Rotifers and lower crustaceans from South-western Iceland

Vesela V. Evtimova†, Ivan S. Pandourski‡

† Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences, Sofia, Bulgaria

Abstract

Background

Iceland has high availability of freshwater, and it is rich in brackish and coastal aquatic bodies. However, knowledge on rotifers and meiobenthic and planktonic crustaceans inhabiting these habitats is lacking, and the inland aquatic fauna in Iceland is relatively understudied in comparison with the fauna of adjacent marine ecosystems. The majority of past research focused on larger lakes with the exception of one study on rotifers from the 1950s (Bartoš 1951) and two more recent studies on crustacean fauna of shallow freshwater bodies (Novichkova et al. 2014, Scher et al. 2000). Data are particularly scarce for the south-western part of the country.

New information

We studied the composition of selected invertebrate taxa in various aquatic (marine, brackish and freshwater) habitats from South-western Iceland with a focus on Rotifera, Cladocera and Copepoda. Samples were collected from 12 localities, including marine interstitial, freshwater temporary shallow pools, swamps, wet mosses, springs, and lakes (both brackish and freshwater). We found 39 taxa in total. Rotifera dominated the sampled water bodies, followed by Copepoda and Cladocera. Three of the recorded taxa are new
for Iceland, of which two are rotifers [Trichocerca cf. mucosa (Stokes, 1896) and T. vernalis (Hauer, 1936)], and one is a marine copepod (Cyclopina gracilis Claus, 1862). For some of the sampled localities (Síkið and Leirvogsvatn Lakes, and some of the smaller habitats) we present the first data on their microinvertebrate fauna.

Keywords
Rotifera, Cladocera, Copepoda, Iceland, new records, marine, brackish, freshwater

Introduction

Iceland is one of the countries with the highest freshwater availability according to UNEP’s Vital water graphics (http://www.eoearth.org/view/article/152861/). Additionally, being an island, it is rich in coastal brackish and saline aquatic habitats. However, little is known about the microcrustaceans and rotifers inhabiting these numerous habitats. The freshwater fauna of Iceland is relatively understudied compared to the fauna of adjacent marine ecosystems. Exhaustive sampling of deep-sea fauna was conducted within the inter-Nordic BIOICE project. As a result, Apostolov (2011) recorded 32 copepod harpacticoids of which 20 are new for the fauna of Iceland.

The first data on freshwater microinvertebrate fauna of Iceland date back to the 19th century (Guerne and Richard 1892a, Guerne and Richard 1892b). The first study on the rotifer fauna from the middle of the 20th century listed 59 species or subspecies (Bartoš 1951). The majority of the available studies on inland water bodies focused on large lakes: Mývatn in the north-east (Örnólfsd and Einarsson 2004, Adalsteinsson 1979, Jónasson 1979, Lindegaard 1979); and Thingvallavatn (Antonsson 1992) and Kerið Lakes (Evtimova et al. 2014) in the south-west of the country. Recently scientists have become increasingly interested in the inland freshwater copepods and cladocerans from small freshwater bodies (Novichkova et al. 2014, Scher et al. 2000). Data on observed morphological variability and teratology of lower crustacean in subpolar environments, including Iceland, were presented by Sinev et al. (2012), Pandourski and Evtimova (2009), Pandourski and Evtimova (2006), Pandourski and Evtimova (2005). These aberrations affected the fifth pair of legs in calanoids, the posterior part of the body in cyclopoids, or the head and antennule in cladocerans.

Our study presents data on taxa composition of Rotifera, Cladocera, and Copepoda in various aquatic habitats from South-western Iceland, including marine interstitial, wet bryophytes, springs, brackish and freshwater ponds and lakes.
**Materials and Methods**

Samples were collected from various aquatic habitats from South-western Iceland. The sampling sites included marine interstitial habitat, puddles, swamps, freshwater or brackish lakes (Table 1, Fig. 1). Rotifers and lower crustaceans were collected using a qualitative plankton net (type “Apstein”, mesh size 38 µm) and a hand-held plankton net (mesh size 40 µm). The hand-held plankton net was used for sieving the sand and rinsing the bryophytes in order to collect the invertebrates inhabiting these substrata. The material was fixed in 70% ethanol.

