CHAPTER 6

Description of major groups of meso- and macrozoo-plankton

This Chapter provides brief information on morphology, reproduction modes, development and ecology of the most common representatives from the major taxonomic groups of meso- and macrozooplankton in the Baltic Sea.

6.1 Cnidaria

Cnidarians are diploblastic metazoans; i.e. they consist of two epithelial layers only – an ectodermal epidermis and an endodermal gastrodermis, separated by a primarily acellular extracellular matrix called mesogloea. The most characteristic structures are the cnidae (nematocysts) produced by specific cells and generally used to catch prey that may be much larger than the individual itself may.

Cnidarians not only use larvae as means of dispersal in the open waters. Additionally, they have achieved an obligate generation completely committed to propagation; a clear and concise description of this process is given elsewhere (Larink and Westheide, 2006). In an alternation of generations, called metagenesis, this sexually reproducing generation usually is a free-swimming **medusa**, which arises from a polypoid generation through budding. In some cases, medusae may also arise asexually from other medusae, but characteristically medusae produce and broadcast either sperm or eggs. The fertilized eggs develop into ciliated free-swimming planulae that later become attached to the bottom and metamorphose into the **polyp**. Polyp and medusa of one species may be very different in phenotype and their relationship is rarely apparent; thus, in many cases they were described as different species.

The Cnidaria comprise **Anthozoa**, **Cubozoa** (exclusively tropical forms), **Scyphozoa**, and **Hydrozoa**, all different in structure, size and reproduction of their polypoid and medusoid forms. In the Hydrozoa, medusae are often secondarily suppressed, in which case the asexual buds of the polyp do not develop into free-swimming medusae but remain sessile. In the Anthozoa, no metagenesis occurs and the exclusively polypoid forms reproduce both sexually and asexually. Planktonic stages of all Anthozoa, Scyphozoa and Hydrozoa can be found in the sea (Figures 6.1−6.3).

The moon jelly, a scyphomedusae *Aurelia aurita* is the most dominant species of the Baltic Sea. Barz et al. (2006) and other authors characterise it as a species, which can reduce the stocks of mesozooplankton communities considerably in years of high abundance (e.g. Möller, 1980; Matsakis & Conover, 1991; Purcell, 1992; Olesen, 1995;

Omori et al., 1995; Lucas et al., 1997; Schneider & Behrends, 1998). These medusae compete for zooplankton with commercially important planktivorous fish species and ctenophores, but they may also prey on fish eggs and larvae and thus directly affect their recruitment (Barz et al., 2006). The Belt Sea, the western Baltic Sea, and the Archipelago Sea are known as strobilation areas for *A. aurita*. However, ephyra are not regularly found in the Baltic Proper. Some authors concluded that *A. aurita* does not strobilate in this area (Janas & Witek, 1993; Barz & Hirche, 2005). However, the occurrence of the other larger Scyphomedusae, *Cyanea capillata* in the western Baltic Sea and in the Baltic proper is always a sign for salt-water influx from the Kattegat area. An indication for strong salt-water influxes is the occurrence of the hydromedusae *Euphysa aurata* in the western Baltic Sea (Wasmund et al., 2004).
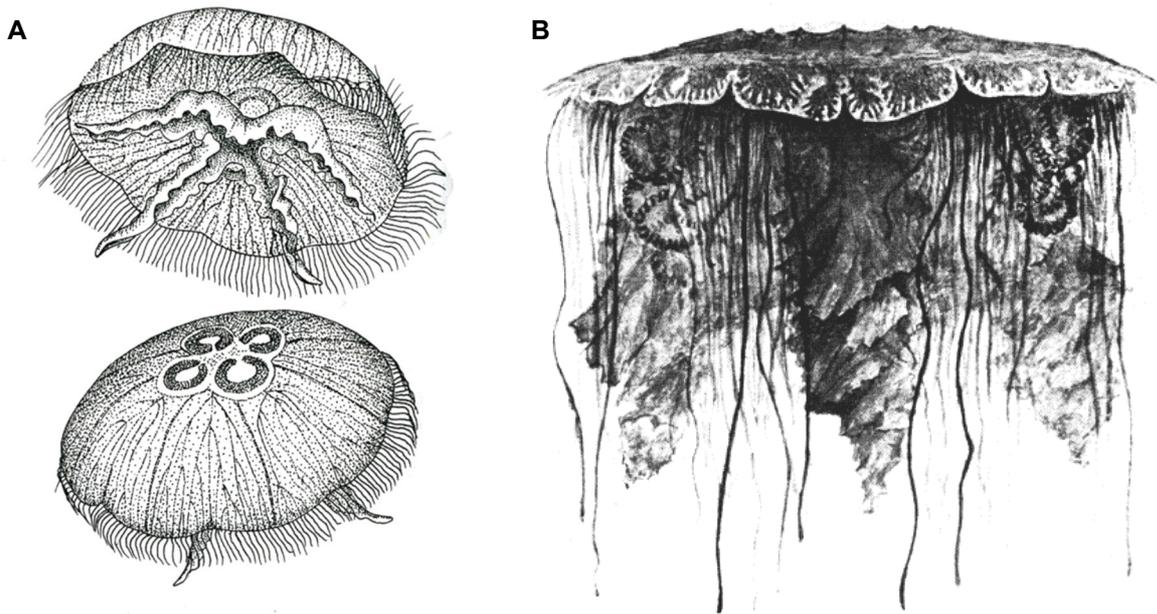
Figure 6.1: Cnidaria, Scyphomedusae: **A**, *Aurelia aurita* (modified from Hayward & Ryland, 2005); **B**, *Cyanea capillata* (after Russel, 1970).
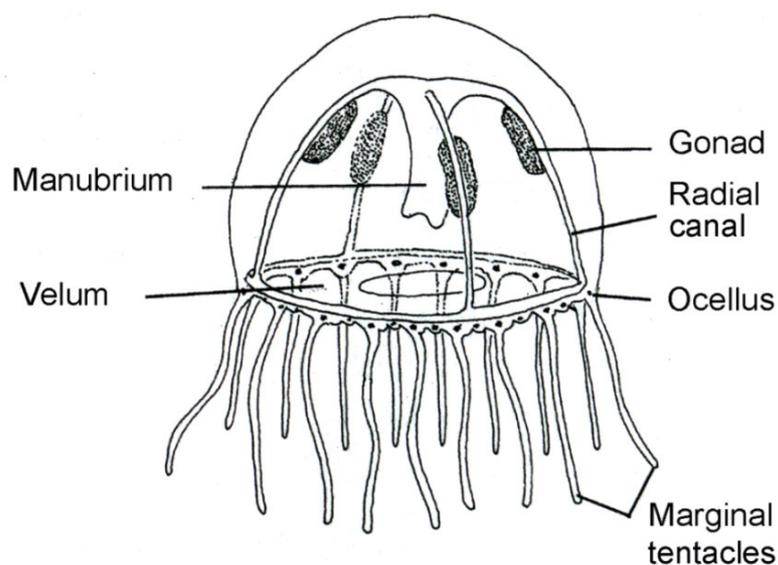
Figure 6.2: Typical hydroid medusae (modified from Hayward & Ryland, 2005).

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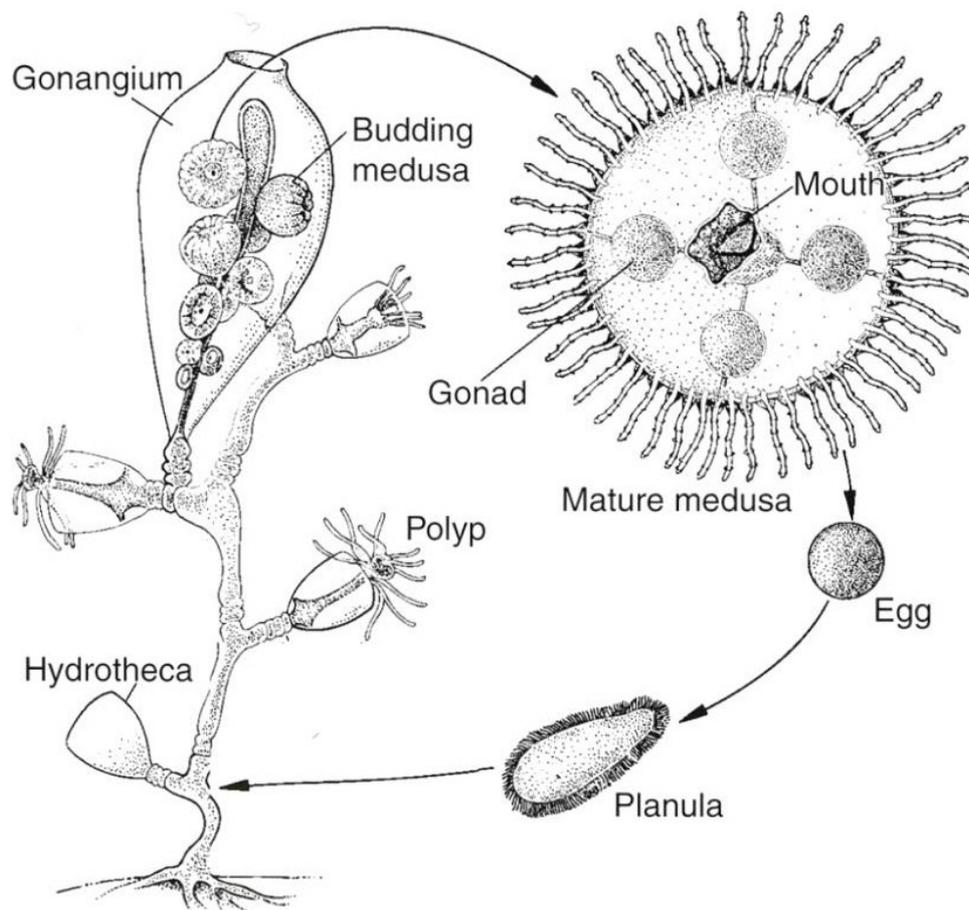
Figure 6.3:   Life cycle of a Leptomedusae *Obelia geniculata* (modified from Larink & Westheide, 2006).

