WORKSHOP ON AMPHIPOD IDENTIFICATION

1996

WORKSHOP MANUAL

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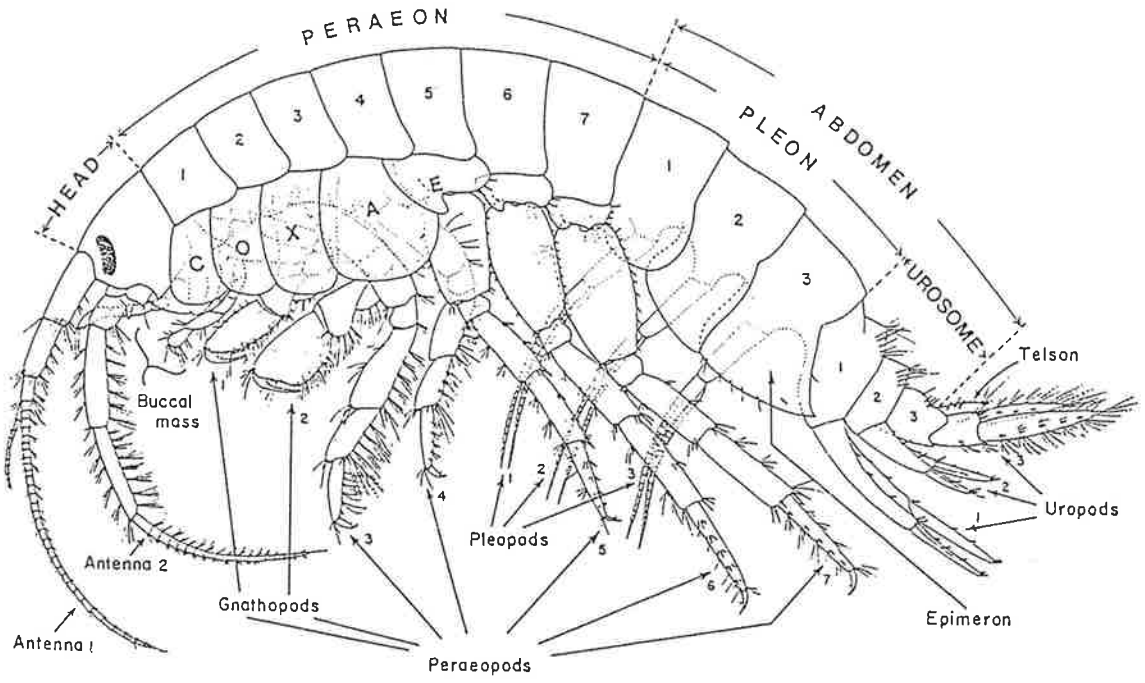
What is an amphipod?

It is a malacostracan crustacean, conforming to the typical malacostracan body plan (6,8,6) in which the first thoracic segment is fused with the head (that segment then bearing the only maxilliped), leaving the thorax - or peraeon - with 7 segments.

The amphipods are amongst those orders of malacostracan crustaceans - Sub-class Peracarida - the females of which carry their eggs in a ventral brood pouch. Some recent authorities have questioned the validity of the peracarid concept. It seems likely now that the Isopoda and Amphipoda are not all that closely related, in spite of the fact that neither of them have a carapace.

Typically (BUT NOT UNIVERSALLY : note *Corophium*) amphipods are flattened side-to-side. This usually (BUT NOT ALWAYS : note *Astacilla*) serves to distinguish them from isopods. However, tanaids may be superficially confused with both groups (although they have a reduced carapace).

The thing to look for as a CERTAIN distinguishing feature of a non caprellidean amphipod is the 3 pairs of uropods. NO OTHER CRUSTACEAN GROUP HAS 3 PAIRS OF UROPODS, but some amphipods lack them.



Basic gammaridean amphipod (lateral view)

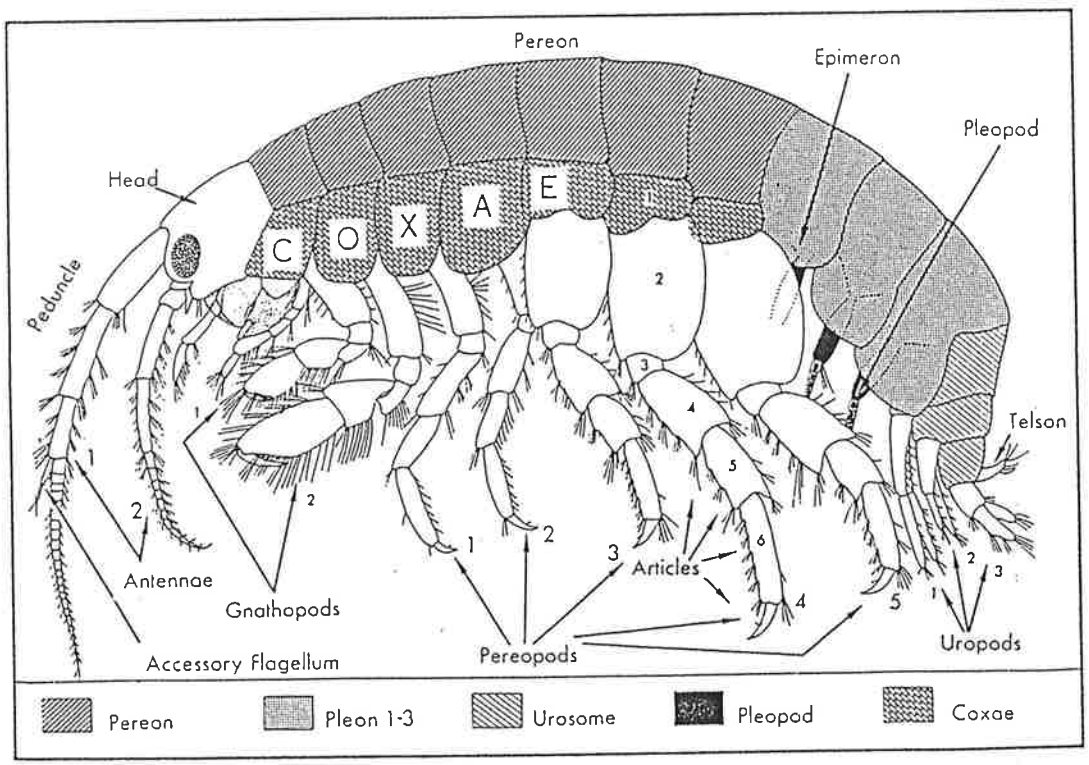
*****!!!!! BEWARE !!!!!*****

Two schemes of peraeopod numbering exist in the amphipod literature

1) Based on the fact that the first 2 pairs of peraeopods are gnathopods, certain authors numbered the remaining thoracic limbs Peraeopods 1-5 (Note Jerry Barnard's early work: see Fig below).

2) Other workers felt that it was more logical and proper that thoracic (peraeon) segment 7 should carry peraeopod 7 and not P5 (see Fig. on previous page)! This has now become the norm and Jerry Barnard's later works conform to this system. Thus thoracic limb numbering goes Gn1, Gn2, P3-7.

Be very careful when looking at keys that you know which system the author is using.



THE 'OLD' PERAEOPOD NUMBERING SYSTEM

13

AMPHIPODA

DEFINITION Carapace absent; eyes sessile; first thoracomere fused to cephalon; antennules typically biramous and well developed; antennae without scales, typically a five-segment peduncle; mouthparts generally arranged in a compact buccal mass; maxillipedes without epipodites, at least partially fused coxae; thoracopods uniramous, second and third typically as subchelate gnathopods, coxae typically expanded into ventrolateral plates, at least some thoracopods with inner branchial epipodites, oöstegite brood pouch; anterior pleomeres usually with well-developed pleura, posterior pleomeres associated as urosome, rami of first three pleopods annulate, last two pleopods uropodiform; telson typically free, often bilobate.

HISTORY Latreille erected the order Amphipoda in 1816 for what we today consider gammarideans. However, even at this early date the whale louse *Cyamus* (Fig. 13-1C) was recognized as distinctive and placed within the isopods. This distinctiveness was eventually formalized with the inclusion of the caprellids (Fig. 13-1B) and the cyamids in the Laemodipoda, a taxon originally treated as equal in status with the Isopoda and Amphipoda. Milne Edwards further distinguished the hyperiids (Fig. 13-1I, J) from the gammarids (Fig. 13-1D, E, F). However, it was Dana who in 1852 erected the three 'traditional' suborders of the amphipods: caprellideans, gammarideans, and hyperiideans; these were later joined by the peculiar ingolfiellideans (Fig. 13-1A) that Hansen erected in 1903. The Amphipoda have never lacked for monographers, and a few of the most recent surveys have been produced for ingolfiellideans (Stock, 1976, 1981), hyperiideans (Bowman and Grüner, 1973), gammarideans (e.g., Barnard, 1969; Bousfield, 1982b; Lincoln, 1979), caprellids (McCain, 1968; Laubitz, 1970, 1976), and cyamids (Leung, 1967).

At one time, Leach united amphipods with isopods into the taxon Edriopthalma. Calman (1909) gave these two groups separate status in his classification of the peracarids, and this separation (reinforced as it was by Siewing's consideration of gut and developmental features) has remained unchallenged until recently by Schram (1981, 1984) who felt the shared derived features of amphipods and isopods justify a return to the use of Edriophthalma.

MORPHOLOGY Though recent taxonomic work on amphipods seems to have resulted in the erection of familial and subfamilial taxa at an increas-

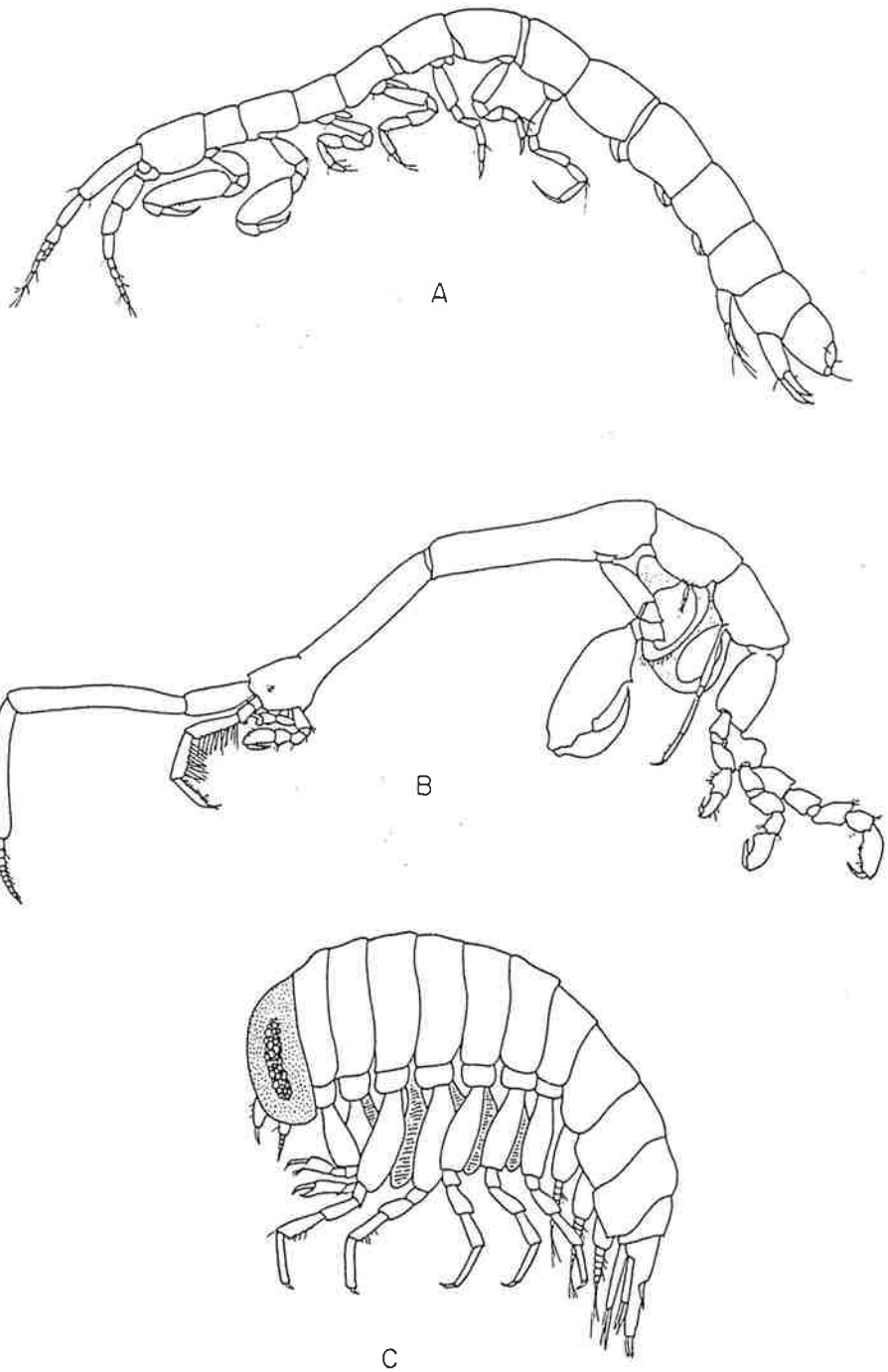
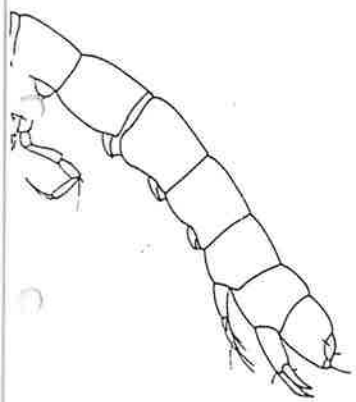
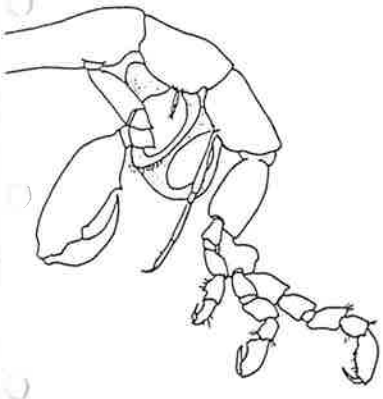
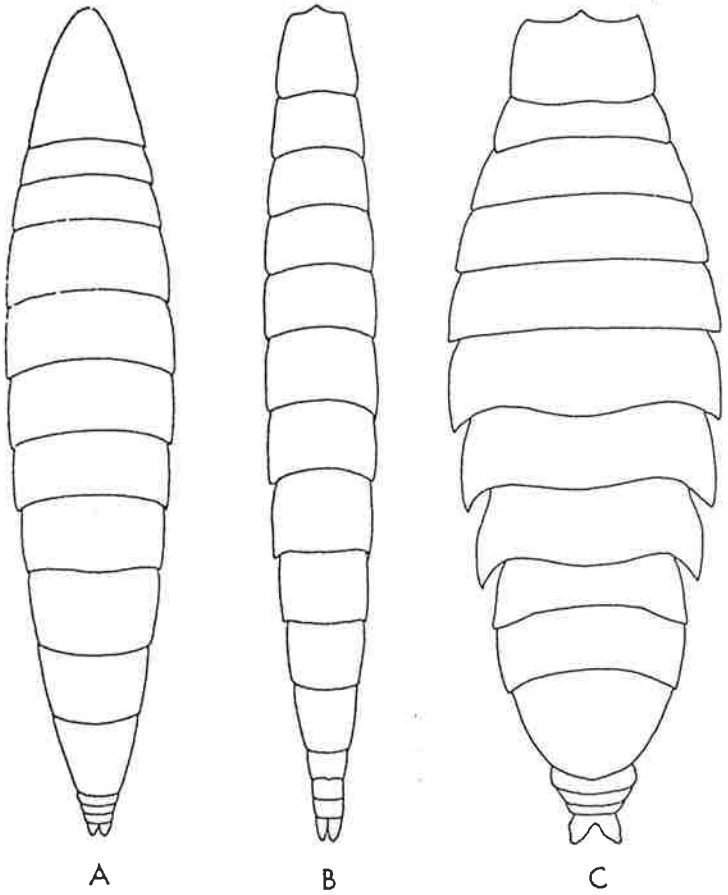


Figure 2 Other amphipod suborders (lateral view)
A—Ingolfiellidea. B—Caprellidea. C—Hyperiidea.

[From Bousfield (1973) Shallow-water gammaridean Amphipoda of New England, Cornell Univ. Press]







Basic gammaridean body outlines (dorsal view)
A—Fusiform. B—Subcylindrical. C—Broad (truncate) fusiform.

Figure 3

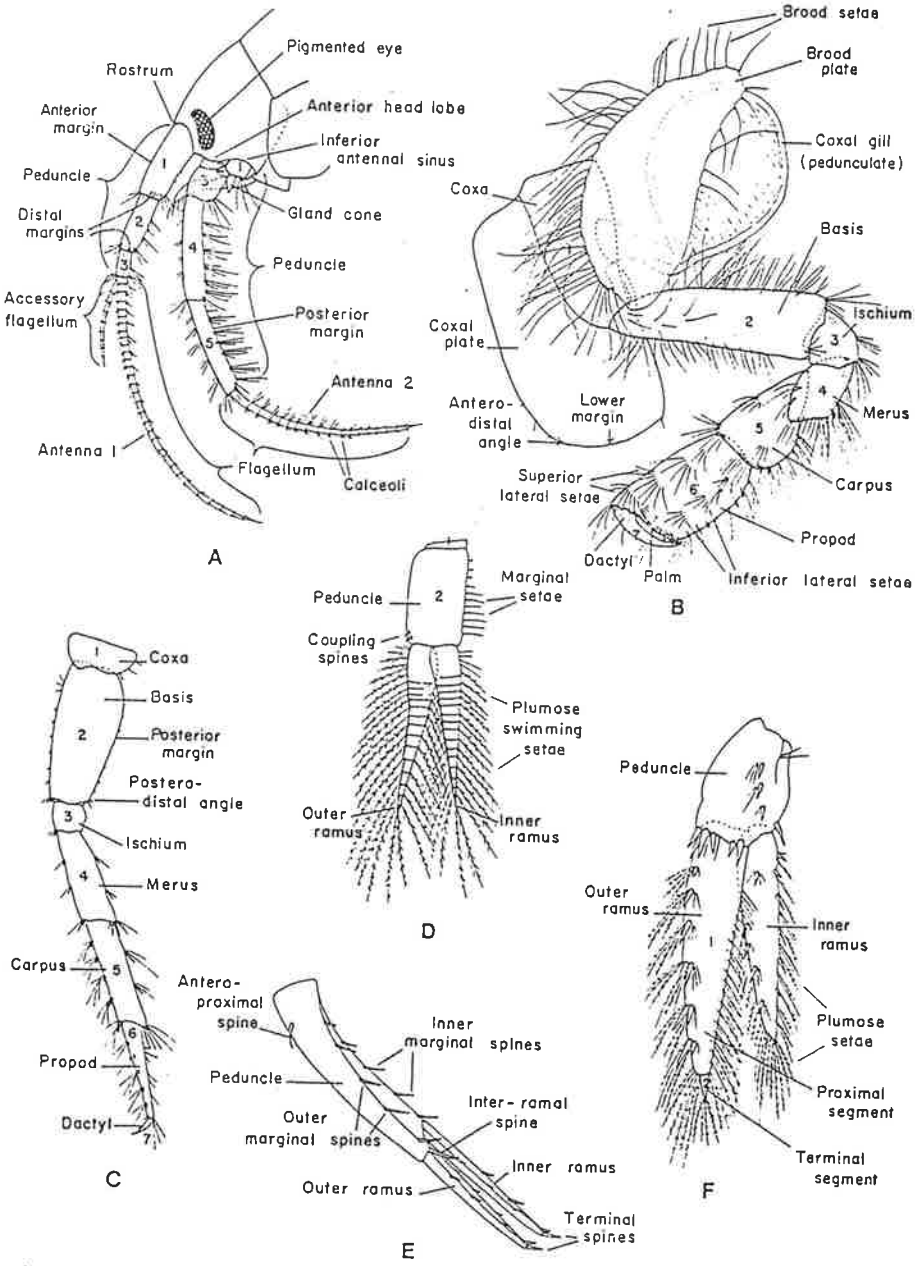
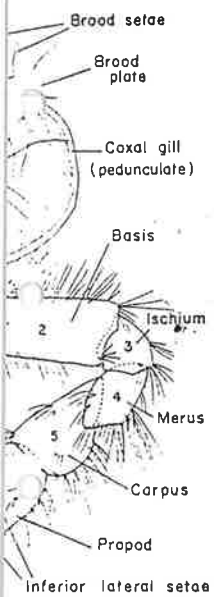
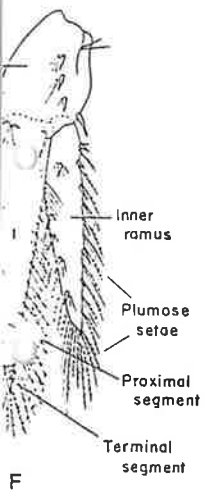


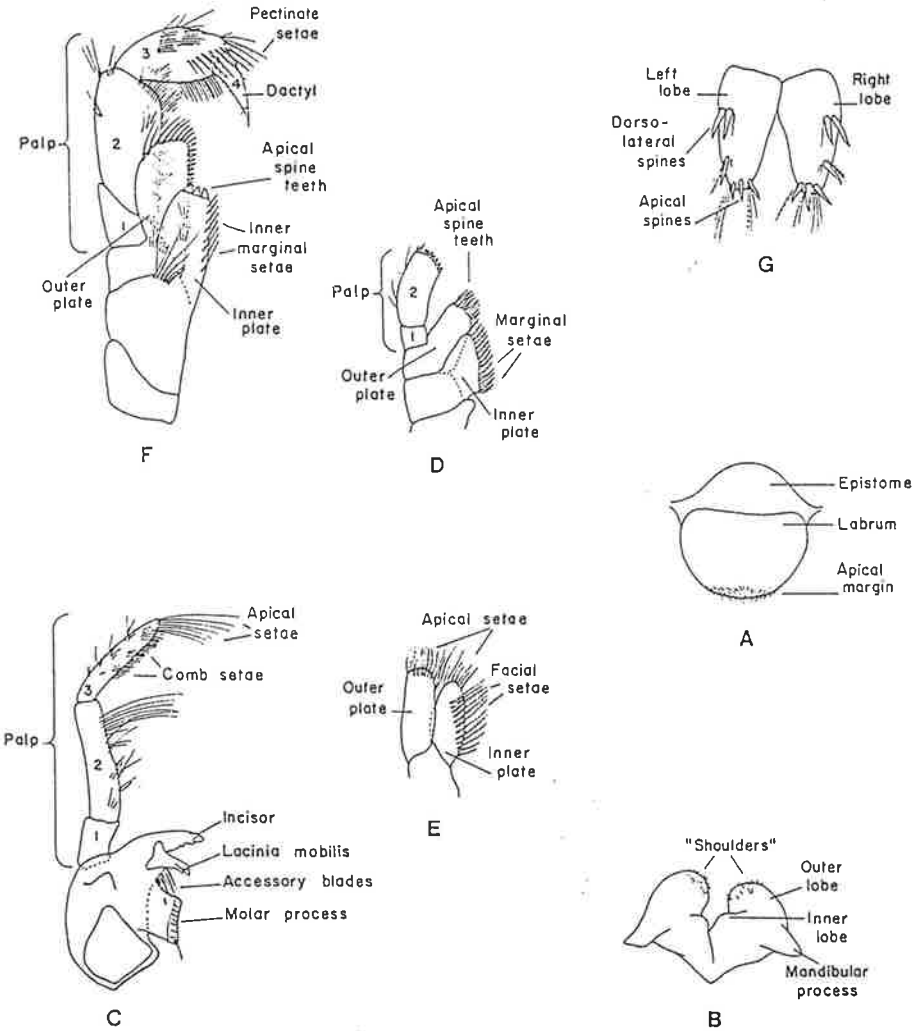
Figure 4 Basic gammaridean body appendages (not to scale)
A—Head region. B—Gnathopod 2. C—Peraeopod 7. D—Pleopod. E—Uropod 1. F—Uropod 3.





F

—Pleopod. E—



Basic gammaridean mouthparts and telson **Figure 5**

A—Upper lip. B—Lower lip. C—Mandible. D—Maxilla 1. E—Maxilla 2. F—Maxilliped. G—Telson.

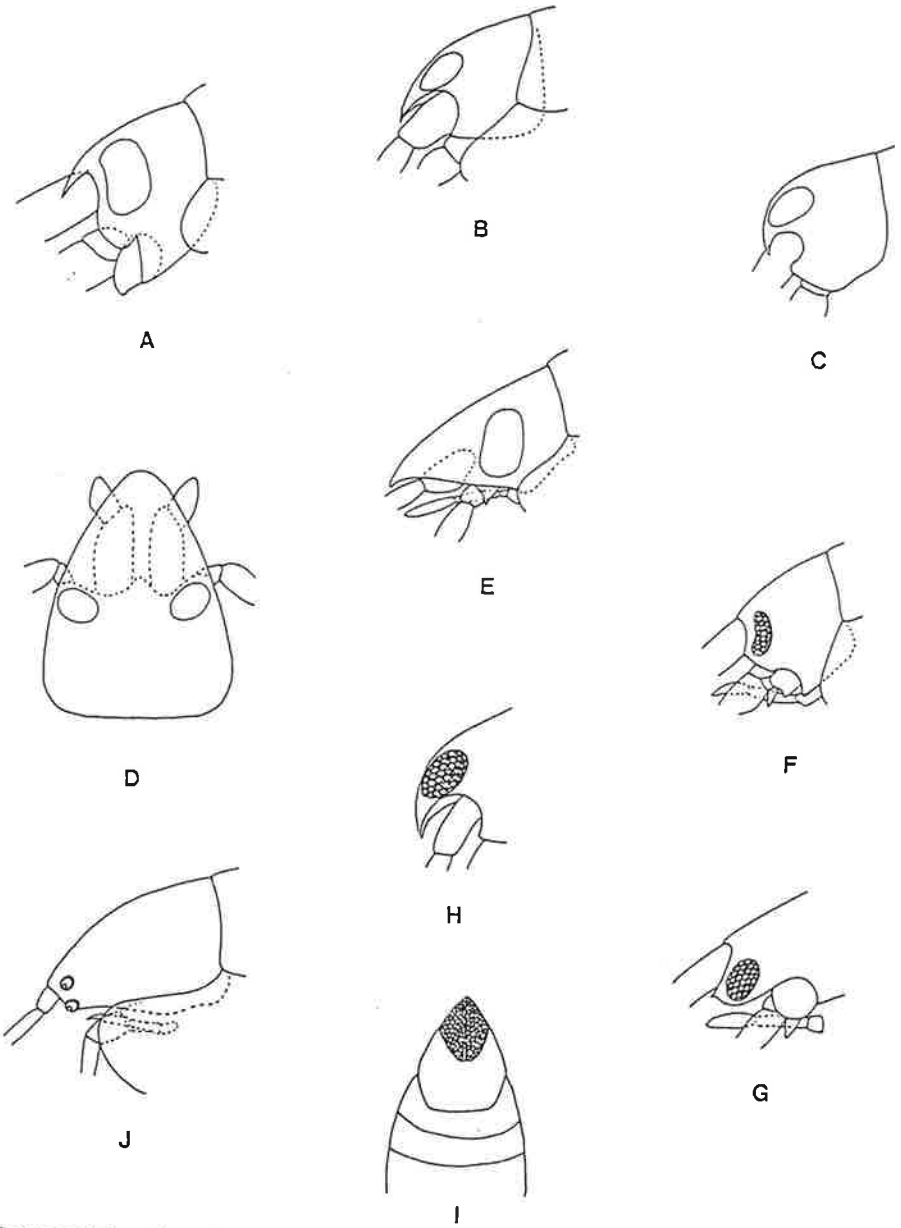
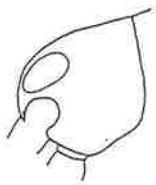
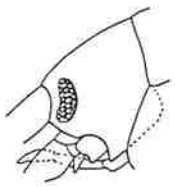


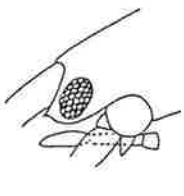
Figure 6 **Characteristics of rostrum (A–E), eye position and shape (F–I)**
A—Acute. B—Falcate. C—Decurved. D—Hooded (dorsal view). E—Hooded (lateral view). F—Lateral, reniform. G—Anterior, ovate. H—Rostral, fused (lateral view). I—Rostral, fused (dorsal view). J—Divided with corneal lens.



C

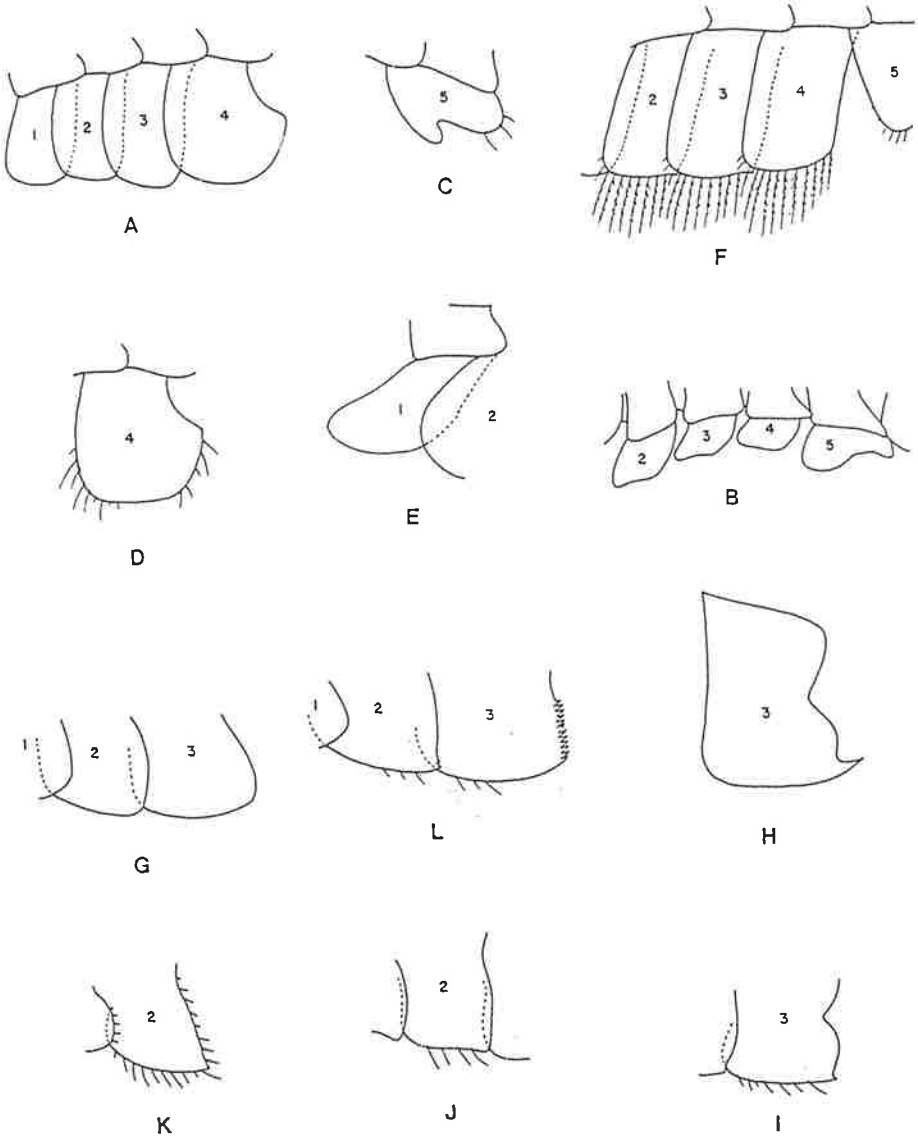


F



G

lorsal view). E—Hooded
ate. H—Rostral, fused
d with corneal lens.



Characteristics of coxal plates (A–E) and epimeral plates (G–L): hind corners (G–J), posterior margin (K–L) Figure 7

A—Overlapping. B—Separated. C—Bilobed. D—Excavate posteriorly. E—Anterodistally expanded. F—Marginally setose. G—Hind corners, rounded. H—Toothed, produced. I—Mucronate. J—Subquadrate. K—Setose. L—Serrate. H–I—Sinuous.

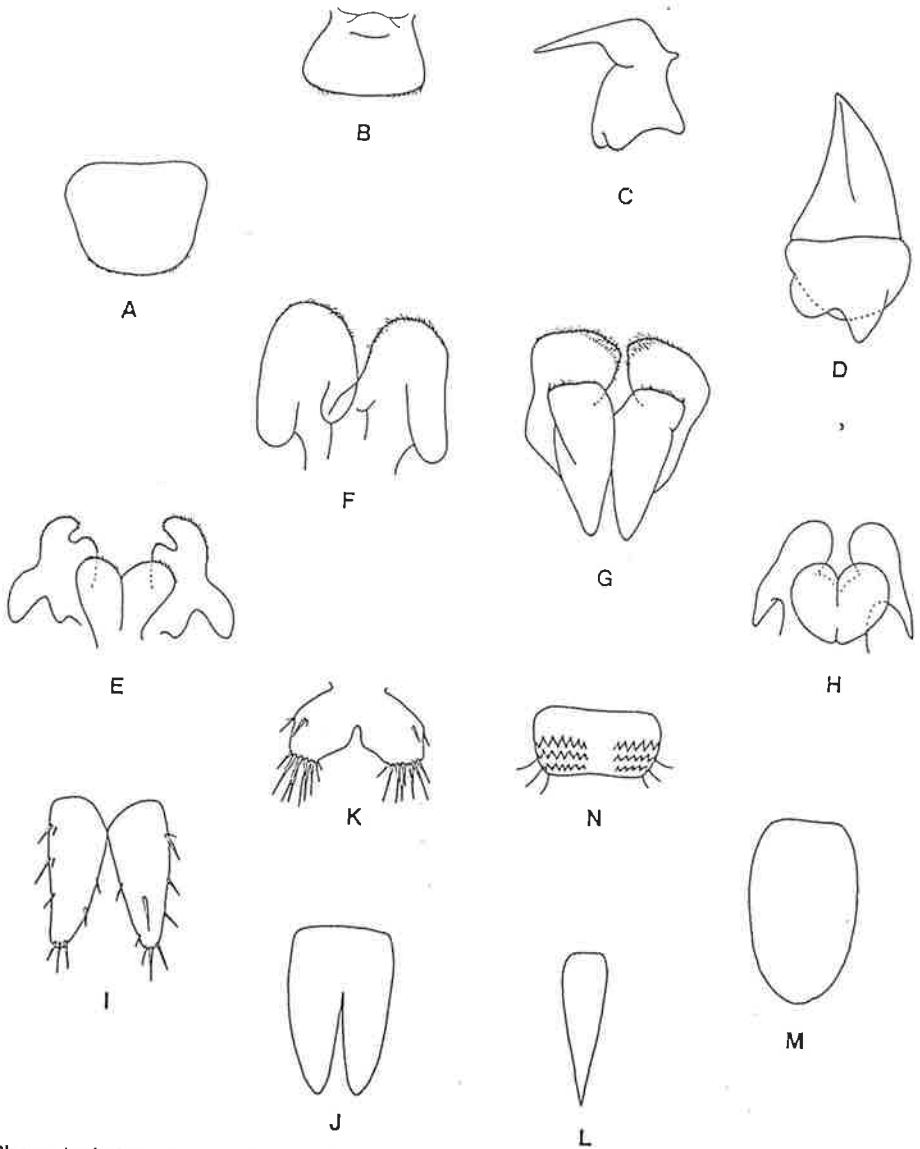
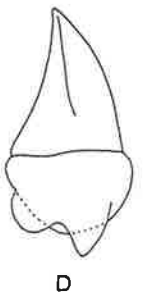
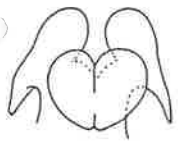


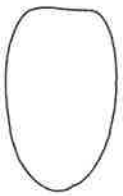
Figure 8 Characteristics of upper lip (A–D), lower lip (E–H), and telson (I–N) A—rounded. B—Broad. C—Bilobed, epistome produced (lateral view). D—Asymmetrically bilobed. E—"Shoulders" notched. F—Inner lobes lacking. G—Mandibular processes lacking. H—Mandibular processes elongate. I—Cleft to base. J—Deeply cleft. K—Broad, notched. L—Entire, acute. M—Entire, linguiform. N—Dorsally uncinate.



D

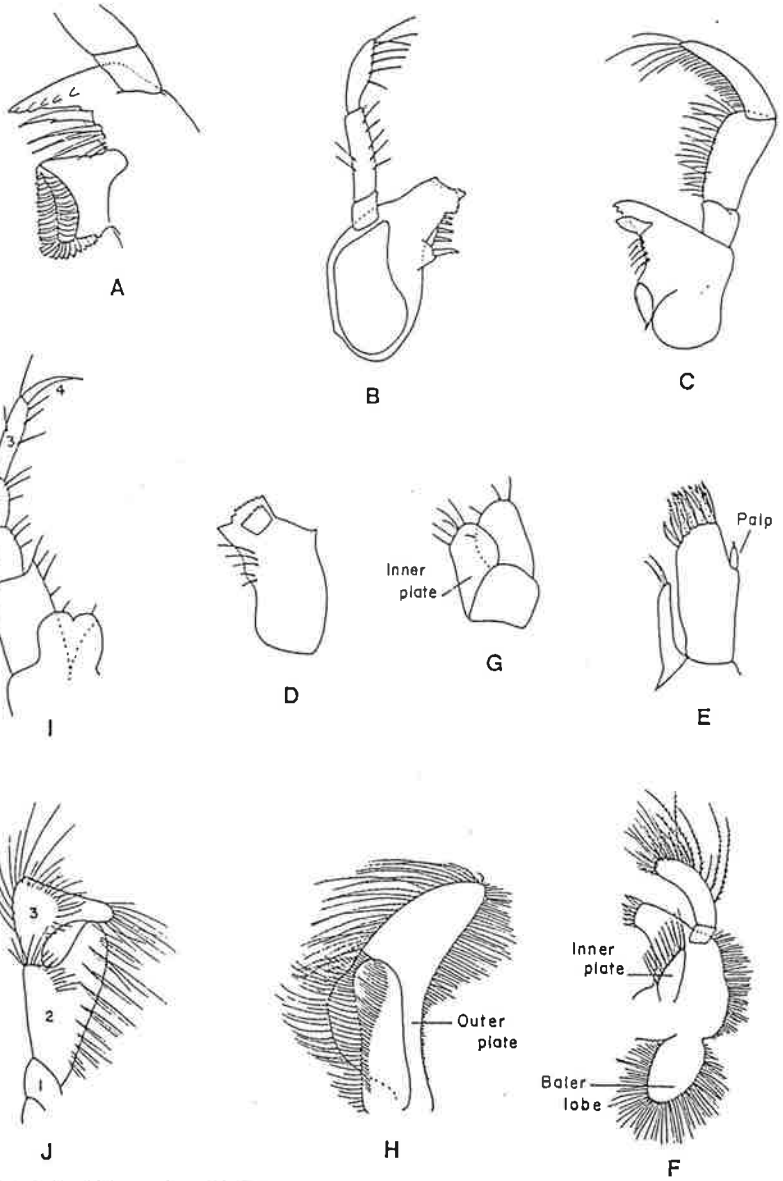


H



M

teral view). D—
er lobes lacking.
es elongate. I—
e, acute. M—



Some characteristics of articulated mouthparts: mandible (A–D), maxilla 1 (E–F), maxilla 2 (G–H), maxilliped (I–J)
A—Molar strong, triturating. B—Molar vestigial. C—Palp strong, falcate. D—Palp lacking. E—Palp vestigial. F—Basal baler lobe large. G—Plates small, weakly armed. H—Outer plate large, lunate. I—Inner plates fused, palp dactylate. J—Palp geniculate.

