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# THE CRUSTACEAN FAUNA (BRANCHIOPODA, COPEPODA) OF SHALLOW FRESHWATER BODIES IN ICELAND

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**The Crustacean Fauna (Branchiopoda, Copepoda) of Shallow Freshwater Bodies in Iceland. Scher O., Defaye D., Korovchinsky N. M., Thiéry A.** — A survey of shallow freshwaters of Iceland was conducted in June and July 1996. The 34 stations prospected were rainpools, ditches, wetlands. The composition of their crustacean communities, investigated by qualitative net samples, is discussed in relation to water characteristics. One notostracan, *Lepidurus arcticus* (Pallas, 1793), 17 cladoceran species (5 Daphniidae, 10 Chydoridae, 1 Macrothricidae, 1 Polyphemidae), and 12 copepods (2 Diaptomidae, 7 Cyclopidae, 3 Canthocamptidae) were identified. Two species are reported for the first time from Iceland: the diaptomid *Diaptomus* (*Chaetodiaptomus*) *rostripes* Herbst, 1955 and the chydorid *Alona rustica* Scott, 1895. Taxonomical comments about different species are added, and their ecological pecularities are given. The species richness as well as the biogeographical features of the freshwater zooplankton of Iceland are discussed in relation to neighbouring Greenland and Northern Europe.

Key words: Branchiopoda, Copepoda, species richness, distribution, biogeography, Iceland.

**Фауна ракообразных (Branchiopoda, Copepoda) мелких пресных водоемов Исландии. Шер О., Дефай Д., Коровчинский Н. М., Тьери А.** — Обследование мелких пресных водоемов Исландии проведено в июне-июле 1996 г. Материал собирался в дождевых и талых лужах, канавах, болотах. Среди 30 обнаруженных видов отмечены 1 вид щитней *Lepidurus arcticus* (Pallas, 1793), 17 видов ветвистоусых ракообразных (5 представителей сем. Daphnidae, 10 — Chydoridae, 1 — Macrothricidae, 1 — Polyphemidae), 12 видов веслоногих ракобразных (2 вида сем. Diaptomidae, 7 — Cyclopidae, 3 — Canthocamptidae). Два вида указаны впервые для фауны Исландии: *Diaptomus* (*Chaetodiatomus*) *rostripes* Herbst, 1955 и *Alona rustica* Scott, 1895. Состав ракообразных в водоемах обсуждается в связи с экологической характеристикой последних. Для отдельных видов представлены краткие таксономические и экологические замечания. Обсуждаются видовое разнообразие и биогеографические особенности Исландии в связи с фаунистическими контактами с Гренландией и северной Европой.

Ключевые слова: Branchiopoda, Copepoda, видовое разнообразие, распространение, биогеография, Исландия.

## Introduction

In Iceland, freshwater habitats are common and frequent, represented by many lakes, as well as springs, rivers, and temporary ponds, of these the lakes have received the most attention. In the North, Lake Myvatn and the river Laxб had been the subject of detailed investigations headed by Dr. P. M. Jynasson (Jynasson, 1979), while in the South-East, Lake Thingvallavatn had been the subject of intensive researches (Jynasson, 1992). These studies described both biological features and environmental conditions and provide extensive data on geology, climate and the vertebrate fauna.

The freshwater fauna of Iceland has been also the subject of investigations by de Guerne, Richard (1892 a, b), Wesenberg-Lund (1894), Poulsen (1924), Larsen, Røen (1964), Elgmork, Halvorsen (1971) and Antonsson (1992). However, the shallow waterbodies have remained less well known. In order to improve our knowledge of inland waters in Iceland, a survey of several freshwater locations was carried out during the summer of 1996. Thirty four different stations, located all around the island, were sampled. These included different kinds of small freshwater biotopes, such as shallow lakes, temporary ponds, pools, and spring mosses.

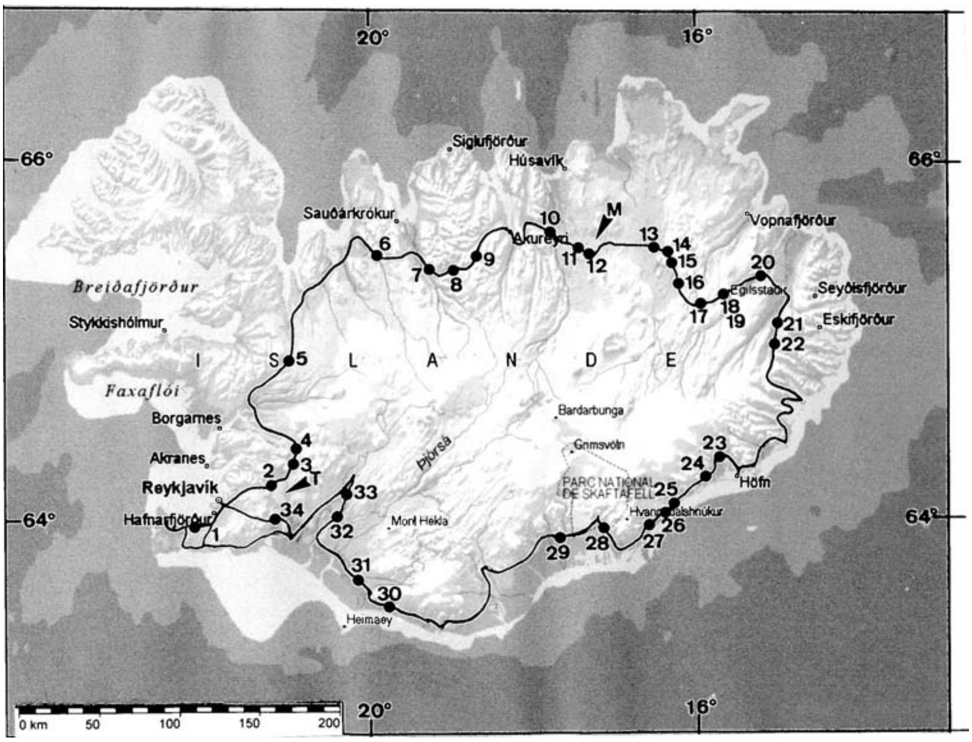


Fig. 1. Location of the sampled temporary ponds. The two main lakes Thingvallavatn and Myvatn are indicated by arrows T and M.

Рис. 1. Карта расположения обследованных временных водоемов. Два главные озера Тингваллаватн и Миватн указаны стрелками Т и М.

**Material and methods**

Study area and climate. Iceland is a subpolar island situated on the Mid-Atlantic Ridge, with high volcanic activity (e. g. the spectacular volcanic eruption in Bardarbunga, Vatnajцkull on 11 october 1996). This mountainous island extends from 63°25′ to 66°30′ N, and from 13°30′ to 24°30′ W, and has a surface of 102.846 $km^2$. Only 1% of the surface is cultivated, 20% is covered by meadows, 12% are covered by glaciers (=jцkull in Icelandic), and 2% by lakes (=vatn). More over, much of the island is covered by sands (40%), the remaining lands being desertic volcanic regions (Bordin et al., 1990). The climate is determined in large part by the oceanic currents, the warm Gulf Stream at the South and West of the country, and the cold polar North and East. Iceland is divided into two climatic types: a temperate rainy climate with cool and short summers in the southern and western regions, and a snow climate in large areas of northern Iceland and in the highlands. The temperature conditions depend on the altitude, as well as on the distribution of cloud cover, precipitation and frequency of winds and their directions. In January, Iceland lies between isotherms — 4°C to 0°C, and in July between isotherms +8°C and +10°C. Mean annual rainfall is highest in the South (> 3.000 mm per year) and lowest in the North (between 400 and 1.000 mm per year) (fig. 2). On mountains, rainfall can reach 4.500 mm. However, the rain regime shows irregular variations depending on years in relation to cyclones which frequently pass in winter.

