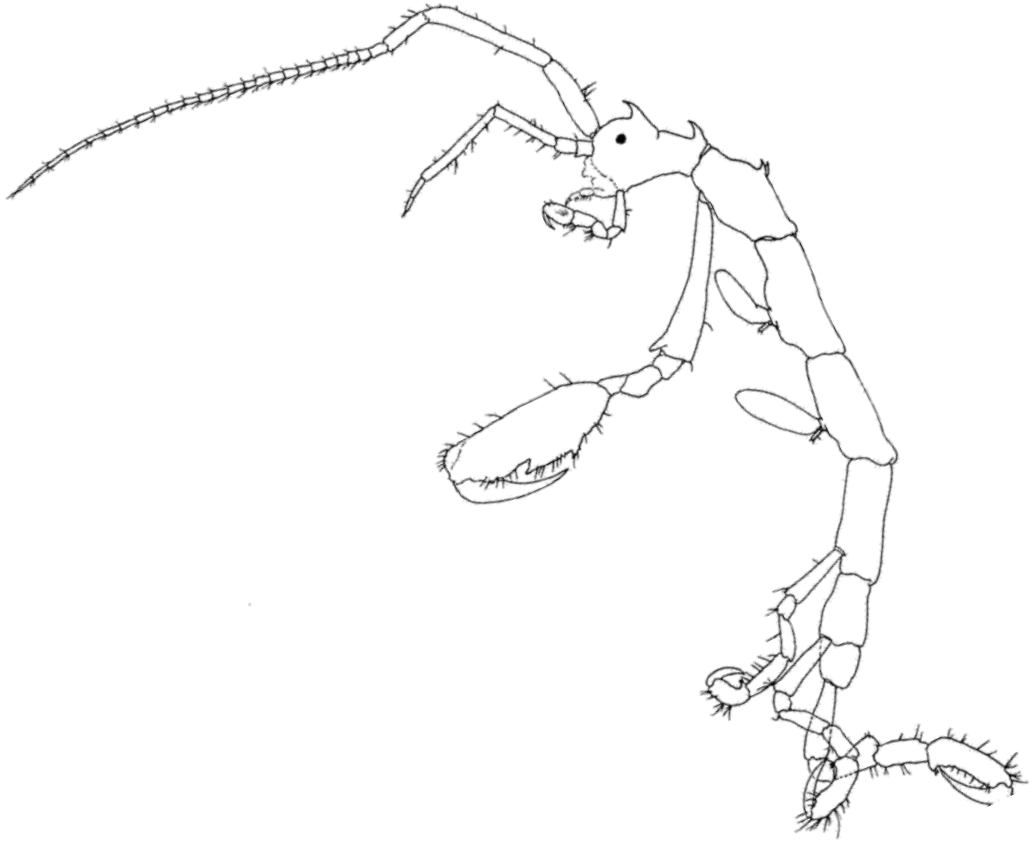
CAPRELLIDEA

Identification guide to British caprellids



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Contents

INTRODUCTION TO BRITISH CAPRELLIDS

Traditionally, Caprellidea have been considered as a suborder of the order Amphipoda. The order Amphipoda is an order of malacostracan crustaceans with no carapace and generally with laterally compressed bodies. This order includes near 10,000 species (80% marine, 17% freshwater and 3% terrestrial) distributed in four suborders: Gammaridea (with more than 90% of the species), Caprellidea, Hyperiidea and Ingolfiellidea (Fig. 1)

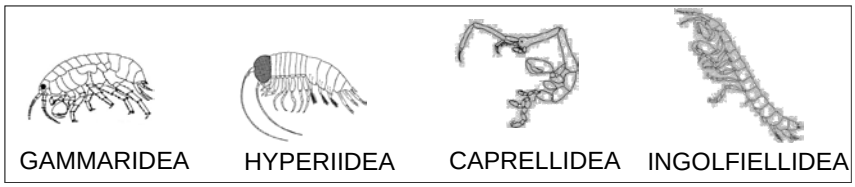


Fig. 1. The four suborders of the order Amphipoda

In connection with British amphipods, there is a lack of detailed studies dealing with caprellids. We can point out the synopses of the Caprellidea conducted by Harrison (1944) who reported the presence of 12 species of caprellids and also one Cyamid species. Smaldon (1990) in the context of the volumes of the Marine Faune of the British Isles and North-west Europe, included some keys and drawings for 13 caprellid species, the 12 species considered by Harrison plus *Aeginina longicornis*. And this is the number of species which has been recognized for British Isles by Guerra-García & Takeuchi (2002). Howson & Picton (1997) in the species directory of the marine fauna and flora of the British Isles and surrounding seas also reported 13 species of caprellids, together with 9 species of cyamids. However, the list of species did not included *Aeginina longicornis*, but added *Caprella andreae*. Guerra-García (2002a) redescribed in detail two of the most common species distributed along UK, *Caprella linearis* and *Caprella septentrionalis*. Recently, Willis et al. (2004) reported the first record of the alien caprellids amphipod *Caprella mutica* for the UK. So, to our knowledge the total number of species recorded from UK is, so far, 15 species. This species richness is low when compared with other adjacent areas such as the North Atlantic (33 species) (Larsen, 1998) or the Mediterranean (41 species) (Sturaro & Guerra-García, 2012).

TAXONOMICAL AND PHYLOGENETICAL NOTES

The Caprellidea (Crustacea, Malacostraca, Peracarida) comprise more than 400 described species (Guerra-García, unpubl.), and the genus *Caprella* Lamarck, 1801 is the most important, including around 50% of the total number of species (Guerra-García & Tierno de Figueroa, 2009). The suborder Caprellidea has been traditionally classified into five families (Caprellidae, Caprogammaridae, Cyamidae, Paracercopidae, Phitisicidae) (Vassilenko, 1974; Takeuchi, 1993). Laubitz (1993) considered 3 additional families (Caprellinoididae, Pariambidae and Protellidae) and her classification in eight families instead of five has been adopted subsequently by most authors (Ito et al., 2008, 2011). However, Guerra-García (2002b), in a review of the characters of families Pariambidae and Protellidae, found multiple inconsistencies and suggested to adopt, while the phylogeny and higher classification of the caprellids are

still under debate, the minimum number of families, following Takeuchi (1993). The studies of Vassilenko (2006) seem to support to Takeuchi (1993) more than Laubitz (1993) concerning the phylogeny of Caprellidea. Myers & Lowry (2003) have recently proposed a new phylogeny and classification for the suborder Corophiidea Leach, 1814. Based on the hypothesis of the evolution of different feeding strategies, the Corophiidea are divided into two infraorders, the Corophiida and the Caprellida. In their new classification, the superfamily Caprelloidea contains five families: Caprellidae, Caprogammaridae, Cyamidae, Dulichiidae and Podoceridae, and the Caprellidae are subdivided into three subfamilies: Caprellinae, Paracercopinae and Phtisicinae. According to this approach, Caprelloidea would be a superfamily instead of a suborder.