6.2 Ctenophora

Ctenophora, or comb jellies, are presumably holoplanktonic organisms. Usually they are several centimetres long; they occur in all seas, and most of the ctenophore species are considered to be cosmopolitan (Larink & Westheide, 2006).

The body of comb jellies has biradial symmetry: one central plane passes through both tentacle pouches and another plane is at a right angle to this, passing through the mouth slit (Fig. 6.4). Each plane divides the body into equal halves. Eight comb rows (ctenes) consisting of transverse plates of fused cilia are the locomotory organs by which the animals actively swim, the oral pole forward.

The **Tentaculifera** species have two long contractile tentacles, each emerging from the bottom of a deep epidermal pouch – the example is the ovoid species of the genus *Pleurobrachia*; their regular branches (tentilles) are covered with sticky colloblasts that on contact adhere to prey (e.g., to planktonic copepods and other smaller organisms). **Lobata** (e.g. *Bolinopsis infundibulum*) are tentaculiferan comb jellies with two additional oral lobes flanking the mouth and the reduced tentacles. The lobes form a large cavity into which water and potential prey organisms are drawn by large cilia during the mouth-forward locomotion. The **Atentaculata** lack tentacles completely, the example is the cylindrical species of the genus *Beroe*. They feed on other ctenophores by swallowing them through their large slit-like mouth.

The ctenophore species are usually closely paired in predator-prey relationships that control their abundance. In the Northern and Baltic seas, once per year (between March and July) these comb jellies reproduce massively, increasing in abundance by as much as four orders of magnitude within one to three months (Larink & Westheide, 2006). *Pleurobrachia pileus* feeds on herbivorous zooplankton, especially on the copepods that appear in spring: one individual *P. pileus* may eat as many as 300 copepods per day; then usually *Beroe gracilis* appears which feeds exclusively on *P. pileus* and practically eliminates it within three weeks. *Beroe cucumis* feeds mainly on *B. infundibulum*.
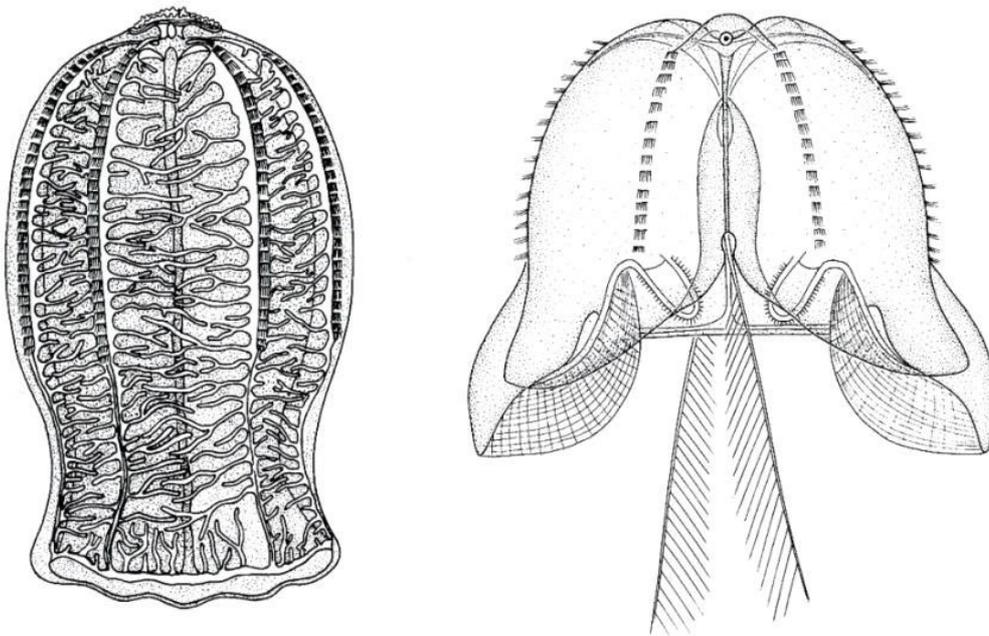
Figure 6.4: Ctenophores; general schematic view of *Beroe* sp. (left) and *Bolinopsis* sp. (right, modified from Westheide & Rieger, 1996).

The ctenophore species *Mnemiopsis leidyi* is one of the most recent invaders to the Baltic Sea. In summer 2006, the first observations of this West Atlantic comb jelly in Northern Europe were reported from the North Sea, the Skagerrak and the south-western Baltic Sea (Faasse & Bayha, 2006; Hansson, 2006; Javidpour et al., 2006). During autumn/winter 2006 and spring 2007, the further spread of this invasive ctenophore from the south-western towards the central Baltic Sea up to the south eastern Gotland Basin was reported (Kube et al., 2007a). The abundances were generally low (max. 4 ind. m^{-3}). While *M. leidyi* was found in the entire water column in Kiel Bight, it occurred exceptionally below the halocline in the deep stratified central Baltic basins. Data of a weekly sampling program at a nearshore location in Mecklenburg Bight between January and May 2007 showed that up to 80% of the individuals were juveniles, smaller than 1 mm total body length, and that *M. leidyi* survived the winter in the Southern Baltic Sea, even when abundances dropped down to <1 ind. m^{-3} in February. During the summer of 2007, a regional gradient in population density of *M. leidyi* remained. The abundances west off Darss Sill exceeded those in the Baltic proper by one to two orders of magnitude. The maximum abundances of 500 ind. m^{-3} in Kiel Bight corresponded to those in the area of origin of *M. leidyi* – off the North American coast, and to those in the Black Sea during the 1980s. Generally, the adults were smaller in the Baltic Sea (6 cm) than in the Black Sea (18 cm) (Kube

et al., 2007b). In 2007, *M. leidyi* spread up to the entrance of the Gulf of Finland and the central Bothnian Sea, where it was recorded by the Finish Institute of Marine Research in August/September 2007 at abundances lower than 10 ind. m⁻³. The highest densities including juveniles were found in the water layers around the halocline.

A first assessment of the physiological demands of this species versus the environmental conditions of the Baltic Sea showed that the successful establishment of this ctenophore is probable in the south-western and central Baltic Sea (Kube et al., 2007a). At present, it is likely that *M. leidyi* has been successfully established in the Baltic Sea as the fifth ctenophore species.

6.3 Rotifera

The phylum Rotifera, or rotifers in English usage, is a group of microscopic aquatic or semi-aquatic invertebrates, which comprises around 2000 species of unsegmented, bilaterally symmetrical pseudocoelomates. The majority of rotifers inhabit fresh waters; however, some genera also occur in brackish and marine habitats. For example, about 20 of 32 species comprising the genus *Synchaeta* are described as marine (Nogrady, 1982). Only one order (Seisonidea, containing a single genus) and about 50 species of rotifers are exclusively marine; only two species are encountered in the plankton of the open Atlantic Ocean (Nogrady et al., 1993). Rotifers are not as diverse or abundant in marine environments as microcrustaceans but they are common in many brackish, coastal, near shore and interstitial marine communities (Egloff, 1988), where they occasionally comprise the dominant portion of the zooplankton biomass (Schnese, 1973; Johansson, 1983). In the brackish waters of the open Baltic Sea, rotifers form a highly diverse and widely distributed group due to significant influence of the waters from the extended coastal areas with the rich fauna of freshwater and euryhaline rotifers (Telesh & Heerkloss, 2002; Telesh, 2004).

Morphologically, rotifers possess two main distinctive features: corona and mastax. The ciliated region at the apical end (head) of a rotifer is called the **corona** ("wheel organ"); it is used for locomotion and food gathering (Fig. 6.5). In adults of rotifers from some families, ciliation is reduced and the corona is replaced by a funnel or bowl-shaped structure (the infundibulum), at the bottom of which the mouth is located. Along the edge of the infundibulum of most species, there is a series of long setae (bristles).

The other universal characteristic of rotifers is a muscular pharynx, the **mastax**, possessing a complex set of hard jaws called **trophi** (Fig. 6.6). Most rotifers are free living, they swim in the pelagial or crawl on substrata (bottom sediments, stems of macrophytes); however, many species live permanently attached to plants (the latter are called sessile rotifers). Very few rotifers are parasitic; the vast majority of rotifers are solitary but some (ca. 25 species) form colonies of various sizes (Wallace, 1987).

