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Rotifers (Rotifera) from the inland waters and terrestrial habitats of East Antarctic oases (Enderby Land and Prydz Bay)

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Abstract: The paper presents the results of rotiferological studies carried out during the set of the Belarusian Antarctic Expeditions (2007–2017) in East Antarctica (Enderby Land and Prydz Bay). The plankton samples were collected from 52 water bodies (lakes and meltwater ponds), and from terrestrial habitats (lichen fouling, algal mats) from several sites. A total of 20 species were found, 12 of them belonging to Monogononta, 8 – to Bdelloidea. Despite the presence of some cosmopolitan species and Antarctic endemics, the set of species and forms seems to be the firstly noted taxa in East Antarctica.

Key words: Bdelloidea, Monogononta, diversity, Antarctica, Thala Hills, Larsemann Hills

INTRODUCTION

The history of rotifers studies in Antarctica originates in 1900s and is related to registrations of numerous bdelloids (subclass Bdelloidea) from unidentified taxa, which were allocated by F. Richters (1904, 1907) from moss samples. Murray (1910) carried out the pioneer work which contained the information of the newly described species of Antarctic rotifers. There we can gather information about 16 species (12 of them are bdelloids and four are monogononts).

From the beginning of 20th century, the rotifer species list of Antarctic biodiversity realm (i.e. including Maritime Antarctica and Subantarctica) has been increased significantly (Sudzuki 1964; 1979; 1988; Dartnall 1983 and many others). The number of known species is now 153 (Fontaneto et al. 2015b). All these studies were carried out in different types of habitats, both aquatic (inland lakes with different degrees of salinity, meltwater ponds, maritime coastal) and terrestrial (mosses, lichens, and soil). Species composition varies according to type of the habitat, with monogonont species (subclass Monogononta) mostly in planktonic samples and bdelloids primarily in terrestrial habitats. Most of the obtained data are summarized in the set of taxonomy and faunal bulletins (Dartnall 1983, De Paggi & Koste 1984, Sudzuki 1988, Adams et al. 2006; Velasco-Castrillon et al. 2014a and others). Perhaps, the most comprehensive dataset was used in the article of Fontaneto et al. cited above (2015b) which is devoted to analysis of rotifer biogeography patterns in Antarctica. But the survey area is still small in comparison to habitats available on the continent (Convey 2010; Convey et al. 2014), thus we may assume that the rotifer species list in Antarctica will be much bigger.

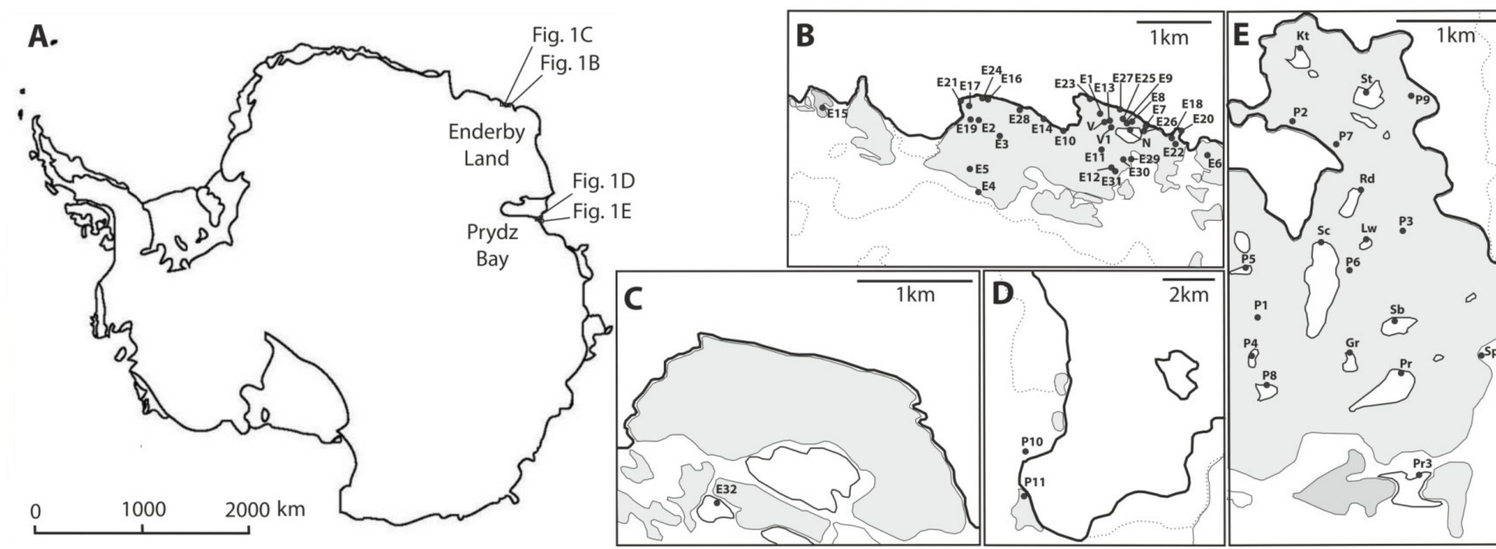

Fig. 1. Study sites. **A** – The location of study areas on the map of Antarctica; **B** – The area of 'Vecherniaya Mount' field base (Thala Hills oasis); **C** – The area of 'Molodiozhnaya' field base (Thala Hills oasis); **D** – The area of 'Druzhniy–4' field base; **E** – The area of 'Progress' station (Larsemann Hills oasis); On **1B–E** the areas without permanent ice cover are in gray.

In accordance with the most recent data related to significant rotifers endemism in Antarctica (Velasco-Castrillon et al. 2014b; Iakovenko et al. 2015) we believe that the researching of these invertebrates at the icebound continent could lead to results of large importance in understanding of distribution, biogeography and evolution of the phylum Rotifera. In that way basic primary studies of the rotifer diversity in different localities of Antarctica are still absolutely needed.

This article contains the results of the research carried out during seasonal Belarusian Antarctic Expeditions (further referred as BAE) collecting both plankton samples and terrestrial substrates in East Antarctica. The analysis of the obtained data concerns both taxonomy and diversity of rotifers (especially those concerning poorly investigated bdelloids) as well as their biogeography.

Materials and Methods

Study sites

All studies were carried out in two regions of East Antarctica: Enderby Land and Prydz Bay. The location of the sampling sites (water bodies and the places of terrestrial substrates picking) is shown on the map (Fig. 1).

Enderby Land. The area around two neighboring Antarctic field bases – 'Vecherniaya Mount' (Belarus) and 'Molodiozhnaya' (Russian Federation) in Thala Hills oasis was investigated. We sampled 33 water bodies within the territory, three of which are being large freshwater lakes and the rest are being small unnamed lakes and meltwater ponds (Fig. 2). In addition to plankton samples, algal and lichen mats from terrestrial habitats were also taken.

Fig. 2. Examples of studied habitats. **A** – Meltwater pond. **B** – Lichen fouling. **C** – Algae *Prasiola crispa*.

