

Review of tintinnid species (Ciliophora: Tintinnina) from the Barents Sea

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Summary

The paper presents a list of tintinnid species (Tintinnina Kofoid et Campbell, 1929) in the Barents Sea according to records from the XX through the XXI century. The research also includes original data (2012–2017), which allowed identifying three new tintinnid species in recent years: *Ormosella hackeli* Kofoid et Campbell, 1929, *Parundella caudata* (Ostenfeld, 1899) Jörgensen, 1924, and *Amphorellopsis tetragona* (Jörgensen, 1924) Kofoid et Campbell, 1929. These three alien species of marine ciliates belong to the warm-water fauna; they were recorded in the western part of the Barents Sea and are inherited to the North Cape Current. The research includes a brief biogeographic characteristic and photographic material of alien tintinnids in the Barents Sea.

Key words: Barents Sea, ciliates, distribution, plankton, Tintinnina

Introduction

Currently the total number of tintinnid species (suborder Tintinnina Kofoid et Campbell, 1929) in the Barents Sea remains unknown. There are heterogeneity and inconsistency of taxonomy information in plankton records (Lifshits, 1978; Burkovsky, 1974; Dolan et al., 2017). The morphological variability of lorica complicates distinguishing between typical forms of tintinnids, varieties and different stages of life cycle (Rossolimo, 1927; Lifshits, 1977; Dolan et al., 2017). In addition, records of the species composition of ciliates in the Western Arctic that allow to reliably assess the present ciliate diversity in the Barents Sea are limited

and episodic (Meunier, 1910; Burkovsky et al., 1974; Burkovsky, 1976; Lifshits, 1977, 1978; Lifshits et al., 1978; Dolan et al., 2017).

In recent decades, the thermal and ice regimes have been changed in the Barents Sea (Polyakov et al., 2017; Aksenov and Ivanov, 2018). This makes a comparative analysis of the tintinnid ciliates from the Barents Sea in the XX century and at present an ecologically relevant issue. The Atlantic currents provide more than 50% of the warm water contribution to the Barents Sea, so “atlantisation” is one of the key causes of water warming in the Western Arctic (Aksenov and Ivanov, 2018). Thus, there appears a possibility of natural invasion of the Barents Sea by the warm-water tintinnid species.

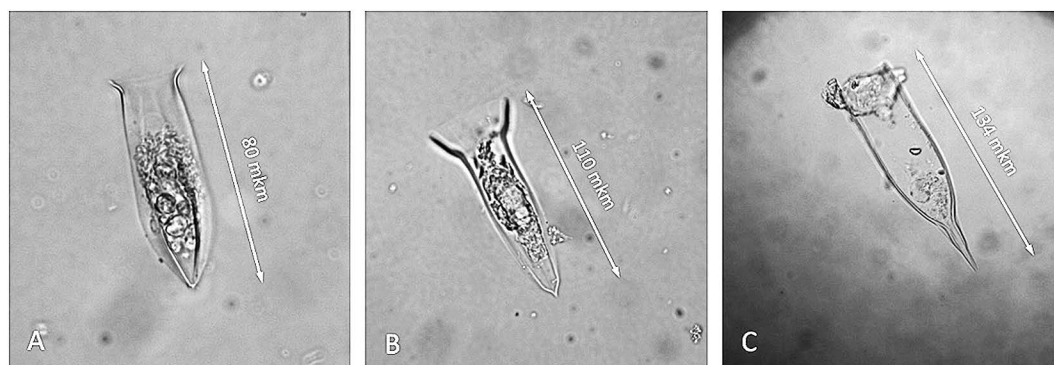


Fig. 1. General view of the Barents Sea tintinnids: *Amphorellopsis tetragona* (A), *Ormosella haeckeli* (B), *Parundella caudata* (C).

Material and methods

To analyze the species composition of tintinnids, we summarized the published data from the XX century until present. In addition, this research bases on the original data from the plankton samples of the Murmansk Marine Biological Institute collected in 2012–2017. The plankton material was collected in the autumn-winter and spring seasons; the sampling area is located in the western part of the Barents Sea: the standard oceanographic section “Kola meridian” (69°30′–77° N, 33°30′ E). Sampling was carried out using a bathometer and plankton net with a mesh size of 30 μm; the obtained samples were concentrated by gentle inverse filtering through a lavsan filter and were fixed in buffered formaldehyde (1% final concentration). A Nageotte counting chamber was used to examine ciliate assemblages. In order to clarify the tissues of the organisms, a hypochlorite solution was applied, followed by heating.