Sampling. Thirty four stations were sampled qualitatively from 24 June and 29 July 1996, with a plankton net (50 µm mesh). In the field, water temperature and conductivity (referring to $20°C=C_{20}$) were measured using a WTW® (Wissenschaftliche Technische Werke) conductimeter LF 91. Dimensions of the waterbodies were estimated. Their depth was measured to the nearest 20 cm. Material was preserved in 10% formalin. Copepods, notostracans and cladocerans were sorted under a stereoscope at x10 magnification. Drawings were made using a camera lucida. For notostracans, measurements and numeration of the following characters, were made under a stereoscope equiped with an ocular micrometer: maximum carapace length (MCL, accuracy □ 0.5 mm), telson width (TW □ 0.05 mm), egg diameter (ED □ 10 µm), number of abdominal legless somites, and number of eggs per female. The body length, including the plate of telson and total length including the cercopods were not measured because of their imprecision (broken cercopods, more or less contracting body into the preservative). A part of the tadpole shrimps sample, *Lepidurus arcticus*, have been deposited in the collections of the Muséum National d'Histoire naturelle (Paris, France), registr. N MNHN-Bp 658. Eggs were removed from brood pouches and kept in a separate vial.

The species found are listed below, following the recent taxonomic opinions by Fryer (1987) and Brtek (1997) for "Large Branchiopods", by Frey (1973, 1980), Orlova-Bienkowskaja (1998), Smirnov (1992, 1996) for the cladocerans, and by Dussart (1958) and Dussart, Defaye (1983) for the copepods. For each species the stations in which they are been collected are indicated.

The sampling stations are listed in table 1 and mapped in figure 1. Unless otherwise indicated, each described station is situated along the road no. 1, the main road around the island.

**Table 1. Location, characteristics of the sampled water bodies (dimension — m, depth — cm, conductivity — µS cm$^{-1}$, t°C) and crustacean fauna in June, July 1996 (A — adults, C — copepodite)**

**Таблица 1. Местонахождение, характеристика водоемов (размеры — м, глубина — см, электропроводность — µS cm$^{-1}$, t°C) и фауна ракообразных в июне, июле 1996 г. (А — взрослые, С — копеподиты)**

| Station N | Characteristics | Biota: crustacean fauna |
|---|---|---|
| 1 | Pond 1: About 24 km of Keflavik, 24.06, 40×10 m, 10–15 cm, cond. 3700, 8.5°C | *1 harpacticoid* (♀) *D. bisetosus* (♂) |
| 2 | Near Thingvellir, 25.06, 10×15 m, 30 cm, cond. 32.4, 14.9°C | *P. fimbriatus* (♀), *M. rapiens* (3 ♀) |
| 3 | 10 km after Thingvellir (track 56), 26.06, 500×200 m, >100 cm, cond. 37.4, 11.4°C | *C. sphaericus*, *A. excisa* |
| 4 | Cross tracks 52 and 35, 26.06, 300×100 m, >100 cm, cond. 77.9, 10.2°C | Lack of crustacean? |
| 5 | About 30 km before Staour, 28.06, 15×5 m, >100 cm, cond. 109.1, 14.4°C | *E. serrulatus* (♀), *S. vetulus, M. hirsuticornis, C. sphaericus, E. lamellatus, A. excisa, A. harpae, A. affinis, A. quadrangularis, A. guttata* |
| 6 | About 20 km after Blöndosbaer, 1.07, 10×5 m, 50–60 cm, cond. 150, 16.8°C | *M. viridis* (♀+C), *E. serrulatus* (A+C), *P. fimbriatus, C. quadrangula, E. lamellatus, C. sphaericus, Ceriodaphnia* sp., *D. pulex, A. harpae* |
| 7 | 15 km after Varmahlio, 2.07, 20×3 m, 10–15 cm, cond. 342, 15.3°C | *E. serrulatus* (♂), *A. vernalis* (♀+C), *M. viridis* (♀) |
| 8 | Waterfall in mountains, 2.07, —, 5 cm, cond. 60.1, 11.8°C | *S. vetulus, E. lamellatus, A. excisa, A. harpae, A. affinis, A. intermedia* |
| 9 | About 10 km after the refuge of Bakkasel, 3.07, 30×10 m, 50–80 cm, cond. 210, 10.2°C | *M. viridis* (A+C), *E. serrulatus, E. lamellatus, C. sphaericus* |
| 10 | 5 km after Gooafoss, complexe of several ponds, 6.07, 20×20 m, 10–15 cm, cond. 170.5, 14.3°C | Lack of crustacean? |
| 11 | 30 km after Gooafoss, 6.07, 20×3 m, 10–20 cm, cond. 326, 18.4°C | *D. rostripes* (♂, ♀), *D. bisetosus* (♀), *A. vernalis* (♀), *S. vetulus, C. sphaericus* |
| 12 | 33 km after Gooafoss, 6.07, 35×4 m, 20 cm, cond. 133.1, 18.5°C | *Megacyclops* sp. (*viridis*?) (♀), *E. serrulatus* (A), *S. vetulus, C. sphaericus* |
| 13 | 33 km after Reykjahlio, 8.07, 3×1 m, 15 cm, cond. 168.7, 16.3°C | *C. abyssorum* (♂+♀+C), *E. serrulatus* (1♀), *A. affinis* |
| 14 | At Grimmstaoir, 8.07, 15×3 m, 15 cm, cond. 581, 17.4°C | *D. rostripes* (♂+♀), *A. vernalis* (♀), *Cyclops* sp (C), *S. vetulus, S. mucronata, D. pulex, M. hirsuticornis, C. sphaericus, A. excisa, A. harpae, A. affinis, P. pediculus* |
| 15 | Near Grimmstaoir, 8.07, 15×3 m, 15 cm, cond. 1240, 16.6°C | *S. vetulus, S. mucronata, D. pulex, M. hirsuticornis, C. sphaericus, A. excisa, A. harpae, P. pediculus* |
| 16 | About 22 km after Grimmstaoir, 9.07, 3×3 m, 10–15 cm, cond. 393, 14.2°C | — |
| 17 | About 80 km before Egilsstaoir, 9.07, 40×30 m, >100 cm, cond. 12.1, 11.1°C | *Lepidurus arcticus* (Plankton not sampled) |
| 18 | 6 km after the refuge, 10.07, 20×15 m, 50–60 cm, cond. 149.2, 11.1°C | *D. rostripes* (♂+♀), *Megacyclops* sp. (C), *S. vetulus, C. sphaericus, E. lamellatus, A. harpae* |
| 19 | Same location as 18, 10.07, cond. 126, 11.8°C | *D. rostripes* (♂+♀), *M. viridis, C. sphaericus, P. pediculus, S. vetulus, A. harpae* |
| 20 | About 20 km before Egilsstaoir, 10.07, 20×4 m, 20 cm, cond. 80, 17.7°C | *D. rostripes* (♂+♀), *A. vernalis* (♀), *S. vetulus, S. mucronata, C. sphaericus, P. pediculus, A. excisa, A. affinis, A. intermedia* |
| 21 | 23 km after Egilsstaoir, 12.07, 1.5×1 m, 10 cm, cond. 140.9, 14.5°C | *S. vetulus, S. mucronata, E. lamellatus, A. affinis, C. sphaericus* |
| 22 | 31 km after Egilsstaoir, 12.07, 40×30 m, >100 cm, cond. 149.8, 13.7°C | *S. vetulus, C. sphaericus, A. excisa, P. pediculus* |

