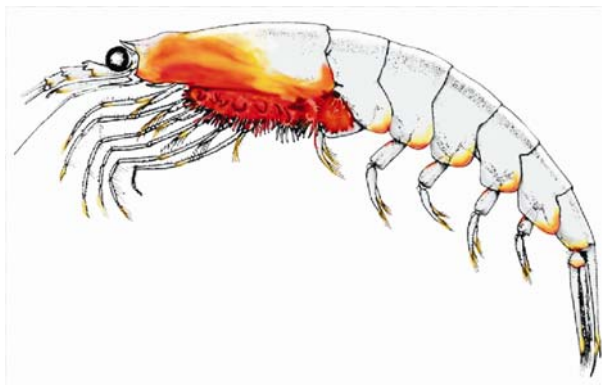


Versión en español



## CLASS MALACOSTRACA

# Order Euphausiacea

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## 1. Brief definition of the group and the main diagnostic characters

Euphausiids are small holoplanktonic shrimp-like crustaceans. The term "euphausiid" is commonly used for all members of the crustaceans superorder Eucarida, order Euphausiacea, distributed in two families (Euphausiidae and the mono-specific Bentheuphausiidae, the single genus and species *Bentheuphausia amblyops*). There are 86 known species of Euphausiacea and amongst 11 genera (Baker *et al.*, 1990). The word *Euphausia* derives from Greek *eu* for good or true, combined with *-phausia* for shining or light emitting. Another term, krill, has become synonymous with euphausiid. Krill was first used in this sense by Norwegian whalers who applied it to the swarming little fish (krill) which signaled whale feeding grounds.

### 1.1. Morphology

(Text sources from: Einarsson, 1945; Mauchline, 1980, 1984; Boden *et al.*, 1955; Mauchline & Fisher, 1969; Brinton, 1975; Baker *et al.*, 1990; Gibbons *et al.*, 1999; Brinton *et al.*, 2000).

Nevertheless, to identify characters clearly and for the sake of brevity, specialized terms were necessary. A diagram of a generalised euphausiid and details of some parts are shown in Figure 1.

Like other eucarids, euphausiids have the body divided in 5 cephalic, 8 thoracic, and 6 abdominal segments. The first 2 body regions are fused as a cephalothorax, covered by a carapace fused to the entire thorax and which extends laterally on each side of the body, but does not cover the gills. So, the body is composed of two main parts, the **cephalothorax** and the **abdomen**. The cephalothorax includes the **carapace** dorsally and laterally. Features of the carapace useful in identifications include the length and shape of the **rostrum** or **frontal plate** (which lies between the eyes), as well as the number of various **lateral** and **post-ocular spines**. A mid-dorsal **keel** and accompanying **cervical groove** may be present in some species. Other diagnostic feature are the two pairs of **antennae** and the **eyes** anteriorly, and the **mouthparts** and **thoracic limbs** ventrally. The abdomen comprises six articulating segments which carry the **pleopods** ventrally and the **telson** and **uropods** posteriorly. Euphausiids lack statocysts.

The paired uppermost antennae (Fig. 2), the **antennules** (first antennae), each consist of a three-segmented **antennular peduncle** and a pair of many segmented **antennular flagella**. The anterior-dorsal margin of the first segment is often elongated to form a plate which overlaps the base of the second segment. The plate is known as the **antennular lappet** and its size and shape serve as very useful diagnostic characters, particularly for *Euphausia* species. It may be rounded or have one (simple), or two (bifid) points or many marginal spines (pectinate). The second segment of the antennular peduncle may have variously shaped **spines** or rounded **tubercles** near the distal margin, while the third segment often has a raised **keel**. These spines, tubercles and keels are also useful for identification, again particularly for *Euphausia* species.

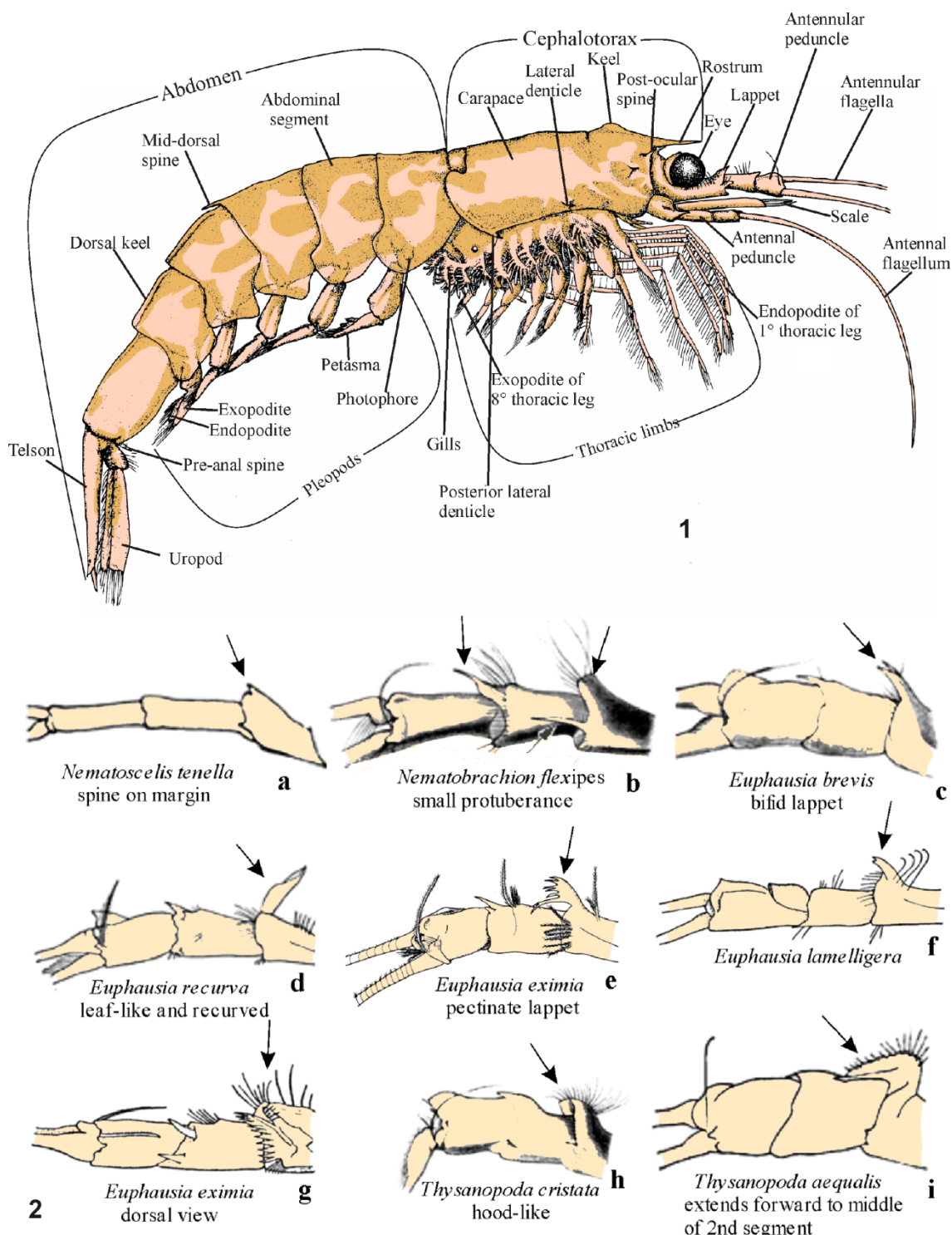


Fig. 1. Generalized euphausiid morphology (after Brinton, 1975). Fig. 2. Lateral and dorsal views of antennular peduncle. Sources from Baker *et al.*, 1990: b, d, e, h; Boden *et al.*, 1955: f, g; Brinton, 1975: a, c, i.

The paired lower **antennae** (second antennae) each consist of a basal segment bearing an **antennal scale** and a two segmented **antennal peduncle** ending in a long **flagellum**. There is generally little specific variation in the shape of the peduncle or the antennal scale except in *Stylocheiron* in which the scale can be useful for distinguishing groups of species.

