than width, setation similar to female (Fig. 20F).

Antennule typically modified (Fig. 20D,E). Coupling denticles reduced, proximal denticle U-shaped with distal end tooth-like, distal denticle small with serrated border and plumose seta. No ventral blade but small anterior spine (Fig. 20E). Terminal segment broad, less than one third length of compound segment.

Mandible (Fig. 20C) with first pilose seta of palp slender. P1, P3 and P4 as for female. P2 with 2 plumose setae on distal article of endopod (Fig. 21E). First terminal seta on P5 longer than remainder, unipinnate (Fig. 21H).

**Remarks.** This species has been named after the seaweed, *Phyllospora*, upon which populations are commonly found. It is deep orange-brown in colour. It is easily distinguished by its large size, very broad rostrum, shape of urosome, quadrate caudal rami and peg fields on the endopod of P1.

**Distribution and abundance.** *Porcellidium phyllosporum* is a southern species. It is common at Broulee and Twofold Bay stations, and isolated individuals have been found at Kioloa, but it has not been recorded further north. Moderate sized populations (50+) have been found on *Phyllospora comosa* and smaller populations on encrusted stones in the sublittoral zone. Isolated individuals are occasionally found on *Ecklonia*, *Pterocladia*, *Colpomenia* and *Sargassum* in the sublittoral.

#### *Acutiramus* n.gen.

**Diagnosis.** Anterior of female cephalosome semicircular, male truncated; hyaline border and dorsal pits present; urosome not very broad, epimeral expansions indistinctly divided into anterior and posterior lobes, posterior lobe narrow, pointed, caudal rami included in caudal arch of urosome; caudal rami rhomboidal with oblique posterior border, seta 4 at apex, setae 2 and 3 close together; maxillule endopod with 6 setae; maxilliped basis with fimbriate process, coxal lobe fimbriate; male P2 endopod with 2 plumose terminal setae; male P5 with 6 terminal setae; female P5 extends beyond caudal rami and may touch posteriorly.

**Females.** Cephalosome may be raised into an anteriomedial bulge above the rostrum. Rostrum narrow relative to cephalosome width (see w/R ratio in Table 4, Appendix).

Epimeral expansions of urosome not very broad, division into anterior and posterior lobes indistinct, region of posterior lobe narrow, triangular or pointed,

marginal setules present, caudal rami partly accommodated in caudal arch of urosome. Urosome width narrow relative to cephalosome (see urosome width/body width ratio in Table 4, Appendix).

Caudal rami rhomboidal with oblique posterior border, terminal seta 4 situated at apex.  $\beta$  seta may be close to  $\alpha$  or midway between  $\alpha$  and  $\gamma$ . Terminal setae 2 and 3 close together, slender and may lie parallel to the oblique posterior border so that they are difficult to see, seta 1 at lateral end of oblique border.

Maxillule endopod with 6 setae. Maxilliped coxa and basis with fimbriate border, fimbriate process on basis. P1 without conspicuous denticulate peg fields on endopod. In its natural position P5 appears falciform (lanceolate) and reaches beyond the caudal rami to touch its fellow posteriorly, but when detached it is ovate or oblong, its posterior extremity is rounded or truncated, not acute.

**Males.** Anterior outline of cephalosome truncated with medial convexity. Hyaline border and dorsal pits as for female.

Caudal rami quadrate, posterior border not oblique, setation as for female but terminal setae 2 and 3 not parallel to posterior border.

First pilose seta on mandibular palp not swollen. P2 endopod with 2 plumose setae on terminal article, spinose seta absent. P5 rhomboid with 6 terminal setae.

**Species composition.** *Acutiramus acuticaudatus* (Thompson & Scott, 1903); *A. brevicaudatus* (Thompson & Scott, 1903); *A. ovatus* (Geddes, 1968) (not Haller, 1879); *A. rufolineatus* n.sp.; *A. quinquelineatus* n.sp.

**Remarks.** The features which distinguish this genus from *Porcellidium* are the rhomboid caudal rami with oblique terminal border and apical fourth seta, and the fifth limbs (P5) which wrap round behind the caudal rami. The urosome is relatively narrow and appears more pointed due to the narrow triangular posterior lobe. Although the urosome may be short, the caudal rami are not excluded from the caudal arch. The egg mass may not be completely covered by the urosome, but in such cases the eggs are covered by the expanded P5 limbs.

The generic name refers to the pointed caudal rami (*L. acutus* = pointed + *ramus* = branch, oar).

### *Acutiramus rufolineatus* n.sp.

Figs 22-24

**Type material.** HOLOTYPE adult female with egg-mass detached, AM P35448; ALLOTYPE adult male, AM P35449; PARATYPES 3 ovigerous females, 2 males and 1 male coupled to juvenile female, AM P35450; 4 female and 4 male paratypes [Br.69] BM(NH) 1992.484-491, (other material [Aw 12] BM(NH) 1992.492-501). Dissections from which illustrations were made have been designated paratype material (slides 1170, 1171 female, 1173 male); these and remaining type population held at ZANU, registration Po.G.[Br.69] [total type

population 144 females (116 carrying eggs), 71 males (5 coupled to juvenile females)]. Taken from *Lobophora variegata* below MLWN tide level, Broulee rock platform, Broulee, NSW (35°52'S 150°11'E), 22 Nov. 1976, V.A.P. Harris.

**Diagnosis.** *Adult female.* Amber yellow with red dorsal stripe; mean length 0.52 mm, rostrum width 0.06 mm, ratio of cephalosome width to rostrum 4.8; cephalosome with medial prominence above rostrum; dorsal surface pitted; urosome plus caudal rami heart shaped, no lateral notch; caudal rami rhomboidal with oblique posterior border, terminal setae 1, 2 and 3 lie parallel to edge (difficult to see), 4 at apex of ramus; no peg field on endopod of P1; P5 rectangular with rounded corners, extends beyond urosome and caudal rami.

*Adult male.* Lateral corner of antennule socket prominent, continued as an 'epaulet' to rounded shoulders; caudal ramus quadrate, posterior border not oblique; antennule with ventral blade.

**Dimensions.** *Females.* Mean length 0.52 mm (SD = 0.013, N = 20), cephalosome length 0.28 mm, width 0.31 mm (SD = 0.007), height 0.07 mm, body length to width ratio 1.67. Rostrum 0.06 mm wide, ratio of body width to rostrum 4.8. Urosome width to length ratio 1.3. Caudal ramus length to width ratio 2.3.

*Males.* Mean length 0.48 mm (SD = 0.012, N = 20), cephalosome length 0.25 mm, width 0.28 mm (SD = 0.007), height 0.07 mm, body length to width ratio 1.72.