Figure 9

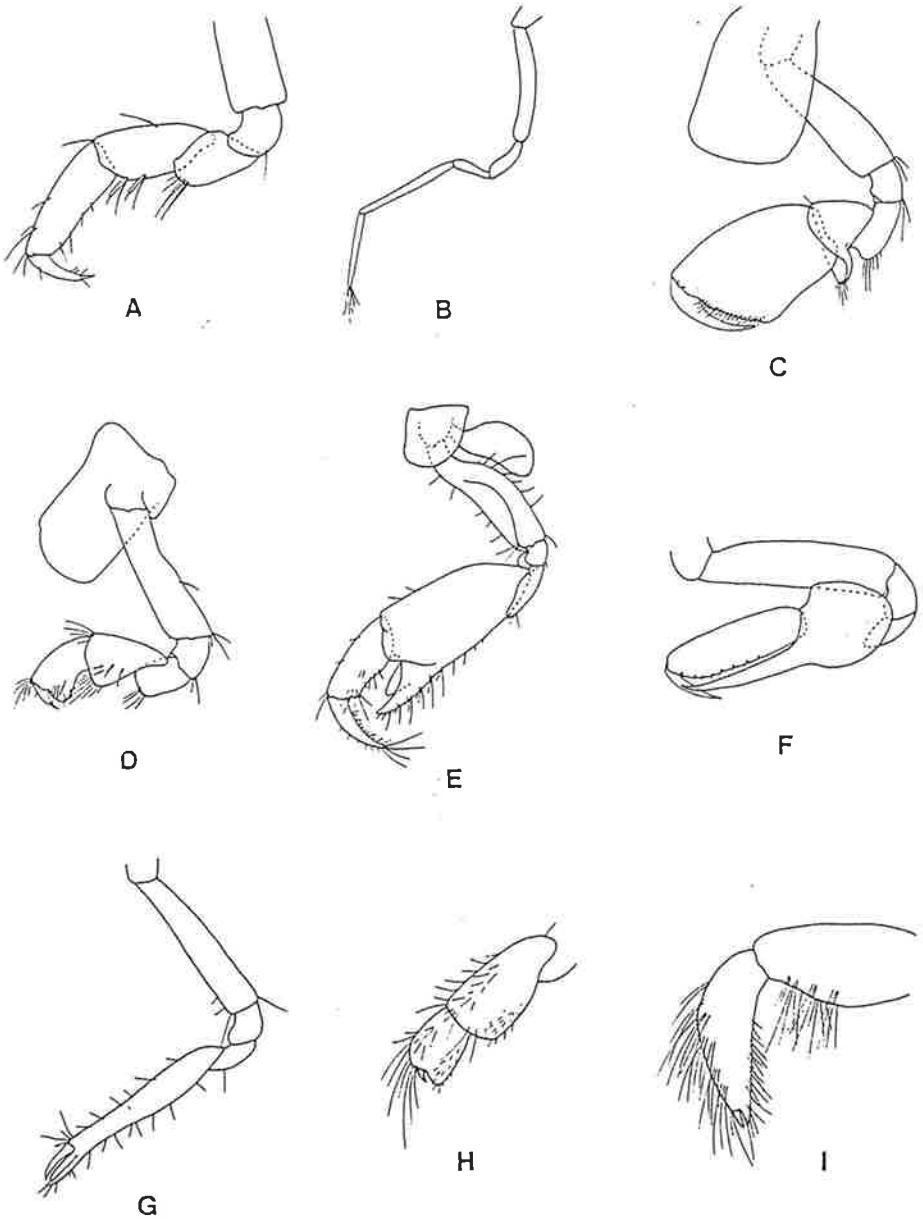
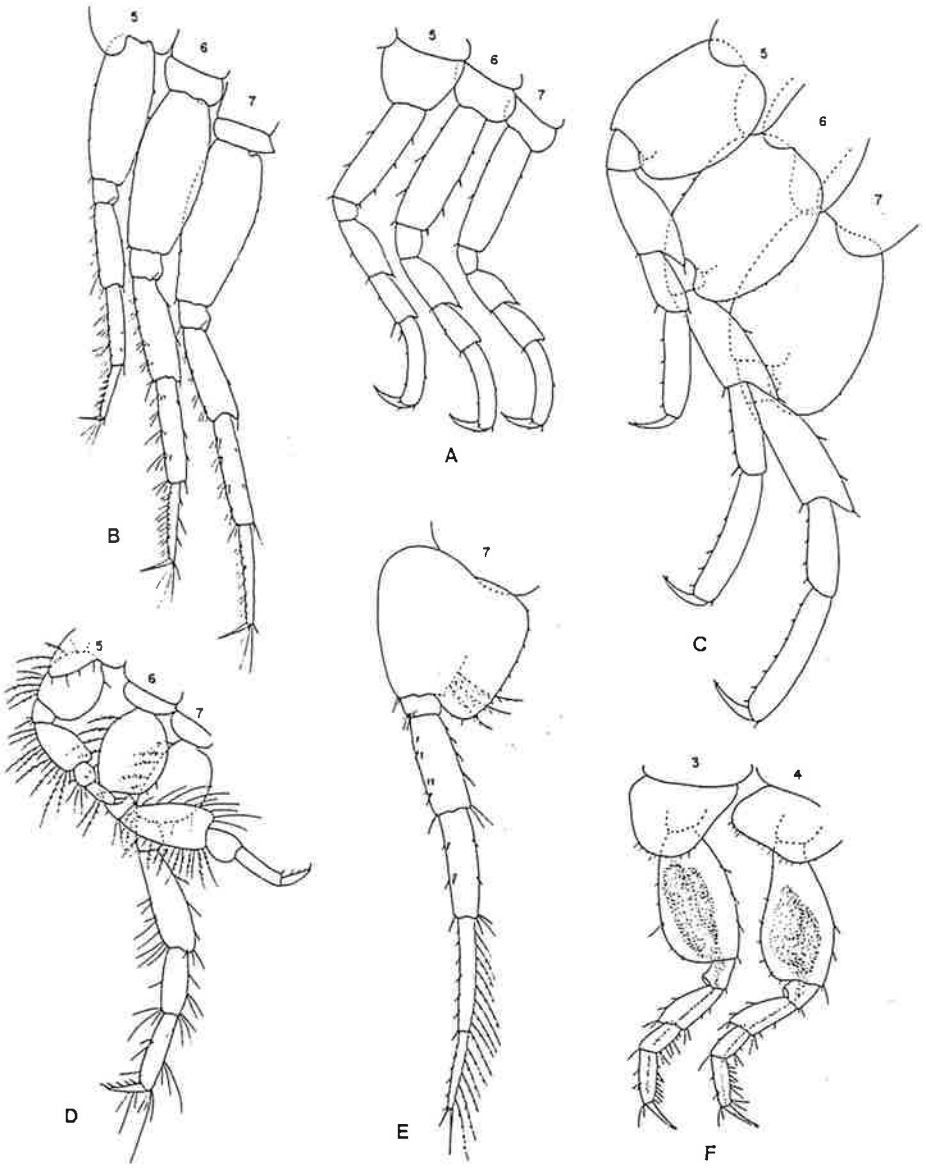


Figure 10 **Characteristics of gnathopods**
A—Simple, normal. B—Simple, filiform. C—Subchelate, powerful. D—Subchelate, weak. E—Complexly subchelate. F—Carpochelate. G—Chelate. H—Minutely subchelate. I—Minutely chelate.



Characteristics of peraeopods
A—Basis linear. B—Basis slightly expanded. C—Basis broadly expanded. D—Posteriorly directed (5, 6). E—Elongate, linear distal segments. F—Basis glandular.

Figure 11

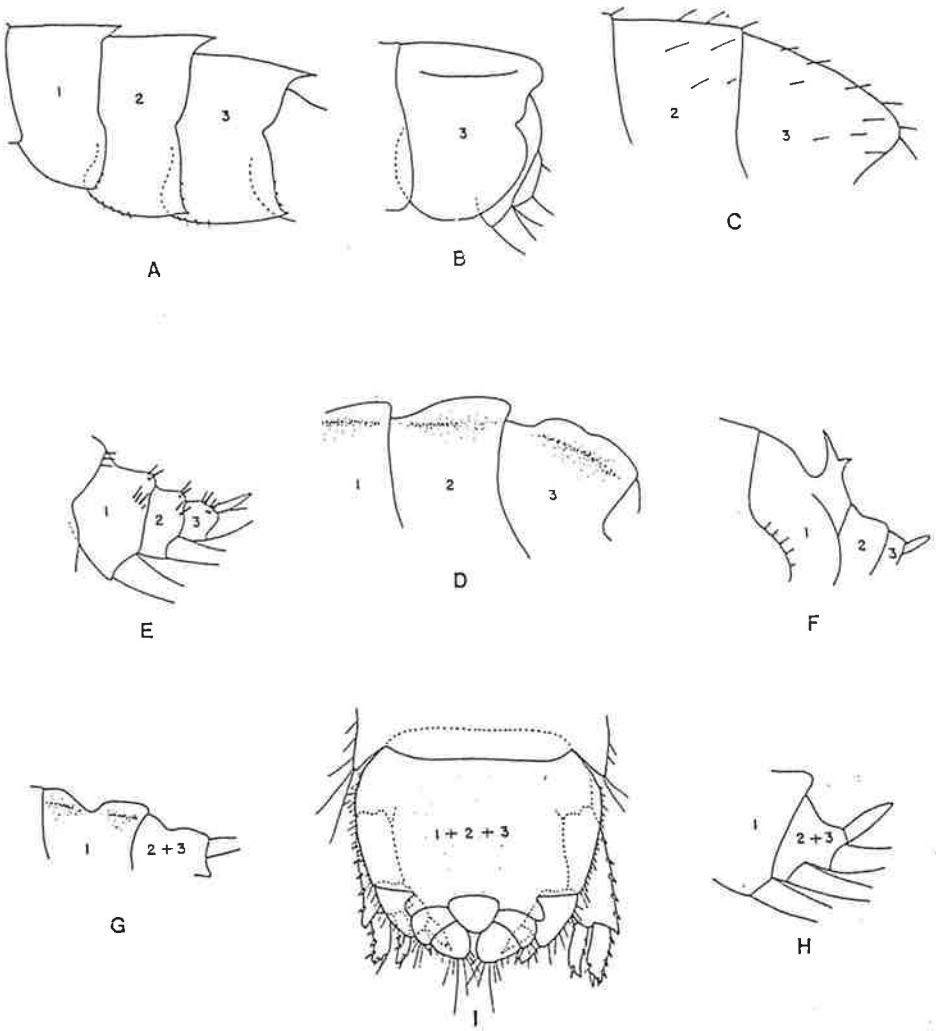
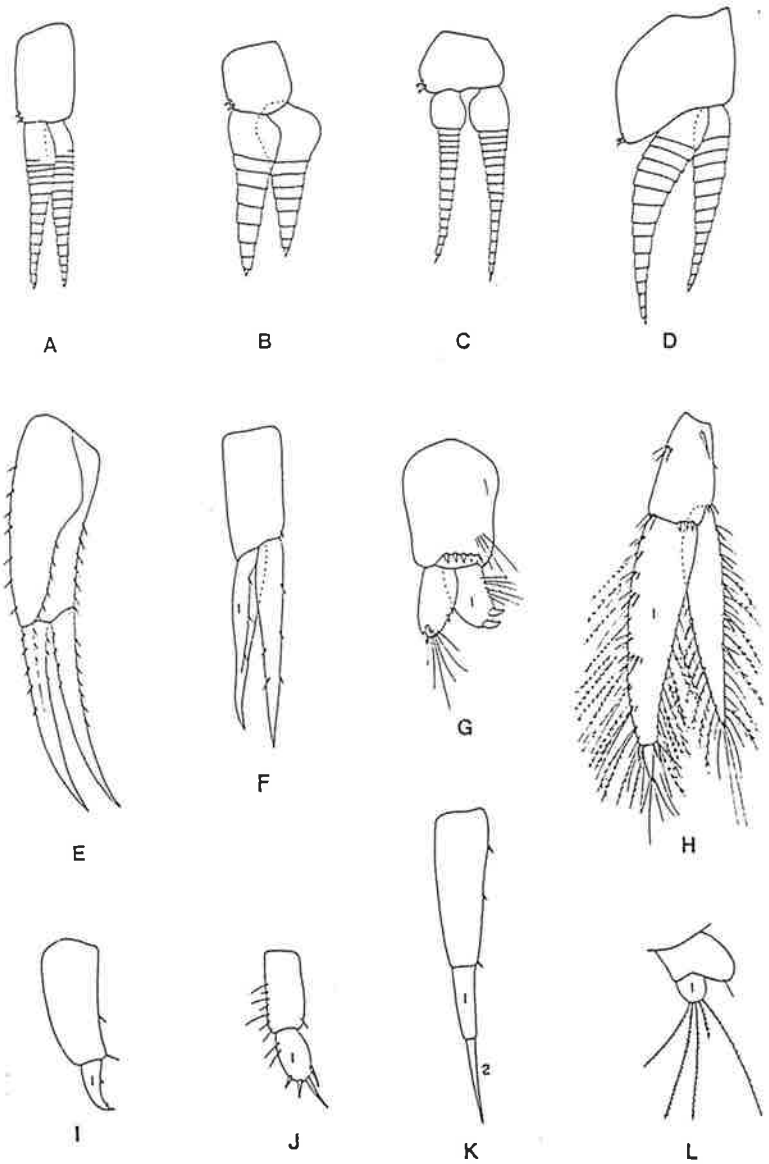


Figure 12 **Characteristics of abdomen: pleon (A–D), urosome (E–I)**
A—Mucronate. B—Posteriorly recurved overhanging urosome. C—Setose, hirsute. D—Carinate. E—Spinose. F—Toothed. G—Bicarinate. H—Posteriorly carinate. I—Segments fused (dorsal view).



Characteristics of pleopods (setae not shown) (A–D), uropod 1 (E), uropod 3 (F–L). A—Normal. B—Rami proximally expanded. C—Peduncle broad. D—Peduncle expanded medially. E—Rami falciform. F—Rami lanceolate. G—Outer ramus with hook spines. H—Rami foliaceous. I—Uniramous, uncinate. J—Uniramous, spatulate. K—Uniramous, styliform. L—Uniramous, peduncle medially lobate.

Figure 13

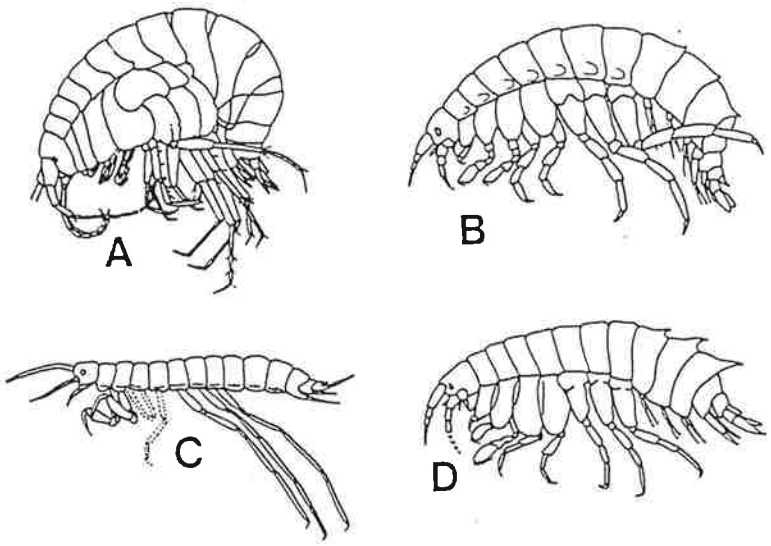


Fig. 13-9. Fossil amphipods. (A) *Palaeogammarus sambiensis*, Upper Eocene, the earliest known amphipod; (B) *Andrussovia sokolovi*, Middle Miocene; (C) *Hellenis saltatorius*, Lower Miocene; (D) *Praegmelina sambiensis*, Upper Eocene. (From Hessler, 1969)

amber of Late Eocene–Early Oligocene age. However, the most extensive fossil amphipod fauna comes from the Miocene of the Caspian region of the USSR and includes the genera *Andrussovia*, *Hellenis*, and *Praegmelina* (Fig. 13-9B, C, D), and a species of '*Gammarus*.' There are other materials from other localities (various species assigned to '*Gammarus*' and '*Melita*') but it is noteworthy that all fossil amphipods found so far are from Europe. There are some 18 species recognized in seven genera (Hurley, 1973; Bousfield, 1982a), and these are classified in five families and four superfamilies.

TAXONOMY Though quite numerous, amphipods, with a few exceptions, pretty well all conform to a basic plan. Even so, there has been little consensus on how to classify them. An extreme position maintains that all are subsumable under a single taxon, Gammaridea, which then becomes virtually synonymous with the concept Amphipoda. A more reasonable view that presently enjoys fairly wide support is to recognize four major groups. Within these, three groups have only modest controversy within them: Caprellidea, Hyperiidea, and Ingolfiellidea.

The Gammaridea, however, are the subject of great controversy (see, e.g., Bousfield, 1978; Barnard and Karaman, 1980) with no consensus in sight on the arrangement of families and superfamilies (not even within a paper; see, e.g., Barnard and Karaman, 1983). Bowman and Abele (1982) essentially followed Barnard (1969). On the other hand, this book has opted for a taxonomic arrangement similar to Bousfield's (1983), not only

[FROM SCHRAM, F.R. (1986) Crustacea, Oxford University Press, 606 pp.]

to present an alternative to the above but also because the methodology used to arrive at this particular arrangement is repeatable and thus the methodology's results (i.e., the actual classification) are testable.

I would not necessarily agree with the exact methods nor this particular taxonomy of the gammarideans in all details. Bousfield and associates use basically phenetic techniques that utilize numerical averages to group taxa. Such an approach would give at best a 'first estimate' of relationships. While it does try to distinguish advanced from primitive characters, it also produces higher taxonomic groupings that have within their ranks 'exceptions' to the defining characters. Currently, only a few authorities are beginning to look at character matrices in the context of basic body plans using rigid cladistic techniques. It would seem that in the long run only such an analysis will hold forth the promise of producing a classification of amphipods that is at once natural and whose basic assumptions are obvious. For example, preliminary analysis of amphipod taxa using a Wagner 78 program by myself and R. C. Brusca produced a cladogram of relationships among amphipod taxa quite at odds with anything currently in the literature.

The precarious nature of amphipod taxonomy at the specific level is illustrated by the findings of Pinkster (1983) in part of the *Gammarus pulex* group, who described a species that could not be effectively diagnosed. *G. stupendus* could not be keyed using the usual criteria because distinct polymorphism in the taxon appeared to indicate three species, whereas hybrid experiments revealed the three types to be conspecific. In addition *G. stupendus*, because of its extreme variation, could not be distinguished from geographically adjacent species, *G. fossarum* and *G. iberica* but was not able to hybridize with them.

Infraorder Ingolfiellidea Hansen, 1903 Recent
  Family Ingolfiellidae Hansen, 1903
    Metaingolfiellidae Ruffo, 1969
Infraorder Caprellidea Leach, 1814 Recent
 Section Caprellida Bousfield, 1979
  Superfamily Phtisicoidea Vassilenko, 1968
    Family Paracercopidae Vassilenko, 1968
      Phtisicidae Vassilenko, 1968
      Dodecadidae Vassilenko, 1968
  Superfamily Caprelloidea White, 1847
    Family Caprogammaridae Kudrjaschov and Vassilenko, 1966
      Aeginellidae Vassilenko, 1968
      Caprellidae White, 1847
 Section Cyamida Bousfield, 1979
  Superfamily Cyamoidea White, 1847
    Family Cyamidae White, 1847
Infraorder Hyperiidea Milne Edwards, 1830 Recent

Section Physosomata Pirlot, 1929
Superfamily Lanceoloidea Bovallius, 1887
Family Lanceolidae Bovallius, 1887
Chuneolidae Woltereck, 1909
Microphasmidae Stephenson and Pirlot, 1931
Superfamily Scinoidea Stebbing, 1888
Family Archaeoscinidae Stebbing, 1904
Scinidae Stebbing, 1888
Mimonectidae Bovallius, 1885
Proscinidae Pirlot, 1933
Section Physocephalata Bowman and Grüner, 1973
Superfamily Vibiloidea Dana, 1852
Family Vibiliidae Dana, 1852
Cystosomatidae Willemoës–Suhm, 1875
Paraphronimidae Bovallius, 1887
Superfamily Phronimoidea Dana, 1853
Family Hyperiidae Dana, 1852
Dairellidae Bovallius, 1887
Phrosinidae Dana, 1853
Phronimidae Dana, 1853
Superfamily Lycaeopsoidea Chevreux, 1913
Family Lycaeopsidae Chevreux, 1913
Superfamily Platysceloidea Bate, 1862
Family Pronoidae Claus, 1879
Anapronoidae Bowman and Grüner, 1973
Lycaeidae Claus, 1879
Oxycephalidae Bate, 1861
Platyscelidae Bate, 1862
Parascelidae Bovallius, 1887
Infraorder Gammaridea Latreille, 1803 Eocene–Recent
Superfamily Eusiroidea Stebbing, 1888 Recent
Family Pontogeneiidae Stebbing, 1906
Calliopiidae Sars, 1893
Eusiridae Stebbing, 1888
Paramphithoidae Stebbing, 1906
Amathillopsidae Pirlot, 1934
Bateidae Stebbing, 1906
Paraleptamphopus family group
Superfamily Oedicerotoidea Lilljeborg, 1865 Recent
Family Oedicerotidae Lilljeborg, 1865
Exoedicerotidae Barnard and Karaman, 1983
Paracullispiidae Barnard and Karaman, 1983
Superfamily Leucothoidea Dana, 1852 Recent
Family Pleustidae Buchholz, 1874
Amphilochidae Boeck, 1872

Leucothoidae Dana, 1852
Anamixidae Stebbing, 1897
Maxillipiidae Ledoyer, 1973
Colomastigidae Stebbing, 1899
Pagetinidae K. H. Barnard, 1932
Laphystiopsidae Stebbing, 1899
Nihotungidae Barnard, 1972
Cressidae Stebbing, 1899
Stenothoidae Boeck, 1871
Thaumatelsonidae Gurj., 1938
Superfamily Talitroidea Costa, 1857 Recent
Family Hyalidae Bulycheva, 1957
Dogielinotidae Gurjanova, 1954
Hyalellidae Bulycheva, 1957
Najnidae Barnard, 1972
Ceinidae Barnard, 1972
Talitridae Costa, 1857
Eophliantidae Sheard, 1938
Phliantidae Stebbing, 1899
Temnophliantidae Griffiths, 1975
Kuriidae Barnard, 1964
Superfamily Crangonyctoidea Bousfield, 1977 Eocene–Recent
Family Paramelitidae Bousfield, 1977 Recent
Neoniphargidae Bousfield, 1977 Recent
Niphargidae S. Karaman, 1962 Recent
Crangonyctidae Bousfield, 1973 Eocene–Recent
Superfamily Phoxocephaloidea Sars, 1891 Recent
Family Urothoidae Bousfield, 1979
Phoxocephalidae Sars, 1891
Platyischnopidae Barnard and Drummond, 1979
Superfamily Lysianassoidea Dana, 1849 Recent
Family Lysianassidae Dana, 1849
Uristidae Hurley, 1963
Superfamily Synopioidea Dana, 1853 Recent
Family Synopiidae Dana, 1853
Family Argissidae Walker, 1904
Superfamily Stegocephaloidea Dana, 1852 Recent
Family Stegocephalidae Dana, 1852
Acanthonotozomatidae Stebbing, 1906
Ochlesidae Stebbing, 1910
Lafystiidae Sars, 1893
Superfamily Pardaliscoidea Boeck, 1871 Recent
Family Pardaliscidae Boeck, 1871
Stilipedidae Holmes, 1908
Hyperiopsidae Bovallius, 1886

Astyridae Pirlot, 1934
Vitjazianidae Birstein and Vinogradov, 1955
Superfamily Liljeborgioidea Stebbing, 1888 Recent
Family Liljeborgiidae Stebbing, 1888
Sebidae Walker, 1908
Salentinellidae Bousfield, 1977
Paracrangonyctidae Bousfield, 1982
Superfamily Dexaminoidea Leach, 1814 Recent
Family Atylidae Lilljeborg, 1865
Anatylidae Bulycheva, 1955
Lepechinellidae Schell., 1926
Dexaminidae Leach, 1814
Prophliantidae Nicholls, 1940
Superfamily Ampeliscoidea Bate, 1861 Recent
Family Ampeliscidae Bate, 1861
Superfamily Pontoporeioidea Sars, 1882 Recent
Family Pontoporeiidae Sars, 1882
Haustoriidae Stebbing, 1906
Superfamily Gammaroidea Leach, 1814 Oligocene–Recent
Family Acanthogammaridae Garjej., 1901 Oligocene–Recent
Anisogammaridae Bousfield, 1977 Recent
Gammaroporeiidae Bousfield, 1979 Recent
Gammaridae Leach, 1814 Oligocene–Recent
Pontogammaridae Bousfield, 1977 Miocene–Recent
Typhlogammaridae Bousfield, 1979 Recent
Mesogammaridae Bousfield, 1977 Recent
Macrohectopidae Sowinsky, 1915 Recent
Behningiella–Zernovia family group? Recent
Iphiginella–Pachyschesis family group? Recent
Superfamily Melphidippoidea Stebbing, 1899 Recent
Family Melphidippidae Stebbing, 1899
Hornellia–Cheirocratus family group
Megaluropus family group
Phreatogammaridae Bousfield, 1982
Superfamily Hadzioidea Karaman, 1932 Recent
Family Hadziidae Karaman, 1932
Melitidae Bousfield, 1973
Carangoliopsidae Bousfield, 1977
Superfamily Bogidielloidea Hertzog, 1936 Recent
Family Bogidiellidae Hertzog, 1936
Artesiidae Holsinger, 1980
Superfamily Corophioidea Dana, 1849 Pleistocene–Recent
Family Ampithoidae Stebbing, 1899 Recent
Biancolinidae Barnard, 1972 Recent
Isaeidae Dana, 1853 Recent

Ischyroceridae Stebbing, 1899 Recent
Neomegamphopidae Myers, 1981 Recent
Aoridae Stebbing, 1899 Recent
Cheluridae Allman, 1847 Recent
Corophiidae Dana, 1849 Pleistocene–Recent
Podoceridae Stebbing, 1906 Recent

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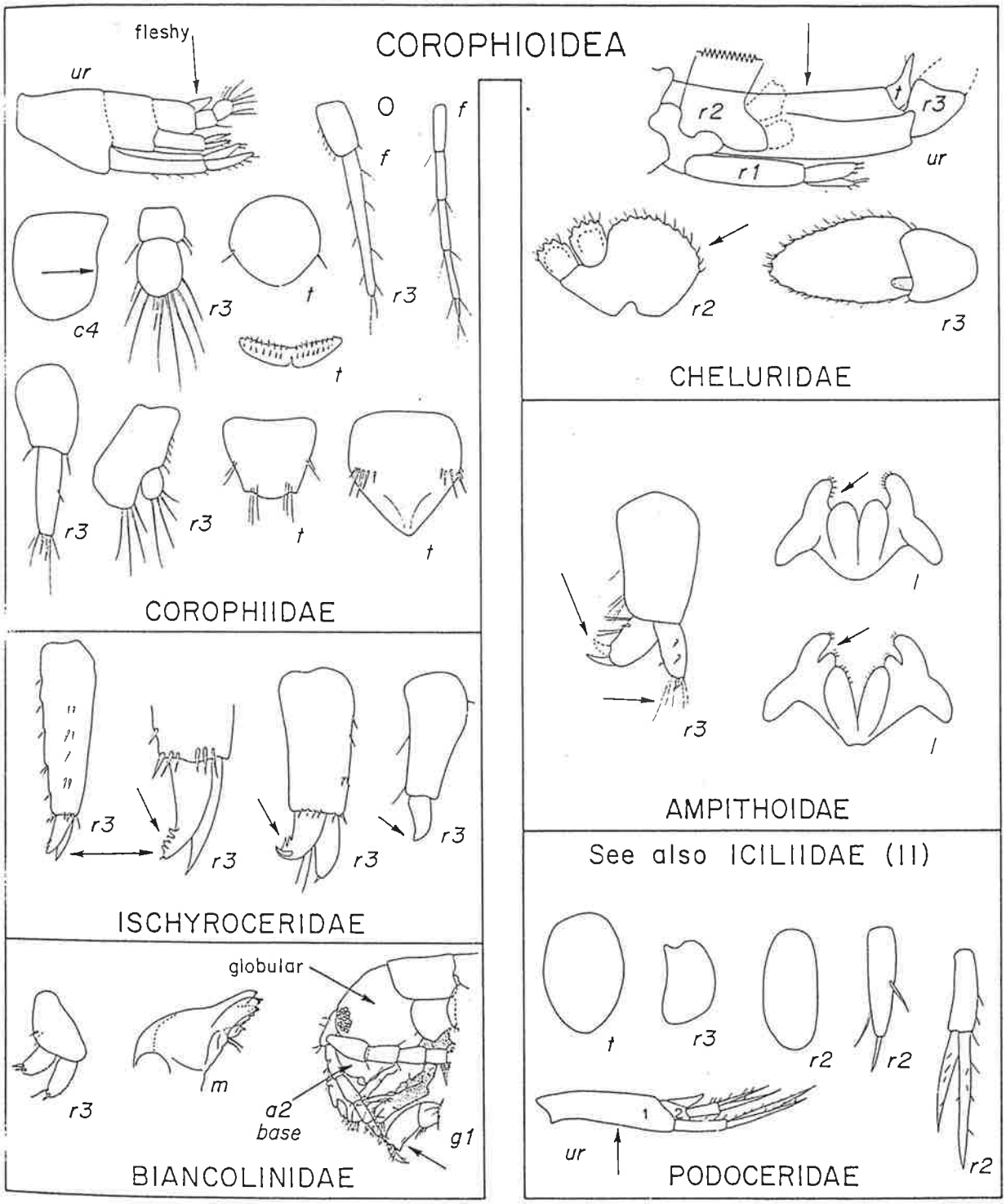
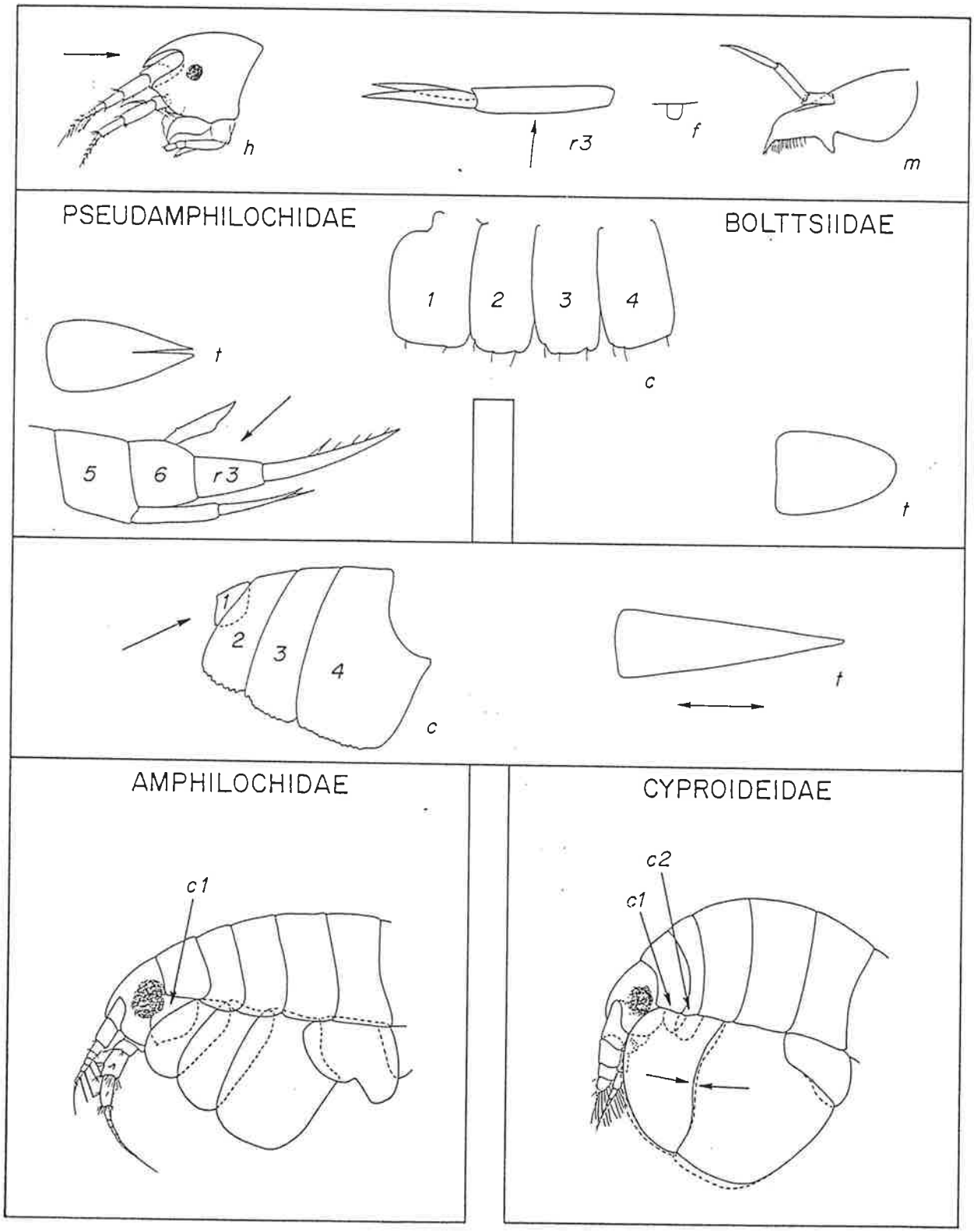


Fig.2. Pictorial key.



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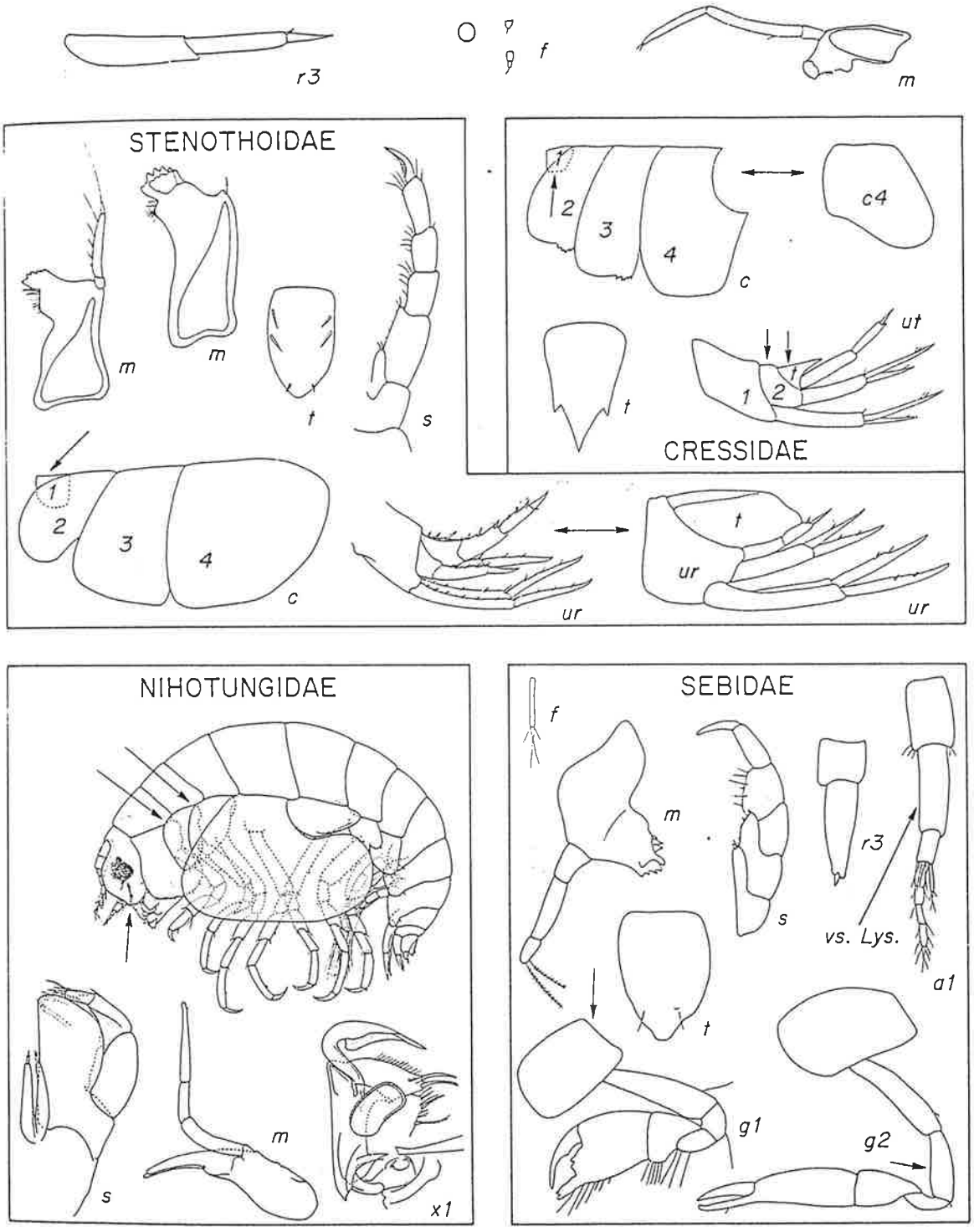

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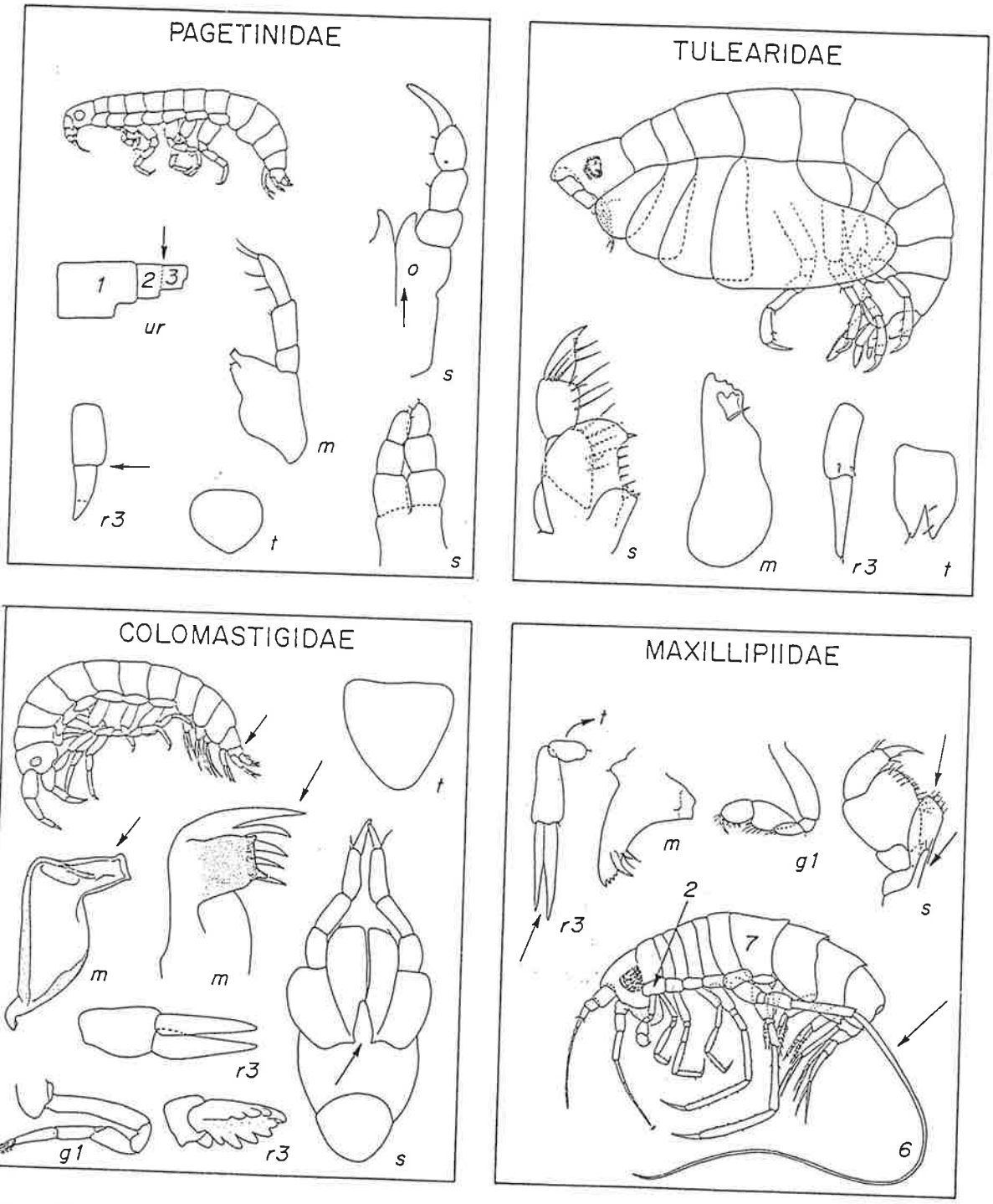