Table 1.
Locations and dates of sampling with coordinates and notes on water body type, habitat and substratum.

| Site No. | Date       | Collection method | Habitat/substratum sampled | Notes                                                                 | Coordinates         |
|----------|------------|-------------------|----------------------------|----------------------------------------------------------------------|---------------------|
| 1        | 02.07.2004 | Sieving           | Marine interstitial, coarse sand | Garðskagaviti lighthouse; low tide                                     | 64°04'57.68"N, 22°41'36.08"W |
| 2        | 08.07.2004 | Hand-held net     | Brackish lake, water column  | Bessastaðatjörn Lake, coastal, shallow, coarse volcanic sand, macrophytes; | 64°06'26.02"N, 21°59'43.79"W |
| 3        | 29.06.2004 | Hand-held net     | Freshwater swamp, scraping overgrown stones | Small, c/a 200 m from Sandgerði Marine Centre | 64°02'41.29"N, 22°42'45.64"W |
| 4        | 29.06.2004 | Hand-held net     | Freshwater swamp, near the bottom | Small, beside Sandgerði Marine Centre, towards the sea; polluted | 64°02'42.08"N, 22°42'45.14"W |
| 5        | 30.06.2004 | Hand-held net     | Puddle overgrown by grass    | Beside Sandvikurtjörn Lake                                            | 63°51'14.90"N, 22°41'21.68"W |
| 6        | 04.07.2004 | Zooplankton net   | Freshwater lake, water column | Síkið Lake; west of Garður Village                                    | 64°04'18.20"N, 22°38'45.38"W |
| 7        | 05.07.2004 | Zooplankton net   | Freshwater lake, water column | Leirvogsvatn Lake, stoney bottom, high transparency, oligotrophic, no macrophytes | 64°12'07.42"N, 21°27'44.05"W |
| 8        | 05.07.2004 | Zooplankton net   | Freshwater lake, water column | Small shallow, c/a 5-6 km eastwards from Stardalur and 35 km north-east of Reykjavik | 64°12'37.89"N, 21°19'23.27"W |
The specimens were mounted temporarily in a mixture of glycerin and ethanol and were identified to the lowest practicable level following Wallace and Snell (2010), Sørensen (2009), Segers (1995), Einsle (1993), Monchenko (1974), Manuylova (1964). Harpacticoids were identified by Dr Apostolov and presented in earlier works (Apostolov 2014, Apostolov 2007).

**Results**

A total of 39 taxa from Rotifera, Cladocera, and Copepoda were recorded from Southwestern Iceland during our study. The most diverse were the rotifers with 21 taxa belonging to nine families and two orders. We found 11 taxa of copepods which belonged to five families from three orders, and seven taxa of cladocerans from three families. Twelve associated invertebrate taxa were also found in our samples Table 2.
Table 2.
List of taxa recorded from various habitats in South-western Iceland. For site numbers (No) please see Table 1.

| Group      | Taxon                                      | Site No. |
|------------|--------------------------------------------|----------|
| Rotifera   |                                            |          |
| Class Eurotatoria |                                    |          |
| Order Ploima |                                    |          |
| Family Brachionidae |                                |          |
|             | *Keratella americana* Carlin, 1943         | 8; 12    |
|             | *Keratella cochlearis* (Gosse, 1851)       | 7        |
|             | *Keratella quadrata* (Müller, 1786)        | 3; 4; 5; 6; 7 |
|             | *Keratella* sp.                            | 3        |
|             | *Notholca acuminata* Ehrenberg, 1832       | 2        |
| Family Lecanidae |                                      |          |
|             | *Lecane crenata* (Harring, 1913)           | 10; 12   |
|             | *Lecane* sp.                               | 10       |
|             | *Lecane nana* (Murray, 1913)               | 9        |
|             | *Lecane* sp.                               | 9        |
| Family Asplanchnidae |                                    |          |
|             | *Asplanchna* sp.                           | 7        |
| Family Lepadellidae |                                  |          |
|             | *Colurella sulcata* (Stenroos, 1898)       | 12       |
|             | *Colurella* sp.                            | 12       |
|             | *Lepadella* (s. str) sp.                   | 10       |
|             | *Lepadella* sp.                            | 4        |
| Family Nothommatidae |                                 |          |
|             | *Cephalodella* sp.                         | 9; 12    |
| Family Euchlanidae |                                       |          |
|             | *Euchlanis dilatata* Ehrenberg, 1832       | 10       |
| Family Proalidae |                                       |          |
|             | *Proales* sp.                              | 11       |
| Family Trichocercidae |  |
|----------------------|--|
| *Trichocerca cf. mucosa* (Stokes, 1896) | 6 |
| *Trichocerca vernalis* (Hauer, 1936) | 8 |
| *Trichocerca sp.* | 9 |