**Table 1. (Cont.)**

| Station N | Characteristics | Biota: crustacean fauna |
|---|---|---|
| 23 | 23 km after Höfn, 15.07, 25×15 m, 20 cm, cond. 177.5, 17.8°C | *M. viridis* (♀), *E. serrulatus* (♀), *Paracyclops* sp. (♂), *S. vetulus, S. mucronata, E. lamellatus, A. affinis, M. hirsuticornis* |
| 24 | 33 km after Höfn, 16.07, 80×10 m, 10–15 cm, cond. 91.0, 21.6°C | *D. castor* (A), *E. serrulatus* (A+C), *M. viridis* (A+C), *P. fimbriatus* (♀), *A. vernalis* (♀), *S. vetulus, S. mucronata* |
| 25 | About 5 km before Jokulsarlön, 16.07, 100×40 m, >100 cm, cond. 73.9, 18.4°C | *E. serrulatus, Megacyclops* sp. (C), *M. hirsuticornis, S. vetulus, E. lamellatus, C. sphaericus, A. nana, A. harpae, A. affinis, A. intermedia, A. rustica* |
| 26 | Jokulsarlön, 17.07, lagoon, >500 cm, cond. 7690, 4.4°C | — |
| 27 | 17.5 km after Jokulsarlön, 17.07, 40×20 m, 50–80 cm, cond. 37.5, 17.3°C | — |
| 28 | 2 km after Skaftafell, 19.VII, 35×30 m, 20 cm, cond. 192.6, 11.9°C | *E. serrulatus* (A+C), *M. viridis, M. mrazeki* (♀), *E. richardi* (♂+♀+C), *A. affinis, Simocephalus* sp. (ephippia) |
| 29 | 31 km after Skaftafell, 19.07, 30×20 m, 10 cm, cond. 80.0, 20.1°C | — |
| 30 | 41 km after Vik, 21.07, 40×30 m, >100 cm, cond. 242.0, 15.5°C | *M. albidus* (♀+C), *M. viridis* (♀+C), *E. serrulatus* (♀+C), *S. serrulatus, C. sphaericus, A. harpae* |
| 31 | 10 km before Hvolsvöllur, 22.07, 50×20 m, 10–15 cm, cond. 177.0, 17.4°C | Unidentified Cyclopoids (C) + Harpacticoids (C), *C. sphaericus* |
| 32 | 18 km after cross road 1 and 30 to Geysir, on track 30, 23.07, 20×20 m, 10 cm, cond. 81.4, 25.2°C | — |
| 33 | 5 km after Fluoir, track 30, 23.07, 25×10 m, 20 cm, cond. 121.4, 23.1°C | *D. bisetosus* (♀) |
| 34 | Hverageroi, 29.07, 1.5×1 m, 25 cm, cond. 547.1, 36.2°C | — |

## Results

## List of species

**Class Branchiopoda** Latreille, 1817
Order Notostraca G. O. Sars, 1867
Family Triopsidae Keilhack, 1909
*Lepidurus arcticus* (Pallas, 1793): St. 17.
Order Anomopoda G. O. Sars, 1865
Family Daphniidae Straus, 1820
*Ceriodaphnia quadrangula* (O. F. Müller, 1785): St. 6
unidentified *Ceriodaphnia* sp.: St. 6.
*Daphnia pulex* Leydig, 1860: Sts 6, 14, 15.
*Scapholeberis mucronata* (O. F. Müller, 1776): Sts 14, 15, 20, 21, 23, 24.
*Simocephalus serrulatus* (Koch, 1841): St. 30.
*Simocephalus vetulus* (O. F. Müller, 1776): Sts 5, 8, 11, 12, 14, 15, 18, 19, 20, 21, 22, 23, 24, 25.
*Simocephalus* sp. (ephippia): St. 28.
Family Chydoridae Stebbing, 1902
Aloninae Frey, 1967
*Acroperus harpae* (Baird, 1834): Sts 5, 6, 8, 14, 15, 18, 19, 25, 30.
*Alona affinis* (Leydig, 1860): Sts 5, 8, 13, 14, 20, 21, 23, 25, 28.
*Alona guttata* G. O. Sars, 1862: St. 5.
*Alona intermedia* (G. O. Sars, 1862): Sts 8, 20, 25.
*Alona quadrangularis* (O. F. Müller, 1785): St. 5.
*Alona rustica* Scott, 1895: St. 25.
Chydorinae Stebbing, 1902
*Alonella excisa* (Fischer, 1854): Sts 3, 5, 8, 14, 15, 20, 22.
*Alonella nana* (Baird, 1850): St. 25.
*Chydorus sphaericus* (O. F. Müller, 1785): Sts 3, 5, 6, 9, 11, 12, 14, 15, 18, 19, 20, 21, 22, 25, 30, 31.
Eurycercinae Kurz, 1875
*Eurycercus lamellatus* (O. F. Müller, 1785): Sts 5, 6, 8, 9, 18, 21, 23, 25.
Family Macrothricidae Norman et Brady, 1867
*Macrothrix hirsuticornis* Norman et Brady, 1867 (s. l.): Sts 5, 14, 15, 23, 25.
Order Onychopoda G. O. Sars, 1865
Family Polyphemidae Baird, 1845

*Polyphemus pediculus* (Linnaeus, 1761): Sts 14, 15, 19, 20, 22.

**Class Copepoda** H. Milne Edwards, 1830
**ORDER CALANOIDA G. O. SARS, 1902**

**FAMILY DIAPTOMIDAE BAIRD, 1850**

*Diaptomus* (*Diaptomus*) *castor* (Jurine, 1820): St. 24.
*Diaptomus* (*Chaetodiaptomus*) *rostripes* Herbst, 1955: Sts 11,14, 18, 19, 20.
Order Cyclopoida Burmeister, 1834
Family Cyclopidae Dana, 1853
Eucyclopinae Kiefer, 1927
*Macrocyclops albidus* (Jurine, 1820): St. 30.
*Eucyclops* (*Eucyclops*) *serrulatus* (Fischer, 1851): Sts 5, 6, 7, 9, 12, 13, 23, 24, 25, 28, 30.
*Paracyclops fimbriatus* (Fischer, 1853): Sts 2, 6, 24.
*Paracyclops* sp. unidentified: St. 23.
Cyclopinae Kiefer, 1927
*Acanthocyclops vernalis* (Fischer, 1853): Sts 7, 11, 14, 20, 24.
*Diacyclops bisetosus* (Rehberg, 1880): Sts 1, 11, 33.
*Megacyclops viridis* (Jurine, 1820): Sts 6, 7, 9, 19, 23, 24, 28, 30
*Megacyclops* sp. unidentified: Sts 12, 18, 25.
*Cyclops abyssorum* G. O. Sars, 1863: St. 13
*Cyclops* sp. unidentified: St. 14.
Order Harpacticoida G. O. Sars, 1902
Family Canthocamptidae Brady, 1880
*Mesochra rapiens* (Schmeil, 1894): St. 2.
*Epactophanes richardi* Mrozek, 1893: St. 28.
*Moraria mrazeki* Scott, 1903: St. 28.