The Euphausiidae can be separated roughly into two groups according to the general shape of the **eyes** (Fig. 3). With the exception of the genus *Thysanoessa* in which the eye-types are mixed, all species of a genus have either round (*Thysanopoda*, *Meganyctiphanes*, *Nyctiphanes*, *Pseudeuphausia* and *Euphausia*) or bilobed (*Stylocheiron*, *Nematoscelis*, *Nematobranchion*, *Tessarabranchion*) eyes divided by a constriction into clearly distinguishable upper and lower lobes. The shape and size of the eyes can be an important specific character, particularly in *Stylocheiron* and to a lesser extent in *Nematoscelis* species. It

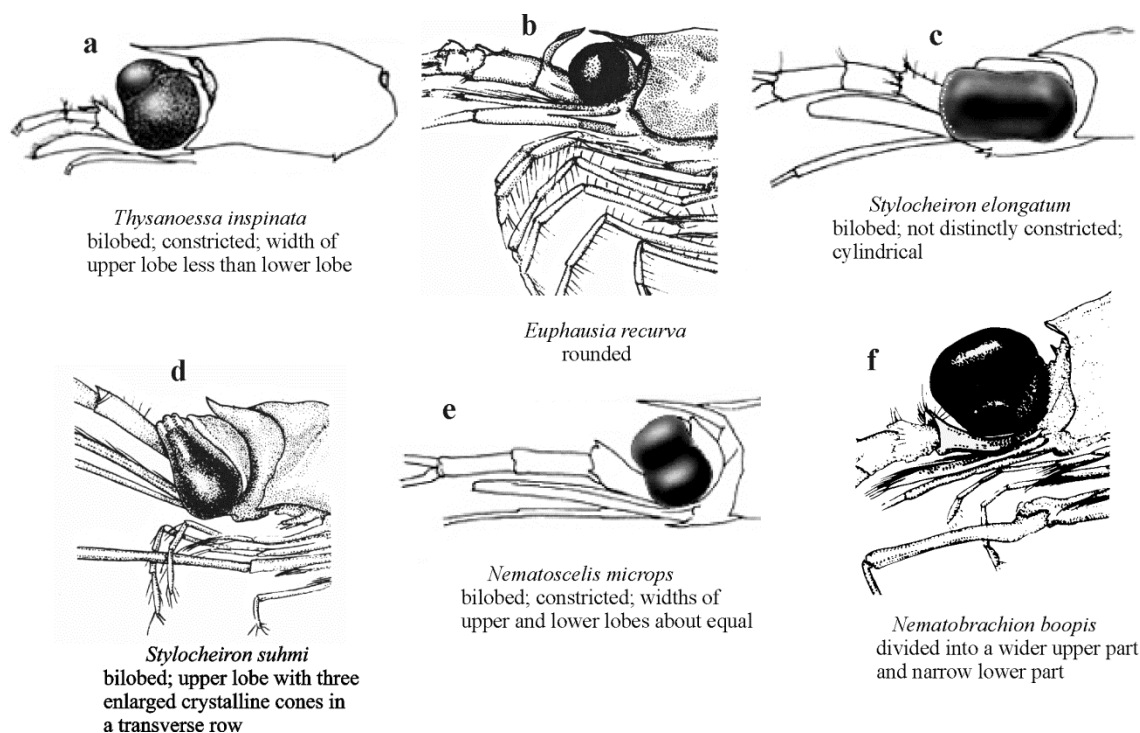


Fig. 3. Differences in the form of the eyes. Sources, from Baker *et al.*, 1990: **b, d, f**; Brinton *et al.*, 2000 **a, c, e**.

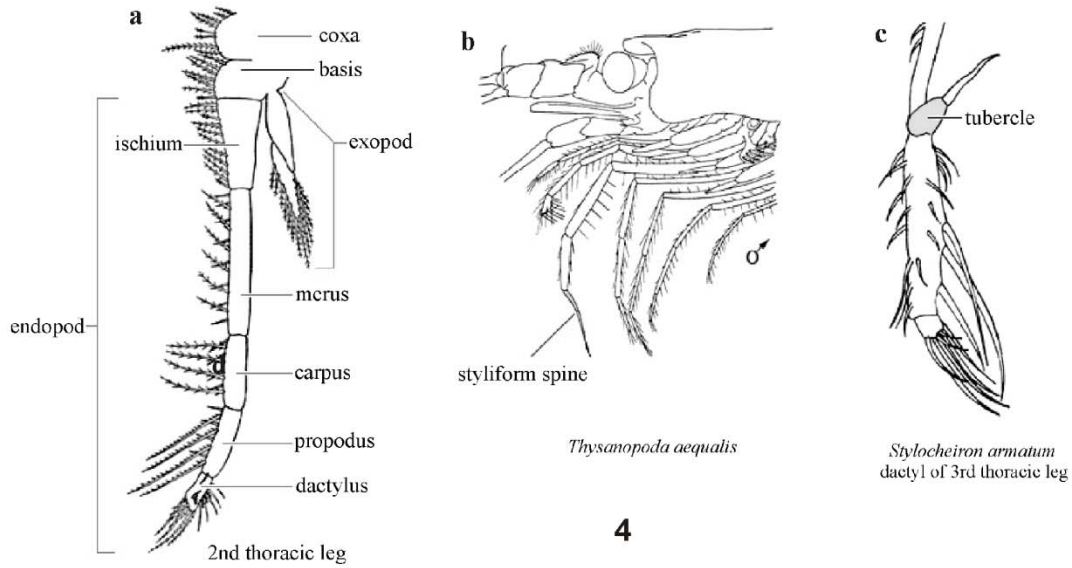
is worth noting that some species, which are clearly round-eyed as juveniles and adults, have quite marked bilobed eyes in the larval stages. Genera with bilobed eyes also tend to have elongated second or third thoracic legs.

The mouthparts consist of the **labrum** followed by the paired **mandibles**, **labia**, **maxillules** (first maxillae) and the **maxillae** (second maxillae). These are used very little in routine identification but can be invaluable in the specialized task of identifying euphausiid remains in the stomach contents of predators. A very detailed account of mouthpart structure in most euphausiid species has been given by Mauchline (1967).

