

**Epibionts (*Paracineta*)
and parasites
(*Ellobiopsis*) on copepods
from Spitsbergen
(Kongsfjorden area)**

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WOJCIECH WALKUSZ^{1,*}
LESZEK ROLBIECKI²

¹ Institute of Oceanology,
Polish Academy of Sciences,
Powstańców Warszawy 55, PL-81-712 Sopot, Poland;
e-mail: walwo@iopan.gda.pl

*corresponding author

² Department of Invertebrate Zoology,
University of Gdańsk,
al. Marszałka Piłsudskiego 46, PL-81-378 Gdynia, Poland;
e-mail: lrolbiecki@ocean.univ.gda.pl

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Abstract

Parasites of the genus *Ellobiopsis* and epibiotic ciliates of the genus *Paracineta* were found on the body surface of some copepod taxa collected in the Kongsfjorden area (west Spitsbergen, Svalbard) during summer 2002.

Paracineta sp. individuals were noted in *Metridia longa* and *Paraeuchaeta norvegica* (0.5% of the population infected in each species). This study provides the first record of the presence of *Paracineta* sp. in the latter species. Remarkably, epibionts were attached exclusively to females.

Calanus finmarchicus and *C. glacialis* were invaded by *Ellobiopsis* spp., but the level of infection was generally low (0.06% and 0.09% of the population infected, respectively). Parasite distribution within both host populations was similar – 80% of infected specimens were at copepodid stage V. This study also provides the first record of *C. glacialis* serving as a host to *Ellobiopsis*.

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1. Introduction

Copepods are the link between primary producers (phytoplankton) and higher trophic levels (fish, birds); they thus play an important role in aquatic ecosystems. The significance of this role has been reported for many planktivorous organisms, including whales (Baumgartner et al. 2003), birds (Karnovsky et al. 2003) and fish (Beaugrand et al. 2003). Since parasitism may reduce copepod fitness even with lethal effect (Willey et al. 1990, Allen & De Stasio 1993, Chiavelli et al. 1993), it appears important to assess this phenomenon.

The body surface of crustaceans, including copepods, serves as a convenient living environment for many groups of organisms. These include the so-called epibionts (bacteria, algae and various invertebrates), which settle on the body surface of other living organisms that thereby become basibionts (e.g., Carman & Dobbs 1997, Fernandez-Leborans & Tato-Porto 2000a,b). Also, copepods often serve as hosts for parasitic Protozoa, Monogenea or even Isopoda (Kabata 1973, Corkett & McLaren 1978, Théodoridès 1989, Meyers 1990, Shields 1994).

Epibionts and parasites of copepods are a common and important group of organisms from both the pathological and epizootical point of view. High densities of epibiontic ciliates decrease copepods' ability to move and maintain a desired depth. They may also reduce the fertility of basibionts. Moreover, copepods with parasites appear to be less stable in the water column, thus becoming an easy target for predators. They may also have difficulties with foraging (e.g., Willey et al. 1990, Allen & De Stasio 1993, Chiavelli et al. 1993).

Ellobiopsis are regarded as dangerous parasites of copepods. They can adversely affect fertility in females (Albaina & Irigoien 2006) and cause feminisation in males (Shields 1994). There are also a number of studies reporting the lethal effects of *Ellobiopsis* infection on copepods (Timofeev 2002). *E. chattoni* was found to be particularly dangerous for *C. finmarchicus*: this copepod species is of great importance for the commercial fisheries in the north Atlantic (Beaugrand et al. 2003).

The aim of the current study was to describe the phenomenon of epibiosis and parasitism on *Calanus finmarchicus*, *C. glacialis*, *Metridia longa* and *Paraeuchaeta norvegica* from the waters of the Spitsbergen shelf (Kongsfjorden area).