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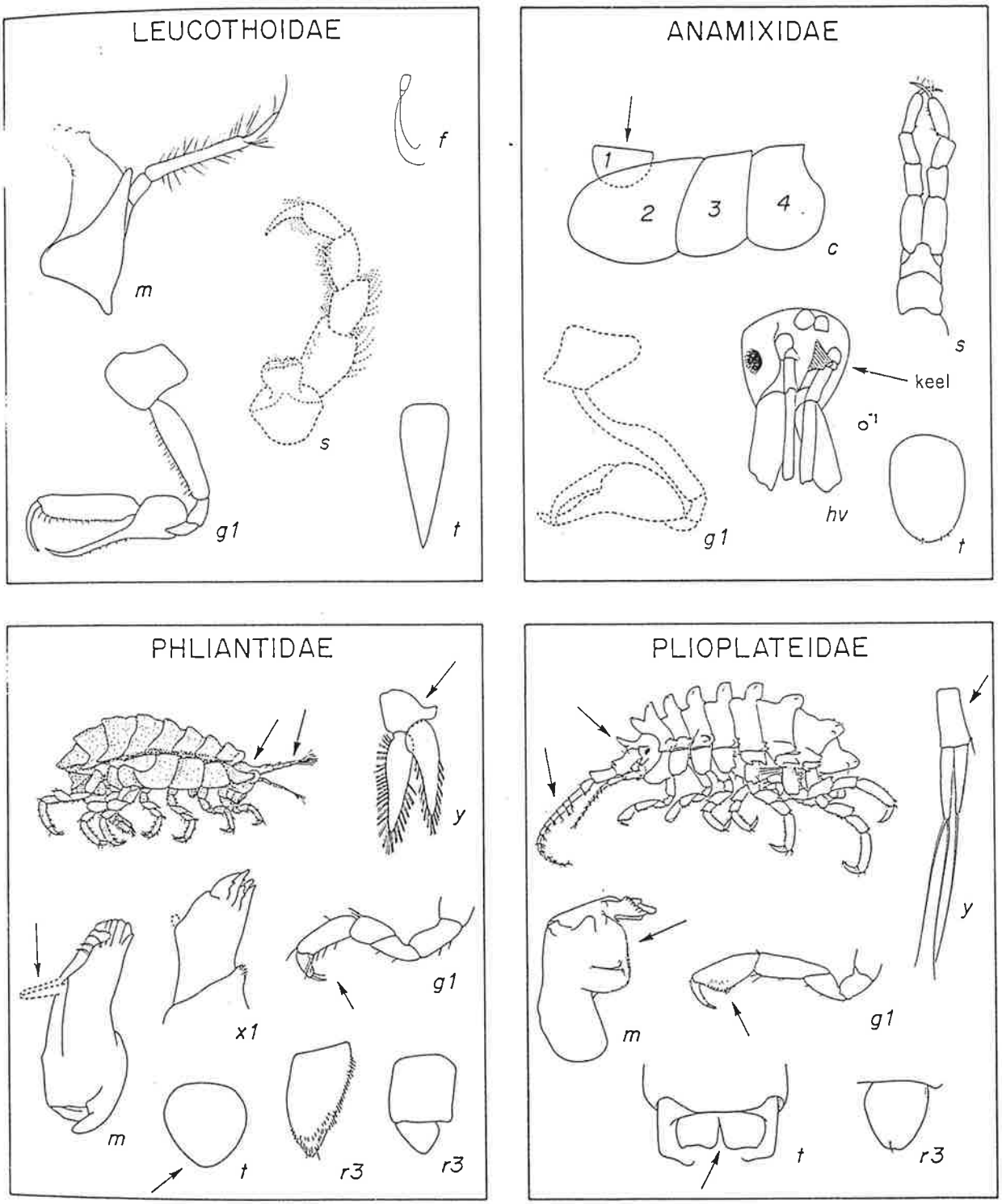

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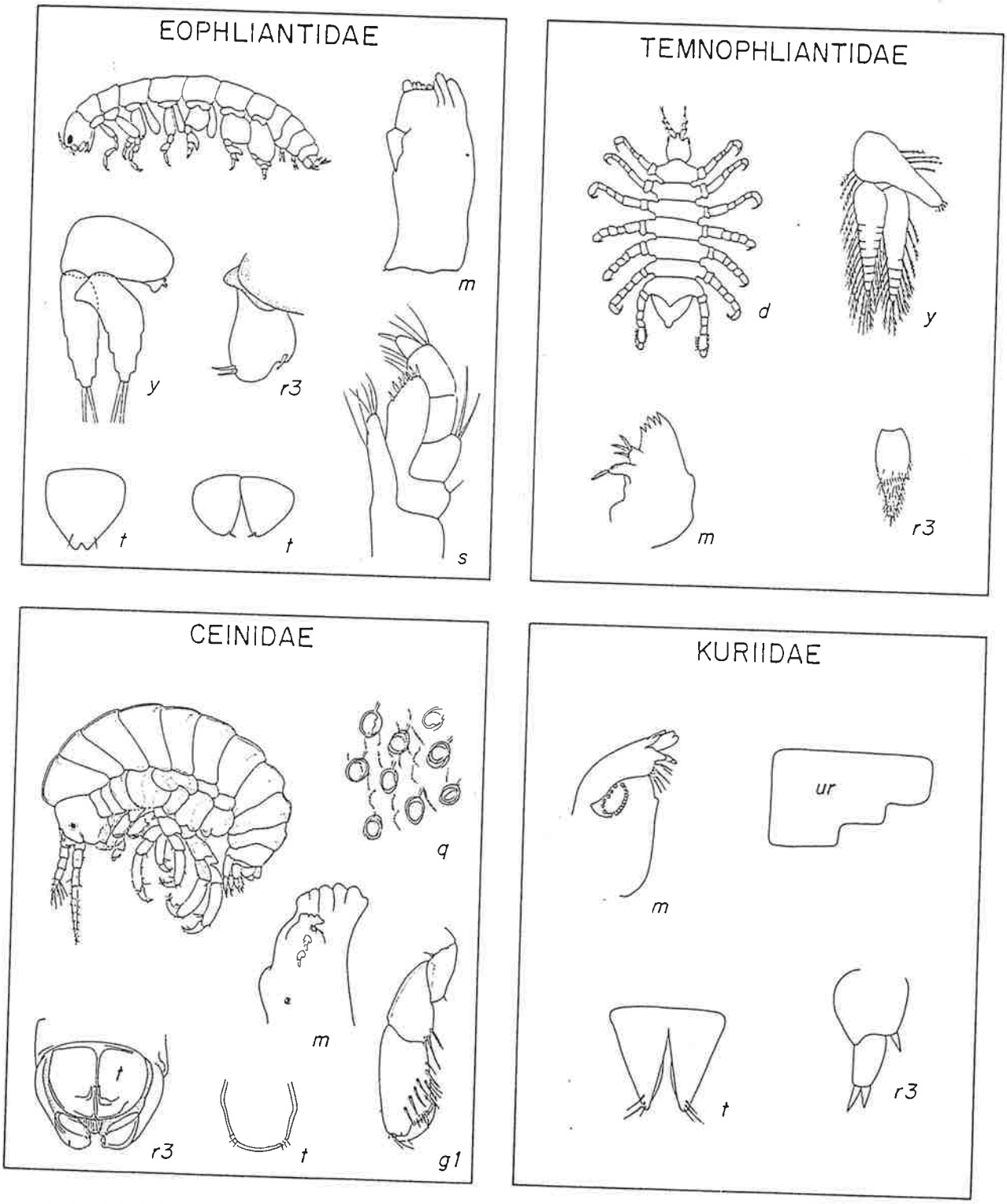

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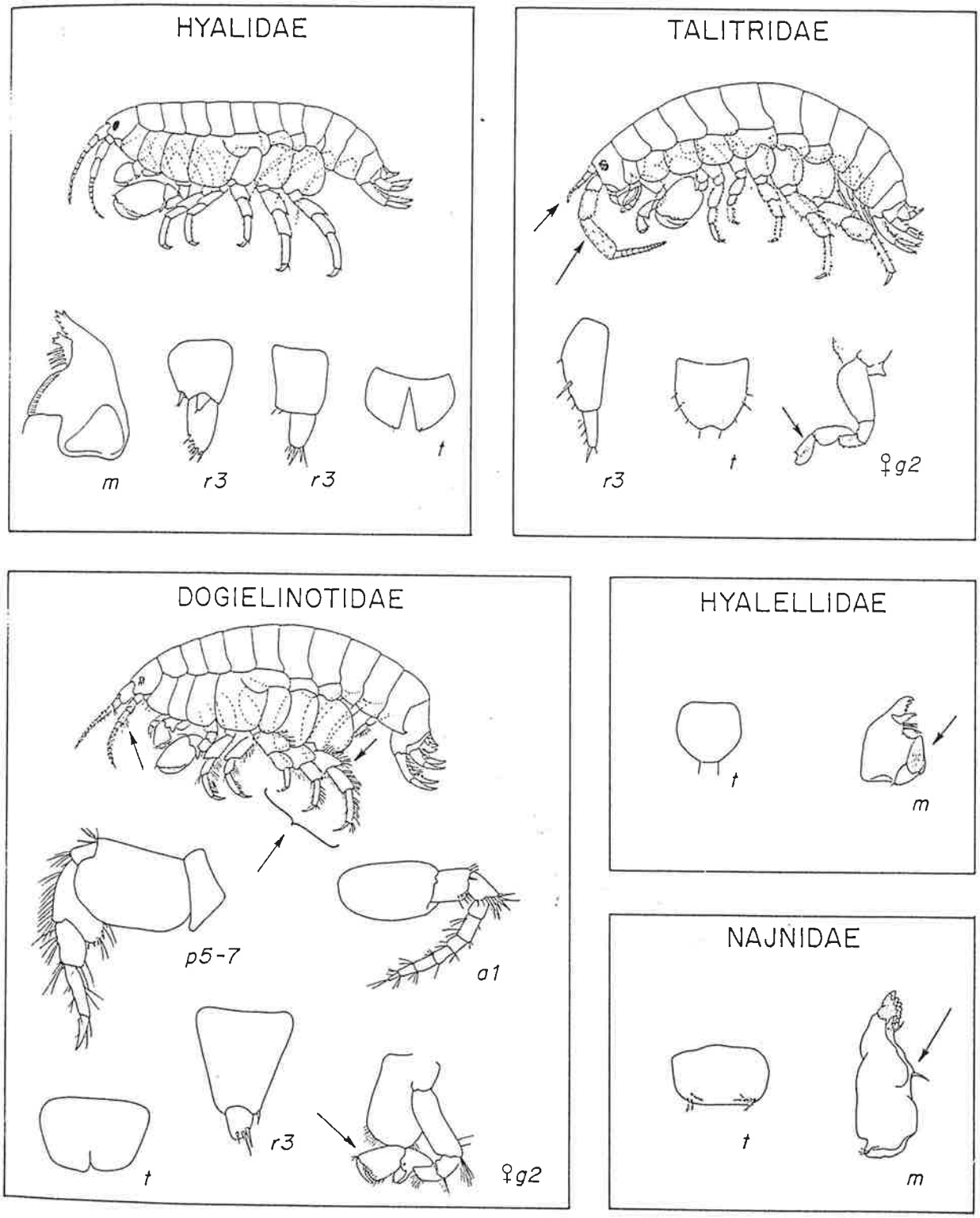

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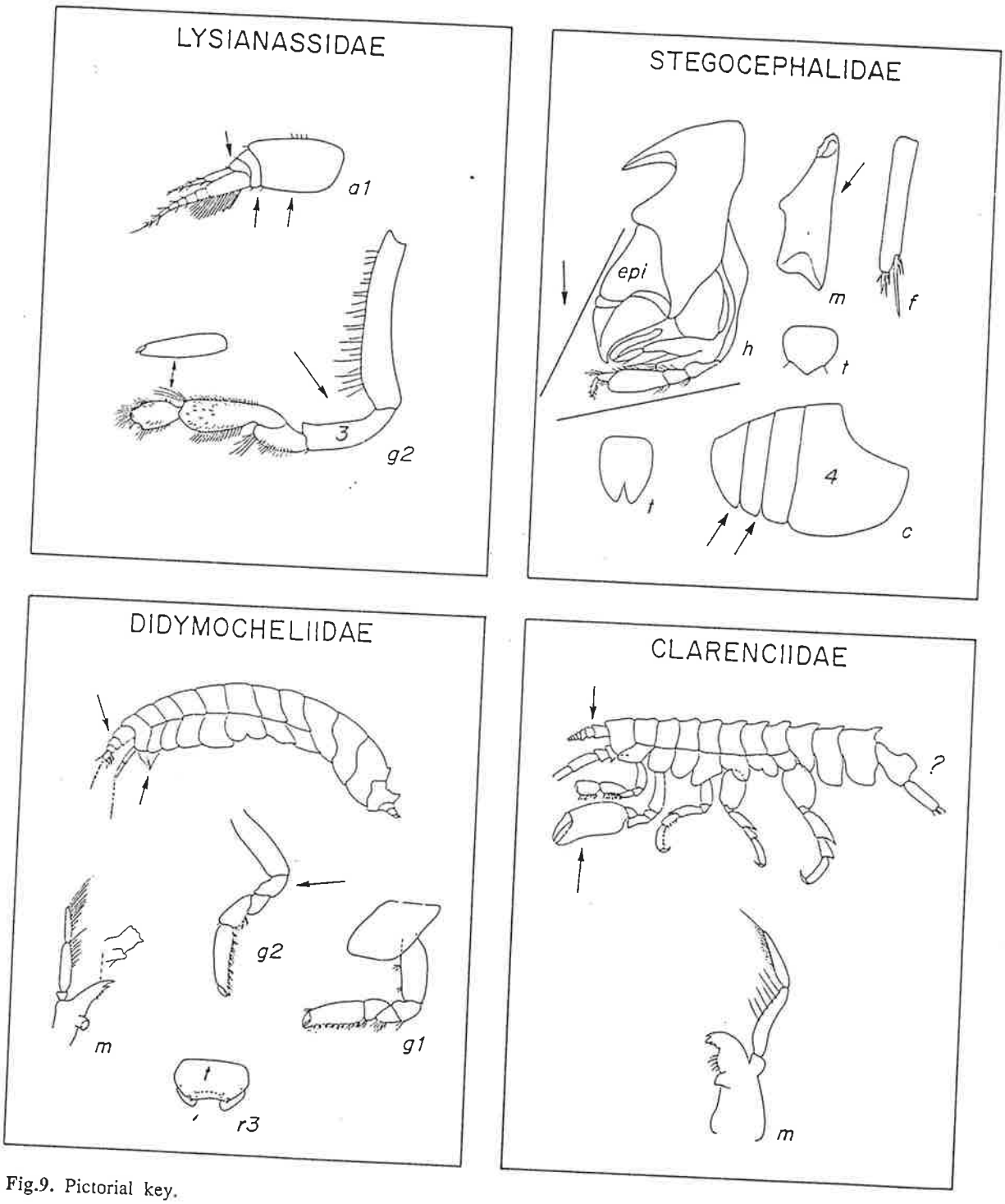

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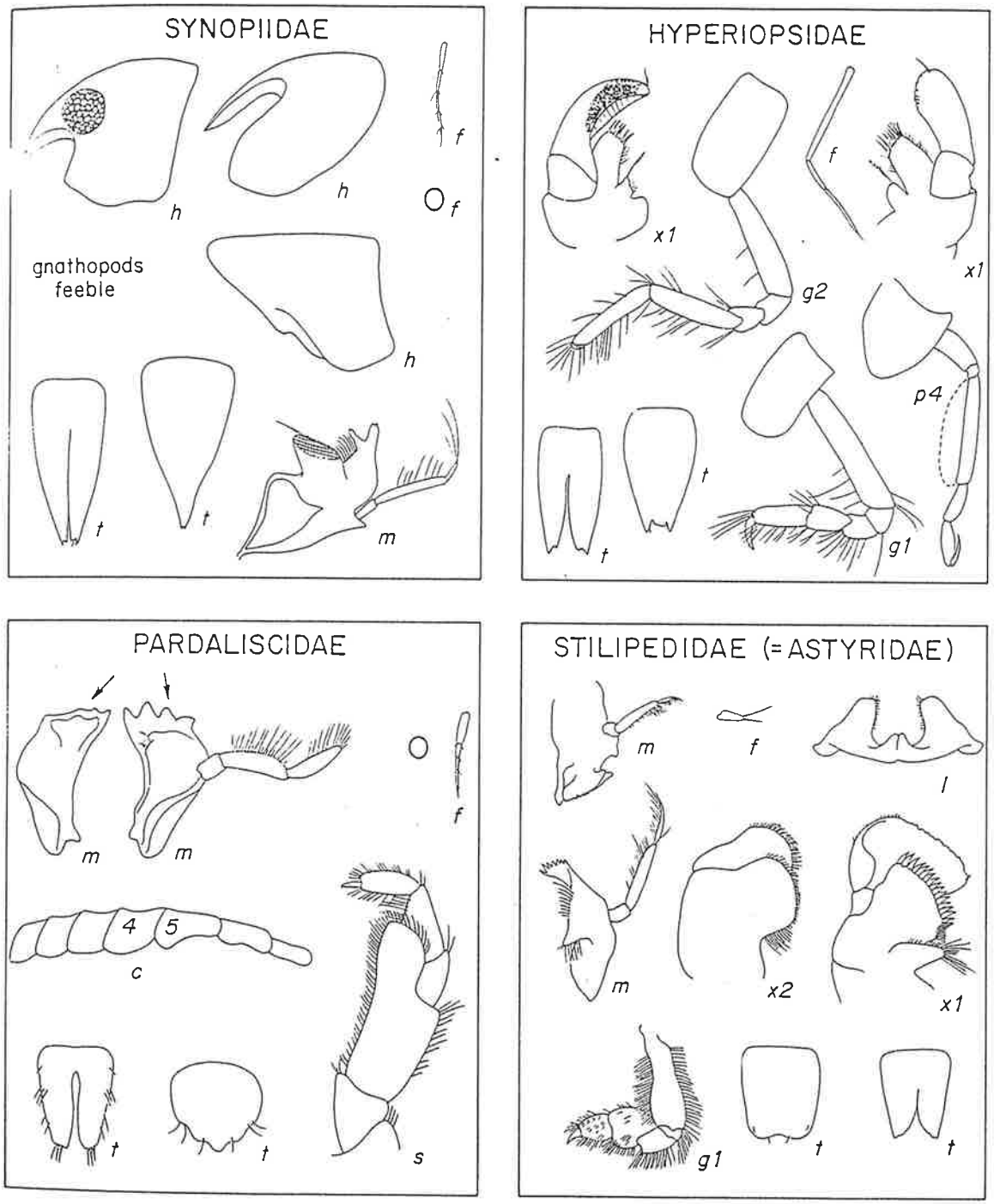

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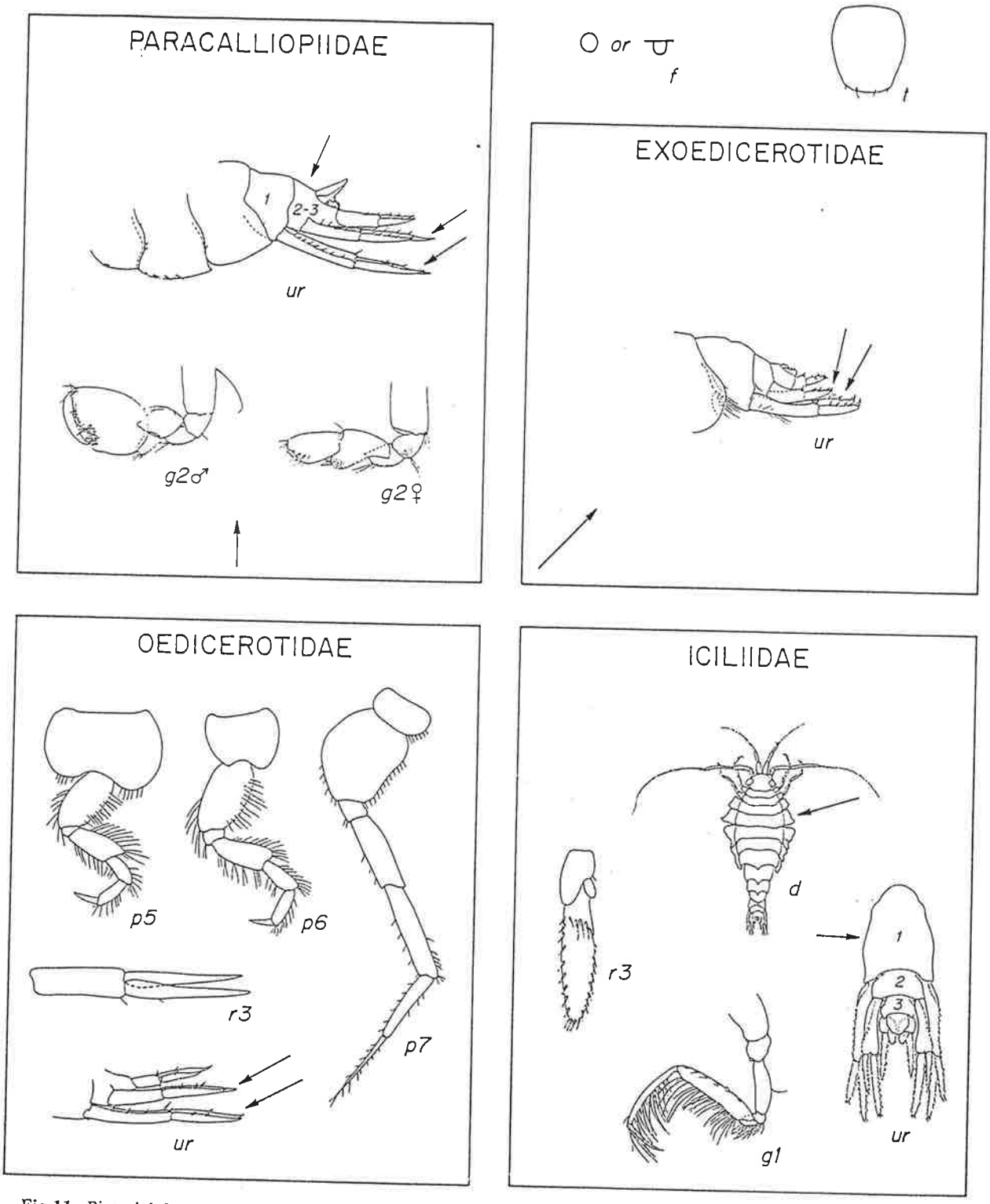

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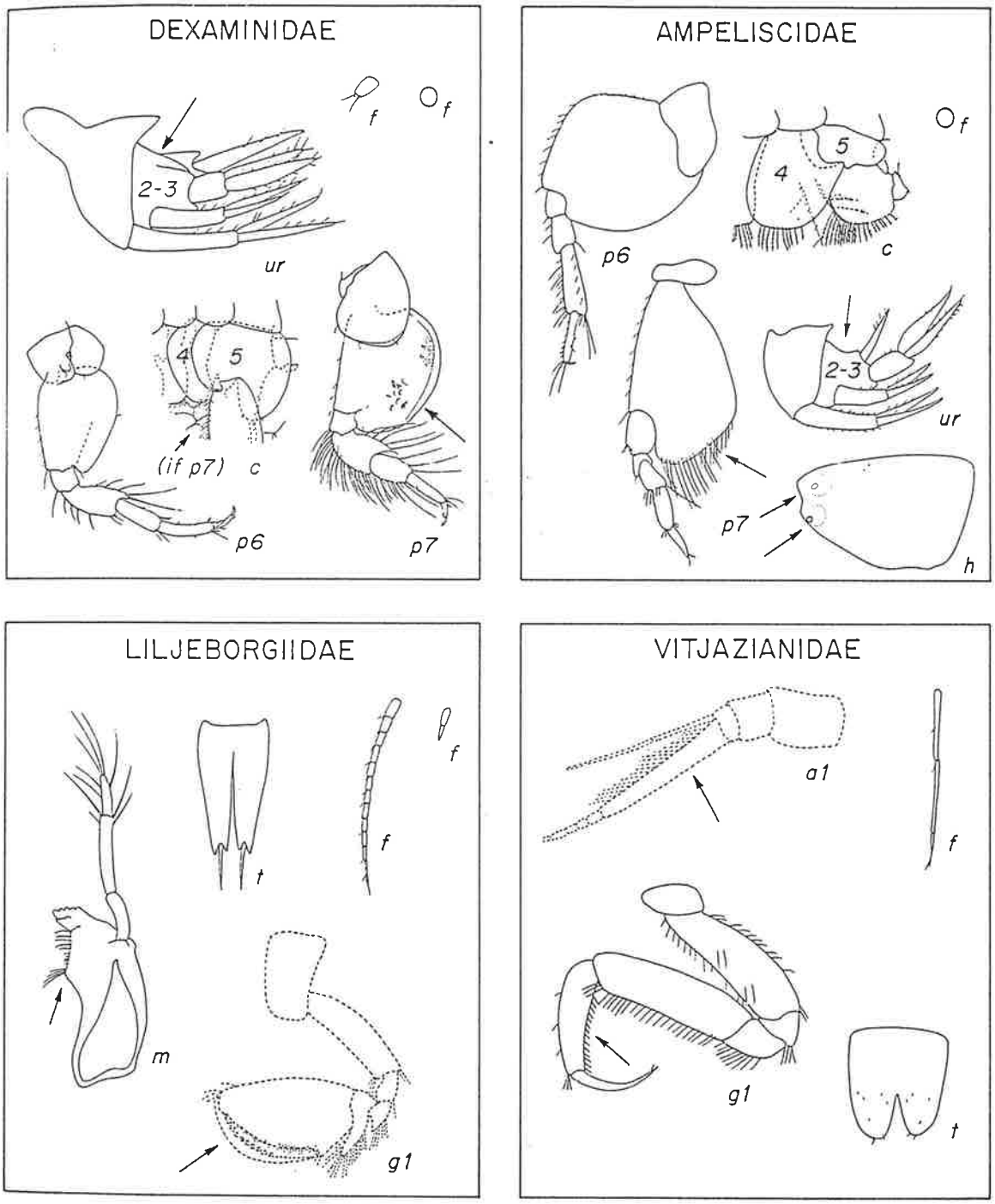

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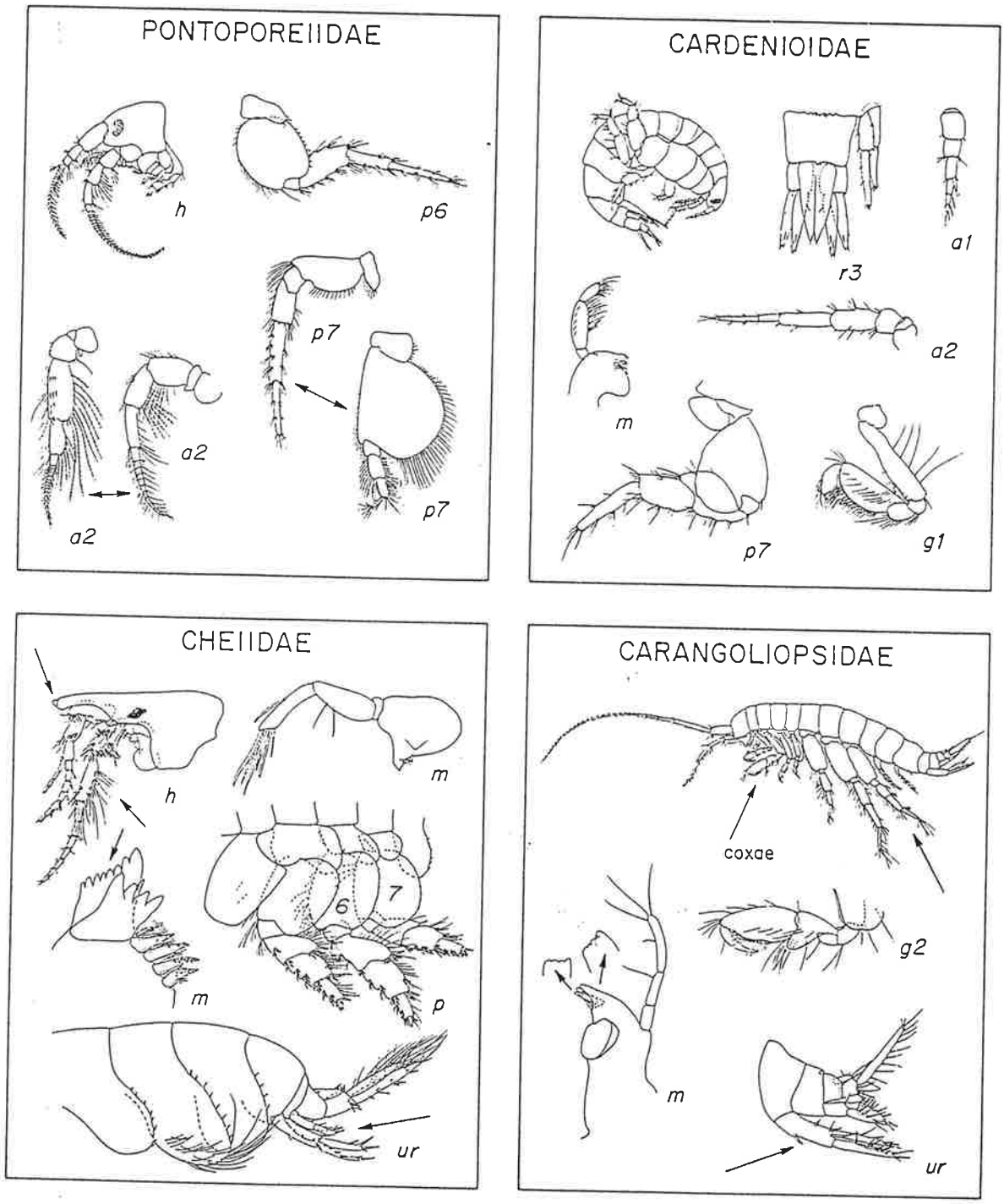

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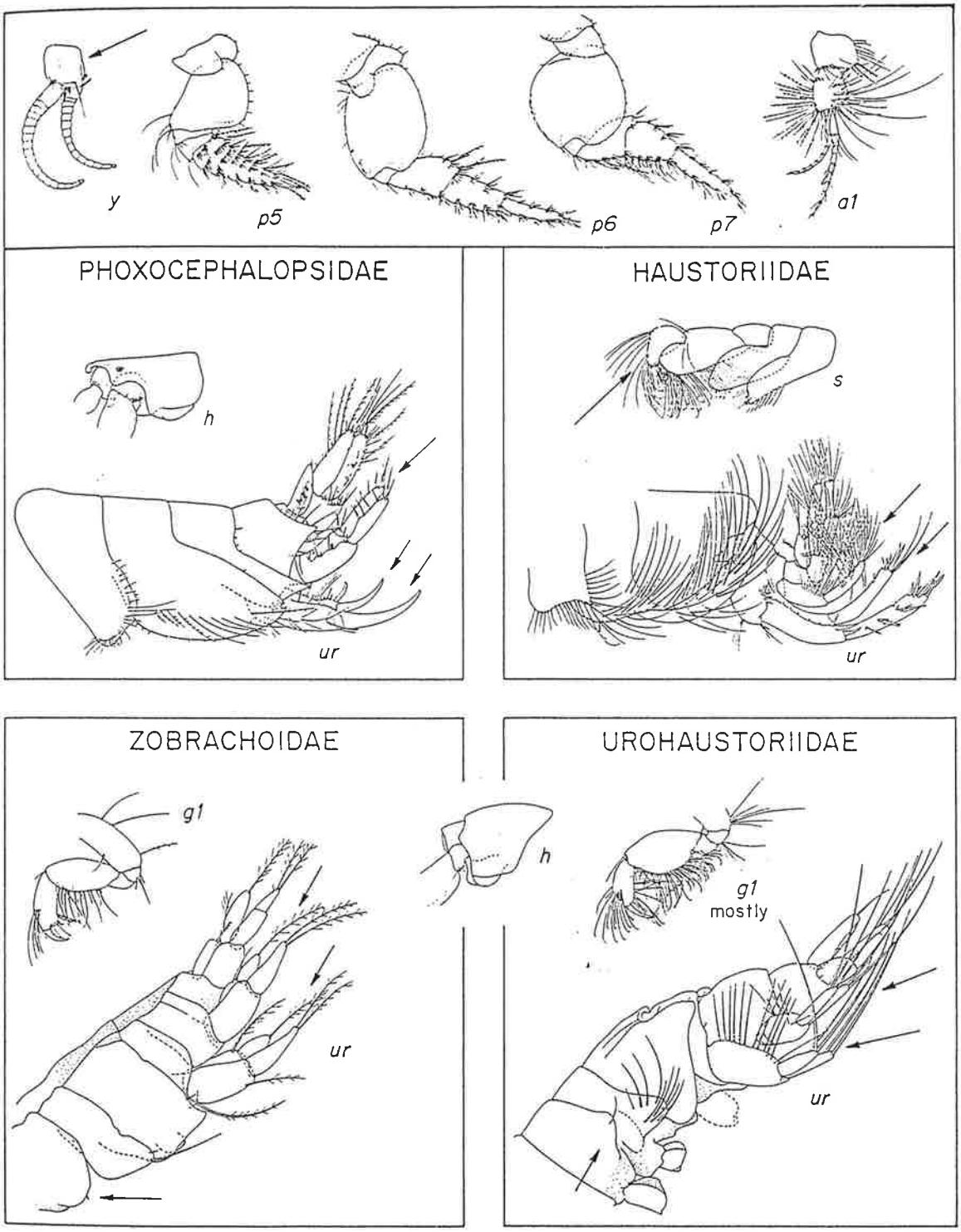

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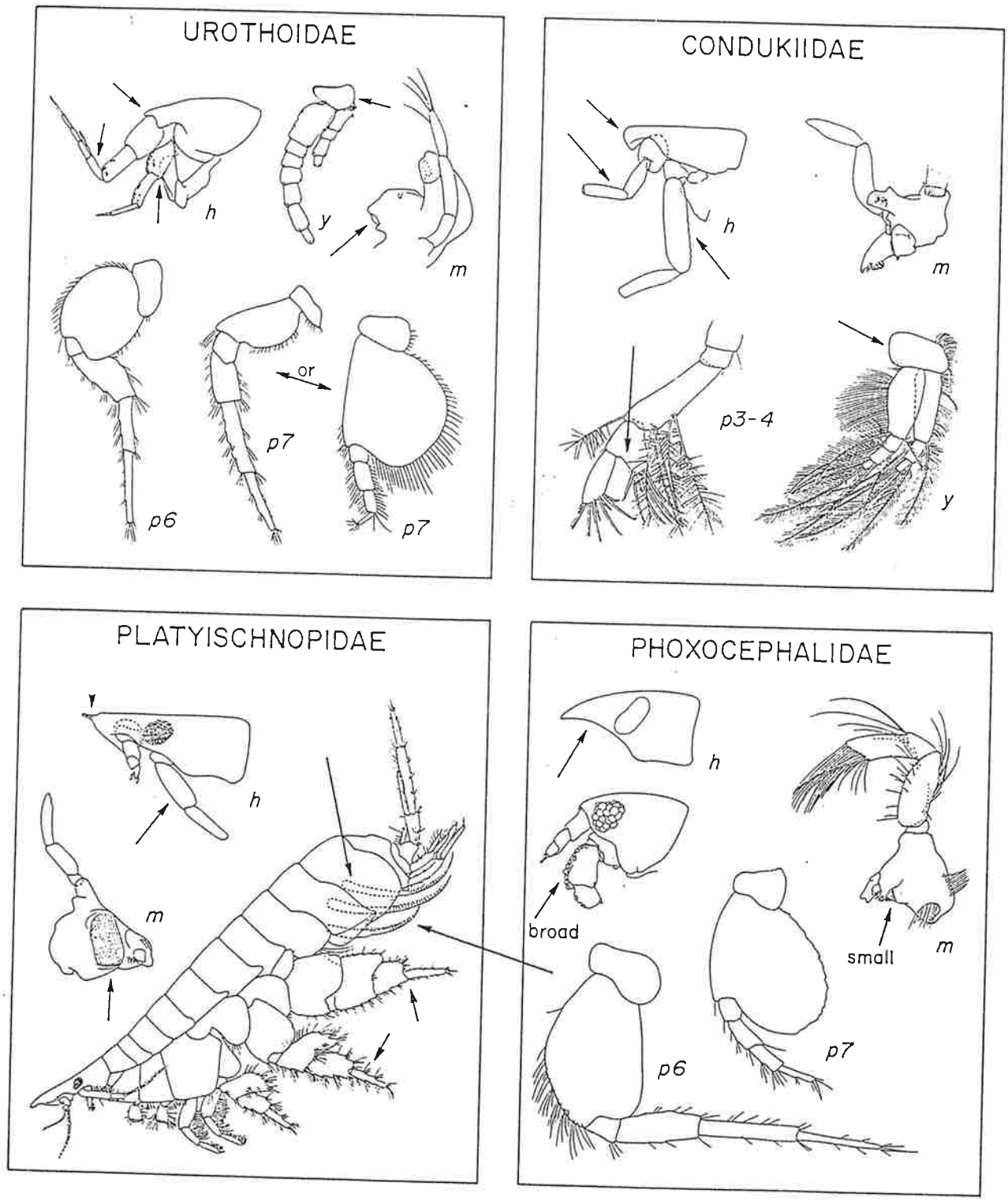

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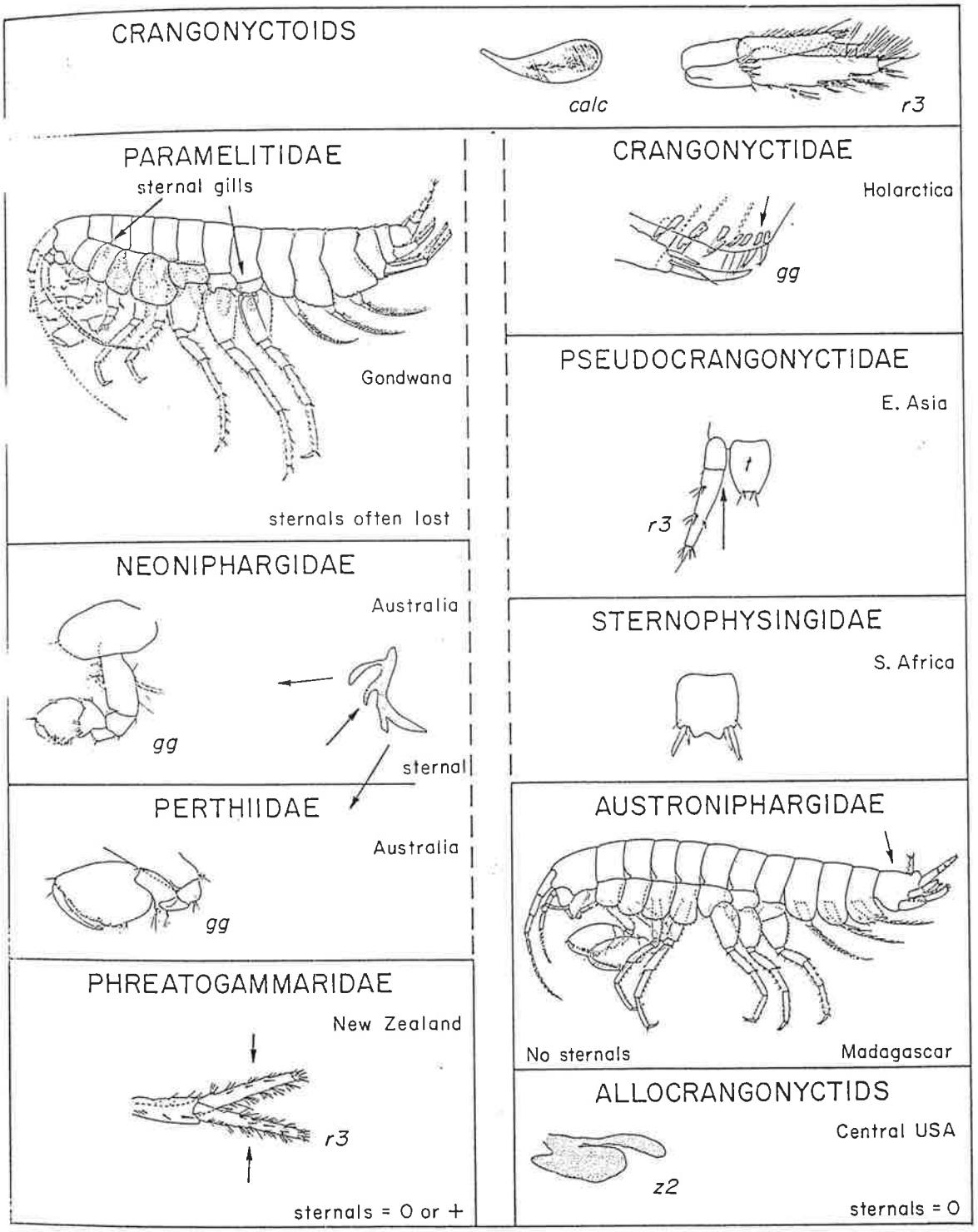