**Adult female** (Fig. 22A). Anterior outline of cephalosome semicircular, bulges in midline over narrow rostrum, lateral angle of antennule socket visible from above (Fig. 23B). Body narrows posteriorly giving animal an ovate (egg shaped) outline. Hyaline border of cephalosome 5  $\mu$ m wide, dorsal surfaces with shallow pits 2.5  $\mu$ m in diameter.

Urosome plus caudal rami heart shaped in outline (Fig. 23A); boundary between anterior and posterior lobes indistinct, indicated by scar, no lateral notch, posterior lobe bordered with fine setules, apex acutely rounded. Caudal arch deep (one-third length of urosome).

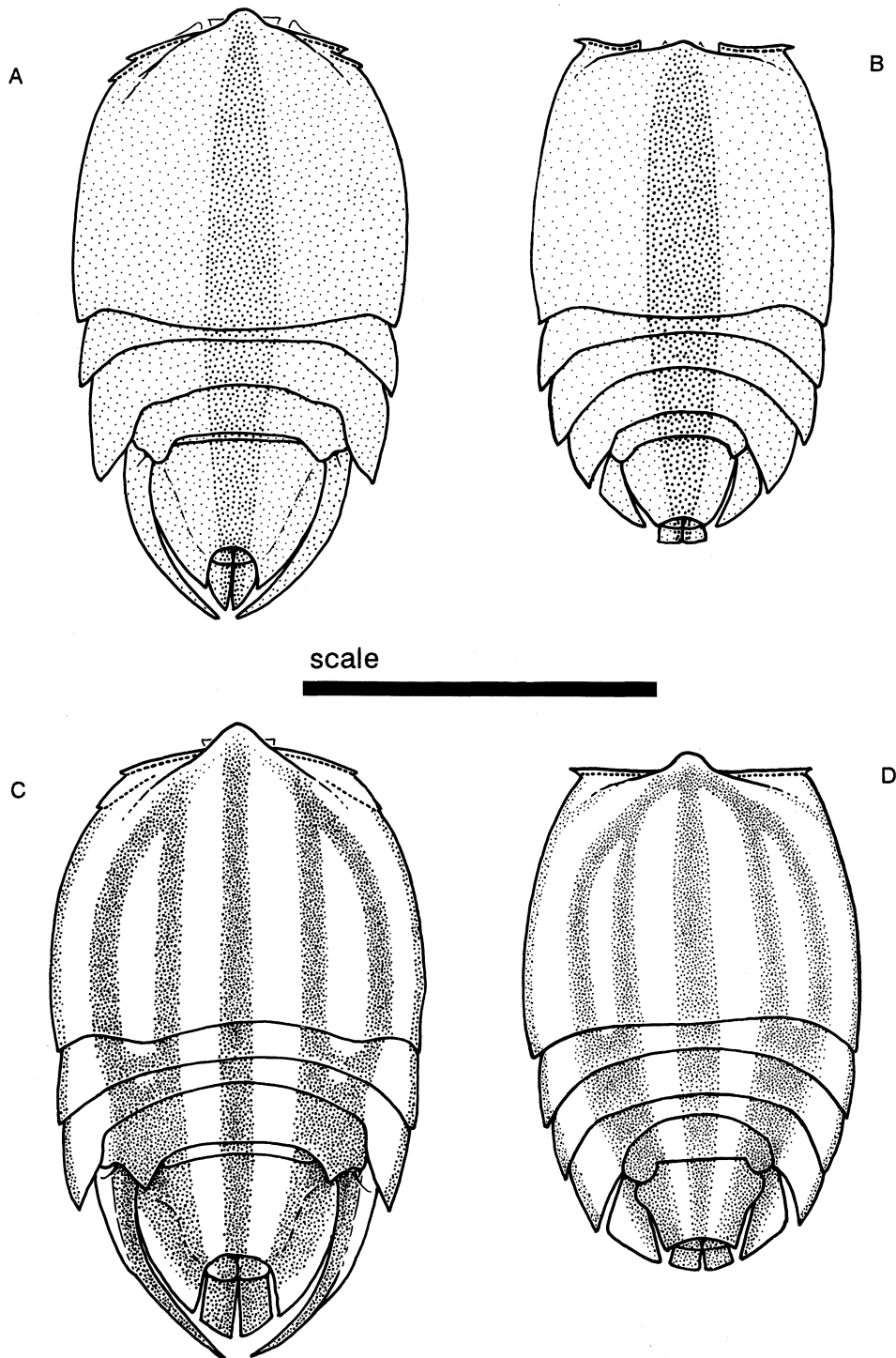
Caudal rami rhomboidal with oblique terminal border (Fig. 23D), terminal seta 4 pinnate, situated at bluntly pointed apex, seta 1 and  $\gamma$  seta tend to lie parallel to oblique edge and are difficult to see, 2 and 3 recessed in border (seldom clearly visible), terminal fringe of setules present but difficult to see (compare with description of male).

Limbs with typical setation. Spatulate claw on endopod of antenna serrated, terminal portion of geniculate setae plain (Fig. 23E). Mandible as shown in Figure 23I. Maxillule (Fig. 23H) with 4 setae on proximal endite, 3 on each of the other endites. Maxilla as shown in Figure 23G. Maxilliped with medial coxal lobe rounded, border of coxa and basis fimbriate, fimbriate process on basis (Fig. 23F). No denticulate peg fields on endopod of P1 (Fig. 23J). Terminal article of P2 endopod with sabre-like serrulate spinous seta