2. Material and methods

Material was collected along a transect from the shelf slope (Fram Strait) to Kongsfjorden on Spitsbergen (Svalbard) during a cruise of r/v

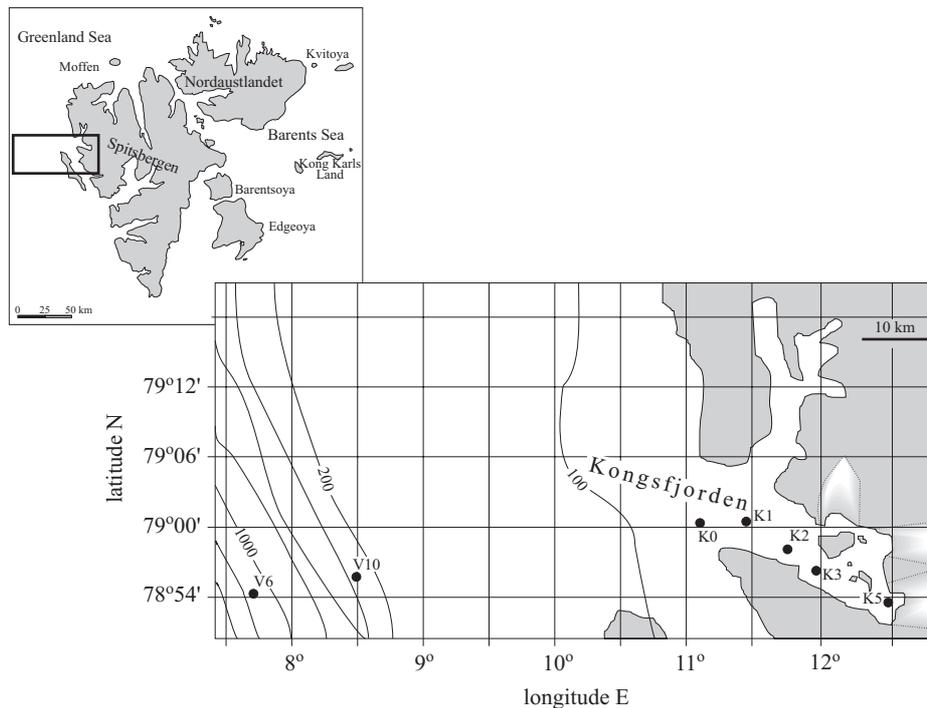


Fig. 1. Map of the Kongsfjorden area and the location of the sampling stations

‘Jan Mayen’ on 21–23 September 2002. Two stations (V6 and V10) were established outside the fjord (over the slope and at the entrance to the shelf trench), and five stations (K0, K1, K2, K3, K5) were located in Kongsfjorden itself (Fig. 1). A Multi Plankton Sampler (Hydro-Bios, Kiel) with a 0.25 m² net opening and five nets of 0.180 mm mesh size were used as sampling gear. Two replicates were taken at each station. Samples were preserved in a 4% solution of borax-buffered formaldehyde in seawater. The developmental stages of copepods (*C. finmarchicus*, *C. glacialis*, *M. longa* and *P. norvegica*) were determined in the course of laboratory analysis.

3. Results

Epibiontic ciliates of the genus *Paracineta* Collin, 1911 (Fig. 2) were noted on 60 copepods: 59 *M. longa* individuals (0.5% of the population) and one *P. norvegica*. The *Paracineta* sp. were nearly all found on adult females of *M. longa* (only one infected male was reported), although younger copepodid stages were also found in the population. Among the specimens of *P. norvegica*, one female was infected by *Paracineta* (0.5% of collected individuals).

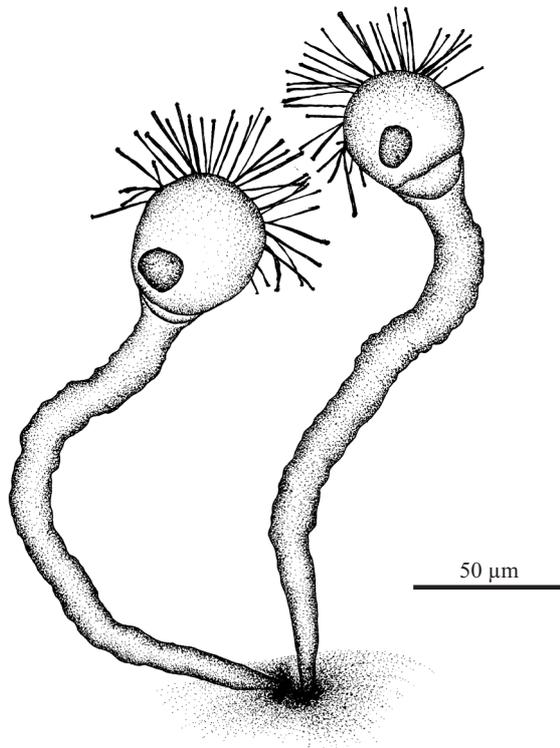


Fig. 2. Schematic drawing of *Paracineta* sp.