Prydz Bay. 19 water bodies were sampled in the area of the Russian station 'Progress' (Larsemann Hills oasis), 10 of which were denominated relatively large freshwater lakes. One bottom organic sediment sample was collected from a completely dried meltwater pond. Several samples (plankton from one lake and lichen fouling) were collected near the field base 'Druzhniy–4' and included to the selected data from Prydz Bay area (see Table 1).

Data collection

All field investigations were carried out during the 1st, 2nd, 4th, 5th, 6th, 8th and 9th BAE, which were implemented in austral summer seasons in the following order: 2007/2008; 2008/2009; 2010/2011; 2012/2013; 2013/2014; 2015/2016; 2016/2017.

Samples of zooplankton were collected with the use of standard hydrobiological procedures (Schwoebler 1972 and others) with plankton nets (diameter of mesh is 45 μm or 20 μm). Samples were collected with the use of different methodologies corresponding to aims of particular collection (depending on aims of an expedition). In the present analysis we showed data revealed from both qualitative and quantitative samples (40, 50, 150, 200 and 400 l); in the second case a recalculation in absolute density indexes (individuals in 100 l^{-1}) for each species found in a sample was made. The material was preserved in 6 % formaldehyde solution. The samples of terrestrial substrates (lichens and algal maths) were collected on rocks and lakeshores by hand-picking. These samples were not preserved to keep alive bdelloid rotifers that cannot be identified after formalin or ethanol fixation.

All samples were delivered at the Scientific and Practical Center for Bioresources of the National Academy of Sciences of Belarus (further referred as SPC for Bioresourses) Minsk city, Belarus.

Table 1. List of samples examined.

Studies in **Enderby Land**				
Sign	Type	Habitat	Coordinates	Date of sampling
V	Plankton	Lake Verhnee	67.655639^0 S 46.152056^0 E	Jan 2008
V’	Plankton	Lake Verhnee	67.655694^0 S 46.152056^0 E	Jan 2011
V’’	Plankton	Lake Verhnee	67.655694^0 S 46.152056^0 E	Dec 2012, Jan 2013
V’’’	Plankton	Lake Verhnee	67.655667^0 S 46.152056^0 E	Jan 2016
V1	Plankton	Lake Verhnee-1	67.656278^0 S 46.154944^0 E	Dec 2012, Jan 2013
N	Plankton	Lake Nizhnee	67.656361^0 S 46.160528^0 E	Jan 2008
N’’	Plankton	Lake Nizhnee	67.656222^0 S 46.160444^0 E	Jan 2016
E1	Plankton	Lake (innom.)	67.655056^0 S 46.151917^0 E	Dec 2012, Jan 2013
E2	Plankton	Lake (innom.)	67.654417^0 S 46.110250^0 E	Jan 2013
E3	Plankton	Lake (innom.)	67.655028^0 S 46.117417^0 E	Jan 2013
E4	Plankton	Meltwater pond	67.661889^0 S 46.109556^0 E	Jan 2013
E5	Plankton	Meltwater pond	67.659639^0 S 46.107167^0 E	Jan 2013
E6	Plankton	Meltwater pond	67.659694^0 S 46.185472^0 E	Jan 2013
E7	Plankton	Meltwater pond	67.655722^0 S 46.161278^0 E	Feb 2013
E8	Plankton	Meltwater pond	67.655722^0 S 46.160056^0 E	Feb 2013
E9	Plankton	Meltwater pond	67.655472^0 S 46.156722^0 E	Feb 2013
E10	Plankton	Meltwater pond	67.656861^0 S 46.140722^0 E	Feb 2013
E11	Plankton	Meltwater pond	67.659167^0 S 46.151750^0 E	Feb 2013
E12	Plankton	Meltwater pond	67.659972^0 S 46.154583^0 E	Feb 2013
E13	Plankton	Lake (innom.)	67.655667^0 S 46.151683^0 E	Jan 2009
E14	Plankton	Lake (innom.)	67.654850^0 S 46.132950^0 E	Jan 2009
E15	Plankton	Lake (innom.)	67.653633^0 S 46.059733^0 E	Jan 2009
E16	Plankton	Lake (innom.)	67.651717^0 S 46.112767^0 E	Jan 2009
E17	Plankton	Meltwater pond	67.652783^0 S 46.107000^0 E	Jan 2009
E18	Plankton	Lake (innom.)	67.656850^0 S 46.175167^0 E	Jan 2009
E19	Plankton	Lake (innom.)	67.654717^0 S 46.110283^0 E	Feb 2009
E20	Plankton	Meltwater pond	67.654467^0 S 46.176983^0 E	Jan 2009
E21	Plankton	Meltwater pond	67.652400^0 S 46.105983^0 E	Jan 2009
E22	Plankton	Lake (innom.)	67.656850^0 S 46.175167^0 E	Jan 2009
E23	Plankton	Meltwater pond	67.652200^0 S 46.147533^0 E	Jan 2009
E24	Plankton	Lake (innom.)	67.651867^0 S 46.113617^0 E	Jan 2009
E25	Plankton	Lake (innom.)	67.655433^0 S 46.156350^0 E	Feb 2009
E26	Plankton	Lake (innom.)	67.653917^0 S 46.156783^0 E	III 2009
E27	Plankton	Lake (innom.)	67.657050^0 S 46.161950^0 E	III 2009
E28	Lichen	Fouling on stone	67.653567^0 S 46.123683^0 E	Jan 2009
E29	Algal math	Lake shore	67.658776^0 S 46.159734^0 E	Jan 2013
E30	Plankton	Meltwater pond	67.658444^0 S 46.157833^0 E	Jan 2016
E31	Plankton	Meltwater pond	67.659944^0 S 46.154389^0 E	Jan 2016
E32	Plankton	Lake (innom.)	67.667434^0 S 45.852946^0 E	Jan 2008
Studies in **Prydz Bay**				
Sign	Type	Habitat	Coordinates	Date of sampling
Gr	Plankton	Lake Gornoe	69.398733^0 S 76.376533^0 E	Jan 2014
Kt	Plankton	Lake Kitayskoe	69.377533^0 S 76.375917^0 E	Jan 2014
Lw	Plankton	Lake Law	69.388900^0 S 76.382250^0 E	Jan 2014
Pr	Plankton	Lake Progress	69.400450^0 S 76.407717^0 E	Jan 2014

