Protistology 10 (3), 91–96 (2016)

Protistology

Tintinnid ciliates (Spirotrichea, Choreotrichia, Tintinnida) of the Black Sea: recent invasions

Nelli A. Gavrilova and Igor V. Dovgal

Kovalevsky Institute of Marine Biological Research of Russian Academy of Sciences, Sevastopol, 299011, Russia

| Submitted August 29, 2016 | Accepted September 24, 2016 |

Summary

Among 23 species of tintinnid ciliates known for the Black Sea, nine nonindigenous species (*Eutintinnus lususundae, E. tubulosus, E. apertus, Eutintinnus sp., Salpingella decurtata, Tintinnopsis tocantinensis, Rhizodomus tagatzi, Amphorellopsis acuta* and *Nolaclusilis* sp.) were registered in the Sevastopol Bay and the adjacent coastal regions of the Crimea during 1997-2014. Some of those aliens (e.g., *A. acuta* and *E. tubulosa*) were often dominating in the plankton community and possibly replacing the indigenous species, such as *Codonella lagenula, Helicostomella subulata, T. compressa, T. lobiancoi, T. rossolimi* and *Metacylis jorgensenii*. We infer that the observed changes in the ciliate species composition were likely related to the invasion of the ctenophore *Mnemiopsis leidyi* into the Black Sea in the 1980s, which had caused significant alterations in the plankton community.

Key words: tintinnid ciliates, Black Sea, invasive species

Introduction

Tintinnid ciliates are a vital microplanktonic link in aquatic food chains. They feed on planktonic algae and cyanobacteria and can consume up to 27% of annual primary production in coastal waters (Capriulo and Carpenter, 1983). Up to 90% of carbon from primary production can cycle through microzooplankton, including tintinnids (Jackson, 1980; Lynn and Small, 2000). At the same time, tintinnids constitute an important seasonal food component for meso- and macrozooplankton, such as copepods (Capriulo and Carpenter, 1983), large zooflagellates and fish larvae (Stoecker, 2013).

The tintinnid ciliates have been studied in the Black Sea since 1870s (Gavrilova and Dolan, 2007). It is considered that tintinnid diversity is relatively low in the Black Sea: 27 species of Tintinnida were known for this water basin according to the data published in the XX century (Rossolimo, 1922; Dolgopolskaya, 1940; Morozovskaya, 1968; Pertran, 1968; Zagorodnyaya, 1992; Murzov et al., 1999).

However, after the nomenclature revision of Dolan (2006), the list of the Black Sea tintinnids was reduced to 20 species, namely: *Codonella lagenula* (Claparède et Lachmann, 1858), *Helicostomella subulata* (Ehrenberg, 1833), *Tintinnopsis campanula* Ehrenberg, 1840, *T. compressa* Daday, 1887, *T. lobiancoi* Daday, 1887, *T. rossolimi* Morozovskaya, 1968, *T. baltica* Brandt, 1896, *T. karajacensis* Brandt, 1896, *T. cylindrica* Daday, 1887, *T. tubulosa* Levander, 1900, *T. beroidea* Stein, 1867, *T. meunieri* Kofoid et Campbell, 1929, *T. urnula* Meunier, 1910, *T. minuta* Wailes 1925, *Tintinnidium*

doi:10.21685/1680-0826-2016-10-3-3
© 2016 The Author(s)
Protistology © 2016 Protozoological Society Affiliated with RAS

mucicola (Claparède et Lachmann, 1858), *Metacylis jorgensenii* (Cleve, 1902), *M. mereschkovskii* Kofoid et Campbell, 1929, *Favella ehrenbergii* (Claparède et Lachmann, 1858), *Stenosemella ventricosa* (Claparède et Lachmann, 1858) and *S. nivalis* (Meunier, 1910) (Gavrilova and Dolan, 2007).

It should be mentioned meanwhile that 42 tintinnid species were listed earlier, in the little-known review article published by Gassowski (1960). However, three of those species – *Leprotintinnus bottnicus* Jörgensen, 1900, *L. pellucidus* (Cleve, 1899) and *Urnulla* sp. were indicated for the Azov Sea whereas two other species, *T. fluviatile* (Stein, 1863) and *T. semiciliatum* Sterki, 1879 (named *Strombidinopsis gyrans* Kent, 1881), are known as freshwater species. Additionally, some other species names in the list of Gassowski (1960) are synonyms.