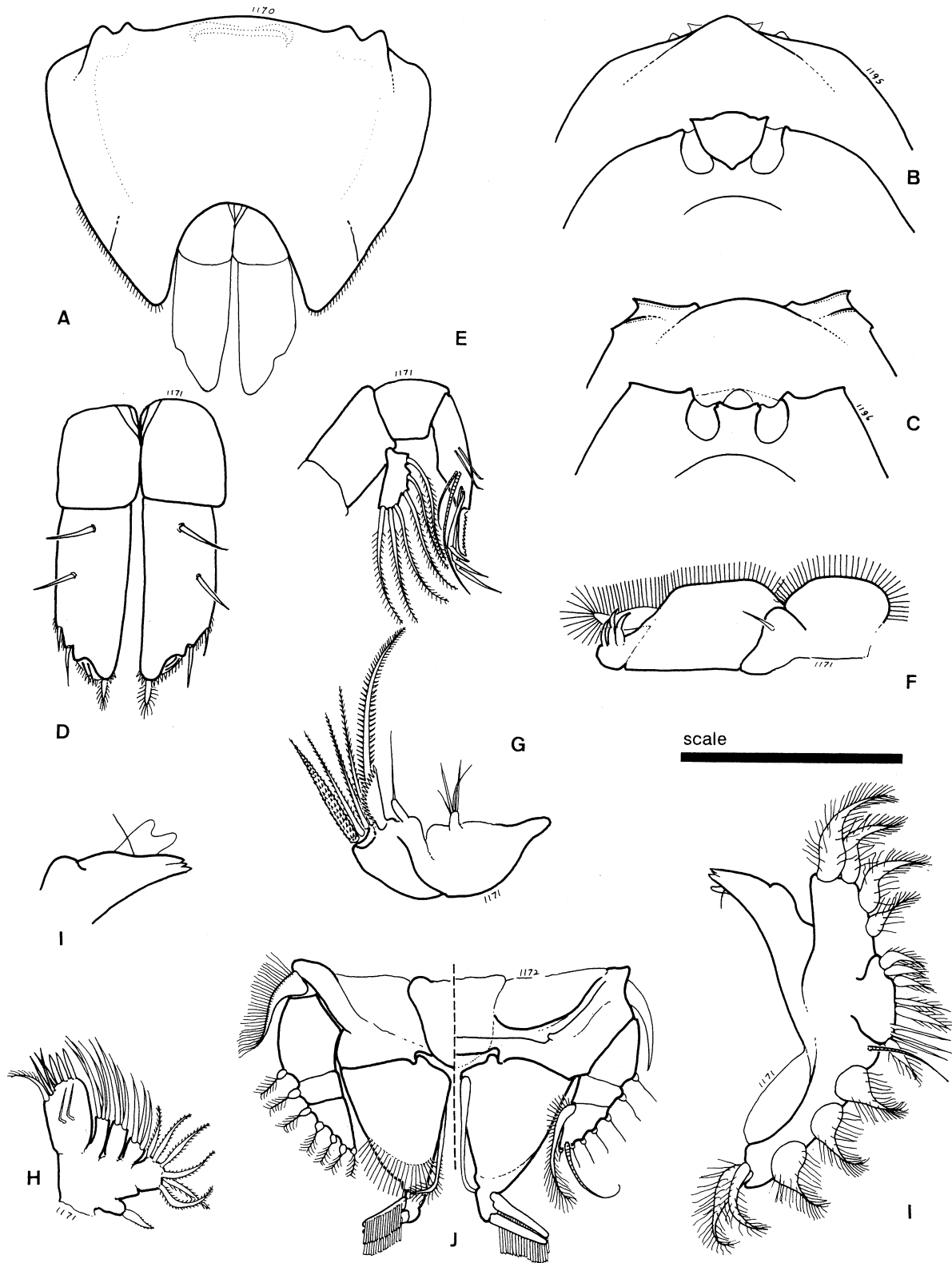
(Fig. 24A). Sabre-like spinous seta on P3 endopod much longer than endopod (1.6:1). P4 as in Figure 24C. Distal article of P5 rectangular with rounded posterior corners when removed and laid flat (in their natural position they appear falciform and wrap round behind the urosome and caudal rami to touch posteriorly), lateral

border with strong setules, 1 terminal seta (Fig. 24F).

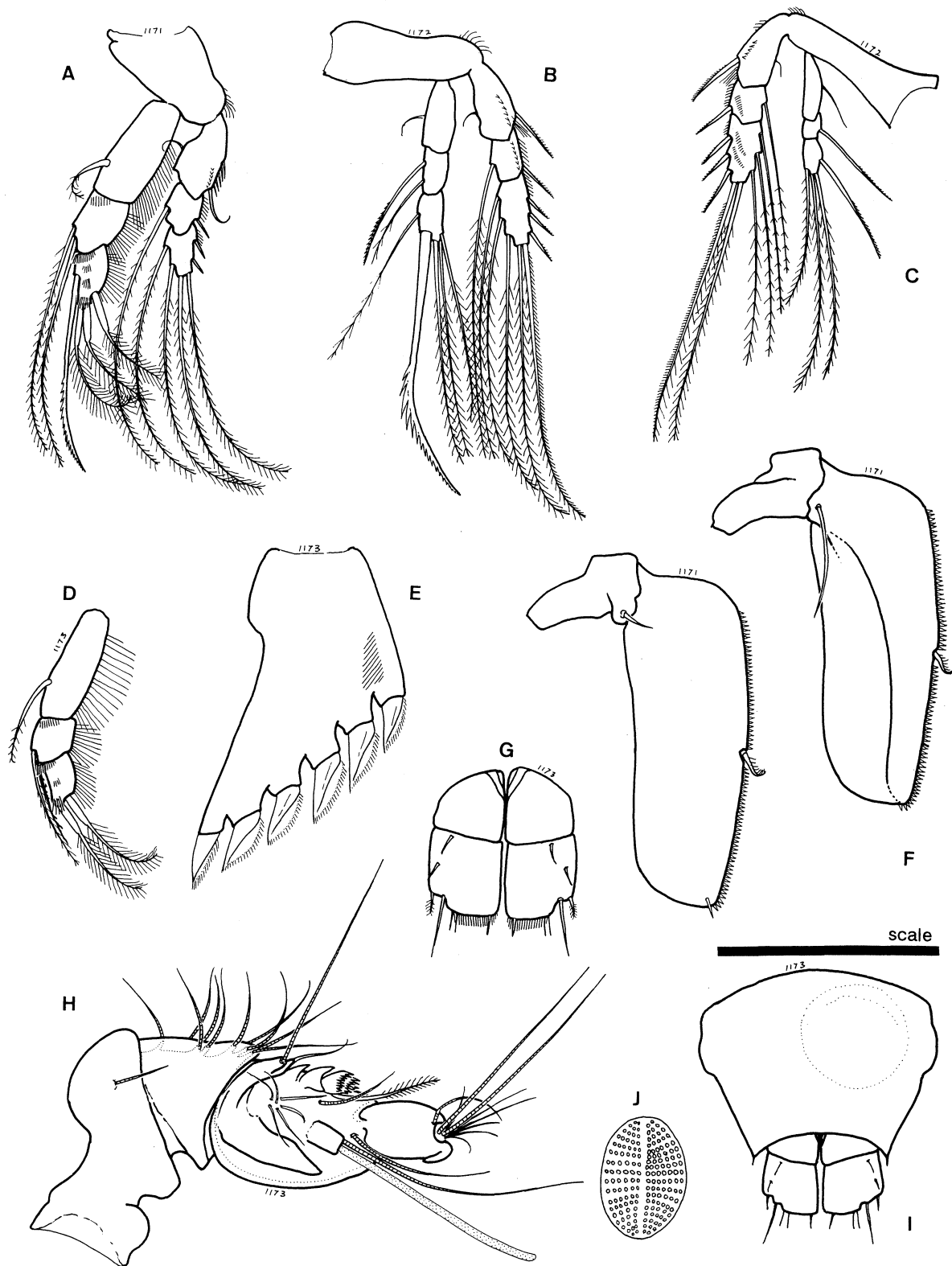
**Adult male** (Fig. 22B). Anterior outline of cephalosome a truncated ellipse, strongly bowed forward in the midline; lateral angle of antennule socket prominent, continued laterally as distinct 'epaulet', shoulder angular



**Fig. 22.** *Acutiramus rufolineatus*: A – adult female, dorsal view; B – adult male, dorsal view. *Acutiramus quinquelineatus*: C – adult female, dorsal view; D – adult male, dorsal view. Scale bar: A,B = 0.32 mm; C,D = 0.34 mm.



