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A limnological reconnaissance of the Vestfold Hills

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Contents

Abstract

Thirty-eight bodies of water in the Vestfold Hills, East Antarctica, were sampled for rotifers and other aquatic invertebrates. The waters comprised three shallow pools, which freeze solid in the winter; true lakes that, because of the peculiar nature of the Vestfold Hills, encompass land-locked bodies of fresh, brackish, marine and hypersaline waters; and one marine/coastal station, which is cut off from the rest of the fjord by ice during the winter.

Twenty-six species of rotifer, Protozoa, nematodes, two species of platyhelminth, at least two species of tardigrade, and seven species of arthropod were found. From these results the lakes of the Vestfold Hills could be divided into six categories—pools, freshwater lakes, fresh/brackish lakes, brackish lakes, marine lakes and hypersaline lakes—each of which has its own distinctive fauna.

Key Words: Rotifers, Lakes, Salinity, Vestfold Hills, Antarctica.

1. Introduction

The most noteworthy feature of limnology of the Vestfold Hills is the great range of salinities of its lakes, extending from Crooked Lake, one of the largest freshwater lakes in the Antarctic, through a complete spectrum of intermediate salinities to Deep Lake, one of the most saline lakes in the world after the Dead Sea. Since the first descriptive biological survey of the area (Johnstone et al. 1973) most of the limnological studies carried out here have concentrated on the saline and hypersaline lakes, especially the meromictic ones (Bayly 1978; Burton and Hamond 1981; Marchant and Perrin 1986; van den Hoff and Franzmann 1986; Bayly and Burton 1987; Burke and Burton 1988; Bayly and Eslake 1989; Gibson et al. 1989; Wang et al. 1990), and only recently have the freshwater lakes received any attention (Everitt 1981; Laybourn-Parry and Marchant 1991, 1992; Laybourn-Parry et al. 1992).

This report describes the rotifers collected from the Vestfold Hills in the period November 1990 to February 1992. Although rotifers are predominantly a freshwater group, none of the lakes in the Vestfold Hills was excluded from this survey on account of increased salinity. Thirty-eight water bodies were examined—many for the first time. The physical characteristics of their waters were measured and, as well as the rotifers, the presence of other invertebrates was noted.

2. Materials and methods

Samples were collected in a variety of ways. When the lakes were ice-covered a 20 cm diameter hole was first cut in the ice with a petrol-driven ice drill. Rigid plastic tubing was then passed through the hole and lowered to the required sampling depth. Water, and benthic sediments (if the tubing had been lowered to the bottom), were then sucked up by means of a hand-operated baling pump (after the method of Dartnall and Hollowday 1985). At other times this apparatus was deployed from the ice-edge, or hung over the side of an inflatable rubber or rigid fibreglass boat. Surface, mid-water and bottom samples were always taken and the phrases 'a depth of 11.2 m' or 'samples were taken from 11.2 m' indicate that the bottom was at that depth. In addition. fragments of cyano-bacterial mats were collected from around the shoreline of a few of the freshwater/brackish lakes. These mats, which originated in deep water, are levitated to the surface by the production of gases and are subsequently blown to the lake edge. Hand nets (53 µm mesh) were used in very shallow pools, and in two instances a fine (53 µm mesh) plankton net was used. Then the net was thrown out into the water and allowed to sink so that when retrieved it sampled on or just above the bottom.

On return to the Davis station laboratory the samples were filtered through an ultra-fine plankton net (mesh size 20 µm), and examined using a binocular dissecting microscope and a high-powered compound microscope. Drawings of rotifers and other invertebrates were made from free-swimming specimens, from living specimens kept under slight compression by means of a coverslip mounted on Vaseline, from specimens relaxed and narcotised with tetra-sodium pyrophosphate (Robotti and Lovisolo 1972), and from permanent slides which were examined under phase contrast. Permanent slides were made using polyvinyl-lactophenol. This method, whilst ideal for rotifer trophi (Russell 1961), is not necessarily recommended for all loricated species since some details are lost as the polyvinyl-lactophenol clears. The method does however guarantee a slide which, given the rarity of some species, was deemed to be important.

Bathymetric surveys were carried out on two lakes (Ace Lake, and the unnamed lake at grid reference 980940). The surveys were done in the winter when the lakes were ice-covered. Holes were drilled at 10m intervals, a leaded line was lowered to the bottom, and the depth was measured after the method of Light (1976).

At the laboratory both conductivity and pH measurements were made on the lake water samples. The pH was measured using a Corning pH meter model 240 and the conductivity/salinity with a WTW Microprocessor Conductivity Meter model LF196. To cover the great range in ionic concentrations the salinity results are given in different units. For freshwater lakes the measurements are given in microsiemens per centimetre (µS/cm), and for marine and super-saline lakes in parts per thousand (‰). Intermediate values (brackish water) are given in millisiemens per centimetre (mS/cm) and parts per thousand.

The 38 Sampling Sites

Chronological listing

Lake 1	Laternula Lake	Lake 14	Mossel Lake	Lake 27	Ekho Lake
Lake 2	'Clear Lake Tarn'	Lake 15	Chelnok Lake	Lake 28	unnamed lake
Lake 3	Clear Lake	Lake 16	Pauk Lake	Lake 29	little unnamed lake
Lake 4	McCallum Lake	Lake 17	Depot Lake	Lake 30	melt pool
Lake 5	Burton Lake	Lake 18	Dingle Lake	Lake 31	Lake Abraxas
Lake 6	Anderson Lake	Lake 19	Deep Lake Tarn	Lake 32	Franzmann Lake
Lake 7	Lebed' Lake	Lake 20	Deep Lake	Lake 33	Deprez Basin
Lake 8	Nicholson Lake	Lake 21	Hand Lake	Lake 34	Ace Lake
Lake 9	Watts Lake	Lake 22	Waterfall Lake	Lake 35	Highway Lake
Lake 10	Ellis Fjord	Lake 23	Lake Zvezda	Lake 36	Pendant Lake
Lake 11	Lake Druzhby	Lake 24	Lake Bisernoye	Lake 37	Fletcher Lake
Lake 12	Crooked Lake	Lake 25	Lake Vereteno	Lake 38	Grace Lake
Lake 13	'Teat' Lake	Lake 26	'Pointed' Lake		