Order Flosculariaceae

Family Trochosphaeridae

*Filinia terminalis* (Plate, 1886) 3

**Class Branchiopoda**

Order Anomopoda

Family Daphnidae

*Daphnia pulex* Leydig, 1860 6

Family Chydoridae

*Acroperus harpae* (Baird, 1835) 8
*Alona affinis* (Leydig, 1860) 8; 10; 12
*Alona quadrangularis* (Müller, 1785) 8; 10
*Chydorus sphaericus* (Müller 1776) 6
*Chydorus sp.* 7

Family Macrothricidae

*Macrothrix hirsuticornis* Norman & Brady, 1867 6

**Class Maxillopoda**

Order Calanoida

Family Temoridae

*Eurytemora velox* (Lilljeborg, 1853) 2

Order Cyclopoida

Family Cyclopidae

*Acanthocyclops vernalis* (s. lat. Fischer, 1853) 9; 12
*Cyclops abyssorum* Sars, 1863 6
*Diacyclops bisetosus* (Rehberg, 1880) 3; 9
*Eucyclops serrulatus* (Fischer, 1851) 6; 8; 9; 10
*Megacyclops viridis* (Jurine, 1820) 8
*Paracyclops fimbriatus fimbriatus* (Fischer, 1853) 8
Keratella quadrata (Müller, 1786) was recorded at five of the sampled localities, while the copepod Eucyclops serrulatus (Fischer, 1851) and the cladoceran Alona affinis (Leydig, 1860) were found at four and three of the sites, respectively. Twenty-eight taxa were recorded only at one of the 12 sampling locations. We recorded the highest diversity of rotifers and the lowest diversity of crustaceans from bryophytes near Öxaráfoss waterfall in Þingvellir National Park.
Discussion

We present data on rotifers and lower crustaceans from 12 aquatic habitats. For two of the stations (6 and 7), the lakes Sikið and Leirvogsvatn, we present the first data on zooplankton, and possibly also the first data for some of the smaller habitats (e.g. stations 3, 4, 5, 11). The majority of the recorded taxa either have a cosmopolitan distribution or are previously known from Iceland. For three of the recorded species we found no previous records in the available literature from Iceland: the rotifiers *Trichocerca cf. mucosa* (Stokes, 1896) and *T. vernalis* (Hauer, 1936), and the copepod *Cyclopina gracilis* Claus, 1862. Rotifer dominated the sampled water bodies, followed by Copepoda and Cladocera. The most frequent taxon was the rotifer *Keratella quadrata*, previously recorded from Iceland by Bartoš (1951). All of the recorded rotifer species have a cosmopolitan distribution.

Many of the cladoceran taxa we recorded are frequently found in the arctic region. *Acroperus harpae* (Baird, 1835) is typical for the littoral fauna of freshwater lakes from the Holoarctic region (Novichkova et al. 2014, Sinev et al. 2012). Arctic populations of *Macrothrix hirsuticornis* Norman & Brady, 1867 are known to have high densities of specimens that are characterised with longer bodies and greater number of eggs per female (Meijering 2003, Margaritora and Usai 1983, Meijering 1979). *Macrothrix hirsuticornis* and *Alona quadrangularis* (Müller, 1785) are widely distributed and often are found in arctic regions and similar environments, likely owing to the resistance of their diapausing eggs to very low temperatures (Meijering 2003). We found these two species in permanent freshwater lakes (stations 6, 8, and 10).