The general characteristics of the Caprellidea include a slender and cylindrical body, fusion of the head and the pereonite 1, rudimentary coxae, two or three pairs of gills, brood plates on pereonites 3 and 4, reduced or absent pereopods 3 and 4 in most cases, and a degenerated abdomen and abdominal appendages (Ito et al., 2008). These characteristics, especially the abdomen structure, are highly divergent from the body plan of other malacostracan crustaceans; therefore, caprellids are of great interest for understanding the morphological evolution in crustaceans. In spite of this, the phylogenetic relationships among the Caprellidea are poorly understood. Most of the caprellid families have reduced or absent pereopods 3 and 4, and the pleon is greatly reduced in size, without segmental structure and bearing only one to three pairs of vestigial appendages. However, there are two families that do not show the above mentioned typical caprellid body plan. The Caprogammaridae have an elongated and segmented pleon with pleopods, but pereopods 3 and 4 are rudimentary as in other caprellids (Takeuchi & Ishimaru, 1991), while the Phtisicidae possess well-developed six-articulate pereopods 3 and 4 but a reduced abdomen lacking developed pleopods. Consequently, the unique character status of these families implies that there has been either a reacquisition or multiple losses of both pereopods and pleon within the Caprellidea lineages (Ito et al., 2011). It is generally accepted that Caprellidea derived from Gammaridea (cf. Myers & Lowry, 2003; Ito et al., 2008), which are characterized by well developed pereopods 3 and 4, and by presence of pleon. Takeuchi (1993) suggested that the Caprellidea could be polyphyletic: the Phtisicidae could have evolved from a different ancestor than the Caprogammaridae and other caprellids, and he suggested a podocerid-like ancestor for the line Caprogammaridae-Caprellidae. Laubitz (1993) also suggested the possibility of polyphyly but with a different approach, with one lineage (provided with mandibular molar) including the Caprogammaridae, Pariambidae, Protellidae and Caprellidae, derived from the Corophioidea, and an other lineage (without mandibular molar), including Phtisicidae, Caprellinoididae, Cyamidae and Paracercopidae, derived from the Leucothoidea. The idea of two major lines of evolution seems also to be supported by a recent study of Guerra-García & Tierno de Figueroa (2009) based on the analysis of digestive contents in 62 caprellid species. However, the recent morphological cladistic analysis of the Corophioidea showed that Caprellidea would be monophyletic (Myers & Lowry, 2003). Ito et al. (2008) conducted the first molecular study based on 18S rRNA and their results also indicated that the Phtisicidae and other caprellid families form a monophyletic clade. However, a close phylogenetic relationship between Corophioidea and Caprellidea was not definitively supported by Ito et al. (2008). Given the complicated morphological evolution, Ito et al. (2011) suggested the possibility of Caprellidea as an exception to Dollo's law (evolution is irreversible, once a complex morphological character is lost in the course of evolution, it never reappears). In this sense, the ancestral state reconstruction based on the obtained molecular phylogeny suggested that once lost, the pereopods 3 and 4

were regained in the Phtisicidae, while the pleon was regained in the Caprogammaridae, while the possibility of independent losses could not been excluded.

For the present study, taking into account that the phylogeny and classification is still under debate, we have considered the Caprellidea as a suborder, including the families Caprellidae, Caprogammaridae, Cyamidae, Paracercopidae, Phitisicidae. In British waters there are members of the families Caprellidae, Phtisicidae and Cyamidae. However, the Cyamidae strongly differ from the traditional caprellids, having a deeply depressed body form adaptaed to a parasitic mode of life. Consequently, their distribution patterns depend on the hosts (different cetacean species) and can change depending on the migration of the species. In the present revision we have focused on the typical caprellids of the families Caprellidae and Phtisicidae.

ECOLOGICAL NOTES (see also Woods, 2009)

Caprellids inhabit algae, hydroids, ascidians, anthozoans, bryozoans, sponges, seagrasses and sediments (McCain 1968; Guerra-García 2001). They feed on suspended materials, prey on other organisms, or graze on epibiotic fauna and flora (Caine 1974; Thiel et al. 2003). In general terms, they can be considered as detritivores (Guerra-García and Tierno de Figueroa 2009). Caprellids are important prey for many coastal fish species (Caine 1987, 1989, 1991) and have also been found to be useful bioindicators of marine pollution and environmental stress (Guerra-García and García-Gómez 2001; Ohji et al. 2002; Takeuchi et al. 2004; Guerra-García and Koojul 2005; Guerra-García et al. 2010). Woods (2009) conducted a very nice and complete review of the caprellid ecology and life history, caprellid feeding, environmental tolerances, diseases, toxins and allergenicity associated with caprellids, caprellids culture methodology and caprellids nutritional value as an overlooked marine finfish aquaculture resource.

DISTRIBUTION

Many caprellid species have a wide distribution and there are many examples of species that are considered to be cosmopolitans (Takeuchi & Sawamoto 1998). With their general morphology, caprellids are well adapted to cling to substrata such as algae and hydroids (Takeuchi & Hirano 1995). Using their last pereiopods they can firmly hold onto branches of algae, bryozoans and hydrozoans. The pleopods, which are used for swimming in other amphipod crustaceans, are reduced in caprellids. Therefore, although caprellids can swim (Caine 1979), they probably are not very efficient swimmers. This, as well as the lack of a planktonic larval stage, suggests that cosmopolitan caprellid species may be distributed passively by clinging to floating materials rather than by active swimming. Floating material such as macroalgae are easily distributed between distant locations (Ingólfsson 1995, Hobday 2000a) and caprellids and other amphipods are commonly found on this type of substrata (Hobday 2000b). Many caprellid species are also very unselective with respect to their substratum and they colonize a wide variety of different substrata. For example the species *C. equilibra* has been found on algae, seagrass, bryozoans, bivalves, sponges and other substrata (Krapp-Schickel 1993). This low selectivity for a variety of substrata with a high floating potential suggests that these species might have a wide local and regional distribution, particularly in regions where ocean currents transport suspended