Nearly all free-living rotifers are suspension-feeders that utilise microalgae smaller than 12 µm in diameter (sometimes as large as 18 µm), bacteria and detritus (Pourriot, 1977); some are obligate or occasional predators. Most rotifers are either obligatory parthenogenetic (e.g. the whole class of bdelloids) or produce males for a brief period, sometimes only a few days, each year or season (Nogrady et al., 1993). Male rotifers are usually strongly reduced in size and sometimes only slightly resembling the females of the same species (Fig. 6.5).
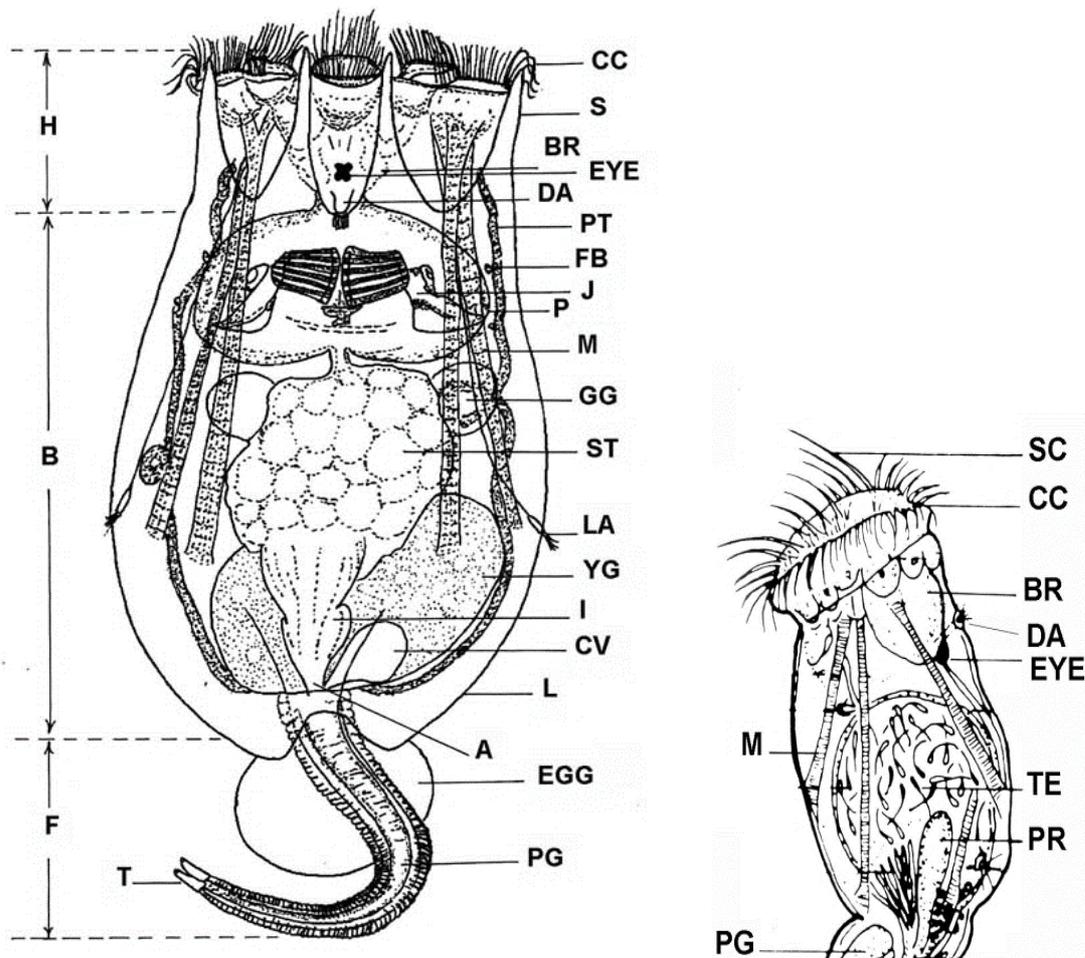
Figure 6.5: Morphology of a rotifer *Brachionus calyciflorus*: female on the left (dorsal view, modified from Pontin, 1978), male on the right (lateral view, modified from Koste, 1978). H – head, B – body, F – extended foot, A – anus position, BR – brain, CC – coronal cilia, CV – contractile vesicle, DA – dorsal antenna, EYE – eye, EGG – egg, FB – flame bulb, GG – gastric gland, I – intestine, J – jaws, L – lorica, LA – lateral antenna, M – muscle, P – pharynx, PE – penis, PG – pedal gland, PR – prostate, PT – protonephridium, S – spine, SC – sensory cirry, ST – stomach, T – toes, TE – testis, YG – yolk gland (after Telesh & Heerkloss, 2002).
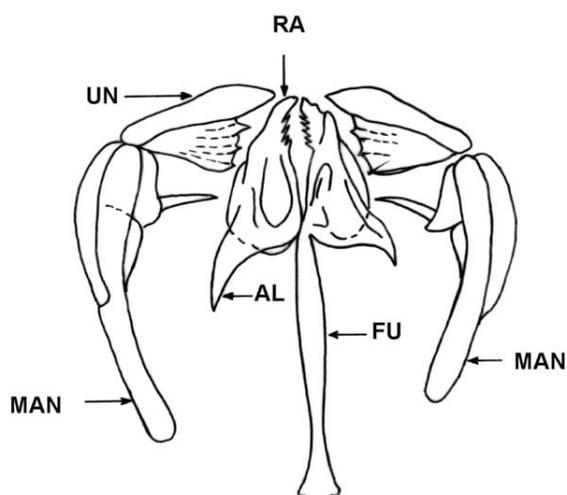
Figure 6.6: General structure of trophi, dorsal view: RA – ramus, UN – uncus, MAN – manubrium, FU – fulcrum, AL – alula (after Telesh & Heerkloss, 2002).

Polymorphism is a common phenomenon to many rotifer species. Individuals of the same species collected from one locality over a period of time often show changes in one or more characteristics from one generation to another (e.g., length of spines, or proportions of the body). In some localities these variations are season-specific: a phenomenon known as cyclo-morphosis, which is most common in some loricate rotifers (e.g., *Keratella* and *Brachionus*), but also can be observed in the illoricates (e.g., *Asplanchna*).

Although rotifers can be considered as a relatively small phylum, they are extremely important in the environments

that they inhabit because their reproductive rates are the fastest for any metazoan (Nogrady et al., 1993). They can populate vacant niches with exceptional rapidity, convert primary (algal) and bacterial production into a form usable for secondary consumers (e.g. insect larvae and fish fry), and perform this transformation with remarkable efficiency producing up to 95% of total zooplankton biomass (e.g., in rivers and estuaries) (Telesh, 1995; Telesh & Heerkloss, 2002).

6.4 Cladocera

The commonly accepted today name of the order Cladocera according to Fryer (1987) belongs to a group of crustaceans of polyphyletic origin (see Telesh & Heerkloss, 2004, and references therein). The order Cladocera includes crustaceans that nearly all, with the exception of just several species, range in size from 0.2 to 3.0 mm. Cladocera are primarily freshwater organisms, and aside from rapid streams and strongly polluted waters, they can be abundant in every water body. In the estuaries, the greatest abundance of species may be collected in the vegetation, and at margins of the macrophytes stands and open water. Many species inhabit weedy littoral areas, some live on/near bottom. Limnetic forms (*Daphnia*, *Diaphanosoma*, *Holopedium*, *Leptodora* and others) are usually light-coloured and translucent; littoral and bottom-dwelling species are ranging in colour of carapace and body tissues from yellowish-brown to reddish-brown, greyish, or nearly black.

The general schemes of body morphology of different cladocerans are presented in Figures 6.7–6.9.

In the Baltic Sea, the Onychopod cladocerans from the genera *Podon*, *Pleopsis* and *Evadne* can be very abundant, especially in spring (see also Chapter 2). *Evadne* individuals consume dinoflagellates and tintinnids, various other particles as well as small zooplankters. *Bosmina* spp. are among other common zooplankters in the open Baltic waters. The majority of species and almost all common ones are eurythermal. Many species can withstand oxygen concentrations of less than one part per million.

Patchiness in spatial distribution and diurnal vertical migrations are common features of cladoceran crustaceans. However, characteristics of aquatic environment expose greater changes along the vertical than along the horizontal dimensions in the water body. Thus, the two contrasting needs of many zooplankters: to feed within the most illuminated zone and not to be seen by visual predators – result in regular movements of the whole populations into and out of the upper illuminated layers (Brandl, 2002).

Different species of *Bosmina* (*Eubosmina*) are the common cladocerans in the Baltic Sea; meanwhile, **taxonomy of the genus *Bosmina* even now remains a field in need of revision** (see review in Telesh & Heerkloss, 2004, p. 36).