Alphabetical listing

Lake 34	Ace Lake	Lake 10	Ellis Fjord	Lake 29	little unnamed lake
Lake 6	Anderson Lake	Lake 37	Fletcher Lake	Lake 4	McCallum Lake
Lake 5	Burton Lake	Lake 32	Franzmann Lake	Lake 30	melt pool
Lake 15	Chelnok Lake	Lake 38	Grace Lake	Lake 14	Mossel Lake
Lake 3	Clear Lake	Lake 21	Hand Lake	Lake 8	Nicholson Lake
Lake 2	'Clear Lake Tarn'	Lake 35	Highway Lake	Lake 16	Pauk Lake
Lake 12	Crooked Lake	Lake 31	Lake Abraxas	Lake 36	Pendant Lake
Lake 20	Deep Lake	Lake 24	Lake Bisernoye	Lake 26	'Pointed' Lake
Lake 19	Deep Lake Tarn	Lake 11	Lake Druzhby	Lake 13	'Teat' Lake
Lake 17	Depot Lake	Lake 25	Lake Vereteno	Lake 22	Waterfall Lake
Lake 33	Deprez Basin	Lake 23	Lake Zvezda	Lake 28	unnamed lake
Lake 18	Dingle Lake	Lake 1	Laternula Lake	Lake 9	Watts Lake
Lake 27	Ekho Lake	Lake 7	Lebed' Lake		

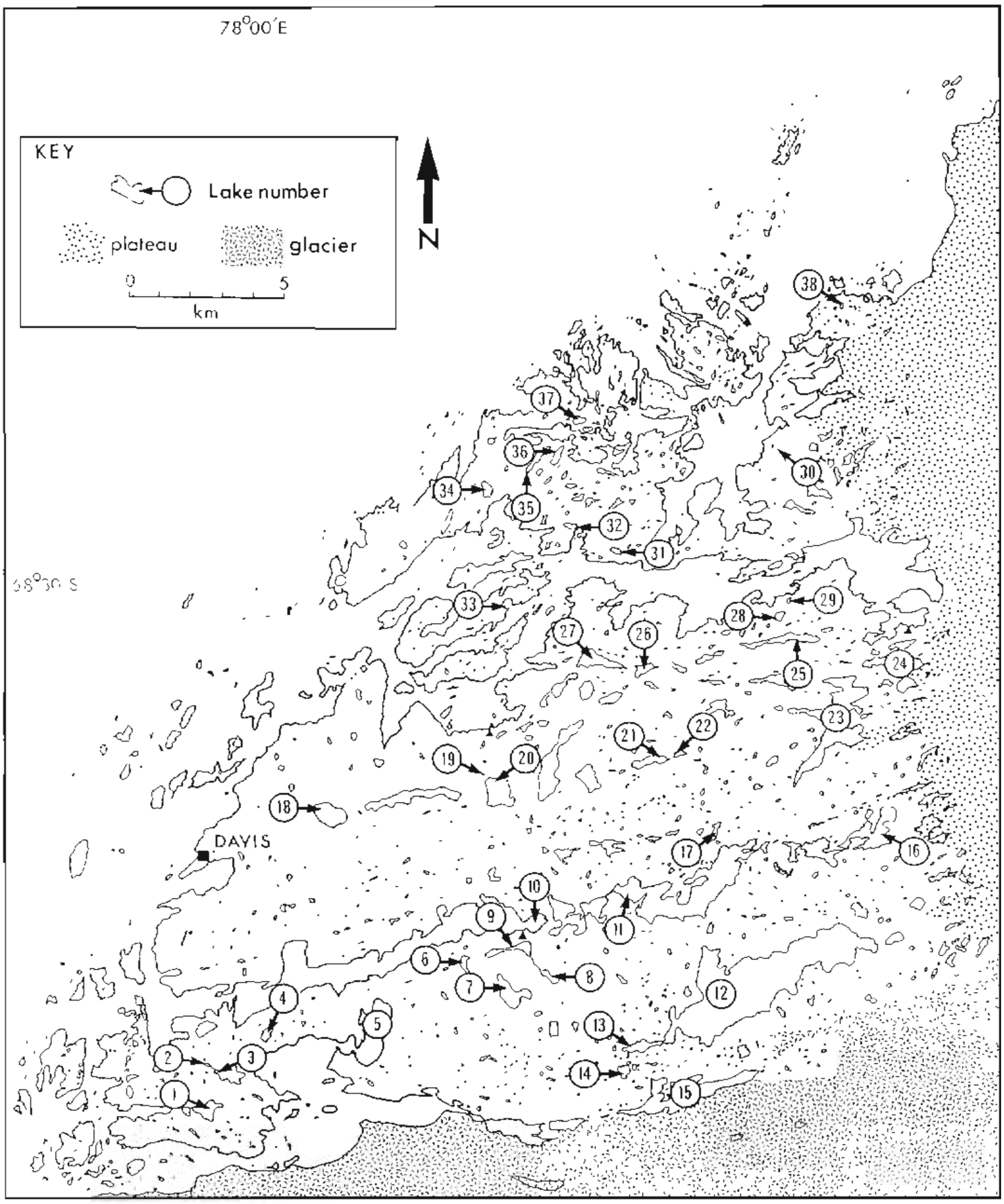

Figure 1. *Map of the Vestfold Hills showing the 38 sampling sites.*

3. The lakes

The Vestfold Hills are situated on the eastern shore of Prydz Bay between latitudes 68°25' and 68°41'S, and longitudes 78°48' and 78°36'E. Roughly triangular in shape, they are bounded to the south by the Sørsdal Glacier, to the east by the continental ice sheet and to the north-west by the sea. Fjords divide the Hills into three rocky peninsulas, each studded with many lakes (see Figure 1). The grid references quoted in the text refer to the second edition of the 1:50 000 map of the Vestfold Hills, published in September 1982. Not all of the lakes have been named and unofficial names are enclosed in quotation marks.

