

## SHORT ARTICLES AND REVIEWS

**THE REDISCOVERY OF THE CLADOCERAN *EURYCEROJSILACIAUS* J.ILLJEBORG, 1887 (BRANCHIOPODA, CHYDORIDAE) IN SCOTLAND**

CATHERINE A. DUIGAN

(Dr C. A. Duigan, Institute of Earth Studies, University College of Wales, Aberystwyth, Dyfed SY23 3DB, Wales.)

**Introduction**

*Eurycercus* is a relatively large micro-crustacean in the Family Chydoridae. Two species of this genus — *E. lamellatus* (O. F. Müller, 1776) and *E. glacialis* Liljeborg, 1887 — are known to occur in Britain and Ireland (Scourfield & Harding 1966; Duigan 1989). The *glacialis* populations have probably existed since the last glacial period, but this species is also capable of extending its range if environmental conditions are favourable. Several papers have given detailed descriptions of the morphological differences between *E. lamellatus* and *E. glacialis* (Frey 1971, 1973; Duigan & Frey 1987a,b) and a redescription of *E. glacialis* from type material was recently completed by Hann (1990). The characteristic external features of *E. glacialis* include a broadly rounded dorsal surface (without a keel; Fig. 1a,b); a flat median headpore on a posteriorly rounded headshield (Fig. 1b); the postabdomen has a centrally flattened dorsal margin, the distal end is sloping and rounded beyond the last denticle, and the postabdominal denticles increase in height but maintain basal width distally (Fig. 2a).

*E. lamellatus* has been recorded throughout the biogeographical regions designated in Limnofauna Europea (Hrbáček et al. 1978). in Britain and Ireland, it is a common chydorid occurring in a great diversity of waterbodies (Scourfield & Harding 1966; Duigan 1989; Duigan & Kovach 1991). *E. glacialis* has been recorded from dune depressions on the west coast of Jutland (Denmark), on the island of Sylt (Germany), moorland pools in the Netherlands (Frey 1975a), and in turloughs in Ireland (Duigan & Frey 1987a,b).

In Scotland a record of *E. glacialis* existed from material collected in 1957 by A. J. Bruce in what was described as flooded grassland near Tain, Ross-shire (Scourfield & Harding 1966). The precise location and field conditions of this collection were not recorded (Bruce, pers. comm.). Following a preliminary report on the establishment of this location (Duigan 1988a), information was supplied that *E. glacialis* occurred also in "pool on Col of Ronas Hill", Shetland (Maitland, pers. comm.). The

latter record was briefly mentioned in the proceedings of a Nature Conservancy Council symposium on the natural environment of Shetland (Britton 1974). Therefore, the primary aims of this investigation were to locate accurately and assess the ecological status of these two *E. glacialis* populations in Scotland.

### Sampling

On 9 April and 6 May 1988, a total of sixteen waterbodies was sampled near Tain on the peninsula between Cromarty Firth and Dornoch Firth (Fig. 3A). On 21 August 1990, a collection was made from a small lochan between the summits of Ronas Hill and Mid Field, Shetland (OS Grid Reference HU 312 838; Figs. 3A, B, 4), which seemed to match the site description given in Britton (1974). A smaller lochan to the NNW of this waterbody (Fig. 3B) was also sampled, but no Cladocera were found. All these qualitative samples were taken using a hand-held plankton net (0.2mm mesh), and the material was preserved in alcohol or approximately 4% formalin. Identifications were carried out using Scourfield & Harding (1966), Flossner (1972), and Duigan & Frey (1987a,b).

### Ronas Hill Site, Shetland

A total of 73 parthenogenetic females of *E. glacialis* was recovered from the sample taken from the small lochan on the coll of Ronas Hill (Figs. 3b, 4). The length-frequency distribution of this population (Fig. 5) correlates with data collected from a Danish population (see Fig. 64, Frey 1973) with egg production at a body length of 3 mm or greater. No males were found, but free ehippia were present in the sample (Fig. 2c), indicating that the autumnal period of gamogenesis was complete. The relatively large size of this chydorid species allows it to utilize large food particles, but also makes it highly susceptible to predation (Frey 1975a; Duigan & Frey 1987b). For this reason it is usually found where fish are absent with the exception of a small number of sites in Ireland (Duigan 1989) and Denmark (Frey 1975a).