All of the freshwater cyclopoid crustaceans recorded have cosmopolitan distribution and have been previously recorded from Iceland. We found only one marine copepod *Cyclopina gracilis* Claus, 1862. It is very common in the North Atlantic Ocean (Carey 1992, Grainger and Mohammed 1991, Mohammed and Neuhof 1985) but previously has not been reported from Iceland. The dominant cyclopoid in our samples was *Eucyclops serrulatus* (Fischer, 1851). *Cyclops abyssorum* Sars, 1863 is known to be among the dominant copepods in the large Icelandic lakes and is an important structural element for their zooplankton assemblages (Novichkova et al. 2014, Antonsson 1992). According to Larsen and Røen (1964) and Scher et al. (2000) another common cyclopoid for Iceland is *Megacyclops viridis* (Jurine, 1820). We found both *C. abyssorum* and *M. viridis* as well but only from shallow freshwater lakes (sites 6 and 8, correspondingly).

The two species of the harpactocoid genus *Bryocamptus* we recorded are associated with wet mosses (Evtimova et al. 2014, Apostolov 2007). *Nitokra spinipes* Boeck, 1865 can tolerate changes in salinity (Apostolov 2014) and was found from both brackish and freshwater habitats (sites 2 and 3).
Conclusions

This manuscript presents faunistic data on microinvertebrate aquatic fauna, including new species records, from an understudied region where detailed data are still scarce. We found 39 taxa from 12 sites, and three of the recorded taxa are new for Iceland. Moreover, here we present first data on the zooplankton of Sikið and Leirvogsvatn Lakes. Future studies in the region would likely further enrich our knowledge on the composition and origin of microinvertebrate aquatic fauna of the island.

Acknowledgements

The study was financed through Improving the Human Potential Programme of the European Union, Access to Research Facilities (ARI). We thank Dr Gudmundur Vidir Helgason (Institute of Biology, University of Iceland) for organisation and assistance with fieldwork in Iceland.

Funding program

Improving the Human Potential Programme of the European Union, Access to Research Facilities (ARI), within FP5.

Project

Taxonomy, faunistics and zoogeography of brackish and freshwater copepods (Crustacea) from the Reykjanes peninsula, Iceland (June 2004 – September 2007).

Hosting institution

Sanðgerdi Marine Centre and the Institute of Biology, University of Iceland.

Author contributions

Both authors contributed equally to samples collection and processing, and the writing of the manuscript.
References

- Adalsteinsson H (1979) Zooplankton and Its Relation to Available Food in Lake Mývatn. Oikos 32(1-2): 162. DOI: 10.2307/3544226
- Antonsson Ú (1992) The Structure and Function of Zooplankton in Thingvallavatn, Iceland. Oikos 64: 188-221. [In English]. DOI: 10.2307/3545052
- Apostolov A (2007) Copepodes harpacticoïdes des eaux douces de l’Islande. Rivista di idrobiologia 43: 96-113.
- Apostolov A (2011) Les harpacticoïdes marins (Crustacea, Copepoda) d’Islande. Libra scorp, Burgas, 367 pp. [In French]. [ISBN 978-954-471-163-4]
- Apostolov A (2014) Contribution to the study of marine harpacticoid fauna (Crustacea, Copepoda) of Iceland. ZooNotes 62: 1-5.
- Bartoš E (1951) Rotatoria of the Czechoslovakian Iceland-expedition. Hydrobiologia 3 (3): 244-250. DOI: 10.1007/bf00043716
- Carey A (1992) The ice fauna in the shallow southwestern Beaufort Sea, Arctic Ocean. Journal of Marine Systems 3 (3): 225-236. DOI: 10.1016/0924-7963(92)90002-p
- Einsle U (1993) Crustacea, Copepoda: Calanoida und Cyclopoida. Sueßwasserfauna von Mitteleuropa. 8 / 4 - 1. Gustav Fischer Verlag, 210 pp.
- Evtimova V, Pandourski I, Apostolov A (2014) First study on the zooplankton of the Kerid (Kerið) Crater Lake, Iceland. ZooNotes 55: 1.
- Grainger EH, Mohammed AA (1991) Some diagnostic characters of copepodid stages of the cyclopoid copepod Cyclopina schneideri T. Scott and adults of arctic marine Cyclopinidae . Canadian Journal of Zoology 69 (9): 2365-2373. DOI: 10.1139/z91-333
- Guerne d, Richard J (1892a) Sur la faune des eaux douces de l’Islande. Comptes Rendus de l’Académie des Sciences, Paris 114: 1-3. [In French].
- Guerne d, Richard J (1892b) Voyage de M. Charles Rabot en Islande. Sur la faune des eaux douces. Bulletin de la Société zoologique de France 17: 75-80. [In French].
- Jónasson P (1979) Ecology of eutrophic, subarctic Lake Myvatn and the River Laxá. Oikos 32 (1-2): 1-308.
- Larsen F, Reen U (1964) Entomostraca from the Skafafell area, Iceland. Videnskabelige Meddelelser dansk naturh Foren 127: 135-149.
- Lindegaard C (1979) The Invertebrate Fauna of Lake Mývatn, Iceland. Oikos 32: 151. DOI: 10.2307/3544225
- Manuylova E (1964) Branchiopod crustaceans (Cladocera) from the USSR. Nauka, Moskow, Leningrad, 327 pp. [In Russian].
- Margaritora F, Usai MC (1983) Systematic and ecological data on Macrothrix hirsuticornis Norman and Brady (Crustacea, Cladocera) in Lake Campo Felice (Apennine Abruzzi). Bolletino di zoologia 50: 137-142. DOI: 10.1080/11250008309439437
- Meijering M (1979) Life cycle, ecology, and timing of Macrothrix hirsuticornis Norman and Brady (Cladocera, Crustacea) in Svalbard. Polarforschung 49: 157-171.
- Meijering P (2003) The long-lasting resistance of diapausing eggs from Arctic Cladocera frozen at −18°C. Polish Polar Research 24 (2): 167-172.
- Mohammed AA, Neuhof V (1985) Arctocyclopina pagonasta, a new genus and species of the family Cyclopinidae (Cyclopoida, Copepoda) from the annual sea ice in the
Monchenko V (1974) Fauna Ukraini, Cyclopidae. 27. Naukova dumka, Kiev, 452 pp. [In Ukrainian].