Pr3	Plankton	Lake Progress-3	69.412067^0 S 76.403033^0 E	Jan 2014
Rd	Plankton	Lake Reid	69.386833^0 S 76.376833^0 E	Jan 2014
Sp	Plankton	Lake Serpe	69.400000^0 S 76.408967^0 E	Jan 2014
Sb	Plankton	Lake Sibthorpe	69.395650^0 S 76.398283^0 E	Jan 2014
Sc	Plankton	Lake Scandrett	69.389717^0 S 76.369533^0 E	Jan 2014
St	Plankton	Lake Stepped	69.375000^0 S 76.385000^0 E	Jan 2014
St'	Plankton	Lake Stepped	69.375000^0 S 76.385000^0 E	Feb 2011
P1	Plankton	Lake (innom.)	69.396906^0 S 76.355166^0 E	Jan 2011
P2	Plankton	Lake (innom.)	69.378638^0 S 76.365493^0 E	Jan 2011
P3	Plankton	Lake (innom.)	69.388991^0 S 76.389154^0 E	Jan 2011
P4	Plankton	Lake (innom.)	69.398946^0 S 76.354684^0 E	Jan 2011
P5	Plankton	Lake (innom.)	69.391896^0 S 76.350283^0 E	Jan 2011
P6	Plankton	Lake (innom.)	69.392361^0 S 76.376957^0 E	Jan 2011
P7	Plankton	Lake (innom.)	69.380373^0 S 76.373553^0 E	Jan 2011
P8	Plankton	Lake (innom.)	69.402023^0 S 76.358659^0 E	Jan 2011
P9	Dry organic sediments	Dry bottom of the pond	69.375539^0 S 76.394536^0 E	Feb 2017
P10	Plankton	Lake (innom.)	69.730995^0 S 73.707651^0 E	Jan 2011
P11	Lichen	Fouling on stone	69.741359^0 S 73.709155^0 E	Jan 2011

Sample processing and species identification

Plankton processing included a detailed examination of an extra concentrated sample (from entire sample volume to approximately 100 ml) in a counting chamber or Petri dish with the use of a binocular microscope (Leica MZ12 and others) to find rotifers. A similar procedure was done in case of terrestrial substrates processing: searching of individuals was carried out in a piece of substrate placed into the Petri dish with distilled water.

The specimens found in samples (fixated in plankton samples and alive in terrestrial substrates) later were moved on a slide and examined under magnification not less than ×40 (×100 and ×200 were preferred) using the light microscopes (Micros, Jenaval and others). Periodically chlorine-containing reagents were used to dissolve soft body of a rotifer and to make details of trophi (sclerotized jaws) visible.

Microphotographs obtained by various cameras (Microscope VISION, AxioCAM) served as confirmative data and also for morphometric analysis which was performed according to recently developed method (Iakovenko et al. 2013). There were measured in µm: total length (TL), greatest trunk width (BW), head length (HL), collar width (HW), rump length (RL), largest rump width (RW), foot length (FL), foot maximal width (FW), ramus length (RaL), neck length (NL), spur length (SL), spur-bearing pseudosegment width (SSW). The ratio (%) of these dimensions was used for body proportion assessment.

The main keys and notes we applied for species identification were: Nogrady et al. 1995; De Smet and Poirrot 1997; Kutikova 1970; Kutikova 1991; Kutikova 2005; Donner 1965; Shiel 1995; Dartnall and Hollowday 1985. We used recent article focused on the taxonomy revise of Antarctic bdelloids (Iakovenko et al. 2015) and some other articles which include species descriptions (Meksuwan et al. 2013).

All samples, specimens and the bank of photo data are stored in collections SPC for Bioresourses.

RESULTS

All rotifer specimens found in Antarctic water bodies and terrestrial substrates during our studies belong to 20 identified species (including several valid infraspecific taxa).

The list of all species is ordered according to taxonomy used in Rotifer World Catalog (Jersabek & Leitner 2013). We give the original names, synonyms and the appropriate references to sources and the corresponding identification keys. Our taxonomic notes are provided to clarify some ambiguities in the identification of species[1].

Kingdom Animalia Linnaeus, 1758
Subkingdom Eumetazoa Buetschli, 1910
Superphylum Platyzoa Cavalier-Smith, 1998
Phylum Rotifera Cuvier, 1910
Class Eurotatoria De Ridder, 1957

Subclass Bdelloidea Hudson & Gosse, 1886
Order Adinetida Melone & Ricci, 1995
Family Adinetidae Bryce, 1910
Genus *Adineta* Hudson & Gosse, 1886

Adineta editae Iakovenko, 2015

Adineta editae Iakovenko 2015: 15.
Adineta gracilis Janson, 1893: 77 – Dartnall & Hollowday 1985: 30, Donner 1965: 274, Kutikova 2005: 271

Notes. Based on the external morphology, we firstly considered these *Adineta* representatives with rostrum lamella not divided into lobes and without filamentous bristles as *Adineta gracilis,* which seemed quite fair. Despite the fact that the species was already recorded in Antarctica (Murray 1910; Sudzuki 1964; Sohlenius et al. 1996; Sohlenius & Boström 2005), its taxonomy has recently become the subject of lively discussion. Especially after Iakovenko et al. (2015), who, using mitochondrial DNA sequencing, morphometry and analysis of masticatory apparatus, suggested to revise most of all Antarctic *Adineta gracilis* recorded in earlier taxonomic works as was the case with *A. editae* Iakovenko, 2015. After the publication of the above quoted work and after the consultation with its author (N.S. Iakovenko) our identification of *Adineta gracilis* has changed, and we reconsidered the species as *Adineta editae.* The main features, that settled our diagnosis and allowed to distinguish *A. editae* from *A. gracilis* were the following traits: (1) larger size (more than 300 μm), (2) relatively massive and wide trunk, (3) absence of the head elongation in the direction from the distal to the proximal.

Adineta cf. grandis Murray, 1910
(Fig. 3A)

Adineta grandis Murray, 1910: 51 – Dartnall & Hollowday 1985: 33, Donner 1965: 273, Kutikova 2005: 275, Iakovenko et al. 2015: 20

Notes. The following traits of *A. grandis* we considered as specific for the species: (1) vivacity and (2) very large sizes of the body (up to 500 μm and even higher) and trophi (up to 30 μm). Hundreds of such individuals (up to approximately 800 per 100 mg of substrate) that had other features of *A. grandis* i.e. colored in orange, reddish or brownish, relatively short foot, rostrum lamella divided in two lobes (Fig. 3A1–4) were found in dry organic sediments. It is worth noting that the obtained body measurements for *A. grandis* strongly coincide with data

[1] Due to rotifer's microscopic size, dormant stage and existing of cryptic species the taxonomic studies in this animal group are extremely complicated. Some doubts may be possibly explained by molecular methods and the detail analysis of the microstructure of trophi (Fontaneto et al. 2009).