This unnamed lochan on Ronas Hill was approximately 45 m long, 35 cm deep at the northern end and 45-55 cm in the centre, following heavy rain. It seems quite likely that this waterbody may dry up during prolonged dry periods. The substrate was mainly composed of sand and stones with a few large boulders, and in some areas there was a covering of silty mud. Water runs off into this waterbody from the surrounding peat and stone debris areas (Fig. 4). The sweep sample was taken mainly through *Juncus bulbosus*, but *Littorella uniflora*, *Isoetes lacustris*, *Lobelia dortmanna*, and filamentous algae were also present (Douse, pers. comm.). *E. glacialis* was found in association with *Alonopsis elongata*

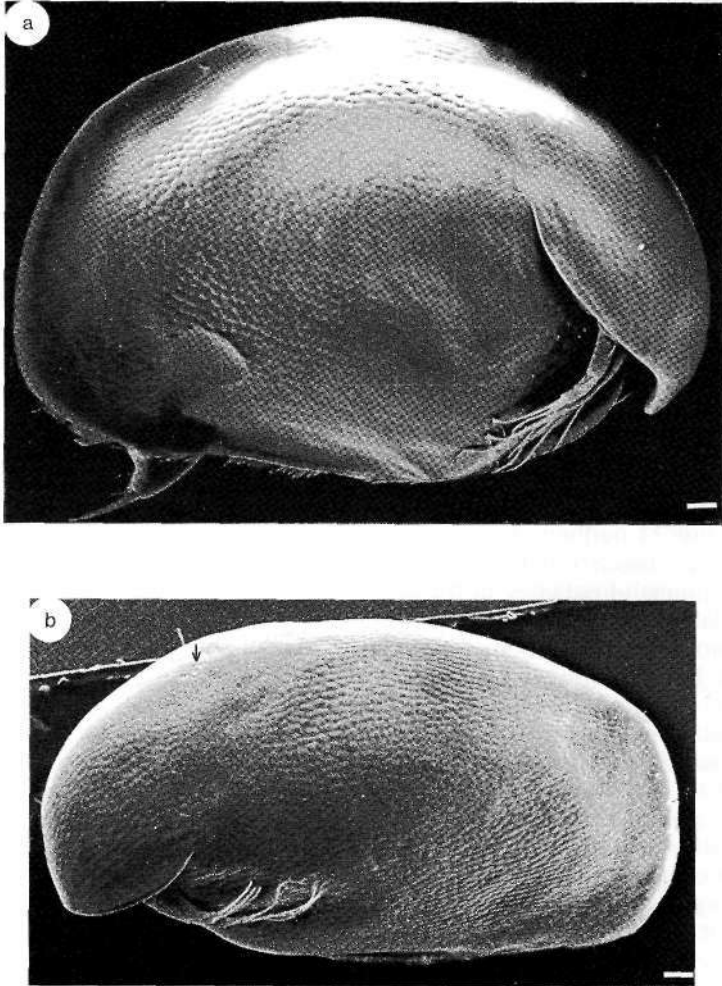


FIG. 1. *Eurycerus glacialis*, parthenogenetic female from lochan on Rona Shetland. a, lateral view (bar = 10 $\mu$ m); b, dorsal view with arrow indicating position of headpore (bar = 10 $\mu$ m).