Novichkova A, Chertoprud E, Gíslason GM (2014) Freshwater Crustacea (Cladocera, Copepoda) of Iceland: taxonomy, ecology, and biogeography. Polar Biology 37 (12): 1755-1767. [In English]. DOI: 10.1007/s00300-014-1559-x

Örnólfssd EB, Einarsson Á (2004) Spatial and temporal variation of benthic Cladocera (Crustacea) studied with activity traps in Lake Myvatn, Iceland. Aquatic Ecology 38 (2): 239-257. DOI: 10.1023/b:aeco.0000032059.99310.d3

Pandourski I, Evtimova V (2005) Teratological morphology of copepods (Crustacea) from Iceland. Acta Zoologica Bulgarica 57 (3): 305-312.

Pandourski I, Evtimova V (2006) First record of Eurytemora velox (Lilljeborg, 1853) (Crustacea, Copepoda, Calanoida) in Iceland with morphological notes. Historia naturalis bulgarica 17: 35-38.

Pandourski I, Evtimova V (2009) Morphological variability and teratology of lower crustaceans (Copepoda and Branchiopoda) from circumpolar regions. Acta Zoologica Bulgarica 61 (1): 55-67.

Scher O, Defaye D, Korovchinsky N, Thiéry A (2000) The Crustacean fauna (Branchiopoda, Copepoda) of shallow freshwater bodies in Iceland. Vestnik zoologii 34 (6): 11-25. [In English].

Segers H (1995) Rotifera, Volume 2: The Lecanidae (Monogononta). Guides to the identification of the microinvertebrates of the continental waters of the world, 2. SPB Academic publishing, 226 pp. [In English].

Sinev A, Zawisza E, Einarsson Á (2012) Usual stable morphotype of Acroperus harpae (Baird, 1834) from lake Myvatn, Iceland (Cladocera: Anomopoda: Chydoridae) revealed by paleolimnological studies. Studia Quaternaria 29: 3-7. URL: http://www.studia.quaternaria.pan.pl/pdfs/sq29/03_07_sq29_zmn.pdf

Sørensen M (2009) Rotifera of the Gulf of Mexico. In: Felder DL, Camp DK (Eds) Gulf of Mexico – Origins, Waters, and Biota. Biodiversity. Texas A&M Press, College Station, Texas, 533–537 pp.

Wallace R, Snell T (2010) Rotifera. Ecology and Classification of North American Freshwater Invertebrates. Academic Press, 173-188 pp. URL: http://dx.doi.org/10.1016/b978-0-12-374855-3.00008-x DOI: 10.1016/b978-0-12-374855-3.00008-x