**Fig. 23.** *Acutiramus rufolineatus*. A – female urosome; B – anterior edge of female cephalosome (dorsal and ventral focus); C – anterior edge of male cephalosome (dorsal and ventral focus); D – female caudal rami; E – antenna; F – maxilliped; G – maxilla; H – maxillule; I – female mandible and incisor process; J – P1, anterior - left, posterior - right. Scale bar: A,J = 0.1 mm; B,C = 0.2 mm; D = 0.075 mm; E,I = 0.065 mm; F,G,H = 0.055 mm.



**Fig. 24.** *Acutiramus rufolineatus*. A – female P2; B – P3; C – P4; D – male P2 endopod; E – male P5; F – female P5 (dorsal and ventral); G – male caudal rami; H – male antennule showing coupling denticles; I – male urosome; J – diatom from dorsal surface of *A. rufolineatus*. Scale bar: A,B,C,D,I = 0.1 mm; E,H = 0.055 mm; F = 0.125 mm; G = 0.075 mm; J = 0.03 mm.

(Fig. 23C). Hyaline border and dorsal pits as in female. Urosome as in Figure 24I.

Caudal rami almost quadrate, posterior border not oblique (Fig. 24G), lateral corner emarginate, terminal seta 1 pinnate, 2 and 3 plain close together, 4 plain set in from medial corner, terminal fringe of fine setules present.

Antennules typically modified (Fig. 24I). Three small coupling denticles, distal denticle with finely serrated distal edge. Ventral blade present, half length of compound segment. Terminal segment half length of compound segment.

First pilose seta of mandibular palp slender. P1, P3 and P4 as for female. P2 with 2 plumose setae on distal article of endopod (Fig. 24D). Terminal setae of P5 deltoid with medial ridge and serrulate lateral border (Fig. 24E).

**Remarks.** The trivial name refers to the red dorsal stripe which runs from rostrum to caudal rami (*L. rufus* = red + *linea* = a line); the rest of the body is amber yellow. In males the antennules and anterior edge of the cephalosome may be red. Occasionally individuals are found which lack the red stripe.

Individuals detached from seaweed swim briefly then roll into a ball like a pill woodlouse (ie, conglobate), sink to the bottom and remain motionless for a short period before righting themselves. An oval diatom 16  $\mu\text{m}$  long is commonly found living on the dorsal surface (Fig. 24J); it appears to be specific to *A. rufolineatus* and has not been found on *A. quinquelineatus* or *P. pulchrum*.

This species is easily distinguished from the similarly coloured *P. pulchrum* by its small size, heart-shaped urosome, P5 reaching beyond caudal rami, epaulets on the male and the ability to conglobate.

**Distribution and abundance.** *Acutiramus rufolineatus* is a common and widespread species recorded from Ballina in the north of NSW to Moruya in the south, but it has not been recorded for Merimbula or Twofold Bay.

Large populations (greater than 100) are found on *Lobophora variegata* in tide pools about LWN tide level, but not on *Hormosira* growing in the same pools. Large populations are also encountered on *Ecklonia radiata* in the infralittoral fringe. Occasionally isolated individuals may be found on *Sargassum*, *Colpomenia*, *Cystophora*, *Phyllospora* and encrusted stones.

#### *Acutiramus quinquelineatus* n.sp.

Figs 22, 25, 26

**Type material.** HOLOTYPE adult female with egg-mass detached, AM P35451; ALLOTYPE adult male, AM P35452; PARATYPES 3 ovigerous females, 2 males and 1 male coupled to juvenile female, AM P35453; 2 female and 2 male paratypes [Br.85] BM(NH) 1992.502-505, (other material [Tb

7] BM(NH) 1992.506-515). Dissections from which illustrations were made have been designated paratype material (slides 1222, 1158 female, 1156 male); these and remaining type population held at ZANU, registration Po.U.[Br.85] [total type population 19 adult females (12 carrying eggs), 15 males (3 coupled to juvenile females)]. Taken from holdfasts of *Ecklonia radiata* in the infralittoral fringe at edge of Broulee rock platform, Broulee, NSW (35°52'S 150°11'E), 14 Sept. 1982, V.A.P. Harris.

**Diagnosis.** *Adult female.* White with 5 pink lines down back; mean length 0.55 mm, rostrum width 0.07 mm, ratio of cephalosome width to rostrum 4.8; cephalosome with medial prominence above rostrum; conspicuous pits on dorsal surface; urosome plus caudal rami triangular in outline, distinct lateral notch and cleft, posterior lobe pointed; caudal rami rhomboidal, divergent, posterior border oblique,  $\beta$  seta halfway down ramus, terminal seta 4 pinnate situated at apex, 2 and 3 fine close together; no peg field on endopod of P1; P5 not pointed with notch in blunt apex, extends beyond caudal rami to meet fellow posteriorly.

*Adult male.* Shoulders with prominent 'epaulet'; caudal rami quadrate; small ventral blade on antennule.

**Dimensions.** *Females.* Mean length 0.55 mm (SD = 0.012, N = 18), cephalosome length 0.29 mm, width 0.34 mm (SD = 0.012), height 0.09 mm, body length to width ratio 1.6. Rostrum 0.07 mm wide, ratio of body width to rostrum 4.8. Urosome width to length ratio 1.3. Caudal ramus length to width ratio 3.0.