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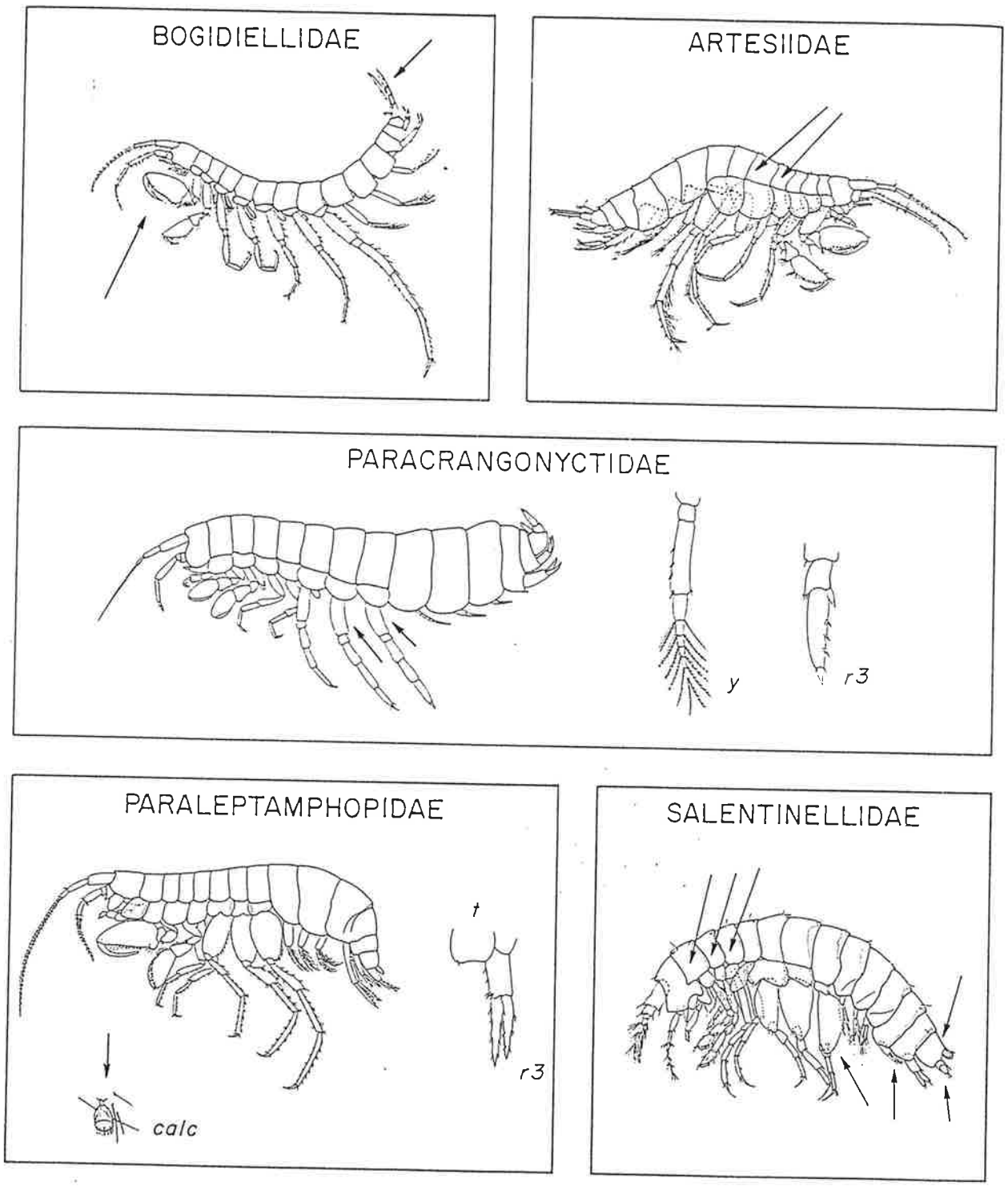

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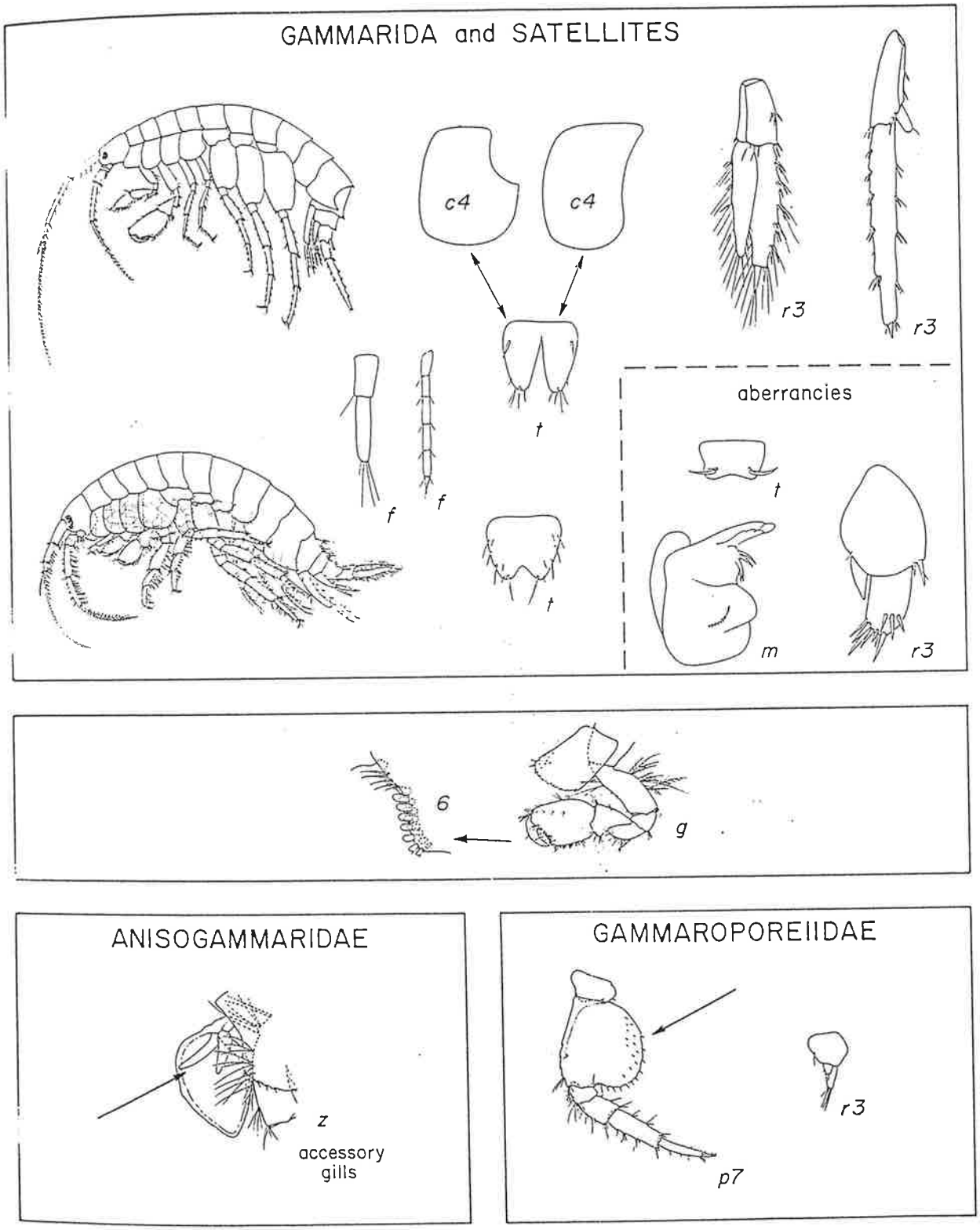

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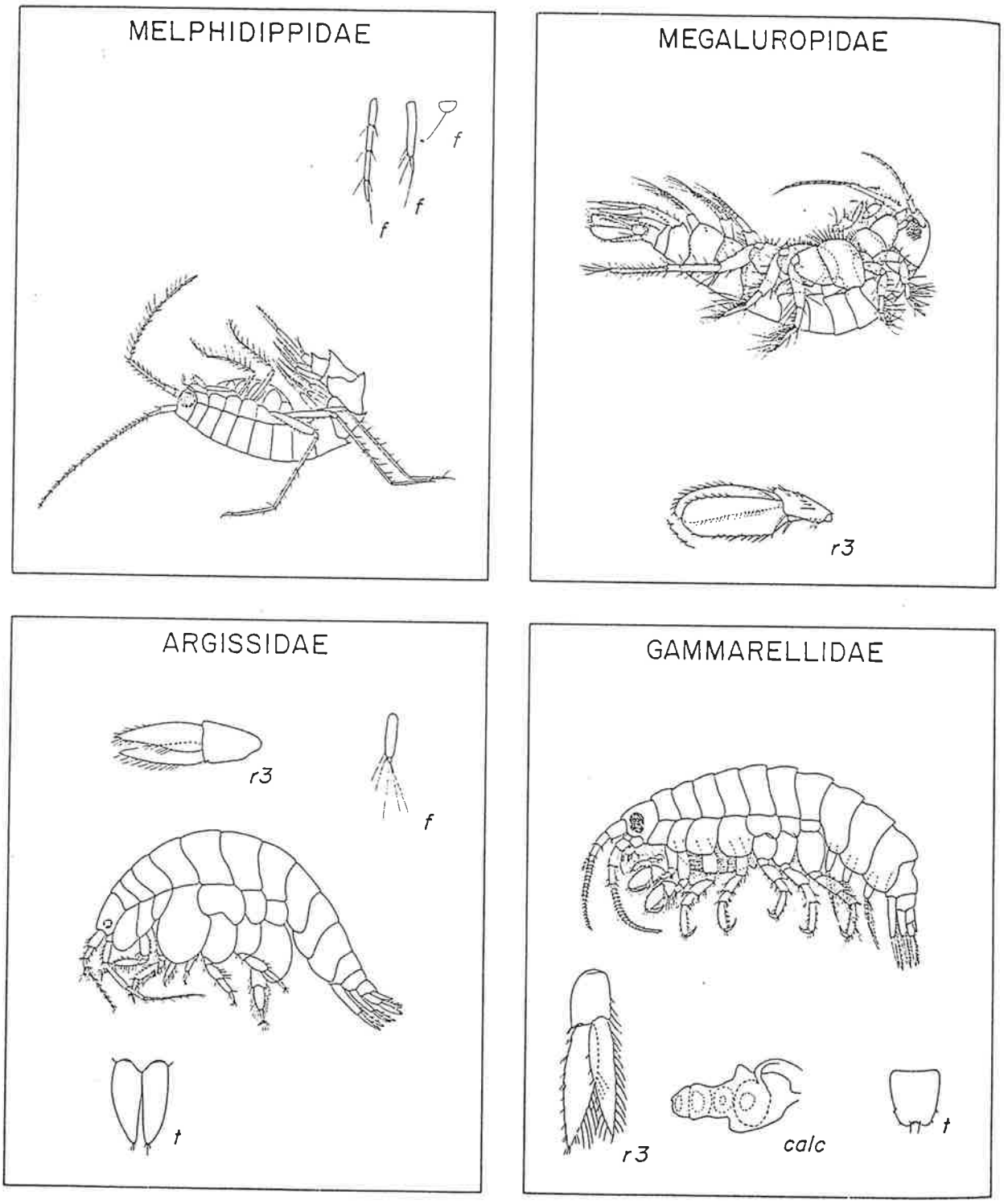

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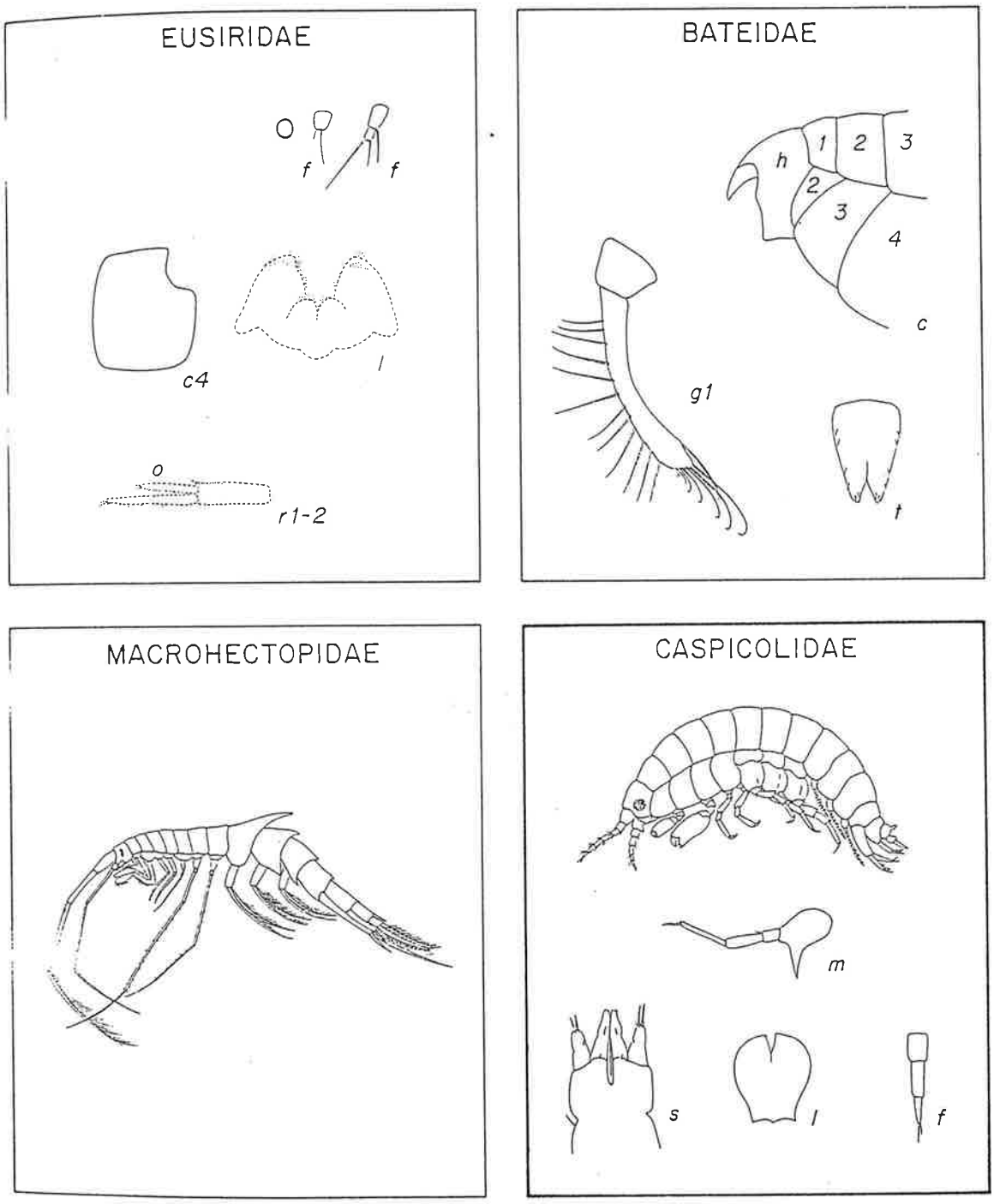

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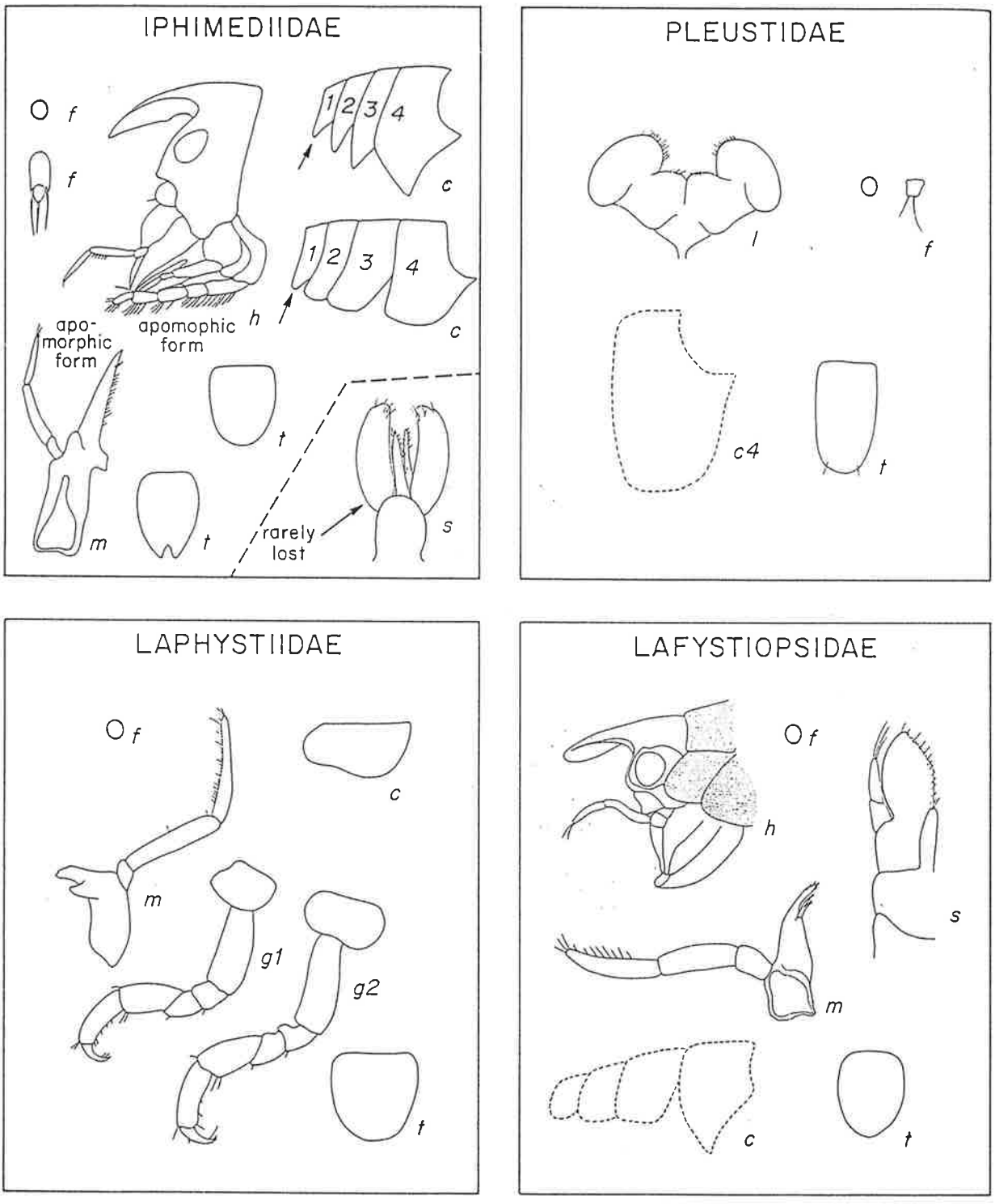

Fig.21. Pictorial key.

List of publications of general applicability to the systematics of the British amphipod fauna published since Lincoln (1979)

Ruffo, S. (ed.) (1982) The Amphipoda of the Mediterranean. Part 1. Gammaridea (Acanthonotozomatidae to Gammaridae), *Mem.Inst.Oceanogr.Monaco*, No.13, 1-364 [ISBN 2-7260-0133-5 , available from Musee oceanographique (Service des publications), Avenue Saint-Martin, Monaco-Ville, MC 98000 Monaco]

Ruffo, S. (ed) (1989) The Amphipoda of the Mediterranean. Part 2. Gammaridea (Haustoriidae to Lysianassidae), *Mem.Inst.Oceanogr.Monaco*, No. 13, 365-576. [ISBN 2-7260-0140-8]
***** a third volume in this series is yet to come, to complete the set***

Sims, R.W., Freeman, P. & Hawksworth, D.L., 1988. Key works to the Fauna and Flora of the British Isles and North-western Europe, 5th edn, *The Systematics Association, Special Volume*, No.33. (Clarendon Press, Oxford), 312pp.

For amphipods of the world, up-dates on Jerry Barnard's (1969) The families and genera of marine gammaridean Amphipoda, *Bull.U.S.natl Mus.*, 271, 1-535. are now available in the form of:-

Barnard, J.L & Karaman, G.S., 1991. The families and genera of marine gammaridean Amphipoda (except marine gammaroids). Part 1., *Rec.Australian Mus.*, Suppl. 13 (Part1), 1-417.

----------, 1991.------- Part 2., *Rec.Australian Mus.*, Suppl 13 (Part 2), 419-866. [available from Assistant Editor (Community Relations), Australian Museum, PO Box A285, Sydney South, NSW 2000, Australia]

Note also: for freshwater amphipods

Barnard, J.L. & Barnard, C,M., 1983. *Freshwater Amphipoda of the world*. 2 vols (I. Evolutionary patterns; II. Handbook and Bibliography), Hayfield Associates, Mt Vernon, Virginia, 1-358, 359-829.

NEWSLETTERS

The **Amphipod Newsletter** appears sporadically when funds and enthusiasts allow.
Contact: Professor Wim Vader, Tromso Museum, 9000 Tromso, Norway
British subscriptions are handled through Dr Mike Thurston, Institute of Oceanographic Sciences, Wormley, Nr Godalming, Surrey GU8 5UB

The **Plankton Newsletter** recently ran an issue devoted to amphipods (Vol 15, December 1991) [Editors: P.H.Schalk & S.van der Spoel, P.O.Box 16915, 1001 RK Amsterdam, The Netherlands]

List of regional works on amphipod fauna relevant to the British Isles (post Lincoln, 1979)

Costello, M.J., Holmes, J.M.C., McGrath, D. & Myers, A.A. 1989. A review and catalogue of the Amphipoda (Crustacea) in Ireland, *Irish Fisheries Investigations*, Ser.B.(Marine), No.33, 70pp.
[available from Government Publications Sale Office, Sun Alliance House, Molesworth St., Dublin 2, Ireland]

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CATALOGUE OF CAPRELLIDS

McCain, J.C. & Steinberg, J.E., 1970. Amphipoda I: Caprellidea I, *Crustaceorum Catalogus* (edited by H.-E.Gruner & L.B.Holthuis) Dr W.Junk, Den Haag, 78pp.

These are not groups which I know much about, but the references above are useful starting points.

The old Linnean Society key to caprellids by Harrison (1944) leaves a great deal to be desired, re-utilising as it does the indifferent figs from Chevreux & Fage. Geoff Smalldon (ex Swansea & Royal Scottish Museum) was working on a replacement for the new Linn.Soc. series when he gave up science. I did have a draft copy of his key, which was a distinct improvement, but I can't find it!!!!!!!!!!! Must have lent it to someone and never got it back. Otherwise I'd have reproduced it for you here.

[FROM BARNARD, J.L. (1969) Bull. U.S. natl Mus. 271]

TIN 271

collections of the British
London.
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Hist., ser. 2, vol. 1, pp.

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owski, Regiomonti, pp.

Appendix I

Dissection of an Amphipod

For Right-handed Operators.

In a flat-bottomed syracuse dish, the amphipod is laid on its left side with its legs projecting away from the operator, so that it appears up-side down through the oculars of the stereoscope. The body is covered to more than twice its depth with alcohol to prevent the effects of surface tension during dissection and to ameliorate the glare of reflected light from projecting legs.

A pair of jeweler's forceps with very fine points, a fine dissecting needle such as an insect pin mounted on a stick of wood, and a coarse, standard dissecting needle are used. At least five standard glass slides, one depression slide, and six thin cover slips are needed. A small drop of glycerine is placed on two of the flat slides, a tiny drop each on three of the flat slides, and the depression-slide concavity is sparingly filled with glycerine (other media are used for permanent mounts; permanent slides have the disadvantage of restricting the manipulation of mounted parts for 3-dimensional observation; parts from glycerine slides may be stored permanently in alcohol in a tiny vial made of a bit of capillary tubing with one end closed by melting in a fire, the other end stoppered with cotton, pith, or plastic foam).

One commences removing the pereopods (legs) of the amphipod at either the fourth or fifth coxa (sideplate) depending on which of these coxae is largest or would pull away from the body without entangling other legs or coxae. The amphipod is up-side down on its left side, being held with a coarse needle in the left hand through a body segment or with forceps or a blunt stick, and the coxa is being pulled and ripped gently at its base with the fine forceps. In most cases the coxa can be pulled free of the body carrying some of its proximal musculature. Occasionally the firmness of the attachment dictates the use of a fine scalpel.

When the coxa is removed, the remainder of the leg and gill (and if a female the brood lamella) will come with it. As the legs are excised identifying marks are noted in order to record the leg sequence for positioning on the slide. Particularly confusing are coxae 3 and 4 because they are often similar in size and shape, as are the last three pereopods.

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Pereopods and gnathopods are removed to one side of the dish until all seven legs have been collected. Antennae 1 and 2 are dissected at their bases (right side only). Care in removal of antenna 2 at its juncture is needed because it often breaks easily at joint 2 or 3.

The seven coxae-legs and two antennae are removed in a group from the dish of alcohol to the flat slide with the largest drop of glycerine. When placed in the glycerine the parts will disperse the drop, but a light breath of air will accelerate evaporation of the alcohol and the amalgamation of the puddle. The legs must be fully immersed in the glycerine to prevent drying and uptake of air bubbles. Do *not* put on the cover slip.

The right uropods 1, 2, and 3, both lobes of the telson, and one member of each pair of the pleopods are removed and placed on two of the flat slides with tiny drops of glycerine; the parts are manipulated, while the glycerine puddles coalesce, and arranged so that their respective dorsal (uropods) and anterior (pleopods) sides are up. A clean cover slip, gripped in the forceps, is lowered horizontally over the glycerine until it can be dropped smartly onto the puddle without engaging air bubbles. Glycerine is to be applied sparingly so as to prevent excessive sliding of the cover slip. If the perimeter of the cover slip lacks glycerine it may be added later by placing a small drop at the edge.

Before removing mouthparts determine whether they are grouped in a coniform or quadratiform bundle from lateral view.

Mouthparts are removed from the head, again with the amphipod head pointing away from the observer so that motion to the right with the forceps can be used to snap off the mouthparts. The maxillipeds, which are the most posterior mouthparts, cover all the other mouthparts and must be removed at their base first; both maxillipeds will come off together. More anteriorly, a pair of bilobed second maxillae is to be removed and then the first maxillae, each of which appears to have three lobes (inner lobe, outer lobe, and palp but in a few genera lacking a palp). The inner lobes are difficult to remove in connection with the outer unless special care is taken and caution must be exercised not to damage the lower lip. Mandibles are removed next; they are usually brittle and easily broken; they are most easily removed by rotating them to ascertain the basal muscular attachment and snipping this with forceps. Sclerotic connections to upper and lower lips also must be broken to avoid their damage. Usually each mandible will have a palp. After maxilla 1 and the mandibles are removed, a lower lip and an upper lip will remain; the lower lip is extensive and for removal must be grabbed deeply in its muscular and tendon attachments without separating the inner and outer lobes. After practice one may desire to remove lower lips before dissecting

mandibles as the two mouthparts often are closely connected with tissues and the mandibles will tear the lower lip when being removed.

The upper lip and epistome are not removed from the head at this time. Their interrelationship from lateral view must be preserved. The observer should note the condition of the ventral margin of the upper lip from anterior view (rounded, incised, truncated) before mounting the carcass on the depression slide.

Mouthparts are transferred to a tiny drop of glycerine on a flat slide, arranged in sequence and fitted with a cover slip. Preferably the mouthparts are arranged so that the following parts project upward or are on top: mandibular molars and the inner lobes of lower lip, maxillae, and maxillipeds. If the base of the maxillipeds curves upward, it may be cut off so that the cover slip will set firmly. The mandibles should be arranged with the molars projecting obliquely toward the observer or directly lateral, if the center of gravity so permits. Often mandibles are placed on a separate slide with supports for the cover slip to prevent crushing. Supports may be made of wire or sand grains.

Because a unilateral dissection has been made, the remaining amphipod carcass has a complete set of pereonal and pleonal parts remaining on one side (the left if done by a right-handed operator). Coxa 1 and any other (left) legs are removed which would obscure the head and pleon from lateral view. The carcass is mounted right side down in the glycerine of the depression slide and a cover slip firmly set. If the amphipod is so large that it will be crushed by the cover slip or lie in a tilted position, two pieces of wire of appropriate thickness (or variously thick insect needles, pins, paper clips cut with nipping pliers) are placed on each side of the amphipod, which is covered with sufficient glycerine to fill the area between the two wires, and the cover slip set on the supports. The top glass should fit the carcass snugly so as to hold it in place but not to crush it. Glycerine has sufficient surface tension so that it will not leak out from under the elevated coverslip as long as the slide is kept in a horizontal position.

One now returns to the first flat slide on which were placed the seven right pereopods (including gnathopods) and the two right antennae. They are arranged in order from anterior to posterior in two rows. Gills from legs 2 to 7 (or 2–6 or 2–5) are removed and placed in sequence on the fourth flat slide of glycerine. If the animal is a female, the brood lamellae are removed in sequence and placed in a row on another slide. At this stage one is working from glycerine to glycerine without the effects of a change in surface tension so that it is easy to keep the parts in order, making notes of characteristics that will permit proper orientation. Cover slips are set in place.

If the amphipod species is dimorphic, a slide of antennae, gnathopods, and uropod 3 of the other sex should be prepared for rapid identification; but a full dissection should be prepared for descriptive purposes.

Parts of greatly differing thickness should not be intermingled on the same slide as the thinner parts will not be properly fitted by the cover slip. Delicate parts may need artificial support of the cover slip as noted above in discussion of the mandibles. Dirt may be removed from heavily setose appendages by use of a fine camel's-hair brush.

Eventually the student will gain sufficient experience for examination of most parts without dissection. Even mouthparts can be partially to fully examined by careful manipulation under a fine stereoscope with adequate 2-directional light sources. Mandibles often can be rotated for viewing molars without their complete removal. This protects unique specimens from unnecessary damage or loss of parts, or the need to mount parts permanently.

The taxonomist anticipating a need to illustrate the organism will leave the telson and the left first coxa attached to the carcass so that a full lateral view of the amphipod is preserved. The telson can be removed for flat mounting after the lateral view is drawn. Usually the left legs distal to their coxae are removed and mounted. The lateral in toto drawing represents a composite reconstruction of body and coxae drawn first, with legs superimposed on the drawing by use of a microprojector or camera lucida in which degree of magnification can be replicated. In this way legs are attached to the body drawing in perfectly flat but somewhat unnatural condition. One must determine accurately the attachment loci of the legs to their coxae by study of the proposed slides 5 and 6 noted below. Generally, it is preferable to make slides of the following composition if illustrations are to be made.

1. Depression slide with carcass.
2. Mandible, maxilliped, lower lip, with support for cover slip.
3. Maxillae, 1, 2.
4. Antennae 1, 2, with support for cover slip to allow rotation and examination of all surfaces by movement of cover slip.
5. Gnathopod 2, if especially thick.
6. Gnathopod 1 and pereopods 1–5.
7. Pleopods 1–3.
8. Uropods 1–3, with support for cover slip to allow rotation of parts.
9. Telson (removed from carcass after lateral illustration).
10. Upper lip and epistome (removed from carcass after lateral illustration).
11. Left legs, except for their coxae.

12. Gills, with support for cover slip.
13. Brood lamellae.

Very frequently, preserved amphipods have broken appendages. Sometimes the loss of uropod 3 is a consistent occurrence especially in gammarids and oedicerotids. So few Gammaridea lack a third uropod that the first assumption always should be that the part has been removed accidently and close examination should be made for sockets and musculature indicating the loss.

Antennae are often broken and such specimens should be avoided until experience is sufficient to recognize amphipods by other means. In the photid-corophiid complex, legs (except gnathopods) and antennae are frequently autotomized when the animals are preserved, and specialists usually have found other means of identification in those families.

The ecologist making a study of a single species should be prepared to take special care in preservation of his material to ensure completeness of the specimens. He may find slow dilution of seawater or special anesthetics suitable to kill the organisms slowly and to prevent autotomy.

[from. HUYS, R. & BOXSHALL, G.A. (1991) copepod evolution Ray Society]

hosts and accumulate in the sediment on the floor of the container. They are collected by filtering the wash water through a fine mesh net. Rapid washing of the marine invertebrate hosts in 5% ethanol in seawater produces few, if any copepods. Maceration of the host by mechanical means obscures any associated copepods in the resulting mass of debris and mucus. For some endoparasites it is necessary to dissolve the host's tissues with aggressive chemicals. Extraction of mesoparasitic copepods, which attach to their hosts via an embedded anchor process, can be achieved by cutting out a 'steak' of the fish large enough to contain all the anchor. This is left in saturated potassium hydroxide overnight at 20°C. The tissues of the fish host dissolve, as do the internal tissues of the copepod, leaving the intact exoskeleton of the copepod showing the undamaged form of the anchor.

Kabata (1985) provided a useful overview of how to recover copepod parasites from dead fish. The fish host is examined according to a set procedure, working through the fish beginning with the outer tissues and proceeding gradually inwards. In this way each tissue is observed intact *in situ* before it is disturbed by dissection.

2. MICROSCOPIC METHODS

A stereomicroscope with swinging arm stands is recommended for dissection as it minimises disturbance. In order to reveal structural details and external coloration, it is necessary to study large calanoids and most fish parasites with inclined incident light. Incident light can heat up the dissection dish when ordinary lamps or low voltage lamps are used so cold light sources are recommended. These offer the greatest brightness and best focusing capacity for observations under high power. Sorting and dissection of small copepods is best achieved with transmitted light using a total magnification of at least 40x but up to 240x is desirable. A compound microscope (bright-field) with a set of objectives including a 100x oil immersion objective is necessary for routine analysis of preparations on glass slides. However, the use of interference contrast illumination is recommended for descriptive purposes. Interference contrast illumination produces a conspicuous 3-dimensional image of all unstained, transparent objects, including the finest details and the images are free from halos.

Minute linear structures which scatter light are often visible under dark-field illumination, even if their thickness is below the resolving power of the objective. However the objects might not be represented with absolute accuracy.

Inverted microscopes for transmitted light are highly recommended for observation of living material in chambers, petri dishes, etc., and for identification without dissection. The advantages are the large working distance which allows the use of tall culture dishes, and the retention of image sharpness at high magnifications.

Linear measurements of copepods and their limbs are made using an eyepiece micrometer whose scale division appears together with the image of the object to be measured. Calibration is performed against a stage micrometer which is usually a glass slide with an engraved scale, 1 or 2 mm in length and divided into 100 or 200 intervals respectively. When drawing with the aid of a camera lucida a scale should be added to the drawing using a stage micrometer at the same objective/eyepiece combination as used for tracing.

3. LIVE OBSERVATIONS

3.1 Mounting

Short-term observations can be made on specimens placed on an ordinary slide in a drop of water, preferably from the same habitat, and covered with a coverslip. Water may be gradually removed with a small piece of filter paper until the animal is immobilised. For larger and soft-bodied animals the edges of the coverslip should be supported by small flecks of wax or by fragments of coverslip. Long-term studies of behaviour using cinematography or video-recordings are typically

performed in special observation chambers which reduce evaporation (see Westheide & Purschke, 1988 for different types).

Artificial sand systems have been used to study the behaviour of meiofaunal copepods. These are designed to simulate the natural conditions. Coineau & Coineau (1979) constructed a transparent model based on small resin casts made from moulds which in turn were prepared from blocks commonly used in the printing industry. A similar but more natural model was designed by Giere & Welberts (1985) by photographic transfer of the normal sand grains to a plastic mould using modern block-generating techniques. Micro-agar plates are also useful for culturing and making live observations on copepods (George, 1975).

3.2 Narcotisation

Freshly collected copepods that are preserved with formalin typically exhibit severe reactions to the preservative before they die. These reactions are often expressed in violent movements that cause ejection of gut contents and dropping of egg sacs, rendering such samples almost useless for analysis of food habits and measurements of secondary productivity. Narcotisation before preservation is therefore recommended. Many of the narcotisation methods may be used for temporarily anaesthetising copepods and allowing their subsequent recovery after observations have been made. Preferably, the animals should not be transferred directly into the narcotising solution because the amount necessary for relaxation depends on the species involved. The anaesthetic should be added drop by drop, gradually replacing the original fluid until the copepods are immobilised.

Gannon & Gannon (1975) recommended carbonated water, chloroform and methyl alcohol as the best agents to narcotise freshwater crustacean zooplankton. Carbonated water (1 volume to 20 volumes of lake water) is preferred because it is cheap, readily accessible everywhere, and easy to use in the field. Both McKay & Hartzband (1970) and Hulings & Gray (1971) preferred propylene phenoxetol for meiofaunal copepods. One volume of a 1.5% stock solution should be mixed to ten volumes of seawater and poured over the sample. The induction time is about 30 minutes. In general, a magnesium chloride solution isotonic to seawater (about 7.5 g $MgCl_2.6H_2O$ dissolved in 100 ml distilled water) is suitable for marine species; the specimens must remain for 10 to 15 minutes before being transferred into fixative.

3.3 Vital staining

Copepods are small organisms and their erratic swimming makes them difficult to observe alive. Vital staining increases their visibility and is useful in making behavioural observations. Various water soluble dyes are available but the basic dyes Neutral red and Methylene Blue are preferred because they are the least harmful to the copepods. *Intra vitam* staining (Dressel et al., 1972) with Neutral Red vividly stains live copepods, providing a rapid technique for sorting dead copepods from live ones. Copepods are placed into fresh or seawater containing the vital stain and only live individuals take up the stain. Copepod eggs are inconsistently stained by this technique. Anstensrud (1989) used Neutral Red to mark particular developmental stages or individuals and, unless the specimens were overexposed, found that the stain had negligible or no effect on the survival and behaviour of the parasitic copepods.

3.4 High-speed cinematography

Studies using high-speed, high-magnification microcinematography allow direct observations of food capture and handling by tethered animals and the analysis of swimming and foraging patterns of freely swimming copepods. A detailed description of the optical pathways employed to observe swimming calanoids and their feeding behaviour is presented by Strickler (1985).

4. FIXATION AND PRESERVATION

In practice it is advisable to use two separate fluids, one for fixation and another for preservation.

Most fixatives are designed for rapid effects on tissues but lead to excessive hardening when used as a preservative over long periods. Furthermore, most fixatives are not suitable for open-dish use because they are corrosive or toxic.

Formalin: Copepods are most conveniently fixed and preserved in 5% buffered formalin solution. This low concentration reduces the tendency of formalin to make copepods brittle. This effect is significant when using higher concentrations but can be ameliorated by adding glycol (2 to 5% propylene glycol) which has the capacity for maintaining flexibility of tissues and joints in arthropods. It is also a powerful inhibitor of fungal growth and appears to assist in the penetration of formaldehyde as a fixative (Steedman, 1976). It is vital to buffer the formalin solution at a minimum pH of 8.2. Suitable buffers for commercial formalin are borax (sodium tetraborate) or hexamethylene tetramine which are added in an amount of 200 $g.l^{-1}$.

Ethanol: Alcohol, although frequently used for museum collections, is less appropriate for preservation because it leads to brittleness, destroys the colour, and leaches the tannins out of cork stoppers and transfers them to the animals, turning them brown or black. The yellow colour of alcohol solutions containing planktonic copepods is generally due to dissolved oils and fat. Transferring such solutions to formalin may result in the deposition of a thin, slimy film on the specimens. Ethanol also produces a milky precipitate with sea water, its dissolved salts being thrown out of solution and often deposited on the specimens obscuring minute morphological details. When diluted with water it becomes too weak to kill bacteria and loses its preservative power. A further disadvantage is that it evaporates rapidly under the stereomicroscope thereby creating currents which make the specimens whirl around uncontrollably during open-dish sorting. There are advantages occasionally in fixing in formaldehyde and then transferring to 75% ethanol.

Preservative for zooplankton: Steedman (1976) recommends a solution made up of propylene phenoxetol (0.5 ml), propylene glycol (4.5 ml) and distilled water or sea water (95 ml) and may easily replace old formaldehyde solutions.

Other preservatives: Many authors claim that the use of glycerine in preservative recipes is advantageous. In general, glycerine can be used to help retaining colours. Volkmann (1979) used aqueous glycerine (2 volumes of glycerine + 1 volume of distilled water) in order to retain the natural colour patterns of *Tisbe* species. Adding a branch of fresh red algae and storing the specimens in the dark might also help (Hamond, pers. comm.). Glycerine also acts as a safeguard against drying up should the vial be imperfectly sealed. Hamond (1969) recommended a preservative made up by 40% formalin (1 part), glycerol (2 parts) and distilled water (15 parts). Scourfield (1946) suggested the following recipe as the best preservative for freshwater cladocerans and copepods; 100% formalin (1 part), absolute alcohol (2 parts), glycerine (1 part), distilled water (12 parts) and a trace of glacial acetic acid.

5. RESTORING DRIED-OUT SPECIMENS

Specimens can dry out as a result of a cracked lid of a vial, bad packing for shipment, or any of a number of other reasons. In order to allow restorative chemicals to penetrate the body tissues air must be expelled from the specimen. Ellis (1981) recommended either direct immersion into 80% IMS (industrial methylated spirit), or, when the specimen fails to sink, the application of gentle heat until the solution reaches boiling point, immediately after which the container should be allowed to cool. Following this procedure the specimen is placed into distilled water and relaxed using different chemical treatments (see Ellis, 1981: 122 for more information). Jeppesen (1988) satisfactorily rehydrated various crustaceans by placing them in a solution of Decon 90 or dioctyl sodium sulfosuccinate ($C_{20}H_{37}NaO_7S$), subjecting them to repeated application of vacuum/equalisation at room temperature for 24 hours, rinsing in water and finally transferring to the desired preservative.

A restorative solution which has proved to be extremely effective for small crustaceans where little swelling is required, is trisodium phosphate ($Na_3PO_4.12H_2O$). Van Cleave & Ross (1947) used a 0.25-0.5% solution, briefly heated the specimens and left them to stand for about 1 hour

whilst cooling. Harding (1956) preferred a 2% solution which generally is sufficient to break down clinging organic matter. Thompson et al. (1966) obtained fairly good results using a mixture of equal volumes of distilled water and ethylene glycol. Dried specimens were completely restored in 12 to 24 hours. Specimens were transferred from the ethylene glycol solution to 50% and then to 70% ethanol. Lactic acid, potassium hydroxide (KOH), sodium carbonate (Na_2CO_3) and a mixture of glycerine and water are also frequently used but seem to cause deterioration of the tissues.

6. SLIDE PREPARATIONS

6.1 Clearing

Prior to dissection the specimen must be cleaned of any attached detritus. This can be achieved by repeatedly sucking up and discharging the specimen into a vial or watch glass, half-filled with water, using a pasteur micropipette, or by vigorous shaking in a small vial two thirds full of water.