According to the review by Detcheva (1992), the Black Sea tintinnid taxonomic list was rather short and contained only 15 different tintinnids. Meanwhile, only nine of them were identified to the species level while two of those (*T. fluviatile* and *Codonella cratera* Leidy, 1887) were freshwater species. One non-native genus, *Codonellopsis* Jörgensen, 1924 with one non-identified species *Codonellopsis* sp. was also mentioned in that review (Detcheva, 1992). However, this genus had never been mentioned in any other publication on the Black Sea ciliates (Rossolimo, 1922; Dolgopolskaya, 1940; Morozovskaya, 1968; Petran, 1968; Gassowski, 1960; Zagorodnyaya, 1992; Murzov et all., 1999; Gavrilova, 2001, 2005, 2007, 2010; Polikarpov et all., 2003; Kurilov, 2005; Gavrilova and Dolan, 2007; Selifonova, 2011a, 2011b).

In the present study, we rely on the previously published sources and the systematic revision that suggest that the list of the Black Sea tintinnid ciliates contains 20 species. During our regular all-seasonal plankton investigations in the Sevastopol Bay and the coastal regions of the Crimea since 1997, several tintinnid species were found that were new for the Black Sea. As shown by the previously published data cited above, the observations on the tintinnid species composition in the Black Sea during the extended periods had been a significant part of the marine monitoring programs. This suggests that the newly registered tintinnid ciliates that were discovered during our study but had not been observed in plankton previously are, most likely, the invasive species.

This article provides the updated list of the tintinnid ciliates in the Sevastopol Bay and the coastal regions of the Crimea, and discusses the changes in species composition of ciliates due to biological invasions in plankton communities of the Black Sea.

Methods

Species composition of tintinnid ciliates was studied in a 10-m water column in the Black Sea costal and open waters in different seasons during 1997 through 2014. Three routine stations were located in waters of different trophic status in the Sevastopol Bay: No. 1 in 2 miles from the Sevastopol Bay in the open sea waters (44°23'2"N; 33°16'23"E), No. 2 at the mouth of the Sevastopol Bay (44°22'29"N; 33°18'28"E), and No.3 in the estuary of the Chernaya River (44°22'14"N; 33°20'40"E) (Fig. 1). Sampling was carried out twice per month all year round. Water samples were taken with a lockable modification of the small Apstein plankton net (mouth diameter 8.5 cm, mesh size 55 µm). The total volume of concentrated seawater samples amounted 56.7 L. The samples (60-70 mL) were preserved in glutaraldehyde solution to reach the final concentration of 4%. Then the samples were concentrated to 10-20 mL by the sedimentation method.

Abundance and diversity of tintinnid ciliates were investigated using the counting chamber "Nazhotta" (0.8 cm^3) and the light microscope "Nikon Eclipse TS-100" with 100× and 400× magnifications. The microphotographs of tintinnid ciliates were made using digital video camera "Ikegami ICD-848p" at 400× magnification, with the exception of one large species, *Eutintinnus lususundae*, which was photographed at 100× magnification.

Results and discussion

During our investigations, the first alien tintinnid species were registered in the Black Sea in August and September of 2001; those were *Eutintinnus lususundae* Entz, 1885, *E. tubulosus* Ostenfeld, 1899, *E. apertus* Kofoid et Campbell, 1929 and *Eutintinus* sp. (Polikarpov et al., 2003; Gavrilova, 2001, 2005; Kurilov, 2005). The representative of another genus, *Salpingella decurtata* Jörgensen, 1924, was for the first time recorded in 2002 and since then it has been regularly observed in the samples during summer and autumn (Gavrilova, 2010).