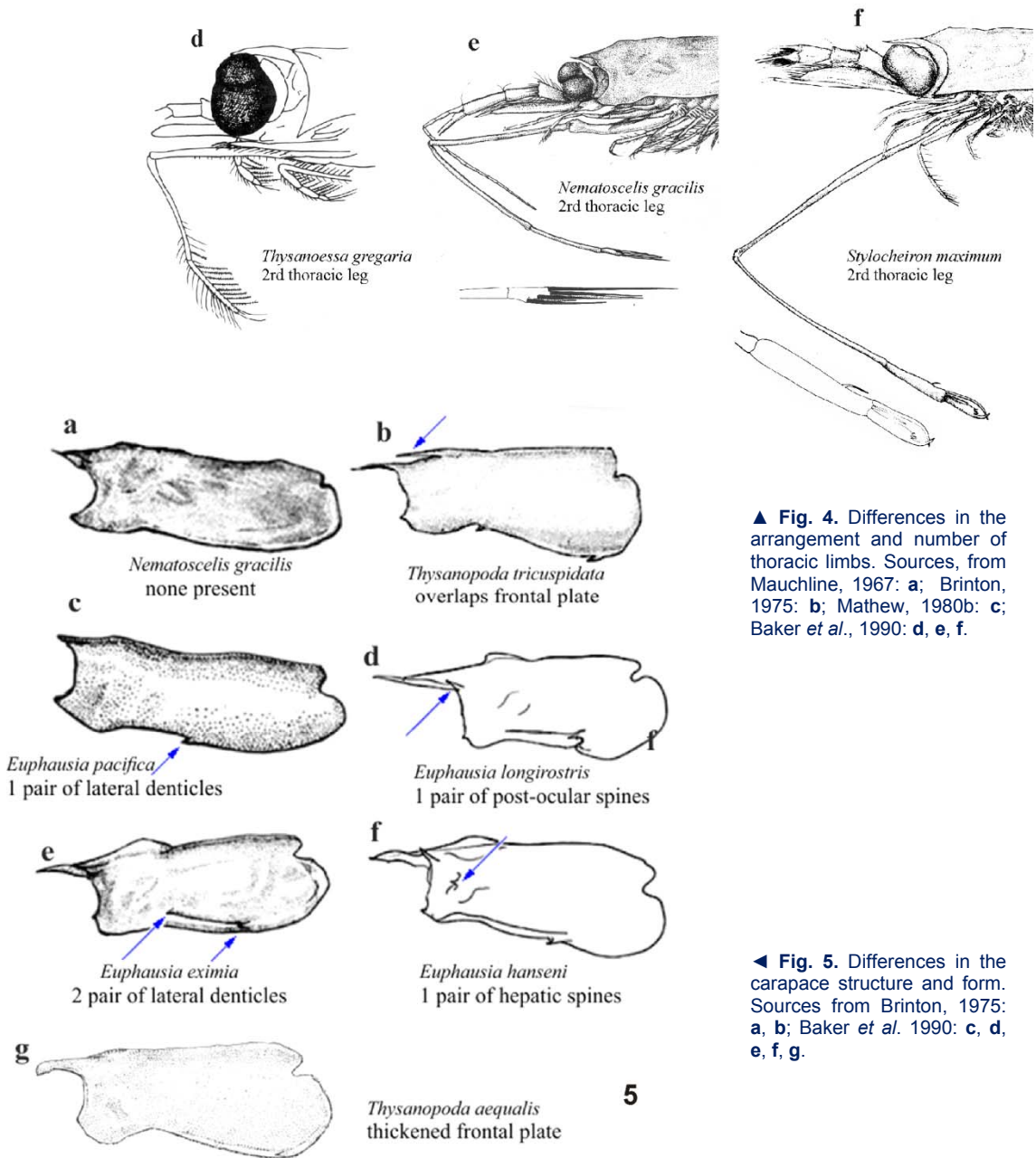
The morphology and number of **thoracic limbs** can provide valuable clues to genus identification (Fig. 4). There are eight pairs of thoracic limbs, the distal one of which bears a two segmented **exopodite** and a 5 segmented **endopodite**. In numbering the limbs, the most anterior is counted as the first. Only *Bentheuphausia* has the full complement of eight typical thoracic legs; in all the other genera the eighth legs are reduced to simple inconspicuous lobes with a few setae. The length and number of segments present on the seventh leg varies with genus, and the position of this limb can be identified by the presence of a photophore on the coxa. There is a consistent relationship between the eye shape and the form of the thoracic legs. In round-eyed species the unreduced thoracic legs are all similar, whereas in those with bilobed eyes one or two pairs are greatly elongated. For genera which display elongated second and/or third legs (*Stylocheiron*, *Nematoscelis*, *Thysanoessa*, *Nematobrachion*) the arrangement of setae on their more distal segments can be diagnostic. The **coxa** bears obvious **gills** on its posterior margin and these are characteristic of euphausiids and can be used to immediately separate them from decapods. It should be noted, however, that the legs, particularly the elongated ones, are delicate and prone to damage in nets. As a result they are frequently broken off and elongated limbs are frequently lost.

The **carapace** (Fig.5), which covers the thoracic region, has a number of features that are useful for identifying species or, more often, groups of species. The **rostrum**, which lies centrally between the eyes, can be long and sharply pointed, reduced to a slightly raised obtuse protrusion, or may be absent as in *Pseudeuphausia* in which the **frontal plate** is extended forward and has a concave anterior margin. In a few species there is a **post-ocular spine** immediately posterior to the eye. Mid-dorsally, just posterior to the frontal plate, there is often a longitudinal **carapace keel** (see Fig.1). In addition to the post-ocular spines the carapace may have spines in three other positions. Mid-laterally and approximately above the base of the first thoracic limb, there may be an **hepatic spine** and on or near the lateral margin there can be one or two **lateral denticles**. In the genus *Nematoscelis* the presence or absence of a lateral denticle can be sex dependent.

Variations in the morphology of the **abdomen** (Fig. 6) are used to separate many euphausiids at the species level. The six abdominal segments are numbered from anterior to posterior. The dorsal surface of segments three to five may be raised to form a **longitudinal keel** (see Fig.1), the posterior edge of which may be extended mid-dorsally to form as a **spine** of variable length. When spines occur on all three segments that on the third is nearly always the largest. The exoskeleton plates covering segments one to five are known as **pleuræ** and the sculpturing of their posterior and ventral margins varies with species. Although the sixth segment is cylindrical and lacks pleura, its relative dimensions can be used in the identification of some species.



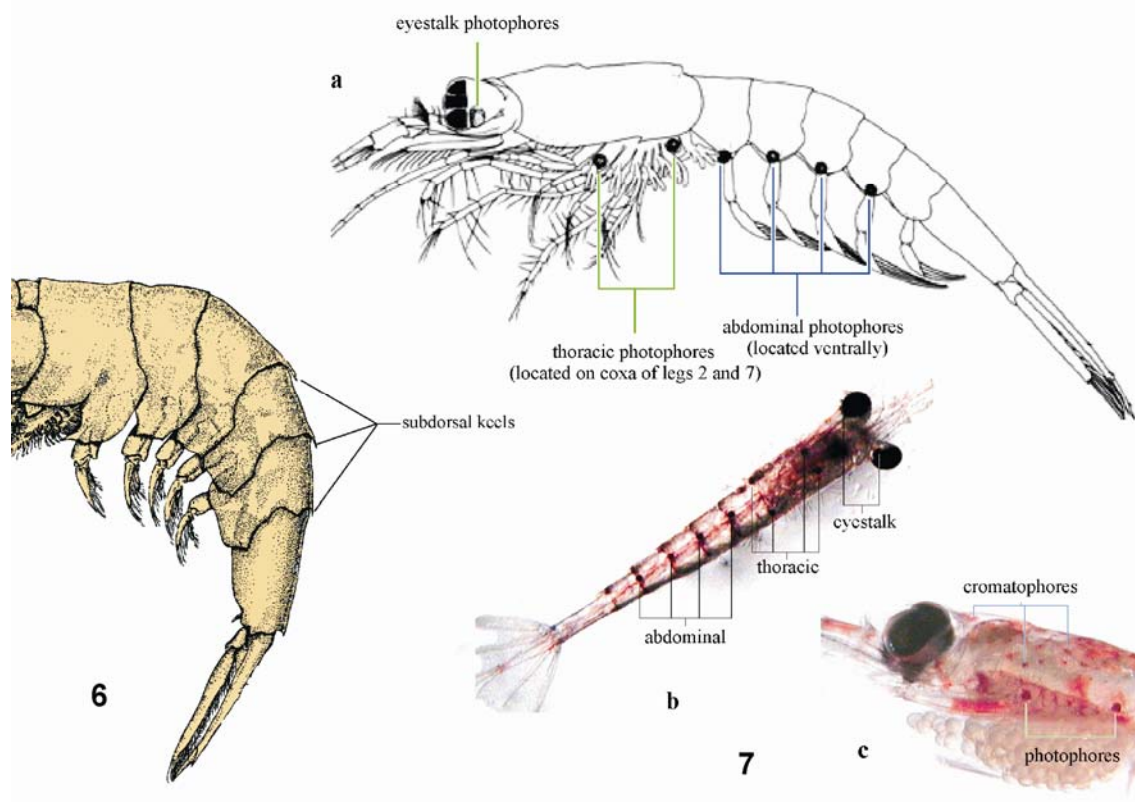
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▲ Fig. 4. Differences in the arrangement and number of thoracic limbs. Sources from Mauchline, 1967: a; Brinton, 1975: b; Mathew, 1980b: c; Baker et al., 1990: d, e, f.

◀ Fig. 5. Differences in the carapace structure and form. Sources from Brinton, 1975: a, b; Baker et al. 1990: c, d, e, f, g.



**Fig. 6.** Subdorsal keels (after Brinton, 1975). **Fig. 7.** Photophores position. Sources from Knight, 1975: **a**; Brinton *et al.*, 2000: **b**, **c**.