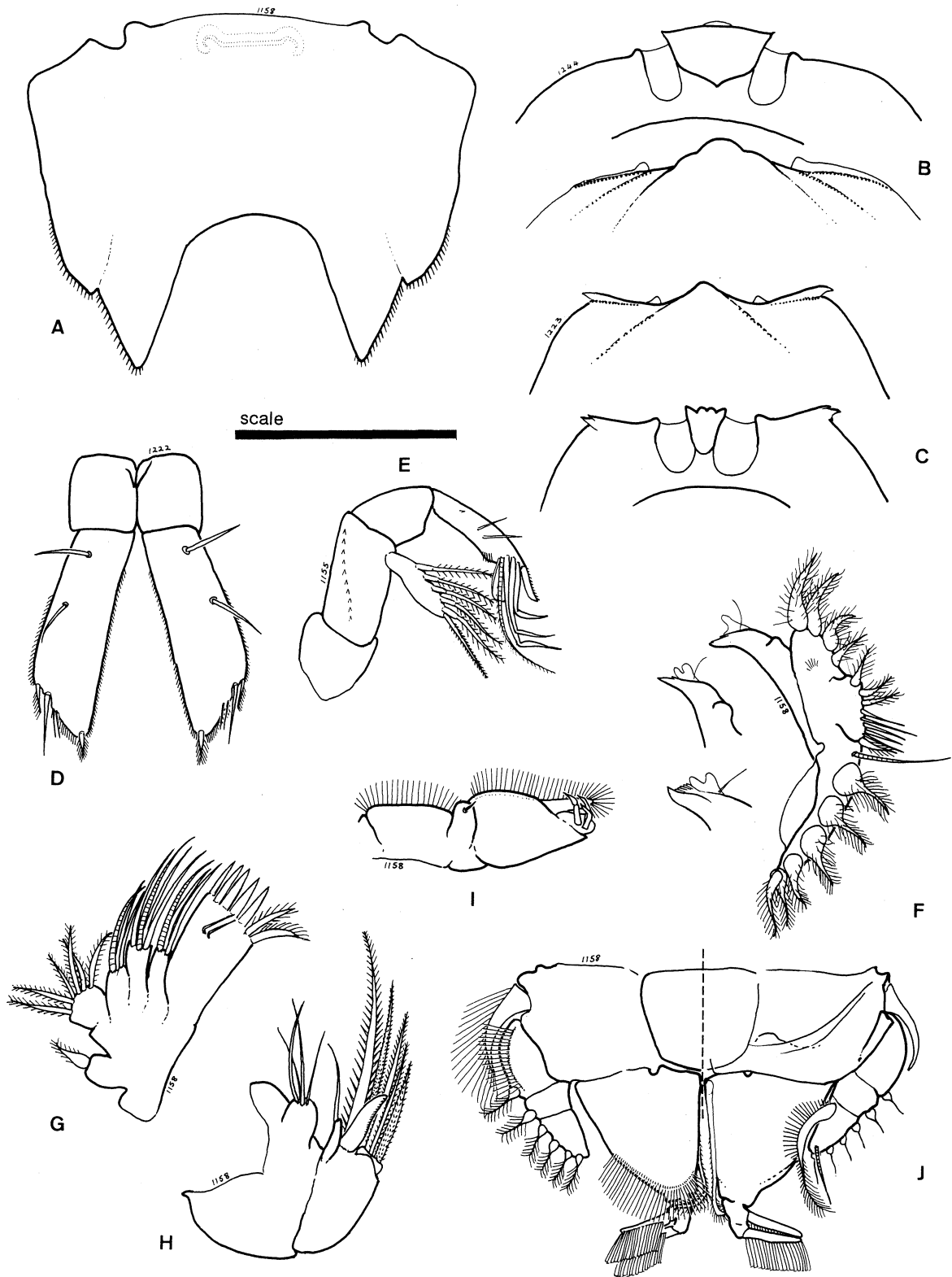
*Males.* Mean length 0.43 mm (SD = 0.011, N = 14), cephalosome length 0.25 mm, width 0.3 mm, body length to width ratio 1.43.

**Adult female** (Fig. 22C). Anterior outline of cephalosome semicircular with prominent hump or protuberance in midline, lateral angle of antennule socket projects slightly (Fig. 25B) Rostrum narrow, not prominent, slightly bowed anteriorly with acute corners. Hyaline border of cephalosome and epimeral lobes 7  $\mu\text{m}$  wide, dorsal pits conspicuous, 3  $\mu\text{m}$  in diameter. Dorsal surface of caudal rami with reticulate pattern of ridges.

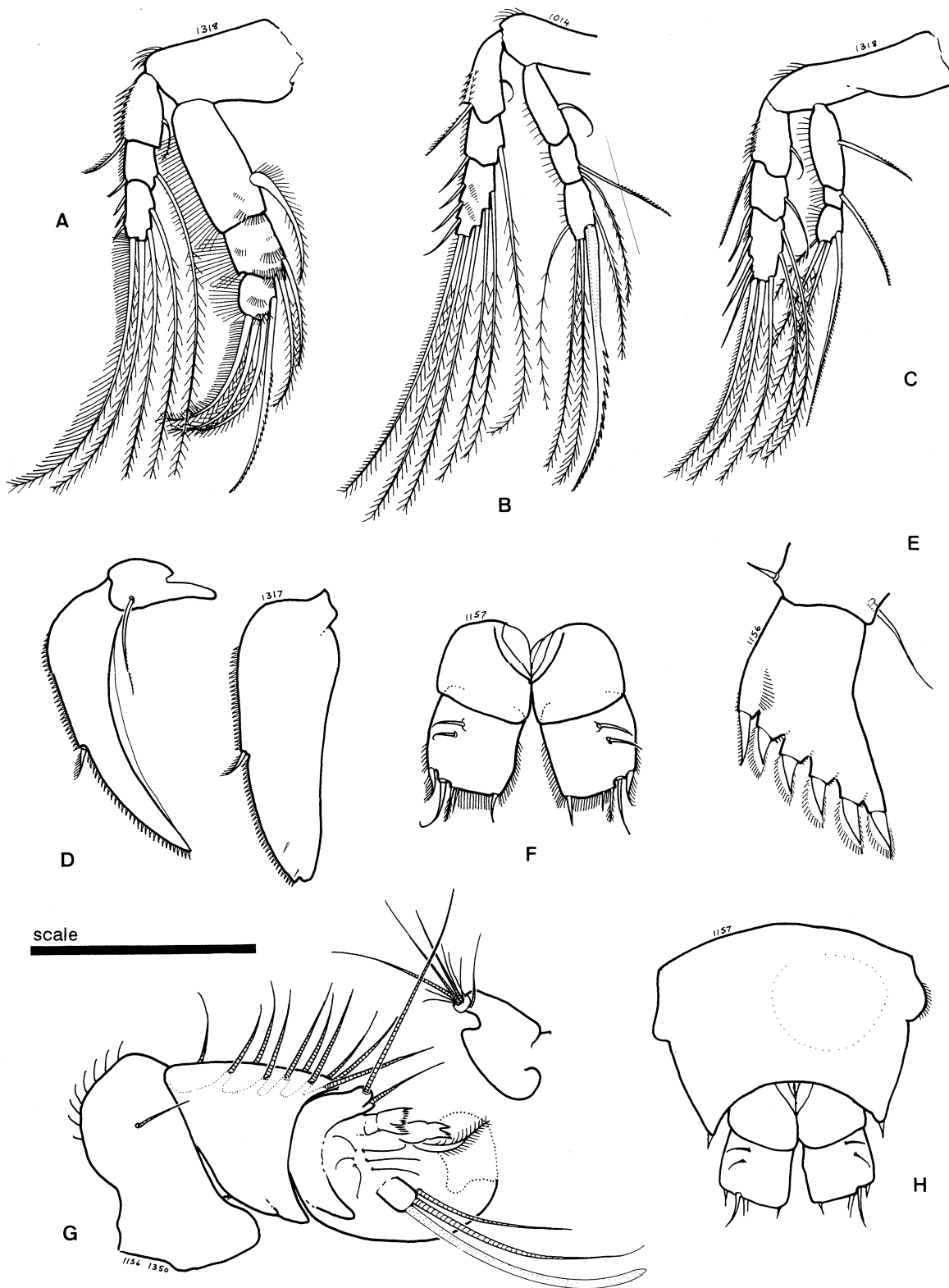
Urosome (Figs 22C, 25A) plus caudal rami triangular in outline; distinct lateral notch and cleft, posterior lobe pointed, fine setules on posterior half of lateral border. Caudal arch deep (about half urosome length).