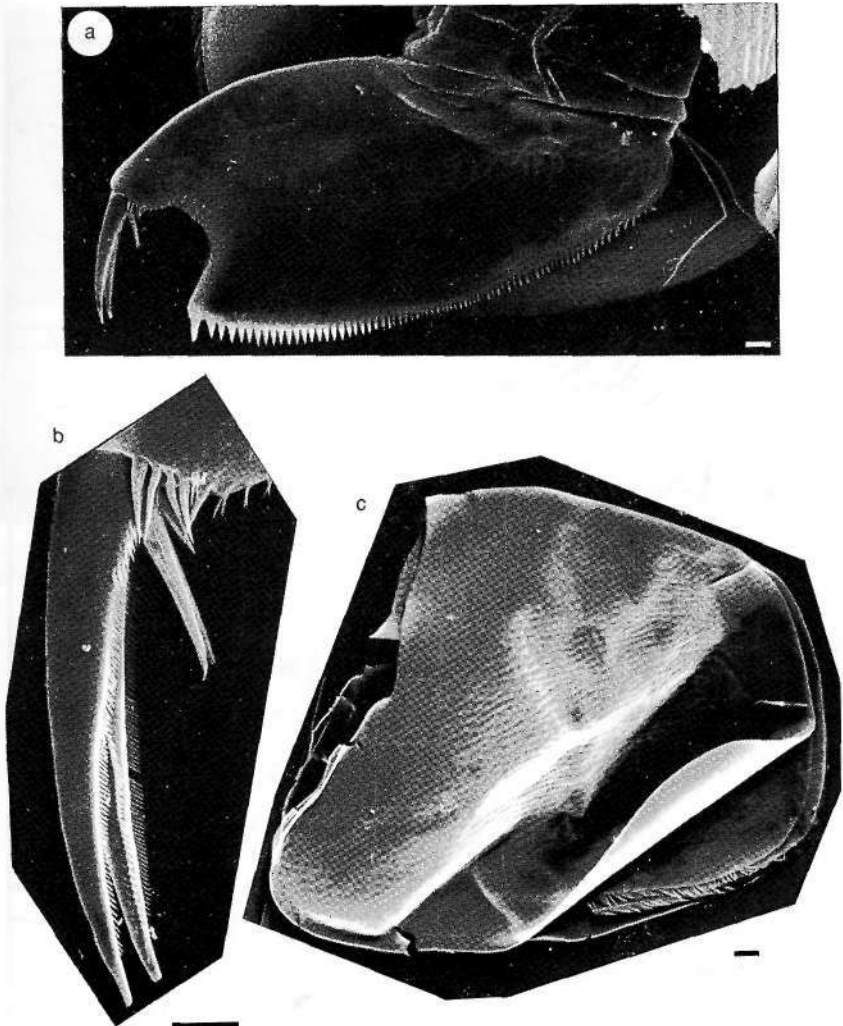


FIG. 2. *Eurycerus glacialis*, parthenogenetic female from lochan on Ronas Hill, Shetland. a, postabdomen (bar = 10 $\mu$ m); b, detail of postabdominal claw (bar = 50 $\mu$ m); c, ehippium (bar = 10 $\mu$ m).

