

Two New Genera Belonging to the Family Porcellidiidae  
(Crustacea, Copepoda, Harpacticoida) from  
Iwate Prefecture, Japan

By

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**Abstract** A new genus, *Clavigofera*, is defined to accommodate a new species, *C. pacifica*. A second new genus, *Kushia*, (characterised by a conspicuous comb on the male antennule) is defined and three new species, *K. gamoi*, *K. zosteraphila* and *K. igaguria* assigned to it. Animals were collected from various seaweeds at Kadonohama Bay, Ofunato, Iwate Prefecture, Japan. The relationship of *Clavigofera pacifica* to members of the 'clavigerum complex' is discussed. *Porcellidium clavigerum* PESTA, *P. ulvum* HICKS, *P. laurencium* HICKS and *P. echinophilum* HUMES et GELERMAN are moved to the new genus as *Clavigofera clavigera*, *C. ulva*, *C. laurencia* and *C. echinophila*.

### Introduction

PESTA (1935) described a species of *Porcellidium*, *P. clavigerum* from Hawaii that differed from other known species in the form and spacing of the terminal caudal setae. HUMES and GELERMAN (1962) found a similar animal associated with a sea urchin in Madagascar, which they called *P. echinophilum*. Closely related animals have been described by HICKS (1982) from Algoa Bay, South Africa as *P. ulvum* and *P. laurencium*. The close similarity of these four species has been noted by HICKS who refers to them as the 'clavigerum complex'. All these animals show features which set them apart from other members of the genus *Porcellidium* as defined by HARRIS and IWASAKI (1996).

Another member of the 'clavigerum complex' has been found in many of the samples collected by N. IWASAKI from Kadonohama Bay, Iwate Prefecture, Japan. It is proposed to separate this species from *Porcellidium* and assign it to a new genus. Three other species found at Kadonohama show characters which

exclude them from *Porcellidium*. They are placed in another new genus.

### Materials and Methods

All specimens described here were collected from seaweeds in the sub-littoral at Kadonohama Bay, Ofunato, Iwate Prefecture. Collection data and methods used have been described by HARRIS and IWASAKI (1996). Holotype, allotype and paratype specimens for each of the new species have been deposited in the National Science Museum, Tokyo (NSMT). Paratype material has been deposited in British Museum of Natural History (BMNH), National Museum of New Zealand (NMNZ), Australian Museum, Sydney (AMS). The remainder of the paratype material and all the samples from the collecting stations are held by Dr N. IWASAKI, Usa Marine Biological Institute, Kochi, Japan.

### Systematics

#### Family Porcellidiidae SARS 1904

#### Genus *Clavigofera* n. gen.

*Diagnosis.* Anterior of female cephalosome rounded, may be slightly truncated, rostrum prominent; male cephalosome truncated anteriorly; hyaline border present, marginal glands open dorsal to hyaline border, dorsal pits present; female urosome divided into anterior and posterior lobes by notch or notch and cleft, anterior lobe with lateral patch of horizontal striations, posterior lobe narrow, pointed posteriorly, bordered with fine setules, caudal arch of urosome deep, encloses greater part of caudal rami; caudal rami rectangular, may widen posteriorly, terminal border straight, not emarginate,  $\alpha$  &  $\beta$  setae not close together ( $L/(\alpha - \beta) < 5$ ),  $\gamma$  seta inserted on terminal border, terminal setae 1 to 4 all alike, pinnately lanceolate, equally spaced, 2 & 3 not close; male antennule without ventral blade or anterior comb, coupling denticles reduced in size; first seta on male mandibular palp slender; maxillule endopod with 6 setae, exopod with one or two setae; maxilliped basis with fimbriate process, coxal lobe rounded, fimbriate; P1 peg field absent or very small; male P2 terminal article with 3 setae (2 plumose + 1 spinous; P2 = 1:2:s, 2, 0); male P5 with 6 terminal setae; female P5 lanceolate, P5's extend beyond urosome but do not touch one another posteriorly.

*Remarks.* The genus is clearly defined by the evenly spaced pinnately lanceolate terminal setae of caudal rami, the striated lateral patch on the urosome and the presence of 3 setae on the terminal article of the male's P2. Four species previously assigned to *Porcellidium* (*P. clavigerum* PESTA, 1935; *P. echinophilum* HUMES et GELERMAN, 1962; *P. laurencium* HICKS, 1982; and *P. ulvum* HICKS, 1982) exhibit these characters and are removed to the genus *Clavigofera*.

The generic name *Clavigofera* (gender feminine) refers to the shape of caudal

setae on PESTA's species (*L. clava* = a club + *fero* = to bear or carry).

*Species composition.* *Clavigofera pacifica* n. sp., (designated type species). Other species are, *Clavigofera clavigera* (PESTA, 1935); *C. echinophila* (HUMES et GELEMAN, 1962); *C. laurencia* (HICKS, 1982); and *C. ulva* (HICKS, 1982). The genus *Clavigofera* is represented in the Indian Ocean (South Africa and Madagascar) and the Pacific Ocean (Japan, Hawaii and E. Australia).

*Clavigofera pacifica* n. sp.

(Figs. 1-2)

*Type material.* Holotype, recently metamorphosed adult female without egg mass, NSMT-Cr 11950, length 0.58 mm. Allotype, adult male, NSMT-Cr 11951, length 0.45 mm. Paratype specimens: 12 ♀ + 10 ♂ plus juvenile stages, NSMT-Cr 11952; slide (1446, 2 ♀ + 1 ♂), NSMT-Cr 11953; 4 ♀ + 3 ♂ plus juvenile stages and slide (1447), BMNH 1996.960-969; 3 ♀ + 2 ♂ and slide (1450), AMS; 3 ♀ + 2 ♂, NMNZ.

Type population from *Sargassum sagamianum* var. *yezoense*, Station 3, sample numbers 3-2 & 3-4, Kadonohama Bay, Ofunato, Iwate Prefecture, Japan, collected by N. IWASAKI, 5.10.93.

*Diagnosis.* Adult female. Colourless or very pale yellow; mean length 0.58 mm, rostrum width 0.07 mm, cephalosome width to rostrum ratio 5.6; urosome with lateral notch, cleft not open; alpha seta located about half way down caudal ramus ( $\alpha/L\% = 52\%$ ); small triangular patch of denticles on endopod of P1, P3 terminal seta much longer than endopod (1.5:1).

Adult male. Ventral seta on first segment of antennule not plumose,  $\delta$  seta on compound segment shorter than antennule (not whip-like).

*Dimensions.* Females. Mean length 0.58 mm (S.D. = 0.013, N = 26), cephalosome width 0.37 mm (S.D. = 0.013, N = 26). body length to width ratio 1.54. Rostrum 0.07 mm wide, body width to rostrum ratio 5.6. Urosome width to length ratio 1.25. Caudal ramus length to width (maximum) ratio 2.2. Position of  $\alpha$  seta,  $\alpha/L\% = 52.3\%$  (see Fig. 1E).

Males. Mean length 0.42 mm (S.D. = 0.01, N = 16), cephalosome length 0.24 mm, width 0.31 mm (S.D. = 0.008, N = 16), body length to width ratio 1.33.

*Description.* Adult female (Fig. 1A). Pale yellow or colourless. Anterior of cephalosome rounded (not semicircular), slightly truncated. Rostrum prominent, narrow relative to width of body, projects about 1/3 of its width (Fig. 2C). Hyaline border 10  $\mu$ m wide. Dorsal pits 5-6  $\mu$ m.