Among cladocerans, there are three non-indigenous species that have recently invaded different regions of the open Baltic Sea: *Cercopagis pengoi, Evadne anonyx* and *Cornigerius maeoticus* (for details see: Chapter 2; Ojaveer & Lumberg, 1995; Rodionova et al., 2005; Rodionova & Panov, 2006, and references therein).
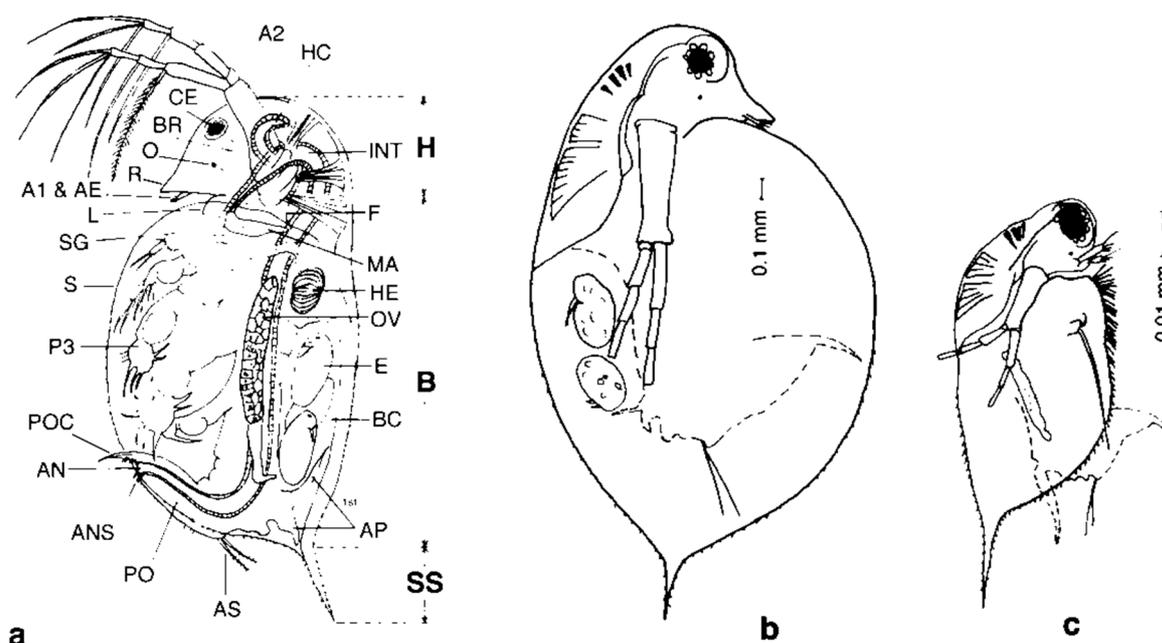
Figure 6.7:   *Daphnia*, schematic, lateral. **a,** Female: A1 – first antenna (antennule), A2 – second antenna, AE – aesthetascs, AN – anus, ANS – anal spines, AP – abdominal processes, AS – abdominal setae, B – body, BR – brain, BC – brood chamber, CE – compound eye, E – embryo, F – fornix, H – head, HC – hepatic caecum, HE – heart, INT – intestine, L – labrum, MA – mandible, O – ocellus, OV – ovary, PO – postabdomen, POC – postabdominal claw, P1 – P5 – trunk limbs 1–5, R – rostrum, S – shell, SG – shell gland, SS – shell spine; **b,** *D. pulex*, female; **c,** *D. pulex*, male (after Telesh & Heerkloss, 2004).

The great importance of planktonic Cladocera in the aquatic trophic webs as food for fish was emphasised first in late XIX century, and since then by innumerable investigators (see Telesh & Heerkloss, 2004, and references therein). The dynamics of fish and zooplankton have been linked intimately ever since fish evolved from macrophagy to microphagy (Kerfoot & Lynch, 1987). Various studies of the stomach contents of young fish show from 1% to 95% of Cladocera by volume, and very few studies show less than 10% (Pennak, 1978). However, some cladoceran species (e.g., a large-bodied predatory cladoceran of the Ponto-Caspian origin, *Cercopagis pengoi*, one of the recent invaders in the Baltic Sea), being a suitable food item for planktivorous fish, may also demonstrate structural and functional impact on zooplankton community thus performing competitive interactions for food (smaller crustaceans) with fish populations as shown recently for the Baltic proper (Gorokhova, 1998), the Gulf of Riga (Ojaveer & Lumberg, 1995), and the Gulf of Finland (Antsulevich & Välipakka, 2000; Telesh et al., 2000; Telesh & Ojaveer, 2002; Naumenko & Telesh, 2019; Telesh & Naumenko, 2021).

In general, the role of zooplankton for the earlier juvenile fish is critical to high fish survival so that they can take advantage of an abundance of phytoplankton and detritus when available (Fernando, 2002).
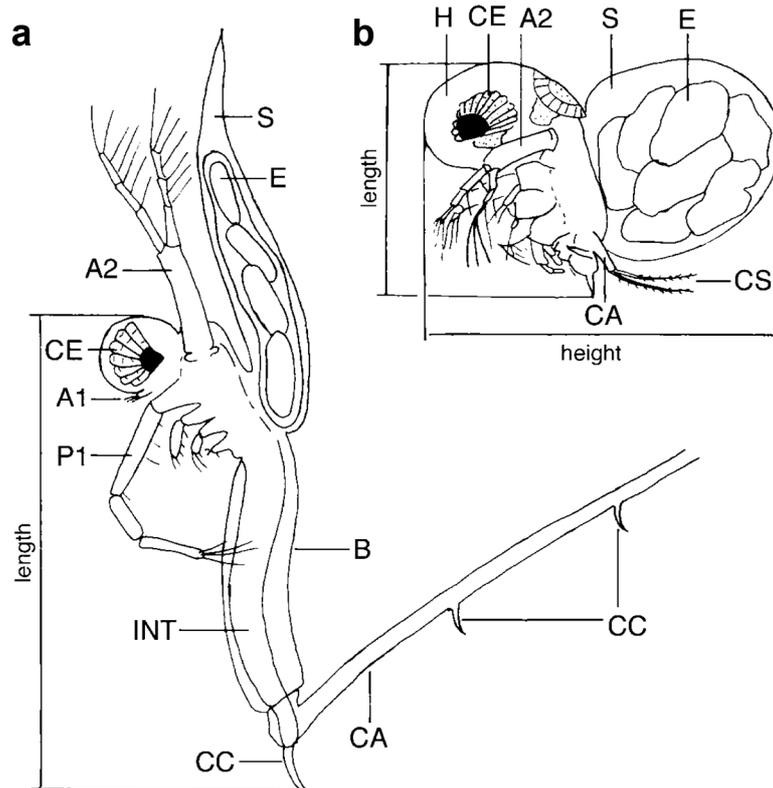
Figure 6.8: Morphology of Onychopoda: **a** – *Cercopagis*, **b** – *Polyphemus*: A1 – first antenna (antennule), A2 – second antenna, B – body, CA – caudal appendage, CC – caudal claw, CE – compound eye, E – parthenogenetic embryos, CS – caudal setae (setae notatoria), H – head, INT – intestine, P1 – trunk limb (thoracic leg) 1, S – shell (brood chamber) (after Telesh & Heerkloss, 2004).
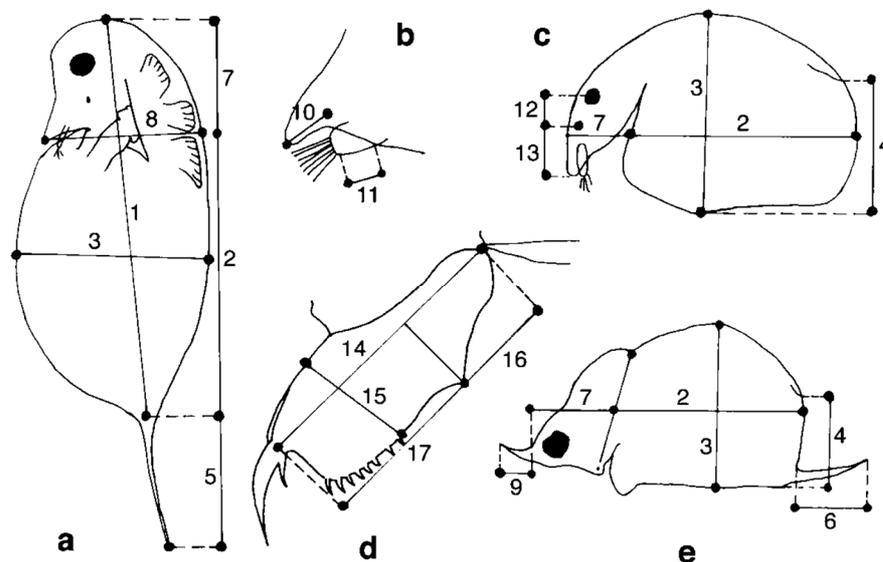
Figure 6.9: How to measure Cladocera: **a, b** – *Daphnia*; **c, d** – *Alona*; **e** – *Scapholeberis*. **1** body length, **2** length of carapace, **3** maximum height of valve, **4** height of posterior margin of valves, **5** length of shell spine, **6** length of mucro, **7** length of head, **8** height of the posterior margin of head shield, **9** length of the horn on the proximal edge (vertex) of head shield, **10** length of rostrum, **11** length of antenna 1, **12** distance between eye and ocellus, **13** distance between ocellus and the end of rostrum, **14** length of postabdomen, **15** maximum width of postabdomen, **16** length of proximal part of postabdomen, **17** length of distal part of postabdomen (from Telesh & Heerkloss, 2004, adapted from Flössner, 2000).