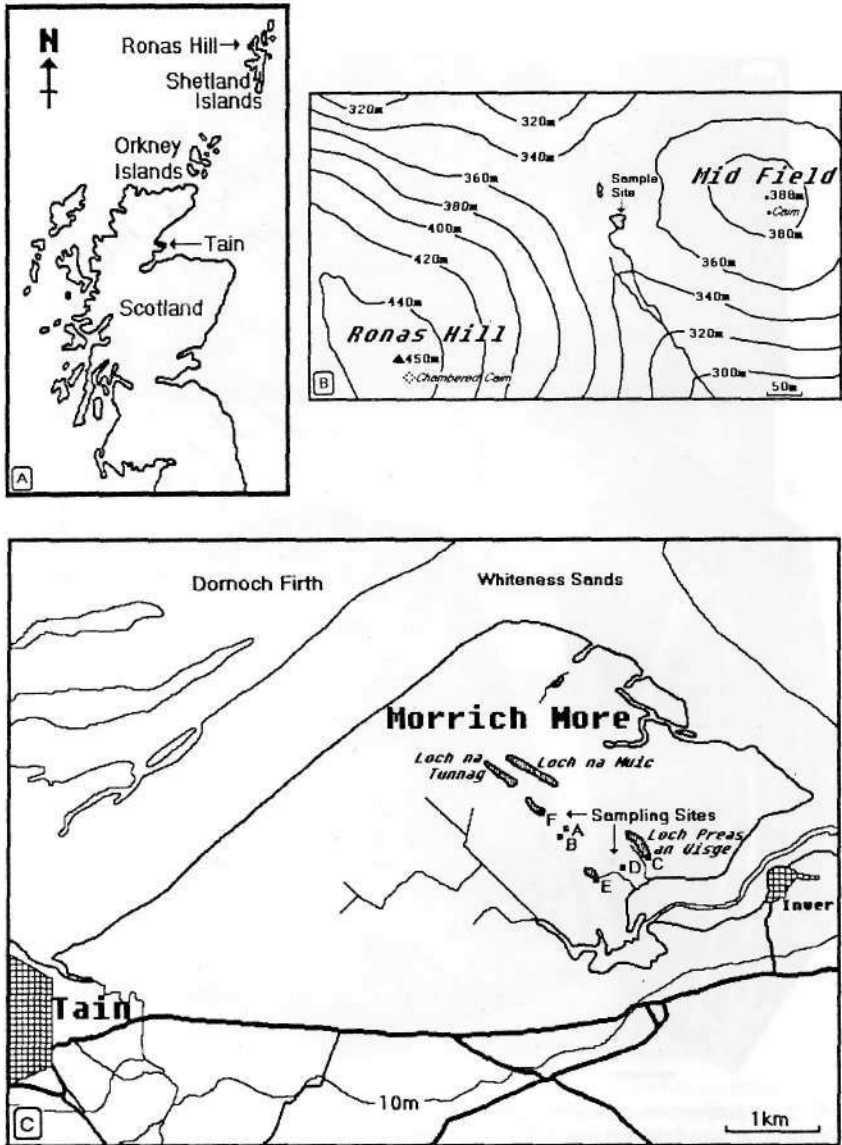


FIG. 3. A, Locations of populations of *Eurycercus glacialis* in Scotland; B, Lochan on Ronas Hill, Shetland; C, Morrich More Area, near Tain, Ross-shire.



FIG. 4. The unnamed lochan on Ronas Hill, on the mainland of Shetland. From a colour photograph taken by Dr Warren L. Kovach (August 1991).

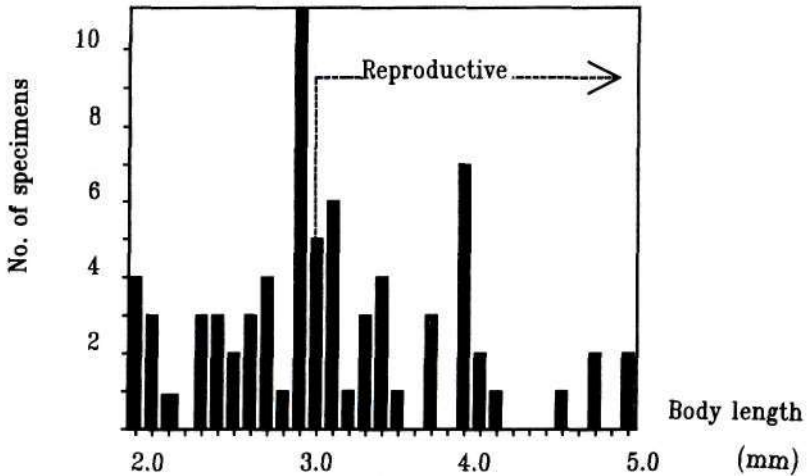


FIG. 5. Length-frequency distribution of the population of *Eurycercus glacialis* collected from the lochan on Ronas Hill, Shetland. 73 females were measured and the smallest female with eggs in its brood pouch had a body length of 3.1 mm.

(Sars, 1862) which is frequently found in non-productive and acid, oligotrophic waters (Duigan 1989). Other invertebrate families present include plecopterans, Corixidae, Chironomidae, Dytiscidae and Enchytraeidae. There was no resident fish population.

### Morrich More Site, Ross-shire

*E. glacialis* was found in small numbers in three samples taken from waterfilled depressions behind sand dunes on the Royal Air Force Range near Tain (OS Grid Reference NH 840 835; Fig. 3C). The cladoceran species occurring in six pools and lakes within this immediate area are given in Table 1. The terrestrial vegetation was characterized by mossy hummocks, heathers, sedges, and creeping willows. At temporary waterbodies A, B, and D this vegetation was submerged in less than 1 m of water. Sites C (Loch Preas an Uisge), E, and F (lake south of Loch na Muic) are indicated as permanent waterbodies on the Ordnance map, but they undergo large seasonal fluctuations in water level. They also supported the growth of aquatic macrophytes such as *Chara*. At the time of sampling the water was very clear and there were no in- or out-flowing streams. However an outflow from sampling site E is indicated on the OS map but it seems to be of a temporary nature (Fig. 3c). Enquiries confirmed that there are no records of fish populations, but these waterbodies still support a diverse aquatic fauna including members of the Ostracoda, Copepoda, Plecoptera, Hydrozoa, Gastropoda and Amphibia.