Urosome anterior lobe with characteristic lateral patch of striations on the ventral side (Fig. 1C, D), posterior lobe narrow, straight sided, bordered with fine setules, apex acutely pointed; lateral notch, cleft not open. Caudal arch deep (about 2/3 length of urosome).

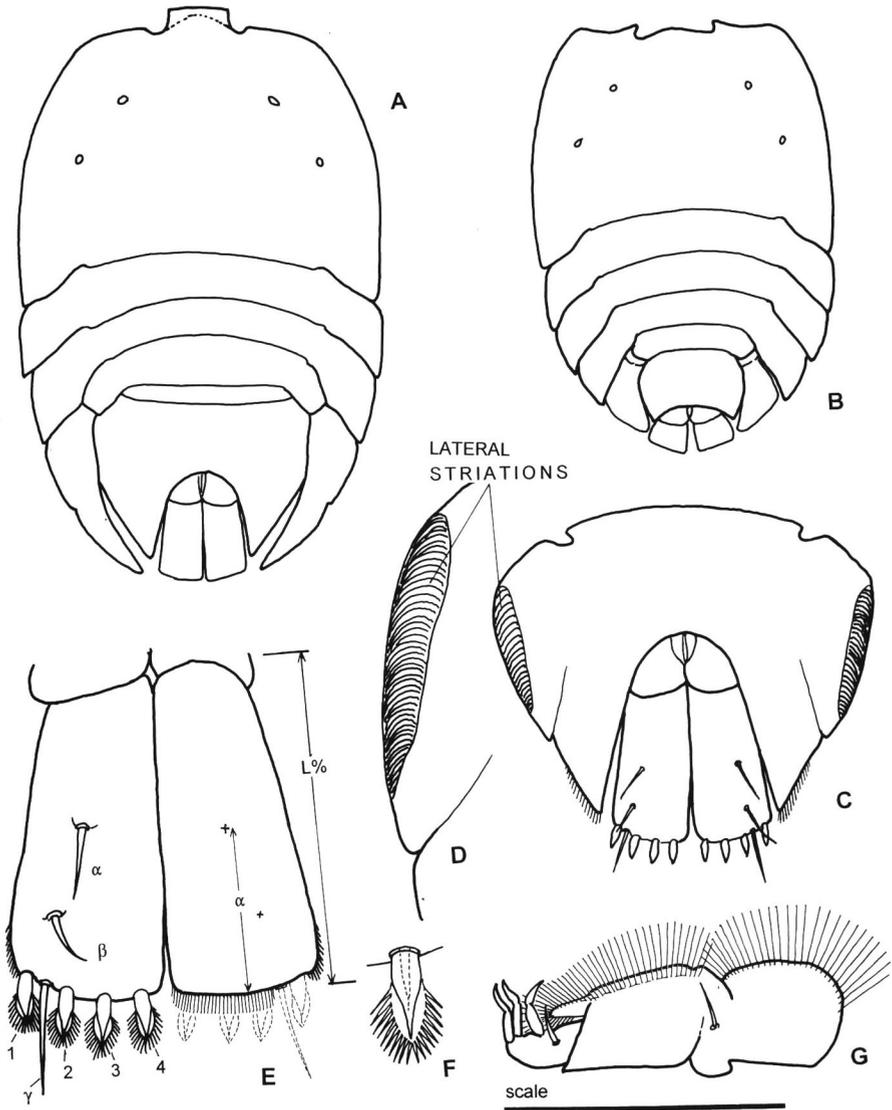


Fig. 1. *Clavigofera pacifica*. A. Adult female. B. Adult male. C. Female urosome and caudal rami. D. Detail of lateral striations and cleft. E. Caudal rami. F. Detail of terminal caudal setae. G. Maxilliped. Scale bar: A, B=0.3 mm; C=0.19 mm; D, E=0.082 mm; G=0.06 mm.

Caudal rami rectangular (Fig. 1E), widen distally, not emarginate,  $\alpha$  seta about half way,  $\beta$  about 3/4 way down ramus, terminal setae pinnately lanceolate (Fig. 1F), all the same size, equally spaced, 2 & 3 not close together, terminal

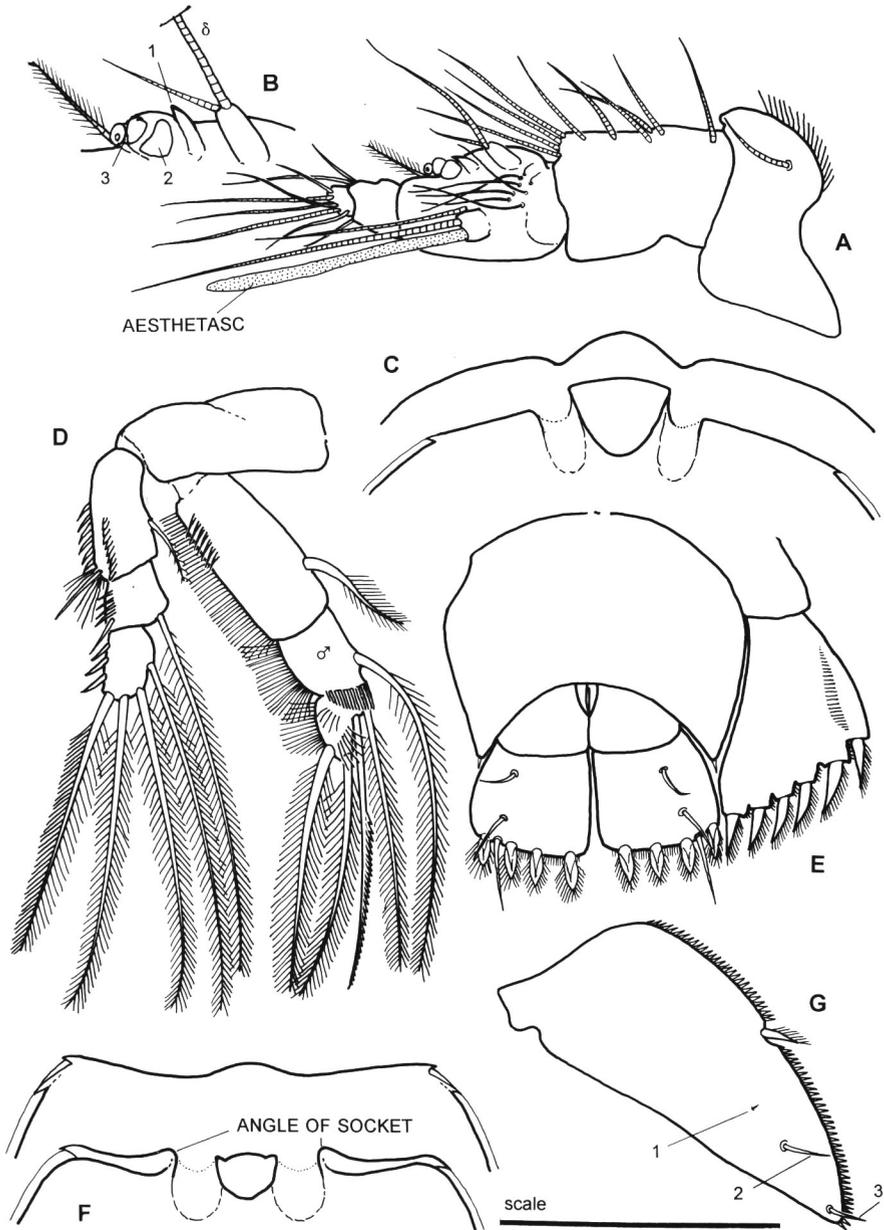


Fig. 2. *Clavigofera pacifica*. A. Male right antennule, ventral view. B. Detail of coupling denticles. C. Anterior edge of female cephalosome, dorsal and ventral focus. D. Male P2. E. Male urosome, P5 and caudal rami. F. Anterior edge of male cephalosome. G. Female P5, dorsal. Scale bar: A=0.06 mm; C, F=0.19 mm; D=0.082; E=0.1 mm; G=0.135 mm.

fringe of fine setules present.