## Species richness

Although localities were sampled only once, in July, we attempted to determine the major factors affecting the crustacean distribution. From the present data, most crustacean species can be regarded as freshwater forms. Their tolerance to salinity can be considered as low. A relationship between the crustacean species richness and the water conductivity was

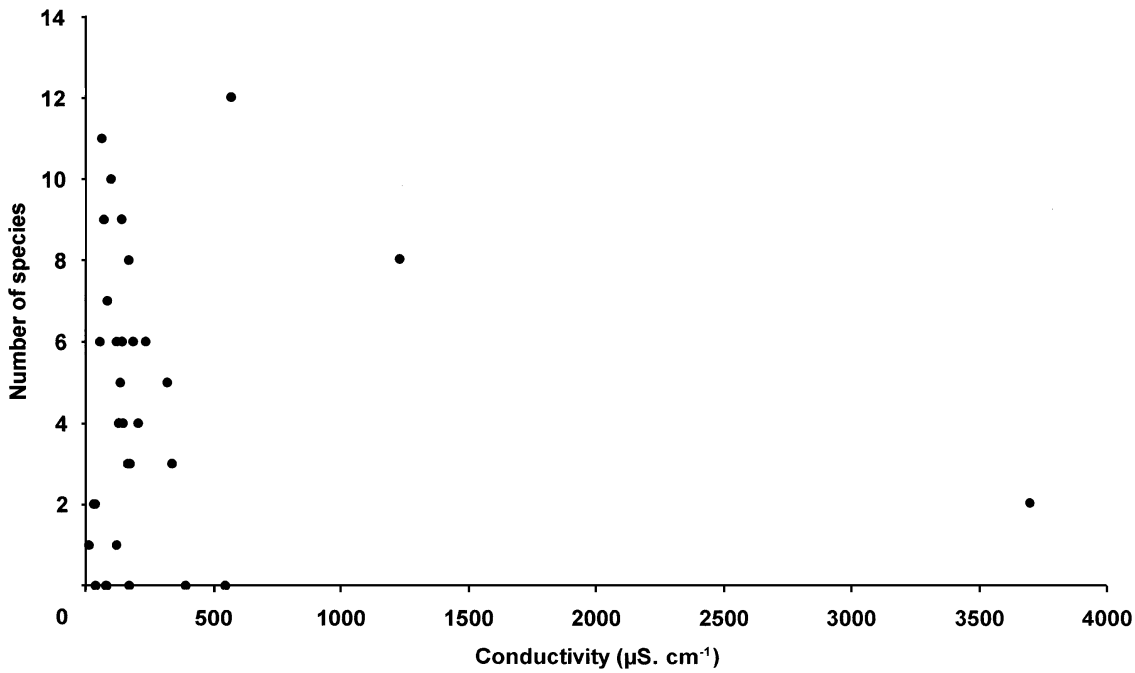


Fig. 2. Crustacean species richness per station in relation to conductivity of water.

Рис. 2. Разнообразие видов ракообразных на каждой станции в зависимости от электропроводности воды.

noted although there was considerable variation between localities (fig. 2). There were up to ten or more species present in waters having conductivities below 1.000 μS $cm^{-1}$, eight to two species at conductivities from 1.000 to 3.000 μS $cm^{-1}$, while at conductivities above 3.000 μS $cm^{-1}$ there were two or fewer (fig. 2).

Regarding the depth and surface of ponds, it seemed that no relationship between basin size and fauna can be established. Generally large pieces of water had quite similar faunas, to those of small ponds of similar conductivity. On the other hand, it can be noted that most of the stations having rich crustacean fauna were located in the sub-arid and arid areas (<1.200 mm). The major factor affecting distribution would be the ephemerality of the pond, linked to geographic position and climatic conditions.

## Taxonomic notes

Branchiopoda Notostraca

*Lepidurus arcticus* (Pallas, 1793): (synonymies in Brtek, 1997) 24 females, ranging in MCL from 7.5 to 14.9 mm, were collected on 7 July 1996 (2 cohorts: 2 females 7.5–7.6 mm, and 22 females between 9.0 to 14.9 mm, mean 12.04±1.74 mm). The number of legless somites ranged from 4 to 5. The figure 3 shows the relationship between carapace length and telson width, with the following equation: $MCL_{(mm)}$=8.055, $TW_{(mm)}$=2.249 (n=23, $r^2$=0.918). This one is useful to estimate the length of disappeared specimens in dried ponds, using chitineous fragments such as telson, often recovered intact in sediments. The youngest females bearing eggs are 10.1 mm MCL, with one egg per brood pouch. The number of eggs per female increases with age, and thus with length of the female (fig. 4), the oldest having up to 6 eggs (3 per brood pouch). The ED ranged between 690 and 750 μm, according to Fryer (1988), but bigger than the diameter indicated for specimens from Russia by Thiéry et al., (1995).

Tadpole shrimps were collected in only one pond, station 17, approximately 65°30'N–16°E, situated on a Pleistocene ground. Its main characteristics are given in table 1.

Branchiopoda cladoceran

Many cladoceran taxa of species level need thorough revision (Korovchinsky, 1996). For this reason most of species found in Iceland could be identified only routinely. At the same time, the recent taxonomic revisions give an opportunity to make more precise identification of some taxa or discuss their diagnostic features. The representatives of commonest Icelandic species are shown in figure 5.

Daphniidae: *Simocephalus serrulatus.* Rather typical specimens according to modern re-

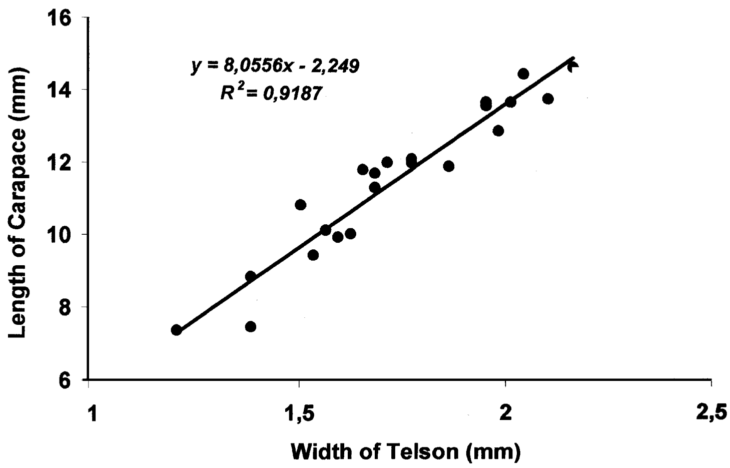


Fig. 3. Relationship between the carapace lenght (MCL in mm) and telson width (TW in mm) in *Lepidurus arcticus.*