Epibionts most often covered the rear of the copepods' prosome (Fig. 3). When there were less than 50 *Paracineta* individuals on the body surface, they settled exclusively on the prosome, but when their abundance exceeded this number, they were also noted on the copepods' urosome or even covered the entire body surface.

The *Paracineta* sp. found can be described as follows (measured after fixing in 4% formaldehyde, measurements in millimetres, $n = 30$): total body length (without tentacles) 0.109 – 0.292 (mean 0.183); body cell shape from spheroid to oval, length and width 0.031 – 0.068 \times 0.019 – 0.058 (mean 0.046 \times 0.039); nucleus size 0.010 – 0.023 \times 0.008 – 0.016 (mean 0.016 \times 0.011); stalk length 0.053 – 0.292 (mean 0.137); tentacles located on the upper half of the body cell, length 0.019 – 0.047 (mean 0.033).

Parasites of the genus *Ellobiopsis* Caullery, 1910 (Fig. 4) were found on specimens of *C. finmarchicus* (43 individuals, 0.06% of the population infected) and *C. glacialis* (8 individuals, 0.09% of the population infected). *Ellobiopsis* were reported only on copepodid stages CIV (18.6% and 12.5% of all infected *C. finmarchicus* and *C. glacialis*, respectively) and CV (81.4%

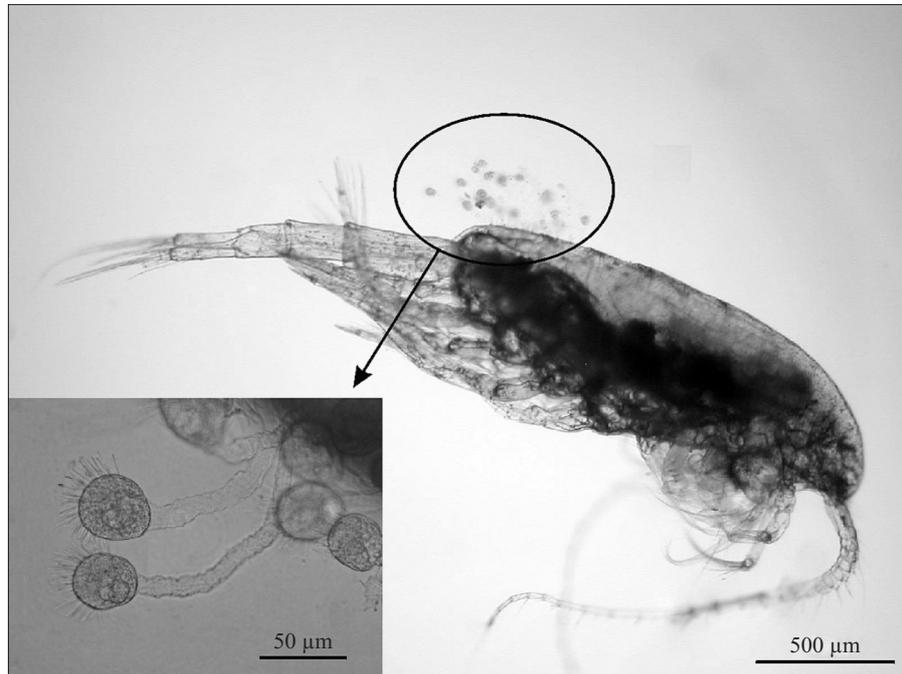


Fig. 3. *Metridia longa* with *Paracineta* sp.; insert: close-up of *Paracineta* sp. on *Metridia* prosome

and 87.5% of all infected *C. finmarchicus* and *C. glacialis*, respectively), although all the developmental stages were present in the water column.