Notes on all the lakes sampled are given below. They contain details of the flora and fauna as well as some physical characteristics of the lakes. The pH and salinity values given alongside each lake name are field observations. In the case of saline/meromictic lakes where a range is indicated, the first value was obtained from the surface, or at the ice/water interface, and the second was obtained from the bottom. In freshwater lakes the higher value corresponds to winter readings and the lower value to those obtained in the summer. The maximum values for depth and salinity, and details of the oxic/anoxic boundary, were compiled from field observations and published reports (notably Gibson et al. 1989; Roberts 1992).

Lake 1
Laternula Lake pH 7.7 conductivity 190 mS/cm = salinity 188‰

This meromictic lake, which is anoxic below 6 m, was sampled twice. In February 1991 when the salinity was 182‰ a number of very large triangular (*Trigonium* sp.) and centric marine diatoms were found in 4.5 m. In June when a point (grid reference 773817) close to the deep spot (9.5 m) was sampled, nothing was found. At this time the water, from just below the ice to just above the anoxic layer at 6 m, was uniform: pH 7.7; salinity 188‰; and temperature - 12.8°C.

Lake 2
'Clear Lake Tarn' pH not measured conductivity 334 µS/cm

'Clear Lake Tarn' lies to the northwest and some 25 m above Clear Lake. It is a shallow pool less than 2 m deep that freezes solid during the winter. The pool was sampled twice—in December 1990 and November 1991. Then the fauna was found to be virtually identical to that of Deep Lake Tarn (Lake 19). It included ciliated protozoans, an eyed platyhelminth, tardigrades, nematodes and the following species of rotifer: *Epiphanes senta, Lepadella patella,* the thin form of *Notholca* sp., *Adineta barbata, A. grandis, Habrotrocha constricta, Philodina gregaria* and *Philodina* sp. 2.

Lake 3
Clear Lake pH 8.1–8.6 conductivity to 14.6 mS/cm = salinity 9.7‰

This deep (61 m) meromictic lake is anoxic below 30 m and has a maximum recorded salinity of 14‰ (Gibson et al. 1989). A small volume of melt water flows into the western end of this lake from 'Clear Lake Tarn' during the summer. The sampling site, which was close to the southern shore of the shallow western bay at grid reference 773829, was visited on three occasions, in January, February and November of 1991. Then small dinoflagellates (*?Peridinium* sp.) were seen in the surface waters. The benthic fauna (the bottom was at 4.7, 6.4 and 4.2 m for the three visits) was limited to holotriches, a platyhelminth, two species of nematode and five species of rotifers (*Encentrum spatitium, E. brevifulcrum, E. salinum, Notholca* sp. and an unidentified bdelloid with a $3/3_{+1}$ dental formula). Several small diatoms were also seen. Three species of planktonic choanoflagellate have been reported from this lake (Marchant and Perrin 1986).

Lake 4
McCallum Lake pH 8.6–8.8 conductivity 15.7–26 mS/cm = salinity 9–16‰

This meromictic lake with a deep spot at 32 m is anoxic below 19 m (Gibson et al. 1989). The lake was sampled just once, in February 1991, when a large number of small nematodes and just one specimen of the rotifer *Encentrum spatitium* were found on the bottom at a depth of 7.2 m.

Lake 5
Burton Lake pH 8.1 conductivity 53–60 mS/cm = salinity 34–38‰

This meromictic saline lake is 18 m deep, is anoxic below 11 m, and has a maximum recorded salinity of 44‰ (Gibson et al. 1989). The lake is seasonally connected to Crooked Fjord and the sea via ice-dammed shallows at the southwestern end. Two calanoid copepods, an anthomedusa and a ctenophore have been reported (Bayly 1986; Bayly and Eslake 1989) as well as the fish *Pagothenia borchgrevinki* (Boulenger) (Williams 1988). Of these only one of the calanoids—*Drepanopus bispinosus*—was found in this study. There were in addition many holotrichia, at least two species of nematode and a large marine amphipod on the bottom at 8.8 m. The benthic samples were rich in diatoms and several fish scales were seen. No rotifers were found.

Lake 6
Anderson Lake pH 8.4 salinity 33–77‰

This lake was sampled once—during the winter in August 1991. Samples were taken at the ice/water interface and at a depth of 3 m but nothing was found. This lake is 22.8 m deep and has a maximum recorded salinity of 150‰ (Gibson et al. 1989). The oxycline is close to the surface at 4–5 m where the water temperature was 14°C. During the summer the temperature at the oxycline may be as high as 25°C (Roberts 1992).

Lake 7
Lebed' Lake pH 7.7 conductivity 197 mS/cm = salinity 216‰

This hypersaline lake was visited just once—in January 1992—when a plankton-net sample was taken. This yielded nothing but a few rock fragments. There are two reports in the literature that this lake contains *Acanthocyclops mirnyi* (Korotkevich 1958; and Borutsky 1962, who studied the samples collected by Korotkevich). The record of a freshwater copepod in such a saline lake is recycled here and is most probably explained by contamination with samples which were taken at that time from Crooked Lake.

Lake 8
Nicholson Lake pH 7.4 conductivity 1094 µS/cm

Nicholson Lake is situated some 14 m above Watts Lake, and in the summer a small stream links the two. The lake was visited only once, in November 1990, when three separate samples were taken along the eastern shore. The samples included surface, midwater and bottom (11 m) trawls. Only a few animals were recovered but these included three rotifers (*Lepadella patella, Notholca* sp., and *Philodina* sp. 1), a small nematode and the cladoceran *Daphniopsis studeri*.

Lake 9
Watts Lake pH 7.6–8.6 conductivity 472–4140 µS/cm

A point halfway along the northern shore where the water was less than 5 m deep was the principal sampling site. Here were extensive algal mats. In mid-January 1992 some of these mats became detached and floated to the surface, revealing a layer of purple sulphur bacteria belonging to the genera *Thiocapsa, Chromatium, Vinosum* and *Siderocapsa* (P. Hirsch pers. comm.). This lake was visited on five occasions: in November and December 1990, August and October 1991, and January 1992. It is one of the more productive lakes, and the fauna included ciliated Protozoa, tardigrades, nematodes, the rotifers *Encentrum mustela, Lepadella patella, Lindia torulosa, Notholca* sp., *Ptygura crystallina, Adineta grandis, Philodina gregaria*, and *P.* sp. 1, as well as the freshwater cladoceran *Daphniopsis studeri* and the copepod *Acanthocyclops mirnyi*.