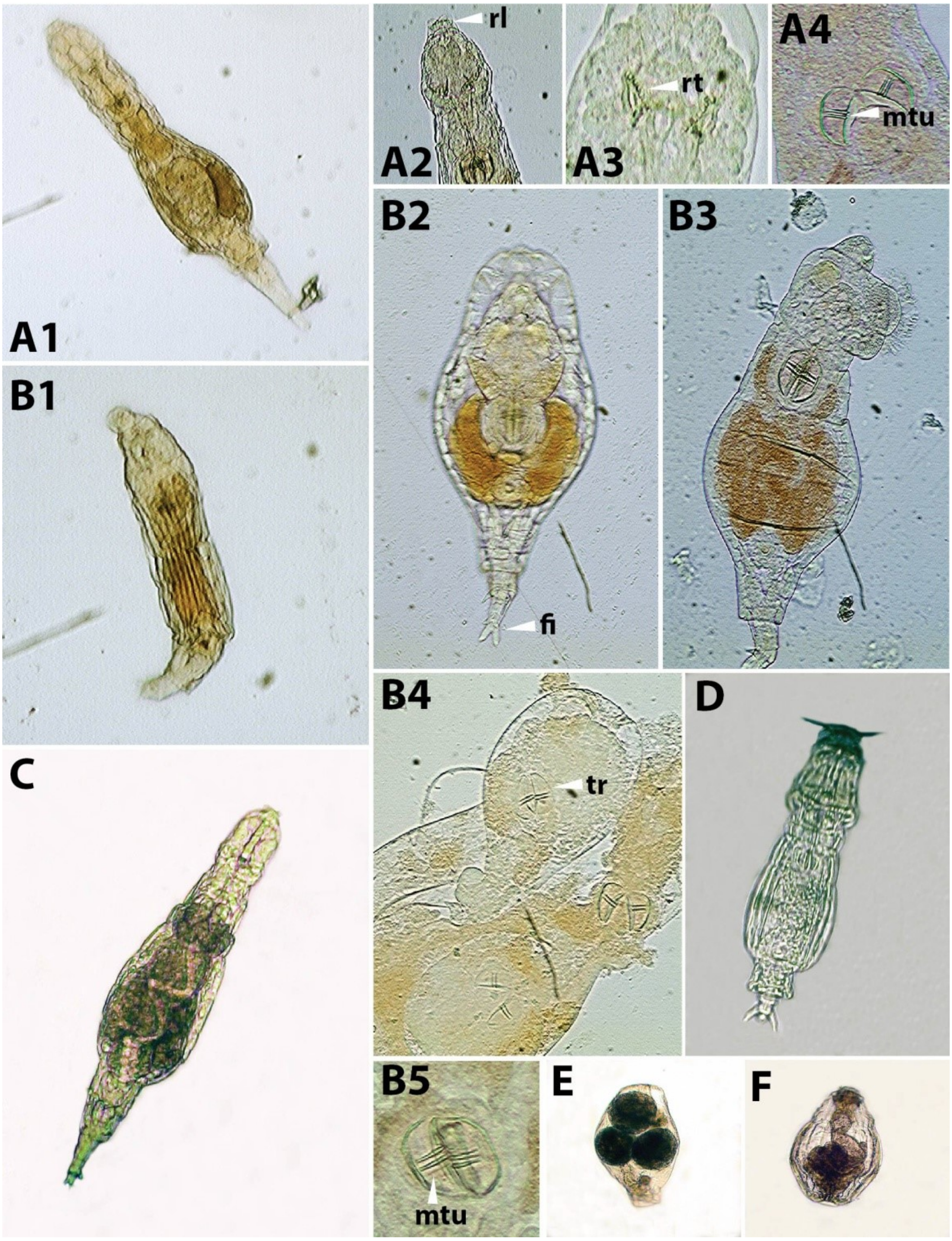

Fig. 3. Rotifers of Bdelloidea subclass. **A** – *Adineta cf. grandis* Murray, 1910: **A1** – dorsal view, **A2** – head, **A3** – fragment of head of the pressed specimen, **A4** – masticatory apparatus. **B** – *Philodina gregaria* Murray, 1910: **B1** – lateral view, **B2** – dorsal view of the pressed specimen, **B3** – dorsal view of the pressed specimen with semi-spread corona, **B4** – three embryos from one maternal specimen, **B5** – masticatory apparatus. **C** – *Adineta cf. vaga vaga* (Davis, 1873). **D** – *Adineta steineri* Bartoš, 1951. **E**, **F –** Unidentified bdelloid rotifers in contracted shape (examples); **mtu** – major teeth in unci; **rl** – rostrum lamella; **rt** – rake teeth; **fi** – fingers; **tr** – trophi.

from a completely different location of Antarctica – Cape Royds (type locality) and Antarctic Peninsula. Absolutely all ratio indices were within the range indicated for *A. grandis* from other regions (Table 2). All this supports the unambiguity of this identification; still the cryptic species *A. fontanetoi* Iakovenko et al., 2015 should not be excluded. This species has the same external morphology as *A. grandis* and the differences may be found only at the molecular level or in slightly larger sizes of trophi. In this way, we have no choice except to consider this species as *A*. cf. *grandis*.

***Adineta steineri* Bartoš, 1951**
(Fig. 3D)

Adineta steineri Bartoš 1951: 478 – Donner 1965: 270, Kutikova 2005: 271

Notes. The species is easily identifiable because of long bristles on the trunk (Fig. 3D). *A. steineri* is widely distributed outside Antarctica, but was found at the continent, too (Sohlenius et al. 1996; Sohlenius & Boström 2005).

***Adineta cf. vaga vaga* (Davis, 1873)**
(Fig. 3C)

Callidina vaga Davis 1873: 201
Adineta vaga – Donner 1965: 295, Kutikova 2005: 275

Notes. This morphospecies was identified as typical form of the *Adineta vaga* (Davis, 1873), which is the very common oviparous species characterized by rostrum with two lobes bearing not bristles but only very short cilia (Fig. 3C). Iakovenko et al. (2015) pointed that newly described *A. emsliei* Iakovenko et al., 2015 strongly resembles *A. vaga.* However, the registered morphospecies (1) was colourless, not bright orange or brown; (2) has triangular simple spurs, not needle-formed based on bulbs. These diagnostic peculiarities approached the observed rotifers much closer to *A. vaga* and distingushed them from *A. emsliei*. However, the morphometric analysis shows the similarity with *A. emsliei* in basic proportions of the head, body and foot. Also the rump of the species is rather long but narrower (Table 2). Obviously, for more correct comparison, more data (measured individuals) are needed.

***Adineta cf. vaga minor* Bryce, 1893**

Adineta vaga minor Bryce 1893: 146 – Donner 1965: 274, Kutikova 2005: 275.

Notes. As with *Adineta* cf. *vaga vaga,* the identification of another form of the species was ambiguous. Due to the smaller sizes (250–300 µm), the 'subtle' exterior and smooth transition from the posterior end of the trunk to the preanal segment, the morphospecies was considered *A. vaga minor* Bryce, 1893.

Order Philodinida Melone & Ricci, 1995
Family Philodinidae Harring, 1913
Genus *Macrotrachela* Milne, 1886

***Macrotrachela kallosoma* (Schulte, 1954)**

Mniobia kallosoma Schulte 1954: 606
Macrotrachela kallosoma – Donner 1965: 151, Kutikova 2005: 142

Genus Philodina Ehrenberg, 1830

Philodina alata Murray, 1910

Philodina alata Murray 1910: 46 – Donner 1965: 207, Kutikova 1991: 93, 95, Kutikova 2005: 207

Notes. All individuals in plankton samples are contracted but could be identified by two characteristic lateral appendages.