Parasites were always attached to one of the mouth appendices, to the antennae I (antennule) or to one of the swimming legs (Fig. 5). In most cases, only one parasite was found on the host body surface. A maximum of three individuals of *Ellobiopsis* on one copepod specimen was observed in just one case.

The *Ellobiopsis* spp. found can be described as follows (measured after fixing in 4% formaldehyde, measurements in millimetres; $n = 10$): body varying from spheroid (juvenile specimens) to pear-shaped (adult specimens); total body length (including the stalk) 0.234 – 1.027 (mean 0.736); maximum width 0.166 – 0.498 (mean 0.362). The majority of all *Ellobiopsis* possessed well-developed gonomeres.

4. Discussion

Ciliates of the genus *Paracineta* are mainly marine epibionts, inhabiting the body surface of different groups of crustaceans (Curds 1987, Fernandez-Leborans & del Arco 1996, Fernandez-Leborans & Tato-Porto

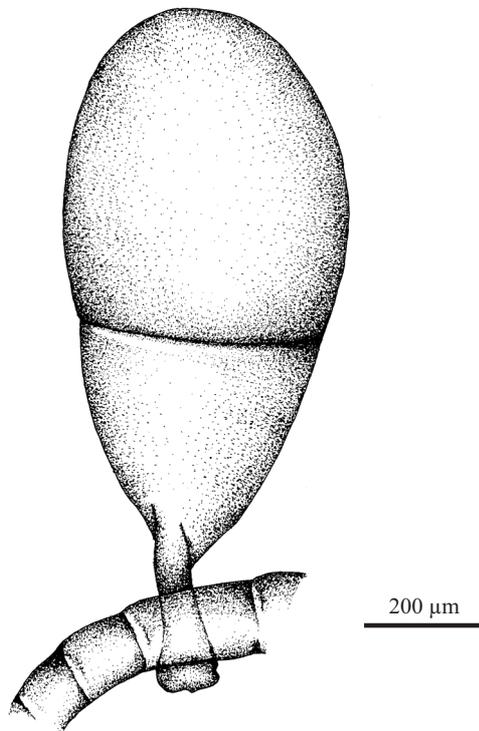


Fig. 4. Schematic drawing of *Ellobiopsis* spp. attached to antennae I

2000b, Fernandez-Leborans 2003). In copepods, they have been previously noted in *Gaetanus antarcticus*, *G. curvicornis*, *Pleuromamma abdominalis*, *P. xiphias*, *Metridia lucens* and *M. longa* (Fernandez-Leborans & Tato-Porto 2000b).

In the Kongsfjorden area, *Paracineta* were found in *M. longa* and *P. norvegica*. The second species turned out to be a previously unreported basibiont for these ciliates. *Paracineta* were located in a certain part of the copepod's body, namely, on the dorsal part of the prosome (when less numerous) and prosome/urosome (when occurring in high abundance), which tallies with the previous observations of Sherman & Schaner (1965). In *M. longa*, ciliates of *Paracineta* were identified only in adults, a fact previously noted by Sherman & Schaner (1965). Those authors stated that the lack of *Paracineta* in the younger copepodid stages could be due to moulting, which efficiently removes epibionts; it might also be the case that since adults have a larger body surface to be covered, they are preferred by the epibionts. We would endorse the latter hypothesis, as epibionts were found mostly on females, whose body surface is larger than that in the