Limbs typical of family. Geniculate setae of antenna articulate, claw comb-like. Maxillule exopod with single bulbous seta. First article of P1 exopod with plain ridge parallel to edge, no denticles on ridge, small triangular patch of denticles at the lateral extremity of fimbriate crescent on endopod, P2 endopod with serrulate spinous seta + 3 plumose setae on distal article. Sabre-like spinous seta on distal article of P3 endopod much longer than endopod (1.5:1). P5 lanceolate, first dorsal seta very small or absent, 2 & 3 long, equal in size, apical seta small (Fig. 2G), apex of P5s reach beyond posterior lobe of urosome.

Adult male (Fig. 1B). Colour, hyaline border and dorsal pits as for female. Anterior of cephalosome truncated, lateral angle of antennule sockets visible from above, shoulders rounded (Fig. 2F).

Caudal rami quadrate ( $L/w=1$ ), setation as for female (Fig. 2E).

Antennule (Fig. 2A). Seta on first article not plumose, compound segment smaller than segment 2, dactyl (terminal segments) short. Coupling denticles small, rounded, without serrated edge or denticulation (Fig. 2B). P2 with serrulate spinous seta + 2 plumose setae on terminal article of endopod (Fig. 2D).

*Remarks.* An analysis of the 'clavigerum complex' will be given in the Discussion.

*Distribution and abundance.* *Clavigofera pacifica* shows a marked preference for *Sargassum sagamianum* var. *yezoense*, but small populations were found on *Undaria pinnatifida*. Ninety six per cent of adult animals were found on these two seaweeds. Isolated individuals have been found on *Laminaria religiosa*, *Grateloupia carnosa* and *Zostera marina*.

#### Genus *Kushia* n. gen.

*Diagnosis.* Anterior of female cephalosome semicircular, rostrum projects beyond cephalosome; anterior of male truncated; hyaline border and dorsal pits present; urosome broad, not divided into anterior and posterior lobes, caudal rami included in caudal arch of urosome; caudal rami with external corner strongly bevelled, terminal border (between setae 2 & 4) at right angles to medial edge of ramus,  $\alpha$  &  $\beta$  setae close together ( $L/(\alpha-\beta) \geq 5$ ),  $\gamma$  inserted on ventral side of ramus along bevelled edge, terminal setae 2 & 3 close together; male antennule with conspicuous comb which projects forward from anterior edge of compound segment, comb is attached to the accessory lobe, ventral blade absent; first seta on mandibular palp slender; maxillule with six setae on endopod, one seta on exopod (Fig. 4G); maxilliped basis with fimbriate process, fimbriate rounded coxal lobe (Fig. 4H); P1 without peg field on endopod; male P2 endopod with two plumose terminal setae (P2 = 1:2:0, 2, 0); male P5 with 6 terminal setae; female P5 with wide ventral expansion, P5s extends beyond urosome to touch bevelled edge of

caudal ramus, but do not touch one another posteriorly.

*Species composition.* *Kushia zosteraphila* n. sp., (designated the type species); *K. gamoi* n. sp.; *K. igaguria* n. sp.

*Remarks.* This genus is characterised by three unique features. 1) A wide leaf-like ventral expansion of the female P5 that lies under the lateral edge of the urosome (see Fig. 3D, E). 2) The insertion of  $\gamma$  seta on the ventral side along the bevelled lateral edge of the caudal ramus. 3) A conspicuous comb on the accessory lobe that projects forward from the compound segment of the male's antennule. The conspicuous horn-like proximal coupling denticle on the male antennule of *Porcellidium akashimum* (HARRIS and IWASAKI, 1996) is not the same structure as the anterior comb of *Kushia*. Although they look similar, the anterior comb of *Kushia* is part of the accessory lobe. The generic name *Kushia* (gender feminine) refers to this unusual structure which resembles a type of comb used by Japanese ladies to adorn their hair when they wear a kimono (Japanese, *kushi* = a comb).

The genus is known from Japan and E. Australia.

*Kushia zosteraphila* n. sp.

(Figs. 3, 6A–B, 7C–D)

*Type material.* Holotype, adult female with egg mass removed, NSMT-Cr 11954, length 0.88 mm. Allotype, adult male, NSMT-Cr 11955, length 0.74 mm. Paratype specimens: 12 ♀ + 10 ♂ plus juvenile stages, NSMT-Cr 11956, slides (1444, 1 ♂; 1445, 2 ♀ + 1 ♂), NSMT-Cr 11957; 3 ♀ + 3 ♂ and slide (1442), BMNH 1996.970–977; 2 ♀ + 2 ♂ and slide (1441), AMS; 2 ♀ + 2 ♂, NMNZ.

Type population from *Zostera marina*, Station 2, sample number 2–3, Kado-nohama Bay, Ofunato, Iwate Prefecture, Japan, collected by N. IWASAKI, 5.10.93.

*Diagnosis.* Adult female. Pale brown, 4 transverse bands of dark red-brown at joints between cephalosome, metasome segments and urosome; mean length 0.93 mm, rostrum width 0.13 mm, cephalosome width to rostrum ratio 4.4; lateral edge of urosome convex, not bordered with setules, posterior apex not pointed; caudal rami expand posteriorly (maximum width about 1/2 way down ramus), length to width ratio < 2, posterior-lateral corner strongly bevelled, terminal edge at right angles to medial edge,  $\alpha$  &  $\beta$  setae close together ( $L/(\alpha - \beta) = 5$ ),  $\gamma$  inserted ventrally on bevelled edge, terminal setae pinnate, seta 1 small close to  $\gamma$ , 2 & 3 close together, cross over one another; first dorsal seta on P5 as large as second and third setae.

Adult male. Colouration as for female; mean length 0.76 mm; antennule dactyl bent (~-shaped), proximal coupling denticle flat with double comb-like edge (not echiniform), distal denticle very small.