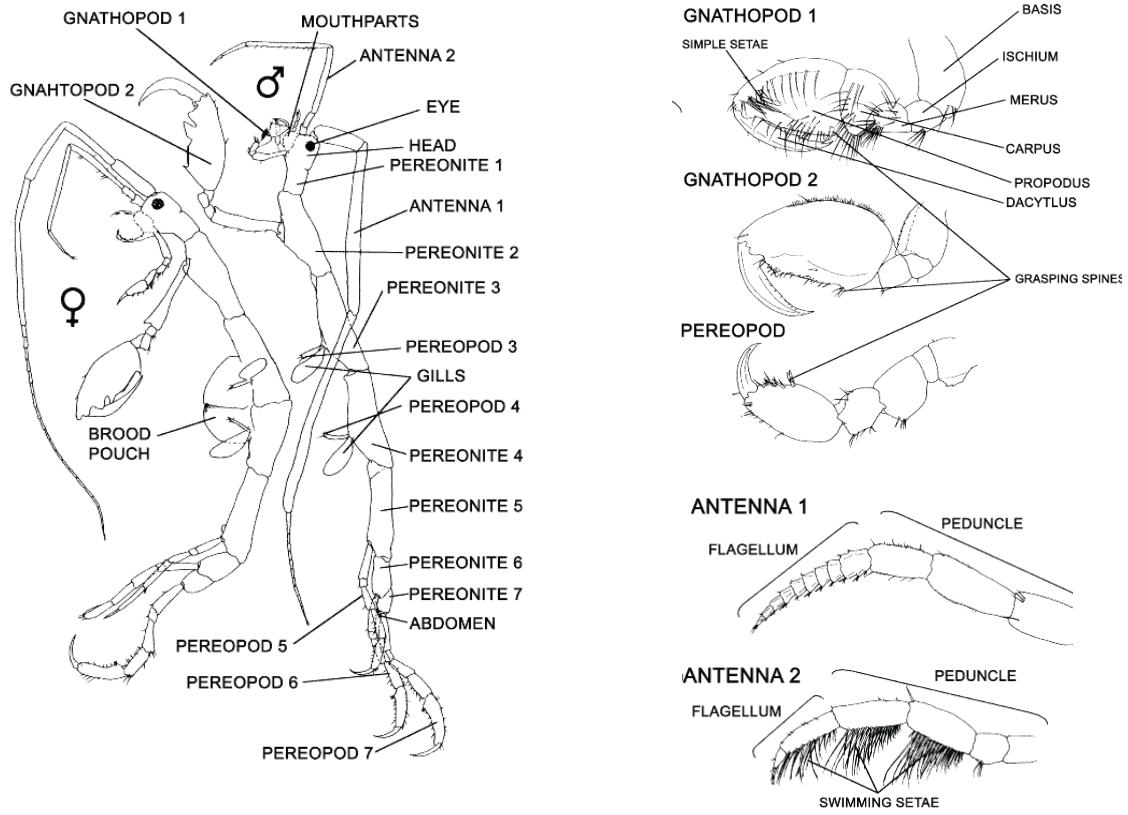
or floating materials (algae, bryozoans, wood or buoys and other anthropogenic material) over large distances. Although the abundance and species richness of caprellids in many areas of the world's oceans is still poorly known, Laubitz (1970) pointed out that surface water temperature is an important factor determining the distribution of the littoral caprellids along the American coast of North Pacific. Water temperature may also affect the distribution of caprellids in the eastern South Pacific and other areas throughout the world where water temperatures present a strong spatial gradient.