Dissection is best achieved on cavity slides with the specimens immersed in a viscous fluid that also serves to clear the specimen. Glycerol and propylene glycol are widely used but lactic acid is a better clearing agent. Lactic acid renders the cuticle more supple and may be used as a temporary clearing agent. Over an extended period it will soften most tissues to a point at which they disintegrate. Most clearing media are hypertonic and specimens have to be protected from collapsing by sudden loss of internal fluids. This can be achieved by penetrating the exoskeleton with a dissection needle, or by soaking in a 50% aqueous solution of the medium before transfer to the undiluted mountant.

Examination of integumental structures is considerably facilitated by removal of internal tissues. This can be done by carefully warming the specimens in 10% KOH by weight in distilled water at about 90°C for 1-2 hours. After rinsing the exoskeleton in distilled water and subsequent staining in an aqueous Chlorazol Black E (1%) solution for about 10-20 seconds, the specimen can be transferred to glycerol for examination. Pepsin can be used to dissolve soft tissues but usually does not work on formalin-fixed animals.

6.2 Staining

Staining with Rose Bengal, Lignin Pink or Chlorazol Black E may facilitate sorting of copepods from sediments or extraction residues and may give some benefit under bright field microscopy, but it is preferable not to stain when using Nomarski interference contrast microscopy. Rose Bengal can be employed either at the time of preservation or on samples already partly processed. Formalin fixed samples can be stained with 10 ml of 1% Rose Bengal solution (1 g Rose Bengal in 1 l of 10% formalin). Rose Bengal stains best at a pH of 4-5, however it obscures natural colour patterns and fine structural detail. Borax carmine stains all crustaceans and other small zooplankton red and facilitates their recognition in plankton samples (Nichols in Steedman, 1976). This method is particularly useful for the identification, staging and enumeration of nauplii and early copepodid stages, since they are virtually transparent even after fixation.

According to English & Heron (in Steedman, 1976) Solophenol blue 2RL (= Chlorantine fast blue 2RLL) can stain some copepod structures slowly and selectively to a pale mauve shade, this contrasts with most dyes (e.g. Chlorazol Black E, Ligin pink) which penetrate the chitin so quickly and stain so intensely that morphological details may be obscured. Specimens are gradually immersed and briefly soaked in a few drops of a mixture of about 10 mg Solophenol blue 2RL per ml lactic acid.

6.3 Mounting and sealing media

Alcohol-soluble mounting media: Euparal is an excellent mounting medium for stained sections and whole mounts. Even old preparations can be dissolved in 95% ethanol for remounting.

Hydrocarbon-soluble mounting media: Canada balsam dissolved in xylene, benzene or chloroform is particularly useful for whole mounts because of its high solids content. A disadvantage is that Canada balsam mounts darken with time, eventually assuming a dark amber colour.

Water-soluble mounting media: Suitable media are Hoyer's or Faure's medium, 10% glycerin in 95% ethanol and Zeis W15. The latter is recommended because of its unsually high refractive index of 1.515. The original recipe of Hoyer's medium contains 200 g chloral hydrate but Higgins' (1983) modification reduced this amount to 100-125 g to prevent overclearing of specimens. Higgins further recommends the addition of 2 g iodine crystals and 1 g potassium iodide.

Lactic acid & Berlese's fluid: These media should not be used as mountants because of their strong clearing properties.

Gurr's Neutral Mounting Medium: Hockin (1980) proposed using Gurr's neutral mounting medium as an alternative to acidic mounting media such as Canada balsam and Polyvinyl Lactophenol. It is a slow-drying medium so that the specimens can be positioned and arranged precisely. It is recommended for some interstitial copepods which are sensitive to other mountants.

Polyvinyl lactophenol: This is widely used but is not recommended for type collections since it overclears the preparation within about ten years. The mountant is also gradually replaced by rosettes of long thin crystals and often dries out if not sealed.

Lactophenol: This is by far the best medium for microscopic preparations. It does not have a strong clearing effect and allows the preparation to be remounted in a more suitable orientation, even after a long period. It consists of melted phenol crystals (30 ml), lactic acid (10 ml), glycerol (20 ml) and distilled water (10 ml). Preparations have to be sealed. Many commercial sealants such as Araldite, Murrayite, Bioseal, and Glyceel are available.

6.4 Dissection

The dissection medium depends on the mountant used. Both Reyne's and Hoyer's media are aqueous based and therefore the specimen has to be dissected in water. For lactophenol and polyvinyl lactophenol the dissection is done in lactic acid. Dissection is performed using two dissecting needles made from ca. 0.2 mm diameter tungsten wire projecting about 2-3 cm from a holder (pin vice or glass capillary tube). The tip of the needle can be sharpened by electrolysis using a 6-volt supply (a stereo microscope lamp transformer is suitable), where the needle is dipped in a saturated solution of potassium hydroxide. The immersed part of the needle must be dipped repeatedly and gently in and out to give the desired shape of the point.

Another method for sharpening needles is based on anhydrous sodium nitrite (Wells, 1988) but is not recommended here as it can be dangerous. Crystals of $NaNO_2$ are carefully melted in a crucible to give a deep yellow liquid. When the end of a thin wire is dipped into this, a ball of incandescence forms at once on the tip below the liquid surface and migrates rapidly up the wire into the open air, where it vanishes, leaving the end of the wire eroded to a fine point.

The following dissection technique is recommended for routine identification work:

1. Dissection is carried out under maximum magnification (at least 40x) and entails using one needle to hold the specimen steady on its side, while using the other needle to cut laterally through the body somites.

2. First hold the prosome and cut away the urosome, then proceed anteriorly to divide the prosome into the individual pedigerous somites together with their respective appendages and finally tease off the first swimming legs from the cephalothorax.

3. The head appendages should then be separated from the cephalic shield. In practice it might be possible to dissect all the mouthparts when dealing with large species, however in smaller animals only the antennules, antennae and maxillipeds might be successfully removed.

4. Place a streak of polyvinyl lactophenol (or Reyne's mountant) transversely across the centre of the slide.

5. Transfer each part as it is dissected, to the mountant on the point of a dissecting needle to its equivalent position in the streak. The urosome should be mounted ventral face up (in podopleans the fifth leg can be separated at this stage). It is crucial that the swimming legs are mounted in the correct order (particularly the second to fourth swimming legs which are often very similar) and anterior face upwards.

6. In order to avoid the dissected parts floating around when the coverslip is placed on top, allow the mounting medium to become tacky. Place a cross of mountant on a coverslip or a drop of mountant on top of the streak and gently lower the coverslip into position.

7. Note the positions of the dissected parts on an adhesive label.

An alternative method is to mount each element in one of six drops of polyvinyl lactophenol, placed within a 15x15 mm area and cover all the drops with a small coverslip. Using this method there is little risk of transposing the limbs but it is inconvenient for examination, especially under oil immersion. Here, the position of each element can be labeled on the underside of the slide with a fine indelible pen.

For detailed taxonomic studies it is necessary to dissect out all the cephalothorax appendages, to separate the fifth leg from the urosome (in podopleans) and to ensure that the legs are mounted anterior face upwards. It is recommended that each of the dissected parts is mounted on a separate slide, or, in the case of minute species, that the head appendages are mounted separate from the swimming legs, and the latter from the urosome. Alternative dissection strategies are described by Hamond (1969) and Coull (1973).

6.6 Mounting

The Cobb metal slide frame preparation holds a double coverglass mounted preparation and allows the microscopic examination of copepod from either of the two surfaces. This technique was introduced for harpacticoids by Perkins (1956) and was also used by Humes & Gooding (1964). A recent variation of the Cobb slide is the Higgins-Shirayama slide which consists of two standard microslide-sized pieces of plastic fused into a single unit the same thickness of a standard slide. It allows for a more precise centering of the specimen at a level equidistant between the upper and lower surface of the finished preparation.

The open-mount technique described by Humes & Gooding (1964) offers the advantage that a single specimen can provide a full set of observations, since dissection can be stopped at any point and the results examined or drawn under the compound microscope even with oil immersion. With the slide upside down the dissected parts are placed in a small drop of lactic acid on the exposed surface of the coverslip. The animal may then be examined under the compound microscope by inverting the slide. The dissected parts are thus hanging in a drop of fluid and are not exposed to any compression. For permanent preparations the dissections can be covered with Hoyer's medium and a smaller cover slip which allows the mounted specimen to be examined from both sides.

The mounting procedure we have used in the course of this study is extremely simple. The specimen or the dissected part is mounted in lactophenol in a 'sandwich slide', i.e. the coverslip is supported on both sides or on one side, by fragments of broken coverslip or by complete coverslips. The number of supporting coverslips required can be adjusted according to the thickness of the specimen. The art of making a sandwich slide is to pinch the specimen just enough to hold it in position without squashing it out of shape. The pressure of the coverslip can be regulated by sliding the supporting coverslips in or out rather than by the addition or subtraction of lactophenol. It is extremely important in the analysis of segmentation patterns that limbs are viewed in their natural shape and configuration. Ordinary mounting techniques inevitably result in squashing of the dissected parts, thereby distorting length:width ratios and the 3-dimensional structure. Folds and depressions are heavily accentuated in squashed preparations and can be misinterpreted as genuine segmentary boundaries such as the alleged praecoxa-coxa boundary in the maxilliped of the Oithonidae. A second advantage of this technique is that it allows the specimen or the limb to be re-orientated by manipulation of the top coverslip so that it can be

HOW DO YOU TELL THE SEX OF AN AMPHIPOD?

The sex of a juvenile amphipod cannot be established. Sexual differentiation begins at a particular moult, the number of which may vary between species and within a species with season. Females develop fully functional, and increasingly marginally setose, brood plates (oostegites) on peraeopods 2-5 (2-4 in podocerids) gradually over a series of moults. Oostegites are attached medial to the gills (branchiae) and arise from the medial base of the coxal plates. At the moult at which a female becomes sexually mature the brood plates become fully setose and these interlocking and overlapping plates form a ventral chamber - the brood pouch or marsupium - which holds the eggs during development.

The openings of the paired oviducts are situated laterally on the sternum of peraeon segment 5. In males the reproductive openings occur on paired penial papillae lateral to the mid-line on the ventral surface of peraeon segment 7. Males usually have secondary sexual development of the 2nd gnathopods (1st in Aoridae)and often of the 2nd antennae also. These features also develop gradually over a series of moults after sexual differentiation.

THUS CHECK: PRESENCE OF PAIR OF COXAL OUTGROWTHS IN VENTRAL GUTTER OF PERAEON (may only be buds) FOR A **FEMALE**
PRESENCE OF ENLARGED GNATHOPODS / PENIAL PAPILLAE FOR **MALE**
IF NONE OF THESE THINGS VISIBLE IT IS A **JUVENILE**

**** Occasionally, intersex individuals may be met with. These have oostegites + male gnathopods. Reports of this phenomenon come mainly from work on gammarids and talitrids****

Breeding biology of amphipods

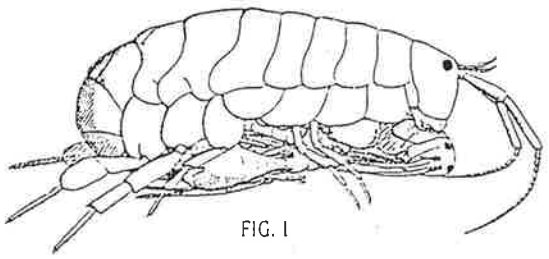

FIG. 1

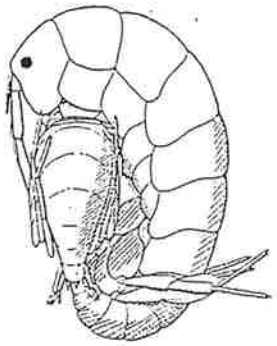

FIG. 2

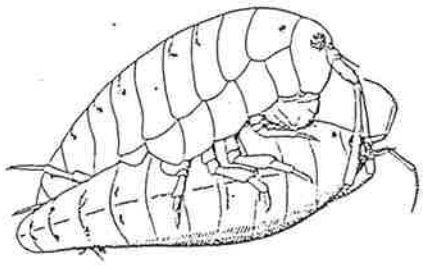

FIG. 3

FIG. 1. Mating in *O. gammarella*: male carrying female
FIG. 2. Copulation in *O. gammarella*.
FIG. 3. Copulation in *T. saltator*.

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A selection of recent papers on amphipod breeding biology which summarise most literature:-

Borowsky, B., 1991?. Patterns of reproduction of some amphipod crustaceans and insights into the nature of their stimuli. In, *Crustacean sexual Biology*, Bauer & Marrin (eds), Columbia University Press, N.Y., pp.33-49.

Conlan, K.E., 1991. Precopulatory mating behavior and sexual dimorphism in the amphipod Crustacea. *Hydrobiologia*, 223, 255-282.

Powell, R. & Moore, P.G., 1991. The breeding cycles of females of seven species of amphipod (Crustacea) from the Clyde Sea area. *J.Nat.Hist.*, 25, 435-479.

Sainte-Marie, B., 1991. A review of the reproductive bionomics of aquatic gammaridean amphipods: variation of life history traits with latitude, depth, salinity and superfamily. *Hydrobiologia*, 223, 189-227.

Steele, D.H., 1991. Is the oostegite structure of amphipods determined by their phylogeny or is it an adaptation to their environment? *Hydrobiologia*, 223, 27-34.

six successive moults, hence producing six broods, once having reached maturity. The number of broods produced per female may, however, vary.

Embryonic development

In gammarids, sexual maturity is achieved long before maximum size is reached. Mating involves an initial period of pairing, towards the end of which the female moults, and the male deposits sperm in the open brood-chamber.

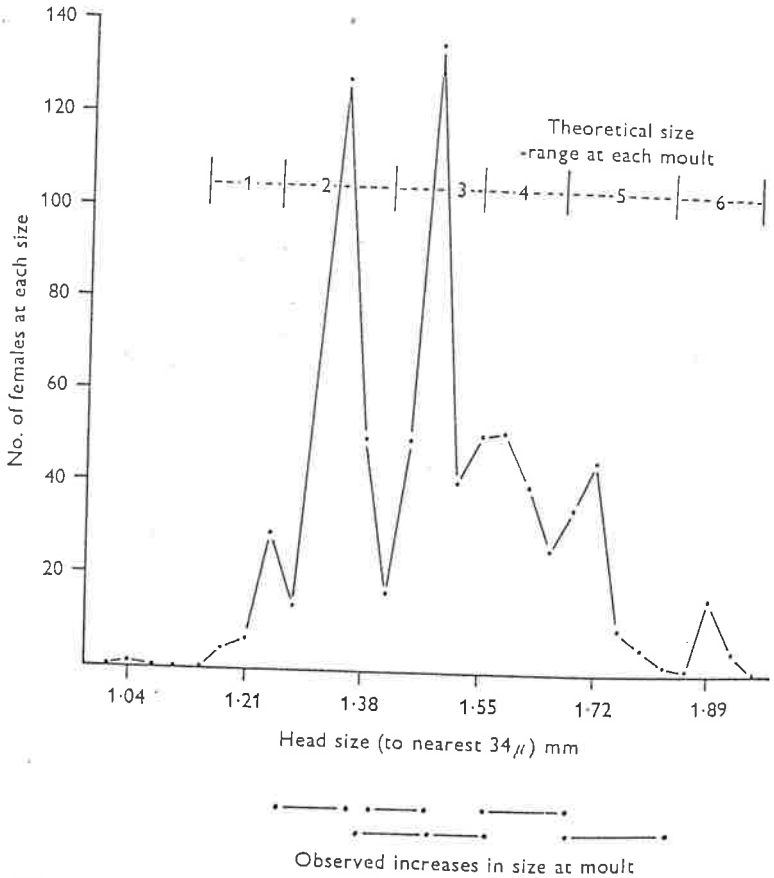
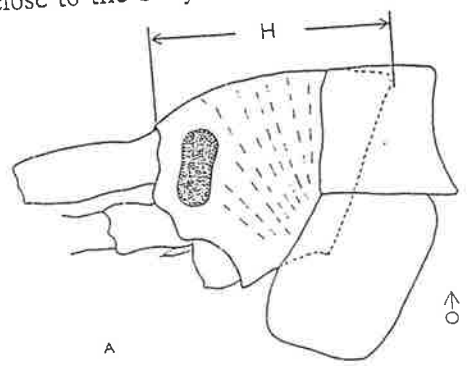


Fig. 2. Size range of females. Observed increases in size during moults and a theoretical increase in size during a maximum of 6 moults is indicated.

The pair separate and the female releases her eggs into the brood-chamber where fertilization occurs.

The male of *M. obtusatus* pairs with a female which is carrying or has released her young, or more rarely, it will pair with a female carrying eggs almost ready to hatch. During the period of pairing the male carries the female

using his second gnathopods which are inserted under the edge of the tergum of the first peraeon segment of the female. Other limbs are often used to hold the female, who in turn assumes an inactive position with the limbs held close to the body.



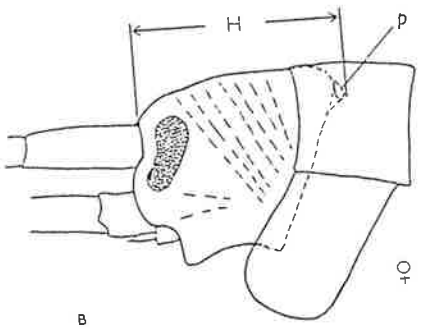


Fig. 3

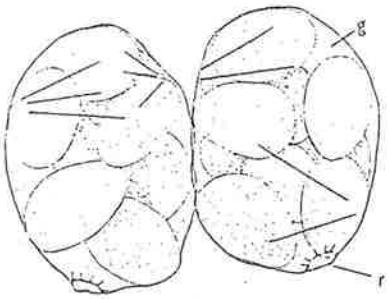


Fig. 4

Fig. 3. Diagram of the head of (A) a male and (B) a female. Mature female has a laterally situated posteriorly projecting process (*p*) on the head. 'H' represents the head length.

Fig. 4. Newly laid egg masses, consisting of eggs in a gelatinous matrix. This female was large, and the brood-chamber contained a total of 19 eggs. *g*, Gelatinous sac; *r*, region of attachment to the opening of the oviduct.

The term 'egg' is used in this report synonymously with 'embryo', representing all developmental stages before hatching.

The embryonic development of *M. obtusatus* is essentially similar to that of *Gammarus pulex* which has been described in detail by Weygoldt (1958). The following description is mainly for the purpose of completeness.

After deposition of sperm in the brood-chamber of a newly moulted female, eggs, usually two at a time, one from each oviduct, are found to be released together with a gelatinous substance. Initially the eggs are of variable shape,

compressed together to form two gelatinous masses (Fig. 4). Within a few hours the gelatinous masses dissolve internally to form two sacs, allowing eggs to move freely and acquire a more uniform oval shape. After about 12 h the sacs completely dissolve, releasing the eggs which become distributed along the whole length of the brood-chamber. It seems likely that this mechanism serves to hold and protect the eggs until the brood-plates of the newly moulted female have hardened, and their fringing hairs have become extended and interlaced to form a chamber.

Egg size was found to vary according to the stage of development and ranged from 550 to 887 μ in mean diameter. The eggs are deep red in colour and contain large numbers of oil globules.

Cleavage is initially total, but later becomes superficial. The first two divisions are perpendicular to each other resulting in four equal-sized blastomeres. The third dividing plane is perpendicular to the first two, producing an upper tier of four micromeres, spirally arranged above the lower tier of four macromeres. The fourth division produces the 16 cell stage consisting of 8 micromeres upon 8 macromeres. Synchrony of division is lost after the 16 cell stage, the micromeres dividing at a greater rate than the macromeres.

Further division of the micromeres results in an oval-shaped group of pigment-free blastomeres, the germinal disc. At the apex of the germinal disc a group of micromeres forms the rudiment of the dorsal organ, and in the meantime gastrulation proceeds from the posterior region of the disc. Somites of the antennulary, mandibular and maxillary segments appear, and after the formation of the maxillary rudiments a transverse caudal furrow, the primary flexure of the body, is formed behind them. The furrow deepens, part of the disc behind being folded forward to become the caudal papilla. As the furrow deepens more segments are formed, and the point of flexure of the body shifts backwards, the caudal papilla elongating and extending forward. In the last stages of embryonic development the heart begins to beat, and spots of red pigment develop in the optic rudiments. Prior to hatching, peristaltic movement of the gut, and other muscular movements of the embryo become evident.

In brief, the development can be summarized into the following six stages, all of which are easily distinguished under the microscope.

(1) Early cleavage stages, prior to the formation of the germinal disc. All cells are pigmented (Fig. 5A).
(2) Development of the germinal disc and appearance of the dorsal organ rudiment (Fig. 5B).
(3) Formation of the caudal furrow and appearance of appendage rudiments (Fig. 5C).
(4) Segmentation of all the appendages, reduction of the dorsal organ, development of the optic rudiments and of the heart (not beating), widening of the caudal furrow, change of the embryo to a more oval shape with the head occupying the apex (Fig. 5D).

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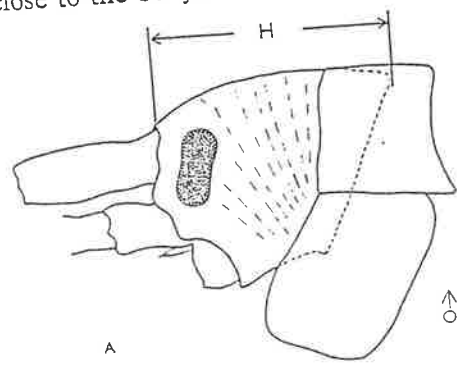

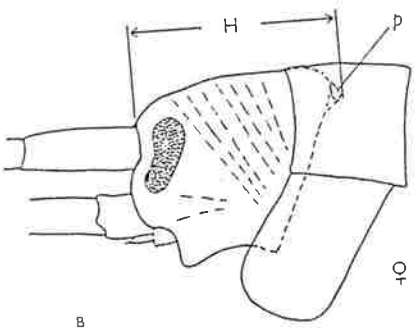

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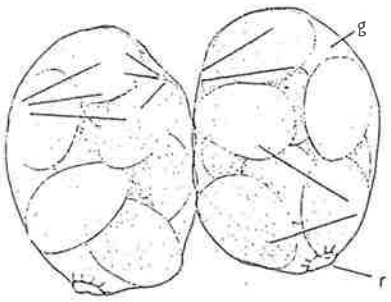

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(5) Appearance of red pigment spots on the eye rudiments, beating of the heart, further reduction of the dorsal organ, and muscular movement, especially the gut (Fig. 5E).
(6) Hatched juveniles inside the brood-chamber.

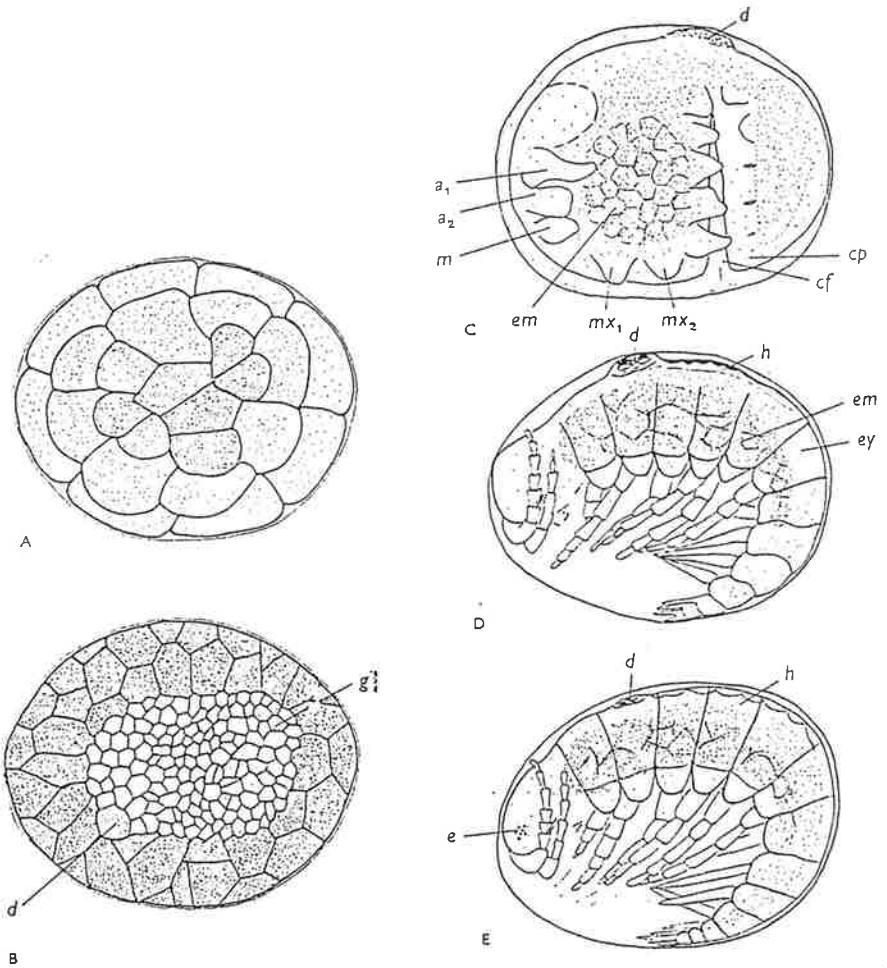

Fig. 5. Embryonic development. A. Stage 1, about 30 cell stage. B. Stage 2, showing the germinal disc (*g*) of non-pigmented cells and the dorsal organ rudiment (*d*). C. Stage 3, a_1, first antenna; a_2, second antenna; *m*, mandible; mx_1, first maxilla; mx_2, second maxilla; *cf*, caudal furrow; *cp*, caudal papilla; *em*, endodermal mass; *d*, dorsal organ. D. Stage 4, *h*, heart; *em*, endodermal mass; *ey*, endodermal yolk; *d*, dorsal organ. E. Stage 5, *e*, eye; *d*, dorsal organ; *h*, heart.

The six developmental stages require on the average 1·1, 4·3, 1·7, 1·8, 4·2 and 3–14 days respectively at a temperature of 7–9 °C.

Hatching was observed on a few occasions. Hatching spines are present on the urosome of the embryo which cause a splitting of the egg membrane

Ann. Zool. Fennici 11: 216 – 219. 1974

Identification of juvenile Baltic Gammarids (Crustacea, Amphipoda)

BRAGE RYGG

RYGG, B. 1974: Identification of juvenile Baltic Gammarids (Crustacea, Amphipoda). – Ann. Zool. Fennici 11: 216 – 219.

A key is presented to the juvenile stages of *Gammarus locusta*, *G. oceanicus*, *G. salinus*, *G. zaddachi*, and *G. duebenii*. The key is valid for specimens of 1.8 – 4.5 mm body length, and thus includes even recently hatched juveniles.

Brage Rygg, Norwegian Institute for Water Research, P.O. Box 333, Blindern, Oslo 3, Norway.

1. Introduction

In an ecological study of mixed populations of *Gammarus* species on the south coast of Finland, specific identification of animals of all sizes, including recently hatched juveniles, was necessary.

Morphological descriptions and methods for identifying North European brackish-water *Gammarus* species were published by SPOONER (1947), SEGERSTRÅLE (1947, 1959), KINNE (1954), and DENNERT *et al.* (1969). However, keys to the distinctions between *G. oceanicus*, *G. salinus* and *G. zaddachi* with body lengths under 4 mm were not presented. The juveniles may leave the mother's brood pouch at 1.8 mm body length. An identification method was therefore developed that would include specimens in this size range.

2. Material and methods

Embryo-carrying females of the various species were collected from the sea, sorted, and kept in aquaria to produce their offspring. The young were fed with *Cladophora glomerata* and killed Mysids. A reasonable number of specimens of each size group were taken out and preserved in 4 % formalin for subsequent examination. That the morphological structure of aquarium-bred animals was representative was checked by comparison with material from known monospecific *Gammarus* stocks in the sea.

The examination was made with the aid of a stereomicrometer binocular, using magnifications up to 50×. The specimens were always kept in water or dilute formalin.

Report No. 503 from Tvärminne Zoological Station, University of Helsinki.

3. Key to the identification

Setation of antennal segments II and III, in conjunction with antennal length (A in Fig. 1), constitutes the basis for specific identification. The setation pattern may be expressed as the number of groups of setae on segments II and III, respectively, e.g. 3:2, 3:2, 2:1, 2:1, 1:1 in a-e in Fig. 2. At antennal lengths of less than 0.80 mm all the species have only one group of setae (the distal) on both segments.

To facilitate inspection the antenna should be removed from the head, and the inner side of the antenna with its accessory flagellum should be facing downwards. All drawings in Figs. 1 and 2 are of left-side antennae.

Specimens having antennal lengths exceeding 2.2 mm (corresponding to body lengths exceeding 5.5 mm) could conveniently be identified by the methods described by KINNE (1954).

1. Setae on antennal segment III much shorter than breadth of segment ..... *G. locusta* (Fig. 1f, 2e)
   Setae on segment III longer than breadth of segment 2
2. Length of antenna under 0.80 mm 3
   Length of antenna 0.80 mm or more 4
3. Setae on segments II and III slightly curved. In segment III angle between axis and setae 50 – 70°, ratio of length of setae to length of segment 0.7 – 0.9 .... *G. salinus* (Fig. 1b)
   Setae on segments II and III not curved. In segment III angle between axis and setae about 45 °, ratio of length of setae to length of segment 0.5 – 0.7 .... *G. zaddachi* (Fig. 1a)
4. Setae on segments II and III not curved. In segment III angle between axis and setae 45 – 60 °, ratio of length of setae to length of segment 0.9 – 1.0 .... *G. oceanicus* (Fig. 1c)

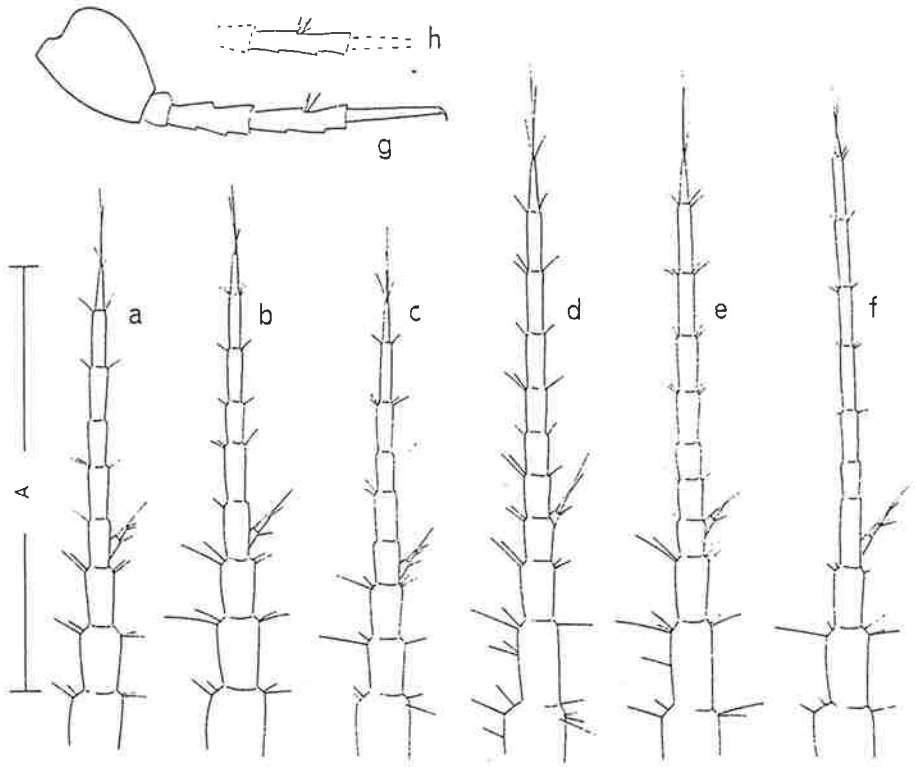

Fig. 1. a – f: *Gammarus* antennae. a = *G. zaddachi*, b = *G. salinus*, c = *G. oceanicus*, d = *G. zaddachi*, e = *G. salinus*, f = *G. locusta*. – g – h: Pereiopod VII of *G. zaddachi* (g) and *G. salinus* (h). Only the spines and setae relevant to the distinction between the two species are shown. A = antennal length. – Scale for a – f: see Fig. 2.

4.

Antennal length (mm)	Number of groups of setae; segment II : segment III 1 : 1	2 : 1	3 : 1	2 : 2, 3 : 2, 4 : 2
0.80 – 0.99	5	6	6	*G. zaddachi*
1.00 – 1.29	*G. oceanicus*	»	»	»
1.30 – 1.46	»	5	*G. salinus*	»
1.47 – 1.67	»	»	»	7
1.68 – 2.20	»	*G. oceanicus*	»	»

~~4. Combinations:~~

5. Distal setae on segments II and III slightly curved ..... *G. salinus* (Fig. 1e; 2b, c)
   Distal setae on segments II and III not curved ..... *G. oceanicus* (Fig. 2d)
6. Distal setae on segments II and III slightly curved. In segment II angle between axis and distal setae 80 – 90 °. In segment III ratio of length of distal setae to length of segment 0.7 – 1.0 ..... *G. salinus* (Fig. 1e)
   Distal setae on segments II and III not curved. In segment II angle between axis and distal seate 70 – 80 °. In segment III ratio of length of distal setae to length of segment 0.5 – 0.5 ..... *G. zaddachi* (Fig. 1d)
7. Distal setae on segments II and III not curved ..... *G. zaddachi* (Fig. 2a)
   Distal setae on segments II and III slightly curved 8
8. When the antenna of *G. zaddachi* reaches a length of 1.5 – 1.7 mm (corresponding to a body length of about 4 mm), the distal setae on antennal segment III curve and elongate slightly and are no longer distinguishable from those of *G. salinus*. However, this change coincides with the appearance of a new difference between the two species. In *G. zaddachi* the seta situated halfway down on the posterior edge of segment V of pereiopod VII elongates beyond the corresponding spine(s), whereas in *G. salinus* this seta remains shorter than the spine(s) or is lacking (Fig. 1 g – h). This difference was noted by DENNERT *et al.* (1969) and provides a convenient and reliable method for distinction between medium-sized *G. zaddachi* and *G. salinus*.

The fifth *Gammarus* species living in the Baltic, *G. duebenii*, is confined to special littoral and supralittoral habitats and is not normally found in localities occupied by any other member of the genus (RYGG 1972).

G. duebenii is conveniently distinguished from the other brackish-water *Gammarus* species by the shape of the postero-distal angle of the basal segment in pereiopods VI and VII, which is more produced in *G. duebenii* (SEGERSTRÅLE 1946). The juveniles exhibit the same difference (Fig. 3).

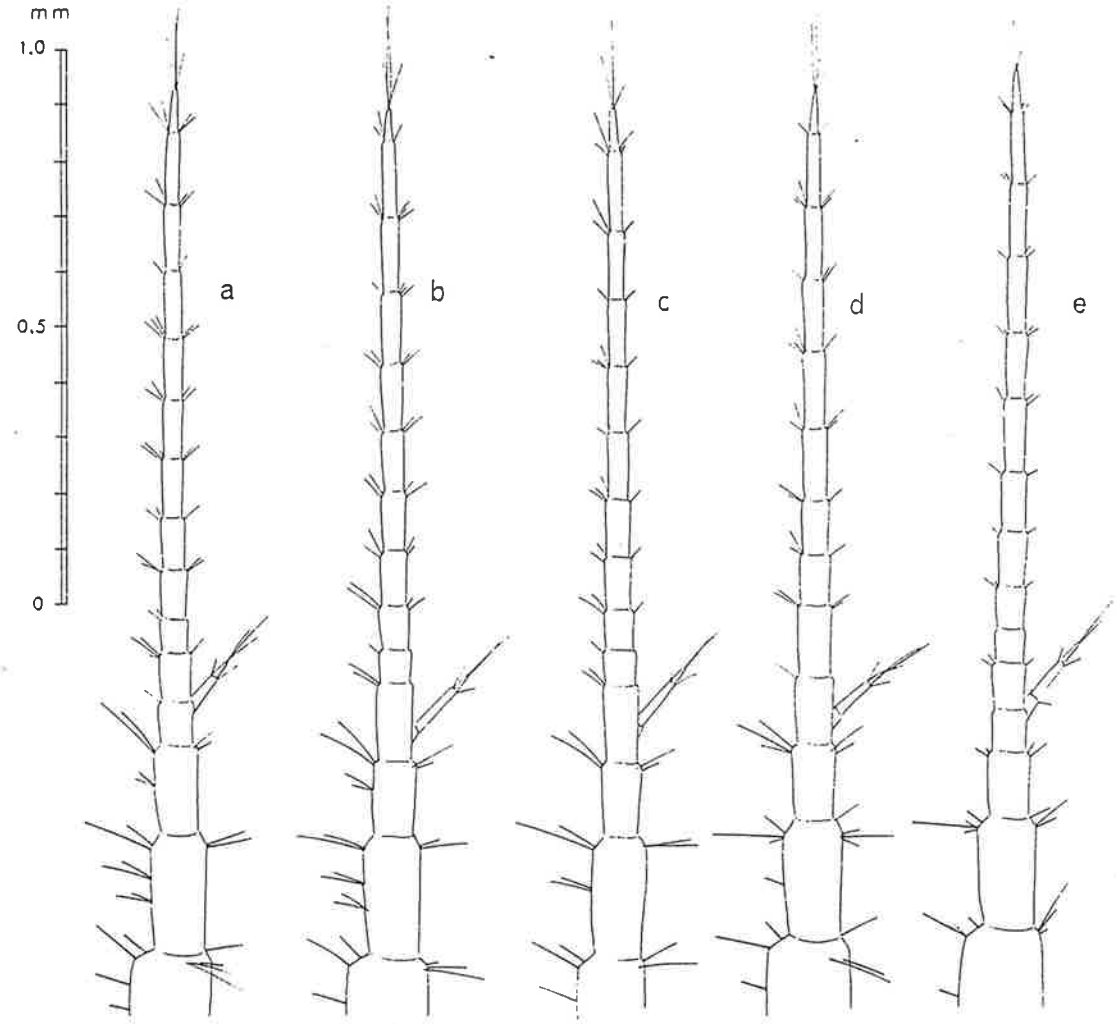

Fig. 2. *Gammarus* antennae, a = *G. zaddachi*, b = *G. salinus*, c = *G. salinus*, d = *G. oceanicus*, e = *G. locusta*.

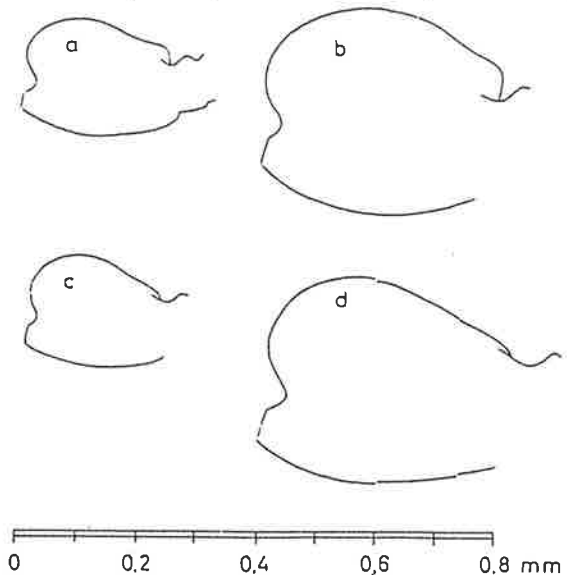

Fig. 3. Basal segment of pereiopod VII. a = *G. duebenii* (body length 2.0 mm), b = *G. duebenii* (body length 3.6 mm), c = *G. zaddachi* (body length 2.0 mm), and d = *G. oceanicus* (body length 3.6 mm).

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Family GAMMARIDAE *(sensu lato)*

Diagnosis : Body laterally compressed, smooth or with dorsal elements, urosome segs free (rarely coalesced). A1 generally longer than A2 (except in *Cheirocratus* and *Megaluropus*), accessory flagellum present. Labrum symmetric, rarely weakly asymmetric, with distal margin convex or concave. Labium with or without inner lobe. Mandible molar triturative, incisor toothed; palp 3-articulate, third article with a row of short D-setae on posterior margin, several submarginal C-setae (on inner face) and several long distal E-setae; on inner surface in the middle occur one or more groups of B-setae, on outer surface one or more groups of A-setae. Often some of these groups of setae are absent. Mx1 inner plate with setae, outer plate with variable number of spines, palp 1-2 articulate, symmetric or asymmetric. Mx2 inner plate with or without a medial row of setae, both plates with distal setae. Mxp inner and outer plates well developed, palp 4-articulate. Coxae 1-4 long or short, coxa 5 as long as or shorter than coxa 4. Gn1 larger than Gn2, as long as or smaller than Gn2, subchelate or simple. Gn2 subchelate or simple. P3-4 simple, P5-7 normal, usually similar to each other. Pleopods well developed, usually biramous (except in *Bogidiella*), peduncle with 2 retinacula (except in *Gammarella*). U1-2 generally well developed, rarely partially reduced (*Longigammarus, Neogammarus,* etc.). U3 short or long, biramous, inner ramus variously developed, outer ramus long, 1- or 2-articulate. Telson usually cleft, rarely entire (*Gammarellus,* some *Bogidiella* species), short or long. Gills simple, on pereon segs 2-6, 2-7 or 4-6. Oostegites narrow or broad, on pereon segs 2-5 or 3-5.