Рис. 3. Зависимость между длиной карапакса (MCL в мм) и шириной тельсона (TW в мм) у *Lepidurus arcticus.*

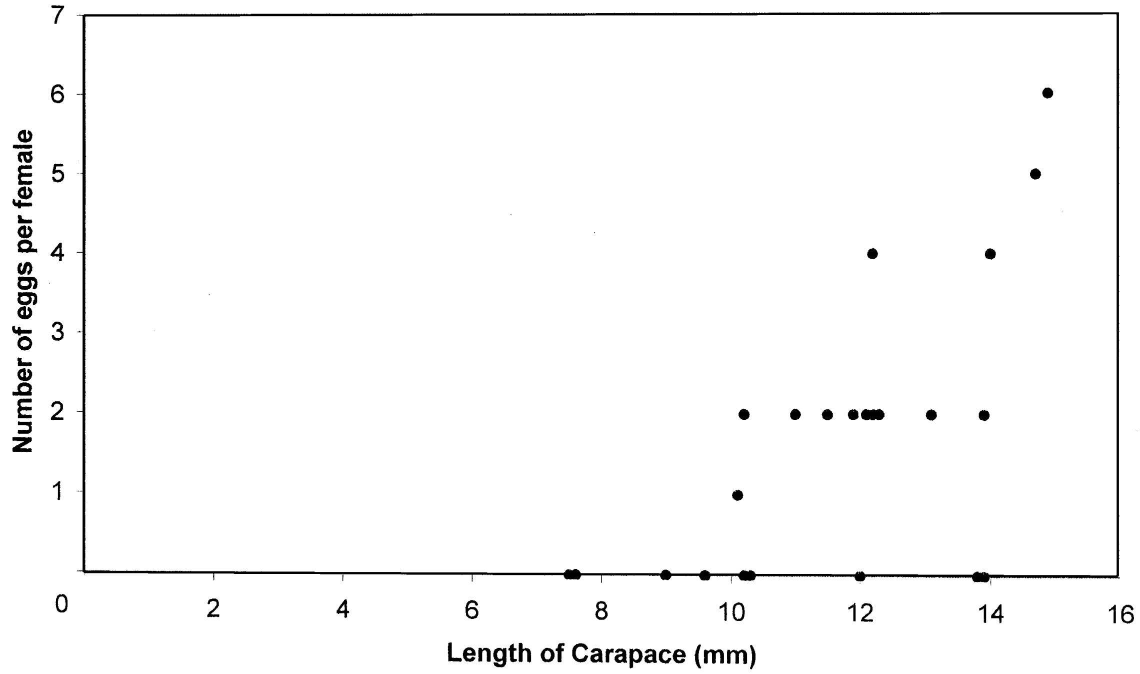


Fig. 4. Relationship between the number of eggs per female and its length of carapace (i. e. its age).

Рис. 4. Зависимость между количеством яиц у самки и длиной ее карапакса (т. е. ее возрастом).

vision of the genus (Orlova-Bienkowskaja, 1998).

*Scapholeberis mucronata.* The morphology of specimens is in accordance with the description of the species by Dumont, Pensaert (1983).

Macrothricidae: *Macrothrix hirsuticornis.* Some specimens have typical traits for the species antennal armament: 1 large spine on the second segment of upper antennal branch. In other specimens, this armament consists of two large spines which is characteristic of *M. glandica* Lilljeborg, 1901 (Smirnov, 1992) sometimes considered as a variety (Røen, 1981) or a subspecies of *M. hirsuticornis* (Røen, 1994). One specimen shows the intermediate pattern having 1 large and 1 small spine on this segment.

Chydoridae: *Eurycercus lamellatus.* The morphology of specimens is in accordance with the recent descriptions of species from different European localities (Frey, 1973, Duigan, Frey, 1987) (fig. 5, b).

*Chydorus sphaericus.* The typical representatives of the species from Europe were redescribed in detail (Frey, 1980). Its precise identification needs the observation of males which were absent in Icelandic material. At the same time, the diagnostic features of females seem rather typical. *Chydorus arcticus* also known from Iceland (Røen, 1987) was poorly described and is synonymized to *C. sphaericus* until further detailed revision (Smirnov, 1996) (fig. 5, d).

*Alona affinis.* According to the modern revision of the species (Sinev, 1998, pers. com.) the diagnostic features of Icelandic specimens including males are quite characteristic (fig. 5, c).

*Alona rustica.* Only two specimens were found, one mature and one immature females, a different shell reticulation: numerous small protuberances in the former and longitudinal lines in the latter. The taxonomy of the species and significance of these morphological differences need further examination.

Copepoda

*Diaptomus* (*Chaetodiaptomus*) *rostripes* (fig. 6, a–e) is very close to *D. glacialis*, which has been identified as common in Iceland by Poulsen (1924). A notable difference between these two species, particularly referred to by Kiefer (1978), is the shape of the rostrum. *D. rostripes* has short, blunt rostral spines, whereas they are very long in *D. glacialis.* All