At present this lake is slightly brackish (2.6‰) but with a freshwater fauna. At some time in the past it was saline and was connected to Ellis Fjord and the sea. An old marine terrace can be seen running round the lake some 5 m above the water's current surface. Water flows from Nicholson Lake into Watts Lake. Periodically water from Lake Druzhby overflows Ellis Rapids and floods into Watts Lake. This was observed on 16 November 1989.

Lake 10
Ellis Fjord pH 7.0–8.4 salinity 0–25‰

Eight visits were made to this site at the eastern end of Ellis Fjord. Although an integral part of Ellis Fjord, it is cut off from the rest of the fjord during the winter by a plug of ice across the shallows. During the summer large quantities of freshwater drain in across Ellis Rapids. The samples taken ranged in salinity from 0 to 25‰ depending on proximity to Ellis Rapids (the outflow from Lake Druzhby). Close to the outflow a number of freshwater species were seen living—including the cladoceran *Daphniopsis studeri* and the rotifers *Notholca* sp., *Adineta grandis, Lepadella patella* and *Philodina* sp. 1—while further out the full spectrum of marine inshore zooplankton was to be found. This included *Drepanopus bispinosus*, other calanoid copepods, an amphipod, harpacticoids, marine worm larvae and a ctenophore. Three species of rotifer were also found in these 'marine' samples—*Encentrum salinum, E. spatitium*, and *Proales reinhardti* which was found nowhere else in the present survey though it has been reported from Crooked Lake (Korotkevich 1958; Kutikova 1958b). Diatoms were very abundant in the sediments, and bivalve molluscs were found on the bottom. Seaweeds, including the green alga *Enteromorpha intestinalis*, were present in large numbers.

Lake 11
Lake Druzhby pH 7.0–7.3 conductivity 30–50 µS/cm

Lake Druzhby, the second-largest lake in the Vestfold Hills, has a large catchment area (100 km^2), taking water from both the Sørsdal Glacier and the Plateau (Tierney 1975). Water from the plateau drains through Pauk Lake (Lake 16) and into Lake Druzhby. Water from the Sørsdal Glacier drains through Chelnok Lake (Lake 15), over Chelnok Falls into Mossel Lake (Lake 14), via 'Teat' Lake

(Lake 13) and Crooked Lake (Lake 12) along the Tierney River into Lake Druzhby. Water from Lake Druzhby drains though Ellis Rapids into Ellis Fjord.

Lake Druzhby consists of a series of linked basins. The sampling site was in shallow water, less than 10 m deep, close to the southern shore of the basin at grid reference 897895. A depth in excess of 50 m was recorded in the middle of this basin. This lake was sampled on a monthly basis (14 visits). As expected there was a marked decline in the number of species and specimens during the winter, followed by a spring 'bloom'.

The sediments in shallow water consisted of a pale grey-green spongy mud. Single stems of the benthic moss *Bryum pseudotriquetrum* were regularly seen. The fauna consisted of platyhelminths, tardigrades, at least two species of nematodes, eleven rotifers (*Cephalodella* spp., *Collotheca ornata cornuta, Encentrum mustela, Epiphanes senta, Lepadella patella, Lindia torulosa, Notholca* sp., *Ptygura crystallina, Adineta* sp., *Philodina* sp. 1 and *Habrotrocha constricta*), the cladoceran *Daphniopsis studeri* and the copepod *Acanthocyclops mirnyi*. Several fish scales, presumably deposited with the faeces of skuas, were seen in the benthic sediments.

Lake 12
Crooked Lake pH 7.0 –7.4 conductivity 16–40 μS/cm

The largest lake in the Vestfold Hills, Crooked Lake is about 7 km long, 2.5 km wide and 157 m deep. The surface area of the lake is in excess of 8 km² and includes three main islands. Water from the Sørsdal Glacier drains via Chelnok Lake (Lake 15), over Chelnok Falls to Mossel Lake (Lake 14), and via 'Teat' Lake (Lake 13) into Crooked Lake at its western end. The water from Crooked Lake flows into Lake Druzhby via the Tierney River at grid reference 923884 (Tierney 1975).

This lake has steep margins and it was difficult to obtain suitable shallow-water sites for benthic sampling. Several different locations were looked at—between the island at grid reference 925855 and the northern shore, along the eastern shore of the outflow arm, and in shallow water on the eastern side of the headland at grid reference 930867.

The sediments in shallow water consist of a pale grey-green spongy mud—similar to that in Lake Druzhby (Lake 11). Single stems of benthic moss (*Bryum pseudotriquetrum*) were seen on a number of occasions. The fauna consisted of tardigrades, an acoel, at least two species of nematodes, ten rotifers (*Cephalodella* spp., *Collotheca ornata cornuta, Encentrum forcipatum, E. mustela, Lepadella patella, L.* sp., *Notholca* sp., *Ptygura crystallina, Adineta grandis,* and *Philodina* sp. 1), the cladoceran *Daphniopsis studeri* and the copepod *Acanthocyclops mirnyi*.

Crooked Lake is cited in the literature under three other names—Krok Lake, Lake Krutvatnet and Lake Posadochnoe. Earlier studies carried out in this lake have been on the cladoceran *Daphniopsis studeri* (Akatova 1966), *D. studeri* and the copepod *Acanthocyclops mirnyi* (Borutsky 1962), and on the microbial plankton (Laybourn-Parry et al. 1992).

Lake 13
Teat' Lake pH 7.2–7.4 conductivity 42–65 μS/cm

'Teat' Lake is situated at the western end of Crooked Lake, and from the official map of the region (second edition of the 1:50 000 map of the Vestfold Hills, which was published in September 1982) would appear to be part of it. However, it lies several metres above, and is separated from Crooked Lake by rocky shallows, thus constituting a lake in its own right. It is part of the system that drains water from the Sørsdal Glacier to Ellis Fjord—it receives water from Mossel Lake (Lake 14) and passes it on to Crooked Lake.