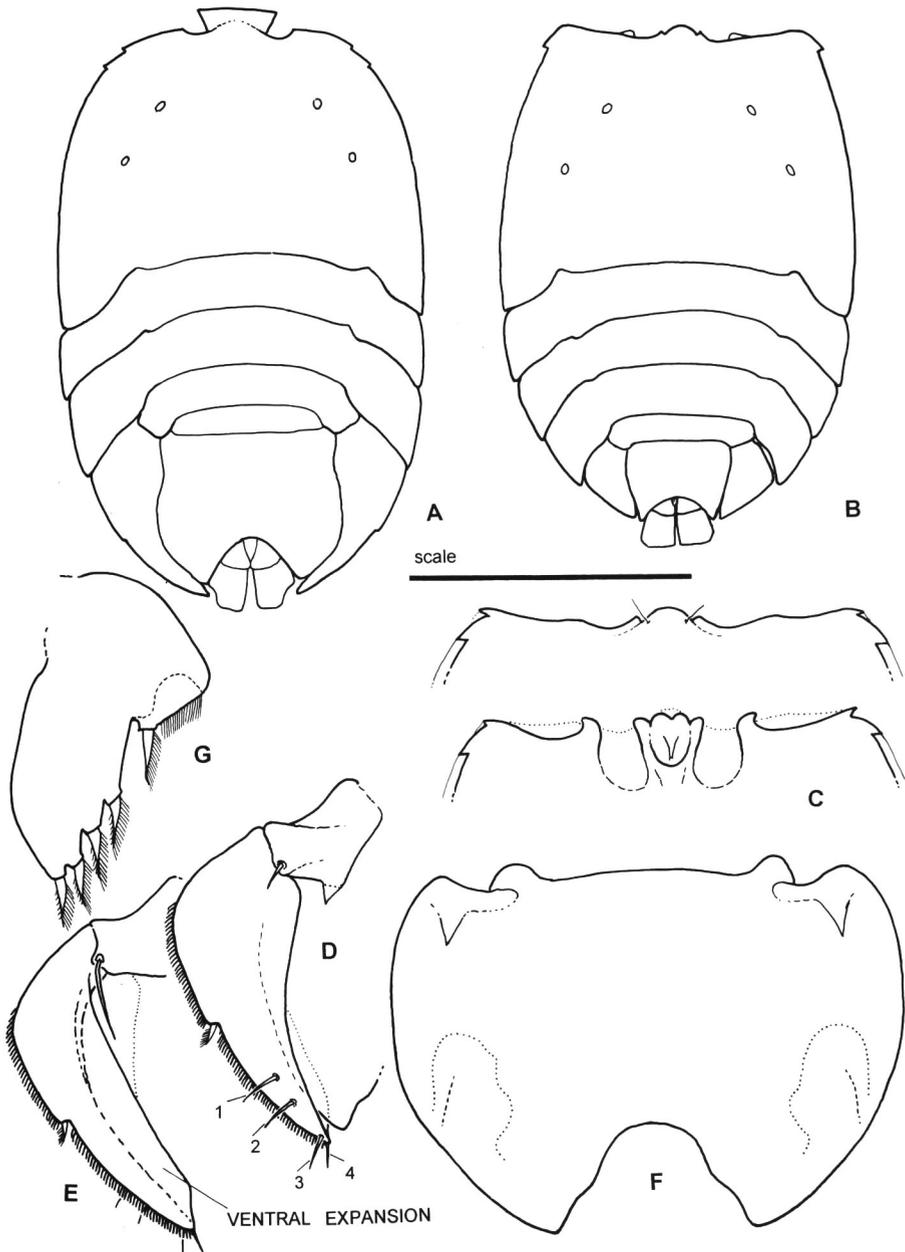


Fig. 3. *Kushia zosteraphila*. A. Female. B. Male. C. Anterior border of male cephalosome, dorsal and ventral focus. D, E. Female P5. F. Female urosome. G. Stage V juvenile female, P5. Scale bar: A, B=0.45 mm; C, D, E=0.3 mm; F=0.19 mm; G=0.135 mm.

*Dimensions.* Females. Mean length 0.93 mm (S.D.=0.037, N=23), cephalosome width 0.6 mm (S.D.=0.026, N=23), body length to width ratio 1.55. Rostrum 0.135 mm wide, body width to rostrum ratio 4.4. Urosome width to length ratio 1.4. Caudal ramus length to width (maximum) ratio 1.9.

Males. Mean length 0.76 mm (S.D.=0.035, N=22), cephalosome length 0.46 mm, width 0.54 mm (S.D.=0.024, N=22), body length to width ratio 1.4.

*Description.* Adult female (Fig. 3A). Colouration, pale yellow-brown, the anterior and posterior edge of the cephalosome, and the posterior edge of metasome segments 1, 2 and 3 are coloured dark red-brown. This gives the impression of four bands round the body. The internal (sternal) edge of the cephalosome, trabeculae and P5 may also be dark red-brown. Anterior of cephalosome slightly truncated from semicircle, sides of body (cephalosome + metasomal segments) almost parallel. Rostrum prominent, projects about 1/3 of its width. Hyaline border and dorsal pits present.

Urosome broad, almost semicircular in outline, lateral edge convex, apices not pointed, lateral border without setules; caudal arch 1/3 length of urosome (Fig. 3F). No evidence of division into anterior and posterior lobes but a clear (non-pigmented) area may indicate region of fusion.

Caudal ramus (Fig. 6A) widens posteriorly reaching maximum width a little more than half way down ramus, it then narrows giving a strongly bevelled external corner, border setules do not pass onto ventral side of ramus, terminal border (between setae 2 & 4) at right angles to medial edge, fringed with fine setules ventrally;  $\alpha$  &  $\beta$  setae close ( $L/(\alpha-\beta)=5$ ),  $\gamma$  seta inserted ventrally 2/3 along bevelled edge (Fig. 6B), terminal setae pinnate, seta 1 small on bevelled edge, setae 2 & 3 close together, seta 3 thin, crosses seta 2, seta 4 set in from medial corner of ramus.

Limbs typical of family. Antenna, terminal portion of geniculate setae on endopod plain, claw comb-like. First peraeopod P1 with small triangular patch of pegs at lateral end of fimbriate crescent. Sabre-like spinous seta on P3 endopod much longer than endopod (1.5:1). Coxa-basis of P5 with proximal V-shaped process that lies ventral to urosome (Fig. 3D), distal article of P5 falciform with ventral expansion which lies ventral to edge of urosome (Fig. 3E), first dorsal seta prominent, as large as second dorsal seta. Stage V female copepodites have four unipinnate postero-lateral setae on P5 (Fig. 3G).

Adult male (Fig. 3B). Colouration as for female except that P5 is not red-brown. Anterior edge of cephalosome strongly truncated, shoulders sharply angular with 'epaulet', lateral angle of antennule socket visible from dorsal view (Fig. 3C).

Caudal rami quadrate ( $L/w=1$ ), without bevelled lateral edge,  $\gamma$  seta inserted on terminal border.

Antennule (Fig. 7C) dactyl (terminal segment) bent ( $\sim$ -shaped), ratio of

body length to dactyl 9.4, comb on accessory lobe 0.036 mm long, proximal coupling denticle flat with double serrated edge (not echiniform), distal denticle very small with serrations. P5 with conspicuous row of ventral setules (more than 12).

*Remarks.* *Kushia zosterophila* is uniquely associated with the marine vascular plant, *Zostera marina* after which it has been named. This species could be confused with the closely related *K. gamoi* or *K. igaguria* but is easily identified by 4 distinct colour bands across its body, its size and the first dorsal seta on female's P5 which is as long as the second seta (Fig. 3D). Its colouration could lead to confusion with *Porcellidium ofunatense* which has 4 orange-brown bands between segments (HARRIS and IWASAKI, 1996), but the male of *P. ofunatense* lacks a projecting comb on its antennule and the female P5s do not reach to the caudal rami.

*Distribution and abundance.* Sample 2-3 taken from *Zostera marina* contained 408 adult and juvenile specimens of *K. zosterophila*. This species has not been found on any other seaweed sampled at Kadonohama Bay. The geographical distribution of *K. zosterophila* has not been determined.

***Kushia gamoi* n. sp.**

(Figs. 4, 6C-D, 7A-B)

*Porcellidium* sp., GAMÔ, 1969, p. 345-349.

*Type material.* Holotype, adult female with egg mass removed, NSMT-Cr 11958, length 0.66 mm. Allotype, adult male, NSMT-Cr 11959, length 0.54 mm. Paratype specimens: 4 ♀ + 4 ♂, NSMT-CR11960, slide (1438, 2 ♀ + 1 ♂), NSMT-Cr 11961; 4 ♀ + 3 ♂ and slide (1439), BMNH 1996.978-987; 2 ♀ + 2 ♂ and slide (1461), AMS; 2 ♀ + 2 ♂, NMNZ.