Results and discussion

According to the references, the taxonomic composition of tintinnid ciliates is represented by 20 genera, including 73 species (Table 1). Original data display first appearance of three alien tintinnid species in the Barents Sea region. In 2012–2017, the presence of *Parundella caudata* (Ostenfeld, 1899) Jörgensen, 1924 (Fig. 1C) and *Ormosella haeckeli* Kofoid et Campbell, 1929 (Fig. 1B) (Makarevich and Oleinik, 2017) was confirmed. *Amphorellopsis tetragona* (Jörgensen, 1924) Kofoid et Campbell, 1929 (Fig. 1A) has not been previously noted in the Barents Sea and adjacent waters (Meunier, 1910;

Rossolimo, 1927; Burkovsky et al., 1974; Burkovsky, 1976; Lifshits, 1977; Dolan et al., 2017).

***Amphorellopsis tetragona* (Jörgensen, 1924) Kofoid and Campbell, 1929 (= *Amphorella tetragona* Jörgensen, 1924).**

The species was described in the Mediterranean Sea (Brandt, 1906; Jörgensen, 1924; Zakaria et al., 2007; Dolan, 2016). *A. tetragona* was noted in the Eastern Pacific (Kofoid and Campbell, 1929; Gomez, 2007), in the Marmara (Toklu-Aliçli et al., 2010; Durmus and Balkis, 2014) and the Adriatic (Monti et al., 2012) seas.

In the original description (Kofoid, Campbell, 1929), the genus *Amphorellopsis* included 7 species, which differed mainly in the number and degree of development of the facets and plicae. A key feature that differentiates *A. tetragona* from other species of genus *Amphorellopsis* is four alary plicae and more flaring mouth above fusiform bowl (Kofoid, Campbell, 1929).

***Ormosella haeckeli* Kofoid and Campbell, 1929.**

For the first time, tintinnids of this species were found in the Pacific Ocean: Peruvian and Equatorial Counter Current (Kofoid and Campbell, 1929); date on *O. haeckeli* was included to ciliate fauna of the South Atlantic (Alder, 1999; Dolan and Pierce, 2014). Previously this species was listed for the Barents Sea as *Ormosella* aff. *cornucopia* (Makarevich and Oleinik, 2017).

In the first description, the genus *Ormosella* included 7 species, of which 3 are characterized by common features: contracted bell-shaped lorica; wall of lorica is hyaline without agglutinates; the collar is clearly defined, in the shape of a truncated cone; the aboral part is sharply narrowed. The

Table 1. (Continuation).

Species (according to the a World Register of Marine Species "WoRMS")	Literature source†												Original name in the literature source	
	1	2	3	4	5	6	7	8	9	10	11	12		
<i>Ptychocylis drygalskii</i> Brandt, 1896	+						+							
<i>Ptychocylis minor</i> Gruber, 1879*							+							
<i>Ptychocylis obtusa</i> Brandt, 1906		+		+	+	+	+	+	+	+	+			
<i>Ptychocylis urnula</i> (Claparède et Lachmann, 1858)							+		+		+			
<i>Salpingacantha ampla</i> Kofoid et Campbell, 1929							+							
<i>Salpingacantha undata</i> (Jørgensen, 1899)							+							
<i>Salpingacantha unguiculata</i> (Brandt, 1906) Kofoid et Campbell, 1929							+	+						<i>Salpingella</i> cf. <i>ungiculata</i> (8)
<i>Salpingella acuminata</i> (Claparède et Lachmann, 1858) Jørgensen, 1924	+	+	+	+	+	+	+		+	+				
<i>Salpingella decurtata</i> Jørgensen, 1924							+							<i>Tintinnus acuminatus</i> (1, 9), <i>Salpingella</i> aff. <i>acuminate</i> (10)
<i>Salpingella minutissima</i> Kofoid et Campbell, 1929							+							
<i>Salpingella rotundata</i> (Kofoid et Campbell, 1929)**							+							
<i>Salpingella secata</i> (Brandt, 1896)							+	+						
<i>Steenstrupiella steenstrupii</i> (Claparède et Lachmann, 1858) Kofoid et Campbell, 1929							+							
<i>Stenosemella oliva</i> (Meunier, 1910)		+	+	+	+		+	+						<i>Stenostomella</i> cf. <i>oliva</i> (8)
<i>Stenosemella robusta</i> *		+	+	+	+									
<i>Stenosemella steinii</i> Jørgensen, 1912									+		+			
<i>Stenosemella ventricosa</i> (Claparède et Lachmann, 1858) Jørgensen, 1924							+		+		+			
<i>Tintinnopsis acuta</i> *	+													
<i>Tintinnopsis angusta</i> Meunier, 1910	+													
<i>Tintinnopsis baltica</i> Brandt, 1896							+							
<i>Tintinnopsis beroidea</i> Stein, 1867		+	+		+		+		+		+			
<i>Tintinnopsis campanula</i> Ehrenberg, 1840			+		+				+		+			
<i>Tintinnopsis cylindrica</i> Daday, 1887	+								+					
<i>Tintinnopsis fimbriata</i> Meunier, 1919		+	+		+		+		+					
<i>Tintinnopsis fucus</i> *									+					
<i>Tintinnopsis japonica</i> Hada, 1932		+			+									
<i>Tintinnopsis karajacensis</i> Brandt, 1896							+		+					
<i>Tintinnopsis lata</i> Meunier, 1910	+						+							
<i>Tintinnopsis major</i> Meunier, 1910	+													
<i>Tintinnopsis meunieri</i> Kofoid et Campbell, 1929			+				+							
<i>Tintinnopsis nana</i> Lohmann, 1908			+		+		+		+					
<i>Tintinnopsis nitida</i> Brandt, 1986							+		+					
<i>Tintinnopsis oliva</i> *	+													
<i>Tintinnopsis parvata</i> (Joergensen, 1924)*									+					