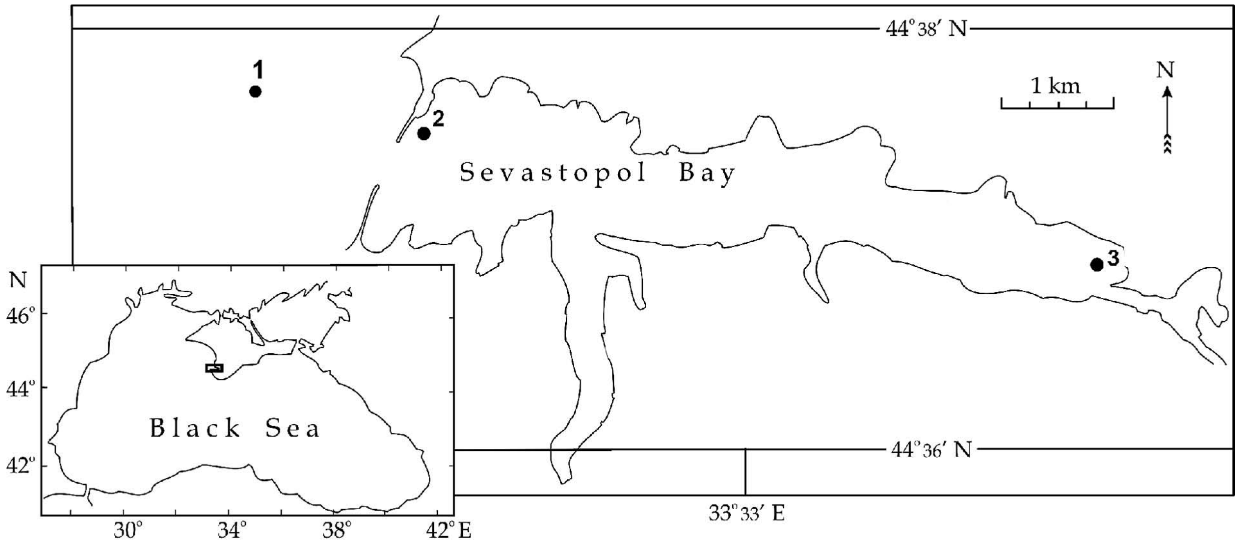

Fig. 1. Map showing sampling locations.

The other findings of new tintinnid ciliate species in the Black Sea dated back to 2009 (*Rhizodomus tagatzi* Strelkov et Wirketis, 1950; *Tintinnopsis tocantinensis* Kofoid et Campbell, 1929), and *Amphorellopsis acuta* Schmidt, 1902 was first recorded in 2010 (Gavrilova, 2010; Selifonova, 2011a, 2011b).

Thus, nine species new for the studied region of the Black Sea have been recorded during the period of time from 1997 till 2014, namely: *E. lususundae* (Fig. 2, A), *E. tubulosus* (Fig. 2, B), *E. apertus* (Fig. 2, C), *Eutintinnus* sp. (Fig. 2, D), *S. decurtata* (Fig. 2, E), *T. tocantinensis* (Fig. 2, G), *R. tagatzi* (Fig. 2, F), *A. acuta* (Fig. 2, H) and *Nolaclusilis* sp. (Fig. 2, I).

The registration of nonindigenous ciliate species in the Black Sea is not a rare event, and those ciliates often reach high abundances during certain seasons. For example, the tintinnids *E. tubulosa, A. acuta* and *Nolaclusilis* sp. were dominating the ciliate community: *E. tubulosa* reached the density of 3.7×10^6 cells/m^3 in August 2008 at the station 2, *A. acuta* reached the density of 3.8×10^6 cells/m^3 in September 2011 at the station 3 and *Nolaclusilis* sp. reached the density of 19.6×10^6 cells/m^3 in August 2008 at the station 3.

Our data allowed compiling the updated list of the Black Sea Tintinnida, which consists of 23 species including the nonindigenous ones.

At the same time, we did not register several common Black Sea ciliate species in the samples collected since 1997 through 2014 (e.g., *Codonella lagenula, Helicostomella subulata, T. compressa, T. lobiancoi, T. rossolimi* and *Metacylis jurgensenii*). Interestingly, one of those 'vanished' species, *T. campanula*, re-appeared in plankton of the studied area after a 10 years period of absence, and since 2008 it has become a ciliate community member again.