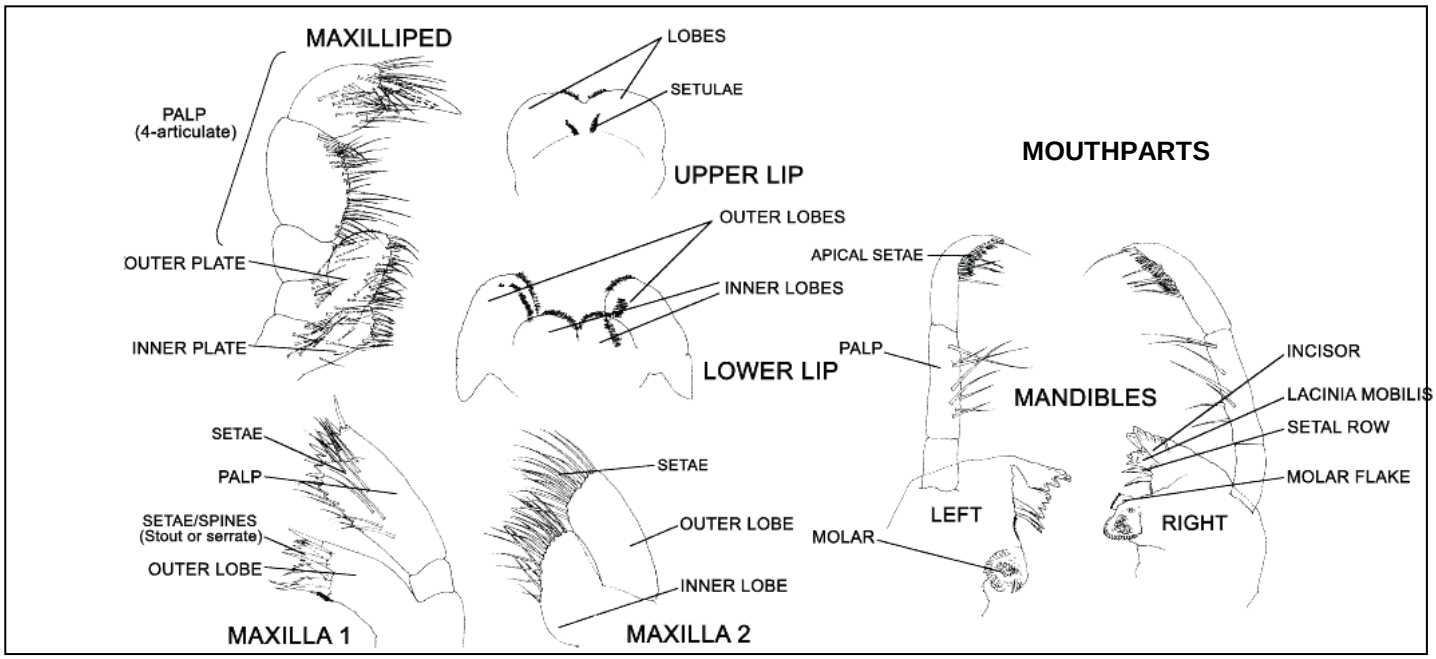
MORPHOLOGY

The structure of a caprellids is less complex than that of a gammaridean amphipod. The animal may be divided into a head, a thorax or pereon, and an abdomen (Fig. 2). The head and the pereonite 1 may be completely or partically fused. Antenna 1 is longer than antenna 2. Antenna 1 has a three-jointed peduncle and a multiarticulate flagellum. Antenna 2 has a peduncle of four joints and a shorter flagellum, normally of two articles. Antenna 2 may bear parallel rows of long, so–called ‘swimming setae’ on the central border of the peduncle and flagellum. The pereon may be smooth or may possiss dorsal and/or lateral tubercles or acute projections. A pair of round or oval gills is normally found on the ventro-lateral borders of pereonites 3 and 4, and on pereonite 2 in some species. The gnathopods are normally larger than other pereopods and modified into grasping claws. The pereopods may be completely absent from pereonites 3 and 4, or may be reduced to minute appendages. Pereopods 5, 6 and 7 are normally of approximately equal length and are used for holding on to the substratum while the animal feeds with the gnathopods. The propodus of the posterior pereopods may bear one or two spines on its inner surface, these being termed ‘grasping spines’. The pleon is totally reduced in caprellids differently from gammarids, and the small abdomen may be furnished with lobes and/or articulated appendages. Female caprellids develop paired lamellae on the ventral borders of pereonites 3 and 4, and these lamellae enlarge to form a brood-pouch for the developing eggs. Some species show a clear sexual dimorphisms, with males being larger than females and possessing more robust gnathopods.

Although abdomen and mouthparts are usually of taxonomic importance, their minute size makes it a difficult feature to observe. For these reason, we have tried to develop an easy key avoiding the use of these characters that usually require complicate dissections.

The key and figures included here apply only to fully-grown adult animals, especially males, since juveniles often do not show features which are taxonomically important in the adults. The colour of an animal is an unreliable character, and many of the species exhibit various colours when alive.





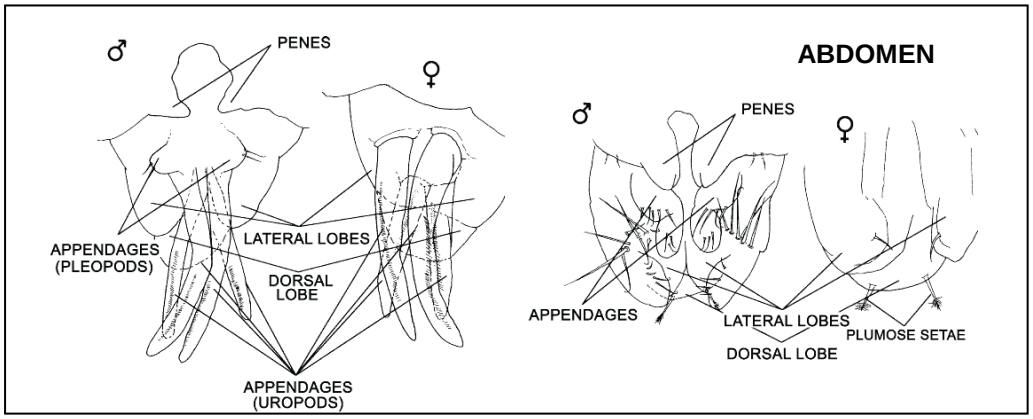


Fig. 2. Lateral view and different parts of a generalized caprellid. Modified from Guerra-García (2006)

CLASSIFICATION

Suborder Caprellidea

Family Caprellidae Leach, 1814

- Genus *Aeginina* Norman, 1905
  - *Aeginina longicornis* (Kroyer, 1843)
- Genus *Caprella* Lamarck, 1801
  - *Caprella acanthifera* Leach, 1814
  - *Caprella andreae* Mayer, 1890
  - *Caprella equilibra* Say, 1918
  - *Caprella erethizon* Mayer, 1901
  - *Caprella fretensis* Stebbing, 1878
  - *Caprella linearis* (Linnaeus, 1767)
  - *Caprella mutica* Schurin, 1935
  - *Caprella penantis* Leach, 1814
  - *Caprella septentrionalis* Kröyer, 1838
  - *Caprella tuberculata* Bate & Westwood, 1866
- Genus *Pariambus* Stebbing, 1888
  - *Pariambus typicus* (Kröyer, 1845) Synonym
- Genus *Parvipalpus* Mayer, 1890
  - *Parvipalpus capillaceus* (Chevreux, 1888)
- Genus *Pseudoprotella* Mayer, 1890
  - *Pseudoprotella phasma* (Montagu, 1804)

Family Phtisicidae Vassilenko, 1968

- Genus *Phtisica* Slabber, 1769
  - *Phtisica marina* Slabber, 1769

Family Cyamidae Rafinesque, 1815 (parasitic of whales and dolphins; not included in the present revision, for details see Leung, 1967, Margolis et al., 2000)

- Genus *Cyamus* Latreille, 1796
  - *Cyamus boopis* Lütken, 1870
  - *Cyamus catodontis* Margolis, 1954
  - *Cyamus ceti* (Linnaeus, 1758)
  - *Cyamus erraticus* Roussel de Vauzème, 1834
  - *Cyamus gracilis* (Roussel de Vauzème, 1834)
  - *Cyamus ovalis* Roussel de Vauzème, 1834
- Genus *Isocyamus* Gervais & van Beneden, 1859
  - *Isocyamus delphinii* (Guérin-Méneville, 1836)
- Genus *Platycyamus* Lütken, 1870
  - *Platycyamus thompsoni* (Gosse, 1855)
- Genus *Scutocyamus* Lincoln & Hurley, 1974
  - *Scutocyamus parvus* Lincoln & Hurley, 1974