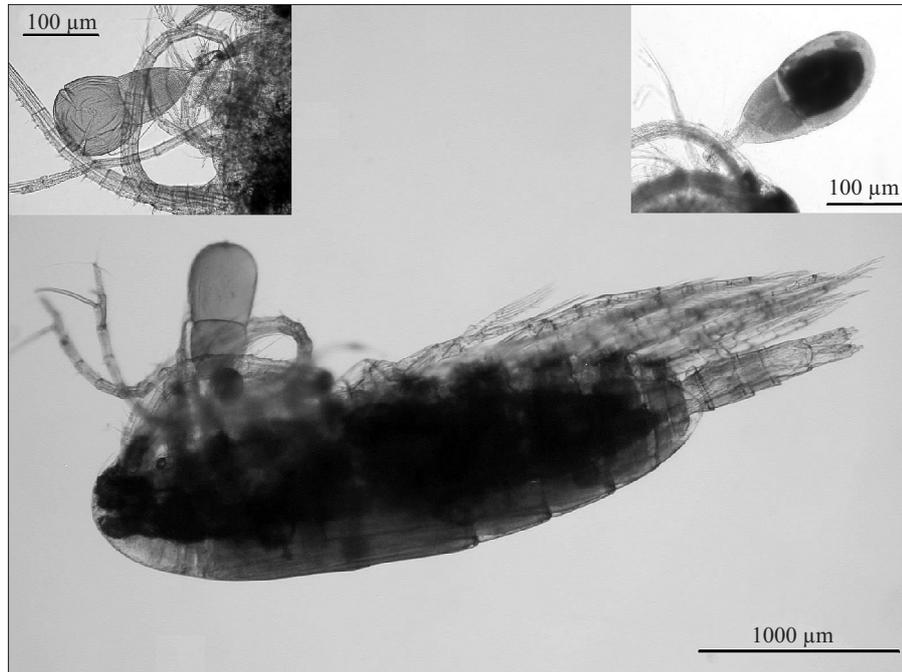


Fig. 5. *Calanus finmarchicus* infected by *Ellobiopsis* sp.; insert: close-up of two different *Ellobiopsis* individuals on copepods

younger stages and males. The occurrence of various epibionts on copepods is a common phenomenon among females (Xu & Burns 1991) and has been observed in adults of other crustaceans (e.g., Sherman & Schaner 1965, Chiavelli et al. 1993, Xu 1993).

Representatives of the genus *Ellobiopsis* are common parasites of both pelagic marine and freshwater Copepoda (Théodoridès 1989, Shields 1994, Bridgeman et al. 2000). Their taxonomic status remains vague, however; they have been classified as Pyrrophyta (Caullery 1910), Sarcocystophora (Shields 1994, after Steuer 1932), Flagellata incertae sedis (Wickstead 1963), Dinoflagellida (e.g., Marshall et al. 1934, Corkett & McLaren 1978), and Miozoa (Cavalier-Smith 2002). It has also been suggested that they belong to the Fungi (Boschma 1956); recently, however, they were included in a newly created phylum, the Myxozoa (Cavalier-Smith & Chao 2004).

The genus *Ellobiopsis* consists of three species – *E. chattoni*, *E. elongata* and *E. fagei*. It is suggested, however, that *E. fagei* is synonymous with *E. chattoni*, whereas the latter is a complex species (Shields 1994).

Ellobiopsis spp. have been noted in many species of Copepoda, including *Acartia danae*, *A. clausi*, *Acrocalanus gibber*, *Calanus finmarchicus*, *C. helgolandicus*, *Calocalanus* sp., *Clausocalanus arcuicornis*, *Cosmocalanus*

vulgaris, *C. darwini*, *Ctenocalanus vanus*, *Euchaeta marina*, *E. wolfendeni*, *Gaetanus antarcticus*, *G. curvicornis*, *Metridia longa*, *Paracalanus aculeatus*, *P. crassirostris*, *Penaeopsis retacuta*, *Pleuromamma gracilis*, *P. borealis*, *Portunus pelagicus*, *Pseudocalanus elongatus*, *P. minutus*, *Pseudocalanus* spp., *Temora longicornis*, *T. stilifera*, and *Undinula* (= *Cosmocalanus*) *vulgaris* (e.g., Boschma 1956, Wickstead 1963, Corkett & McLaren 1978, Shields 1994, Timofeev 2002, Fahmi & Hussain 2003, Albaina & Irigoien 2006, Skovgaard & Saiz 2006). This study provides the first evidence of *C. glacialis* being a host to *Ellobiopsis*. This finding seems important, since *C. glacialis* is considered to be a key organism of high latitudes (Scott et al. 2000), serving as food for many planktivorous organisms like polar cod (Lønne & Gulliksen 1989) or little auks (Wojczulanis et al. 2006).