Philodina gregaria Murray, 1910
(Fig. 3B)

Philodina gregaria Murray, 1910: 42 – Dartnall & Hollowday 1985: 33, Donner 1965: 202, Kutikova 2005: 221

Table 2. Body dimensions (Mean±SD) and proportions (Min–Max) of the bdelloid species: comparison of data obtained with literature data (cases of maximum coincidence are in bold)

Parameter	*Adineta grandis* Present study	*Adineta grandis* Iakovenko et al., 2015	*Adineta vaga / Adineta emsliei* Present study	*Adineta vaga / Adineta emsliei* Iakovenko et al., 2015
Measures, μm				
TL	465±22	414±61	310	294±44
BW	108±2	94±22	71	69±15
HL	68±5	70±9	46.5	49±8
HW	**58±4**	**56±7**	37.2	39+5
NL	72±5	82±19	40	50±10
RL	**57±2**	**52±10**	53	41±8
RW	**47±2**	**46±10**	36.5	35±7
FL	**51±4**	**52±12**	43.5	36±5
SL	13	11±2	-	7±1
SSW	16	13±2	-	9±1
RaL	27.8±1.5	25.4±1	16.5	15.7±2
Proportions, %				
HL / TL	13	13–19	15	13–18
HW / HL	77–94	66–97	80	71–94
NL / TL	15–16	11–27	13	14–21
BW / TL	22–24	16–31	23	19–27
RL / TL	11–12	7–16	17	11–16
RW / RL	83–84	74–103	69	74–98
FL / TL	10–11	6–15	14	10–16
FW / FL	50–52	40–56	-	29–45
SL / SSW	81	60–98	-	60–94

Subclass Monogononta Plate, 1889
Order Collothecaceae Harring, 1913
Family Collothecidae Harring, 1913
Genus Collotheca Harring, 1913

Collotheca ornata (Ehrenberg, 1832)

(Fig. 4B)

Froscularia ornata Ehrenberg 1832: 146.
Collotheca ornata – Kutikova 1970: 688, Meksuwan et al. 2013: 13, Shiel 1995: 33

Notes. Despite the fact that *C. ornata cornuta* is considered more typical of Antarctica (Dougherty & Harris 1963, Dartnall 1995, 2000 and others), we considered the collected individuals to be representative of the typical species *C. ornata* due to the lack of a specific worm-like appendage on the spinal blade.

Order Ploima Hudson&Gosse, 1886
Family Brachionidae Ehrenberg, 1838
Genus Kellicottia Ahlstrom, 1938

Kellicottia longispina (Kellicott, 1879)

Anuraea longispina Kellicott 1879: 19
Kellicottia longispina – Kutikova 1970: 613

Genus Keratella Bory de St. Vincent, 1822

Keratella cochlearis (Gosse, 1851)

Anuraea cochlearis Gosse 1851: 202
Keratella cochlearis – Kutikova 1970: 600, Shiel 1995: 70

Keratella tecta (Gosse, 1851)

Anuraea tecta Gosse 1851: 202
Keratella cochlearis tecta – Kutikova 1970: 603
Keratella tecta – Shiel 1995: 70

Genus Notholca Gosse, 1886

Notholca verae Kutikova, 1958
(Fig. 4E)

Notholca verae Kutikova 1958: 45 – Kutikova 1970: 618, 623, Kutikova 1991: 94

Family Dicranophoridae Harring, 1913
Genus Encentrum Ehrenberg, 1838

Encentrum saundersiae (Hudson, 1885)

Taphrocampa saundersiae Hudson 1885: 614
Encentrum (Parencentrum) saundersiae – Kutikova 1970: 410
Encentrum saundersiae – De Smet & Pourriot 1997: 164

Family Epiphanidae Harring, 1913
Genus Epiphanes Ehrenberg, 1832

Epiphanes senta (Müller, 1773)
(Fig. 4C)

Vorticella senta Müller 1773: 109
Epiphanes senta – Dartnall & Hollowday 1985: 6, Kutikova 1970: 507, Shiel 1995: 62

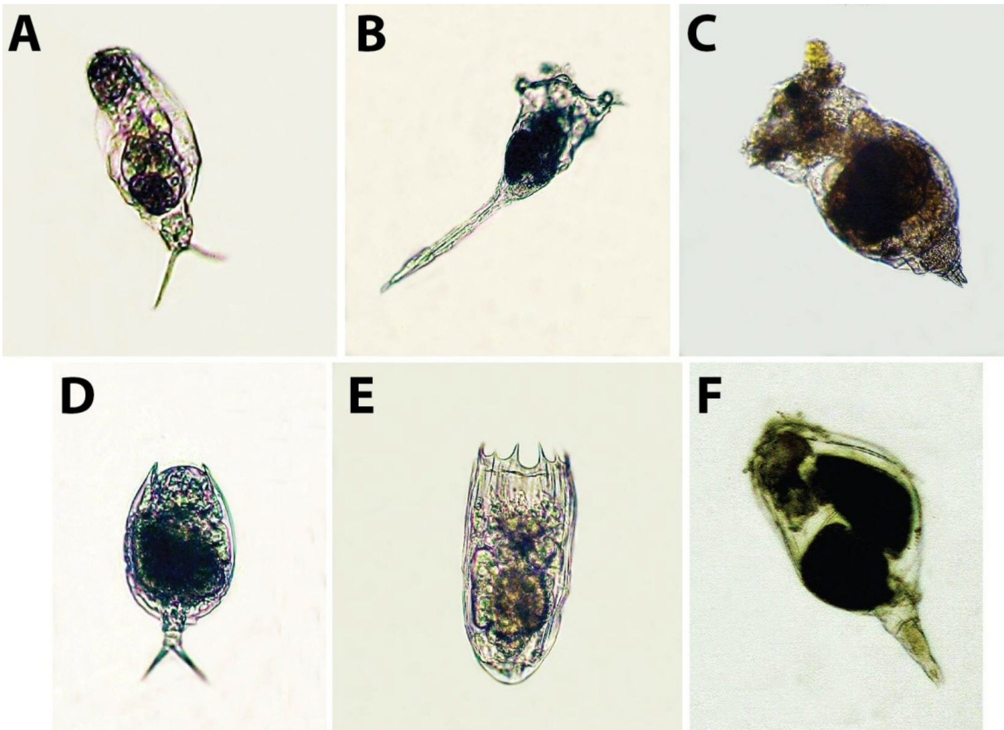

Fig. 4. Rotifers of Monogononta subclass. **A** – *Cephalodella forficata* (Ehrenberg, 1832); **B** – *Collotheca ornata* (Ehrenberg, 1832); **C** – *Epiphanes senta* (Müller, 1773); **D** – *Lepadella patella* (Müller, 1773); E – *Notholca verae* Kutikova, 1958; **F** – *Resticula gelida* (Harring & Myers, 1924).

Genus Rhinoglena Ehrenberg, 1853

Rhinoglena cf. frontalis Ehrenberg, 1853

Rhinoglena frontalis Ehrenberg 1853: 190 – Kutikova 1970: 504, Shiel 1995: 63

Notes. The identification raised some doubts because other representatives of the genus – *Rhinoglena fertoeensis* (Varga, 1929) and recently described *Rh. kutikovae* De Smet, 2008 – also inhabit East Antarctica, Bunger Hills oasis (Kutikova 1958, 1991, De Smet & Gibson 2008). Especially, we did not observe trophi of the collected *Rhinoglena* individuals; hence, we should determine the species as '*Rhinoglena* cf. *frontalis*'.