In general, the contribution of alien species to the overall list of the Black Sea tintinnids is considerable and accounts for ca. 33%. Moreover, if we exclude from this list those species that have not been recorded in the studied region during the recent years, the contribution of the invasive tintinnid species will increase to 44% of the total tintinnid ciliates species number. The reasons for the mentioned changes in the ciliate community structure are not known yet. It is possible, however, that these changes might be related to the invasion of the ctenophore *Mnemiopsis leidyi* Agassiz, 1865 to the Black Sea in the early 1980s.

The invasion of *M. leidyi* caused a significant decrease of the overall zooplankton biomass in the Black Sea by the early 1990s (Vinogradov et al., 1995). It is not completely unlikely, therefore, that the plankton-eating ctenophore, which had caused such a striking effect on the Black Sea pelagic food web, could have eliminated some common native tintinnid species, and their ecological niches might have been filled in by the nonindigenous ciliates.

Later on, however, the subsequent invasion of the predatory ctenophore *Beroe ovata* Bruguière, 1789 to the Black Sea in the early 1990s significantly reduced the abundance of *M. leidyi* within a forthcoming decade (Vostokov et al., 2001). This fact, in turn, has led to an increase of the zooplankton biomass in the

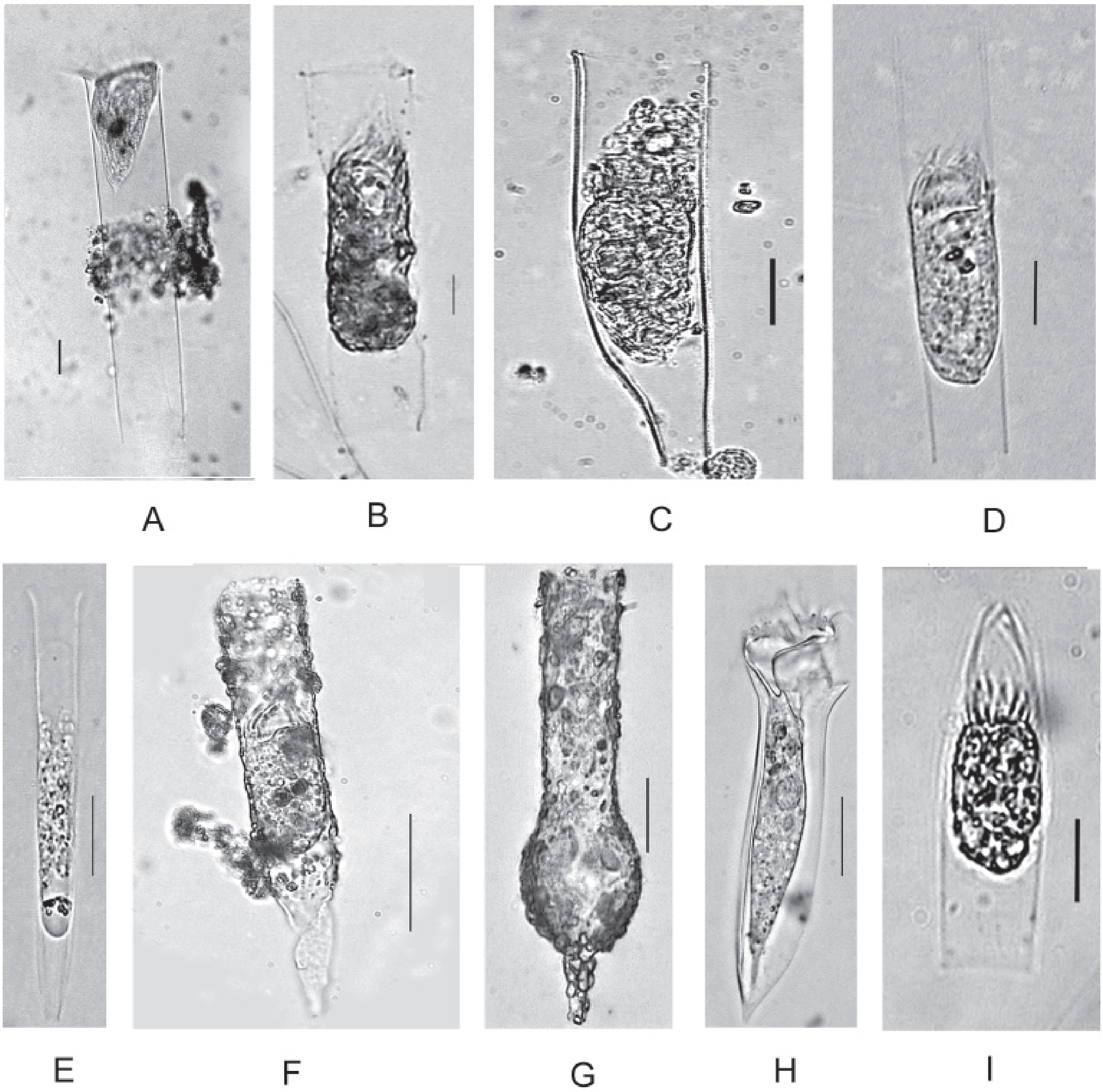

Fig. 2. Invasive tintinnid species found in the Black Sea in 1997-2014. A - *Eutintinnus lususundae*; B – *E. tubulosus*; C – *E. apertus*; D – *Eutintinnus* sp.; E – *Salpingella decurtata*; F – *Rhizodomus tagatzi*; G – *Tintinnopsis tocantinensis*; H – *Amphorellopsis acuta*; I – *Nolaclusilis* sp. Scale bars: A, D, G – 20 μm, B, C, I – 10 μm, E, H – 15 μm, F – 50 μm

Black Sea (Finenko et al., 2003). It is possible that the above-mentioned recovery of the population of *Tintinnopsis campanula* after a 10-years long absence in the plankton could be associated with the latter circumstance. Nevertheless, the restoration of the former tintinnid species composition in the Black Sea plankton community is hardly possible since the ecological niches of the 'vanished' indigenous ciliates have already been occupied by the alien tintinnid species.