6.5 Copepoda

Copepoda is a very diverse and the most abundant group of metazoans in the pelagial of the World Ocean (Larink & Westheide, 2006). Free-living planktonic copepods range in body length from 0.5 to 5 mm. Copepod crustaceans from three suborders inhabit the open waters of the Baltic Sea: Calanoida, Cyclopoida and Harpacticoida (Fig. 6.10). These crustaceans form a ubiquitous component of the zooplankton community.

Copepods differ in size, external morphology, ecology and feeding habits. Most Calanoida are free-living, planktonic, herbivorous, fine particles filter feeders. Cyclopoida are also planktonic crustaceans, but very often they inhabit near-bottom biotopes; they are generally micro-predators that feed on small invertebrates and even fish larvae but also consume algae. Harpacticoida are mainly meiobenthic or epibenthic grazers, they occur in plankton only sporadically, being washed out from their bottom habitats by strong water movements. In general, Harpacticoida are only temporarily in plankton, although these crustaceans are often found in zooplankton samples collected in the shallow estuarine waters.
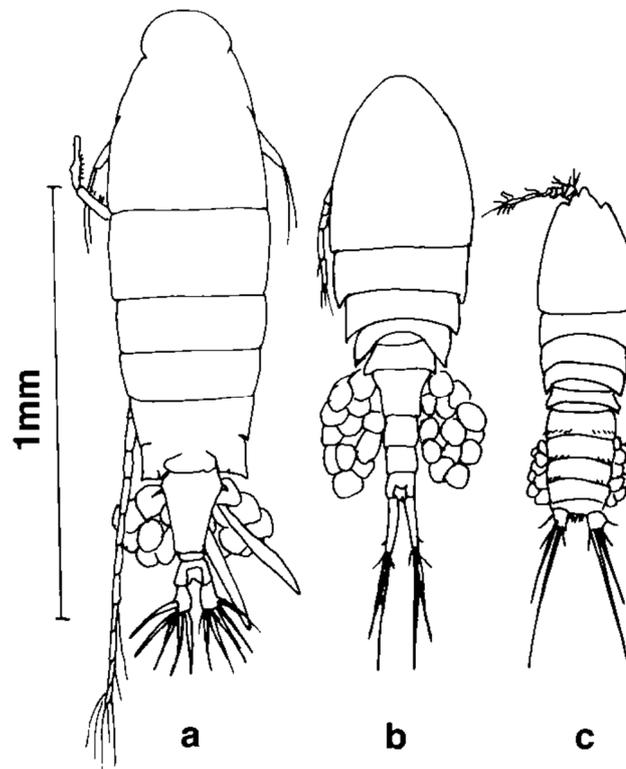
Figure 6.10: Scheme of calanoid (**a**), cyclopoid (**b**) and harpacticoid (**c**) copepods (after Telesh & Heerkloss, 2004).

Copepods are food to many predators, mainly planktivorous fish. The choice of a copepod as a prey is a function of its size, morphology, motion (angle, speed, escape ability) and pigmentation. The coloured species are more vulnerable to predation than pale or transparent ones. Presence of fish can influence physiological parameters and population dynamics of copepods. To limit predation, some copepods can retreat to habitats devoid of the predator, perform vertical migrations, form swarms, or enter into dormancy (Dussart & Defaye, 2001).

Copepods have different tolerance to salinity; the presence or absence of some species allows deductions on the physical-chemical characteristics or the degree of pollution of the environment (Dussart & Defaye, 2001).
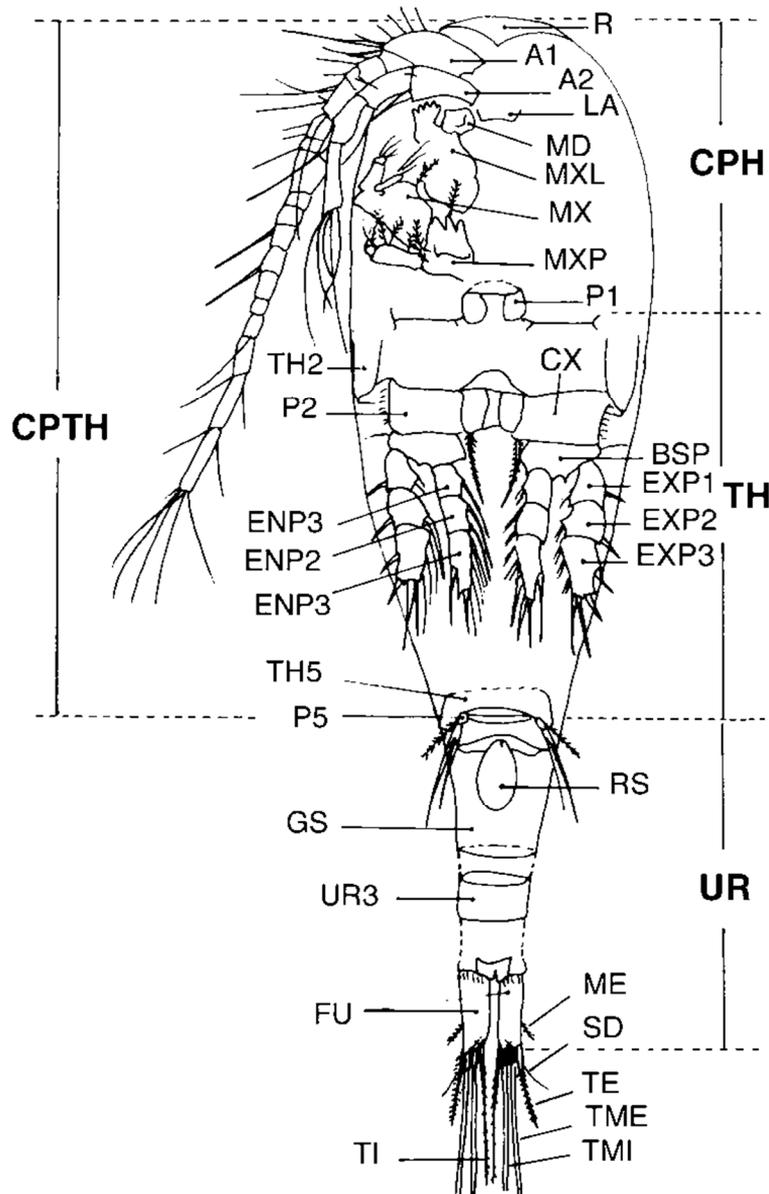
Figure 6.11: Morphology of a female cyclopoid (ventrally): CPH – cephalosome, TH – thoracosome, CPTH – cephalothorax, UR – urosome, R – rostrum, A1 – antennule (antenna 1), A2 – antenna 2, LA – labrum, MD – mandible, MXL – maxillule, MX – maxilla, MXP – maxilliped, P1, P2, P5 – swimming legs 1, 2, 5, TH2, TH5 – thoracic somites 2 and 5, CX – coxa, BSP – basipodite, EXP1, EXP2, EXP3 – exopodites 1-3, ENP1, ENP2, ENP3 – endopodites 1-3, GS – genital double somite, RS – seminal receptacle (= *receptaculum seminis*), UR3 – urosomite 3, FU – furca, ME – marginal (external) furcal seta, SD – dorsal furcal seta, TE – terminal external furcal seta, TME – terminal medial external seta, TMI – terminal medial internal seta, TI – terminal internal furcal seta (from Telesh & Heerkloss, 2004, after Dussart & Defaye, 1995, with modifications).

However, the important role of copepods as biological indicators cannot be assessed unless the copepod species identification is properly fulfilled. Taxonomic differentiation of copepods is based mainly on external morphology of mature females and males. Species identification of copepods is an important though tedious

procedure. Shape, colour and size of the body, relative size of the appendages (particularly the length of antennules relative to the cephalosome or the urosome) and other measurements are noted. After general observations, drawings of the whole animal should be made.

For cleaning the crustacean and making its body more transparent, the animal must be kept in a drop of concentrated lactic acid ($CH_3CHOHCOOH$) for a time from 1 h up to overnight, depending on the size of the crustacean. Sometimes it is possible to recognize the copepod species without dissection (Alekseev, 2002; Telesh & Heerkloss, 2004). However, in most cases, species identification of copepods requires not only examination of the whole crustacean under the microscope but also a dissection and mounting of relevant structures. For more details of this procedure see Downing and Rigler (1984), Huys and Baxshall (1991), ICES (2000), Dussart and Defaye (2001), Alekseev (2002).