The percentage of infected organisms in the population depends on the host species, location and season. In the Kongsfjorden area, the percentage of organisms infected by *Ellobiopsis* was very low (0.06% and 0.09% of the *C. finmarchicus* and *C. glacialis* population, respectively). Low levels of *Ellobiopsis* infection (0.56–1%) were observed in populations of *Acartia clausi*, *A. danae*, *Acrocalanus gibber* and *Paracalanus aculeatus* in the Persian Gulf, Kuwait (Fahmi & Hussain 2003). A slightly higher level of infection (6.8%) was noted for *Calanus helgolandicus* from the Bay of Biscay, Spain (Albaina & Irigoien 2006), but much higher ones in *Undinula* (= *Cosmocalanus*) *vulgaris* (26%) from the Zanzibar Channel, Africa (Wickstead 1963) and *Calanus finmarchicus* (15–45%) from the Norwegian Sea (Timofeev 1997, 2002). The Norwegian Sea population of *Calanus* is the source of that species for the entire sub-Arctic and Arctic region, including the Kongsfjorden area, where the samples used in the current study were collected (Walkusz et al. 2003). On the assumption that zooplankton organisms are passively transported with the sea currents, *Ellobiopsis* presumably has a specific temperature optimum; its transport further northwards (towards colder regions) will therefore cause its activity to drop, possibly leading to a dramatic reduction in its viability. Hence, any increase in water temperature predicted as a consequence of climate changes (Arctic Climate Impact Assessment 2004) may trigger a mass occurrence of *Ellobiopsis* (secondary climate change effect) and eventually lead to a significant increase in copepod mortality.

Most of the *Ellobiopsis* were found on the mouth appendages, fewer on the antennules and the fewest on the swimming legs, which is consistent with previous results (e.g., Marshall et al. 1934, Timofeev 1987, Albaina & Irigoien 2006). It is assumed that the choice of settling spot is made by *Ellobiopsis* during host foraging (Albaina & Irigoien 2006). The feeding mode of Calanoida is well known and has been extensively reported in the

literature (Koehl & Strickler 1981). During feeding, their mouth appendages create a stream of water containing food particles that are delivered to the mouth opening. Thus, mouth appendages and antennae I are among the first body parts exposed to the invasive stages of *Ellobiopsis*. Furthermore, the appendage joints appear to be relatively more accessible in terms of parasite anchoring than the copepod integument, which is multilayered (Mauchline 1998). Although a copepod respire through its entire body surface, its excretory system is located in a particular area. In our opinion, the invasive stages of *Ellobiopsis* might be additionally attracted to the holding area by copepod excretion products from the maxillary glands, but this hypothesis requires further study.

In summary, our investigation has provided evidence that *Paracinet* ciliates are found in adult individuals of *M. longa* and *P. norvegica* from the Kongsfjorden area. The latter species turned out to be a previously unreported basibiont for this epibiont. *C. finmarchicus* and *C. glacialis* were hosts to parasitic *Ellobiopsis*, with copepodid stages IV and V being the worst infected. It is the first record of *C. glacialis* serving as a host to *Ellobiopsis*. In comparison with other localities, the infection levels for both *Paracinet* and *Ellobiopsis* were low. With climatic changes (water temperature rise), however, this could change and have a serious impact on local copepod populations.

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References

- Albaina A., Irigoien X., 2006, *Fecundity limitation of Calanus helgolandicus, by the parasite Ellobiopsis sp.*, J. Plankton Res., 28 (4), 413–418.
- Allen Y. C., De Stasio B. T., 1993, *Individual and population level consequences of an algal epibiont on Daphnia*, Limnol. Oceanogr., 38 (3), 592–601.
- Arctic Climate Impact Assessment (ACIA), 2004, *Impacts of a warming Arctic: Arctic climate impact assessment*, Cambridge Univ. Press, Cambridge, 1042 pp.
- Baumgartner M. F., Cole T. V. N., Campbell R. G., Teegarden G. J., Durbin E. G., 2003, *Associations between North Atlantic right whales and their prey, Calanus finmarchicus, over diel and tidal time scales*, Mar. Ecol. Prog. Ser., 264, 155–166.