The **pre-anal spine** (see Fig.1) lies mid-ventrally and just forward of the posterior margin of the sixth segment, is rarely useful for identification purposes. The paired biramous **uropods** are inserted on either side of the pre-anal spine and between, but dorsal to them, is the **telson**. Neither are used for identification purposes in adults, but the number of terminal spines on the telson is an essential character in determining the developmental stage of larvae.

The name *Euphausia* is derived from the luminescence produced by large light organs or **photophores** (Fig. 7). With the exception of *Bentheuphausia ambylops* and *Thysanopoda minyops* (Brinton, 1987), photophores are present in all species of euphausiids and occur in reduced numbers in *Thysanopoda spinicaudata* and the *Stylocheiron* species. Their distribution on the body is generally conservative: one at the base of each eye, a pair on the coxae of thoracic segments three and seven, and one mid-ventrally on abdominal segments one to four. In *Thysanopoda spinicaudata* the only photophores present are those on the eyes whereas in *Stylocheiron* they occur on the eyes, the seventh thoracic limbs and the first abdominal segment. The photophores are of little value as an aid to identification except that their distribution serves to distinguish *Stylocheiron* from other genera, which can be useful when working with damaged specimens.

**Abdominal segments** one to five each carry a pair of **pleopods** used for swimming. These are of uniform structure and are composed of a very muscular basal segment bearing an outer **exopodite** and an inner **endopodite**. Except in *Bentheuphausia*, the endopodites of the first and second pleopods of adult males are modified as sexual organs. The various lobes, hooks and processes that develop on the endopodite of first pleopods are modified in males to form **petasma** or copulatory organ (Fig. 8). The form of the mature petasma is of diagnostic value at the species level. However, the disadvantage is that it can only be used to identify adult males and also in the genera *Thysanoessa* and *Stylocheiron* the petasma is particularly small and difficult to prepare for examination. The modified second pleopod of the male has never been used as an aid in species identification (e.g. Bargmann, 1937). The petasma is composed of four main lobes (setiferous, auxiliary, median and inner), some of which may be enlarged or lost. The relative size, shape and arrangement of the different processes on the lobes of the petasma are also variable, and it is here that differences should be sought when separating species. So, sexes can be readily distinguished by the presence or absence of petasma.

The external reproductive organ of the female is called the **thelycum** and is situated on the ventral surface of the sixth and seventh thoracic segments (Fig.9a) It is the external opening to the female reproductive tract, and it consists of various outgrowths from the ventral body wall and the coxal plates (Fig.9b). Points of difference to notice when examining thelyca include the relative shape and sizes of the coxal and sternal plates. Mated females can be readily identified by the presence of one or more spermatophores attached to the thelycum (Fig. 9c). The spermatophore is located in a central depression in the thelycum

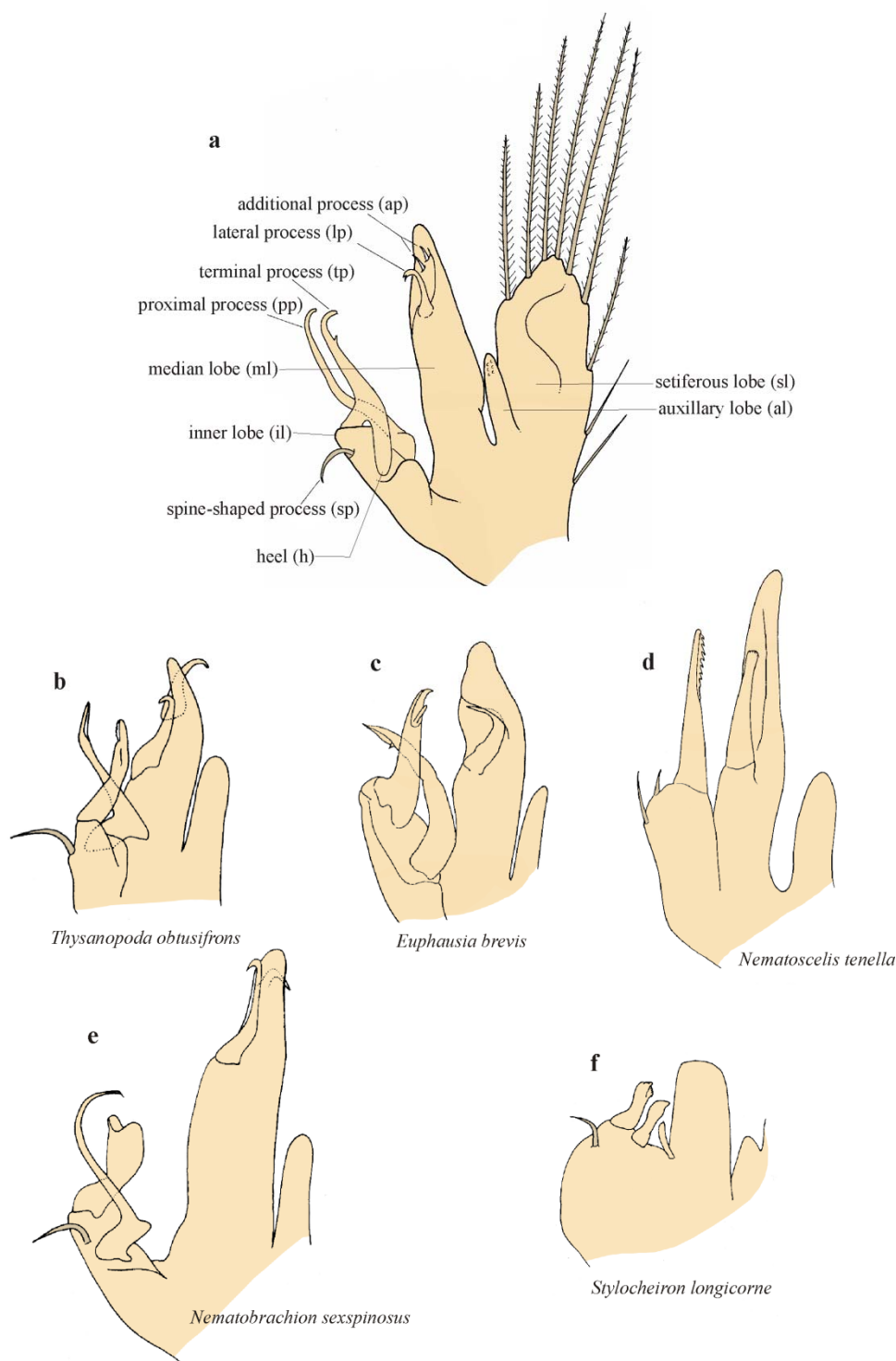
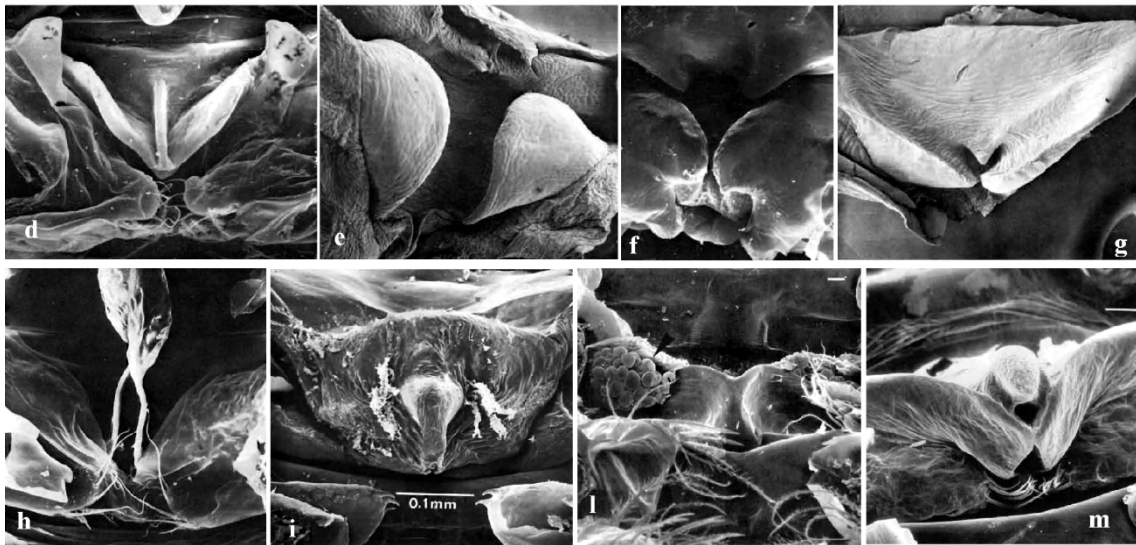
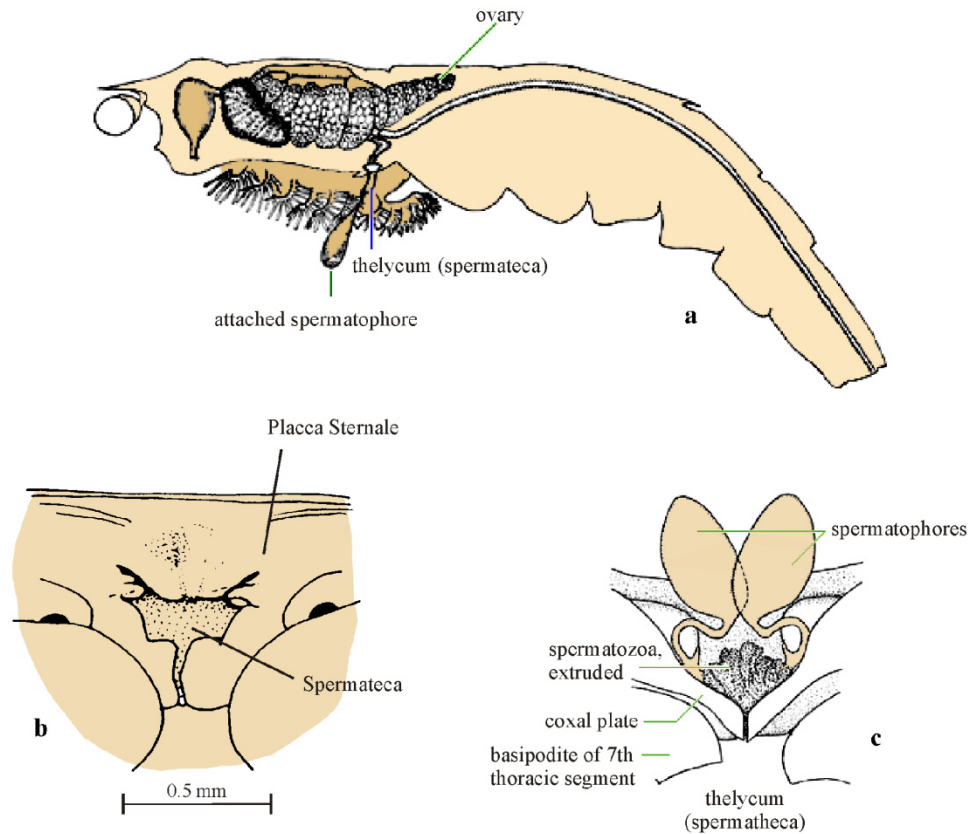