TYPE GENUS: *Gammarus* Fabricius, 1775

KEY TO GENERA

1. Gn1 simple 2
— Gn1 distinctly subchelate 3
2. U3 both rami foliaceous, distinctly rounded. Coxa 4 much longer than coxa 5, with well developed posterodistal lobe . . . . . *Megaluropus*
— U3 both rami lanceolate. Coxa 4 short, not or hardly longer than coxa 5, without posterodistal lobe . . . . . *Cheirocratus*
3. U3 inner ramus shorter than 1/2 outer ramus art 1 4
— U3 inner ramus longer than 1/2 outer ramus art 1 14
4. Dactylus of P5-7 without nail, but bearing 2 distal setae only. Gn2 art 5 remarkably produced posteriorly. Head obtuse, with produced anteroventral tip . . . . . *Carangoliopsis*
— Dactylus of P5-7 with distinct nail, without distal setae. Gn2 art 5 not produced posteriorly. Head not obtuse, never with produced anteroventral tip 5
5. Coxae 1-4 very short, much broader than long. U3 outer ramus art 2 more than 1/2 art 1 6
— Coxae 1-4 longer than broad. U3 outer ramus art 2 shorter than 1/3 art 1 or completely absent. 7
6. Md palp art 3 much shorter than art 2. Basis of P5-7 similar to each other. Labrum concave distally . . . . . *Psammogammarus*
— Md palp art 3 longer than art 2. Basis of P5-7 different from each other. Labrum with convex distal margin . . . . . *Eriopisa*
7. Telson emarginate. U3 in male very long (1/2 body) and narrow, 1-articulate, art 1 long. Mx2 outer plate with several supplementary long plumose setae . . . . . *Pseudoniphargus*
— Telson deeply cleft. U3 in male not elongated. Mx2 outer plate without supplementary long plumose setae 8
8. U3 very short, not exceeding tip of U1; peduncle as long as outer ramus . . . . . *Gammarella*
— U3 moderately long, much exceeding tip of U1; peduncle much shorter than outer ramus. 9
9. Gn2 much larger than Gn1. A1 peduncle very elongated, art 2 as long as or longer than art 1 10
— Gn2 slightly or not all larger than Gn1. A1 peduncle not elongated, art 2 shorter than art 1 11
10. U3 outer ramus 2-articulate. Mx2 inner plate with medial row of setae . . . . . *Abludomelita*
— U3 outer ramus 1-articulate. Mx2 inner plate without medial row of setae . . . . . *Melita*
11. U1 well developed, normal, rami with lateral and distal spines . . . . . *Echinogammarus*
— U1 partially reduced, rami narrow, with distal spine only 12

12. Mx2 both plates short and broad ..... *Longigammarus*
— Mx2 both plates long and narrow 13
13. Urosome segs with dorsal spines and setae. P3 in males inflated, with fan of plumose setae along posterior margin ..... *Rhipidogammarus*
— Urosome segs without dorsal spines and setae. P3 in males normal, without fan of plumose setae along posterior margin ..... *Neogammarus*
14. Coxae 3-4 much shorter than coxae 1-2. Telson short, cleft 1/3, quadrangular. Mxp palp art 4 reduced, very short ..... *Maerella*
— Coxae 3-4 as long as or longer than coxae 1-2. Telson variable, but not quadrangular. Mxp palp art 4 normal 15
15. Coxae 1-4 short, broader than long. Eyes absent 16
— Coxae 1-4 long, as long as or longer than broad. Eyes present 17
16. Mx1 palp 1-articulate. Md palp art 3 shorter than art 1 ..... *Marinobogidiella*
— Mx1 palp 2-articulate. Md palp art 3 longer than art 1 ..... *Bogidiella*
17. Telson long, slightly emarginate. Gn1-2 similar in size and shape ..... *Gammarellus*
— Telson short, deeply cleft. Gn1-2 not similar in size and shape 18
18. Gn1 much smaller than Gn2. A1 peduncle elongated. Labium with inner lobes 19
— Gn1 slightly smaller than Gn2. A1 peduncle relatively short. Labium without inner lobes ..... *Gammarus*
19. Mandibular palp art 3 distinctly falciform ..... *Elasmopus*
— Mandibular palp art 3 non falciform 20
20. Mx2 inner plate with median oblique row of setae ..... *Ceradocus*
— Mx2 inner plate without median oblique row of setae, with distal setae only ..... *Maera*

Genus *ABLUDOMELITA* G. Karaman

Abludomelita G. KARAMAN, 1981, p. 39
Melita (partim) CHEVREUX & FAGE, 1925, p. 227; J.L. BARNARD, 1969, p. 245

Diagnosis: Body usually with dorsal teeth. Eyes present (in Mediterranean species). A1 longer than A2, A1 peduncle long, accessory flagellum with several articles, A2 slender. Coxae moderate. Labrum entire, labium with inner lobes. Mandible normal, palp 3-articulate, art 1 narrow or dilated, arts 2-3 of various length. Mx1 inner plate triangular, with a row of setae; outer plate with 9 spines, palps 2-articulate, dissimilar. Mx2 both plates narrow, inner plate with medial row of setae. Mxp well developed, palp 4-articulate. Gn1-2 subchelate, Gn2 in males much larger and different from Gn1. P3-7 normal, U1-2 normal. U3 inner ramus scale-like, short; outer ramus long, 2-articulate (in Mediterranean species). Telson cleft nearly to the base, lobes acuminate.

Female differs from male in smaller Gn2. Oostegites narrow, on pereon segs 2-5.

TYPE SPECIES: *Melita gladiosa* Bate, 1862

KEY TO SPECIES

1. Pleon segs 1-3 distal margin with 3 teeth. Ep3 ventral and posterior margin serrate .... *A. gladiosa*
— Pleon seg 1 distal margin smooth or with 1 tooth, pleon seg 3 with 0-1 tooth. Ep3 distal margin not serrate 2
2. Pleon seg 1 distal margin smooth, pleon seg 2 with 1-3 teeth. Ep3 posterior margin smooth ..... *A. obtusata*
— Pleon segs 1-2 distal margin with 1 tooth. Ep3 posterior margin serrate ..... *A. aculeata*

FROM GLEDHILL, T., SUTCLIFFE, D.W. & W.D. WILLIAMS. 1976. F.B.A. Key No 32

Genus GAMMARUS

Nine species are recorded from fresh and brackish waters in and around the British Isles. In Britain the two common freshwater species are *Gammarus pulex* and *G. lacustris*. Both have rounded eyes. All other members of the genus normally have elongated eyes. *G. duebeni* is the common freshwater species in Ireland. These three species have a marked extension to the lower posterior corner of the basipodite on walking legs 3–5; in *G. pulex* this corner has a slender spine. The posterior corners of epimera 2 and 3 are subrectangular in *G. duebeni* and *G. pulex*; in all other species the corners are acute.

The above three freshwater species are less transparent in life than the remainder. *G. locusta* is marine but is occasionally found in estuaries; it is immediately recognizable by the three triangular urosome segments. In Scotland it may be replaced by *G. oceanicus* which is intermediate in many respects between *G. locusta* and *G. salinus*. More often found in brackish than fresh water are *G. zaddachi*, *G. tigrinus* and *G. chevreuxi*. These three are very "hairy" in appearance, with numerous and sometimes dense tufts of long setae on the antennae, legs, uropods and telson. In mature adult males of *G. tigrinus* and *G. chevreuxi* (occasionally in *G. zaddachi*) many of the long setae are curled.

G. salinus and *G. oceanicus* do not occur in fresh water, except where it trickles over the shore and is subject to tidal influence. These two resemble the less "hairy" specimens of *G. zaddachi*. Both *G. salinus* and *G. zaddachi* are distinguished from all others in the genus by possessing numerous dense tufts of setae on the ventral margin of segment 1 on antenna 1.

Table 2. Distribution of lateral lines or groups of setae on outer face of mandible palp segment 3.

Species	No. of lateral lines
G. pulex	1
G. lacustris	1
**G. duebeni*	1
G. chevreuxi	1
G. locusta	1–2
G. tigrinus	2
G. oceanicus	2–3
**G. zaddachi*	3–5
**G. salinus*	3–5

* Setae also present on ventral margin of mandible palp segment 1.

In *G. zaddachi*, *G. salinus*, *G. oceanicus*, *G. tigrinus* and *G. chevreuxi* the most reliable characters diagnostic for immature as well as adult specimens of both sexes are setation on the mandibular palp and the fifth walking leg. In preserved specimens the mandibular palp is reflexed upwards from the mandible, so that segment 3 of the palp lies between the bases of the second (lower) pair of antennae (fig. 23). The setation is best examined under a binocular microscope on palps removed together with the mandibles so that the *outer* face is readily identifiable. Where possible

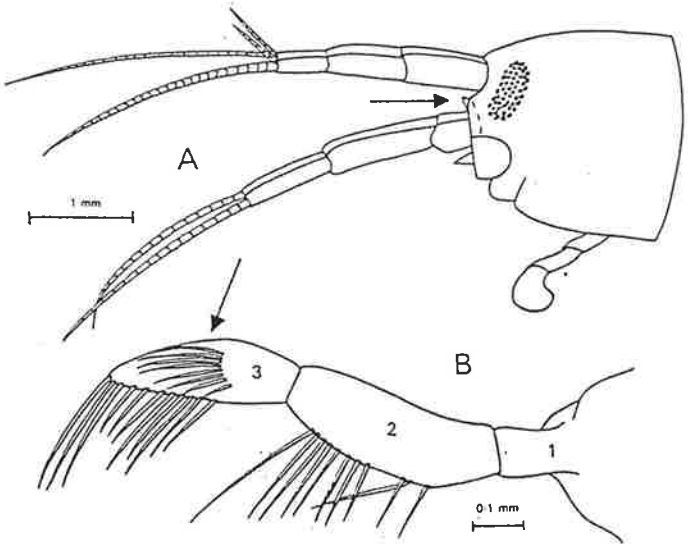


Fig. 23. Head of *Gammarus*: A, showing position of mandible palp (♂); B, detail of mandible palp, with lateral setae shown on segment 3 (♂).

hold the palp in a variety of attitudes to determine the number of lines or groups of setae set obliquely across the outer lateral face of segment 3 (figs 23, 32; Table 2, p. 32). (N.B. Often the inner lateral face of segment 3 has a similar grouping of setae, but the setation here is more variable). For holding the palp, a drop of viscous medium such as lactic acid has the advantage that it will retain the required attitude of the palp long enough to allow inspection under fairly high magnification, and the palp may then be mounted directly into polyvinyl lactophenol on a slide and examined again under a microscope.

Experimental "jizz" key to live, mature littoral gammarids in Scotland

[Requires no assessment of mouthpart or gnathopod detail to use. Mature animals are females carrying a brood or bearing setose oostegites, or males with well developed gnathopods. Once you have a verdict, check against further detail of that species in Lincoln: ** P.G.Moore's contrivance. All comments welcomed**]

Note: the cycle of generic splitting and lumping has now come full circle with Vader & Palerud's listing (1991) of erstwhile *Gammarus*, *Marinogammarus*, *Echinogammarus* and *Eulimnogammarus* back under the one umbrella - *Gammarus*. What the generic truth is is presently unclear. One problem is that *Echinogammarus* and *Eulimnogammarus* are genera founded on central European FRESHWATER species. How separate are the Gammarus's with U3 rami subequal vs those with a short inner ramus (problem of *finmarchicus*) is unclear. Further work like that of Holmes (1975) on a wider range of taxa would help establish the relative closeness of entities. With these considerations in mind the key below refers only to specific names.

1. Adults small (< 15mm) [Note: length measured from rostrum to telson: **not** incl. uropods] ..... 2.

   Adults large (> 15mm) ..... 3.

problem with small & big sp. etc

2. Adults very small (male < 7mm; female < 8mm); antenna 1 rather longer than antenna 2; body colour pale slate-blue to greenish grey; no well defined orange patches on hinder pleon segments (at most: diffuse patches of pink); eggs dark green when newly laid, embryos bright orange; marine littoral HWN-LWN in areas of freshwater influence..... ..... *stoerensis*

   Adults small (male < 14mm; female < 11mm); antenna 2 nearly same length as antenna 1; antenna 2 flagellum resembles a worn-out bottle brush; body colour pale green often suffused with tinges of brown, pink or blue; irregular bright orange patches on sides of all pleon segments usually present, often with small orange spots at base of peraeopods 5-7; male uropod 3 has outer ramus inner margin with long setae; eggs very dark, almost black, when newly laid changing to dull yellow as embryos develop; marine littoral, under stones from HWN to MTL ..... *pirloti*

3. Uropod 3 rami markedly inequal; no orange patches on pleon..... 4.

   Uropod 3 rami subequal; orange patches on pleon present or not ..... 7.

4. Uropod 3, inner ramus appreciable length (40% of outer); uropod 3 outer ramus lacking 2nd article; peraeopods 5 - 7 bases hind angle clearly free ..... 5.

   These features not combined ..... 6.

5. Body colour uniformly pale brown or yellowish; epimeron 3 slightly acute; uropod 3, outer ramus setal tufts noticeably fan-shaped; marine littoral, MTL in rock pools, under stones (often with *obtusatus*, but usually scarcer) ..... *finmarchicus*

6. Body form sleek; body colour pale brown to olive green, often with distinct purple or pinkish tinge; eggs deep purple when newly laid, becoming yellow /orange, epimeron 3 obtuse ; male uropod 3 outer ramus not setose all round; marine littoral, MTL to MLWN ..... *obtusatus*

   Body heavier built; body colour dark blue /green, sometimes suffused with reddish or yellowish brown, tends always to be darker in appearance than other species; egg colour dark brownish when newly laid, becoming dull yellow; epimeron 3 shape distinctly acute ; male uropod 3 outer ramus setose all round; marine littoral MLWN ..... *marinus**
   [* check for *olivii* in SW England]

7. From fully marine habitats ..... 8.

   From brackish water habitats, or ones with some degree of freshwater influence ..... 9.

8. Urosome segments 1-3 with very prominent, angular dorsal humps; epimeron 3 posterior margin with rank of short setules; head distinctly shorter than peraeon segments 1 and 2 together; body colour greenish yellow with orange patches laterally; at low water mark, often swimming in swarms at the tide edge..... *locusta*

   Urosome 1-3 dorsal humps rounded; epimeron 3 posterior margin with 1-2 setae only; body colour uniform grey, yellow or greenish brown (often darker in female); coastal, MTL to shallow sublittoral ..... *oceanicus*

9. Antenna 1, peduncle segment 1 ventral margin without dense tufts of setae; Antenna 2 sinus deep; telson lobes with setae plus 4 apical spines [may need a bit of careful orientation to see with a stereo mic, see O.K with compound mic: generally arrayed like sun's rays] ..... 10.

   Antenna 1, peduncle segment 1, ventral margin with dense groups of setae; Antenna 2 sinus slight; telson lobes with setae plus 2 or 3 apical spines ..... 11.

10. Peraeopods densely setiferous; uropod 3, both rami margins extremely densely setose, inner marginal setae plumose; male antenna 2 flagellum extremely setose; body colour green-brown, peraeon and pleon segments with lateral orange patches; eggs purplish brown when newly laid becoming cream in later stages; in freshwater trickles and brackish pools on edge of rocky shores .... *duebeni**
    [* note: 2 subspp exist, *G.duebeni duebeni* and *G.d.celticus* - the latter lives in freshwater in Ireland]

11. Antenna 2, peraeopods, urosome dorsal humps and telson with numerous long setae; telson lobes with 2 - 3 spines in apical group; body colour light greyish green or yellow with darker transverse markings, often with red spots on lateral pleosome segments; prefers *very* low salinities in estuaries, often reaching limits of tidal influence .... *zaddachi*

Antenna 2, peraeopods, urosome dorsal humps and telson with few shorter setae; telson with 3 spines in apical group; body colour pale brownish or greenish brown, partially transparent with slight transverse banding; some have red lateral markings on pleon; egg colour purplish, going pinkish with age;less tolerant of *very* low salinities than *zaddachi*, therefore more seawards in distribution in estuaries ..... *salinus*

Some final notes on other gammarid spp.

G.chevreuxi: NOT RECORDED FROM SCOTLAND. A brackish water species characterised in the male by the festoons of curly setae (on antennae, maxilliped, gnathopods 1 & 2, peraeopods 3 & 4) - these curled setae absent from females and young males.

G.tigrinus: TO MY KNOWLEDGE NOT RECORDED FROM SCOTLAND, but currently undergoing a distributional expansion through English FRESHWATERS. Male also has curly setae on antenna 2 and peraeopods.

G.pulex and *G.lacustris*: are both FRESHWATER spp which can be found in Scotland. Note they have non reniform eyes (cf spp. keyed above), ie. rounded or weakly oval. *G.lacustris* usually in lakes(ie. not running water, except immediate lake outflow): *G.pulex* in running streams.

G.insensibilis: NOT RECORDED FROM SCOTLAND, present in English Channel and outer Thames estuary. Would key out as *locusta* on above key (or possibly as *salinus* since it will tolerate dilution of seawater - lives in coastal lagoons). From *locusta* it may be distinguished by having no rank of epimeron 3 posterior marginal setae (1 only) , and from *salinus* and *locusta* by the male having no calceoli.

G.crinicornis: NOT RECORDED FROM SCOTLAND. Would key out as *oceanicus* on above key. Compared with *oceanicus*, however, it has longer, curled setae on male antenna 2 and no setae in telson apical spine group).

Notes on *Bathyporeia*

ALWAYS CONSIDER THE POSSIBILITY THAT PLEON 4 DORSAL SPINES AND SETAE CAN GET BROKEN OFF

ALSO

TAKE CARE WITH *B.ELEGANS*

This is a very variable species [care needed in Lincoln's key at couplet 4]. The number of setae on antenna 1 peduncle article 1 can vary from 2 to 5. The shape of the peduncle can also vary a lot. Can be without spines on urosome or with more than one pair.

With fresh material, body colour is a good character, as is egg colour in ovigerous females.

The hardest feature of Lincoln's key to use in practice is the coxal plate corner.
Two alternative formal keys to the genus are included below, together with a summary table of jizz features.

Suggest look first at the antenna 1 peduncle. Sharply pointed ones likely to be *tenuipes* or *pelagica*. Blunt ended ones *gracilis, elegans, guilliamsoniana*. *B.guilliamsoniana* is characterised by the strong cusp on epimeron 3 THOUGH THIS IS LESS NOTICEABLE in males.

Bathyporeia key from Hayward & Ryland (1990)

6. Dorsal surface of urosome segment 1 with spines directed forwards and bristles directed backwards — 7

Dorsal surface of urosome segment 1 with all bristles directed backwards — 11.

7. Adults small (<3.5 mm). Epimeral plate 3 with only a single group of spines just above ventral margin
Bathyporeia nana

Adults larger. Epimeral plate 3 with more than one group of spines just above ventral margin — 8

8. Epimeral plate 3, in adult female and juvenile male, with a well-developed tooth at posterio-ventral corner. Adult male with tooth reduced, may be indicated only by uneven border — 9

Epimeral plate 3 evenly rounded at posterio-ventral corner — 10

9. Epimeral plate 3 with well-developed tooth at posterio-ventral corner, extending beyond vertical margin of posterior border (reduced in males). Antenna 1 peduncle article 1 with more or less rounded tip; coxae 2 and 3 with tooth at posterio-ventral corner
Bathyporeia guilliamsoniana

Epimeral plate 3 with small tooth almost at posterio-ventral corner, not extending beyond vertical margin of posterior border (reduced in males). Antenna 1 peduncle article 1 with angular tip and more or less vertical anterior border; coxae 2 and 3 without tooth on posterio-ventral corner
Bathyporeia pelagica

10. Antenna 1 peduncle article 1 with sharply angular tip; coxae 2 and 3 with well-developed tooth at posterio-ventral corner
Bathyporeia tenuipes

Antenna 1 peduncle article 1 with rounded tip; coxae 2 and 3 with small tooth on posterio-ventral corner
Bathyporeia elegans

11. Antenna 1 peduncle article 1 with round, narrow tip. Epimeral plate 3 with not more than three groups of spines just above ventral border
Bathyporeia pilosa

Antenna 1 peduncle article 1 with semi-rounded, broad tip. Adult epimeral plate 3 with four to six groups of spines just above ventral margin
Bathyporeia sarsi

Bathyporeia key from (1966)

pode du gnathopode I, presque exactement ovale chez *B. pelagica*, à bord palmaire subrectiligne chez *B. nana;* sur le nombre des groupes d'épines situés près du bord ventral de la troisième plaque épimérale (deux à cinq groupes chez *B. pelagica*, un seul chez *B. nana*); enfin, sur le nombre des soies plumeuses portées par le bord interne de l'uropode 3 du mâle (11 soies chez *B. nana*, 16 à 20 chez *B. pelagica*).

IV. — DIAGNOSE

Bathyporeia de 2,8 à 3 millimètres de long, verdâtre translucide, yeux rouge vif se décolorant dans l'alcool. Premier segment de l'urosome avec 1 paire de soies dirigées vers l'avant et 1 paire d'épines dirigées vers l'arrière. Segment basal de l'antennule avec une soie plumeuse unique à la partie proximale du bord ventral. Apex du segment basal de l'antennule arrondi. Première, deuxième et troisième plaques coxales sans dent à l'angle postérieur. Propode du premier gnathopode à bord palmaire subrectiligne. Méropodite du troisième péréiopode portant à son bord postérieur 2 soies simples et une soie plumeuse. Troisième plaque épimérale à bord ventro-postérieur arrondi chez le mâle adulte, légèrement anguleux chez le mâle jeune. Chez la femelle, troisième plaque épimérale à angle postérieur portant une dent, aiguë chez les individus jeunes, émoussée et réduite chez les individus adultes. Dans les deux sexes, un seul groupe de 2 à 4 épines près du bord ventral de la troisième plaque épimérale.

La découverte de *Bathyporeia nana* nous donne l'occasion de compléter et de mettre à jour la clef élaborée par WATKIN en 1938. Aux 7 espèces retenues par cet auteur, nous ajoutons *B. megalops* Chevreux, omise par WATKIN, et *B. quoddyensis*, décrite par SCHOEMAKER en 1949.

1.a. Premier segment de l'urosome portant des épines dirigées vers l'arrière et des soies dirigées vers l'avant	2
b. Premier segment de l'urosome ne portant que des soies dirigées vers l'avant	9
2.a. Seconde et troisième plaques coxales sans dent à l'angle postérieur	3
b. Seconde et troisième plaques coxales avec une dent à l'angle postérieur	5
3.a. Premier segment de l'urosome portant, en plus des soies dirigées vers l'avant, plusieurs paires d'épines dirigées vers l'arrière	*quoddyensis* (1) SCHOEMAKER, 1949

	b. Premier segment de l'urosome portant, en plus des soies dirigées vers l'avant, une seule paire d'épines dirigées vers l'arrière	4
4.a.	Troisième plaque épimérale avec, à l'angle postérieur, une dent nette chez la femelle, réduite chez le mâle, et portant, près du bord ventral, deux à cinq groupes d'épines. Apex de l'article basal de l'antennule anguleux. Longueur minimum : 5 mm	*pelagica* BATE, 1862
	b. Troisième plaque épimérale avec, à l'angle postérieur, une dent nette chez la femelle jeune, réduite chez la femelle adulte, absente chez le mâle, et portant, près du bord ventral, un seul groupe d'épines. Apex de l'article basal de l'antennule arrondi. Longueur maximum : 3 mm	*nana* n. sp.
5.a.	Troisième plaque épimérale avec, dans les deux sexes, une dent bien développée à l'angle postérieur	*guilliamsoniana* (BATE), 1857
	b. Troisième plaque épimérale sans dent à l'angle postérieur, à bord inféro-postérieur régulièrement arrondi ..	6
6.a.	Apex de l'article basal de l'antennule dessinant un angle aigu	*tenuipes* (2) MEINERT, 1877
	b. Apex de l'article basal de l'antennule régulièrement arrondi	7
7.a.	Premier segment de l'urosome portant, en plus des soies dirigées vers l'avant, plusieurs paires d'épines dirigées vers l'arrière. Seconde et troisième plaques coxales avec une dent bien développée à l'angle postérieur	*gracilis* SARS, 1891
	b. Premier segment de l'urosome portant, en plus des soies dirigées vers l'avant, une seule paire d'épines dirigées vers l'arrière	8
8.a.	Article ischial du péréiopode 5 présentant un prolongement dentiforme aigu. Seconde et troisième plaques coxales avec une dent bien développée à l'angle postérieur.	*megalops* (3) CHEVREUX, 1910
	b. Article ischial du péréiopode 5 sans prolongement dentiforme aigu. Seconde et troisième plaques coxales avec une dent réduite à l'angle postérieur	*elegans* WATKIN, 1938
9.a.	Troisième plaque épimérale ne portant pas, près du bord ventral, plus de trois groupes d'épines. Apex de l'article basal de l'antennule arrondi et étroit	*pilosa* LINDSTRØM, 1855
	b. Troisième plaque épimérale portant, près du bord ventral, de quatre à six groupes d'épines. Apex de l'article basal de l'antennule arrondi mais large	*sarsi* WATKIN, 1938

(1) La femelle seule est connue.
(2) D'après WATKIN, certains mâles de cette espèce possèdent, sur le premier segment de l'urosome, plusieurs paires d'épines dirigées vers l'arrière.
(3) Le mâle seul est connu.

JIZZ features in *BATHYPOREIA*

SPECIES	Tidal level	Egg colour	Body colour	Eye colour	Male A2 flag.	Body size
B.elegans	MLWN to sublitt.	yellow/ orange	translucent, no red	?	> body	5-6
B.guilliamsoniana	MLWN & below, but commonest in shallow sublitt.	yellowish	translucent, no red	bright red	> body	8
B.nana	MLWS to sublitt.	blue	translucent pale green	bright red	2x body	3
B.pelagica	above MTL to sublitt.	blue	much red on peraeon & pleon	dark red	> body	6
B.pilosa	MHWN downwards, usually the highest sp.	blue	traces of red on pleon	dark red	1/2 - 2/3 body	6
B.sarsi	MHWN downwards	blue	translucent white, flushed yell./green in middle	vermilion	< 1/2 body	7
B.tenuipes	sublitt. only	?	?	?	> body	6
B.gracilis	sublitt. only	?	?	?	?	6

FROM ALAN MYERS

Re female Aoridae, the differences are subtle and qualitative in the main, so that keys even to regional taxa are not really useable by the inexperienced. However, as long as they are **complete** and in fresh condition, the following may be useful in these islands:.

At generic level, the maxilliped wings distinguish *Microdeutopus* and *Lembos* from *Autonoe* and *Aora*.

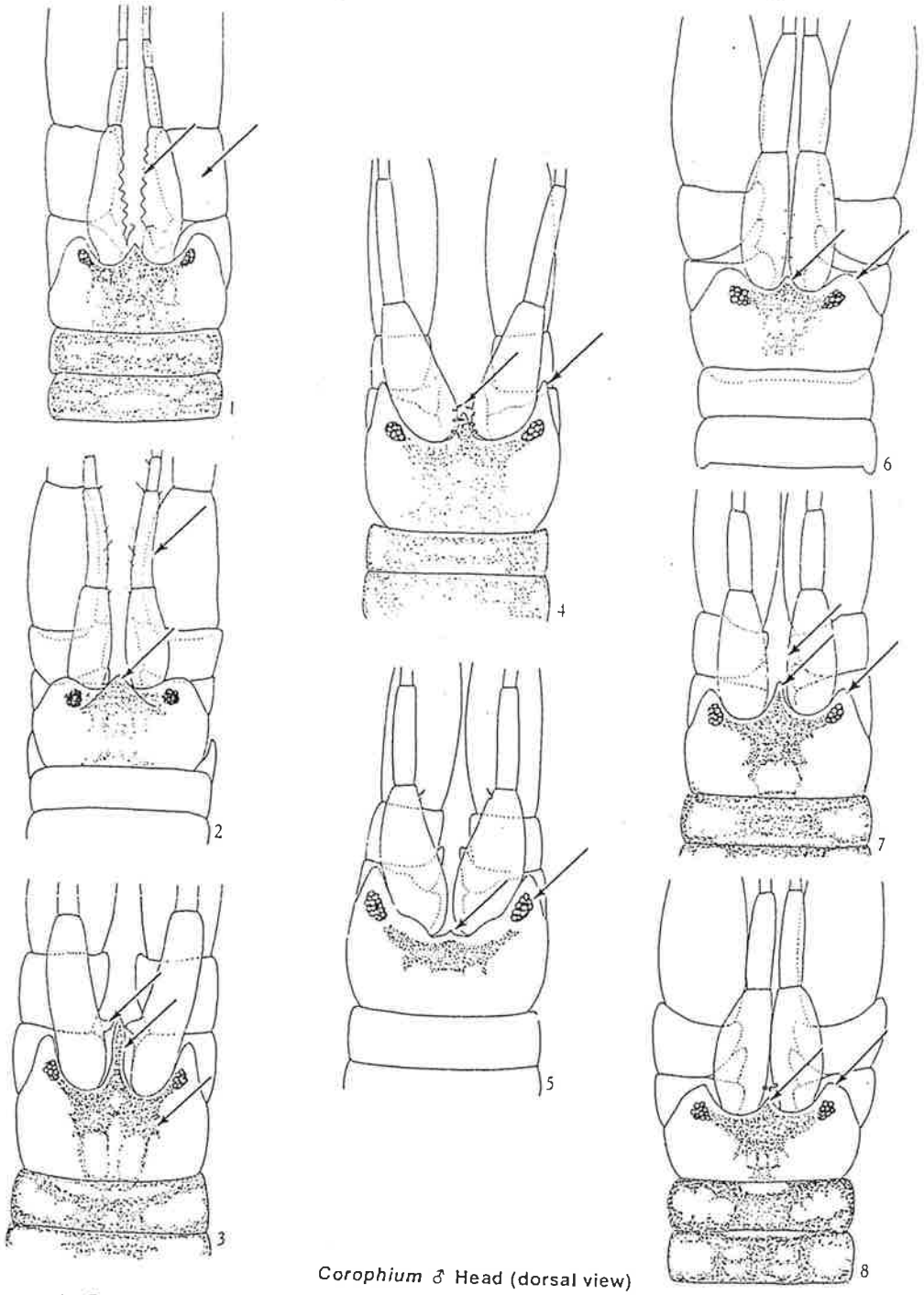
In *Microdeutopus*, *M. anomalus M. chelifer* and *M. stationis* have a multiarticulate accessory flagellum whereas *M. gryllotalpa* and *M. versiculatus* have one long and one rudimentary article. These latter two species of course also share a novel slender and setose G2 of which that of *M. versiculatus* is much the more extreme. *M. stationis* differs from *M. anomalus* and *M. chelifer* in the smoothly round palm of G1 and the presence of spines (as opposed to setae) on the telson. *M. anomalus* and *M. chelifer* females are practically indistinguishable except in pattern when you happen to have the two together!

Lembos is represented by *L. websteri* only, and this has a different "gimp" and pattern from the others, plus a 1+ accessory flagellum (like *M. grylloptalpa* and *M. versiculatus* from which it is obviously different).

There is only one common *Autonoe* and one common *Aora* so they should not give problems, bearing in mind the characteristic pattern of *A. gracilis*. Other rarer *Autonoe* and *A. spinicornis* can of course cause problems!

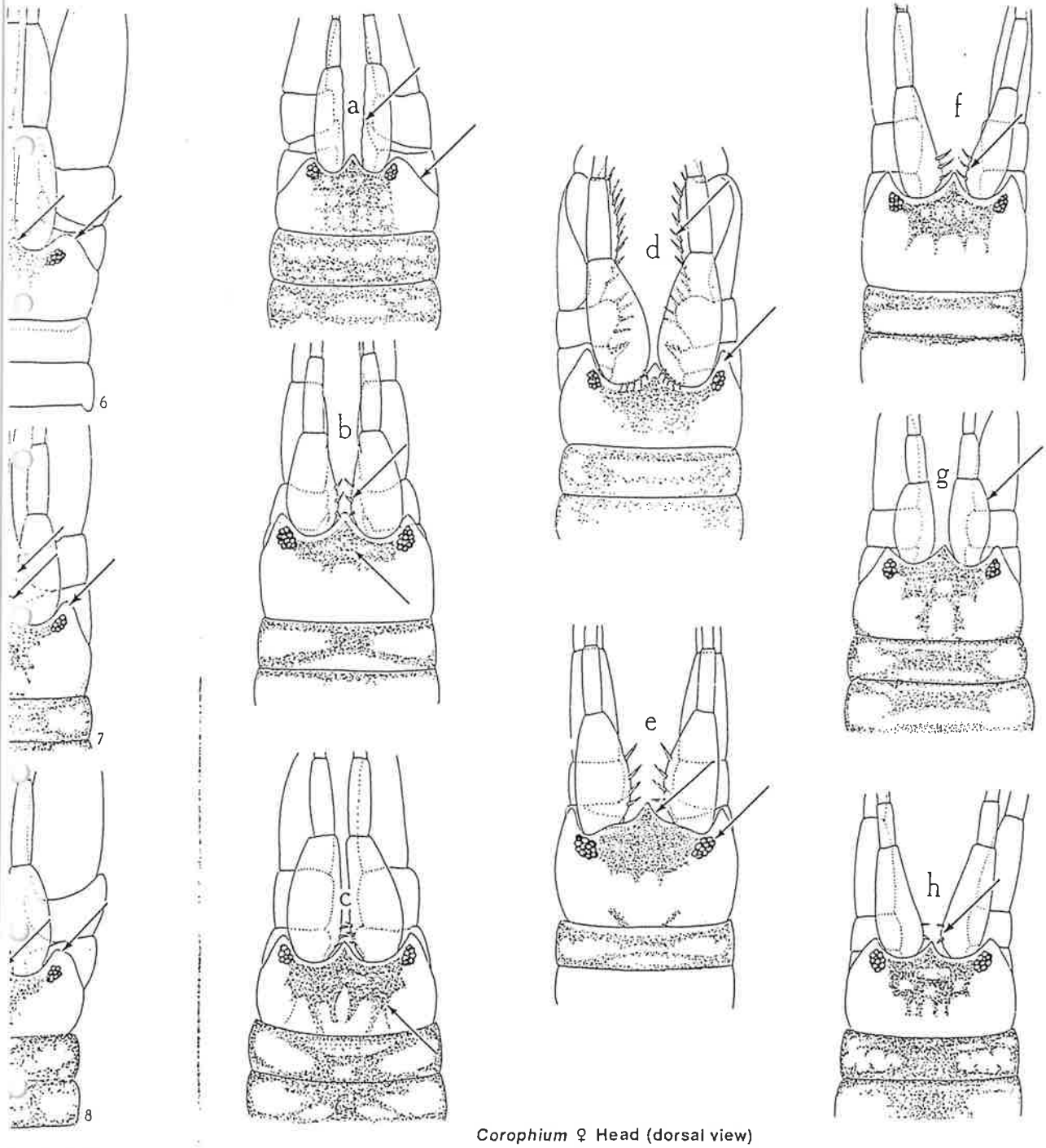
That's it for what it is worth!

[FROM BOUSFIELD (1973) Shallow-water gammaridean Amphipoda of New England. Cornell Univ Press]



Corophium ♂ Head (dorsal view)

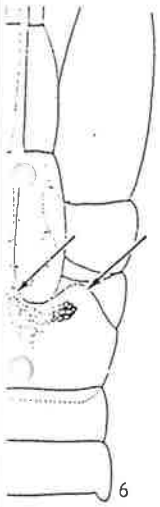
1. *Corophium volutator* 2. *Corophium simile* 3. *Corophium insidiosum* 4. *Corophium crassicorne* 5. *Corophium acherusicum* 6. *Corophium tuberculatum* 7. *Corophium lacustre* 8. *Corophium acutum*

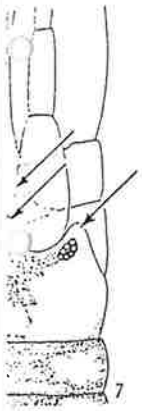


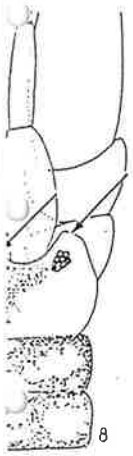
Corophium ♀ Head (dorsal view)

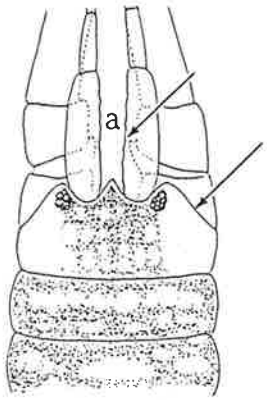
a. *Corophium volutator* **b.** *Corophium bonelli* **c.** *Corophium insidiosum* **d.** *Corophium crassicorne* **e.** *Corophium acherusicum* **f.** *Corophium tuberculatum* **g.** *Corophium lacustre* **h.** *Corophium acutum*

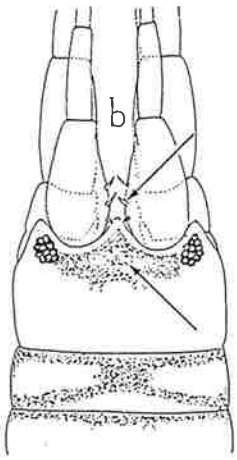
4. *Corotum*

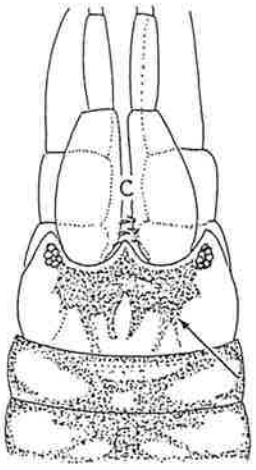


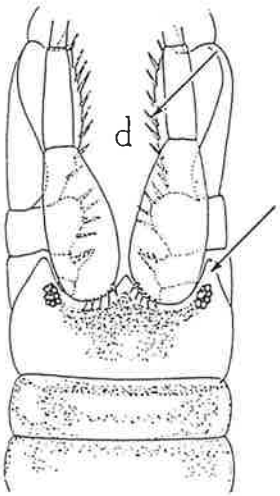


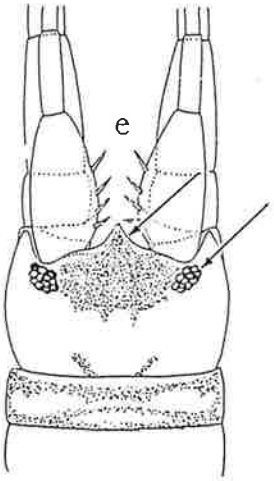


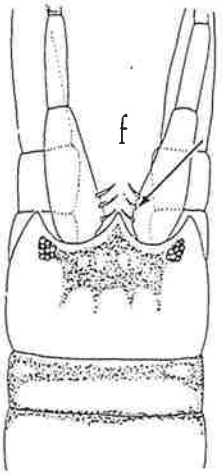


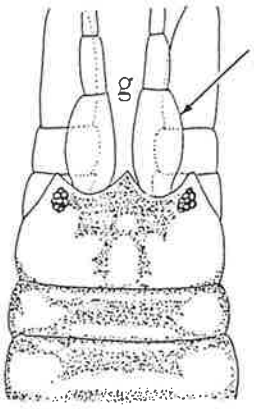


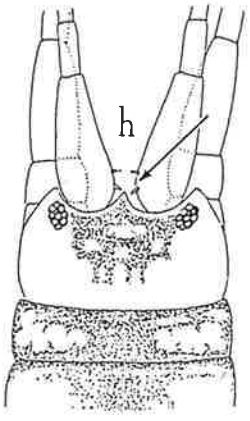








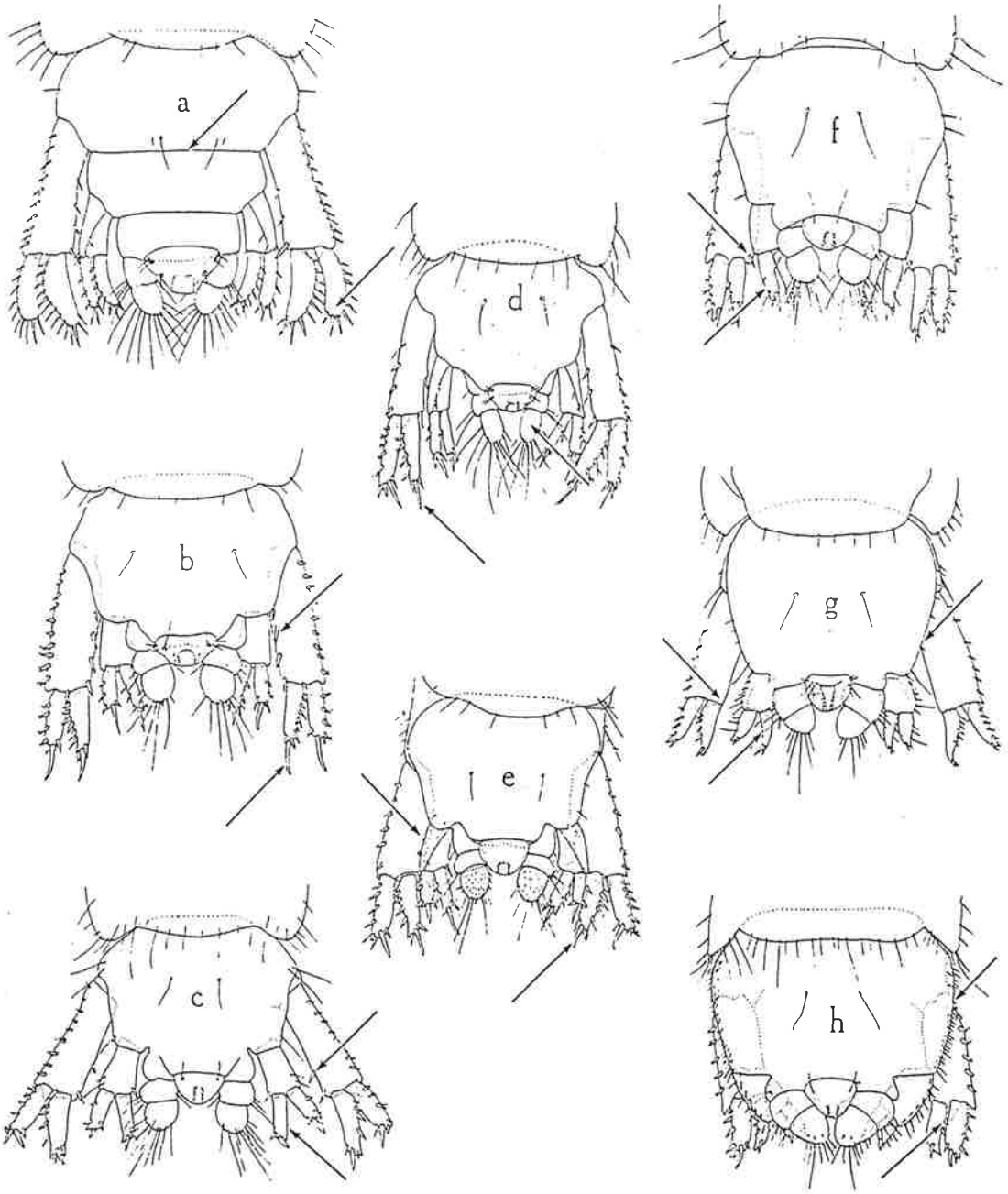




Corophium ♀ Head (dorsal view)

a. *Corophium volutator* **b.** *Corophium bonelli* **c.** *Corophium insidiosum* **d.** *Corophium crassicorne* **e.** *Corophium acherusicum* **f.** *Corophium tuberculatum* **g.** *Corophium lacustre* **h.** *Corophium acutum*

4. *Coro-*
tum



***Corophium* Urosome (dorsal view)**

a. *Corophium volutator* b. *Corophium bonelli* c. *Corophium insidiosum* d. *Corophium crassicorne* e. *Corophium acherusicum* f. *Corophium tuberculatum* g. *Corophium lacustre* h. *Corophium acutum*

Table 1. The major diagnostic characters of C. volutator and C. arenarium

[FROM MILLS, A. (1978) Comparative studies on the biology of Corophium volutator (Pallas) and Corophium arenarium Crawford - PhD thesis]

Diagnostic Character	COROPHIUM VOLUTATOR		COROPHIUM ARENARIUM	
	Female	Male	Female	Male
First peduncular segment of antennule A1	Inner margin weakly crenulate (Fig. 1a). Ventral margin weakly crenulate with 2, rarely 3, prominent spines (Fig. 3a)	Inner margin strongly crenulate (Fig. 1b). Ventral margin strongly crenulate with 2, rarely 3, inconspicuous spines (Fig. 3b)	Inner margin not crenulate (Fig. 2a) Ventral margin concave with 2, rarely 3, prominent spines (Fig. 3d)	Inner margin slightly crenulate (Fig. 2b) Ventral margin strongly concave with 2, rarely 3, inconspicuous spines (Fig. 3e)
Fifth peduncular segment of antennae A2	Inner ventro-lateral margin with 1 large distal and acute process (Fig. 1a) or rarely 1 spine (Fig. 1c). Inner lateral margin without a distal process.	Inner ventro-lateral margin with 1 large distal and acute process. Inner lateral margin with 1 distal process (Fig. 1b)	Inner ventro-lateral margin beset with 1 distal spine never a process (Fig. 2a). Inner margin has 1 spine midway along length (Fig. 3f)	Inner ventro-lateral margin with 1 long distal and acute process (Fig. 2b) Inner margin without spines (Fig. 2b).
First uropod both sexes	Outer edge of basis with a single row of spines (Fig. 4a).		Outer edge of basis with double row of spines replaced proximally by a single row of setae (Fig. 4b)	

4th = in Lincoln

note: 1 ugle longs A2 has 6 art peduncle

Fig. 1a. Dorsal view of cephalon (c) of an adult female C.volutator, 8.0mm in body length (measured from the anterior edge of the rostrum to the posterior margin of the telson), showing small median triangular rostrum (r) and lateral eyes (o). Inner margin of the first peduncular segment (p 1) of antennule (a) is weakly crenulate and bears a single inconspicuous proximal spine. Inner ventro-lateral margin of fifth peduncular segment (p. 5) of antenna (an) bears a large distal and acute process;

Fig. 1b. Dorsal view of cephalon (c) of adult male C. volutator, 8.0mm in body length, showing small median triangular rostrum (r) and lateral eyes (o). Inner margin of the first peduncular segment (p 1) of antennule (a) is strongly crenulate and there is no proximal spine. Inner ventro-lateral margin of the fifth peduncular segment (p 5) of antenna (an) bears a large distal and acute process;

Fig. 1c. Fifth peduncular segment (p 5) of antenna (an) of adult female C. volutator showing a single spine on the inner ventro-lateral margin instead of a large distal and acute process.