Type material from *Sargassum sagamianum* var. *yezoense*, Station 3, sample number 3-2 and *Undaria pinnatifida*, Station 5, sample number 5'-5, Kadonohama Bay, Ofunato, Iwate Prefecture, Japan, collected by N. IWASAKI, 6.10.93.

*Diagnosis.* Adult female. Uniform red-brown; mean length 6.4 mm, rostrum width 0.085 mm, ratio of cephalosome width to rostrum 4.8; lateral border of urosome almost straight with border of very fine setules, posterior apex pointed; sides of caudal ramus almost parallel, external corner bevelled, length to width ratio  $> 2$ ,  $\alpha$  &  $\beta$  setae close ( $L/(\alpha - \beta) = 5.7$ ),  $\gamma$  seta inserted about 2/3 down bevelled edge, terminal setae pinnate, seta 1 1/3 along bevelled edge, 2 & 3 close together; first dorsal seta on P5 much smaller than second seta.

Adult male. Colouration as for female; mean length 0.52 mm; antennule dactyl straight, proximal coupling denticle with double serrated edge (not echiniform).

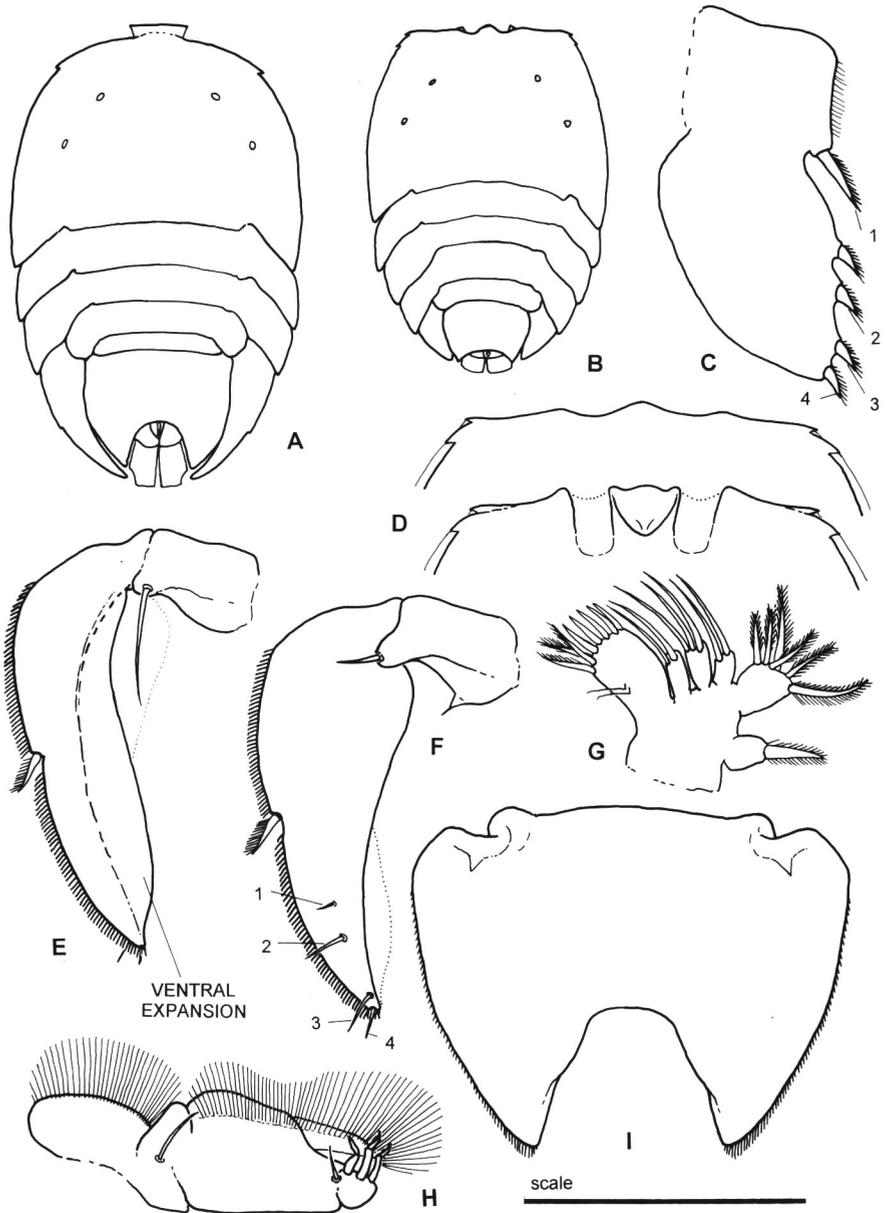


Fig. 4. *Kushia gamoi*. A. Female. B. Male. C. P5 of female stage V juvenile. D. Anterior border of male cephalosoma, dorsal and ventral focus. E, F. Female P5, ventral and dorsal view. G. Maxillule. H. Maxilliped. I. Female urosome. Scale bar: A, B=0.45 mm; C, E, F, H=0.1 mm; D=0.225 mm; G=0.082 mm; I=0.15 mm.

*Dimensions.* Females. Mean length 0.64 mm (S.D.=0.008, N=20), cephalosome width 0.41 mm (S.D.=0.015, N=20), body length to width ratio 1.56. Rostrum 0.086 mm wide (S.D.=0.002, N=20), body width to rostrum ratio 4.8. Urosome width to length ratio 1.3. Caudal ramus length to width ratio 2.2.

Males. Mean length 0.52 mm (S.D.=0.015, N=17), cephalosome length 0.32 mm, width 0.38 mm (S.D.=0.006, N=17), body length to width ratio 1.4.

*Description.* Adult female (Fig. 4A). Colouration, uniform red-brown, no distinct transverse bands of colour. Anterior of cephalosome semicircular. Rostrum projects 1/3 of its width. Hyaline border and dorsal pits present.

Urosome broad (Fig. 4I), lateral edges slightly convex (almost straight), bordered with fine setules, apices bluntly pointed, caudal arch slightly more than 1/3 length of urosome.

Caudal ramus sides almost parallel for 2/3 their length (Fig. 6C), external corner bevelled, terminal border at right angles to medial edge, terminal fringe of fine setules ventrally;  $\alpha$  &  $\beta$  setae close together ( $L/(\alpha-\beta)=5.7$ ), seta 1 inserted 1/3 and  $\gamma$  seta 2/3 along ventral side of bevelled edge, terminal setae pinnate, 2 & 3 close together, seta 3 thin, crosses seta 2, seta 4 set in from medial corner (Fig. 6D).

Limbs typical of family. Antenna, terminal portion of geniculate setae on endopod articulate, plain, claw comb-like. First pereopod P1 with small triangular patch of pegs at lateral end of fimbriate crescent. Sabre-like spinous seta on P 3 endopod much longer than endopod (1.6:1). Coxa-basis of P5 with proximal V-shaped process that lies ventral to urosome (Fig. 4F), distal article of P5 falciform with ventral expansion which lies ventral to edge of urosome (Fig. 4E), first dorsal seta much smaller than second dorsal seta (Fig. 4F).

Adult male (Fig. 4B). Colouration as for female. Anterior edge of cephalosome truncated, shoulders sharply rounded (Fig. 4D).

Caudal rami sub-quadrangle ( $L/w=0.8$ ), no bevelled lateral corner,  $\gamma$  seta inserted on terminal border.