Table 1. (Continuation).

Species (according to the a World Register of Marine Species "WoRMS")	Literature source†												Original name in the literature source
	1	2	3	4	5	6	7	8	9	10	11	12	
<i>Tintinnopsis parvula</i> Jörgensen, 1912		+	+		+		+			+			
<i>Tintinnopsis patula</i> Meunier, 1910	+												
<i>Tintinnopsis rapa</i> Meunier, 1910							+						
<i>Tintinnopsis sacculus</i> Brandt, 1896									+		+		
<i>Tintinnopsis sinuata</i> Brandt, 1896							+						
<i>Tintinnopsis tubulosa</i> Levander, 1900									+		+		
<i>Tintinnopsis turbo</i> Meunier, 1919													
<i>Tintinnopsis undella</i> Meunier, 1910		+			+		+						

† Literature sources: 1 – Meunier, 1910; 2 – Burkovsky, 1976; 3 – Lifshits, 1977; 4 – Lifshits, 1978; 5 – Lifshits et al., 1978; 6 – Boltovskoy et al., 1991; 7 – Matishov et al, 2000; 8 – Jensen and Hansen, 2000; 9 – Dvoretzkiy, 2010; 10 – Makarevich and Oleynik, 2017; 11 – Dvoretzkiy and Dvoretzkiy, 2018; 12 – this work. * Species is absent in base of "WoRMS"; ** "nomen dubium"; *** "taxon inquirendum".

researched tintinnids were identified as *O. haeckeli* Kofoid and Campbell, 1929 by 12 longitudinal equal facets on the bowl and pedicel; large collar, clearly prominent from a bowl with an inner nuchal edge (Kofoid and Campbell, 1929).

***Parundella caudata* (Ostenfeld, 1899) Jörgensen, 1924** (= *Tintinnus caudatus* Ostenfeld, 1899; = *Undella* (*Parundella*) *caudata* Jörgensen, 1899).

A typical representative of the ciliate fauna, inhabiting the waters of the South Atlantic (Fernandes, 2004; Thompson and Alder, 2005; Kršinić and Grbec, 2006) and the northern Indian Ocean (Asha Devi et al., 2018); one was found in the Pacific Ocean, the coast of the Philippines and Chile (Fonda Umani et al., 2011; Santiago, 2018). The nearest location to the Barents Sea is North Atlantic, Norwegian, North and Baltic seas (Marshall, 1969; Cordeiro and Sassi, 1997). The earlier information for the presence *P. caudata* in the Barents Sea (Makarevich and Oleinik, 2017) is confirmed by this report.

The first description (Kofoid and Campbell, 1929) included 22 species of the genus *Parundella*, most of which only slightly differed in size, proportions, and general shape of lorica. The investigated tintinnids were assigned to the *Parundella caudata* (Ostenfeld, 1899) Jörgensen, 1924 by a combination indistinct signs (lorica expands slightly below the oral rim, reaching a maximum width in the lower part, then narrows sharply, turning into a long and thin pedicel).

Thus, the found species of tintinnids belong to warm-water fauna. Probably the reason of the atypical finds in the western part of the Barents

Sea is natural invasion through the North Cape Current under the present conditions of temperature fluctuations in this water area. Thereby there is area expansion of ciliate species *A. tetragona*, *O. haeckeli*, *P. caudata* are new for this region in recent years and have a warm-water genesis.

Conclusion

1. The total list of tintinnid composition of the Barents Sea consists of 73 species belongs to 20 genera.

2. *Amphorellopsis tetragona* (Jörgensen, 1924) Kofoid and Campbell, 1929, *Ormosella haeckeli* Kofoid and Campbell, 1929, *Parundella caudata* (Ostenfeld, 1899) Jörgensen, 1924 are new for the Barents Sea and have a warm-water genesis.

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