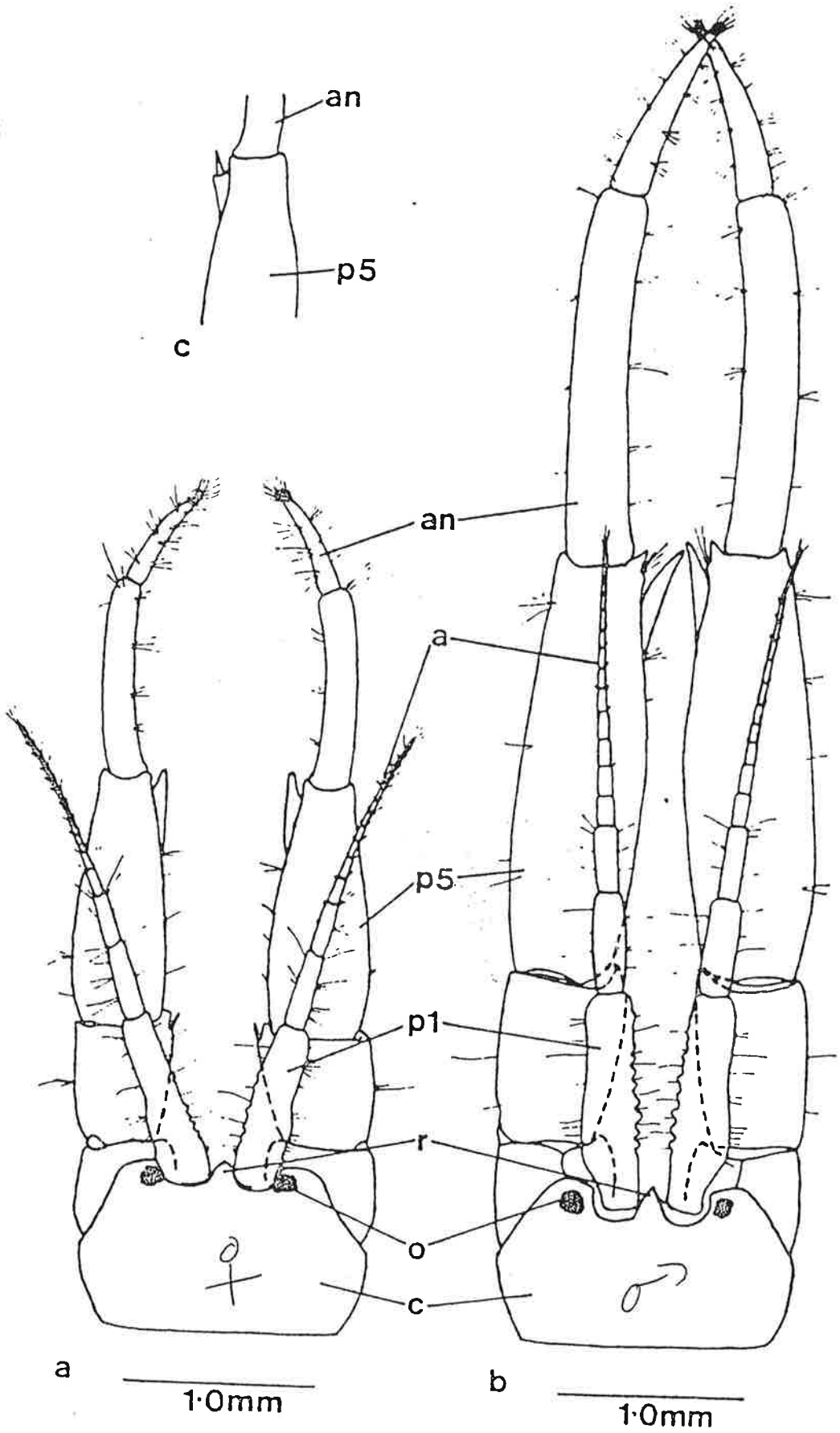


Fig.1

VOLUTATOR

Fig. 2a. Dorsal view of cephalon (c) of adult female C.arenarium, 5.5mm in body length, showing small median triangular rostrum (r) and lateral eyes (o). Inner margin of the first peduncular segment (p 1) of antennule (a) is not crenulate and bears a small proximal spine. Inner ventro-lateral margin of fifth peduncular segment (p 5) of antenna (an) bears a single distal spine and a single spine midway along its length;

Fig. 2b. Dorsal view of cephalon (c) of adult male C.arenarium, 5.3mm in body length, showing small median triangular rostrum (r) and lateral eyes (o). Inner margin of the first peduncular segment (p 1) of antennule (a) is slightly crenulate and bears a small proximal spine. Inner ventro-lateral margin of fifth peduncular segment (p 5) of antenna (an) bears a long distal and acute process and there is no median spine.

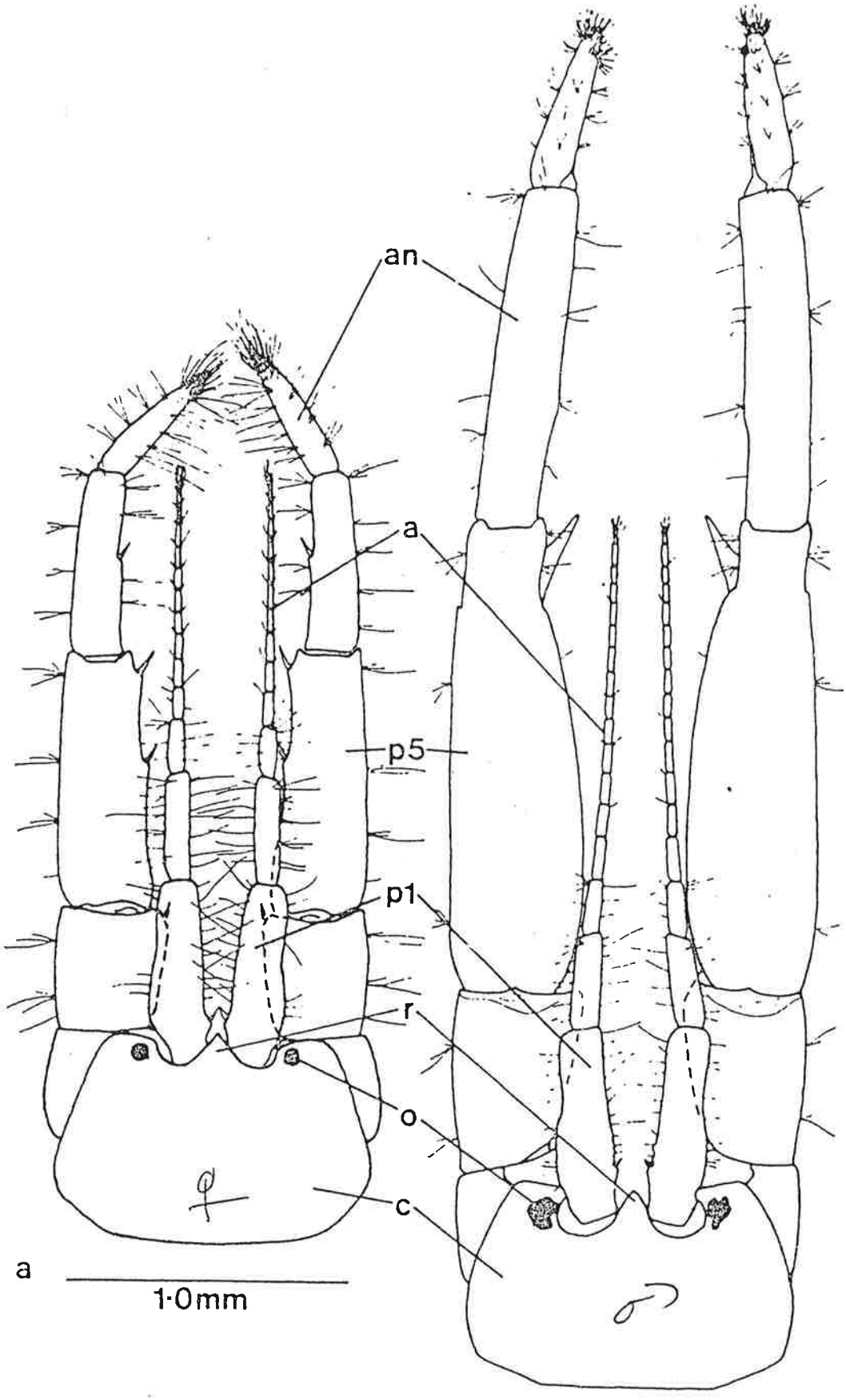


Fig.2

ARGONARIUM

Fig. 3a. Inner lateral view of the antennule of an adult female C. volutator, 7.5mm in body length, showing ventral margin of first peduncular segment (p 1) weakly crenulate with two prominent spines.

Fig. 3b. Inner lateral view of the antennule of an adult male C.volutator, 7.5mm in body length, showing ventral margin of the first peduncular segment strongly crenulate with two inconspicuous spines.

Fig. 3c. Inner lateral view of the antenna of an adult female C. volutator, 7.5mm in body length, showing a large distal and acute process on the inner ventro-lateral margin of the fifth peduncular segments (p 5).

Fig. 3d. Inner lateral view of the antennule of an adult female C. arenarium, 5.5mm in body length, showing ventral margin of the first peduncular segment concave with two prominent spines.

Fig. 3e. Inner lateral view of the antennule of an adult male C. arenarium, 5.5mm in body length, showing ventral margin of the first peduncular segment concave with two inconspicuous spines.

Fig. 3f. Inner lateral view of the antenna of an adult female C. arenarium, 5.5mm in body length, showing a single distal spine and a single median spine on the inner margin of the fifth peduncular segment (p 5). Note also a single median lateral spine on the sixth peduncular segment.

Fig. 3a - f. Bar = 0.5mm.

Fig. 3

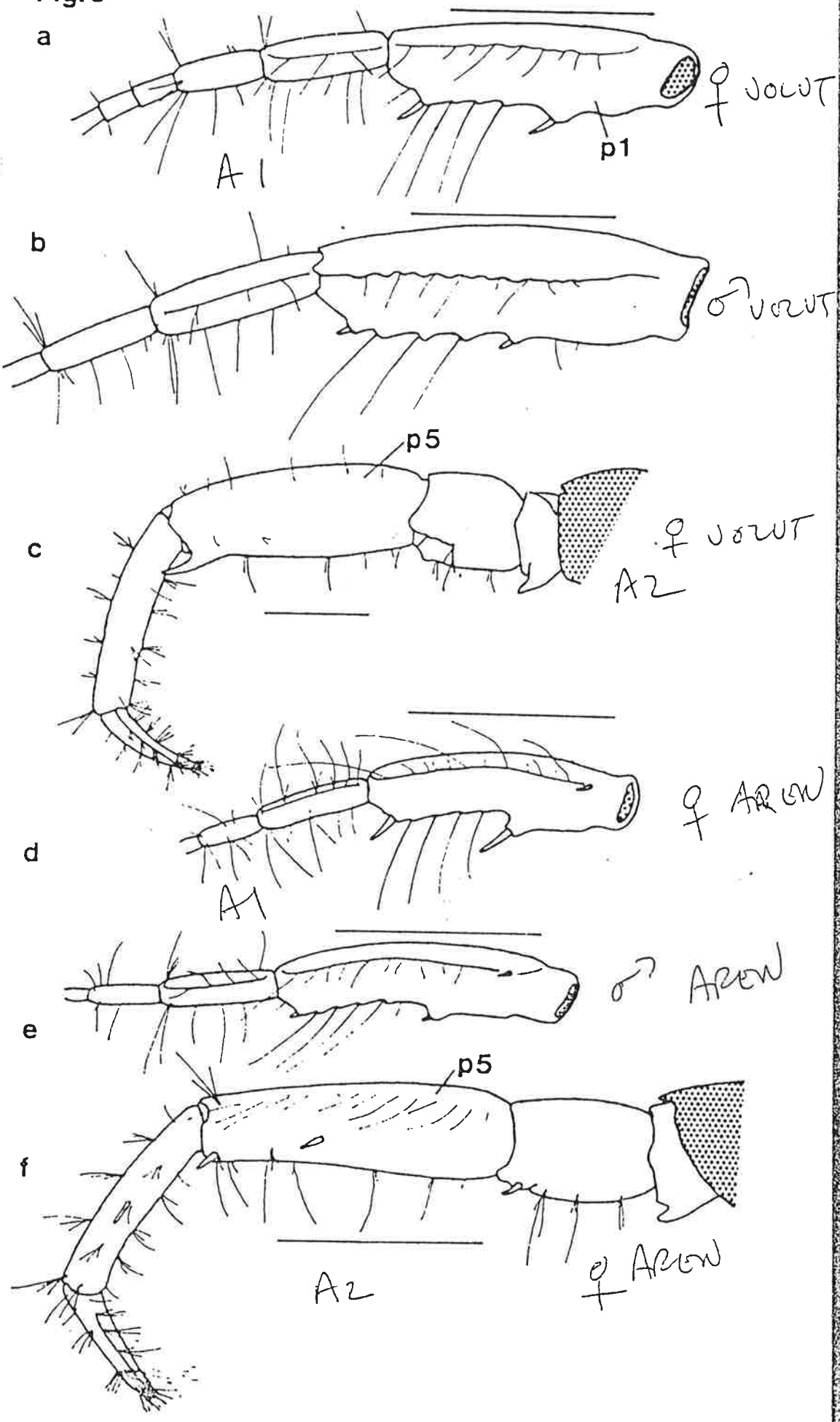
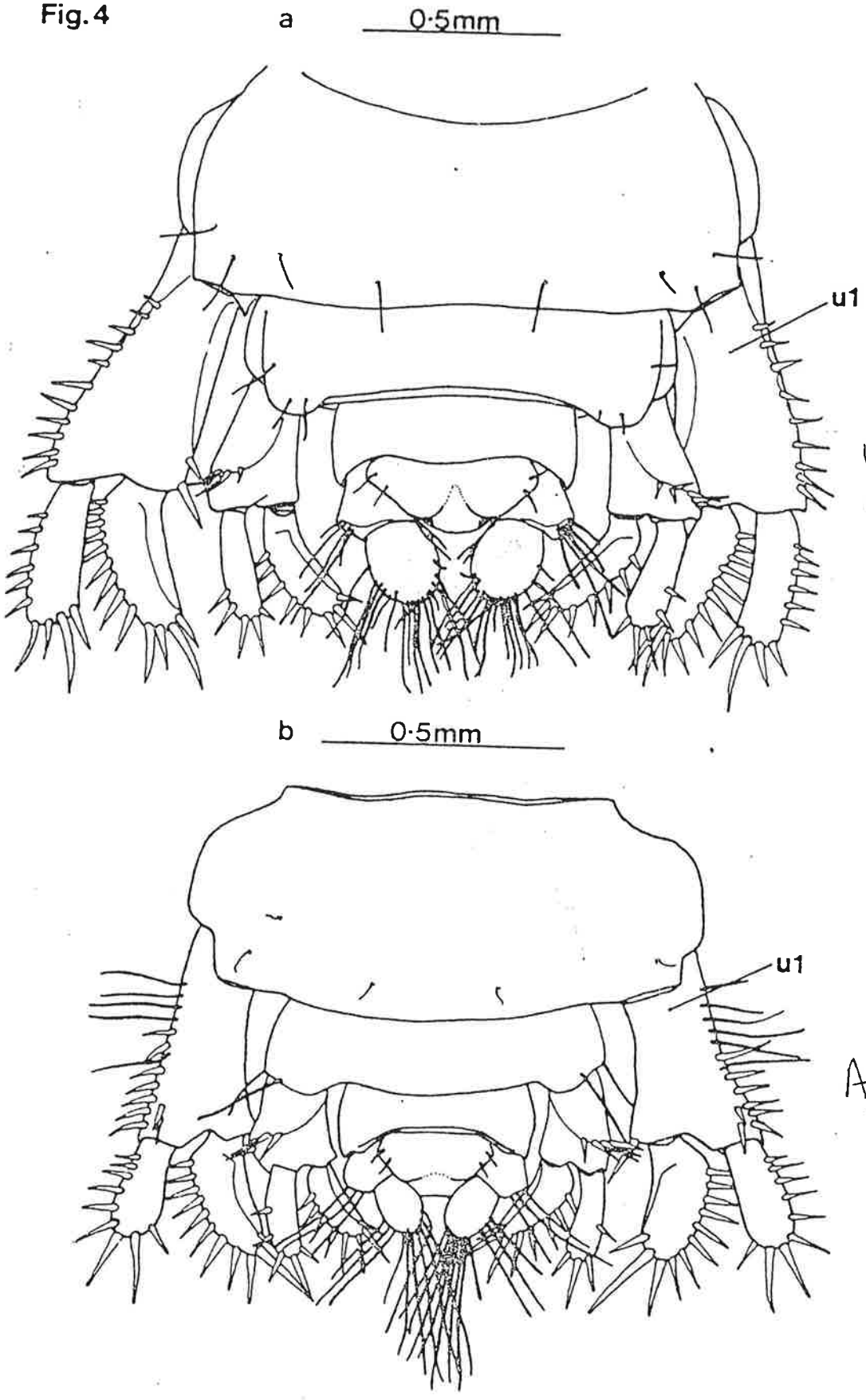

a
A1
p1
♀ JOLUT
b
♂ JOLUT
p5
c
♀ JOLUT
A2
d
♀ ARLOW
A1
e
♂ ARLOW
p5
f
A2
♀ ARLOW

Fig. 4a. C. volutator : dorsal view of the first, second and third uropods, attached to the postero-lateral portions of pleon segments 4 - 6, and the telson, attached to pleon segment 6. The first uropod (U1) has a single row of spines on the outer edge of the basis in both sexes.

Fig. 4b. C. arenarium : dorsal view of the first, second and third uropods, attached to the postero-lateral portions of pleon segments 4 - 6, and the telson, attached to pleon segment 6. The first uropod (U1) has a double row of spines replaced proximally by a single row of setae in both sexes.

Fig. 4



Family ISAEIDAE

Diagnosis : Body smooth. Coxae usually deep, rarely shallow, often ventrally setose ; coxae 2-5 often largest ; coxa 4 not excavate behind ; coxa 5 with deep anterior lobe. Rostrum generally absent ; head strongly recessed at insertion of A2 ; eye lobes often extended, sometimes bearing eyes on proximal or distal portion. Antennae subequal in length or A2 longer ; antennae elongate, slender, primary flagellum often shorter than peduncles, frequently setose ; A2 never sexually dimorphic, accessory flagellum variable. Labrum ventral margin weakly excavate or notched, epistome often strongly produced, acute. Labium with distinct inner lobes, mandibular processes never attenuated. Mandible molar strong ; palp slender, 3-articulate, article 3 generally spatulate, terminally setose. Mxl inner plate small with 1 to several apical setae, outer plate generally with 10 spines, palp large. Mx2 with inner and outer plates well developed. Mxp plates strong. Gn2 subchelate, sexually dimorphic, always enlarged in male and generally larger than Gn1. P3-4 basis usually not expanded ; dactyli with gland ducts. P5-7 elongate ; P7 slightly longer than P6. Pleopod peduncles normal. U1-2 slender ; U1 peduncle rarely with distoventral spine-like process, rami generally subequal. U3 sometimes projecting beyond U1-2, peduncle often elongate, inner ramus tending to reduction, sometimes absent ; terminal spines of rami simple. Telson short, thick, fleshy, entire, sometimes with dorsolateral crests. Coxal branchiae sac-like on pereon segs 2-6. Oostegites large, laminar, smallest on seg 5.

TYPE GENUS : *Isaea* Milne Edwards, 1830

KEY TO GENERA

1. U3 inner ramus very reduced or wanting 2
— U3 inner ramus > 1/2 length of outer 4
2. Accessory flagellum well developed, A1 art 3 < 1 3
— Accessory flagellum absent or scale-like, A1 art 3 > 1 ..... *Photis*
3. Coxae 1-2 deeper than broad ..... *Microprotopus*
— Coxae 1-2 broader than deep ..... *Cheiriphotis*
4. P3-7 widened distally (prehensile) ..... *Isaea*
— P3-7 not widened distally 5
5. Md palp art 3 < 2, accessory flagellum composed of one long and one rudimentary art *Megamphopus*
— Md palp art 3 = 2, accessory flagellum variable or absent, but never as above ..... *Gammaropsis*

Genus *CHEIRIPHOTIS* Walker

Cheiriphotis WALKER, 1904, p. 283

Diagnosis : Head with lateral lobes moderately produced, subocular cephalic margin moderately recessed ; A1 art 1 longer than art 3, accessory flagellum well developed ; coxae 1-4 of varying sizes and shapes ; gnathopods subchelate, ♂ Gn2 carpus vestigial or absent ; U3 peduncle plate-like, outer ramus equal to or shorter than peduncle, inner ramus vestigial or absent.

TYPE SPECIES : *Melita megacheles* Giles, 1885

* Spines on ramus of uropod 2

type 1: few spines	ex: *A. brevicornis* (Fig. 5.8)
type 2: outer ramus with a long subterminal spine	ex: *A. macrocephala* (Fig. 5.9)
type 3: long marginal spines, increasing in length distally	ex: *A. jaffaensis* (Fig. 5.10)
type 4: numerous short spines	ex: *A. multispinosa* (Fig. 5.11)

* Inner ramus of uropod 3

type 1: ramus foliaceous	ex: *A. spinipes* (Fig. 5.12)
type 2: ramus bidentate	ex: *A. bidentata* (Fig. 5.13)
type 3: ramus denticulate or serrulate	ex: *A. lusitanica* (Fig. 5.14)

* Dorsal surface of the telson

type 1: without setae or spines	ex: *A. spinipes* (Fig. 5.15)
type 2: with setae	ex: *A. brevicornis* (Fig. 5.16)
type 3: with spines	ex: *A. toulemonti* (Fig. 5.17)

KEY TO NORTH-EASTERN ATLANTIC *AMPELISCA* FEMALES

1. Dorsal sucker-like structure on pleon segment 1 (Fig. 3.6) . . . . *A. remora*
1. Without dorsal sucker-like structure on pleon segment 1 2
2. Without corneal lenses 3
2. With corneal lenses 10
3. P7, with a large posterior lobe on merus (Fig. 4.3) . . . *A. uncinata* (in part)
3. P7 without large posterior lobe on merus (Fig. 2.2) 4
4. Epimeral plate 3 with a tooth (Fig. 3.11) 5
4. Epimeral plate 3 without tooth 7
5. Uropod 2 rami with a long subterminal spine (Fig. 5.9) . . . . *A. odontoplax*
5. Uropod 2 rami without long subterminal spine 6
6. Uropod 2, rami with many short spines, telson dorsal surface inermous . *A. compacta*
6. Uropod 2, rami with few short spines, telson dorsal surface with spines . *A. amblyops*
7. P7 basis, margin distally excavate (Fig. 4.6) . . . . . *A. heterodactyla*
7. P7 basis, margin rounded 8
8. P7 carpus > ischium + merus . . . . . *A. abyssicola*
8. P7 carpus < ischium + merus 9
9. A 1 length > head + 3 anterior segments of pereon . . . . . *A. pusilla*
9. A 1 length < head + 3 anterior segments of pereon . . . . *A. anophthalma*
10. 2 corneal lenses 11
10. 4 corneal lenses 13
11. P7, merus with large posterior lobe (Fig. 4.3) . . . . *A. uncinata* (in part)
11. P7, merus without posterior lobe (Fig. 2.2). 12
12. P7, propodus and dactylus posterior margin finely setose, epimeral plate 2 with a tooth. . . . . *A. ctenopus*
12. P7, propodus and dactylus posterior margin not finely setose, epimeral plate 2 rounded . . . . . *A. monoculata*
13. P7, basis outer surface with numerous spines, urosome 1 with a peak-ended keel (Figs. 4.7; 5.6) . . . . . *A. spinifer*
13. P7, basis outer surface without spines, urosome 1 different 14
14. Blots of black pigment behind corneal lenses; P7, ischial to dactylus cylindrical (Fig. 4.4) . . . . . *A. rubella*
14. Head without blots of black pigment, P7 different 15
15. P7 merus with a large posterior lobe (Fig. 4.3). 16
15. P7 merus without large posterior lobe (Fig. 2.2) 20
16. Head with antero-superior and antero-inferior margins parallel (Fig. 3.2) . . 17
16. Head with anterior margins not parallel 19
17. Epimeral plate 3, posterior margin sinuous, posterior distal angle with a small or moderate tooth (Fig. 3.12) 18

17. Epimeral plate 3, posterior margin bisinuous, postero-distal angle with a large tooth (Fig. 3.13) . . . . . *A. brevicornis*
18. Urosome seg. 1 with a cockscomb dorsal keel (Fig. 5.5) . . . . . *A. spooneri*
18. Urosome seg. 1 with a pronounced angular keel (Fig. 5.3) . . *A. senegalensis**
19. Urosome seg. 1 with high carina dorsally bisinuate with the end slightly turned up; epimeral plate 2 infero-posterior corner with a small tooth (Fig. 2.3) . . *A. vervecei*
19. Urosome seg. 1 with a pronounced angular keel; epimeral plate 2, infero-posterior corner round (Figs. 5.3, 3.7) . . . . . *A. gibba*
20. Head, anterior half narrow (Fig. 3.3) 21
20. Head different 22
21. A 2 shorter than body length; P_{3-4}, dactylus = carpus + propodus . . . *A. sarsi*
21. A_2 more longer than body length; P_{3-4}, dactylus ≫ carpus + propodus . *A. pseudosarsi*
22. Head broad, anterior edge truncate (Fig. 3.4) 23
22. Head different 25
23. Head with antero-superior corner acute; P7, merus prolonged anteriorly in peg-shape covering a part of carpus (Fig. 4.2). . . . . *A. truncata*
23. Head with antero-superior corner quadrate, P7, merus not prolonged in peg-shape. 24
24. A_2 < body length; without distinguished carina (Fig. 5.7) . . . *A. latifrons*
24. A_2 = body length; carina high and rounded (Fig. 5.2) . . . . *A. provincialis*
25. Uropode 3, inner ramus denticulate or serrulate (Figs. 5.13 and 14) . . . 26
25. Uropode 3, inner ramus not denticulate or serrulate 29
26. P7, merus not prolonged anteriorly in peg-shape . . . . *A. serraticaudata*
26. P7, merus prolonged anteriorly in large peg-shape (Fig. 4.2) 27
27. Uropode 3, inner ramus truncate and bidentate (Fig. 5.13) . . . *A. bidentata*
27. Uropode 3, inner ramus tapered (Fig. 5.14) 28
28. A_1 subegal to A_2 . . . . . *A. unidentata*
28. A_1 shorter than A_2 . . . . . *A. lusitanica*
29. Uropode 2 bearing long spine(s) (Fig. 5.10) 30
29. Uropode 2 bearing only short spines 32
30. Epimeral 3, postero-margin straight, postero-distal angle without tooth (Fig. 2.4) *A. jaffaensis*
30. Epimeral 3, postero-margin bisinuate, postero-distal angle with a large tooth (Fig. 3.13). 31
31. Uropode 2, outer ramus with long marginal spines increasing in length distally; P7, carpus anterior margin notched (Fig. 5.10) . . . . . *A. eschrichtii*
31. Uropode 2, outer ramus with single long subterminal spine; P7, carpus anterior margin rounded (Fig. 5.9) . . . . . *A. macrocephala*
32. Uropode 2 fringed with numerous small spines (Fig. 5.11) 33
32. Uropode 2 with few small spines 39
33. A_2 longer than body length 34
33. A_2 shorter than body length 36
34. Urosome 1 with high carina dorsally bisinuate. Uropode 2 rami fringed regularly on both sides by rows of small spines (Fig. 5.11) . . . . . *A. multispinosa*
34. Urosome 1 with small rounded carina. Uropode 2 rami not regularly fringed with small spines 35
35. A_1 shorter than A_2 peduncle . . . . . *A. ruffoi*
35. A_1 slightly longer than A_2 peduncle . . . . . *A. pseudospinimana*
36. A_1 shorter than A_2 peduncle. Head with antero-distal margin broadly round *A. tenuicornis*
36. A_1 longer than A_2 peduncle. Head narrowly truncated 37
37. A_1 slightly longer than A_2 peduncle. Epimeral plate 3 rounded (Fig. 3.9) *A. diadema*
37. A_1 longer than A_2 peduncle and equal to half length of A_2. Epimeral plate 3 quadrate (Fig. 2.4) 38
38. A_2 shorter than half length of body. Epimeral 2 postero-distal angle with a small tooth (Fig. 2.3). . . . . *A. armoricana*

* Some subspecies of *A. brevicornis* described by Schellenberg (1925) and Reid (1951) and not confirmed could be confused with this species.

38. A_2 longer than half length of body. Epimeral 2 postero-distal angle rounded (Fig. 3.7) . . . . . *A. spinipes*
39. P_{3-4} dactylus shorter than carpus + propodus 40
39. P_{3-4} dactylus longer than carpus + propodus (Fig. 2.5) 43
40. Epimeral plate 2 postero-distal angle with a distinct tooth (Fig. 2.3) 41
40. Epimeral plate 2 postero-distal angle rounded (Fig. 3.7) 42
41. A_1 longer than A_2. Urosome seg. 1 without distinguished carina (Fig. 5.7) *A. antennata*
41. A_1 shorter than A_2. Urosome seg. 1, with a small quadrate carina (Fig. 5.1) . *A. verga*
42. Urosome seg. 1 with rather high dorsal carina, posterior edge overflowing. A_1 shorter than A_2 (Fig. 5.4) . . . . . *A. melitae*
42. Urosome seg. 1 with small carina. A_1 nearly equal to A_2 (Fig. 5.1) . . *A. aequicornis*
43. Gnathopode 1 with large spines on palm (Fig. 3.5) 44
43. Gnathopode 1 without spine on palm 45
44. P7, merus produced anteriorly in peg-shape covering half part of carpus (Fig. 4.2) *A. palmata*
44. P7, merus not produced . . . . . *A. spinimana*
45. Urosome seg. 1 with prominent carina (Figs. 5.3 and 4) 46
45. Urosome seg. 1 with moderate carina 48
46. A_1 longer than half A_2. Telson dorsal surface inermous. Epimeral plate 2 rounded (Fig. 3.12) . . . . . *A. anomala*
46. A_1 shorter than half A_2. Telson dorsal surface with spines. Epimeral plate 2, postero-distal corner angle a small tooth (Fig. 2.3) 47
47. Urosome seg. 1 with pronounced angular carina. A_1 shorter than A_2 peduncle (Fig. 5.3) . . . . . *A. typica*
47. Urosome seg. 1 with a raiser high dorsal carina, posterior edge overflowing. A_1 slightly longer than A_2 peduncle (Fig. 5.4) . . . . . *A. toulemonti*
48. A_1 equal to A_2 length 49
48. A_1 shorter than A_2 50
49. A_1 and A_2 longer than body length. P7 merus prolonged anteriorly in peg-shape covering a part of carpus (Fig. 4.2) . . . . . *A. calypsonis*
49. A_1 and A_2 nearly equal to body length. P7 merus without lobe . . *A. dalmatina*
50. Epimeral 3, postero-distal angle with a distinct tooth. A_2 shorter than half body length (Fig. 3.11) . . . . . *A. hupferi*
50. Epimeral 3, postero-distal angle without tooth. A_2 longer than half body length . 51
51. A_1 slightly equal to A_2 peduncle . . . . . *A. ledoyeri*
51. A_1 longer than A_2 peduncle 52
52. Telson with setae on dorsal surface. Urosome seg. 1 with a small rounded carina (Fig. 2.1) . . . . . *A. planierensis*
52. Telson without setae on dorsal surface. Urosome seg. 1 with a high rounded carina (Fig. 5.2) . . . . . *A. massiliensis*

DISCUSSION

In an attempt to group the species of *Ampelisca* from our study area, a cluster analysis was performed using 51 morphological characters listed by Bellan-Santini & Dauvin (1987). Each character was defined as 0, absence and 1, presence. A similarity matrix was generated using the Sokal & Michener (1958) coefficient. A phenogram was constructed using the inter-groups variance. An index of apomorphy was calculated using only 40 characters (Bellan-Santini & Dauvin, 1987) with apomorphic character (1) and plesiomorphic character (0).

In analysing the phenogram (Fig. 6) it should be kept in mind that the relationship shown in it reflect only the morphological resemblance of the species and inference of phyletic relationship from it should be made with caution

GAMMAROPSIS

KEY TO THE SPECIES

1. Coxa 1 toothed, epistome long and acute . . . . . *G. lobata*
   Coxa 1 smooth, epistome short 2
2. Uropod 3 rami spiniform, lacking a terminal cluster of spines 3
   Uropod 3 rami normal, with a group of terminal spines 4
3. Antenna 1 lacking accessory flagellum; ♂ gnathopod 1 palm evenly rounded; ♀ gnathopod 2 propodus subovoid . . . . . *G. sophiae*
   Antenna 1 with 2–3 articulate accessory flagellum; ♂ gnathopod 1 palm sinuous; ♀ gnathopod 2 propodus narrow, anterior and posterior margins approximately parallel *G. palmata*
4. Accessory flagellum well developed; ♂ gnathopod 2 carpus large, only a little shorter than propodus; ♀ gnathopod 2 propodus, palm weakly excavated with two prominences *G. maculata*
   Accessory flagellum absent; ♂ gnathopod 2 carpus reduced less than one-third length of propodus; ♀ gnathopod 2 propodus palm with deep, flat-bottomed excavation *G. nitida*

Key to the European species of *Siphonoecetes* Kroyer

1 Rostrum weakly developed, not extending beyond eye-lobes 2
– Rostrum strongly developed, extending beyond eye lobes 3
2 Eye absent, represented at most by pigment spots. . . . . *S. pallidus*
– Eye present . . . . . *S. sabatieri*†
3 Uropod 1 inner ramus very slender, over three times as long as broad . . . . . *S. typicus*
– Uropod 1 inner ramus less than three times as long as broad 4
4 Uropod 2 peduncle disto-ventral lamella minutely fimbriate . . . . . *S. dellavallei*
– Uropod 2 peduncle disto-ventral lamella comb-toothed 5
5 Uropod 2 inner ramus less than two thirds length of outer. . . . . *S. neopolitanus*†
– Uropod 2 inner ramus more than two thirds length of outer 6
6 Antenna 2 peduncle article 3 with inner dorso-lateral pigment stripe. . . . . Uropod 1 inner ramus markedly shorter than outer ramus and swollen medioproximally. Uropod 3 peduncle with moderately long setae and bearing a small spine less than half length of ramus . . . . . *S. striatus*

– Antenna 2 peduncle all articles pigmented proximally. Uropod 1 inner ramus sub-equal with or a little shorter than outer ramus, only weakly expanded medio-proximally. Uropod 3 peduncle with very long setae and bearing a strong spine, one half or more length of ramus . . *S. kroyeranus*

PHOTIS

KEY TO THE SPECIES

1. Pereopods 3–4 propodus elongate, slender, about twice length of carpus; ocular lobes elongate, eye situated entirely in ocular lobe; uropods 1–2 rami with few spines *P. longicaudata*
   Pereopods 3–4 propodus short, stout, only slightly longer than carpus, ocular lobes only moderately produced, eye situated only partly in ocular lobe; uropods 1–2 spinose 2
2. Male gnathopod 2 basis with anteroproximal lobe, lacking stridulating ridges; coxa 2 excavate posteroventrally; coxa 3 strongly convex anteriorly, lacking stridulating ridges *P. pollex*
   Male gnathopod 2 basis with anterodistal lobe, outer margin with oblique row of stridulating ridges; coxa 2 evenly rounded; coxa 3 weakly convex anteriorly, with distal stridulating ridges
3. Male gnathopod 2 propodus with proximal tooth 3
   Male gnathopod 2 propodus with distal tooth *P. tenuicornis*
   P. reinhardi

AORA

KEY TO SPECIES (MALES ONLY)

1. ♂ gnathopod 1 propodus with anterodistal 'brush' of long setae, ♂ gnathopod 2 basis slender parallel-sided, anterior margin straight or concave *A. spinicornis*
   ♂ gnathopod 1 propodus lacking anterodistal 'brush' of long setae, ♂ gnathopod 2 basis elongate-ovoid with convex flange on anterior margin *A. gracilis*

N.B. Females of all Aoridae are notoriously difficult to identify. In mixed samples of both species, including males, the females of *A. spinicornis* may be separated by the more setose antenna 2, short broad uropod 3 peduncle and relatively short uropod 3 rami. Some experience with both species is required before isolated females can be identified with confidence.