Family Lepadellidae Harring, 1913

Genus Lepadella Bory de St. Vincent, 1826

Lepadella patella (Müller, 1773)
(Fig. 4D)

Brachionus patella Müller 1773: 341
Lepadella patella – Kutikova 1970: 550, Kutikova 1991: 93

Family Notommatidae Hudson & Gosse, 1886

Genus Cephalodella Bory de St. Vincent, 1826

***Cephalodella forficata* (Ehrenberg, 1832)**
(Fig. 4A)

Notommata forficata Ehrenberg 1832: 134
Cephalodella forficata – Dartnall & Hollowday 1985: 16, Kutikova 1970: 262, Nogrady et al. 1995: 76

***Cephalodella sterea* (Gosse, 1887)**

Furcularia sterea Gosse 1887: 864
Cephalodella sterea – Kutikova 1970: 238, Kutikova 1991: 87, 93, Nogrady et al. 1995: 127

Genus Resticula Harring & Myers, 1924

***Resticula gelida* (Harring & Myers, 1924)**
(Fig. 4F)

Eosphora gelida Harring & Myers 1922: 642
Resticula gelida – Dartnall & Hollowday 1985: 21, Kutikova 1970: 288, Nogrady et al. 1995: 213

Discussion

The rotifer diversity in analyzed plankton samples can be characterized as poor: 12 monogonont species and one valid bdelloid species (*Philodina alata* Murray, 1910) both in lakes and meltwater ponds (Table 3). The maximal numbers of species (if consider also gen. sp.) per water body are 7 and 5 (both for Lake Steppet, Larsemann Hills), but almost all other water bodies contain only one or two identified species (Table 3). According to some published data (Dartnall 1995, Ellis-Evans et al. 1998) inland waters of Antarctica are very sparsely populated with zooplankton community including rotifers. Some authors (Sharov et al. 2015) even assert the fragmentariness and 'lopped' character of trophic webs in the pelagic of Antarctic water bodies. Thus, the observed scarcity of rotifer species recorded during the present study seems to be quite expected. Additionally, rotifers were absent in several meltwater ponds and lakes in both examined regions; these water bodies were not included to the diversity analysis (neither shown in Table 3).

Regarding the bdelloids found in four distinct habitats, 7 species were recorded which is comparable with the whole number of planktonic rotifers (13) from dozens of sampled water bodies. On the other hand, numerous contracted bdelloids were found in plankton samples, too (Table 3). Somewhere (lakes Verhnee-1, Progress, Progress-3, Serpe, Sibthorpe, E2, E3, E16, meltwater ponds E4, E5, E6, E7, E20, and others) bdelloids consisted 100 % from all rotifers in the plankton. As already mentioned above, in many cases contracted bdelloid individuals were identified as *Philodina alata*. The identification to the level of genus of some non-active specimens with typical features for Bdelloidea (ramate mastax, foot with two spurs, etc.) was possible due to an adhesive plate instead of toes that are typical to the genus *Mniobia* (Table 3). Other planktonic bdelloids remained unidentified. Additionally, in both aquatic and terrestrial systems some another rotifers with the typical *Adineta* morphology were found (flattered body, oval head wider than neck, very short rostrum, corona looks like the simple ciliate field on the ventral side of head, thin foot etc.). Number of U-shaped teeth on the grasping apparatus of these rotifers was not established as well as presence / absence of long bristles and the shape of lamella on the rostrum. This species is shown in Table 3 as *Adineta* sp.

Table 3. Species diversity with relative abundance (%) of rotifers in samples collected in Eastern Antarctic oases

Studies in **Enderby Land**																				
Taxon	**V**	**V'**	**V''**	**V'''**	**V1**	**N**	**N'**	**N''**	**E1**	**E2**	**E3**	**E4**	**E5**	**E6**	**E7**	**E8**	**E9**	**E10**	**E11**	**E12**
SUBLASS BDELLOIDEA																				
FAMILY ADINETIDAE																				
Adineta cf. *grandis* Murray, 1910																				
Adineta editae Iakovenko, 2015																				
Adineta steineri Bartoš, 1951																				
Adineta cf. *vaga* (Davis, 1873)																				
Adineta cf. *vaga minor* (Bryce, 1893)																				
Adineta sp.																				
FAMILY PHILODINIDAE																				
Macrotrachela kallosoma (Schulte, 1954)																				
Mniobia sp.																				
Philodina alata Murray, 1910			9				50							17		<1		3	100	100
Philodina gregaria Murray, 1910																				
Bdelloidea sp.	53		89	96	100	91	50	100	97	100	100	100	100	83	100	98	100	96		
SUBCLASS MONOGONONTA																				
FAMILY COLLOTHECIDAE																				
Collotheca ornata (Ehrenberg, 1832)																				
FAMILY BRACHIONIDAE																				
Kellicottia longispina (Kellicott, 1879)	33																			
Keratella cochlearis (Gosse, 1851)						9														
Keratella tecta (Gosse, 1851)	13																			
Notholca verae Kutikova, 1958																				
FAMILY DICRANOPHORIDAE																				
Encentrum saundersiae (Hudson, 1885)																				
FAMILY EPIPHANIDAE																				
Epiphanes senta (Müller, 1773)			<1						<1											
Rhinoglena cf. *frontalis* Ehrenberg, 1853																				
FAMILY LEPADELLIDAE																				
Lepadella patella (Müller, 1773)		100	<1	4					3											
FAMILY NOTOMMATIDAE																				
Cephalodella forficata (Ehrenberg, 1832)																				
Cephalodella sterea (Gosse, 1887)																<1				
Resticula gelida (Harring & Myers, 1922)																				
TOTAL NUMBER OF TAXA	**3**	**1**	**4**	**2**	**1**	**2**	**2**	**1**	**3**	**1**	**1**	**1**	**1**	**2**	**1**	**3**	**1**	**2**	**1**	**1**
TOTAL ABUNDANCE, IND·100 L^{-1}	**-**	**-**	**94**	**14**	**4.5**	**-**	**<1**	**1**	**1063**	**9.5**	**4**	**<1**	**<1**	**3**	**11**	**89**	**83**	**29**	**11**	**6**