This lake was visited twice—in September and November 1991. It does not appear to be very deep and on both occasions samples were taken in shallow water (less than 3 m deep). The bottom was covered with a grey-green felt which had a yellow crust. Several moss strands (*Bryum pseudotriquetrum*) were seen. The fauna was made up of tardigrades, nematodes, six species of rotifer (*Encentrum mustela, Lepadella patella, Notholca* sp., *Ptygura crystallina,* and two bdelloids), the cladoceran *Daphniopsis studeri* and the copepod *Acanthocyclops mirnyi.*

Lake 14
Mossel Lake pH 7.2 conductivity 40 μS/cm

Mossel Lake receives melt water from the Sørsdal Glacier via Chelnok Lake and Chelnok Falls, passes it down the Tierney River system via 'Teat' and Crooked Lakes into Lake Druzhby, and to the sea via Ellis Fjord (Tierney 1975). The water in Mossel Lake was very flocculant and appeared to be a suspension of fine rock 'flour'. The bottom consisted of a fine consolidated pale mud. This lake was sampled three times—in November and December 1990 and August 1991—and, in common with the other lakes of this type, was found to have a typical freshwater fauna: nematodes, the tardigrade *Hypsibius antarcticus,* nine rotifers (*Collotheca ornata cornuta, Encentrum mustela, Lepadella patella, Lindia torulosa, Notholca* sp., *Ptygura crystallina, Resticula gelida* and *Philodina* sp. 1 & 2), the cladoceran *Daphniopsis studeri* and the copepod *Acanthocyclops mirnyi.*

Lake 15
Chelnok Lake pH 7.0 conductivity 60 μS/cm

This freshwater lake receives large quantities of melt water from the Sørsdal Glacier. Water from the lake flows over Chelnok Falls via Mossel, 'Teat' and Crooked Lakes, along Tierney River into Lake Druzhby, and is discharged via Ellis Rapids to the sea. A shallow site, just 2 m deep, was sampled in the winter. This yielded a single moss filament of *Bryum pseudotriquetrum,* some filamentous green algae and cyanobacterial balls (*Nostoc* sp.). No rotifers were found, presumably because the samples were taken in August, though both the cladoceran *Daphniopsis studeri* and the copepod *Acanthocyclops mirnyi* were present.

Lake 16
Pauk Lake pH 6.8 conductivity 26 μS/cm

Pauk Lake receives melt water directly from the Plateau. The lake is deep (>35 m) and plunges very quickly from the shore. It was visited once in December when samples were taken from along the northern shore at a depth of 7 m. The fauna found included the cladoceran *Daphniopsis studeri,* the copepod *Acanthocyclops mirnyi* and five species of rotifer—*Encentrum mustela, Lepadella patella, Notholca* sp., *Ptygura crystallina* and *Philodina* sp 1.

Lake 17
Depot Lake pH 8.5 conductivity 1774 μS/cm

Depot Lake was visited once, in December 1990, when the southern basin was sampled. A single strand of moss (*Bryum pseudotriquetrum*) was found in the benthic sample taken from 11.2 m. The fauna consisted of seven species of rotifer—*Collotheca ornata cornuta, Encentrum spatitium, Epiphanes senta, Lepadella patella, Notholca* sp., *Philodina* sp. 1 and an unidentified bdelloid—the copepod *Acanthocyclops mirnyi* and a platyhelminth. *Daphniopsis studeri* was not found in this survey but has been reported by Laybourn-Parry and Marchant (1991).

Lake 18
Dingle Lake pH 7.4 salinity >200‰

Just one visit was made to this hypersaline lake, in February 1992. Rotifers have been reported from here (Kerry et al. 1977) but they were not identified and were considered by Kerry et al. to have been washed-in from the numerous freshwater streams that flow into this lake. Nothing was found in the present survey.

Lake 19
Deep Lake Tarn pH not measured conductivity 2.25 mS/cm

Deep Lake Tarn lies to the northwest of Deep Lake at 949928 and not to the southwest as indicated on the Vestfold Hills maps (1:50 000 2nd edition, September 1982; and the 1:100 000 2nd edition, December 1983). This shallow body of water, which was the subject of an earlier limnological study (Everitt 1981), contained large numbers of rotifers, tardigrades and nematodes.

Deep Lake Tarn was visited on three occasions, in November 1990, February 1991, and January 1992, when several Holotrichia (Protozoa), two species of nematode, two tardigrades and the rotifers *Collotheca ornata cornuta, Encentrum mustela, Epiphanes senta, Lepadella patella, Notholca* sp., *Adineta grandis, Habrotrocha constricta* and *Philodina gregaria* were all found. This list compares very favourably with that of Everitt (1981) if *Encentrum mustela* and *Epiphanes senta* are taken to be his unidentified species 1 and 2; his *Ptygura* sp. equates to *Ptygura crystallina*; and *Notholca* sp. equates to *N. verae* (see also the section on *Notholca* identification). Everitt (1981) recorded two species that were not found in the present survey. They were *Macrotrachela quadricornifera* (Milne) and *Mnobia russeola* (Zelinca).

Lake 20
Deep Lake pH 7.4 salinity >250‰

Deep Lake is the most saline lake in the Vestfold Hills. It is 36 m deep and the surface lies some 50 m below sea level. Three species of algae have been reported growing in this and a number of other saline lakes (Wright and Burton 1981), but no other life forms. Protozoa, tardigrades, nematodes and rotifers are presumably washed into this lake from Deep Lake Tarn, and it was to be expected that their contracted bodies would be visible and identifiable, but none was recovered on the single visit in January 1992.

Lake 21
Hand Lake pH 8.7 conductivity 9.15 mS/cm = salinity 5.5‰

Hand Lake is a brackish lake with a maximum recorded depth of 29 m and salinity of 7‰. It receives a small amount of 'freshwater' from Waterfall Lake (Lake 22) which lies about 50 m to the east and about 10 m above. The lake was visited only once, in December, and the sample site was at the eastern end of the lake at a depth of 4.65 m. The germlings of a brown alga were seen in the bottom sediments, and mosses (*Bryum pseudotriquetrum*) grew in the lake, surrounded by a green 'jelly'. The fauna was sparse and consisted of an eyed acoel, and the rotifers *Epiphanes senta, Notholca* sp. and *Adineta* sp. Empty 'vases' of the sessile protozoa *Magnifolloculina* sp. were also seen. This lake is potentially one of the more interesting lakes because of its flora.