FROM SHEADER & EVANS (1974)

(3) Both are the only members of the genus to exhibit *bispinosa* and *compressa* forms and their intermediates. *Parathemisto libellula* (Lichtenstein) is a *bispinosa*-type species with P5 much greater in length than P6. *P. abyssorum*, *P. australis*, *P. pacifica* and *P. japonica* are all *compressa*-type species with P5 and P6 subequal.

(4) Both are the only members of the genus that are bipolar in distribution. *Parathemisto gaudichaudi* is an oceanic species, and *P. gracilipes* is neritic, their distributions overlapping where intermediate conditions occur.

As *Parathemisto gaudichaudi* (Guerin) takes precedence over *P. gracilipes* (Norman), the latter name should be dropped.

A key to allow identification of the six members of the genus is presented below:

1.	(*a*) P5 and P6 subequal in length	2
	(*b*) P5 much longer than P6	5
2.	(*a*) Maxilliped without a distal row of setae on the basal plate A1 straight	*P. abyssorum* Boeck
	(*b*) Maxilliped with a distal row of setae on the basal plate A1 straight; Dactyls of P5–P6 pectinate at base	
	(*c*) Maxilliped with a distal row of setae on the basal plate A1 curved; Dactyls of P5–P6 not pectinate at base	4
3.	(*a*) A1 and A2 of female subequal; length of adult 4·5–8·5 mm	*P. pacifica* Stebbing
	(*b*) A2 markedly longer than A1; length of adult 9–17 mm	*P. japonica* Bovallius
4.	(*a*) A1 hooked (Fig. 1); inner margin of inner ramus of U3 strongly serrate	*P. australis* (Stebbing)
	(*b*) A1 curved (Fig. 1); inner margin of inner ramus of U3 serrate or serrulate	*P. gaudichaudi* (*compressa* type)
5.	(*a*) Dactyls of P5–P7 pectinate at base	*P. libellula*
	(*b*) Dactyls of P5–P7 not pectinate at base	*P. gaudichaudi* (*bispinosa* type)

Compared with other members of the genus, *Parathemisto gaudichaudi* is extremely variable in form. Mogk (1927) carried out a morphometric study of the two forms, and concluded that there was a complete range of specimens with characteristics intermediate between the two extremes. Factors affecting the degree of development of the *bispinosa-compressa* condition are not fully understood. It has been suggested that the inheritance of the *bispinosa* condition is sex-linked (Kane, 1966), but the results of the present work show that the degree of expression of the condition can be changed towards either of the extreme forms when specimens moult. The phenotype is therefore continually changing in response to some factor, the nature of which is unknown.

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The "JIZZ" GUIDE to TALITRID AMPHIPODS

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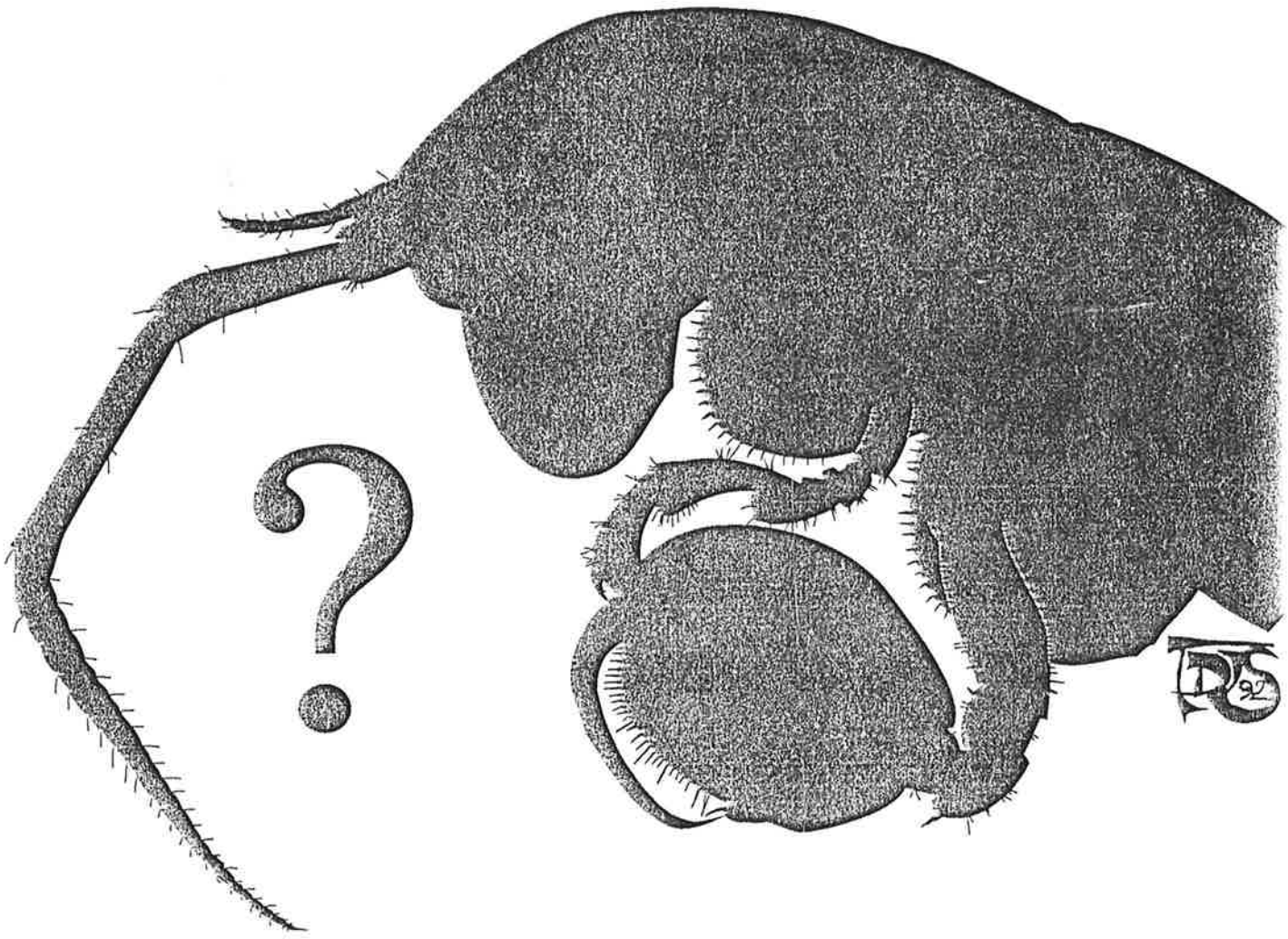

TALITRID AMPHIPOD JIZZ GUIDE

GROUP CHARACTERISTICS

The Talitridae are the only family of amphipods to have successfully colonised land. The majority of the British species are restricted to the supralittoral zones of maritime / estuarine shores. There is, however, one species, *Orchestia cavimana* which penetrates well up into freshwater systems and one fully terrestrial species, *Arcitalitrus dorrieni*. The latter was introduced from Australasia and has become established in Cornwall and at various sites on the west coasts of Scotland and Ireland.

Talitrids are unusual among amphipods in their ability to walk in an upright position on land and have considerable jumping ability. Body robust, compressed and smooth. The head does not bear a rostrum. The first antennae are very reduced: antenna 1 being shorter than the peduncle of antenna 2. The second antennae are robust, especially in male specimens.

Orchestia gammarellus (Pallas) shorehopper, beachflea

Length: Up to 18 mm.

Colour: Variable - brown, olive-brown to grey. Eyes round and black. Blood deep blue upon contact with air.

Habitat: In wrack piles and strandline debris on shingle, gravel and rocky shores(even sometimes on sand) between EHWS and MHWN. Also on saltmarshes and amongst vegetation fringing upper shore (supralittoral).

Habit and behaviour: Very common, attaining massive numbers in certain situations. Ease of collection dependent on environmental conditions; during cold and hot weather animals tend to burrow down into underlying gravel / shingle to avoid freezing / desiccation stress respectively. Found in large numbers in freshly cast seaweed but as this decomposes animals more commonly found interstitially as food material mixes with the substratum. Strongly thigmotactic. Readily jump when disturbed.

Distinctive field characters: Expanded basis, merus and carpus of peraeopod 7 in large males. Enlarged propodus of second gnathopod ("claw") of male has convex palm (compare with other *Orchestia* species). Females lack enlarged second gnathopod propodus and expanded peraeopod 7. Second antennae more robust in males than females. Large male specimens may exhibit horizontal banding on the dorsal surface. Sexes can not be easily differentiated in animals below 8 mm. Females with eggs from March - September: eggs initially purple changing to orange tint nearer to hatching.

Characters in preserved material: Pleopods, rami only about half length of peduncle. ♂: gnathopod 1 subchelate with short palm, merus without posterior lobe; gnathopod 2 robustly subchelate, propodus (broadly oval), palm less than half length of posterior

margin, regularly convex delimited by distinct tooth, dactylus curved; peraeopod 7 merus and carpus expanded ♀: gnathopod 1 subchelate but palm very short; gnathopod 2 carpus with asymmetrical lobe. basis anterior margin slightly concave & Valley

Site(s) on Isle of Cumbrae: Farland Bight.

Orchestia mediterranea (Costa)

Length: Up to 18 mm.

Colour: Brown, grey to greenish. Eyes round and black. Blood deep blue upon contact with air.

Habitat: In shingle, under stones and boulders often with little or no apparent dtrital algae, or amongst organic debris. Usually lower on the shore (MHWN, lower than *Pelvetia* zone on surrounding rocks) than *O. gammarellus* although both species may occur together.

Habit and behaviour: Similar to *O. gammarellus* although not as numerous and less likely to occur in major wrack piles. Generally more similar to aquatic species in behaviour, ie. more likely to squirm on side (in *Gammarus*-like manner) than *O. gammarellus* - it is however a very good jumper. Frequently seeks refuge inside empty gastropod shells which are usually available in normal habitat. Large males often rest on their side (cf. *Gammarus*).

Distinctive field characters: Sleek overall appearance (more laterally compressed compared with *O. gammarellus*). Females virtually indistinguishable from *O. gammarellus* in the field. Enlarged propodus of second gnathopod of mature male has sinuous palm with a median hump and often shows bright reddish coloration on the edges of the palm and dactylus. Large males usually show solid colouration. Eggs purple tending towards orange prior to hatching.

Characters of preserved material: Pleopods, rami equal to length of peduncle. ♂: gnathopod 1 subchelate with short palm, merus without posterior lobe; gnathopod 2 robustly subchelate, propodus (pear shaped), palm more than half length of posterior margin, sinuous with median hump, dactylus curved; peraeopod 7 merus and carpus expanded. ♀: gnathopod 1 subchelate but palm very short; gnathopod 2 carpus with symmetrical lobe.

Site(s) on Isle of Cumbrae: Ballochmartin Bay, Farland Bight (left hand side looking out to sea).

Talitrus saltator (Montagu) Sandhopper

Length: Up to 25 mm.

Colour: Males have pale fawn/grey background coloration with black dorsal markings, the extent of which can vary greatly. Females smaller with greyer background colouration. Males have very large, bright orange second antennae and orange tips to the peraeopods; females have much smaller, grey antennae and grey tipped peraeopods. Blood straw coloured upon contact with air. Eyes large, round and not uniformly black, often with grey/whitish portion. with bundle yellowish dorsally.

Habitat: Sandy shores and dune systems. During day found buried in sand above recent high water mark down to depth of 10 - 20 cm.

Habit and behaviour: Fossorial (burrowing) species which forms distinct burrow zones near the tops of sandy shores, always above the level of the most recent high tide mark. Juvenile specimens are often found under strandline debris. Nocturnally active, emerging from the burrow at night to forage on strandline debris on the beach. *Talitrus* hibernates over winter (between September and March/April) in high shore sand at a depth of up to 70 cm, often several metres above the high water mark. Very active species capable of considerable jumping and long nocturnal migrations.

Distinctive field characteristics: The fattest of the talitrids; the body is broader than the *Orchestia* species and the animal has a generally "heavier" appearance. The general body size and form and paler colour make adults of this species easily distinguishable from *Orchestia*. Bright orange second antennae of males are absolutely characteristic. Smaller individuals can be easily confused with *Talorchestia deshayesii* in the field. Females with eggs between April and September. Colour ?

Characteristics of preserved material: Pereon broad; pleon rather compressed. ♂&♀: gnathopod 1 simple; gnathopod 2 of mitten-type. ♂: Antenna 2 very robust, peduncle article 5 much larger than 4, flagellum up to 35-articulate; most articles with distinct tooth on inner distal angle. ♀: Antenna 2 much less robust and shorter. Uropod 3 has single apical spine. Uropod 3 with single stiff distal spine = ramus

Site(s) on Isle of Cumbrae: Fintry Bay, Sheriff's Port, Indian's Head.

Talorchestia deshayesii (Audouin) sandhopper

Length: Up to 15 mm.

Colour: Variable - fawn / brown to greenish. Sometimes with pinkish tinge, often in form of a median stripe. May also have darker spots which may be close enough together to give the

effect of longitudinal banding. Chocolate brown/black mark laterally on coxal plate 5 is characteristic.

Habitat: Sandy shores / sand gravel. Similar to *Talitrus* in burrowing habits although may also be found under strandline debris.

Habit and behaviour: Overall similar to *Talitrus*: the two species are often found together, although *Talorchestia* may be found slightly lower on the shore.

Distinctive field characteristics: Variability of body colouration makes definite field identification difficult. Adults are appreciably smaller and less robust than adult *Talitrus*. Adult males have characteristic second gnathopod propodus which is much enlarged with the palm having a strong curved proximal process (see diagram). This distinguishes adult males from those of other talitrids (*Orchestia* spp. lack the process and *Talitrus* does not have enlarged propodus of the second gnathopod). Colouration is generally darker than *Talitrus* and lighter than the *Orchestia* species. Definite identification, especially of females and immature animals, requires use of binocular microscope.

Characteristics of preserved material: ♂: gnathopod 1 subchelate with very short palm; gnathopod 2 robustly subchelate, palm with large curved proximal process. ♀: gnathopod 1 simple; gnathopod 2 carpus with asymmetrical lobe, propodus of mitten-type.

Site(s) on Isle of Cumbrae: Sheriff's Port, Indians Head.

Orchestia cavimana (Heller) Bankhopper

Length: Up to 22 mm. (males)

Colour: Dark brown - slate grey.

Habitat: Moist habitats under stones and amongst damp, bankside vegetation in fresh and brackish water situations. Sporadic distribution around the British Isles.

Habit and behaviour: Broadly similar to *O. gammarellus* although no where near as numerous. Often found in isolated "nests" of up to 50 animals under stones (especially flat paving stones or planks of wood on stream/river banks). Tend to show migration up and down stream banks depending on water level (I have found them in association with aquatic species such as *Asellus* and *Crangonyx* and also some distance away from the water course in association with terrestrial isopods such as *Porcellio scaber* and *Oniscus asellus*).

Distinctive field characteristics: Enlarged propodus of second gnathopod of male has a sinuose palm which distinguishes it from male *O. gammarellus* (it is highly unlikely that *O. mediterranea*

and *O. cavimana* are found together). Peraeopod 7 in mature male *O. cavimana* lacks the expansions seen in the other two *Orchestia* species described. Males attain greater size than *O.gammarellus* and tend to have a slate grey coloration.

Characters of preserved material: ♂: gnathopod 1 subchelate with very short palm, merus with knob-like posterior lobe; gnathopod 2 robustly subchelate (oval shape), palm oblique, spinose, markedly sinuous, dactylus moderately robust with inner margin sinuous matching palm; peraeopod 7 merus and carpus not strongly expanded ♀: gnathopod 2 basis with anterior margin more or less regularly convex, merus with small posterior lobe.

Site(s) on Isle of Cumbrae: None. Not found in Scotland although occurs at several sites in northern England, along the Thames valley and Medway estuary.

Arcitalitrus dorrieni (Hunt) Landhopper

Colour: Dark brown to almost black / blue. Cuticle surface often appears to exhibit iridescence. Buccal mass often with reddish coloration. Blood dark blue upon contact with air.

Habitat: Fully terrestrial, living in leaf litter and soil where it performs a similar role to woodlice, with which it is frequently found co-existing. Also found amongst mat-forming vegetation such as *Helixine*.

Habit and behaviour: Cryptozoic / fossorial amongst leaf litter and soil crumbs where it sometimes forms superficial burrow systems. Active, jumping species but often feigns death when disturbed (after an initial bout of hopping).

Distinctive field characteristics: Immediately distinguished from the other species by the terrestrial habit: I know of no site where *Arcitalitrus* is found in association with any of the other species described here. A very delicate species with characteristically dark coloration and slender second antennae and limbs.

Characters of preserved material: Antenna 1 reaching beyond end of peduncle article 4 of antenna 2 (unlike semi-terrestrial species). Antenna 2 slender. Gnathopod 1 simple; gnathopod 2 propodus of mitten-type

Site(s) on Isle of Cumbrae: None. Nearest recorded site on the island of Colonsay, Inner Hebrides.

Other talitrid species recorded from the British Isles:

Orchestia remyi roffensis
Orchestia aestuarensis
Platorchestia platensis
Talorchestia brito

Experimental "jizz" key to adults of common British talitrids.

1) Fully terrestrial, living in leaf litter and soil; dark coloration, delicate with slender second antennae and walking limbs.....*Arcitalitrus dorrieni*

Semi-terrestrial in marine, estuarine or fresh water habitats; robust body with robust second antennae and walking limbs 2

2) Male gnathopod 2 not expanded ("mitten" type); second antennae of male massive and bright orange; animals very rotund and not obviously, laterally compressed; pale fawn/grey colour; sand burrowing.....*Talitrus saltator*

Propodus of male second gnathopod enlarged; second antennae robust but not massive; obviously laterally compressed to some degree. 3

3) Less than 15 mm. Mature male gnathopod 2 palm of propodus and dactylus with distinct "hooked" appearance; grey/pale brown/pinkish background coloration with pronounced black, dorsal markings often forming longitudinal bands and chocolate brown/black mark laterally on coxal plate 5; burrowing in sand/gravel shores..... *Talorchestia deshayesii*

Large males greater than 15 mm in length. Male gnathopod 2 lacking hooked appearance; body colour more or less uniform brown/ grey (may be hint of horizontal banding); may have expanded peraeopod 7 merus and carpus.....4

4) Fresh or brackish water banks; slate grey/brown; male peraeopod 7 not strongly expanded; male gnathopod 2 propodus oval shaped.....*Orchestia cavimana*

Rocky shores, boulder shores, shingle (even possibly sand) and saltmarshes; expanded merus and carpus of peraeopod 7 in male.....5

5) Sleek appearance; male propodus of gnathopod 2 pear-shaped and palm sinuous; palm and dactylus reddish; MHWN, ie. lower than *Pelvetia* zone under stones and boulders on marine shores..... *Orchestia mediterranea*

Gnathopod 2 propodus broadly oval; gnathopod 2 palm convex; no red coloration; may show horizontal banding; EHWS-MHWN on wide range of shores (estuarine and marine). .....*Orchestia gammarellus*

Toxicity testing using amphipods

Began in USA in 1970. R.C. Swartz (EPA, Newport, Oregon) started it off using the phoxocephalid *Rhepoxynius abronius*. The 'Rhepox' test has now become a standard procedure, with the unlooked for consequence that the beast is now loosing ground in the field due to over-collection!

Protocol in ASTM (American Society for Testing Materials). In 1lit. beaker, add 2cm of test sediment, overlain with aerated seawater. Test 10 days duration. Observe whether Rhepox burrow? If yes: continue. If not, then mix sediment with clean diluent sediment until reach a mix they will tolerate, then repeat. At end, see how many still alive. Put live ones back into sediment, see if reburrow.

PROBLEMS:

1) *Rhepoxynius* is a carnivore! This may not be the ideal feeding strategy for a sediment test organism. Is there appropriate food available in the test arena? are animals under food stress as well as toxin stress?

2) animals are probably not eating the sediment. Therefore toxin uptake is probably through the gills not the gut.

3) Seems that this organism was chosen for convenience rather than sensitivity

At recent meeting (1992) of amphipodologists in Washington, D.C., Don Reish stressed that:

1) there was a need for really simple keys for toxicologists to use,

2) since toxicologists not good taxonomists can easily find themselves doing expts on 'wrong' species, or mixtures of spp.

3) attempts should be made to have correct test species always available from lab. cultures (as is now the case for polychaetes), to get around these problems.

Response to these realisations in California has been the formation of SCAMIT (Southern California Association of Marine Invertebrate Taxonomists).

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Standard Guide for Conducting 10-day Static Sediment Toxicity Tests with Marine and Estuarine Amphipods[1]

This standard is issued under the fixed designation E 1367; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This guide (1)[2,3] describes procedures for obtaining laboratory data concerning the short-term adverse effects of potentially contaminated sediment, or of a test material experimentally added to contaminated or uncontaminated sediment, on marine or estuarine infaunal amphipods during static 10-day exposures. These procedures are useful for testing the effects of various geochemical characteristics of sediments on marine and estuarine amphipods, and could be used to assess sediment toxicity to other infaunal taxa, although modifications of the procedures appropriate to the test species might be necessary. Procedures for 10-day static sediment toxicity tests are described for the following species: *Rhepoxynius abronius*, *Eohaustorius estuarius*, *Ampelisca abdita* and *Grandidierella japonica*.

1.2 Modifications of these procedures might be appropriate for other sediment toxicity test procedures such as flow-through or partial life-cycle tests. Methods outlined in this guide should also be useful for conducting sediment toxicity tests with other aquatic taxa, although modifications might be necessary. Other test organisms might include other species of amphipods, other crustaceans, polychaetes, and bivalves.

1.3 Other modifications of these procedures might be justified by special needs or circumstances. Although using appropriate procedures is more important than following prescribed procedures, results of tests conducted using unusual procedures are not likely to be comparable to results of many other tests. Comparisons of results obtained using modified and unmodified versions of these procedures might provide useful information concerning new concepts and procedures for conducting sediment tests with infaunal organisms.

1.4 These procedures are applicable to sediments containing most chemicals, either individually or in formulations, commercial products, and known or unknown mixtures. With appropriate modifications these procedures can be used to conduct sediment toxicity tests on factors such as temperature, salinity, dissolved oxygen, and natural sediment characteristics (for example, particle size distribution, organic carbon content, total solids). These methods can be used to conduct bioconcentration tests and in situ tests and to assess the toxicity of potentially contaminated sediments, or of such materials as sewage sludge, oil, particulate matter, and solutions of toxicants added to sediments. A median lethal concentration (LC50) or median sublethal effect concentration (EC50) of toxicants in highly contaminated sediment mixed into uncontaminated sediment can be determined. Materials either adhered to sediment particles or dissolved in interstitial water can be tested.

1.5 Results of short-term toxicity tests with test materials experimentally added to sediments may be reported in terms of an LC50, and sometimes an EC50 where "concentration" refers to dry or wet weight concentration in sediment. Results of a field survey with single samples to determine spatial or temporal distribution of sediment toxicity may be reported in terms of percent mortality (see Section 10). Such surveys can be designed to provide either a *qualitative* reconnaissance of the distribution of sediment toxicity or a *quantitative* statistical comparison of toxicity among stations.

1.6 This guide is arranged as follows:

[1] This guide is under the jurisdiction of ASTM Committee E-47 on Biological Effects and Environmental Fate and is the direct responsibility of Subcommittee E47.03 on Sediment Toxicology.

NOTE — Table 1 is currently being revised.

Current edition approved June 29, 1990. Published December 1990.

[2] Boldface numbers in parentheses refer to the list of references at the end of this guide.

[3] This guide is based largely on Guide E 729 and Ref (1).

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FROM PAPER IN PRESS

THE EFFECT OF 10 TOXICANTS ON SURVIVAL AND BIOACCUMULATION ON TWO SPECIES OF AMPHIPOD CRUSTACEANS

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ABSTRACT

The toxicity and bioaccumulation of arsenic, cadmium, copper, lead, mercury, zinc, DDT, PCB, and the water-soluble fraction of diesel fuel were measured over a 96-hour period to the gammaridean amphipods *Corophium insidiosum and Elasmopus bampo. Corophium* was more sensitive to arsenic, zinc, DDT, PCB, and the water soluble fraction of diesel fuel; whereas, *Elasmopus* was more sensitive to cadmium ,chromium, and copper. Comparisons of these results to those determined for copepods, cumaceans, isopods, and decapods conducted under the same experimental conditions indicated that the sensitivity of these two species of amphipods were intermediate to the other species of crustaceans. *Corophium* accumulated the greater amounts of chromium, copper, lead, and zinc; whereas, *Elasmopus* accumulated more cadmium, DDT, and PCB after a 20 day experimental period. The toxicity and bioaccumulation of toxicants to other species of marine species of amphipods were discussed and summarized in tabular form.

TABLE 1

MARINE GAMMARIDEAN AMPHIPODS USED IN MARINE TOXICOLOGICAL RESEARCH

Family Ampeliscidae	
Ampelisca abdita	2
Family Ampithoidea	
Ampithoe valida	1
Family Aoridae	
Leptocheirus plumulosa	1
Family Cheluridae	
Chelura terebrans	1
Family Corophiidae	
Corophium acheriscum	1
C. ~~bonelli~~ bonnelli	1
C. insidiosum	3
C. orientalis	1
C. spinocorne	1
C. volutator	5
Grandidierella japonica	4
G. lutosa	1
Family Gammaridae	
Anisogammarus pugettensis	1
Elasmopus bampo	3
Gammarus aequicauda	2
G. daiberi	1
G. duebeni	5
G. insensibilis	1
G. locusta	1
G. micronatus	1
G. oceanicus	3
G. pseudolimnaeus	1
G. sp.	1
Family Haustoriidae	
Eohaustorius estuarius	1
Neohaustorius biarticulatus	1
Pontoporeia affinis	3

Family Hyalidae	
Allorchestes compressa	8
Family Lysianassidae	
Onisimus affinis	1
unidentified	1
Family Phoxocephalidae	
Rhepoxynius abronius	18
Family Talitridae	
Orchestoidea californica	1
O. corniculata	1
Amphipods, unidentified	4

TABLE 2

THE EFFECT OF TOXICANTS ON MARINE GAMMARIDEAN AMPHIPODS
(Data as 96 hour LC50 in mg/L)

Toxicant	*Corophium*	*Elasmopus*	Other Species
Arsenic	0.9	2.8	7-58
Cadmium	1.27	0.57	0.19-7.41
Chromium	11.3	2.4	5.56
Copper	0.36	0.34	0.1->10
Lead	>5.0	>5.0	---
Mercury	0.02	0.02	0.08-0.12
Zinc	2.1	4.5	0.58-2.0
DDT	0.00014	0.002	---
PCB	0.009	0.037	---
Altosid	---	>100.0	0.32-2.15
BTI	---	12.8	---
W-S Diesel	1.2	2.4	---

TABLE 3

CHEMICAL RESIDUES REPORTED IN MARINE GAMMARIDEAN AMPHIPODS (ug/g)

Chemical	*Corophium*	*Elasmopus*	Other Species
Arsenic			
Lab	<10.0	<0.01	---
Field	---	---	2.3-8.9
Cadmium			
Lab	23.0	58.7	46.0
Field	---	---	0.83-8.8
Chromium			
Lab	51.3	11.5	>46.0
Copper			
Lab	3,464	32.0	364
Field	---	---	12.4-94
Lead			
Lab	832	1.2	60.0
Field	---	---	10-23
Mercury			
Lab	27.7	<0.01	---
Field	---	---	0.01-0.47
Zinc			
Lab	253	0.05	109-139
Field	---	---	13-2700
DDT			
Lab	<1.0	2.9	---
PCB			
Lab	<1.0	11.0	---

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WHO WAS WHO

G.O. Sars

Perhaps the greatest carcinologist who ever lived, George Ossian Sars is known for the excellence of his systematic analyses and fine graphic renditions plus the high quality of the plates he produced in the Crustacea of Norway and the Crustacea of the Caspian Sea. The style, proportions and arrangement of his plates have never been duplicated, let alone surpassed. Surprisingly, Sars was known in his early years for his first major work which was on freshwater crustaceans of Norway (1867) and then later he became the great marine expert. Fortunately, Sars was given the great Caspian collections of Dr. Grimm and Mr. Warpachowsky and he rendered them in his usual fine style. Though he largely ignored mouthparts of the Caspian gammaroids, which has frustrated many of us in later years, he obviously realized they were all very similar to each other and only the smallest of differences in palpar setation have been usable for later splitters.

S. Karaman

Stanko Karaman's father was the first scientist of Yugoslavia, and his grandson, Gordan, carries on the tradition of a family laced with scientists. Stanko Karaman is responsible for the exploration of the Balkans in search of cave and epigean amphipods; Gordan now believes the major species have all been discovered. The Karamans have been, and are, very prolific workers, as can be seen in the Bibliography herein.

Linnaeus

Carl von Linne described what has become the first officially valid amphipod name, now known as Gammarus pulex (Cancer Pulex Linnaeus, 1758: 633). It was described in nine Latin words, its type-locality being the "sea shore," which makes it suspect, as pulex is a lake and stream species. Nevertheless, Stebbing (1906) accepts this as the establishment of pulex. The next and final gammaridean amphipod described by Linnaeus (1758) was Gammarus locusta (as Cancer locusta) on page 634. This came from maritime Europe.

Ed. Chevreux

The great French carcinologist, Ed. Chevreux, worked on amphipods between the middle 1880's and the mid-1920's. Though his major contributions were to the marine fauna, especially in his classic "Faune de France," 1925, with Louis Fage, and vital studies of tropical Pacific island chains, he treated many new freshwater species from Europe and North Africa. He also was the recipient of occasional freshwater species from exotic places like the Seychelles, South America, Lake Baikal and the Turkestan.

E.W. Sexton

Mrs. Sexton is the founder of the study of behaviour in amphipods. She used Gammarus chevreuxi for nearly 40 years in her Plymouth laboratory starting about 1910. She learned much about moulting, growth stages, variation, phenotypy and ecophenotypy. She and J.S. Huxley did some work on inheritance of eye colour. She began the work necessary to sort out the difficult taxonomy of the seven dominant species of Gammarus in the salt waters of Europe and discovered what became the scourge of Europe, Gammarus tigrinus.

C. Chilton

Charles Chilton, the New Zealander, studied New Zealand freshwater amphipods, and his fine paper of 1894 is the basis of early knowledge on the group Indeed, his work is the best of the early products on underground species. He also reported on species from the Philippines Australia, and southeast Asia. His famous work on Chilka Lake in India has piqued the imagination of many persons wanting to explore more fully the fauna of this kind of coastal lagoon in the tropics.

E.V. Martynov

Martynov began publishing in 1919 on crustaceans in the area of Rostov-on-Don, extended outward through the Ukraine, the Dnieper, the Crimea, shore drainage of the Black Sea and took on more exotic places such as Issy-Kul, Turkestan and Lake Teletzkoye.

O.A. Sayce

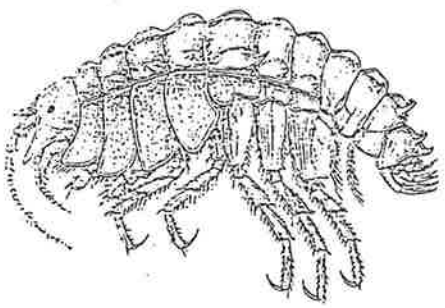
Sayce founded the freshwater amphipod fauna of Australia by describing in excellent form several species between 1899 and 1902; however, G.M Thomson had preceded him by describing in 1893 two species from Mount Wellington and a tributary of the Huon River in Tasmania.

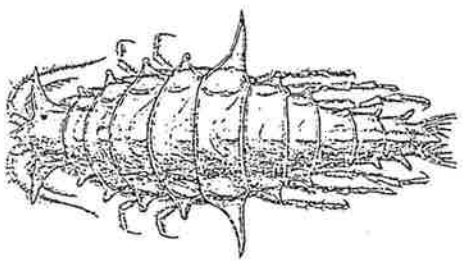
A. Schellenberg

Schellenberg published between 1925 and 1953, though his last papers were obviously published after his death. Schellenberg was one of the first and has been, until a decade ago, one of the few amphipod students to delve into the higher classification and interrelationships of freshwater amphipods. He recognized the unusual character of crangonyctoids (see especially, 1937c). He had a special fascination for Niphargus.

C.R. Shoemaker

Mr. Shoemaker worked at Smithsonian between 1912 and 1958 when he died in his 80's. He published several small papers on epigean Gammarus, Crangonyx, and various cave amphipods from North America and the Caribbean region.





J. Laurens Barnard

(1928 - 1991)

A Brief History

by James D. Thomas

On rare occasions individuals come along in a particular field of science whose presence and contributions forever alter the understanding and practice of the discipline they are engaged in. In the field of carcinology, Jerry Barnard was one of these rare individuals. His extensive contributions to amphipod taxonomy were one of the greatest taxonomic efforts ever by a single investigator. In these times of declining activity in systematics we are not likely to see his equal again, and for this reason his passing is especially painful.

According to Jerry, his career in science began in 1940 when, as a 12 year old, he saw a movie made by marine biologists from the Allan Hancock Foundation of the University of Southern California. From that point on he knew he wanted to be a scientist. His career ended in my living room on Ramrod Key, Florida, on the evening of 16 August 1991, when he suffered a massive heart attack. Between these two points in time he practiced his trade as a naturalist and amphipod taxonomist with focused diligence, becoming the most significant taxonomic presence in this group since the early days of T.R.R. Stebbing and G.O. Sars.

Jerry's command of amphipods was total, covering the entire group from all parts of the world, marine to fresh water, tropical to boreal, shallow coral reefs to hydrothermal vents. While the majority of his contributions to amphipods were taxonomic in nature, he also worked on amphipod behavior, ecology, functional morphology, and phylogeny. At the time of his death he had 25 active manuscripts in various stages of completion, addressing all major aspects of the Amphipoda, including descriptive papers, monographs, book chapters, biogeographic investigations, behavior, ecological studies, and phylogenetics.

An only child, Jerry was born and raised in Pasadena, California. His boyhood "California years" and his early scientific career remained forever etched in his memory, and to ride around Southern California with Jerry was to be taken back into time with a constant commentary on what life was like for a boy growing up in that area.

Jerry entered Pasadena Junior College as a high school junior in 1945 and graduated in 1947. He then enrolled in the zoology program at the University of Southern California and began a research project on corals but soon ran out of material due to the depauperate nature of eastern Pacific corals. He did, however, publish a paper in 1952 with J. Wyatt Durham on the stony corals of

the eastern Pacific. By this time a fellow graduate student in isopods, Robert J. Menzies, had focused Jerry's attention on crustaceans. One day Menzies and the noted authority on eastern Pacific crustaceans, John W. Garth, took Jerry on a tour of the crustacean collections. Remembering his problem with adequate material for study in corals, Jerry inquired which group was well represented in the collections and might be the most difficult to study, to which both Garth and Menzies replied "amphipods". He started on amphipods the next day. At the end of six months he was still unable to identify the first amphipod species he was given. This initial frustration with amphipods was due in large part to the lack of adequate taxonomic illustrations, descriptions, and keys. Jerry overcame these shortcomings by providing detailed illustrations and descriptions of amphipods, but his initial frustration with identifications would motivate his taxonomic efforts for the next 40 years.

In 1949, Jerry started his Ph.D. program at the University of Southern California. He received his Master's degree in 1950. One of his professors, J.W. Mohr, formed the Marine Borer Council to study the effects of marine borers on submerged timbers. Jerry's involvement on this council resulted in the subject of his dissertation, a study of the wood-boring amphipod *Chelura terebrans*. Jerry received his Ph.D. from USC in 1953. From 1953 to 1956 he was a postdoctoral fellow at USC working on floating ice islands in the Central Arctic Basin. His early field work and the many areas around the world he would visit during the beginning stages of his career provided him with a broad conceptual base of amphipod distribution and taxonomy. He related to me many times during our association the critical importance this early field work had on his understanding of amphipods. Wherever Jerry went in the field, he inspired colleagues and students alike in marine invertebrate taxonomy.

In 1958, Jerry joined the newly formed Beaudette Foundation in Solvang, California, as an Associate Investigator. The Beaudette Foundation was funded by Palmer Beaudette, a wealthy philanthropist with an interest in marine biology. From 1958 to 1959 Jerry was a Research Associate at Beaudette, becoming Associate Research Director from 1960 to 1964, and undertaking many research trips, including an NSF-funded study of lagoon ecology and taxonomy of Bahia de Los Angeles and Bahia San Quintin, and the Galápagos International Scientific Expedition. Financial difficulties forced the closing of the Beaudette Foundation in 1964, and Jerry returned from the Galápagos expedition to find himself out of a job. However, this period remained for Jerry a special time in his scientific career, and he often referred to this time as the "halcyon days of taxonomy."

In 1964, Jerry accepted a job at the National Museum of Natural History as Associate Curator of Crustacea. He was to remain in California for a year finishing several projects, since this was the time when the west wing of the Natural History Museum was under construction and no office space was

available. The Barnard family moved to Oxon Hill, Maryland in 1965, but their stay was brief. In January 1967, Jerry and family began a series of postings that would take him to the Bishop Museum in Hawaii (1967-68), the New Zealand Oceanographic Institute at Wellington (1968), and the Western Australian Museum in Perth (1968). These efforts resulted in a series of comprehensive faunal monographs from Hawaii, Micronesia, Australia, and New Zealand. Jerry's initial presence and continued visits in these areas served as a catalyst for marine invertebrate taxonomy that he continued to cultivate until the time of his death.

From 1970 to 1974 Jerry was on loan from the Smithsonian Institution to the University of Arizona, Tucson, to help stimulate research and strengthen their marine field station in Sonora, Mexico. According to those at the station, Jerry's presence was strongly felt in the program and students naturally gravitated to him. The Barnard family returned to the Smithsonian in November, 1974 taking up residence in Alexandria, Virginia. There was a steady stream of colleagues and technicians through his home and his laboratory at the Museum of Natural History.

Jerry published widely on all aspects of amphipods. He produced three major syntheses of the group, the first being the 1969 index to the marine families and genera. This publication immediately became a benchmark in the field since it offered the first diagnoses of amphipod families and genera in a single comprehensive work. The 1969 handbook treated 3,300 species in 670 genera and 54 families. The recent update of this monograph published by the Australian Museum treats 5,733 species in 1,055 genera and 91 families. Unfortunately, Jerry would never see this updated world monograph in final form. In 1983, Jerry published the two-volume world monograph on fresh water amphipods with his wife Charline.

So what have been Jerry's contributions to amphipodology? On the technical side, more than 225-plus publications on amphipods (except for a single paper each on corals and isopods) will remain an unequaled scientific legacy. To many of us though, Jerry was much more than a compendium of taxonomic information. He was a warm and generous man who never lost his focus or appreciation of nature. Jerry was an inspiration to many people, many of whom he never met. His constant encouragement in scientific and financial areas was widely applied to struggling and established taxonomists and naturalists. For those of us working on amphipods JLB is gone in body only. Nearly every time we reach for an amphipod paper, it will be one of Jerry's. What we have lost is his encyclopedic mind, a storehouse of information that could provide us with answers by a phone call or letter, his sage council, and sense of humor. To his credit, Jerry never lost his childlike fascination with the world and people around him, and was always more interested in other peoples projects than his own. He was without pretense, always willing to try a new idea or fresh approach, and

doggedly supported individuals and organizations for which taxonomy could only be a part-time endeavor.

An avid birder, JLB traveled extensively in pursuit of this hobby and was well respected in the international birding community, his life list being among the most extensive in the world. He also had a passion for fire engines and trains, and was a model railroad enthusiast until his first heart attack in 1978. In his office, woe be unto those who inadvertently blocked his path to his laboratory window overlooking Constitution Avenue when the sirens of fire engines wailed. For, despite his bad knees, he could cover the distance from his microscope table to the window with catlike quickness.

It is difficult to imagine amphipods without Jerry Barnard, but his scientific and personal legacy will provide firm footing for those who follow. Farewell old friend, we will do our best to stay the course you so admirably charted for us.

Jerry is survived by his wife Charline, daughter Gretchen, and sons Robert and Roger.

James D. Thomas
Ramrod Key, Florida
March 25, 1992

This will appear in the next issue of The Journal of Crustacean Biology.