- Beaugrand G., Brander K. M., Lindley J. A., Souissi S., Reid P. C., 2003, *Plankton effect on cod recruitment in the North Sea*, Nature, 426 (6967), 661–664.
- Boschma H., 1956, *Ellobiopsidae. Zooplankton*, [in:] *Fiches d'identification du zooplancton*, ICES, 65, 1–4.
- Bridgeman T. B., Messick G., Vanderploeg H. A., 2000, *Sudden appearance of cysts and ellobiopsid parasites on zooplankton in a Michigan lake: a potential explanation of tumor-like anomalies*, Can. J. Fish. Aquat. Sci., 57 (8), 1539–1544.
- Carman K. R., Dobbs F. C., 1997, *Epibiotic microorganisms on copepods and other marine crustaceans*, Microsc. Res. Techniq., 37 (2), 116–135.
- Caullery M., 1910, *Ellobiopsis chattoni n.g., n.sp. parasite de Calanus helgolandicus Claus, appartenant probablement aux Péridiniens*, Bull. Sci. Fr. Belg., 44, 201–214.
- Cavalier-Smith T., 2002, *The phagotrophic origin of eukaryotes and phylogenetic classification of Protozoa*, Int. J. Syst. Evol. Micr., 52 (2), 297–354.
- Cavalier-Smith T., Chao E. E., 2004, *Protalveolate phylogeny and systematics and the origins of Sporozoa and dinoflagellates (phylum Myzozoa nom. nov.)*, Eur. J. Protis., 40 (3), 185–212.
- Chiavelli D. A., Mills E. L., Threlkeld S. T., 1993, *Host preferences, seasonality, and community interactions of zooplankton epibionts*, Limnol. Oceanogr., 38 (3), 574–583.
- Corkett C. J., McLaren I. A., 1978, *The biology of Pseudocalanus*, Adv. Mar. Biol., Vol. 15, F. S. Russell & M. Yonge (eds.), Acad. Press, New York, 2–233.
- Curds C. R., 1987, *A revision of the Suctorina (Ciliophora, Kinetofragminophora), 5. The Paracinetia and Corynophrya problem*, Bull. Brit. Mus. Nat. Hist. (Zool.), 52 (2), 71–106.
- Fahmi A. M., Hussain M., 2003, *Two groups of parasites on the body of copepods*, J. Arid Environ., 54 (1), 149–153.
- Fernandez-Leborans G., 2003, *Ciliate-decapod epibiosis in two areas of the north-west Mediterranean coast*, J. Nat. Hist., 37 (14), 1655–1678.
- Fernandez-Leborans G., del Arco P. G., 1996, *A new species of the genus Corynophrya (Protozoa, Ciliophora: an epibiont of decapod crustaceans)*, Microbios, 86 (346), 27–37.
- Fernandez-Leborans G., Tato-Porto M. L., 2000a, *A review of the species of protozoan epibionts on crustaceans. I. Peritrich ciliates*, Crustaceana, 73 (6), 643–683.
- Fernandez-Leborans G., Tato-Porto M. L., 2000b, *A review of the species of protozoan epibionts on crustaceans. II. Suctorian ciliates*, Crustaceana, 73 (10), 1205–1237.
- Kabata Z., 1973, *Distribution of Udonella caligorum Johnston, 1835 (Monogenea: Udonellidae) on Caligus elongatus Nordmann, 1832 (Copepoda: Caligidae)*, J. Fish Res. Board Can., 30 (12), 1793–1798.