LATERAL VIEW FIGURES

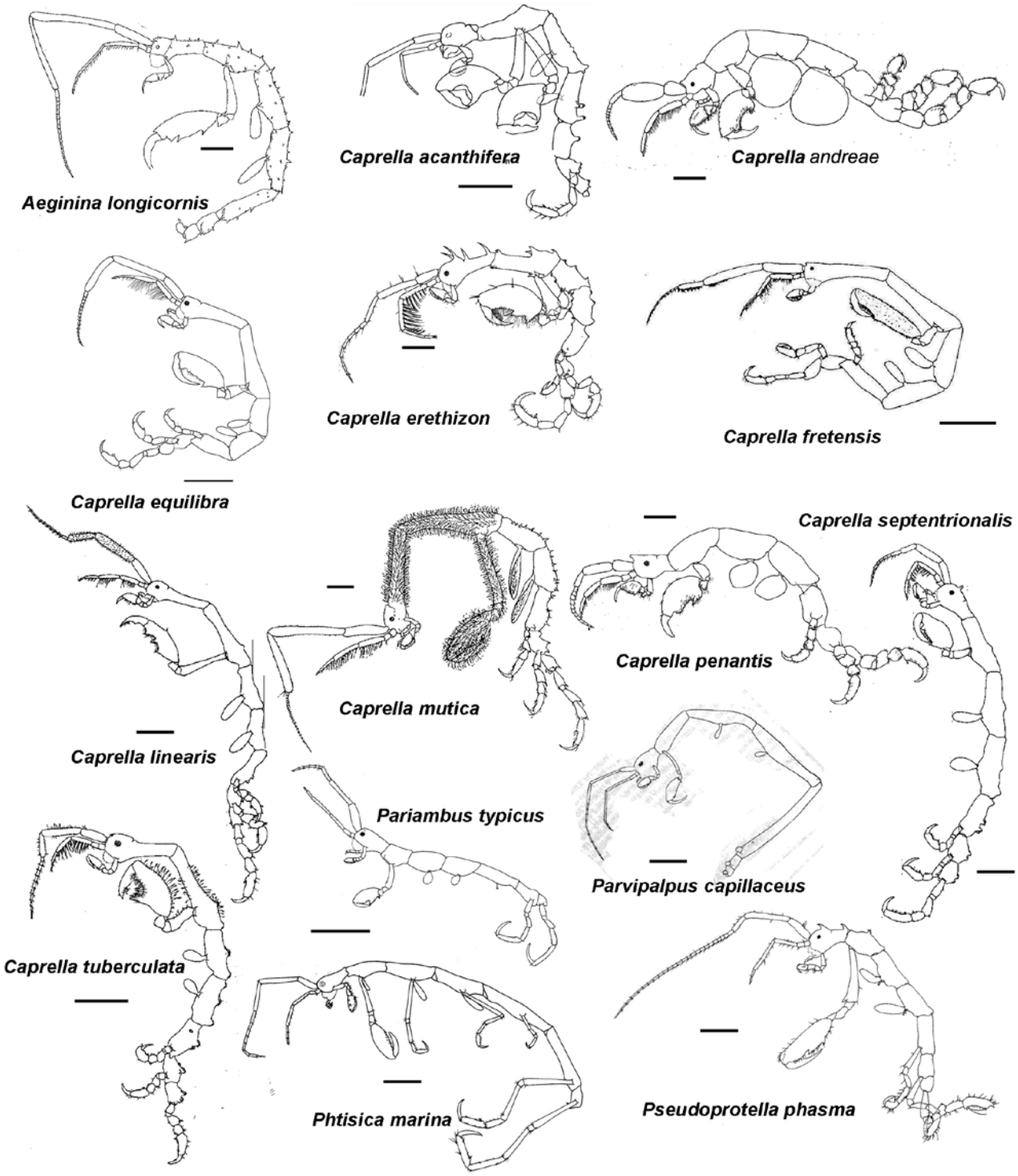


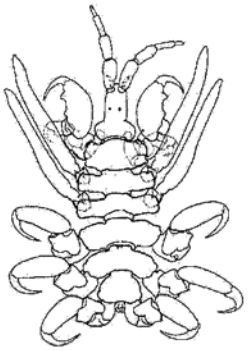
Fig. 3. Lateral view figures of the British caprellids (families Phtisicidae and Caprellidae). Scale bars: 1 mm

ILLUSTRATED KEYS

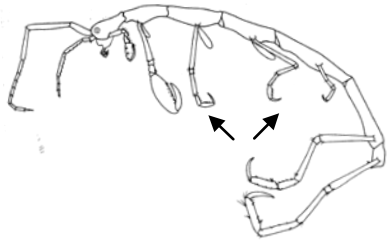
Key to families of British Caprellids

1. Body short, wide and dorsoventrally compressed ..... CYAMIDAE
-Body slender and cylindrical 2

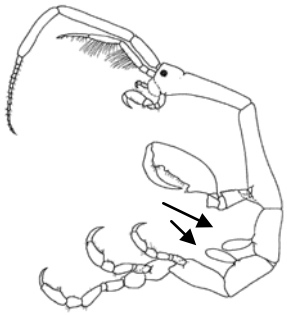
2. Pereopods 3 and 4 fully developed, with 6 articles ..... PHTISICIDAE
-Pereopods 3 and 4 absent or reduced to 1 or 2 articles ..... CAPRELLIDAE



CYAMIDAE



PHTISICIDAE

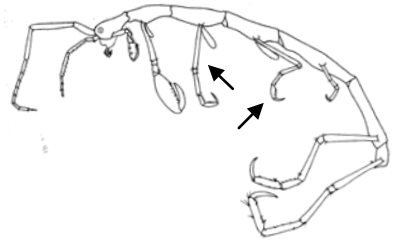


CAPRELLIDAE

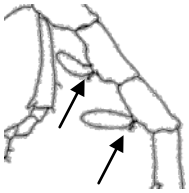
Key to species of British Caprellids (families Phtisicidae and Caprellidae)

This key can be used without dissection (see figure 2)