Fig. 8. Petasma structure in some euphausiid species. Sources, from after Baker *et al.*, 1990: a; Brinton, 1975: b, c, d, e, f.

where it is held in place by a cementing substance. Some thelyca morphology by SEM micrograph, in different species, are showed in Figure 9d. Until relatively recently, descriptions of thelyca were available for almost known species. This situation has changed following the publication of detailed accounts by Sebastian (1966), James (1977), Costanzo & Guglielmo (1976a, b, 1977, 1980, 1981, 1991) and Guglielmo & Costanzo (1977, 1978, 1983). Although it has been shown that it has a strong diagnostic value, examination of the thelycum is not easy and usually requires staining and some dissection, and so has not been used as a routine method. However, it is used to differentiate some species (particularly the "gibba" group of *Euphausia* and the "atlantica/microps" group of *Nematoscelis*), in which the females can be rather difficult to identify, especially if damaged, and in these cases the thelycum can be a helpful diagnostic character. However, this character should be used for identifying only fully mature females because the immature specimens of some species can have thelyca resembling the mature state of others.



**Fig. 9.** Thelycum (female). Sources, from: **a)** schematic side view of thelycum, Brinton, 1975; **b)** schematic drawing, Einarsson, 1942; **c)** *Thyanopoda longicaudata*, Einarsson, 1945; **d-m)** SEM micrographs in different euphausiid species (Costanzo & Guglielmo, 1976a, b; 1980; Guglielmo & Costanzo, 1983): **d)** *Thysanopoda aequalis*, Hansen 1905, 18.5 mm, SEM (X 120); **e)** *Meganyctiphanes norvegica*, M. Sars, 1857, 9.35 mm, SEM (X 175); **f)** *Euphausia krohnii*, Brandt, 1851, 16 mm, SEM (X 150); **g)** *Nematoscelis megalops*, G.O. Sars, 1883, 22 mm, SEM (X 210); **h)** *Stylocheiron longicornis* G.O. Sars, 1883, 9.5 mm, SEM (X 280); **i)** *Nematoscelis tenella*, 18.5 mm; **l)** *Bentheuphausia amblyops*, G.O. Sars, 1885, SEM micrograph, arrow indicating spermathecal mass. Bar = 0.1 mm; **m)** *Nematobranchion sexspinosum*, Hansen 1911, SEM micrograph. Bar = 0.1 mm

## 1.2. Life Cycle

(Text sources from: Guglielmo, 2006; Mauchline, 1984).

The sexes in euphausiids are separate, and mating is thought to involve the transfer of one or two spermatophores by the petasma of the male into the thelycum of the female. The coupling of euphausiids has not yet been observed, but probably occurs at night and is completed in a few seconds. The species of the genera *Thysanopoda*, *Euphausia* and *Meganyctiphanes* leave their **eggs** in open water, while the species of the genera *Nyctiphanes*, *Nematoscelis* and *Stylocheiron* carry the eggs in a pocket incubator attached to the thoracic legs. The species that release their eggs in water produce 40-500 eggs per clutch, depending on the species and size of the female. *Nematoscelis megalops*, although carried the eggs in the incubator pocket, produces 220-250 eggs of small size. *Nyctiphanes couchii* produces 20-100 eggs, while species of *Stylocheiron* 2-50 larger eggs.

From the egg hatches a **nauplius** (Fig.10) that develops and changes in **metanauplius**. This moults to **calyptopis 1**. There are three successive stages of calyptopis that differ for the different segmentation of the abdomen which eventually leads 6 segments ending in telson and uropods. The development of the eyes, however, still remains covered by the carapace. Stadiums calyptopis follow the stages of **furcilia** that resemble miniature adults. The 3rd calyptopis moults to furcilia 1. At this stage, the eyes are free from the carapace and are pedunculated. The stages of furcilia are characterized by the emergence and development of the feet or abdominal pleopods. The differentiation of pleopods occurs in the first three or four stages of furcilia. Even the thoracic appendages (thoracopods) develop in the early stages of furcilia, but their development is not complete if it does not pass through many stages. The minimum number of furcilia required by an euphausiid to become a teenager is 6, as in the Antarctic krill *Euphausia superba*. *Meganyctiphanes norvegica* presents seven stages furcilia, *Euphausia krohni* 6, while species of *Thysanopoda* can get to 11 stages.

The number of moults during development varies not only among species but also within the same species, at different times in the same area and at the same time in different areas. To complete larval development spend 2 or 3 months. The eggs are usually laid in the spring, so that the larvae develop in the plankton in late spring and summer. Larval development is usually completed in July-August and adolescents are growing in autumn, when sexual maturity begins to reproduce next spring. Larval euphausiids to 4 or 5 mm body length are considered true components of the zooplankton, being dispersed primarily by water circulation. Euphausiids are known to form seasonal breeding aggregations in the late winter to facilitate mating. The luminescent organs, the photophores, probably have a communications role in affecting these aggregations. Maturing euphausiids become increasingly capable of directional migration and are sometimes designated micro-nekton. However, this distinction is frequently ignored in analysis of zooplankton net-samples which, indeed, retain substantial proportions of adults, particularly if collected at night.