Copepods can be of different shape: elongated, fusiform, or cylindrical. General schemes of body morphology of cyclopoid and calanoid copepods are presented in Figures 6.11 and 6.12; schematic drawings of their nauplia and copepodites are given in Figures 6.13–6.15.
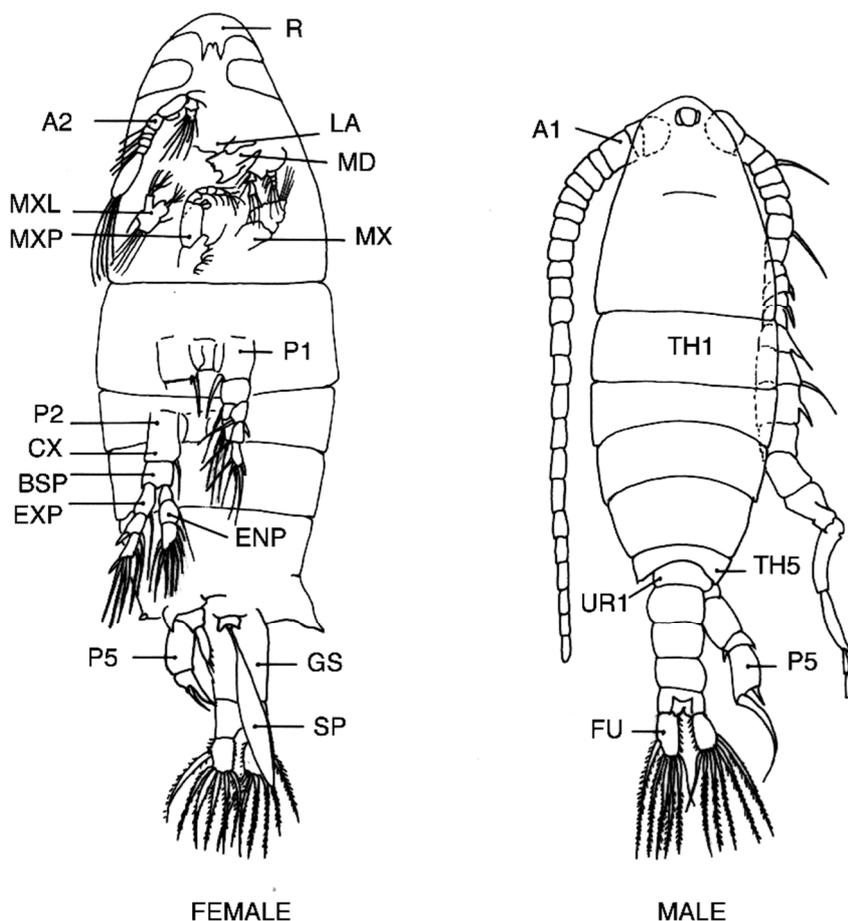
FEMALE   MALE

Figure 6.12: Morphology of a female (ventrally) and male (dorsally) calanoid: R – rostrum, A1 – antennule (antenna 1), A2 – antenna 2, LA – labrum, MD – mandible, MXL – maxillule, MX – maxilla, MXP – maxilliped, P1, P2, P5 – swimming legs 1, 2, 5, TH1, TH5 – thoracic somites 1 and 5, CX – coxa, BSP – basipodite, EXP – exopodite 1, ENP – endopodite, GS – genital double somite, RS – seminal receptacle (= *receptaculum seminis*), UR1 – urosomite 1, FU – furca, SP – spermatophore (from Telesh & Heerkloss, 2004, after Dussart & Defaye, 1995, with modifications).

Most copepods reproduce sexually; however, some cases of parthenogenesis have been reported and checked experimentally (Dussart & Defaye, 2001). The sex ratio (males/females) in a copepod population is usually below 1, often due to a different behaviour of the sexes.

Sexual reproduction implies that the male deposits a spermatophore near the genital aperture of the female. Fertilized eggs develop within a single egg sac attached to the ventral side of the genital somite centrally in Calanoida, or in two symmetrically located egg sacs in Cyclopoida. The duration of the embryonic development depends on many factors, among which temperature is one of the most important. When embryonic development is completed, in most copepods, the female loses the egg sac(s), and the eggs hatch together.

Among Crustacea, copepods have been cited as exhibiting the most complete example of metamorphosis (Dussart & Defaye, 2001). They consequently pass through 6 nauplial (Fig. 6.13) and 5 copepodite stages (Figs 6.14, 6.15) before maturation. The eggs hatch into a larva called nauplius – the typical planktivorous larva of crustacean arthropods. In calanoids, naupliar larvae are ovoid, slender and somewhat compressed laterally (Fig. 6.13a). In cyclopoids, nauplii are dorsoventrally compressed and have a compact, pear-shaped body (Fig. 6.13b).

a b
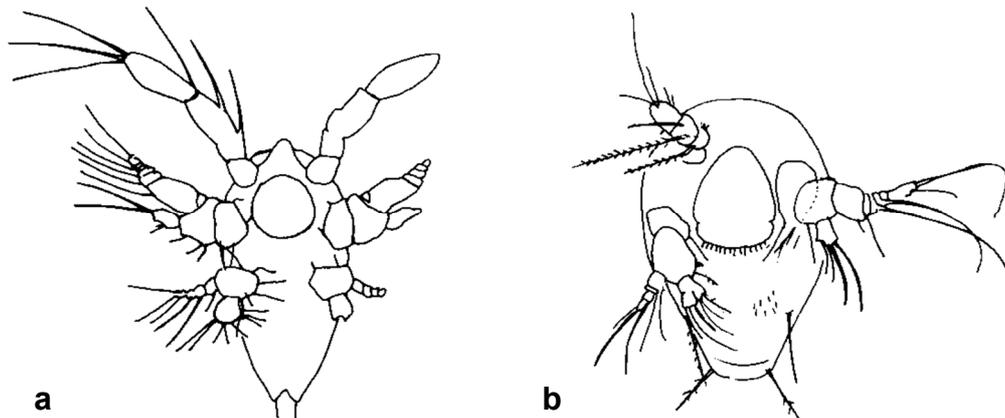
Figure 6.13: Nauplii N2 of calanoid (**a**) and cyclopoid (**b**) copepods, ventral view (modified from Einsle, 1993).

C1 C2 C3 C4 C5 F C5 M
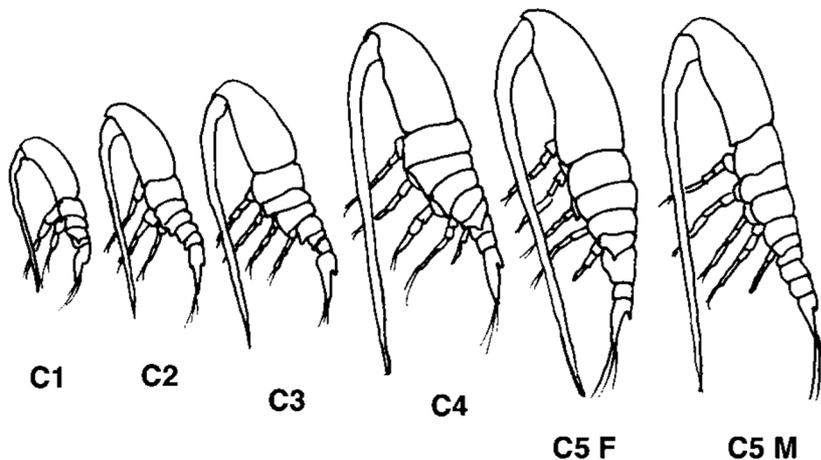
Figure 6.14: Development of copepodite stages (C1–C5, C5F – female, C5M – male) of a calanoid copepod, lateral view (modified from Einsle, 1993).
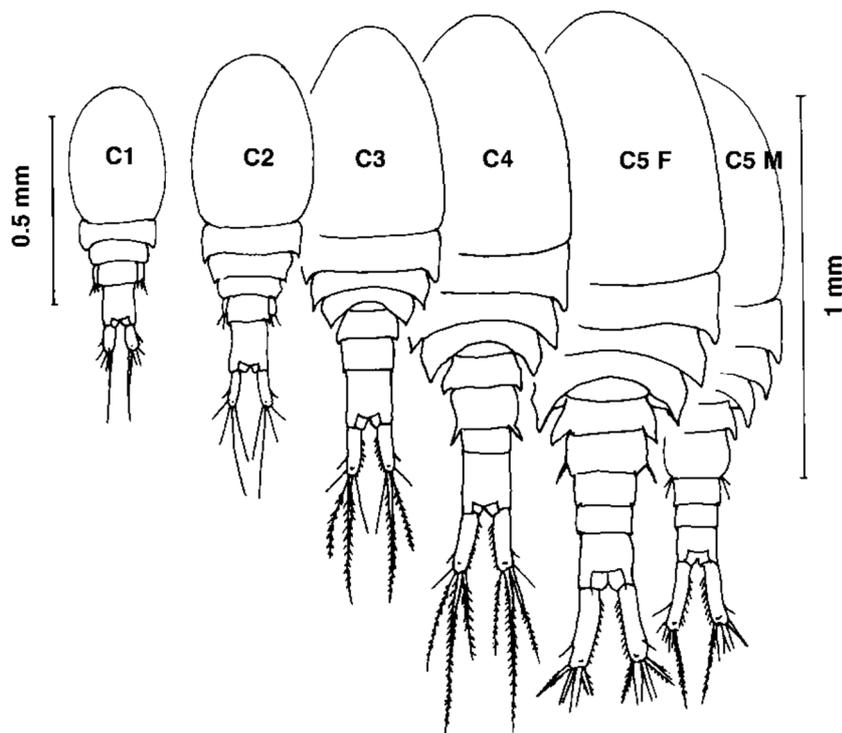
Figure 6.15: Development of copepodite stages of a cyclopoid copepod, dorsal view (modified from Einsle, 1993). Abbreviations as in Fig. 6.14.