References

Capriulo G.M. and Carpenter E.J. 1983. Abundance, species composition and feeding impact of tintinnid micro-zooplankton in central Long Island Sound. Mar. Ecol. Prog. Ser. 10, 277–288.

Detcheva R.B. 1992. Catalogi faunae Bulgaricae. 1: Protozoa, Ciliophora. Bulgarian Academy of Science, Sophia (In German with Bulgarian summary).

Dolgopolskaya M.A. 1940. Zooplankton of the Black Sea at the Karadag area (Zooplankton of the Black Sea near Karadag). Trudy Karadagskoj Biol. St. 6, 57–110 (In Russian).

Finenko G.A., Romanova Z.A., Abolmasova G.I., Anninsky B.E., Svetlichny L.S., Hubareva E.S., Bat L. and Kideys A.E. 2003. Population dynamics, ingestion, growth and reproduction rates of the invader *Beroe ovata* and its impact on plankton community in Sevastopol Bay, the Black Sea. J. Plankton Res. 25, no. 5, 539–549.

Gassowski G.N. 1960. Praktyczne znachennya infuzorij ta istoriya ih vyvchennya na Ukraini (The practical significance of ciliates and the history of their study in Ukraine). Zbirnyk pratc zoologichnogo muzeyu. 29, 58–90 (In Ukrainian).

Gavrilova N.A. 2001. *Eutintinnus* (Ciliophora, Oligotrichida, Tintinnidae) - a new tintinnid genus for the Black Sea fauna. Ekologiya Morya. 58, 29–31 (In Russian with English summary).

Gavrilova N.A. 2005. New for the Black Sea tintinnids species. Ekologiya Morya. 69, 5–11 (In Russian with English summary).

Gavrilova N.A. 2010. Microzooplankton (Tintinnidae). In: The introducers in the biodiversity and productivity of the Sea of Azov and the Black Sea (Eds Matishov G.G. and Boltachev A.R.). SSC RAS Pablish., Rostov-on-Don. pp. 63-69 (In Russian with English summary).

Gavrilova N.A. and Dolan J.R. 2007. A note on species lists and ecosystem shifts: Black Sea tintinnids, ciliates of the microzooplankton. Acta Protozool. 46, 279–288.

Jackson G.A. 1980. Phytoplankton growth and zooplankton grazing in oligotrophic oceans. Nature. 284, 439–441.

Kurilov A.V. 2005. Infuzorii planktona pribrezhnoj zony i limanov severo-zapadnoj chasti Chernogo morya (Planktonic ciliates of the coastal zone and estuaries of the northwestern part of the Black Sea). PhD theses. Sevastopol. 258 p. (in Russian).