## 1.3. Feeding

(Text source from: Guglielmo, 1985)

Marine organisms are linked by complex trophic webs, the knowledge of which is fundamental for understanding the energy flow in the pelagic ecosystem. Detailed informations can be obtained studying the vertical distribution, diel migration and trophodynamic of "key species". In this context, the euphausiids, that feed primarily on phytoplankton and in turns are prey of many fishes, like mesopelagic fishes, are fundamental factors in different models on the dynamics of oceanic ecosystems. Euphausiids are truly omnivorous, although different genera tend towards either herbivorous or strictly carnivorous (*Nematoscelis*, *Nematobrachion*, *Thysanoessa*, *Stylocheiron*; Roger, 1975). Their diet changes from phytoplankton (diatoms and dinoflagellates) and tintinnids to fish eggs and larvae, copepods as well as detritus (Mauchline and Fisher, 1969). Some herbivorous species have a social behaviour, constituting dense swarms that are very important food source for marine mammals (Nemoto, 1959) and high value commercial fishes (Froggia, 1973, 1976).

Knowledge about their eating habits were obtained from the analysis of stomach contents. Rarely are obtained, however, reliable quantitative data, as they are found in the stomach, frequently, the remains of organisms preyed no longer recognizable, having been destroyed by the mouth parts and the armor of the walls of the stomach (Nemoto, 1977). These are the remains of organic material, often times, mixed with debris that euphausiids assume from the bottom after removing it with the movement of the pleopods. Informations on nutrition in this group can be found in Mauchline and Fisher (1969), Mauchline (1980), Casanova (1974) and Artiges *et al.* (1978). Carnivorous feeding, according with Berkes (1975), occurred probably for "encounter feeding", as was also experienced by Fowler (1971) in *M. norvegica*; this species, after touching the prey, traps it between the mouthparts. Also for euphausiids, as well as for copepods, it is believed that each species has not only one type of feeding, but it fits naturally, to the availability of food being able to pass, in a short time (of the order of hours or days) by a strictly herbivorous diet to a omnivorous or carnivorous diet. This has been demonstrated for *M. norvegica* that by day prey on small mesopelagic copepods and during the night filtering phytoplankton in the surface layers (Mauchline & Fisher, 1969).



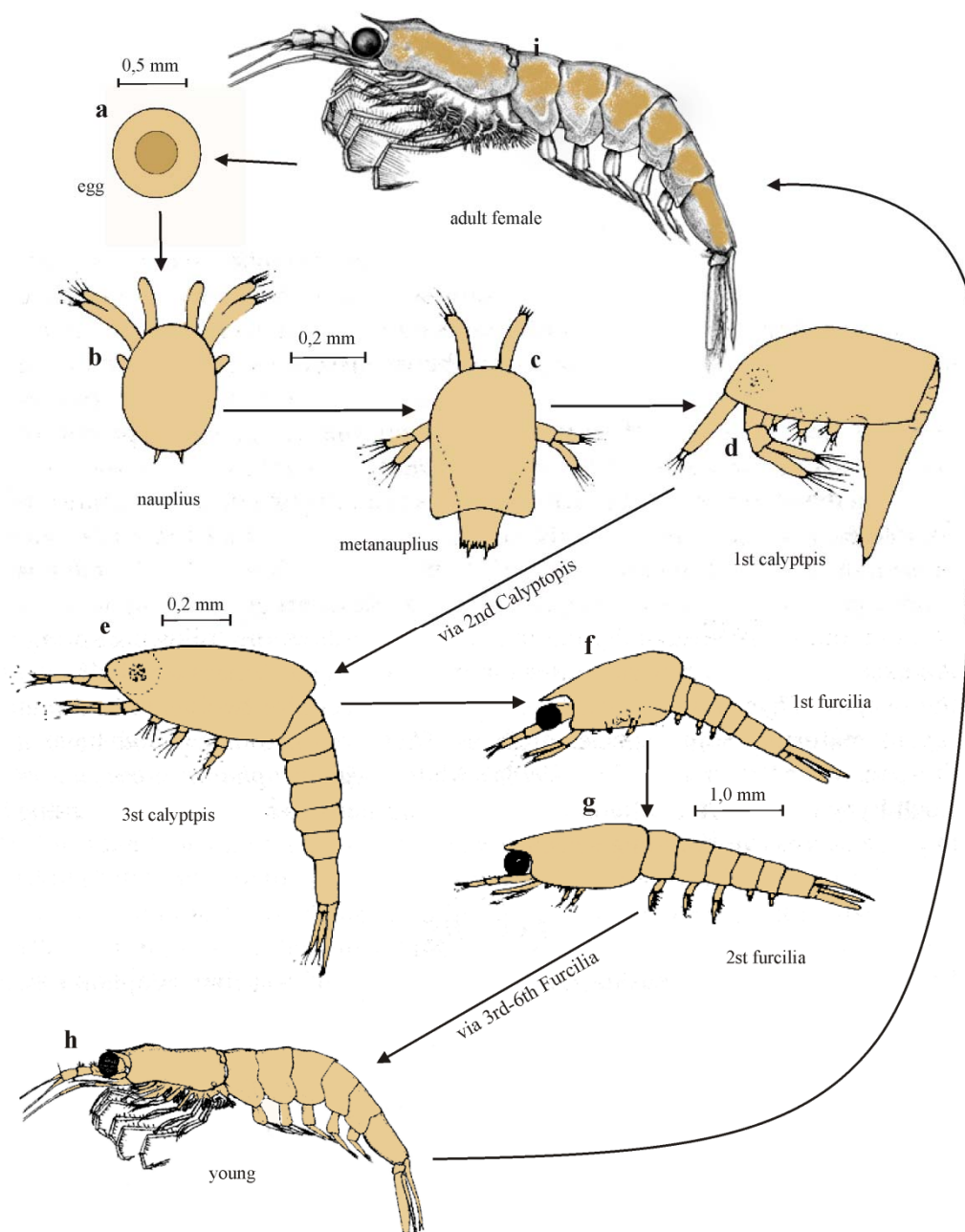


Fig. 10. Life cycle. Source from Mauchline, 1984; Brinton, 2000

#### 1.4. Distribution

(Text source from: Brinton *et al.*, 2000)

Euphausiids are exclusively marine, distributed throughout the coastal seas and oceans of the world, from epi- to bathypelagic zone. Their distribution is frequently associated to horizontal or vertical thermal characteristics, such as the thermocline, oxycline or with particular water masses, such as to frontal zones and upwelling systems, characterized by high productivity values (Dadon and Boltovskoy, 1982; Sameoto *et al.*, 1987; Gibbons *et al.*, 1995; Tarling *et al.*, 1995). Euphausiids are often a dominant component of net-caught zooplankton, particularly at high latitudes such as the antarctic and the subarctic Pacific and Atlantic Ocean basins. Three-dimensional aggregations of euphausiids, usually a daytime phenomenon, have been observed in many species. In some aggregation, they form tight balls or layers, whereas in others aggregations form schools (like *Euphausia superba* under sea ice). In reason of both their pelagic nature and high capability to performed greater vertical distances, euphausiids are an active energy flux from surface layers to deep waters (Casanova 1970). In fact, essentially for trophic purposes, many species display pronounced diel vertical migration and frequently traverse distances in excess of 200 m at night (Mauchline, 1980; Sameoto, 1980a; Sameoto *et al.*, 1987). Thus, detailed informations on their DVM could also provide elements for better understanding their role in the biological pump (Longhurst and Harrison 1988) and in the vertical flux of POM (Minutoli & Guglielmo, 2009, 2012).



**Fig. 11.** a) BIONESS (Bedford Institute Oceanography Net Environmental Sampling System); b) MOCNESS (Multiple Opening/Closing Net and Environmental Sampling System); c) RMT25 Rectangular Midwater Trawl; d) IKMT (Isaacs-Kidd Midwater Trawl).