Antennule dactyl straight (Fig. 7A), ratio of body length to dactyl 10.6; proximal and medial coupling denticles with double comb-like edge, not echini-form, distal denticle very small (Fig. 7B). P5 with proximal row of setules (less than 10).

*Remarks.* This species has been named after Dr Sigeo GAMÔ who described a female specimen from Tanabe Bay that fits the above description. He assigned it to the genus *Porcellidium*, but did not give a name to the species (GAMÔ, 1969). His specimen was collected by a bottom net among detritus of brown algae. Features of the male's antennule and the female's caudal ramus, however, exclude this species from the genus *Porcellidium*. It belongs to the genus *Kushia*. *K. gamoi* is readily distinguished from other species of *Kushia* by its size, uniform

red-brown colour and shape of the caudal rami.

*Distribution and abundance.* The geographical distribution of *K. gamoi* has not been determined, but 5 degrees of latitude separate Ofunato and Tanabe. This suggests that this species is widely distributed in temperate waters of Japan. It is abundant on *Grateloupia carnosa* and *Neodilsea yendoana*, but occasionally animals are found on *Laminaria religiosa*, *Undaria pinnatifida* and *Ulva*.

*Kushia igaguria* n. sp.

(Figs. 5, 6E-F, 7E-F)

*Type material.* Holotype, adult female with egg mass removed, NSMT-Cr 11962, length 0.82 mm. Allotype, adult male, NSMT-Cr 11963, length 0.63 mm. Paratype specimens: 2 ♀ + 2 ♂, NSMT-Cr 11964, slide (1457, 1 ♀ + 1 ♂), NSMT-Cr 11965; 1 ♀ + 1 ♂ and slide (1465), BMNH 1996.988-991; 1 ♀ + 1 ♂ and slide (1466), AMS; 1 ♀ + 1 ♂, NMNZ.

Type material from *Sargassum sagamianum* var. *yezoense*, Stations 2 & 3, sample numbers 2-1, 3-2 & 3-4, Kadonohama Bay, Ofunato, Iwate Prefecture, Japan, collected by N. IWASAKI, 5.10.93.

*Diagnosis.* Adult female. Pale yellow-brown, middle of metasomal segments, urosome and caudal rami darker orange-brown; mean length 0.79 mm, rostrum width 0.11 mm, cephalosome width to rostrum ratio 4.5; lateral border of urosome slightly convex, bordered with setules, posterior lobe pointed, apex rounded; caudal ramus length to width ratio < 2, expands posteriorly (maximum width about 2/3 way down ramus), postero-lateral corner bevelled, lateral edge curves under to ventral side bearing setules,  $\gamma$  seta inserted ventro-laterally, terminal edge of ramus at right angles to medial edge,  $\alpha$  &  $\beta$  setae very close together ( $L/(\alpha - \beta) = 8.3$ ), terminal setae pinnate, 1 small, 2 & 3 close together; first dorsal seta on P5 much smaller than second seta.

Adult male. Colouration as for female; mean length 0.66 mm; antennule dactyl straight, proximal coupling denticle echiniform (pad of spinous setules), distal denticle small.

*Dimensions.* Females. Mean length 0.79 mm (S.D. = 0.023, N = 6), cephalosome width 0.52 mm (S.D. = 0.017, N = 6), body length to width ratio 1.52. Rostrum 0.11 mm wide, body width to rostrum ratio 4.7. Urosome width to length ratio 1.4. Caudal ramus length to width (maximum) ratio 1.75.

Males. Mean length 0.66 mm (S.D. = 0.012, N = 5), cephalosome length 0.38 mm, width 0.46 mm (S.D. = 0.006, N = 5), body length to width ratio 1.3.

*Description.* Adult female (Fig. 5A). Colouration, pale yellow-brown, anterior edge of cephalosome dark orange, dorsal part of metasomal segments, urosome and caudal rami darker orange-brown. Some specimens show slight banding, but this is not as obvious as in *Kushia zosterophila*. Anterior of

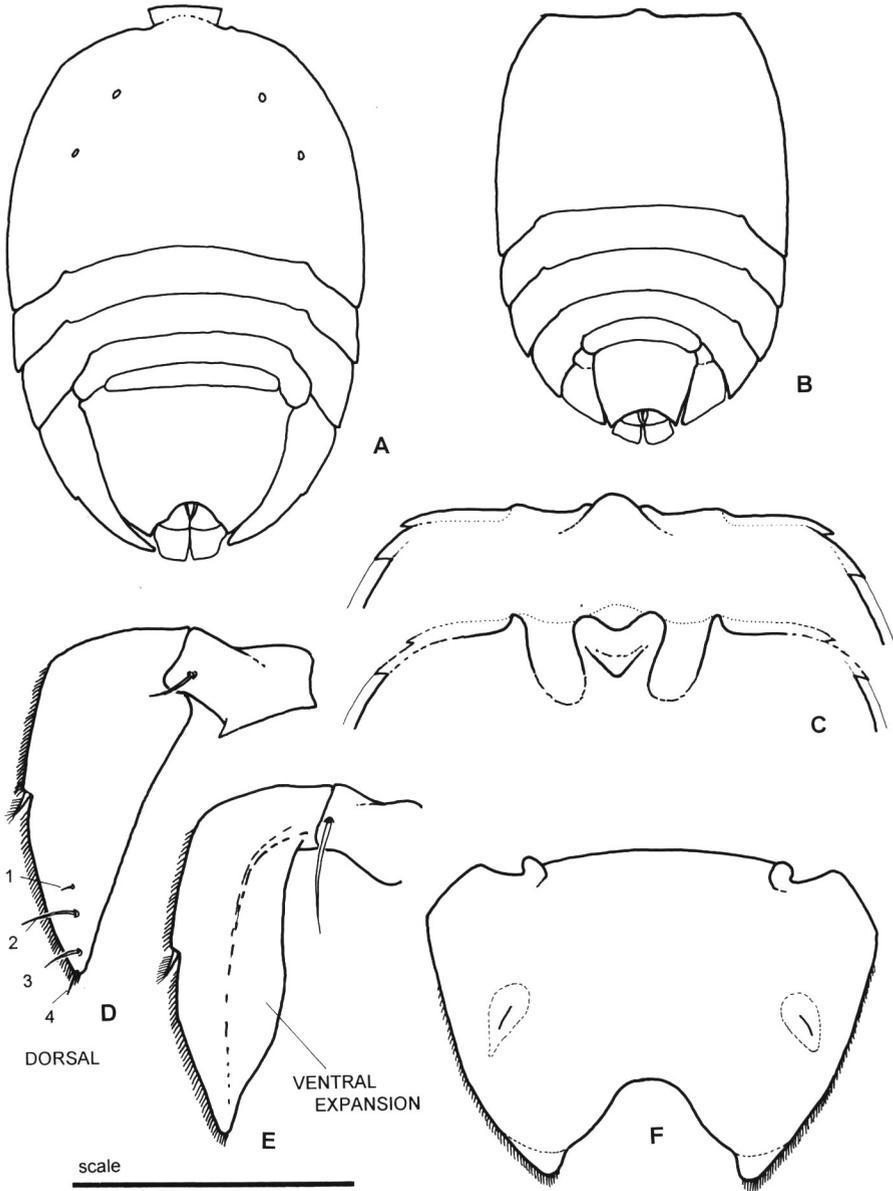


Fig. 5. *Kushia igaguria*. A. Female. B. Male. C. Anterior border of male cephalosoma, dorsal and ventral focus. D, E. Female P5, dorsal and ventral view. F. Female urosome. Scale bar: A, B=0.45 mm; C, D, E=0.225 mm; F=0.19 mm.