- Karnovsky N., Kwaśniewski S., Węślawski J. M., Walkusz W., Beszczyńska-Möller A., 2003, *The foraging behaviour of little auks in a heterogenous environment*, Mar. Ecol. Prog. Ser., 253, 289–303.
- Koehl M. A. R., Strickler J. R., 1981, *Copepod feeding currents: food capture at low Reynolds number*, Limnol. Oceanogr., 26 (6), 1062–1073.
- Lønne O. J., Gulliksen B., 1989, *Size, age and diet of polar cod, Boreogadus saida (Lepechin 1773), in ice covered waters*, Polar Biol., 9 (3), 187–191.
- Marshall S. M., Nicholls A. G., Orr A. P., 1934, *On the biology of Calanus finmarchicus. V. Seasonal distribution, size, weight and chemical composition in Loch Striven in 1933, and their relation to the phytoplankton*, New Ser., 19, 793–827.
- Mauchline J., 1998, *The biology of calanoid copepods*, Adv. Mar. Biol., Vol. 33, J. H. S. Blaxter, A. J. Southward & P. A. Tyler (eds.), Acad. Press, San Diego, 710 pp.
- Meyers T. R., 1990, *Diseases of Crustacea. Diseases caused by protistans and metazoans*, [in:] *Diseases of marine animals*, Vol. III: *Introduction, Cephalopoda, Annelida, Crustacea, Chaetognatha, Echinodermata, Urochordata*, O. Kinne (ed.), Biol. Anst. Helgol., Hamburg, 350–389.
- Scott C. T., Kwasniewski S., Falk-Petersen S., Sargent J. R., 2000, *Lipids and life strategies of Calanus finmarchicus, Calanus glacialis and Calanus hyperboreus in late autumn, Kongsfjorden, Svalbard*, Polar Biol., 23 (7), 510–516.
- Sherman K., Schaner E. G., 1965, *Paracinet* sp., an epizoic suctorian found on *Gulf of Maine Copepoda*, J. Protozool., 12 (4), 618–625.
- Shields J. D., 1994, *The parasitic dinoflagellates of marine crustaceans*, Annu. Rev. Fish Dis., 4, 241–271.
- Skovgaard A., Saiz E., 2006, *Seasonal occurrence and role of protistan parasites in coastal marine zooplankton*, Mar. Ecol. Prog. Ser., 327, 37–49.
- Steuer A., 1932, *Über Ellobiopsis elongata n. sp. aus dem Südatlantik*, Note Inst. ital.-germ. Biol. Mar. Rovigno d'Istria, 5, 1–6.
- Théodoridès J., 1989, *Parasitology of marine zooplankton*, Adv. Mar. Biol., Vol. 25, J. H. S. Blaxter & A. J. Southward (eds.), Acad. Press, New York, 117–177.
- Timofeev S. F., 1987, *The essay of using the data of infestation by parasitic protozoan life-cycle data for populational study of planktonic crustaceans*, [in:] *The life cycles of parasites in biocenoses of northern seas*, Yu. I. Polyansky (ed.), AN SSSR, Apatity, 70–73, (in Russian).
- Timofeev S. F., 1997, *An occurrence of the parasitic dinoflagellate Ellobiopsis chattoni (Protozoa: Mastigophora) on the copepode Calanus finmarchius (Crustacea: Copepoda) and a possibility to use the parasite as biological tag on local populations*, Parazitologiya, 31 (4), 334–340, (in Russian).
- Timofeev S. F., 2002, *The effect of the parasitic dinoflagellate Ellobiopsis chattoni (Protozoa: Mastigophora) on the winter mortality of the calanoid copepod Calanus finmarchius (Crustacea: Copepoda) in the Norwegian Sea*, Parazitologiya, 36 (2), 158–162, (in Russian).

- Walkusz W., Storemark K., Skau T., Gannefors C., Lundberg M., 2003, *Zooplankton community structure; a comparison of fjords, open water and ice stations in the Svalbard area*, Pol. Polar Res., 24 (2), 149–165.
- Wickstead J. H., 1963, *A new record of Ellobiopsis chatloni (Flagellata incerte sedis) and its incidence in a population of Undinula vulgaris var. major (Crustacea Copepoda)*, Parasitology, 53, 293–296.
- Willey R. L., Cantrell P. A., Threlkeld S. T., 1990, *Epibiotic flagellates increase the susceptibility of some zooplankton to fish predation*, Limnol. Oceanogr., 35 (4), 952–959.
- Wojczulanis K., Jakubas D., Walkusz W., Wennerberg L., 2006, *Differences in food delivered to chicks by males and females of little auks (Alle alle) on South Spitsbergen*, J. Ornithol., 147 (4), 543–548.
- Xu Z., 1993, *The infection of Moina macrocopa by a colonial peritrich, Epistylis daphniae, and its effects on the host*, Freshwater Biol., 30 (1), 181–186.
- Xu Z., Burns C. W., 1991, *Effects of the epizoic ciliate Epistylis daphniae, on growth, reproduction and mortality of Boeckella triarticulata (Thompson) (Copepoda: Calanoida)*, Hydrobiologia, 209 (3), 183–189.