Studies in **Enderby Land (continuation)**

Taxon	**E13**	**E14**	**E15**	**E16**	**E17**	**E18**	**E19**	**E20**	**E21**	**E22**	**E23**	**E24**	**E25**	**E26**	**E27**	**E28**	**E29**	**E30**	**E31**	**E32**
SUBLASS BDELLOIDEA																				
FAMILY ADINETIDAE																				
Adineta cf. *grandis* Murray, 1910																				
Adineta editae Iakovenko, 2015																	9			
Adineta steineri Bartoš, 1951																100				
Adineta cf. *vaga* (Davis, 1873)																	48			
Adineta cf. *vaga minor* (Bryce, 1893)																	14			
Adineta sp.		20								100							19			
FAMILY PHILODINIDAE																				
Macrotrachela kallosoma (Schulte, 1954)																	5			
Mniobia sp.																	5			
Philodina alata Murray, 1910																				
Philodina gregaria Murray, 1910																				
Bdelloidea sp.	86	80	100	100	100	98	100	100	99		100	99	75	100	100			100	100	67
SUBCLASS MONOGONONTA																				
FAMILY COLLOTHECIDAE																				
Collotheca ornata (Ehrenberg, 1832)																				8
FAMILY BRACHIONIDAE																				
Kellicottia longispina (Kellicott, 1879)																				25
Keratella cochlearis (Gosse, 1851)	7												25							
Keratella tecta (Gosse, 1851)																				
Notholca verae Kutikova, 1958																				
FAMILY DICRANOPHORIDAE																				
Encentrum saundersiae (Hudson, 1885)									<1											
FAMILY EPIPHANIDAE																				
Epiphanes senta (Müller, 1773)																				
Rhinoglena cf. *frontalis* Ehrenberg, 1853	7					2						<1								
FAMILY LEPADELLIDAE																				
Lepadella patella (Müller, 1773)																				
FAMILY NOTOMMATIDAE																				
Cephalodella forficata (Ehrenberg, 1832)																				
Cephalodella sterea sterea (Gosse, 1887)																				
Resticula gelida (Harring & Myers, 1922)																				
TOTAL NUMBER OF TAXA	**3**	**2**	**1**	**1**	**1**	**2**	**1**	**1**	**2**	**1**	**1**	**2**	**1**	**1**	**1**	**1**	**6**	**1**	**1**	**3**
TOTAL ABUNDANCE, IND· L^{-1}	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**<1**	**2**	**-**

Studies in Prydz Bay																						
Taxon	**Gr**	**Kt**	**Lo**	**Pr**	**Pr3**	**Rd**	**Sp**	**Sb**	**Sc**	**St**	**St'**	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**	**P10**	**P11**
SUBLASS BDELLOIDEA																						
FAMILY ADINETIDAE																						
Adineta editae Iakovenko, 2015																						74
Adineta cf. *grandis* Murray, 1910																				60		
Adineta cf. *vaga* (Davis, 1873)																						
Adineta cf. *vaga minor* (Bryce, 1893)																						
Adineta steineri Bartoš, 1951																						
Adineta sp.																						26
FAMILY PHILODINIDAE																						
Macrotrachela kallosoma (Schulte, 1954)																						
Mniobia sp.																						
Philodina alata Murray, 1910																3					6	
Philodina gregaria Murray, 1910																				40		
Bdelloidea sp.	100	30	67	100	100	69	100	100	100	94	20	54	96	80	100	97	4	100	95		94	
SUBCLASS MONOGONONTA																						
FAMILY COLLOTHECIDAE																						
Collotheca ornata (Ehrenberg, 1832)											<1											
FAMILY BRACHIONIDAE																						
Kellicottia longispina (Kellicott, 1879)																						
Keratella cochlearis (Gosse, 1851)																						
Keratella tecta (Gosse, 1851)																						
Notholca verae Kutikova, 1958						17				<1	78						14		2			
FAMILY DICRANOPHORIDAE																						
Encentrum saundersiae (Hudson, 1885)													2									
FAMILY EPIPHANIDAE																						
Epiphanes senta (Müller, 1773)		70	10			13				2	2	46		20			82		3			
Rhinoglena cf. *frontalis* Ehrenberg, 1853																						
FAMILY LEPADELLIDAE																						
Lepadella patella (Müller, 1773)			23			<1				<1	<1		2									
FAMILY NOTOMMATIDAE																						
Cephalodella forficata (Ehrenberg, 1832)											<1											
Cephalodella sterea sterea (Gosse, 1887)																						
Resticula gelida (Harring & Myers, 1922)										1	<1											
TOTAL NUMBER OF TAXA	**1**	**2**	**3**	**1**	**1**	**4**	**1**	**1**	**1**	**5**	**7**	**2**	**3**	**2**	**1**	**2**	**3**	**1**	**3**	**2**	**2**	**2**
TOTAL ABUNDANCE, IND·100 L^{-1}	**1018**	**142**	**25.3**	**37**	**4**	**75.6**	**7.5**	**9**	**1738**	**355**	**135000**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**55**	**-**

Table 4. Comparison of the data obtained with the earlier published evidences.

Taxon	References in which the taxa are listed†	Regions outside Antarctica where the taxa are found in (according to [16])
SUBCLASS BDELLOIDEA		
FAMILY ADINETIDAE		
Adineta editae Iakovenko, 1893	6, 10, 18, 19, 22‡	-
Adineta cf. *grandis* Murray, 1910	4, 7, 14, 15, 20, 23	Afr, Pal (?) §
Adineta steineri Bartoš, 1951	18, 19	Aus, Nea, Neo, Pal
Adineta cf. *vaga vaga* (Davis, 1873)	10, 14, 18, 19, 24	Afr, Aus, Ind, Nea, Neo, Pal
Adineta cf. *vaga minor* (Bryce, 1893)	-	Aus, Ind, Nea, Pal
FAMILY PHILODINIDAE		
Macrotrachela kallosoma (Schulte, 1954)	-	Aus, Neo, Pal
Philodina alata Murray, 1910	2, 5, 7, 9, 11, 12, 14, 24	-
Philodina gregaria Murray, 1910	1, 2, 4, 7, 8, 14, 15, 21, 24	-
SUBCLASS MONOGONONTA		
FAMILY COLLOTHECIDAE		
Collotheca ornata (Ehrenberg, 1832)	1, 4, 5, 7, 11, 12, 14	Cosmopolitan
FAMILY BRACHIONIDAE		
Kellicottia longispina (Kellicott, 1879)	9	Afr, Ind, Nea, Neo, Pal
Keratella cochlearis (Gosse, 1851)	5, 9, 13	Afr, Aus, Ind, Nea, Neo, Pal
Keratella tecta (Gosse, 1851)	-	Afr, Aus, Ind, Nea, Neo, Pal
Notholca verae Kutikova, 1958	3 (?), 8, 11, 12	-
FAMILY DICRANOPHORIDAE		
Encentrum saundersiae (Hudson, 1885)	-	Aus, Nea, Neo, Pal
FAMILY EPIPHANIDAE		
Epiphanes senta (Müller, 1773)	1, 4, 5, 7, 11, 12, 14, 23	Cosmopolitan
Rhinoglena cf. *frontalis* Ehrenberg, 1853	-	Aus, Ind, Nea, Pal
FAMILY LEPADELLIDAE		
Lepadella patella (Müller, 1773)	4, 5, 8, 11–13, 15, 17, 22	Cosmopolitan
FAMILY NOTOMMATIDAE		
Cephalodella forficata (Ehrenberg, 1832)	-	Aus, Ind, Nea, Neo, Ocn, Pal
Cephalodella sterea (Gosse, 1887)	4, 12	Aus, Ind, Nea, Neo, Ocn, Pal
Resticula gelida (Harring & Myers, 1922)	4, 5	Aus, Nea, Neo, Pal