### 1.5. Collection and Preservation

(Text sources from: Mauchline, 1984; Gibbons *et al.*, 1999)

The equipment required to collect euphausiids is of necessity complex because of their offshore habitat. The animals are active swimmers. Because of their large size and well developed eyes, most adult euphausiids are able to detect and avoid nets, especially during the day (Pillar, 1984). If nets are to be used to estimate euphausiid abundance or biomass, they should be of large mouth area and wide mesh diameter (> 0.5 mm) and be towed obliquely at night. To avoid underestimating abundance, therefore, nets should be towed from as close to the bottom as possible. Multiple opening-closing nets, like to RMT8 (Baker *et al.*, 1973), MOCNESS (Wiebe *et al.*, 1976) and BIONESS (Sameoto *et al.*, 1980b) should be used where possible because these not only yield information on biomass but also on vertical distribution (Fig. 11). To collect large quantities of krill are used pelagic net as PHN (Plankton Hamburg Net) and IKMT (Isaacs-Kidd Midwater Trawl). The younger development stages can be collected using standard vertical mesozooplankton hauls with nets of smaller mouth area and narrower mesh diameter (e.g. WP2 57cm diameter, 200 um mesh size). Various books provide background information on how to construct the nets and use them. References should be made to Wimpenny (1966), UNESCO (1968), Wiebe & Benfield (2003), Sameoto *et al.* (2000).

Adult euphausiids are liable to be very conspicuous in the samples because no other planktonic crustaceans are likely to be so large unless the samples are taken well offshore. Adult euphausiids can therefore be picked out at sea if the sample is decanted, from the collecting jar on the end of the net, into a white plastic tray. The simplest way of preserving a sample of euphausiids or mixed plankton is in 5-8% neutral formalin (depending from individual abundance and size) made up in seawater.

## 1.6. Scientific and applied interest

(Text sources from: Mauchline, 1980; Baker *et al.*, 1990)

Although this is a much smaller number than in most other crustacean orders, the euphausiids probably constitute the most economically important component of the oceanic planktonic biomass because of their relatively large size compared with other zooplankton and the great abundance of many of their species. The euphausiids usually constitute 5-10% of the total biomass of plankton and about 30% of the biomass of the crustacean plankton (Mauchline & Fisher, 1969; Mauchline, 1980). Popularly known as *krill*, they form an important part of the diet of many animals including whales, seals, fishes, birds and, to a lesser extent, man. Euphausiids are important in the diets of the micronektonic fish which in turn are fed on by the tunas (Legand *et al.*, 1972; Roger, 1973, 1975; Roger & Grandperring, 1976; Scotto di Carlo *et al.*, 1982; Guglielmo *et al.*, 1995; Granata *et al.*, 2001). *Euphausia pacifica* is caught commercially in several regions, especially off northern Japan where it is dried and marketed for bait and feed for farmed fish (Fulton, 1976; Mason, 1976; Koops *et al.*, 1977). A bibliography on krill as a human food resource is provided by Grantham (1976, 1977) and Taylor (1976). Estimates of the possible annual yield of a commercial fishery for *Euphausia superba* range 30 to 200 million tons (Everson, 1977). The krill contain large amounts of trace elements, vitamin A, "B" vitamins and important fatty acids (Mauchline, 1980). Krill pastes and meal (Lyubimova *et al.*, 1973; Bulycheva *et al.*, 1977; Fedotova *et al.*, 1977; Leinemann & Christians, 1977; Jahn *et al.*, 1978) can be manufactured and used as animal feed and in the therapeutic diets of patients suffering from stomach ulcers and arteriosclerosis. Lyubimova *et al.* (1973) and Grantham (1977) discuss the production of various manufactured products such as krill sausages, stuffed eggs and shrimp butter. The krill species both in the northern Atlantic and in the Mediterranean Sea is *Meganyctiphanes norvegica*. The presence of birds feeding on surface swarms of euphausiids often aids fishermen in locating schools of fish. They are of interest to oceanographers because species distributions are readily definable and, on a large scale, can be regarded as good indicators of water masses. In the Mediterranean Sea, the two species can play this role are *Thysanoessa gregaria* for the waters of the Atlantic origin and *Stylocheiron suhmi* for the waters of eastern origin (Casanova, 1974). A whale may consume many tons of North Atlantic or antarctic krill in a day. Euphausia species are fished commercially in Japanese, Canadian, and Antarctic waters. They are a high protein food for aquarium and farm animals as well as humans. They can be a delicacy, particularly when freshly caught (Brinton *et al.*, 2000).

## 1.7. Key to families and genera

(Text sources from: Mauchline, 1984; Baker *et al.*, 1990; Gibbons *et al.*, 1999; Miller, 2004).

This illustrated key is intended to help those who may wish to identify euphausiids but are unfamiliar with the Order, either because they are new to it, or simply because specimen identification is peripheral to their main interest. In compiling this key every attempt has been made to keep the terminology simple.

The arrangement used in the key is very common. It must be emphasised that this key is intended for identifying adult or nearly mature specimens. Caution is necessary when examining juveniles because some of the key characters appear at different stages of development. The more obvious characters used for identification of adult euphausiids can be readily observed with the aid of a low power stereomicroscope. A number of guides have been published to aid in the identification of the euphausiids of the world oceans.

Those examining euphausiids for the first time may find the following general account of their morphology helpful. More detailed accounts of euphausiid morphology and anatomy is given by Sars, 1885; Hansen, 1910, 1911, 1912; Einarsson, 1945; Boden *et al.*, 1955; Mauchline & Fisher, 1969; Casanova, 1974; Brinton, 1975; Mauchline, 1980; Baker *et al.*, 1990; Gibbons *et al.*, 1999. A comprehensive, cross-indexed bibliography has been prepared by McWhinnie *et al.* (1981). The most recent systematic work on euphausiids of the world is a CD-ROM expert system for identification (including larval stages) by Brinton *et al.* (2000). It included references to virtually the entire literature on Euphausiacea and a wealth of systematic and biological information.

### Key to families:

- A. Without photophores, with all 8 pairs of thoracic legs well developed ..... **Bentheuphausiidae**  
– Photophores are present and 8<sup>th</sup> or the 7<sup>th</sup> and 8<sup>th</sup> pairs of thoracic legs are rudimentary .....  
..... **Euphausiidae**

### Key to genera:

1. Photophores present on abdominal segments one to four ..... 2  
– Photophores present only on abdominal segment one ..... **Stylocheiron**
2. Eyes round; thoracic legs of approximately equal length ..... 3  
– Eyes divided into two lobes; one or two pairs of thoracic legs very elongated ..... 6
3. Seventh pair of thoracic leg smaller than sixth, with six segments ..... **Thysanopoda**  
– Seventh pair of thoracic leg rudimentary. Anterior margin of frontal plate produced to form a sharp or gently rounded rostrum ..... 4

4. A denticle at the mid-point or on the posterior half of the lateral margin of the carapace. An anterior lateral denticle also may be present ..... 5
  - There is no lateral denticle or, if one is present, it is well anterior to the mid-point of the lateral margin of the carapace. A strong recurved lappet on first segment of antennular peduncle..... **Nyctiphanes**
5. Seventh thoracic leg consisting of two elongated joints and the seventh thoracic exopod present. Strong post-ocular spines and long recurved antennular lappets present..... **Meganyctiphanes norvegica**
  - Seventh thoracic leg consisting of only a minute process and seventh thoracic exopod absent..... **Euphausia**
6. Second thoracic leg elongated ..... 7
  - Third thoracic leg elongated..... **Nematobranchion**
7. Second thoracic legs very slender and naked, with only a tuft of apical bristles. Terminal segment of first thoracic leg with short, robust comb-like spines ..... **Nematoscelis**
  - Second pair of thoracic legs rather strong and last two segments armed with spiniform bristles. Dactylus of 1th pair of thoracic legs not pectinate..... **Thysanoessa**

## 2. Diversity of Macaronesia area

(Text Sources from: Mauchline, 1980; Gibbons *et al.*, 1999)

The order Euphausiacea is divided into 2 families (**Bentheuphausiidae** and **Euphausiidae**), 11 genera and 86 species. The genus *Euphausia* is the most represented with 31 species, followed by *Thysanopoda* with 14 species, *Stylocheiron* with 12 species, *Thysanoessa* with 10 species, *Nematoscelis* with 7 species, *Nyctiphanes* with 4 species, *Nematobranchion* with 3 species, *Pseudoeuphausia* with 2 species and 3 monospecific genera (*Bentheuphausia*, *Meganyctiphanes* and *Tessarabrachion*). Of the 86 species of euphausiids found worldwide, 37 have been recovered from Macaronesia Area (14°30'-39°40' N, 11°25'E-31°30'W), North Atlantic (Table I). The absentees all display limited distribution patterns and are endemic to the Southern Hemisphere or are confined northern.