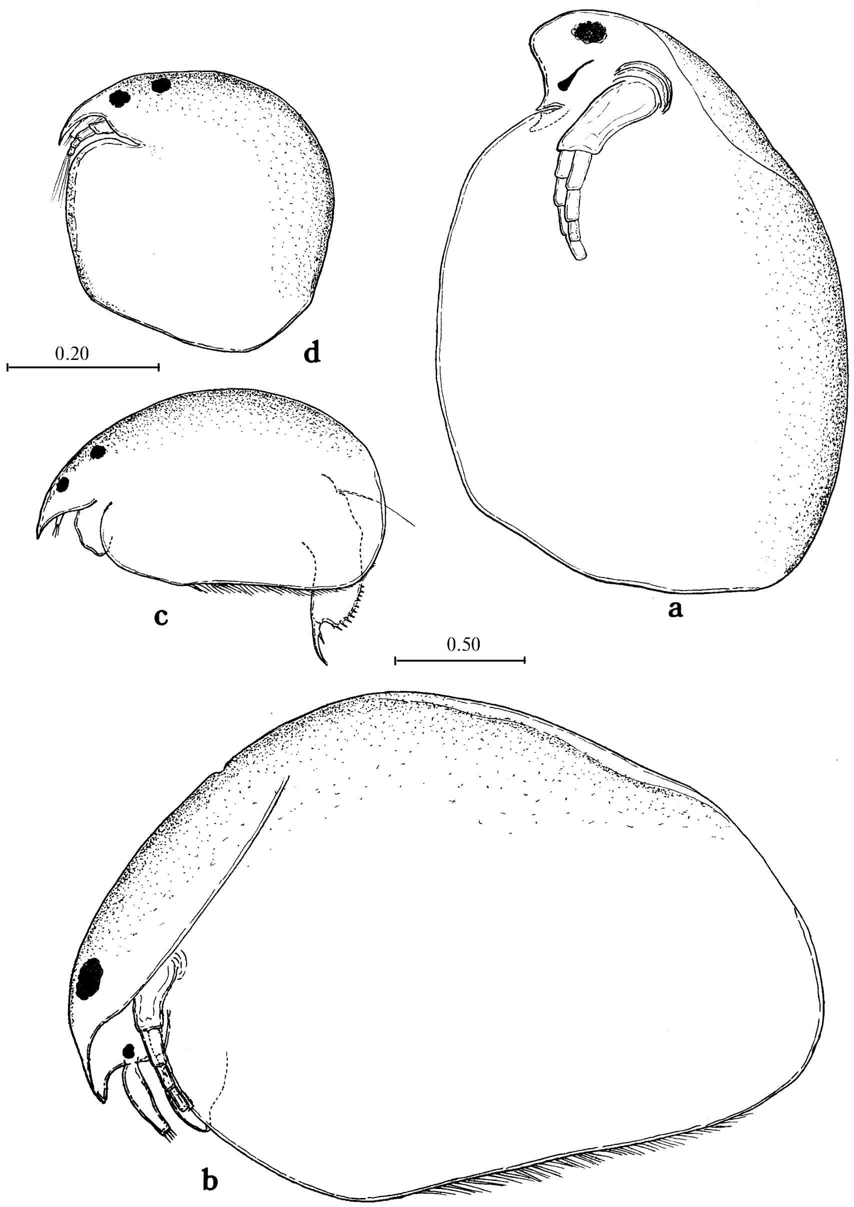


Fig. 5. Commonest Icelandic Cladocerans in left lateral view (N. Korovchinsky drawings): a — *Simocephalus vetulus*; b — *Eurycercus lamellatus*; c — *Alona affinis*; d — *Chydorus sphaericus*. Scale bars in mm.

Рис. 5. Наиболее обычные исландские ветвистоусые (вид слева сбоку) (рисунок Н. Коровчинского): a — *Simocephalus vetulus*; b — *Eurycercus lamellatus*; c — *Alona affinis*; d — *Chydorus sphaericus*. Масштаб в мм.

specimens from samples 15 and 18 have short rostral spines and, are therefore identified as *D. rostripes*.

*Eucyclops serrulatus*, is of typical form, showing a slight variability in furca length, as well as in the orientation of the external furcal seta. Moreover, in most females, the ornamentation of the integument is arranged in rows of tiny cupules on urosomites and furca.

*Paracyclops fimbriatus*. The specimens in the Iceland samples conform to typical *P. fimbriatus*, characterized in particular by the ornamentation of the antennal basipodite and the ornamentation of the natatory legs, especially $P_1$ (not figured).

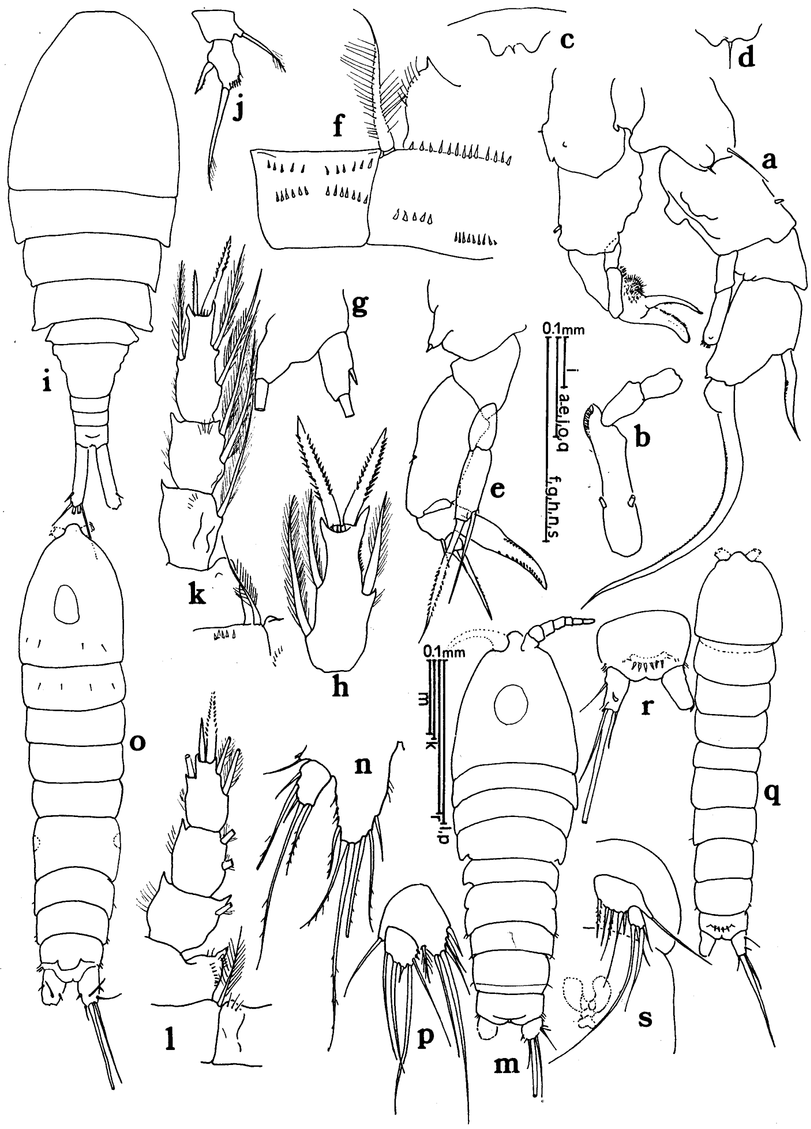


Fig. 6. Copepods (D. Defaye drawings). *Diaptomus* (*C.*) *rostripes*: a — $P_5$ ♂; b — antepenultimate segment of male right antennule; c — rostrum ♀; d — rostrum ; e — $P_5$ ♀. *Megacyclops viridis:* f — precoxal plate, basipodite and coxopodite (part.) of $P_4$ ♀; g — $P_5$; h — $Enp_3$ $P_4$ . *Cyclops abyssorum,* ♀: i — habitus dorsal; j — $P_5$; *k* — $Enp_3$ $P_4$ ; l — *Diacyclops bisetosus* (?) $Enp_3$ $P_4$; *Mesochra rapiens* ♀: m — habitus dorsal; n — $P_5$. *Moraria mrazeki* ♀: o — habitus dorsal; p — $P_5$. *Epactophanes richardi*, ♀: q — habitus dorsal; r — anal somite and furca, s — $P_5$ and part of genital somite. Scale bars 100 μm.

Рис. 6. Веслоногие ракообразные (рисунки Д. Дефай). *Diaptomus* (*C.*) *rostripes:* a — $P_5$ ♂, b — дистальные членики геникулирующей антеннулы; c — рострум ♂; d — рострум ♂ ; e — $P_5$ ♀. *Megacyclops viridis*: f — интеркоксальная пластинка, базоподит и коксоподит $P_4$ ♀; g — $P_5$;, h — эндоподит $P_4$. *Cyclops abyssorum,* ♀: i — общий вид дорсально; j — $P_5$; k — дистальный членик эндоподита $P_4$; l — эндоподит $P_4$ *Diacyclops bisetosus* (?); *Mesochra rapiens*, ♀: m — общий вид дорсально; n — $P_5$. *Moraria mrazeki*, ♀: o — общий вид дорсально; p — $P_5$. *Epactophanes richardi*, ♀: q — общий вид дорсально ; r — анальный сегмент и фурка, s — $P_5$ и часть генитального сегмента. Масштаб 100 мкм.