Caudal ramus rhomboidal, divergent (Fig. 25D), slightly wider posteriorly with oblique distal border, fine setules along most of medial and lateral borders.  $\alpha$  seta less than one-fifth and  $\beta$  seta less than halfway down ramus, terminal seta 4 pinnate situated at apex, 2 and 3 plain close together, seta 1 unipinnate at external corner; terminal fringe of fine setules present. Rami project well beyond urosome, but are surrounded by fifth limbs (see Fig. 22C).

Limbs with typical setation. Antenna (Fig. 25E) with spatulate claw on endopod finely serrated, geniculate setae plain. Mandible slender (Fig. 25F). Maxillule with 3 setae on proximal and distal endites, 4 setae on medial



**Fig. 25.** *Acutiramus quinquelineatus*. A – female urosome; B – anterior edge of female cephalosome (ventral and dorsal focus); C – anterior edge of male cephalosome (dorsal and ventral focus); D – female caudal rami; E – antenna; F – female mandible and incisor process from different angles; G – maxillule; H – maxilla; I – maxilliped; J – P1, anterior - left, posterior - right. Scale bar: A,B = 0.165 mm; C,D,F = 0.1 mm; E = 0.065 mm; G,H = 0.045 mm; I = 0.075 mm; J = 0.09 mm.



**Fig. 26.** *Acutiramus quinquelineatus*. A – female P2; B – P3; C – P4; D – female P5 (ventral and dorsal); E – male P5; F – male caudal rami; G – male antennule, terminal segment displaced to show coupling denticles; H – male urosome. Scale bar: A,B,C,H = 0.1 mm; D = 0.165 mm; E = 0.065 mm; F = 0.075 mm; G = 0.055 mm.



endite, single seta on exopod (Fig. 25G). Maxilla as shown in Figure 25H. Medial lobe of maxilliped (Fig. 25I) rounded with fimbriate edge, fimbriate process present on basis. P1 without denticulate peg fields (Fig. 25J). Terminal article of P2 endopod with sabre-like serrulate spinous seta (Fig. 26A). Sabre-like spinous seta on P3 (Fig. 26B) considerably longer than endopod (1.6:1). P4 with first internal seta on distal article of endopod serrulate spinous (Fig. 26C). P5 lanceolate, apex obtuse with notch, 2 dorsal apical setae (Fig. 26D).

**Adult male** (Fig. 22D). Anterior outline of cephalosome a truncated ellipse, prominent medial dorsal protuberance projects forward in the midline, strongly developed 'epaulets', shoulders angular, lateral angle of antennule socket not prominent (Fig. 25C). Hyaline border and dorsal pits as in female.

Urosome as in Figure 26H; strong apical setule present.

Caudal ramus quadrate (Fig. 26F), slightly emarginate, posterior border not oblique, terminal seta 1 unipinnate, 2 pinnate, 3 and 4 plain, 2 and 3 close together, terminal fringe of fine setules present.

Antennule (Fig. 26G) typically modified. Coupling apparatus reduced to 2 small denticles, proximal with finely serrated edge, distal bicuspid, tooth-like, with associate plumose seta. Small ventral blade (less than quarter length of compound segment). Terminal segment with notch near tip.

First seta on mandibular palp slender. P1, P3 and P4 as for female. P2 with 2 plumose setae on distal article of endopod. First lateral seta of P5 slender unipinnate, remainder triangular with pinnate lateral fringe, row of setules at base of each seta (Fig. 26E).

**Remarks.** The trivial name *quinquelineatus* refers to the five magenta pink stripes that run down the back (*L. quinque* = five + *linea* = a line). Spirit preserved specimens lose their colour and resemble *A. rufolineatus* in size and appearance, but are distinguished by the shape of the fifth limbs (P5).

**Distribution and abundance.** *Acutiramus quinquelineatus* has been recorded from all New South Wales sampling stations ranging from Ballina in the north to Twofold Bay in the south. Although no large populations have been found, nearly all specimens have been taken from *Ecklonia radiata* where it is significantly more abundant on the holdfast and stipe than the thallus, however, Robertson has observed that animals migrate down onto the stipe and holdfast at low tide if the weed is partly exposed and move back to the thallus as the tide returns.

## Discussion

### Taxonomic Characters

A number of new characters for the Porcellidiidae

have been used in the foregoing descriptions which require further explanation or discussion. Of particular significance are the shape of the cephalosome, structure of the urosome, shape and setation of the caudal rami and peculiarities of the limbs.

1. The cephalosome. There is relatively little specific difference in the shape of the anterior border of the female cephalosome, it is usually semicircular or semi-elliptical; rarely truncated. In marked contrast the anterior border of the male cephalosome is usually truncated and shows a wide range of features (the shape of the shoulders, prominence of the antennule socket, presence of an 'epaulet' or extension of the anterior border at the point where the hyaline border starts, etc.). These features offer a quick and positive way of distinguishing species where the females look very similar (for example, spirit specimens of *P. hormosirii*, *P. ocellum* and *P. pulchrum*, see Figs 3A,G; 7A-D).

In the majority of species the lateral border of the cephalosome and epimeral lobes is bordered by a colourless, hyaline fringe which appears to be non-chitinous as it does not stain with the chitin stain chlorazol black. A few sensory setae appear to lie in the plane of the hyaline border, and the ducts of marginal glands open on the dorsal surface immediately above it. However, the lateral edge of the cephalosome may be reflexed ventrally so that it is not visible from above and the hyaline border reduced or lost (Harris, 1994). The hyaline border has not been drawn in any of the illustrations.