†We have taken into account **East Antarctic** regions only – foremost, localities in both **Enderby Land** (Thala Hills) and **Prydz Bay** (Larsemann Hills); as well as other regions of this part of continent, viz. **Princess Elizabeth Land** (Vestfold Hills), **Wilkes Land** (Wilkes station, Bunger Hills, Knox coast), **Queen Mary Land** (Obruchev Hills, Huswell Island), **Victoria Land** (Eastern coast of Ross Sea, Ross Peninsula, Ross Ice Shelf, McMurdo Dry Valleys and McMurdo Sound area, Darvin Glacier and other localities), **Dronning Maud Land** (Langhovde Hills, Schirmacher oasis, the set of nunataks). Numerous data related to rotifer fauna in territories of the western part of continent as well as Maritime Antarctica and Subantarctica (Kerguelen, Malvinas, etc.) are not included in the present review.
‡ All references related to *Adineta gracilis* are given here (see text)
§ **Designations of biogeographic realms: Afr** – Africotropical, **Aus** – Australasian, **Ind** – Indomalayan (Oriental), **Nea** – Nearctic, **Neo** – Neotropical, **Ocn** – Oceanian (Pacific); **Pal** – Palearctic.
References: 1 – Armitage & House (1962); **2** – Chatey (1981); **3** – Cromer at al. (2006); **4** –Dartnall (1995), **5** – Dartnall (2000); **6** – Donner (1972); **7** – Dougherty & Harris (1963); **8** – Everitt (1981); **9** – Hansson et al. (2012); **10** – Iakovenko et al. (2015); **11** – Korotkevich (1958); **12** – Kutikova (1958); **13** – Kutikova (1991); **14** – Murray (1910); **15** – Opaliński (1972); **16** – Segers (2008); **17** – Sharov et al. (2015); **18** – Sohlenius et al. (1996); **19** – Sohlenius & Boström (2005); **20** – Smykla et al. (2010); **21** – Spur (1975); **22** – Sudzuki (1964); **23** – Suren (1990); **24** – Webster & Brown (2010).

Fontaneto et al. (2015b) demonstrated the inverse character of species diversity gradients touching both rotifer groups in Antarctica – with rising of the absolute latitude up to 75˚ S the number of monogonont species was decreasing, while that of bdelloids was increasing. In other words, in continental Antarctica i.e. in a high-latitude region with harsh climate the main centers of meiobiodiversity are different terrestrial organic substrates that bdelloids willingly inhabit in contradistinction to inland waters (meltwater ponds and lakes) with very poor species richness of monogonont rotifers. The described phenomenon shows that our results over Bdelloidea are still preliminary and determines the investigation of rotifers in Antarctic terrestrial habitats as main prospective aim of further studies.

The analysis of rotifer diversity has shown the dominance of common taxa for Antarctica, which were quite expected to find: *Epiphanes senta* (Müller, 1773), *Lepadella patella* (Müller, 1773), and some others. Some of them are cosmopolitans (Table 4). On the contrary, there were found several species and subspecies, which can be regarded as rare or even new for East Antarctica. Firstly we can mention *Collotheca ornata* (Ehrenberg, 1832). Many authors (Murray 1910, Korotkevich 1958, Kutikova 1958, Dougherty & Harris 1963, Dartnall 1995, 2000) declare the presence of *Collotheca ornata cornuta* (Dobie, 1849) in waters of Antarctica. The presence of *Collotheca ornata* (not *cornuta* subspecies) is also pointed, but much less (Armitage & House 1962). Some species among new ones for East Antarctica were also registered in other regions either of the continent or a biogeographical realm (Table 4). For example, Dartnall and Hollowday (1985) point the presence of *Cephalodella forficata* (Ehrenberg, 1832) in samples collected at Signy Island (South Orkney Islands, Subantarctica); Kutikova (1991) points *Macrotrachela kallosoma* (Schulte, 1954) in Falkland Islands. The third one, *Rhinoglena frontalis* Ehrenberg, 1853, was found in the number of Subantarctic territories: Heard Island (Dartnall 1995b), Kerguelen (De Smet 2001), and Macquarie Island (Dartnall 1993, Dartnall et al. 2005). Finally, *Encentrum saundersiae* (Hudson, 1885) and *Keratella tecta* (Gosse, 1851) seem to be found in whole Antarctic region in fact firstly. Furthermore, *Adineta vaga minor* Bryce, 1893 according to literature data was not recorded in Antarctica earlier.

The problem of Antarctic endemic rotifers (bdelloids in the first place) is a real urgent issue. Previously declared cosmopolite nature of these animals is now being questioned (Vellasco-Castrillon et al. 2014; Iakovenko et al. 2015); existing of many rotifer species, unique for remote territories, well correlates with the modern ideas concerning the abundance and occurrence of meiofauna in general as well, viz. 'a very big number of rare species' (Curini-Galletti et al. 2012, Fonseca et al. 2014, Fontaneto et al. 2015a and others). Thus, the set of endemic bdelloid species – *Philodina alata*, *Ph. antarctica* Murray, 1910, *Ph. gregaria* Murray, 1910, *Adineta grandis* Murray, 1910 (questionable – see Segers 2007), and some others – have been revealed for Antarctica since very first studies (Murray 1910). As results of more recent works (Kutikova 1958, De Smet & Gibson 200), some endemic monogononts have become known – *Notholca verae* Kutikova, 1958, *Rhinoglena kutikovae* De Smet, 2008. There were found several endemics in our study: already mentioned *Adineta grandis*, *Notholca verae*, *Philodina alata, Ph. gregaria*; also one another recently described species – *Adineta editae* Iakovenko, 2015. Notwithstanding, cosmopolitan species together with species which are widely distributed including Southern Hemisphere consist more than 50 % of all recorded species (Table 4).

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STRESZCZENIE

[Wrotki (Rotifera) wód śródlądowych i środowisk naziemnych oaz Wschodniej Antarktyki (Enderby Land and Prydz Bay)]

Artykuł dotyczy raportu na temat fauny wrotków (Rotifera) kontynentalnej Wschodniej Antarktyki, nadal słabo zbadanej. W środowiskach wodnych i naziemnych znaleziono w sumie 20 gatunków tych mikroskopijnych bezkręgowców. Wykazaliśmy występownie 12 gaunków z podklasy Monogononta oraz 8 gatunków z podklasy Bdelloidea. Analiza danych wskazuje na bardzo niską różnorodność taksonomiczną wrotków znalezionych w planktonie ponad 50 różnych jezior i wytopisk. Z drugiej strony, dość pobieżny przegląd środowisk naziemnych pozwolił ujawnić aż 7 gatunków wrotków (wszystkie należące do Bdelloidea). Większość stwierdzonych gatunków jest raczej pospolitymi kosmopolitami (*Collotheca ornata, Epiphanes senta* czy *Lepadella patella*) lub antarktycznymi endemitami (*Notholca verae, Philodina alata* lub *Ph. gregaria)*. Mimo to, niektóre gatunki mogą być uważane za nowe stwierdzenia dla Wschodniej Antarktyki (jak *Encentrum saundersiae*, *Keratella tecta* czy *Macrotrachela kallosoma*). Przedyskutowano biogeograficzne osobliwości antarktycznych wrotków. Specjalną uwagę zwrócono na taksonomię gatunków z rodzaju *Adineta* (podklasa Bdelloidea) ujawnionych w środowiskach naziemnych.

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