Table 1. Species of Cladocera recorded at six sampling locations within Royal Airforce Base, near Tain, Ross-shire, Scotland, on 6 May 1988. O=absent; P=parthenogenetic females; Ep=Ephippial females; M=males.

	Sampling Sites					
	A	B	C	D	E	F
<i>Eurycerus glacialis</i>	P	O	O	O	P	P
<i>Acroperus harpae</i>	O	O	O	O	P	O
<i>Alona rustica</i>	O	O	O	O	O	P
<i>Chydorus sphaericus</i>	P,Ep,M	P,M	P,Ep	P	P,Ep	P,Ep,M
<i>Alonella excisa</i>	P	O	P	O	P	P
<i>Simocephalus vetulus</i>	P	P	P	O	P	P

The species diversity of the cladoceran community that occurs with *E. glacialis* is often limited by the temporary nature of the waterbodies and their need to become gamogenetic in early summer. Gamogenesis results in the production of a resting egg (within an ephippium; Fig. 2c), which can survive desiccation and therefore ensure population survival. Ephippial females and/or males were found in five of the *Chydorus sphaericus* populations examined (Table 1), thus demonstrating that this

cladoceran community has adopted the same survival strategy used by *E. glacialis* and its associated species in Irish turloughs (Duigan 1988b). All the species listed in Table 1 have previously been recorded in association with *E. glacialis* (Frey 1975a; Duigan & Frey 1987a,b).

### Distribution and dispersal

*E. glacialis* has been recorded from two contrasting freshwater environments in Scotland. The only features the small mountain lochan and the extensive network of dune waterbodies have in common are their shallow depths and seasonal nature, and the absence of predatory fish, which would severely diminish or eliminate a population of *E. glacialis*. This taxon has also been found in similar locations along the north-west coast of Europe. One of the main centres of its distribution in the Netherlands is in inland heath-moorlands in the district of Drenthe. In Germany and Denmark, it occurred mainly in coastal and sand dune pools (Frey 1975a).

Frey (1975a) postulated that "the idea that populations of *glacialis* in the region peripheral to the North Sea have become established in post-glacial time by the transport of ephippia from Iceland, or less likely Greenland, by waterfowl or shorebirds seems rather unlikely, because the Feroe and Shetland Islands, which might be considered intermediate colonization points between Iceland and Western Europe, both lack the species, and because *Alonopsis elongata*, which is abundant in Lapland and certainly could survive the no-more-severe conditions in Iceland, has never become established there by reverse migration, although it does occur in the Feroes and Shetland". This theory may have to be revised in the light of the confirmation of *E. glacialis* on Shetland, and the transfer of ephippia on the feet and plumage of migrating birds remains a possibility.

### Speciation

Three subgenera have been erected within the genus *Eurycercus* Baird, 1843 — *Eurycercus* for *E. lamellatus*, *Teretifrons* for *E. glacialis* and *Bullatifrons* for *E. macracanthus* and *E. pompholygodes* (Frey 1975b) — and subsequent studies have described several new species within *Eurycercus* (Hann 1980, 1982, 1990; Frey 1978). These studies have also shown that the taxon *E. lamellatus* (O. F. Muller, 1776), which was once considered a widespread Holarctic species, is a complex of several related species and that *E. lamellatus* s. str. known in western Europe does not occur in North America.

Frey (1975a) has suggested that *E. glacialis* Liljeborg, 1887 should now be regarded as a multiple taxon and that the form found in north-western Europe is distinct from that in the Arctic region. Although the theory of non-



cosmopolitanism in Cladocera (Frey 1982a, 1986, 1987a) has been reinforced by several comprehensive studies, in the case of *E. glacialis* the degree of genetic isolation required for such speciation is suspect if there are "stepping-stone" populations of *E. glacialis* on the Scottish islands. The identification of a thriving *glacialis* population on Shetland would leave the way open for a very interesting study on the genetic and morphological differences between these different geographic populations and a detailed comparison with the type material. The techniques of scanning electron microscopy and gel electrophoresis have been effectively applied to a growing number of chydorid taxa including *Elamellatus* (Frey 1975b; Hann 1980, 1982), *Alonopsis elongata* (Kubersky 1977), *Chydorus sphaericus* (Frey 1980; Duigan & Murray 1987), *Chydorus reticulatus* (Frey 1982b), *Oxyurella tenuicaudis* (Michael & Frey 1983), *Disparalona rostrata* (Michael & Frey 1984), *Chydorus faviformis* (Frey 1987b) and *Pleuroxus laevis* (Frey 1988).