1. Pereopods 3 and 4 fully developed, with 6 articles ..... *Phtisica marina*

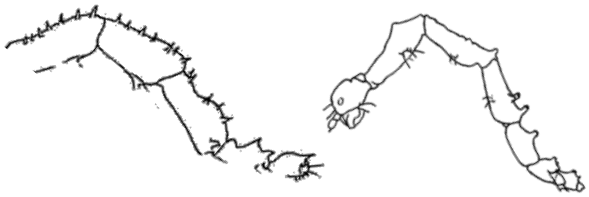


-Pereopods 3 and 4 absent or reduced to 1 or 2 articles 2

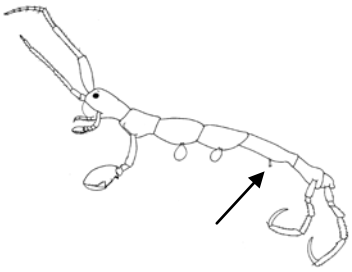


2. Body smooth dorsally.....3

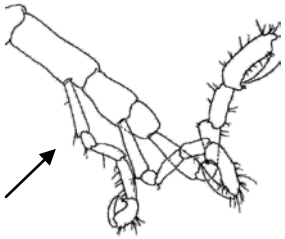
- Body provided with dorsal acute projections or tubercles 8



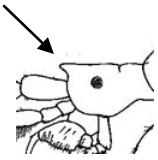
3. Pereopod 5 reduced to 2 articles..... *Pariambus typicus*



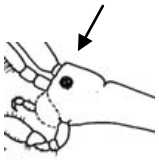
- Pereopod 5 normal, with 7 articles 4



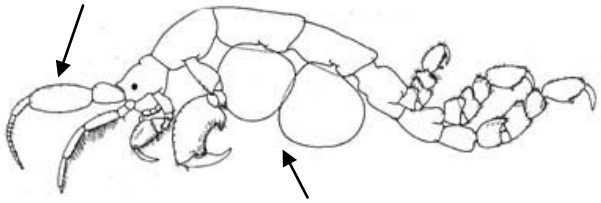
4. Head with rostrum clearly differentiated.....5



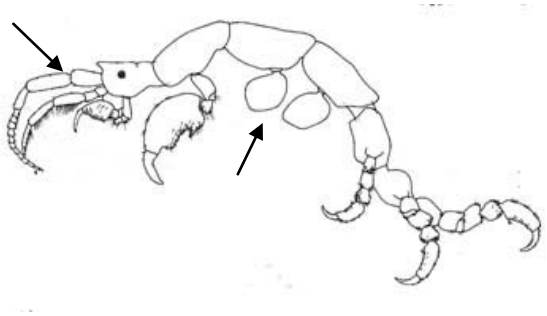
-Head with rostrum not clearly differentiated 6



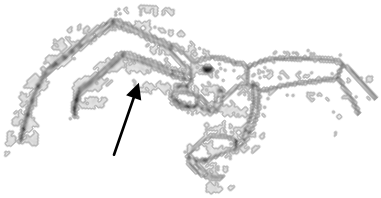
5. Peduncle of antenna 1 (A1) very robust, gills rounded..... *Caprella andreae*



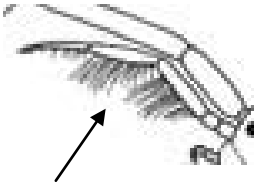
-Peduncle of antenna 1 (A1) slender, gills smaller and elongated .....*Caprella penantis*



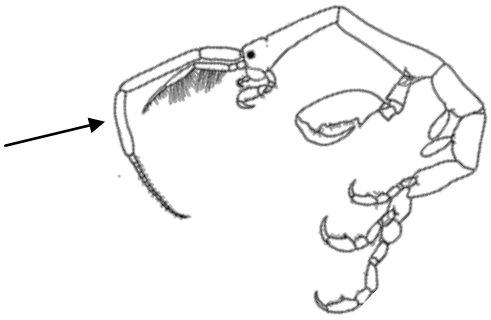
6. Antenna 2 (A2) without swimming setae.....*Parvipalpus capillaceus*



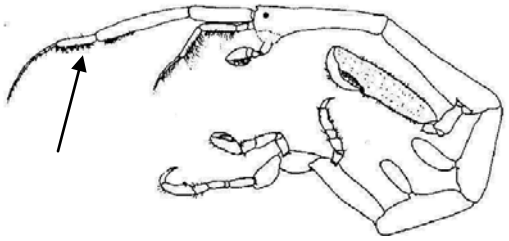
-Antenna 2 (A2) with swimming setae.....7



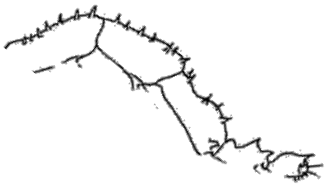
7. 3rd article of A1 peduncle longer than half of the 2nd article.....*Caprella equilibra*



-3rd article of A1 peduncle shorter than half of the 2nd article.....*Caprella fretensis*

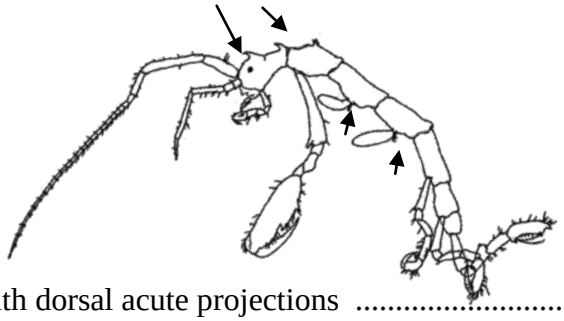


8. Two or more pereonites of the body with dorsal acute projections.....9

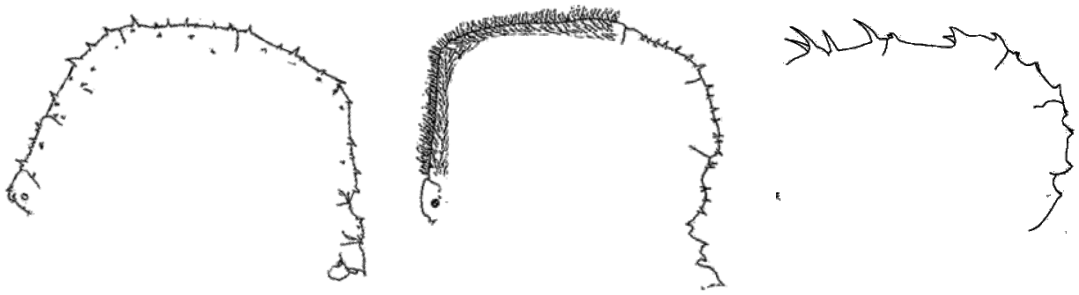


-Body with dorsal tubercles, acute projections lacking 12

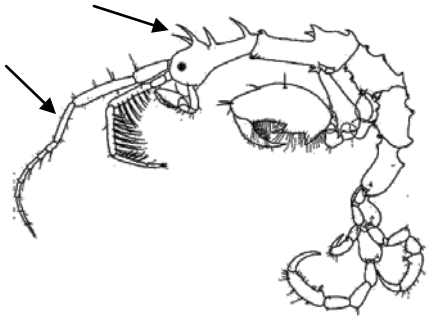
9. Dorsal acute projections only on head and pereonites 1 and 2. Pereopods 3 and 4 present, although very reduced (2 articles).....*Pseudoprotella phasma*