*Megacyclops viridis* is a common species in Iceland as already mentioned by Larsen, Røen (1964). It shows variations, compared to the different descriptions, particularly that of Einsle (1996): in the specimens from sample 10, the precoxal plate of $P_4$ has two rows of spinules, the surnumerary row is located near the distal edge and its spinules are smaller:

moreover, almost all the females observed had the furcal rami ornamented with tiny points of teeth over their whole surface. The spine ornamentation of the basipodite of $P_4$ is generally more marked (spinules more numerous and stronger), but the distribution pattern remains identical. Finally, some variations in the number of teeth (7 to 13) have been noticed for the longitudinal row characteristic of the basipodite of the antenna (fig. 6, f–h).

*Cyclops abyssorum*. The identification of species of the genus *Cyclops* is problematic, especially for specimens from Iceland. Because of the important variations of some morphological characters, due to the ecological conditions, and hence, the presence of several ecotypes in a single species, this genus has been discussed for a long time. The most reliable characters for separating the species are cytogenetical particular patterns of chromatin-diminution, but such information is not available for Icelandic *Cyclops*. Various authors have identified *Cyclops strenuus* (de Guerne, Richard, 1892 a; Ostenfeld, Wesenberg-Lund, 1905; Haberbosch, 1916; Poulsen, 1924, 1939, 1940), and *Cyclops scutifer* (Dussart, 1958; Røen, 1962; Larsen, Røen, 1964) from Iceland. Using a new morphometric approach, Elgmork, Halvorsen (1971) established that it was *Cyclops strenuus medianus* (Lindberg, 1949) now *Cyclops abyssorum medianus* (Dussart, Defaye, 1983). The specimens examined in this study have the morphometrical characteristics given by Elgmork, Halvorsen (1971). We consider them as belonging to *Cyclops abyssorum* s. l., following Einsle (1980, 1996), who prefers to consider the different subspecies as ecotypes or phenotypes of a single species, when morphometry do not allow their separation. This species was identified according to the same argument by Antonsson (1992) for *Cyclops* from Thingvallavatn. The difficulty in establishing the validity of subspecies has also been discussed by Nilssen (1979) for *Cyclops abyssorum*. The specimens examined are very similar to those figured by Einsle (1996) from Lake of Constance, especially in the ornamentation of the coxopodite and precoxal plate of $P_4$, which has a median row of long setae and two symmetrical prominences; the internal setae at the base of coxopodite are thin, unlike those of *C. scutifer*'s ones, which are very thick. The ornamentation of the antennal basipodite is similar, although the small, sparse spines are not visible. However, the terminal spines of Enp3 $P_4$ are slightly different: the internal spine is shorter than the segment (equal in abyssorum from Lake of Constance) and the external spine is longer than in typical abyssorum (0.5 times the internal spine) (fig. 6, i–k).

*Acanthocyclops vernalis*. The specimens examined conform to the Nordic form figured by Kiefer (1978) from Norway. In sample no 24, the lateral setae of Enp3$P_4$ bear spines instead of hairs — this often noted variation is generally interpreted as a response to ecological conditions — and the precoxal plate of $P_4$ has a median row of small spines.

*Diacyclops bisetosus* (fig. 6, 1). A surnumerary, oblique row of spinules has been observed at the internal corner of the basipodite of $P_4$.

For the harpacticoid fauna, two species of Canthocamptidae are new for Iceland: *Mesochra rapiens* (Schmeil, 1894) and *Moraria mrazeki* Scott, 1903, the cosmopolitan species *E. richardi* being already reported. *M. rapiens* is a brackish-waters species (collected in a pond, near the sea) known from Western and central Europe, but also from Alaska and Greenland (Røen, 1962).

## Discussion

### Biological features and biogeographical remarks

Large Branchiopods (Notostraca)

The Large branchiopod's fauna is represented by only one species, *Lepidurus arcticus*. This widely distributed Holarctic species has a circumpolar distribution (Abele, 1982). It is found in North America from Alaska to Labrador, and in Greenland by many authors (Stephensen, 1913; Røen, 1962, 1981; Beaton, Hebert, 1988 etc.). In Europe, it is widely distributed among the Northern countries (see the distribution map in Brtek, Thiéry, 1995). It occurs particularly in Ireland, Bear Island, Spitzbergen (Lilljeborg 1877) and extends from Scandinavia to Siberia (Sars, 1897; Lundblad, 1921; Vekhoff, Vekhova 1994). At lower latitudes, this species is known from Pleistocene strata in Scotland and Denmark (Røen, 1995)

**Table 2. List of copepod species from Iceland (literature data)**

**Таблица 2. Список видов копепод из Исландии (литературные данные)**

| Species | Reference (s) |
|---|---|
| *Leptodiaptomus minutus* (Lilljeborg, 1889) | Guerne, Richard (1892 a, b), Ostenfeld, Wesenberg-Lund (1905), Poulsen (1924), Antonsson (1992), Larsen, Røen (1964) |
| *Diaptomus glacialis* Lilljeborg, 1889: | Guerne, Richard (1892 a, b), Poulsen (1924), Larsen, Røen (1964) |
| *Macrocyclops albidus* (Jurine, 1820) | Adalsteinsson (1979) |
| *Macrocyclops fuscus* (Jurine, 1820) | Guerne, Richard (1892 a, b), Poulsen (1924), Adalsteinsson (1979) |
| *Eucyclops serrulatus* (Fischer, 1851) | Guerne, Richard (1892 a, b), Poulsen (1924), Adalsteinsson (1979) |
| *Paracyclops fimbriatus* (Fischer, 1853) | Guerne, Richard (1892 a, b), Poulsen (1924), Adalsteinsson (1979) |
| *Megacyclops viridis* (Jurine, 1820) | Guerne, Richrd (1892 a, b), Poulsen (1924), Larsen, Røen (1964), Adalsteinsson (1979) |
| *Cyclops strenuus* Fischer, 1851 | Guerne, Richard (1892 a), Haberbosch (1916), Ostenfeld, Wesenberg-Lund (1905), Poulsen (1924) |
| *Cyclops abyssorum* s. l. G. O. Sars, 1863 | Antonsson (1992) |
| *Cyclops cf. abyssorum* G. O. Sars, 1863 | Adalsteinsson (1979) |
| *Cyclops abyssorum medianus* Lindberg, 1949 | Haberbosch (1916), Poulsen (1924), Larsen, Røen (1964), Elgmork, Halvorsen (1971) |
| *Acanthocyclops vernalis* (Fischer, 1853) | Haberbosch (1916), Poulsen (1924), Larsen, Røen (1964) |
| *Diacyclops bisetosus* (Rehberg, 1880) | Kulhavy, Noodt (1968) |
| *Diacyclops languidoides* s. l. (Lilljeborg, 1901) | Kulhavy, Noodt (1968) |
| *Bryocamptus* (*A.*) *cuspidatus* (Schmeil, 1893) | Larsen, Røen (1964), Kulhavy, Noodt (1968) |
| *Bryocamptus* (*A.*) *van douwei* (Kessler, 1914) | Haberbosch (1916) |
| *Moraria brevipes* G. O. Sars, 1862 | Kulhavy, Noodt (1968) |
| *Maraenobiotus vejdovskyi* Mrazek, 1893 | Haberbosch (1916) |
| *Epactophanes richardi* Mrazek, 1893 | Haberbosch (1916), Kulhavy, Noodt (1968) |
| *Parastenocaris glacialis* Noodt, 1955 | Kulhavy, Noodt (1968) |
| *Canthocamptus* sp. | Guerne, Richard (1892 a, b) |