Lynn D.H. and Small E.B. 2000. Phylum Ciliophora Doflein, 1901. In: The illustrated guide to the Protozoa. Second edition. Vol. 1. (Eds Lee J.J., Leedale G.F. and Bradbury P.) Society of protozoologists, Lawrence. pp. 371-656.

Morozovskaya O.I. 1968. Tintinnoinea from the hyponeyston and below layers of the Black and Azov marine pelagic regions. In: Ecological biogeography of marine contact zones (Ed. Vinogradov K.A.) Naukova Dumka, Kiev. pp. 46–59 (In Russian with English summary).

Murzov S.A., Gavrilova N.A. and Samishev E.Z. 1999. Heterotrophic microplankton and ciliates in Sevastopol Bay: the structure, abundance, distribution and variability. In: Area of water and a cost of Sevastopol: ecosystem processes and social services (Eds Pavlova E.V. and Shadrin N.V.). Aquavita, Sevastopol. pp. 121–130 (In Russian with English summary).

Petran A. 1968. Klass Infusoria. In: Opredelitel' fauny Chernogo i Azovskogo morej (Class Infusoria. In: Guide to the fauna of the Black and Azov Seas). Vol.1. (Ed. Vodyanitskij V.A.). Naukova Dumka, Kiev. pp. 21–34 (in Russian).

Polikarpov I.G., Saburova M.A., Manzhos L.A., Pavlovskaya T.V. and Gavrilova N.A. 2003. The Black Sea microplankton biodiversity in the coastal zone near Sevastopol (2001-2003). In: Modern state of coastal waters biodiversity of Crimea (Black Sea sector). (Eds Eremeev V.N. and Gaevskaya A.V.). Ecosea-hydrophysica, Sevastopol. pp. 16–43 (In Russian with English summary).

Rossolimo L. 1922. Tintinnodea planktona Chernogo morya (Tintinnids of the Black Sea plankton). Arch. Rus. Protistol. Soc. 1, 22–34 (in Russian).

Selifonova Zh.P. 2011a. New species of infusorian *Tintinnopsis tocantinensis* Kofoid et Campbell, 1929 (Ciliophora: Spirotrichea: Tintinnida) from the Black Sea. Rus. J. Biol. Invas. 4, 72–76 (In Russian with English summary).

Selifonova Zh.P. 2011b. *Amphorellopsis acuta* (Ciliophora: Spirotrichea: Tintinnida) – new species in the Black Sea. Mar. Ecol. J. 10 (1), 85 (In Russian with English summary).

Stoecker D.K. 2013. Predators of tintinnids. In: The biology and ecology of tintinnid ciliates: models for marine plankton. (Eds Dolan J.R., Montagnes D.J.S., Agatha S., Coats W.D. and Stoecker D.K.) Wiley-Blackwell, West Sussex. pp. 122-144.

Vinogradov M.E., Shushkina E.A., Bulgakova Yu.V. and Serobaba I.I. 1995. The consumption of zooplankton by comb-jelly *Mnemiopsis leidyi* and pelagic fishes in the Black Sea. Oceanologiya. 35 (4), 569–573 (In Russian with English summary).

Vostokov S.V., Arashkevich E.G., Drits A.V. and Lukashev Yu.F. 2001. Ecological and physiological characteristics of the ctenophore *Beroe ovata* in the coastal waters of the Black Sea: quantity, biomass, size distribution, hunting behavior, feeding and metabolism. Oceanologiya. 41 (1), 109–115 (In Russian with English summary).

Zagorodnyaya Y.A. 1992. Obshchaya kharakteristika mikrozooplanktona v Chernom more v pozdne-letnij period (General characteristics of the Black Sea micro-zooplankton in the late summer). IBSS. Sevastopol, Deposited manuscript. 15.12.92 —No 3539. 92, 1–19 (in Russian).

Address for correspondence: Igor Dovgal. Kovalevsky Institute of Marine Biological Research of Russian Academy of Sciences, 2, Nakhimov ave., Sevastopol, 299011, Russia; e-mail: *dovgal-1954@mail.ru*