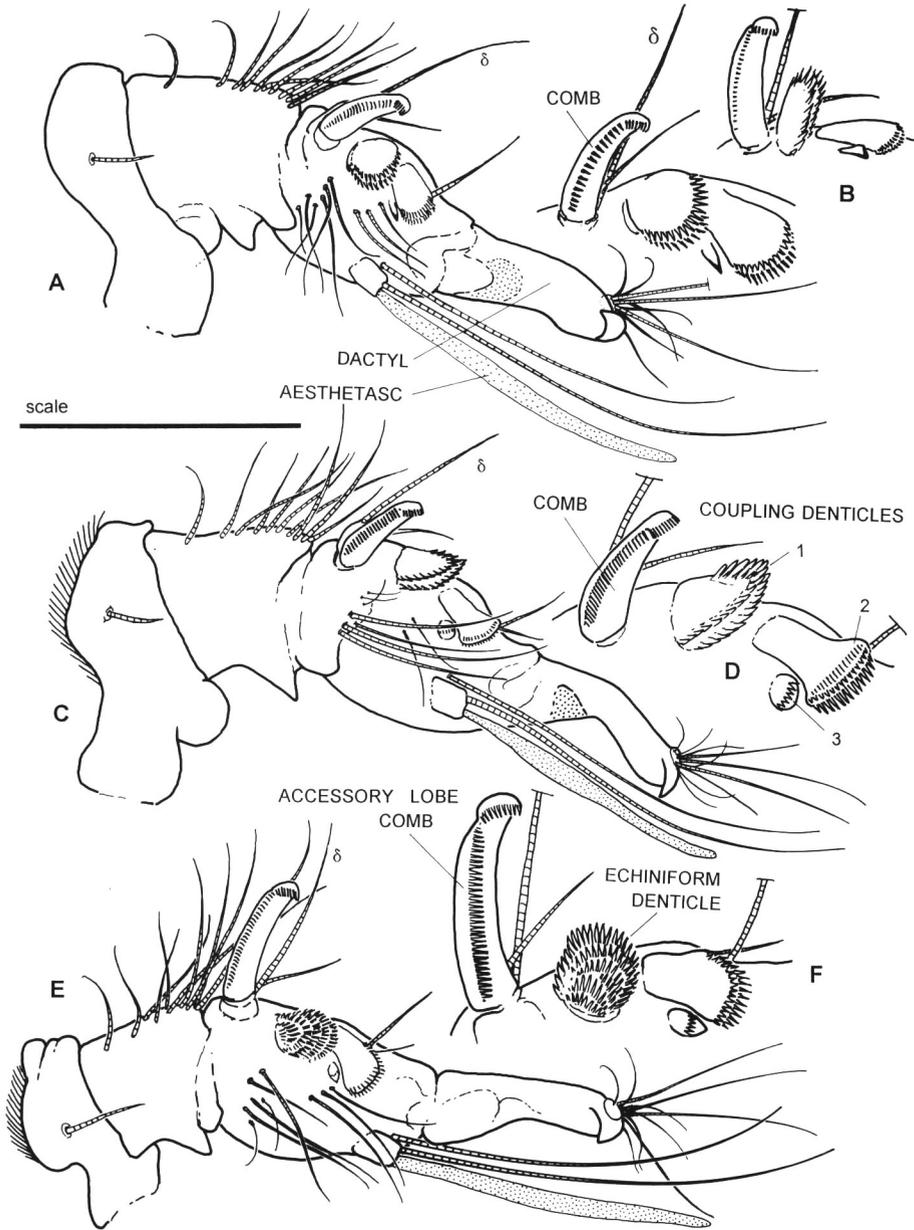


Fig. 6. A–B. *Kushia zosterophila*. A. Caudal rami, left ventral view, right dorsal view. B. Enlarged view of terminal setae. C–D. *Kushia gamoi*. C. Caudal rami, left ventral view, right dorsal view. D. Enlarged view of terminal setae. E–F. *Kushia igaguria*. E. Caudal rami, left ventral view, right dorsal view. F. Enlarged view of terminal setae. Scale bar: A=0.135 mm; B, E=0.1 mm; C, F=0.082 mm; D=0.06 mm.

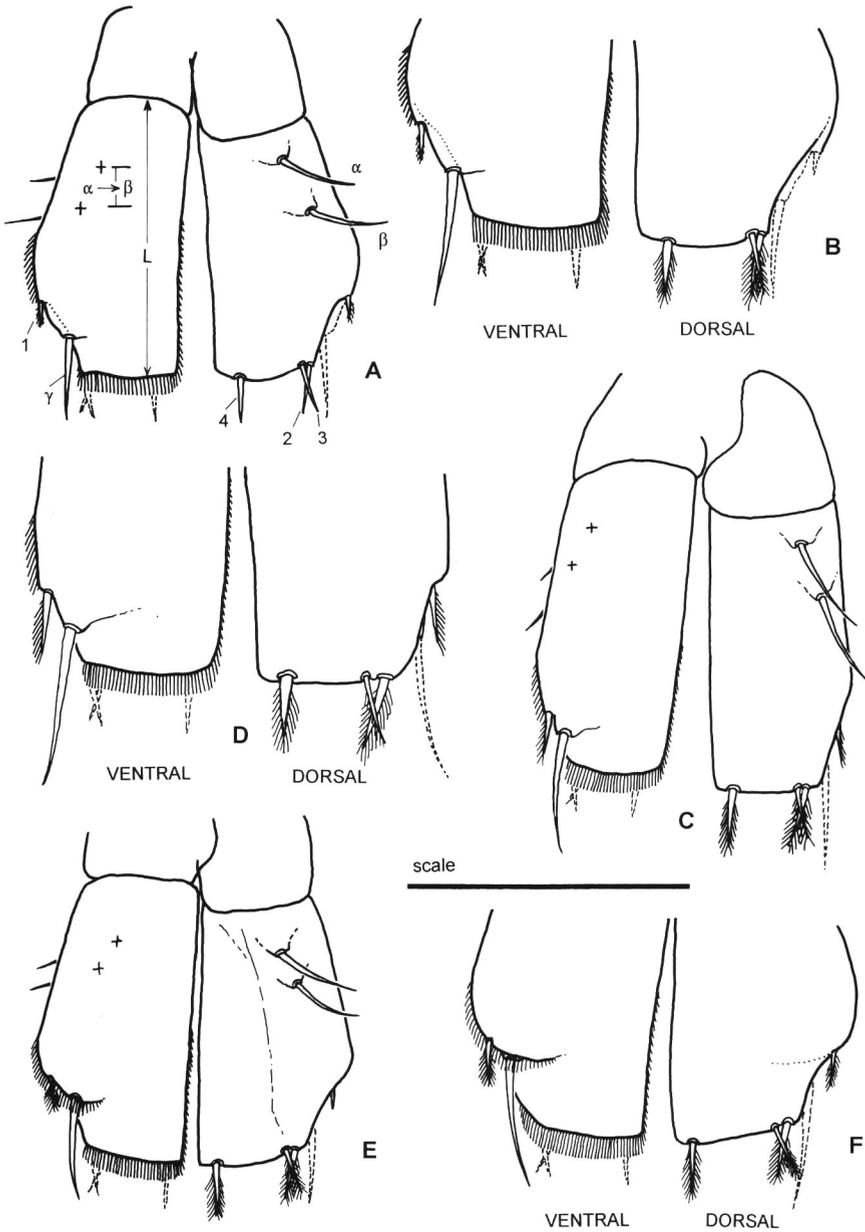


Fig. 7. A-B. *Kuschia gamoi*. A. Male left antennule, ventral view. B. Comb on accessory lobe and coupling denticles, viewed from different angles. C-D. *Kuschia zosterophila*. C. Male left antennule, ventral view showing bent dactyl. D. Accessory comb and coupling denticles. E-F. *Kuschia igaguria*. E. Male left antennule, ventral view. F. Accessory comb and coupling denticles showing echiniform proximal denticle. Scale bar: A=0.082 mm; B, D, F=0.06 mm; C, E=0.1 mm.

cephalosome semicircular, outline of animal ovoid. Rostrum projects 1/4 of its width. Hyaline border and dorsal pits present.