### **The fate of *E. glacialis***

The dune waterbodies at Morrich More have now been positively identified as the only known location of *E. glacialis* in mainland Britain and as such it merits conservation. However, this area is under considerable developmental pressure, because an oil pipeline has been constructed through the site. It is feared that this structure will affect the hydrology of the area north of the pipeline, and it is currently being monitored (J. Rees, NCC, pers. comm.). At the moment the area where *E. glacialis* occurs appears to be unchanged, but only time and future development plans will determine its fate. This makes it all the more important to determine the extent of the distribution of *E. glacialis* on Shetland where there is an abundance of suitable waterbodies.

### **Acknowledgements**

Thanks are due to Dr Andrew Douse, Nature Conservancy Council (NCC), Shetland, for sampling the Ronas Hill lochan and providing a site description; to Dr Mark Young, Department of Zoology, University of Aberdeen, for his advice and co-operation; to Prof. D. G. Frey, Biology Department, Indiana University, USA, for background information and comments on this manuscript; to Dr A. J. Bruce, Northern Territory Museum of Arts and Sciences, Darwin, Australia, for additional background information; to Dr P. S. Maitland, Fish Conservation Centre, Stirling for notification about the Shetland record; to Jenny Rees, NCC, Inverness, for updated information on Morrich More; to Dr W. L. Kovach for assistance in the field and helpful comments on this manuscript; and to the Range Safety Officer and RAF personnel at Tain.

This investigation was funded by two Small Ecological Project Grants (Nos. 595 (1988) and 837 (1991)) to the author from the British Ecological Society. This paper is publication number 162 from the Institute of Earth Studies, UCW, Aberystwyth.

## References

- Britton, R. H. (1974). The Freshwater Ecology of Shetland. In *The Natural Environment of Shetland* (ed. R. Goodier). Proceedings of the Nature Conservancy Council Symposium held in Edinburgh, 29-30 January, 1974. NCC, Edinburgh.
- Duigan, C. (1988a). *Eurycerus glacialis* Liljeborg, 1887 (Crustacea, Cladocera) in Scotland. *British Ecological Society Bulletin* 19, 244-247.
- Duigan, C. (1988b). The Cladocera of Lough Ree and neighbouring waterbodies. *Irish Biogeographical Society Bulletin* 11, 110-113.
- Duigan, C. (1989). The taxonomy, ecology and distribution of the littoral freshwater Chydoridae (Crustacea, Cladocera) of Ireland. PhD. thesis, National University of Ireland. 3 Volumes.
- Duigan, C. & Frey, D. G. (1987a). *Eurycerus glacialis*, a chydorid cladoceran new for Ireland. *Irish Naturalists' Journal* 22, 180-183.
- Duigan, C. & Frey, D. G. (1987b). *Eurycerus glacialis* in Ireland. *Internationale Revue der Gesamten Hydrobiologie* 72, 235-249.
- Duigan, C. A. & Kovach, W. L. (1991). A study of the distribution and ecology of littoral freshwater chydorid (Crustacea, Cladocera) communities in Ireland using multivariate analyses. *Journal of Biogeography*, 18, 267-280.
- Duigan, C. A. & Murray, D. A. (1987). A contribution to the taxonomy of *C. sphaericus sens. lat.* (Cladocera, Chydoridae). *Hydrobiologia* 145, 113-124.
- Flossner, D. (1972). Krebstiere. Crustacea. Kiemen-und Blattfusser. *Branchiopoda. Fishlause. Brachiura. Die Tierwelt Deutschland* 60, 1-501. Gustav Fisher Verlag Jena.
- Frey, D. G. (1971). Worldwide distribution and ecology of *Eurycerus* and *Saycia* (Cladocera). *Limnology and Oceanography* 16, 254-308.
- Frey, D. G. (1973). Comparative morphology and biology of three species of *Eurycerus* (Chydoridae, Cladocera), with a description of *Eurycerus macrocanthus* sp. nov. *Internationale Revue der Gesamten Hydrobiologie* 58, 221-267.
- Frey, D. G. (1975a). The distribution and ecology of *Eurycerus glacialis* (Cladocera, Chydoridae) in Western Europe. *Verhandlungen der Internationale Vereinigungen fur theoretische und angewandte Limnologie* 19, 2922-2934.
- Frey, D. G. (1975b). Subgeneric differentiation within *Eurycerus* (Cladocera, Chydoridae) and a new species from Northern Sweden. *Hydrobiologia* 46, 263-300.
- Frey, D. G. (1978). A new species of *Eurycerus* (Cladocera, Chydoridae) from the southern United States. *Tulane Studies in Zoology and Botany* 20, 1-25.
- Frey, D. G. (1980). On the plurality of *Chydorus sphaericus* (O. F. Miiller) (Cladocera, Chydoridae), and designation of a neotype from Sjaels0, Denmark. *Hydrobiologia* 69, 83-123.