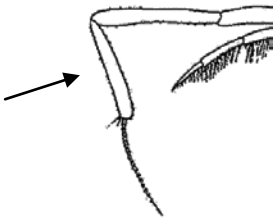
-Body spinose, full with dorsal acute projections 10



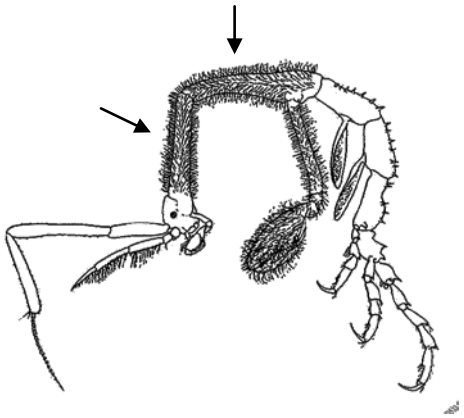
10. 3rd article of A1 peduncle shorter than 2nd article. Two large acute projections on the head.....*Caprella erethizon*



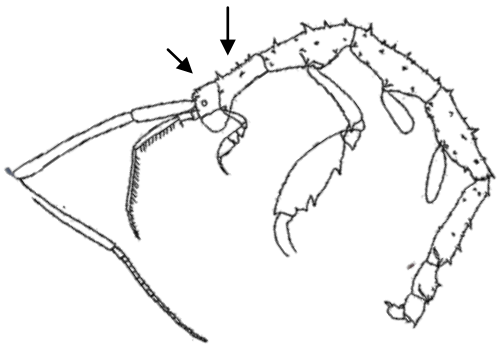
-3rd article of A1 peduncle of the same length than 2nd article.....11



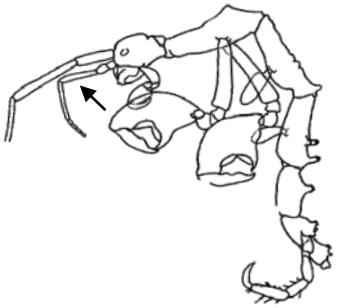
11. Pereonite 1 elongate. Head and pereonites 1 and 2 without projections, but very hairy .....*Caprella mutica*



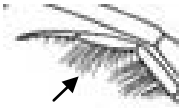
- Pereonite 1 not elongate. Head and pereonites 1 and 2 with acute projections. Body spinose dorsally and laterally .....*Aeginina longicornis*



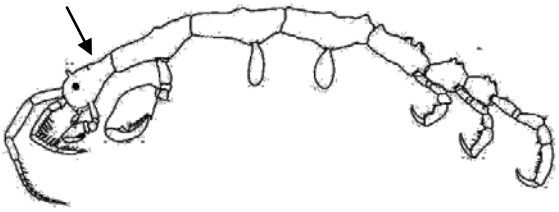
12. A2 with scarce swimming setae .....*Caprella acanthifera*



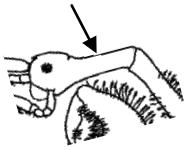
- A2 with dense swimming setae.....13



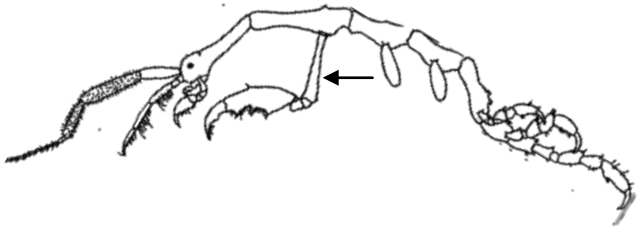
13. Pereonite 1 not elongate .....*Caprella septentrionalis*



- Pereonite 1 elongated.....14



14. Basis of gnathopod 2 longer than half of the pereonite 2 ..... *Caprella linearis*



- Basis of gnathopod 2 shorter than half of the pereonite 2.....*Caprella tuberculata*

REFERENCES

Caine, E.A., 1974. Comparative functional morphology of feeding in three species of caprellids (Crustacea, Amphipoda) from the northwestern Florida gulf coast. Journal of Experimental Marine Biology and Ecology, 15: 81-96

Caine, E.A., 1979. Functions of swimming setae within caprellid amphipods (Crustacea). Biological Bulletin 156: 169-178.

Caine, E.A., 1987. Potential effect of floating dock communities on a South Carolina estuary. Journal of Experimental Marine Biology and Ecology, 108: 83-91

Caine, E.A., 1989. Caprellid amphipod behaviour and predatory strikes by fish. Journal of Experimental Marine Biology and Ecology, 126: 173-180

Caine, E.A., 1991. Caprellid amphiods: fast food for the reproductively active. Journal of Experimental Marine Biology and Ecology, 148: 27-33

Guerra-García, J.M. 2001. Habitat use of the Caprellidea (Crustacea: Amphipoda) from Ceuta, North Africa. Ophelia 55: 27-38

Guerra-García, J.M. & García-Gómez, J.C., 2001. The spatial distribution of Caprellidea (Crustacea: Amphipoda): a stress bioindicator in Ceuta (North Africa, Gibraltar area). PSZNI Marine Ecology, 22: 357-367.

Guerra-García, J.M. 2002a. Redescription of *Caprella linearis* (Linnaeus, 1767) and *C. septentrionalis* Kröyer, 1838 (Crustacea: Amphipoda: Caprellidea) from Scotland, with an ontogenetic comparison between the species and a study of the clinging behaviour. *Sarsia* 87: 216-235

Guerra-García, J.M., 2002b. *Metaprotella tanzaniensis*, a new caprellid (Crustacea: Amphipoda) from Tanzania, with a key to the species of *Metaprotella* and discussion on the family Protellidae. Bulletin of Marine Science 70(3): 909-918.