6.6 Chaetognatha

The majority of Chaetognatha (arrow worms) are holoplanktonic marine invertebrates that can reach relatively high densities in the sea pelagial waters.

Arrow worms of the genera *Sagitta* and *Parasagitta* perfectly represent the type of optimally adapted voracious predators in the plankton community: they are relatively large (15–45 mm), fast, visual, transparent and streamlined animals that see and attack their prey by short forward darting motions when attacking various pelagic organisms, mostly copepods but also small fish, as large as themselves. A *Sagitta* may consume the equivalent of 64% of its body mass in food per day; otherwise, they are an important prey for fish (Larink & Westheide, 2006).

Chaetognaths are protandrous hermaphrodites: paired testes are located in the tail of the elongate body, paired ovaries – in the posterior part of the trunk (Fig. 6.16). Arrow worms have no larvae: development is direct and very rapid for the feeding juveniles.

The most common species in the Baltic Sea are *Parasagitta elegans* and *Parasagitta setosa*. These two species are difficult to distinguish, especially when the specimens are juveniles; but when adult, *P. elegans* becomes larger (up to 20 mm) than *P. setosa* (up to 14 mm). Besides, *P. setosa* is known to prefer more saline waters, and thus its distribution varies with the extent to which Atlantic oceanic water penetrates into the coastal water bodies (Larink & Westheide, 2006).

Chaetognaths are very mobile and are able to swim against substantial water current. They migrate horizontally some hundred meters per day and undergo daily vertical migration. Many of them escape when sampling is performed with inappropriately small plankton net.

6.7 Appendicularia

Appendicularia are the exclusively holo-planktonic tunicates (Chordata, Tunicata). They are also called Larvacea because of their apparent retention of ascidian larval organisation. Appendicularians are tiny solitary animals with peculiar anatomy and unique filter feeding system.

The two types of larvacean that are commonly found in plankton samples can be readily separated by reference to the shape and size of their body and tail. Members of the Oikopleuridae have a relatively compact body and linear tail (Fig. 6.17a), while Fritillaridae have a more delicate body and thin, broad tail (Fig. 6.17b).

Oikopleura dioika is one of the most common appendicularians, rather abundant in the Baltic Sea. It looks like one of the tadpole ascidian larvae, but the prominent tail with notochord and nerve cord is persistent. It is positioned below the trunk, perpendicular to the long axis of the animal and is five times longer than the trunk, reaching 3 mm.

In the plankton samples, commonly only these "naked" animals will be observed. Meanwhile, actually in the sea they live inside of a mucous construction, the so-called house (Fig. 6.18). This construction is almost spherical in shape; it consists of a number of intercommunicating chambers, funnels, filters, intake openings and outlets, and functions as a complicated filtration system. Even very small particles (below 0.5 µm) can be trapped from the water by this system, accumulated and transported to the mouth of the appendicularian. Interestingly enough, it was here in the appendicularian house that the presence of nanoplankton organisms in the sea was first demonstrated by the filtering activity of these animals (Larink & Westheide, 2006).

Water is moved through the appendicularian house by the pressure generated by the beats of the tail. When the tail beats slowly, the animal hardly moves through the water, and filtering is optimal. If particles are few, the tail beats more rapidly; then water is ejected in a greater quantity and thus a jet effect propels the house forward.

The fragile construction of the house is secreted by gland cells (oikoblasts) in the epidermis. When filters are clogged with particulate matter, the animal deserts the house. This also happens when it is captured by plankton net or disturbed otherwise. Before leaving the house, the appendicularian
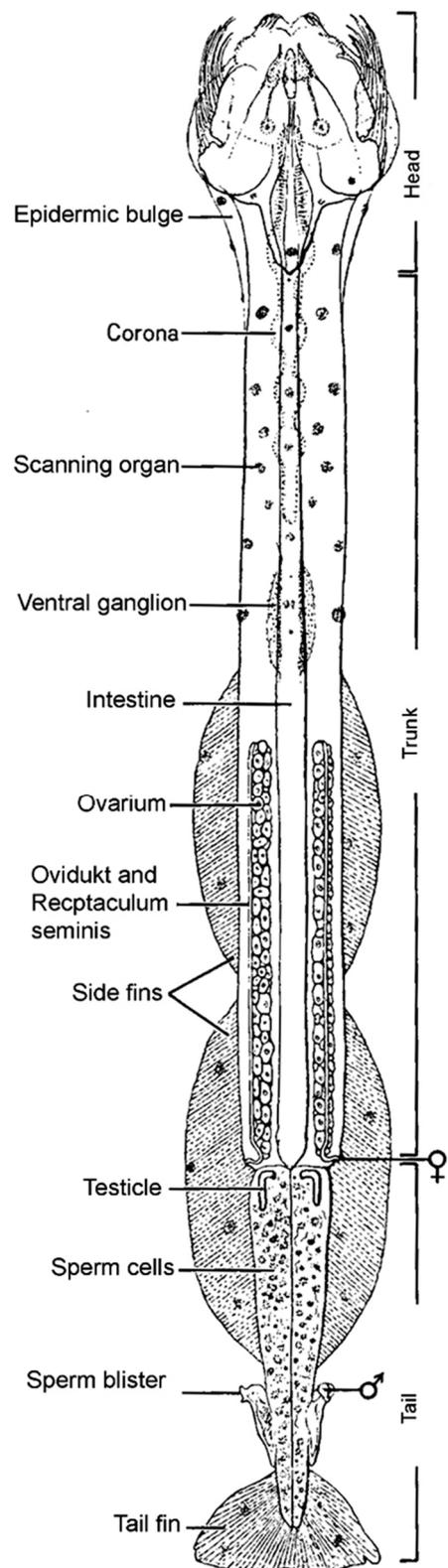
Figure 6.16: *Sagitta bipunctata*, scheme of body morphology (modified from Storch & Welsch, 1999).

Labels: Epidermic bulge, Corona, Scanning organ, Ventral ganglion, Intestine, Ovarium, Ovidukt and Recptaculum seminis, Side fins, Testicle, Sperm cells, Sperm blister, Tail fin, Head, Trunk, Tail

builds (secretes) a new proto-house which can be inflated within few seconds; 4 to 16 new houses can be secreted by one appendicularian every day.
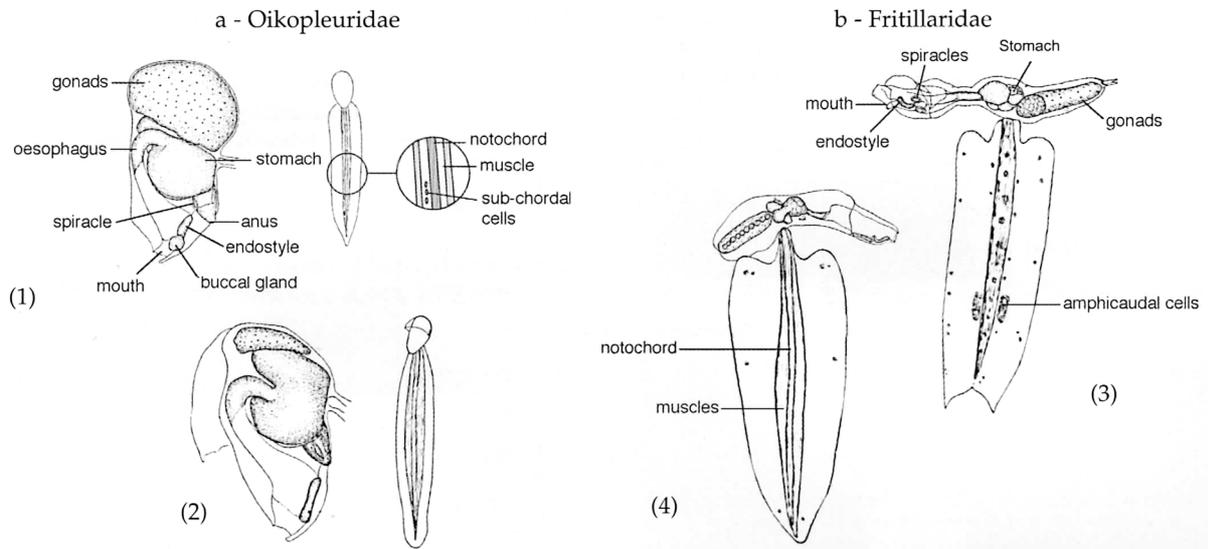
Figure 6.17: Appendicularia, schematic lateral view: a – Oikopleuridae, b – Fritillaridae; 1 – *Oikopleura dioika*, detail of body, whole animal and diagrammatic magnification of tail; 2 – *O. longicauda*, detail of body, whole animal; 3 – *Fritillaria megachile*; 4 – *F. haplostoma* (from Fenaux, 1967, cited after Gibbons, 1997, with modification).
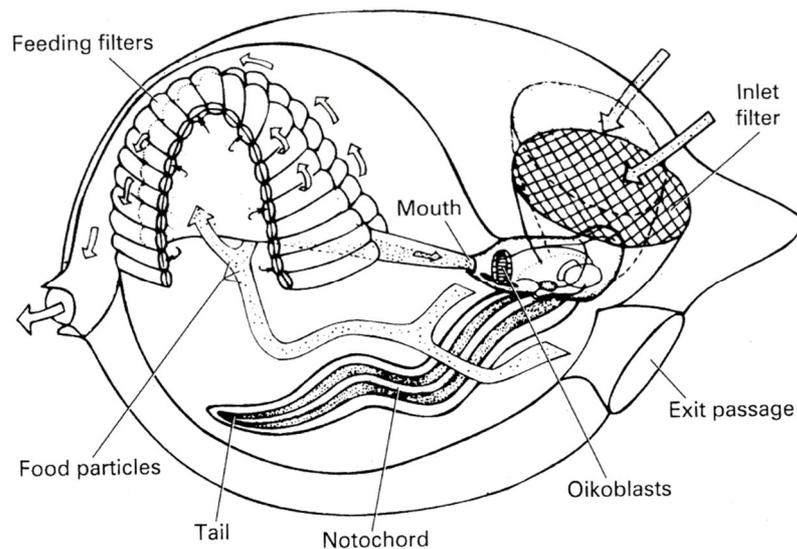
Figure 6.18: *Oikopleura dioika* in its "house" (modified from Larink & Westheide, 2006).