Lake 22
Waterfall Lake pH 7.8–8.1 conductivity 643–960 µS/cm = salinity 0.4‰

Waterfall Lake lies about 10 m above Hand Lake. It was visited only once, in December, when it was sampled at the western end, in water 4.2 m deep. The bottom sediments consisted of green filamentous algae and strands of the moss *Bryum pseudotriquetrum*. Both *Daphniopsis studeri* and *Acanthocyclops mirnyi* were present and at least nine species of rotifer—*Cephalodella* spp., *Collotheca ornata cornura, Encentrum mustela, Epiphanes senta, Lepadella patella, Lindia torulosa, Notholca* sp., *Ptygura crystallina* and *Philodina* sp. 1—were found. This lake is potentially one of the more interesting lakes because of its flora.

Lake 23
Lake Zvezda pH 7.3–7.0 conductivity 62.8–43.9 µS/cm

The third-largest freshwater lake in the Vestfold Hills, Lake Zvezda receives melt water directly from the plateau. This lake was sampled only once, in December 1991, when a shallow (5 m) site was chosen on the eastern shore of the southern arm at grid reference 959939. A number of bdelloids (*Philodina* sp. 1) were found in the water column, but otherwise only a few nauplii of the copepod *Acanthocyclops mirnyi* and one specimen of *Notholca* sp. were recovered.

Lake 24
Lake Bisernoye pH 7.0 conductivity 32 µS/cm

This large freshwater lake receives significant quantities of melt water from the plateau. It is a deep lake (>35 m in the centre of the northern basin). It was visited twice, in November 1990 and 1991, and the sampling point was in shallow water close to the soil between the two basins at depths of 7 m and 4 m respectively for the two visits. Both the cladoceran *Daphniopsis studeri* and the copepod *Acanthocyclops mirnyi* were present, as were two species of nematode and the following rotifers: *Cephalodella* spp., *Lepadella patella, Notholca* sp., *Ptygura crystallina* and *Keratella cochlearis.*

Lake 25
Lake Vereteno pH 8.15 salinity 5‰

Lake Vereteno was visited only once, in January 1991. Although this lake is brackish the fauna is predominantly freshwater in nature and consists of tardigrades, six species of rotifer (*Encentrum spatitium, E. salinum, Epiphanes senta, Lepadella patella, Notholca* sp., and *Adineta grandis*), the cladoceran *Daphniopsis studeri* and nauplii of a copepod, presumably *Acanthocyclops mirnyi*. Only surface and mid-water samples at 7 m were taken.

Lake 26
'Pointed' Lake pH 8.4 salinity 5‰

'Pointed' Lake was visited only once, in December 1990. Only a mid-water sample (at 5 m) was taken. This had a limited fauna including the rotifers *Encentrum spatitium, Epiphanes senta* and *Notholca* sp., and the cladoceran *Daphniopsis studeri.*

Lake 27
Ekho Lake pH 8.4 salinity 39‰

Ekho Lake is a meromictic lake 43 m deep with the anoxic layer at 24 m (Roberts 1992). The lake was sampled twice (in October and November 1991) in shallow (<3 m) water. The muddy bottom was rich in diatoms. Apart from a number of clear ciliated protozoans and a few small dead nematodes, nothing else was seen.

Lake 28
unnamed lake at grid reference 940980 pH 7.2–7.4 conductivity 442–880 µS/cm

A bathymetric survey was carried out on this lake in October 1991. The lake has a simple U-shaped basin with steep sides and a single central deep spot (23 m) (Figure 2). Three streams, to the east, south and west-southwest, bring melt water to the lake in the spring, while a single outflow discharges into Long Fjord through an ice dam, which is normally breached throughout the summer. This lake, which was visited seven times, was found to be one of the more productive lakes in the Vestfold Hills. Clumps of moss (*Bryum pseudotriquetrum*) were observed in shallow water to the southwest of the outflow, and during the summer there was a conspicuous growth of filamentous algae on the bottom. The fauna was varied and consisted of an acoel, tardigrades, two nematodes, 15 species of rotifer (*Cephalodella* spp., *Collotheca ornata cornuta, Encentrum brevifulcrum, E. mustela, E. spatitium, Epiphanes senta, Lepadella patella, Lindia torulosa, Notholca* sp., *Resticula gelida, Ptygura crystallina, Adineta* sp., *Habrotrocha constricta, Philodina gregaria* and the freshwater *P.* sp. 1), the cladoceran *Daphniopsis studeri,* and the freshwater copepod *Acanthocyclops mirnyi*. During the winter the conductivity readings were double those recorded for the summer: 880 against 442 µS/cm.