A wide range of surface ornamentation is found on the dorsal parts of the body, including the caudal rami. In the majority of species this consists of circular, oval or semicircular pits, sometimes with a raised border (see Pl. 1A), which give the animal a malleated or pockmarked appearance. Sometimes the area between pits may be raised into reticulate ridges, particularly on the urosome and caudal rami. In a few species pits are absent, in which case the surface may be smooth or raised into a honeycomb-like ornamentation of ridges. No differences have been found in the hyaline fringe or ornamentation between males and females.

2. The urosome. In the majority of species the female genital segment of the abdomen is expanded into anterior and posterior lobes by lateral epimeral expansions. A cleft, notch or scar may indicate the boundary between lobes, and the degree of fusion that has taken place. Fusion may be so complete that there is no trace of anterior and posterior lobes. Epimeral lobes may be absent, in which case the urosome is narrow, without a caudal arch, and the caudal rami completely excluded from the urosome. Epimeral lobes appear to be absent from males where division into anterior and posterior lobes is usually indistinct. Although the shape of the urosome is difficult to quantify, the wide range in shape provides useful specific characteristics.

3. The caudal rami. The shape of the female caudal rami can be grouped into four categories: triangular (as in *P. tenuicauda* Claus, 1860), rhomboidal (as in *A.*

*rufolineatum*), rectangular (as in *P. ulvum* Hicks and *P. hormosirii*) and quadrate (as in *P. phyllosporum*). In marked contrast, the caudal rami of males is remarkably uniform and nearly always quadrate or sub-quadrate ( $l/w$  less than 1), consequently there is usually a marked difference in shape, but not setation, from the female (compare, for example, Figs 25D and 26F).

On the dorsal surface of each ramus there are two setae, here designated  $\alpha$  (proximal) and  $\beta$  (Fig. 2), which may be very close together (ie, ratio  $\alpha$  to  $\gamma/\alpha$  to  $\beta > 5$ ) as in *P. dilatatum* Hicks (Hicks, 1971), wide apart with  $\beta$  close to posterior border of ramus (subterminal) as in *P. erythrogastrum* or any intermediate position.

Along the terminal (posterior) border of each ramus there are typically five setae, but these are seldom of the same form. One of these resembles  $\alpha$  and  $\beta$  and is much longer than the others; it is never pinnate (*P. brevicaudatum* may be an exception). For these reasons this seta has been designated  $\gamma$  and included in the dorsal series (Fig. 2). The remaining setae (usually 4) are much more variable in appearance; they may be plain or pinnate (Fig. 2). They are numbered 1 to 4 with terminal seta 1 (if present) occupying the external (lateral) corner of the ramus and 4 situated at or near the medial corner. The middle setae, 2 and 3, are usually set close together and more slender than 1 and 4, but in some species (eg, *P. ulvum*, Hicks, 1982) all four setae are identical in shape and equally spaced along the terminal edge. Seta 3 may be very small and easily overlooked, but its presence in the species can be confirmed by examining the male caudal ramus where it will be of similar size to seta 2.

Three features of the caudal ramus appear to show generic differences; viz: very close proximity of the  $\alpha$  and  $\beta$  setae or otherwise; rhomboidal shape of the lamina with oblique posterior border and seta 4 at the apex or otherwise; and both shape and placement of the four terminal setae (ie, 1-4 identical and equidistant or 2 and 3 close together and different to 1 and 4).

4. The limbs. While certain limbs offer only a limited range of form, others show wide variation. Of the former, the following appear to offer generic characteristics: maxillule (endopod\* with 2 or 6 setae), maxilliped (with fimbriate border and fimbriate process or without either), male P2 with 2, 3 or 4 terminal setae, and male P5 (with 1 or 6 terminal setae). On the other hand, denticulate peg fields on P1, ratio in length of P3 endopod and its large sabre-like spinous seta, and the shape of female P5, are features with wide variation that can be used to characterise species.

As noted by Hicks (1982), the male antennule may possess a number of features that are of potential taxonomic value, particularly the structures here referred to as the coupling denticles and a sclerotised finger-like process, the ventral blade. However, the extreme difficulty of studying the male antennule reduces the practical

value of these features in identifying specimens. The structure and homologies of the porcellidid antennule have been described by Harris (1994).

### Interspecific Relationships

Redefining the characteristics of *Porcellidium* raises the question of the relationship of previously described species, but here one is immediately faced with uncertainty for many of the characters crucial to identification have not been given in earlier descriptions and some older Type material has not been traced.

Six previously described species qualify for inclusion in the redefined genus *Porcellidium*: *P. viride*, *P. fimbriatum*, *P. sarsi*, *P. rubrum*, *P. erythrum*, *P. hartmannorum* and *P. algoense*.

There has been considerable confusion over the identity of *P. viride*, *P. fimbriatum* and *P. sarsi* in the past. This is not surprising for the original description of *viride* (*Thyone viridis* Philippa, 1840) was quite inadequate and of a juvenile male. Claus (1889) described a pale green species as *P. lecanoides* which Lang (1948) regarded as synonymous with *P. viride*. Further confusion arose because the description and illustrations Claus gave of *P. fimbriatum* Claus, 1889 did not agree with his previous inadequate account (Claus, 1863). The animal described by Sars as *P. fimbriatum* fits Claus' 1863 description rather than the 1889 description. Bocquet (1948) clearly demonstrated the differences between Sars' animal which he renamed *P. sarsi* and Claus' other two species – *P. fimbriatum* and *P. lecanoides*, all of which are perfectly valid species despite Lang's attempt to synonymise all three as *P. viride* (Lang, 1948). Although females of *P. viride* (*P. lecanoides* Claus) and *P. sarsi* look very similar in shape, they can easily be separated on the structure of the male's antennule, moreover, both species can be distinguished from *P. fimbriatum* on the structure of their urosome, setation of the caudal rami and the colouration of living animals. Table 3 shows the main features which separate these three species.

Their broad urosome, rectangular caudal rami, maxillule endopod with six setae, maxilliped with fimbriate process, male P2 with two terminal setae, male P6 with six setae, and hyaline fringe to the cephalosome, confirm *P. viride*, *P. fimbriatum* and *P. sarsi* as species in the genus *Porcellidium* as defined above. The absence of a ventral blade on the male antennule would place *P. viride* and *P. sarsi* in the 'Naviculum' subgroup, but *P. fimbriatum*, which has a ventral blade to the antennule, cannot be placed in the 'Hormosirii' subgroup because its terminal setae on the caudal ramus are different; it will be placed in a subgroup of its own, the 'Fimbriatum' subgroup.