6.8 Polychaeta

Polychaetes are the basal group of the segmented worms (Annelida). The group comprises ca. 9,000 species distributed almost exclusively in the marine environment. They occur in the pelagial: (a) as larval stages lasting a few hours to several weeks, (b) as modified swimming stages of mature males or females (epitokes, hetero-nereids), or (c) as transparent pelagic holoplanktonic species, the latter belonging to seven families.

Among the enormous diversity of reproductive modes in polychaetes, **epitoky** is the most striking. Epitokous planktonic stages are mature individuals of mainly the benthic species, which have undergone morphological, physiological and behavioural modifications that enable them to leave the bottom and to swim and broadcast their gametes in the water column.

These metamorphosed sexually mature worms are produced by two processes.

(A)   The whole animal is transformed into a swimming epitoke, and once the gametes are released after a short pelagic existence this animal dies, or sometimes reverts to the atokous state (epigamy).

(B)   The (mostly) posterior part of the mature worm is modified, usually equipped with a new head, and then becomes detached as a free-swimming gamete-baring stolon. Whereas this stolon dies after the release of gametes, the unchanged anterior benthic stock of the worm continues to live for further reproductive activity by multiple stolonisation (=schizogamy).

The **trochophora** (Fig. 6.19, left) is a typical larva of polychaetes. Often it follows a spherical **prototrochophore** that is entirely covered with short cilia. The trochophore is characterised by a ciliary band, the **prototroch**, which encircles the body anterior to the mouth and is used for locomotion and feeding. Another parallel circumferential band of cilia is **metatroch**, which posteriorly borders the mouth region. A ciliated region between the two bands is called the food groove.

Early larvae with only a few segments often are called **metatrochophores**, or polytrochous larvae if they possess additional ciliary bands. In metatrochophore I, parapodia are not yet developed. Larvae with additional outer segmental structures are called metatrochophore II. Segmented larvae with functioning parapodia and prominent bundles of chaetae are called **nectochaetae** (Fig. 6.19, right, 6.20).
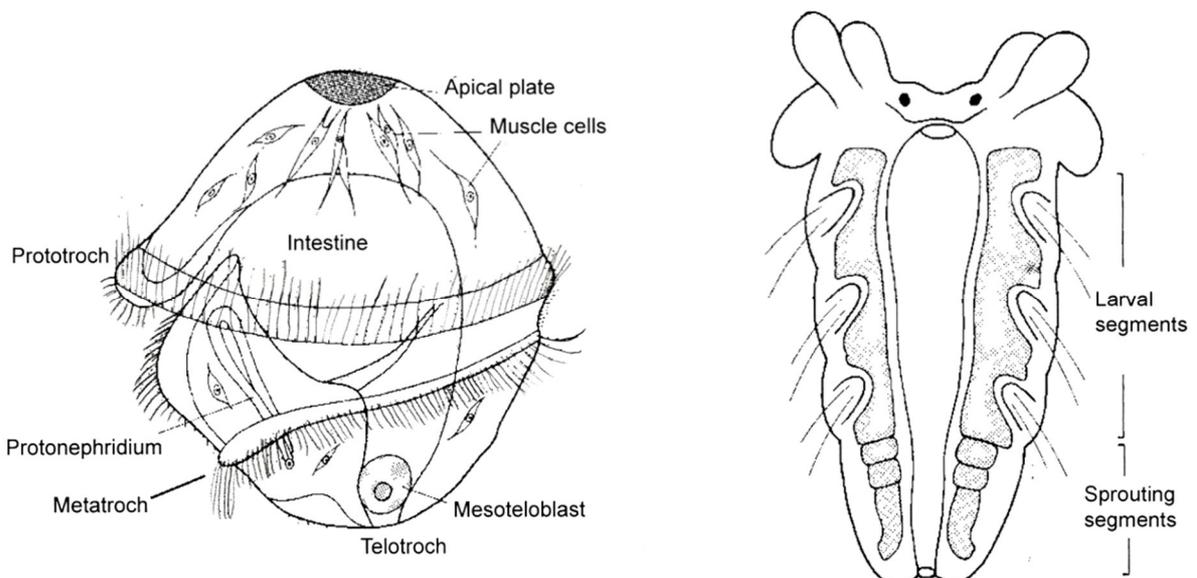
Figure 6.19: Larvae of Polychaeta: trochophora (left) and nectochaeta (right) (from Westheide & Rieger, 1996, with modification).
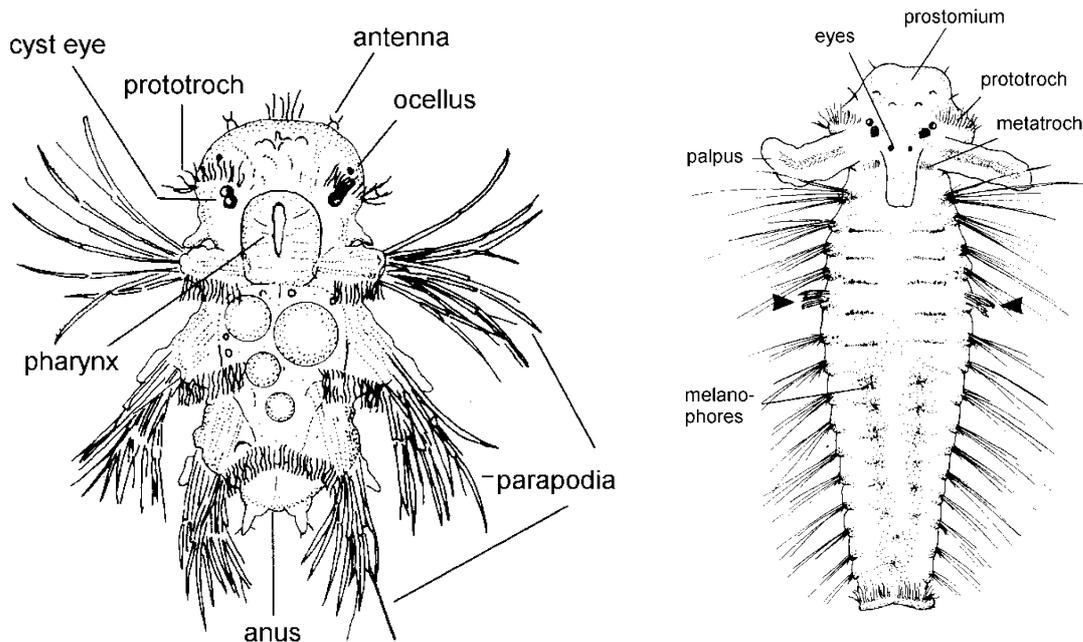
Figure 6.20: Larvae of Polychaeta: nectochaeta at different stages of development (from Storch & Welsch, 1999, with modification).

Trochophores and metatrochophores of polychaetes are easily confused with each other and are difficult to assign to a specific genus, or even to a family taxon.

Larvae of Spionidae (palp worms, the largest group of benthic, sessile of hemi-sessile polychaetes) are generally the most common developmental stages of polychaetes that can be found in plankton throughout the year. High abundance of polychaetes larvae in the pelagial of the sea is not only due to the large number of species in the coastal areas but also to the often long-lasting periods of their development.

Zooplankton composition, abundance, and distribution patterns depend on type and geographical location of the water body, season, time (considering daily vertical migrations), trophic status and a large number of other internal characteristics of the water body as well as numerous environmental (external) factors influencing the aquatic biota. Therefore, adequate sampling design should be developed prior to collecting zooplankton samples, relevant sampling methods should be selected, and appropriate sampling intervals chosen (for details see Telesh et al., 2009).