and was discovered in the valley of the River Wavenay, Southeast England, by Taylor, Coope (1985). Before the present study, *L. arcticus* had been already recorded from Iceland (Kröyer, 1847; Fryer, 1988 etc.). All animals from station 17 were females; a strong female bias has been noted in this species (Lundblad, 1921; Sassaman, 1991 etc.). It was shown to be hermaphroditic by the histological studies of Wingstrand (1978) and the enzyme electrophoresis studies of Beaton, Hebert (1991). Females of *Lepidurus arcticus* attach their eggs to aquatic vegetation, such as moss fronds (Fryer, 1988). The eggs are spherical with a rough surface and an alveolar outer layer (Thiéry et al., 1995). Their diameter varies from 603 to 750 μm, probably in relation with their degree of maturity and, perhaps, with their geographic origin. From the known results (Braem, 1893; Fryer, 1988; Thiéry et al., 1995, present study) the eggs of *L. arcticus* populations are biggest than those from Russia. Clutches can reach up to 41 eggs depending of the age of the female (Arnold, 1966).

The presence of a population of *L. arcticus* in the northeastern Iceland in a volcanic area confirms previous known records. As for all previous records of *L. arcticus* around the arctic circle, the present material was collected in summer (9 July 1996), evidently in relation to the icefree water period (<3 months), *L. arcticus* being mechanically damaged and killed by freezing in ice (Scholander et al., 1953). The existence of two distinct cohorts in a population may indicate a secondary flooding after a rain, as shown by Thiéry (1987, 1991) in temporary ponds in Morocco. The biotope is located in the inner highlands above 300 m, corresponding to the Group III, as precised by Poulsen (1924, p. 90). The bottom is sandy, without aquatic vegetation (Group 1 and 2 from Poulsen 1924, p. 91), and the water has a low conductivity. No fish were seen in the pond, which might have dried out during the summer. In Russia, Vekhoff, Vekhova (1994) consider *L. arcticus* as a remnant of the ancient tundra or tundra-like fauna still widespread more to the north.

However, the Iceland diversity for large branchiopods is lower than the diversity observed in Greenland and Northen Europe. From the relationship between species diversity and latitude for the "large Branchiopods" of Europe established by Brtek, Thiéry (1995), the theorical number of species could be 2 or 3, considering that several other species, mainly fairy shrimps (Anostraca), such as *Branchinecta paludosa*, are known from Greenland (Johansen, 1921), Sweden and Siberia. It is to be noted that another species, *Artemiopsis stefanssoni*, is widely distributed in Greenland (Johansen, 1922 a; Daborn, 1978; Banarescu, 1990). This low species diversity as well as the small body size of *Lepidurus arcticus* specimens, versus other representents of the Triopsidae, could be compared to available data on Insect ecology in Arctic environments by Strathdee, Bale (1998). As already noted by Banarescu (1992) aquatic life is assumed to have been totally destroyed in glaciated areas. After the melting of the ice, Iceland might be populated by species coming from the beringian refugium corresponding to the lower Yukon River basin and encompassing also a part of extreme eastern Siberia, which was connected with extreme western Alaska.

Cladocera

In general 32 or 33 cladoceran species were known in Iceland before (Røen, 1962; Hrbacek et al., 1978) (the species' names of *Bosmina* are different according to the authors), the various lists including all species identified or collected during the present survey except *Alona rustica*. So far, *A. rustica* had not been recorded in Iceland. Røen (1977) listed this species from Greenland but later, he reidentified it as a new species, *A. fabricii* (Røen, 1992).

The material studied lacked species preferred fishless water bodies (*Eurycercus glacialis*) or which are deep and not frozen to the bottom (case of the representatives of Ctenopoda — Sida, Diaphanosoma, Holopedium, genus *Bosmina* and *Daphnia longispina*).

The species *Simocephalus vetulus*, *Eurycercus lamellatus*, *Chydorus sphaericus*, *Alonella excisa*, *Acroperus harpae* and *Alona affinis* were common in most of the samples whereas *Simocephalus serrulatus*, *Ceriodaphnia quadrangula*, *Alonella nana* and *Alona rustica* were present at very low density from only one locality each. On the whole, this is in a good agreement with the previous data on species frequency in Iceland (Poulsen, 1924). Cladoceran species richness in Iceland is slightly higher than in Greenland which has been more studied in detail (31 species) (Røen, 1992, 1994 etc.) even so *Latona setifera*, *Rhynchotalona* and some species of *Alona* have not yet been found. At the same time, such widely distributed and easily identified taxa as Diaphanosoma, Ilyocryptus, Lathonura and *Eurycercus lamellatus* are not known from Greenland.

Copepoda

Twelve copepod species have been identified in thirty samples, containing generally a quantitatively poor fauna. Among calanoids, the presence of *Diaptomus* (*D.*) *castor*, in south of Vatnajцkull is reported from the first time in Iceland, which represents the westernmost limit of its distribution area for Europe. However, it is known also from Greenland (Røen, 1962).

*Diaptomus* (*Chaetodiaptomus*) *rostripes* is a new report while *D.* (*C.*) *glacialis* has not been identified although it is currently known from Iceland. As the differences between the two species are not very discriminent, particularly for P5, it is possible that in the past, *D.* (*C.*) *rostripes* has been identified as *D.* (*C.*) *glacialis*. Attention should be given to the rostral spines which represents a good character to distinguish these two species. New examinations of the material should permit to better know the relative distribution of both species. Moreover, the diaptomid *Leptodiaptomus minutus* (Lilljeborg, 1889) well-know from Iceland (de Guerne, Richard 1892 a; Antonsson, 1992 etc.) has not been found in this study. This can be explained by its preferences of pelagic life — the biotopes studied are of small size- as it is illustrated by its presence in Thingvallavatn (Antonsson, 1992). This nearctic species, known from Iceland from the last century usually inhabits oligotrophic lakes. Iceland constitutes the easternmost limit of its distributional range mostly situated in North America and Greenland.

Cyclopoids from Iceland are represented by some common species, occurring in European ponds, even considered as cosmopolitan (*Macrocyclops albidus, Eucyclops serrulatus* and *Megacyclops viridis*). The genus *Macrocyclops* was known until now only by the species *fuscus*. The genus *Acanthocyclops* is represented by the species *vernalis* already reported from the southern part of Vatnajџkull (Haberbosch, 1916). It appears more largely distributed. *Diacyclops bisetosus* has been found again in the Reykvajik region. Finally, the genus *Cyclops* appears, considering the data from the literature, as commonly present in Iceland.

The copepod fauna of the small water collections of Iceland mainly consists of palearctic species, without strict environmental requirements. This study complete the existing data, but it is likely that the inventory is not finished, particularly concerning the harpacticoids which have been not enough looked for, specially in such habitats as mosses and interstitial waters.

In conclusion, the crustacean fauna inhabiting the shallow freshwater in Iceland seems to be largely allochthonous, with quite limited endemicity.

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