*Porcellidium rubrum* Pallares (1966), *P. hartmannorum* Tiemann (1978) and *P. algoense* Hicks (1982) also display all the previously listed characters of the redefined genus *Porcellidium*, and all possess a ventral blade to the male antennule which places them

\* The maxillule is interpreted differently by Humes & Ho (1969) who describe this structure as the exopod.

in the 'Hormosirii' subgroup. There is some doubt about the position of *P. erythrum* Hicks. Hicks (1982) states that males do not have a finger-like lateral process (ventral blade) which would place it in the 'Naviculum' subgroup, however, topotype material examined by the authors do appear to have a ventral blade and further study is required to determine its true affinities. Interpretation of this structure can be difficult and largely dependent upon orientation of the antennule.

Five species have been described which resemble *Acutiramus rufolineatus* in having a rhomboidal caudal ramus and fifth limbs (P5) that pass behind the caudal rami. Of these *P. scutatum* Claus 1889, and *P. ravanae* Thompson & Scott, 1903 are not described in sufficient detail to be certain about their affinities. *Porcellidium brevicaudatum* Thompson & Scott, 1903 has been accurately redescribed by Humes & Ho, 1969, and although the description of *P. ovatum* Geddes, 1968 (not Haller, 1879), lacks some important information, it gives sufficient detail for comparison with other species. The last of the five species, *P. acuticaudatum* Thompson & Scott, 1903, was inadequately described for comparison, but specimens from Lake Timsáh, Ismalia, collected by Wells (1967) were referred to this species. This material in the BM(NH) has been examined by the senior author for comparison with *A. rufolineatus*.

*Porcellidium acuticaudatum*, *P. brevicaudatum* and *P. ovatum* (Geddes, not Haller) all possess the following characteristics which have been used to define the genus *Acutiramus*: urosome with posterior lobe narrow, triangular, male P2 with two terminal setae, male P5 with six setae, maxillule with six setae on the endopod, maxilliped with fimbriate process, cephalosome with hyaline fringe, female caudal rami rhomboidal with oblique posterior border and seta 4 apical, terminal setae 2 and 3 close together, female P5 passing behind caudal rami and possibly touching. It is suggested that these three species be removed from *Porcellidium* and placed in the new genus as *Acutiramus acuticaudatus*, *A. brevicaudatus* and *A. ovatus*. A comparison with *A. rufolineatus* and *A. quinquelineatus* is given in Table 4.

*Acutiramus brevicaudatus* differs from the others in having  $\alpha$  and  $\beta$  caudal setae close together. Another unique feature illustrated by Humes & Ho, but not found elsewhere in the Porcellidiidae, is a pinnate  $\gamma$  seta on both male and female caudal rami. This unusual feature should be re-examined for it is not unusual to find filamentous micro-organisms attached to setae and looking like pinnae. The two can be distinguished easily for, on pinnate and plumose setae, the pinnae lie at an angle to the shaft, are regularly spaced and of equal length. Filamentous micro-organisms, however, grow out at right angles, are unevenly spaced and of different lengths.

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## APPENDIX

Table 1. Taxonomic characters of the Porcellidiidae.

Constant features (family characters)	Unique characters appearing in 2 or 3 forms (generic characters)	Highly variable characters (specific characters)
form of male antennule	ventral blade on male antennule (present or absent)	denticles on male antennule shape of ventral blade
form of mandible palp	maxillule endopod with 2 or 6 setae	urosome shape
form of maxilla	maxilliped: fimbriate process present or absent	shape and setation of caudal ramus
form of P1	male P2 with 2, 3 or 4 setae on endopod terminal article	P1 peg fields on article 1 of endopod (presence and shape)
form of P3 and P4	male P5: 1 or 6 terminal setae	P3 spine/endopod ratio  shape of female P5
Body tagmosis	ability to conglobate	dimensions
Body shape	presence or absence of hyaline border*	cephalosome l/w ratio
	presence or absence of dorsal pits	dorsal ornamentation
		colouration

\* The lateral margin of the cephalosome may be reflexed ventrally and not visible from the dorsal aspect.

Table 2. Incidence of suctorian *Ophryodendron* on *P. erythrogastrum*\*

	Females	Males	Total
number of adult copepods	86	66	152
number of parasitised copepods	56	19	75
% parasitism of sample	—	—	49%
% parasitism of copepods by sex	65%	29%	
number of suctorians	76	20	96
% distribution of suctorians between sexes	79%	21%	

\* Sample taken from population Ki.21.

Table 3. Comparison of characters.

<i>Porcellidium viride</i>	<i>Porcellidium sarsi</i>	<i>Porcellidium fimbriatum</i>
terminal setae 2 and 3 of caudal rami fine, close together	terminal setae 2 and 3 of caudal rami fine, close together	terminal setae 2 and 3 of caudal rami thick pinnate, not close together
urosome with notch and scar, but no cleft	urosome with notch and scar, but no cleft	urosome with deep cleft
no ventral blade to male antennule	no ventral blade to male antennule	ventral blade present on male antennule
terminal segment of male antennule short, blunt	terminal segment of antennule long, ends in 'hook'	

Table 4. Comparison of Acutiramate species.

Character	Species					
	<i>Acutiramus rufolineatus</i>	<i>Acutiramus quinquelineatus</i>	<i>Porcellidium acuticaudatum</i> <sup>2</sup>	<i>Porcellidium acuticaudatum</i> <sup>3</sup>	<i>Porcellidium ovatum</i> <sup>1</sup>	<i>Porcellidium brevicaudatum</i> <sup>4</sup>
length	0.52 mm	0.56 mm	0.6 mm	0.6 mm	0.62 mm	0.78 mm
l/w ratio	1.67	1.6	1.5	1.7	1.5	1.66
w/rostrum ratio	(mean for 12 other species = 3.87, range 2.6-4.7)					
	4.8	4.8	4.4	4.5	4.7	4.2
female urosome w/body width ratio	(mean for 13 other species = 0.6, range 0.54-0.66)					
	0.52	0.54	0.46	—	0.52	0.46
female urosome w/l ratio	1.3	1.3	1.4	1.4	1.6	1.85
female caudal ramus l/w ratio	2.3	2.6	2.9	2.75	3.5	1.65
female urosome notch	absent	present	very slight	notch	cleft	no notch or cleft
caudal setae 2 and 3	parallel to edge	nearly parallel to edge	—	parallel to edge	nearly parallel to edge	not parallel to edge
$\alpha$ to $\beta$	apart	apart	apart	apart	apart	very close
$\alpha$ to apex/ $\alpha$ to $\beta$ ratio	2.4	3.2	6.6	6.0	3.7	10.4

<sup>1</sup> Geddes, 1968; <sup>2</sup> Thompson & Scott, 1903; <sup>3</sup> Wells, 1967; <sup>4</sup> Humes & Ho, 1969.