One of the most detailed analyses on euphausiid assemblages around Canary Islands, is that produced by the "Discovery" SOND cruise of 1965 in the region of Fuertaventura. Baker (1970) found 28 species in this area, the commonest of which are *Euphausia krohni*, *E. hemigibba*, *Thysanoessa parva*, *Nematoscelis microps/atlantica*, *Stylocheiron longicorne* and *S. elongatum*. Other common species are *Thysanopoda aequalis*, *Euphausia brevis*, *E. gibboides*, *Nematoscelis tenella*, *N. megalops*, *Nematobranchion flexipes*, *Stylocheiron suhmi* and *S. affine*. The great Meteor Seamount lies west of the Canaries at approximately 30°N, 28°30'W. Weigmann (1974) found 20 species of euphausiids in the region around the plateau of the seamount, the dominant species being *Thysanopoda aequalis*, *Euphausia brevis*, *E. hemigibba*, *Stylocheiron suhmi* and *S. longicorne*. Only 7 of these 20 species occurred on the plateau region, dominated by *Euphausia brevis* and *Stylocheiron suhmi*, the depth of water being considered insufficient to allow colonization by the other 13 species. The euphausiid fauna in the area south of the Canaries, off Cape Blanc, north-west Africa, has been studied by Weigmann-Haass (1976) and Andreu (1976). This is a region of coastal upwelling. The species composition of the fauna was similar to that of the Canaries and Meteor Seamount. Meira (1970) recorded 7 species, including the boreal *Thysanoessa longicaudata*, present among the Cape Verde Islands.

Referring to the list of 28 euphausiid species found by Baker (1970), *Stylocheiron affine* can be considered dubious after the worldwide distribution known for this species (Brinton, 1975; Brinton *et al.*, 2000), while *Thysanopoda subaequalis* is now considered a synonym of *T. aequalis* (Brinton *et al.*, 2000). So, to the list of 26 species of euphausiids found by Baker (1970), must be added: one family (Bentheuphausiidae), two monospecific genera (*Bentheuphausia* and *Meganyctiphanes*) and ten species (*Bentheuphausia amblyops*, *Meganyctiphanes norvegica*, *Euphausia hanseni*, *E. mutica*, *E. pseudogibba*, *E. tenera*, *Stylocheiron robustum*, *Thysanopoda acutifrons*, *T. cornuta* and *T. egregia*). Two other species may be considered dubious: *Thysanopoda tricuspoidata* and *Thysanoessa longicaudata* found by Meira (1970) around the Cape Verde Islands.

**Table I. Euphausiid species found in the Macaronesian area, from: Brinton *et al.*, 2000 (CD Room); Mauchline & Fisher, 1969; Brinton, 1975; Gibbons *et al.*, 1999. **CAN**: Canary Islands, Baker, 1970; **MED**: Mediterranean, Mauchline & Fisher, 1969; **DD**: Day Depth (m), Mauchline, 1980; **M**: migrates, Mauchline, 1980;**

Species	CAN	MED	DD	M	References on the horizontal distribution in the Macaronesian
<b>BENTHEUPHAUSIIDAE</b>					
<b><i>Bentheuphausia</i> G.O. Sars, 1885</b>					
• <i>B. ambylops</i> G.O. Sars, 1885			>1000		James (1983, 1987)
<b>EUPHAUSIIDAE</b>					
<b><i>Euphausia</i> Dana, 1852</b>					
• <i>E. americana</i> Hansen, 1911	•		500-700	M	
• <i>E. brevis</i> Hansen, 1905	•	•	200-400	M	
• <i>E. gibboides</i> Ortmann, 1893	•		200-500	M	
• <i>E. hanseni</i> Zimmer, 1915			<300		Mauchline & Fisher (1969)
• <i>E. hemigibba</i> Hansen, 1910	•	•	400-500	M	
• <i>E. krohni</i> Brandt, 1851	•	•	400-600	M	
• <i>E. mutica</i> Hansen, 1905			300-600	M	Hong (1969), Brinton (1975)
• <i>E. pseudogibba</i> Ortmann, 1893			25-100	M	Brinton (1975), Tsetlin (1981b)
• <i>E. tenera</i> Hansen, 1905			300-500	M	Hong (1969), Brinton (1975), James (1983, 1987)
<b><i>Meganyctiphanes</i> Holt &amp; Tattersal, 1905</b>					
• <i>M. norvegica</i> M. Sars, 1857		•	100-400	M	Mauchline & Fisher (1969)
<b><i>Nematobranchion</i> Calman, 1905</b>					
• <i>N. boopis</i> Calman, 1896	•		>300		
• <i>N. flexipes</i> Ortmann, 1893	•		100-600	M	
• <i>N. sexspinosum</i> Hansen, 1911	•		100-200	M	
<b><i>Nematoscelis</i> G.O. Sars, 1883</b>					
• <i>N. atlantica</i> Hansen, 1910	•	•	>250	M	
• <i>N. megalops</i> G.O. Sars, 1883	•	•	>140	M?	
• <i>N. microps</i> G.O. Sars, 1883	•		100-400	M	
• <i>N. tenella</i> G.O. Sars, 1883	•		100-450	M	
<b><i>Nyctiphanes</i> G.O. Sars, 1883</b>					
• <i>N. couchi</i> Bell, 1853	•	•	0-200	M	
<b><i>Stylocheiron</i> G.O. Sars, 1883</b>					
• <i>S. abbreviatum</i> G.O. Sars, 1883	•	•	50-300	M?	
• <i>S. carinatum</i> G.O. Sars, 1883	•		100-300	M?	
• <i>S. elongatum</i> G.O. Sars, 1883	•		200-500		
• <i>S. longicorne</i> G.O. Sars, 1883	•	•	100-300		
• <i>S. maximum</i> Hansen, 1908	•	•	>400	M?	
• <i>S. robustum</i> Brinton, 1962			>450	M?	James (1983, 1987), Brinton (1975)
• <i>S. suhmi</i> G.O. Sars, 1883	•	•	<200		
<b><i>Thysanoessa</i> Brandt, 1851</b>					
• <i>T. gregaria</i> G.O. Sars, 1883	•	•	0-200	M?	
• <i>T. parva</i> Hansen, 1905	•		400-1600		
<b><i>Thysanopoda</i> Milne-Edwards, 1830</b>					
• <i>T. acutifrons</i> Holt & Tattersal, 1905			700-900		Mauchline & Fisher (1969), Brinton (inédito)
• <i>T. aequalis</i> Hanse, 1905	•	•	500-700	M	
• <i>T. cornuta</i> Illig, 1905			>1000	M	Mauchline & Fisher (1969); James (1983, 1987), Tsetlin (1981b)
• <i>T. cristata</i> G.O. Sars, 1883	•		400-800		
• <i>T. egregia</i> Hansen, 1905			>1000		Mauchline & Fisher (1969); James (1983, 1987), Tsetlin (1981b)
• <i>T. microphthalmia</i> G.O. Sars, 1885	•		>500		
• <i>T. monacantha</i> Ortmann, 1893	•		400-800	M	
• <i>T. obtusifrons</i> G.O. Sars, 1883	•		300-600	M	
• <i>T. pectinata</i> Ortmann, 1893	•		500-700	M	

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