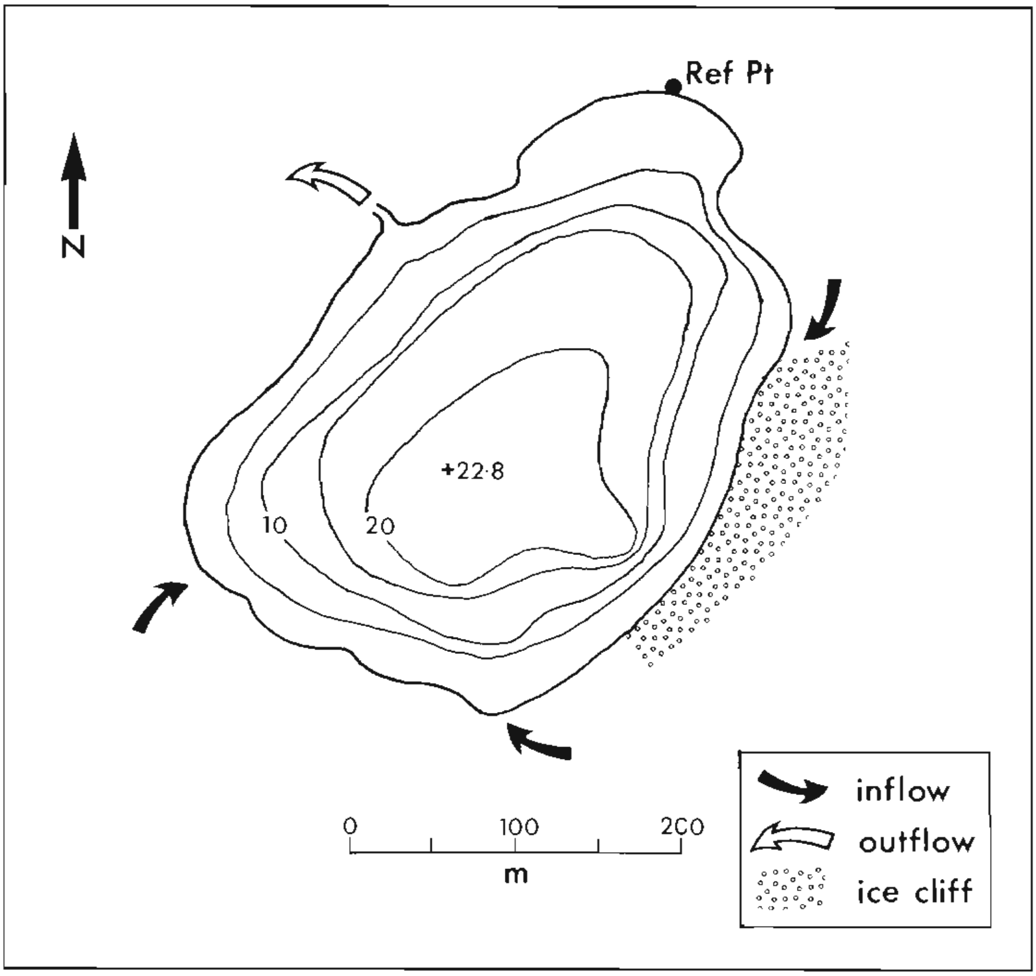

Figure 2. Bathymetric survey of unnamed lake at grid reference 940980.

Lake 29
little unnamed lake at grid reference 944988 pH 7.4 conductivity 1078 μS/cm

This small lake contained very clear water and it was possible during the winter to view the bottom through the ice and so choose the sampling spot. The lake was sampled twice (in May and November 1991) when the bottom sediments consisted of a light green flocculent layer below an algal mat of cyanobacterial balls (*Nostoc* sp.). The fauna was very similar to that of Lake 28 and included the acoel, tardigrades, nematodes, 11 species of rotifer (*Collotheca ornata cornuta, Encentrum mustela, E. spatitium, Epiphanes senta, Lepadella patella, Notholca* sp., *Resticula gelida, Adineta grandis, Habrotrocha constricta, Philodina gregaria*, the freshwater *P.* sp. 1), and the cladoceran *Daphniopsis studeri*. The copepod *Acanthocyclops mirnyi* was not seen but probably occurs in this lake during the summer.

Lake 30
melt pool in Lichen Valley at grid reference 934027 pH 7.5 conductivity 930 µS/cm

This pool was visited once, in January 1991, when scoops of benthic materal and the overlying water were taken from very shallow water (<0.3 m). The fauna was virtually identical to that in the other pools ('Clear Lake Tarn' and Deep Lake Tarn), and consisted of an acoel, tardigrades (*Hypsibius antarcticus* and *Isohypsibius* sp.) and 10 species of rotifer (*Collotheca ornata cornuta, Encentrum mustela, Epiphanes senta, Lepadella patella, Ptygura crystallina, Resticula gelida, Adineta barbata, A. grandis, Habrotrocha constricta* and *Philodina gregaria*).

Lake 31
Lake Abraxas pH not measured salinity 18‰

Lake Abraxas is a meromictic lake 24 m deep and anoxic below 18 m with a maximum recorded salinity of 20‰ (Gibson et al. 1989). The lake was visited once, in January 1991, when a benthic sample was taken from 7 m. This sample contained abundant diatoms. Nematodes, and both adult specimens and nauplii of the calanoid copepod *Paralabidocera antarctica*, and the harpacticoid *?Amphiascoides* sp. were also seen. No rotifers were found.

This lake has been the subject of two earlier studies (Burton and Hamond 1981; Bayly and Eslake 1989). They recorded *Harpacticus furcatus, Paralabidocera antarctica* and *Amphiascoides* sp.

Lake 32
Franzmann Lake pH 7.6 salinity to 33‰ß

Franzmann Lake is a meromictic basin that has in the past been known by a variety of names including 'Alpha Basin'. It is shallow (about 10 m deep), anoxic below 6 m (Roberts 1992), and has a small outflow—ice-dammed in the winter—into a bay off Long Fjord. The lake was visited once in October 1991, when many Protozoa, similar to those seen in Ekho Lake, were present in the surface waters. A number of cast copepod skins (unidentifiable) were also seen. The green alga *Enteromorpha intestinalis* was present in large numbers on the bottom and in shallow water. No rotifers were found.

Lake 33
Deprez Basin pH 7.9 salinity 25‰

Situated on the southern shore of Partizan Island, this meromictic basin is isolated from Long Fjord at low tide during the summer and throughout the winter, when the outflow is frozen over. No rotifers were found nor were any other invertebrates seen when this lake was sampled just once in the winter. The green alga *Enteromorpha intestinalis* was present in large numbers on the bottom. A number of dead fish (Notothenids) were seen on the shore line.

Lake 34
Ace Lake pH 8.5 salinity 25‰

A bathymetric survey of this lake was carried out in November 1991. Compared with the survey carried out in 1978 (Burton 1980), the lake is now 2 m deeper, and has a shallow arm extending out from the northeast corner (Figure 3). This represents an increase in volume of 3.5×10^5 m^3 and is the result of an extended period of positive water balance since 1978. Ace Lake is meromictic, 25.3 m deep and has a maximum salinity of 40‰. It is anoxic below 12 m.