Urosome broad, lateral edges slightly convex, bordered with setules (Fig. 5F), posterior lobe pointed with rounded apex, caudal arch 1/3 length of urosome.

Caudal ramus (Fig. 6E) widens posteriorly reaching maximum width about 2/3 way down ramus, at this point the lateral edge curves round to the under side (ventral) of the ramus, border setules on curved edge pass on to ventral surface of ramus (Fig. 6F), postero-lateral corner bevelled, terminal border at right angles to medial edge, fringed with strong setules;  $\alpha$  &  $\beta$  setae very close together ( $L/(\alpha-\beta)=8.3$ ),  $\gamma$  seta inserted ventrally on curved lateral edge; terminal setae pinnate, seta 1 small, inserted on curved lateral edge, 2 & 3 close together, seta 3 thin, crosses 2, seta 4 set in slightly from medial corner.

Limbs typical of family. Antenna, terminal portion of geniculate setae on endopod articulate, plain, claw comb-like. First pereopod P1 with small triangular patch of pegs at lateral end of fimbriate crescent. Sabre-like spinous seta on P3 endopod much longer than endopod (1.5:1). Coxa-basis of P5 with proximal V-shaped process that lies ventral to urosome (Fig. 5D), distal article of P5 falciform with wide ventral expansion which lies ventral to edge of urosome (Fig. 5E), first dorsal seta much smaller than second dorsal seta (Fig. 5D).

Adult male (Fig. 5B). Colouration as for female. Anterior edge of cephalosome truncated, shoulders rounded (Fig. 5C).

Caudal rami sub-quadrangle ( $L/w=0.8$ ), no bevelled lateral corner,  $\gamma$  seta inserted on terminal border.

Antennule dactyl straight (Fig. 7E), ratio of body length to dactyl 7.6; proximal coupling denticle echiniform (pad of spinous setules), distal denticle small with serrations (Fig. 7F). P5 with short proximal row of setules (less than 7).

*Remarks.* *Kushia igaguria* is characterised by the first (proximal) coupling denticle on the male's antennule. It is a circular pad with several rows of spine-like (echiniform) setules (Fig. 7F). The specific name refers to this feature (Japanese *igaguri*=a chestnut bur). *K. igaguria* is distinguished from other species in the genus by its size, colouration, shape of the urosome and small size of the first dorsal seta on P5.

*Distribution and abundance.* The geographical distribution of this species has not been determined. It has been found in small numbers on *Sargassum sagamianum* var. *yezoense*.

## Discussion

In describing *Porcellidium laurencium* and *P. ulvum*, HICKS (1982) pointed out their close similarity to *P. clavigerum* PESTA and *P. echinophilum* HUMES et

GELERMAN. He considered they formed a natural group within the Porcellidiidae, referred to as the 'clavigerum complex'.

All members of the complex show two characters which separate them from the rest of the species in the genus *Porcellidium*, viz: a conspicuous patch of striations along the edge of the urosome, and four pinnately lanceolate terminal setae on the caudal ramus that are equally spaced and identical in size and shape. This type of terminal seta differs from the slender pinnate seta of other species. The pinnules arise from a clear lateral expansion of the shaft (see Fig. 1F), a feature not found elsewhere in the Porcellidiidae. The clavigerum complex shows one other important character that prevents them being included in the genus *Porcellidium*. The endopod of the male's P2 limb bears three terminal setae; in *Porcellidium* there are only two.

In view of these differences, a new genus, *Clavigofera*, has been defined to take the Japanese species '*pacifica*' and the other members of the clavigerum complex moved to it.

Separation of the species is not easy for they show close morphological similarity. However, they can be separated on biometric data. HICKS (1982) used the position of the  $\alpha$  seta on the caudal ramus ( $\alpha/L\%$ ) to distinguish between the four species. Table 1 compares morphometric data for the clavigerum complex.

*Clavigofera pacifica* is distinguished from *laurencia* on position of the  $\alpha$  seta, and from *ulva* by its size and shorter  $\delta$  seta on the male antennule, but body length and position of the setae on the caudal ramus of *pacifica* and *echinophila* are the same. The question arises, are they synonymous. There are several minor differences which separate them: the seta on the first article of the male antennule is not pinnate in *pacifica*; there is a small patch of denticles on the endopod of P1; the P3 sabre seta/endopod ratio is 1.5:1 for *pacifica* compared with 1.3:1 for *echinophila*; the ventral row of setules on the male P5 is longer in *pacifica*. The

Table 1. Comparison of species within the 'clavigerum' complex (female characteristics).

Species	Body length	length/ width ratio	width/ rostrum ratio	HICKS' <sup>§</sup> ratio for caudal ramus	Substratum
<i>pacifica</i> (Japan)	0.58 mm	1.54	5.6	52.3% <sup>+</sup>	<i>Sargassum</i>
<i>clavigera</i> *	0.48 mm	1.54	? 6.0	67.3%	—
<i>echinophila</i> *	0.57 mm	1.64	5.0	52.3%	sea urchin
<i>laurencia</i> *	0.58 mm	1.67	—	57.7%	<i>Laurencia</i>
<i>ulva</i> *	0.80 mm	1.56	—	62.5%	<i>Ulva</i>

<sup>§</sup> HICKS' ratio =  $\alpha/L \times 100$  (see Fig. 1E and text). \*data from HICKS (1982). <sup>+</sup> N=22, range 48–56%, mean = 52.3%, variance = 6.35. Comparison of mean between species: *pacifica* vs *echinophila* – difference not significant; *pacifica* vs *laurencia* – difference significant (t = 8.059; df 30, P < 0.001).

most compelling reason for regarding them as separate species is their preferred ecological niche. According to HUMES and GELERMAN (1962) *echinophila* lives in association with the sea urchin *Echinometra mathaei* . . . 'attached to branches of the staghorn coral in one metre of water and never exposed at low tide. No algae were seen on the urchin'. In contrast, *Clavigofera pacifica* is abundant on *Sargassum sagamianum* var. *yezoense*, and to a lesser extent *Undaria pinnatifida*, both brown algae.

This difference in ecological niche is sufficient ground for keeping the two species distinct.

Attention has been drawn to the value of the male antennule for taxonomic characters (HICKS, 1982). In describing this organ and the homologies of its setae, HARRIS (1994) has shown that the coupling denticles provide good taxonomic characters at the specific level. Unfortunately these details are usually difficult to see when the antennule is closed in the clasping position, therefore, they are of limited value for species identification. The new genus *Kushia* is an exception, for the comb is clearly visible whether the antennule dactyl is open or closed. This comb is attached to the base of the accessory lobe and associated  $\delta$  seta, it is not one of the coupling denticles. It must not be confused with the curved comb-like claw on the male antennule of *Porcellidium akashimum* which is the first coupling denticle. An undescribed species of *Kushia* is known from northern NSW, Australia.

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