Guerra-García, J.M. & I. Takeuchi, 2002. The Caprellidea (Crustacea: Amphipoda) from Ceuta, with the description of three species of *Caprella*, key for *Caprella* and biogeographical discussion. *Journal of Natural History* 36: 675-713

Guerra-García, J.M., Koonjul M.S. 2005. *Metaprotella sandalensis* (Crustacea: Amphipoda: Caprellidae): a bioindicator of nutrient enrichment on coral reefs? A preliminary study at Mauritius Island. Environmental Monitoring and Assessmente 104: 353-367

Guerra-García, J.M. & J.M. Tierno de Figueroa, 2009. What do caprellids feed on? Marine Biology 156: 1881-1890

Guerra-García, J.M., Ruiz-Tabares, A., Baeza-Rojano, E., Cabezas, M.P., Díaz-Pavón, J.J., Pacios, I., Maestre, M., González, A.R., Espinosa, F., García-Gómez, J.C. 2010. Trace metals in *Caprella* (Crustacea: Amphipoda). A new tool for monitoring pollution in coastal areas? Ecological Indicators 10: 734-743

Harrison, R.J. 1944. Synopses of the British Fauna.Caprellidea (Amphipoda, Crustacea). The Linnean Society of London.

Hobday, A.J. 2000a. Age of drifting *Macrocystis pyrifera* (L.) C. Agardh rafts in the Southern Califronia Bight. Journal of Experimental Marine Biology and Ecology, 253: 97-114.

Hobday, A.J. 2000b. Persistence and transport of fauna on drifting kelp *Macrocystis pyrifera* (L.) C. Agardh) rafts Iin the Southern California Bight. Journal of Experimental Marine Biology and Ecology, 253: 75-96

Howson, C.M. & B.E. Picton. 1997, ed..The species directory of the marine fauna and flora of the British Isles and surrounding seas. Belfast and Ross-on-Wye: Ulster Museum and the Marine Conservation Society.

Ingólfsson, A. 1995. Floating clumps of seaweed around Iceland: natural microcosms and a means of dispersal for shore fauna. Marine Biology 122: 13-21

Ito, A., H. Wada & M.N. Aoki, 2008. Phylogenetic analysis of caprellid and corophioid amphipods (Crustacea) based on the 18S rRNA gene, with special emphasis on the phylogenetic position of Phtisicidae. Biological Bulletin 214: 176-183.

Ito, A., M.N. Aoki & H. Wada, 2011. Complicated evolution of the caprellid (Crustacea: Malacostraca: Peracarida: Amphipoda) body plan, reacquisition or multiple losses of the thoracic limbs and pleons. Dev. Genes Evol., DOI 10.1007/s00427-011-0365-5.

Krapp-Schickel, T., 1993. Suborder Caprellidea. In: S. Ruffo, The Amphipoda of the Mediterranean. Part 3. Mémoires de l'Institut Océanographique, 13: xxi-xxv, 577-813. (Monaco).

Larsen, K., 1998. Caprellidea (Crustacea: Amphipoda) from Faroe Islands Waters, with a key to the North-Atlantic species. Frodskaparrit 46: 81-90.

Laubitz, D.R., 1970. Studies on the Caprellidae (Crustacea, Amphipoda) of the American North Pacific. Publications in Biological Oceanography, 1: i-vi, 1-89. (National Museums of Canada).

Laubitz, D.R, 1993. Caprellidea (Crustacea: Amphipoda): towards a new synthesis. Journal of

McCain, J.C., 1968. The Caprellidae (Crustacea: Amphipoda) of the western North Atlantic. U.S. nat. Mus. Bull., 278: i-iv, 1-147.

Myers, A.A. & J.K. Lowry, 2003. A phylogeny and a new classification of the Corophiidea Leach, 1814 (Amphipoda). Journal of Crustacean Biology 23(2): 443-485.

Ohji, M., Takeuchi, I., Takahashi, S., Tanabe, S., Miyazaki, N. 2002. Differences in the acute toxicities of tributyltin between the Caprellidea and the Gammaridea (Crustacea: Amphipoda). Marine Pollution Bulletin 44: 16-24

Smaldon, G. 1990. Caprellidea. In Hayward & Ryland (eds). The Marine Fauna of the British Isles and North- West Europe. Clarendon Press, Oxford.

Sturaro, N. & J.M. Guerra-García, 2012. A new species of *Caprella* (Crustacea: Amphipoda) from the Mediterranean Sea. Helgoland Marine Research 66: 33-42.

Takeuchi, I., 1993. Is the Caprellidea a monophyletic group? Journal of Natural History 27: 947-964.

Takeuchi, I. & S. Ishimaru, 1991. Redescription of *Caprogammarus gurjanovae* Kudrjaschov & Vassilenko, 1966 (Crustacea: Amphipoda) from Hokkaido, Japan, with notes on the taxonomic status of *Caprogammarus*. Hydrobiologia, 223: 233-281.

Takeuchi, I. & Hirano, R. 1995. Clinging behaviour of the epifaunal caprellids (Amphipoda) inhabiting the *Sargassum* zone on the Pacific coast of Japan, with its evolutionary implications. Journal of Crustacean Biology, 15: 481-492.

Takeuchi, I. & Sawamoto, S. 1998. Distribution of caprellids amphipods (Crustacea) in the western North Pacific based on the CSK International Zooplankton Collection. Plankton Biology and Ecology, 45: 225-230.

Takeuchi, I., Takahashi, S., Tanabe, S., Miyazaki, N. 2004. Butylin concentrations along the Japanese coast from 1997 to 1999 monitored by *Caprella* spp. (Crustacea: Amphipoda). Marine Environmental Research, 57: 397-414

Thiel, M., Guerra-García J.M., Lancellotti D.A., Vásquez N., 2003. The distribution of littoral caprellids (Crustacea: Amphipoda: Caprellidea) along the Pacific coast of continental Chile. Revista Chilena de Historia Natural, 76: 297-312

Vassilenko, S.V., 1974. Caprellids of the seas of the USSR and adjacent waters. Opredeleliteli po Faune SSSR 107: 1-287.

Vassilenko, S.V., 2006. Caprellids. In: V.L. Kasyanov, Biota of the Russian waters of the Sea of Japan, 4: 1-200.

Willis, K.J., E.J. Cook, M. Lozano-Fernandez & I. Takeuchi, 2004. First record of the alien caprellid amphipod, *Caprella mutica*. Journal of the Marine Biological Association of the United Kingdom 84: 1027-1028.

Woods, C.M.C., 2009. Caprellid amphipods: an overlooked marine finfish aquaculture resource? Aquaculture 289: 199-211.