- Frey, D. G. (1982a). Questions concerning cosmopolitanism in Cladocera. *Archiv fur Hydrobiologie* 93, 484-502.
- Frey, D. G. (1982b). The reticulated species of *Chydorus* (Cladocera, Chydoridae): two new species with suggestions of convergence. *Hydrobiologia* 93, 255-279.
- Frey D. G. (1986). The non-cosmopolitanism of chydorid Cladocera: implications for biogeography and evolution. In: *Crustacean Biogeography* (eds. K. L. Heck & R. H. Gore), pp. 237-256. Balkema, Rotterdam.
- Frey, D. G. (1987a). The taxonomy and biogeography of the Cladocera. *Hydrobiologia* 145, 5-17.
- Frey, D. G. (1987b). The North American *Chydorus faviformis* (Cladocera, Chydoridae) and the honeycombed taxa of other continents. *Philosophical Transactions of the Royal Society of London. B.* 315, 353-402.
- Frey, D. G. (1988). Separation of *Pleuroxus laevis* Sars, 1861 from two resembling species in North America: *Pleuroxus straminus* Birge, 1879 and *Pleuroxus chiangi* n. sp. (Cladocera, Chydoridae). *Canadian journal of Zoology* 66, 2534-2563.
- Hann, B. J. (1980). Population differentiation in the *Eurycercus (Bullatifrons)* species complex (Chydoridae, Cladocera) in eastern North America. Ph. D. thesis, Indiana University.
- Hann, B. J. (1982). Two new species of *Eurycercus (Bullatifrons)* from eastern North America. (Chydoridae, Cladocera). Taxonomy, Ontogeny and Biology. *Internationale Revue der Gesamten Hydrobiologie* 64, 585-610.
- Hann, B. J. (1990). Redescription of *Eurycercus (Teretifrons) glacialis* (Cladocera, Chydoridae), and description of new species, *E. (T.) nigracanthus*, from Newfoundland, Canada. *Canadian Journal of Zoology* 68, 2146-2157.
- Hrbařek, von J., Koririek, V. and Frey, D. G. (1978). Cladocera. In *Limnofauna Europaea* (ed. J. Iilies), 2nd edn., pp. 189-195. Fischer Verlag Stuttgart, New York. 532pp.
- Kubersky, E. S. (1977). Worldwide distribution and ecology of *Alonopsis* (Cladocera: Chydoridae) with a description of *Alonopsis americana* sp. nov. *Internationale Revue der Gesamten Hydrobiologie* 62, 649-685.
- Michael, R. G. & Frey, D. G. (1983). Assumed Amphi-Atlantic distribution of *Oxyurella tenuicaudis* (Cladocera, Chydoridae) denied by a new species from North America. *Hydrobiologia* 106, 3-35.
- Michael, R. G. & Frey, D. G. (1984). Separation of *Disparalona leei* (Chien, 1970) in North America from *D. rostrata* (Koch, 1841) in Europe (Cladocera, Chydoridae). *Hydrobiologia* 114, 81-108.
- Scourfield, D. J. & Harding, J. P. (1966). A key to the British Freshwater Cladocera. *Scientific Publications of the Freshwater Biological Association*, No. 5 (3rd edn.), 1-55.