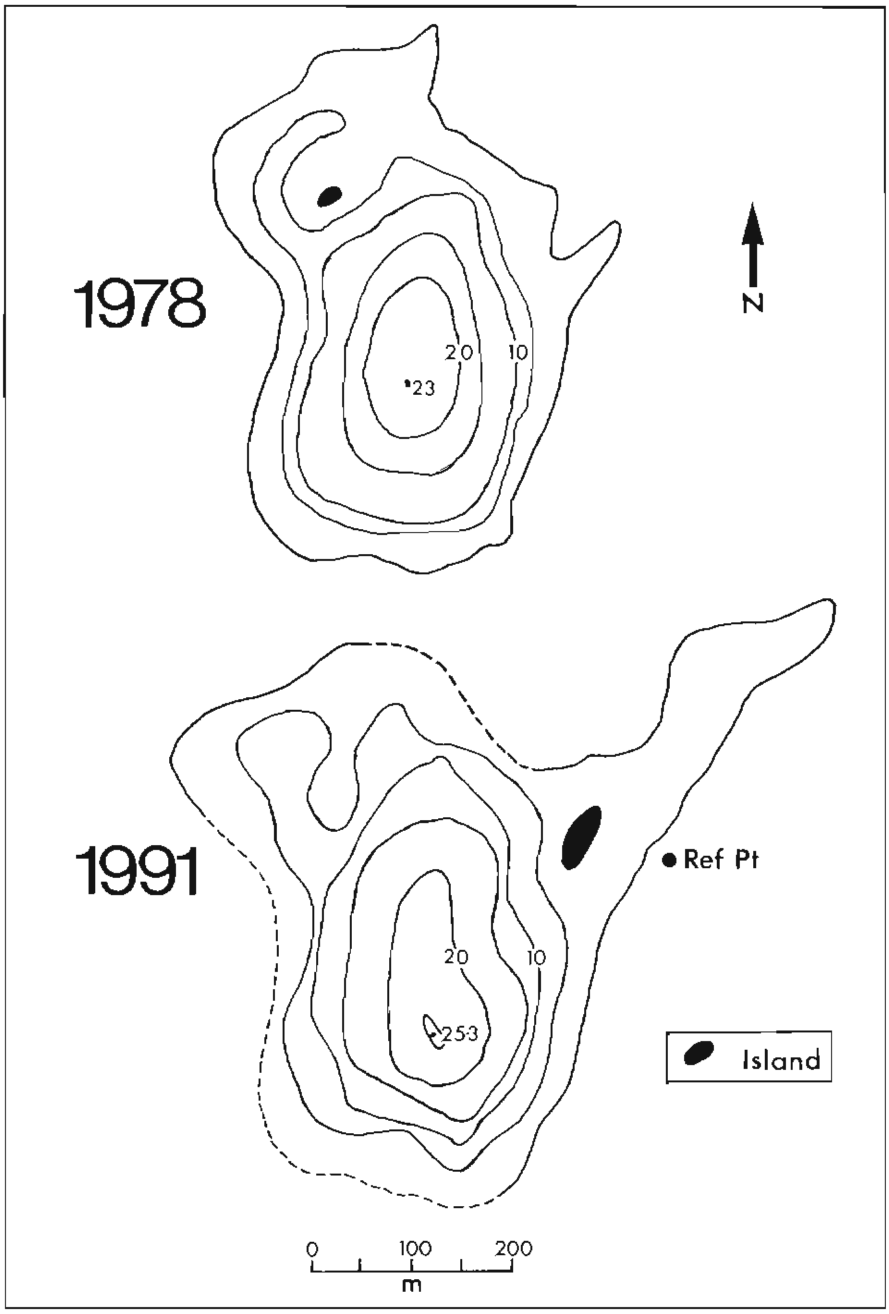

Figure 3. *Bathymetric surveys of Ace Lake in 1978 and 1991. The 1978 survey is redrawn from Burton 1980.*

The lake was visited eight times at regular intervals. Samples were generally taken from shallow water on the eastern margin at a depth of 6 m and close to the island where the benthic vegetation was rich and varied. Here mats of the brown alga *Ectocarpus* sp., plus *Urospora penicilliformis, Rhizoclonium implexium* and abundant small diatoms were found. The fauna was similarly rich, for as well as *Paralabidocera antarctica* there was a small benthic harpacticoid. Protozoans were abundant. In addition to small ciliates and holotrichia, a large tube-dwelling member of the Folliculinidae family with conspicuous wing-like extensions, *Magnifolloculina* sp., was common in the summer, attached to the algal mats. Three species of rotifer (*Encentrum spatitium, E. salinum* and *Notholca* sp.), an eyed platyhelminth and at least two species of nematode completed the fauna.

Ace Lake has been the subject of several invertebrate studies, including that of Bayly and Burton (1987) who studied the vertical distribution of *Paralabidocera antarctica.* They found two population density peaks in the summer (January)—one under the ice, the other just above the anoxylimnon.

Lake 35
Highway Lake pH 8.5–8.6 conductivity to 8.15 mS/cm = salinity 5‰

This brackish lake on Broad Peninsula was sampled three times. The maximum depth recorded for this lake was 17 m. In the first summer (November 1990) the samples contained abundant large specimens of *Daphniopsis studeri*, many of which were gravid with up to 12 young developing in their haemocoels. By the end of January 1991 only one specimen could be found. In the following summer (December 1991) none were seen. The lake was saltier then—an increase from 2.7 to 5‰—and abundant dead specimens of *Notholca* were floating in rafts. In addition small numbers of holotrichia, platyhelminths, tardigrades, nematodes and the rotifers *Encentrum brevifulcrum, E. mustela, E. spatitium, Epiphanes senta* and *Adineta grandis* were living.

Lake 36
Pendant Lake pH 8.3 salinity 16‰

This meromictic lake is anoxic below 11 m (maximum depth 21 m). The lake was visited only once, in January 1991, when large numbers of nauplii and copepodite stages of a saline copepod were seen. *Paralabidocera antarctica* has been reported (Wright and Burton 1981).

Lake 37
Fletcher Lake pH 8.5 salinity 10–72‰

Fletcher Lake is 12 m deep, meromictic and anoxic below 7 m (Gibson et al. 1989). Although Fletcher Lake is the most isolated of the marine-influenced lake basins it is occasionally topped up with seawater from Taynaya Bay. The lake was visited twice, in January and June 1991, when benthic samples were taken from close to the oxic/anoxic boundary at 6 m. Several species of large centric diatom were seen, together with the copepods *Drepanopus bispinosus* and *Paralabidocera antarctica,* and a large and, as yet, unidentified harpacticoid copepod.

Lake 38
Grace Lake pH 8.6–7.3 conductivity to 1200–550 μS/cm

This shallow (about 4 m deep) lake is probably the most productive in the Vestfold Hills. During winter, the pH rose to 8.6 and the conductivity to 1200 μS/cm. During the summer ice-free period, pH was only 7.3 and conductivity 550 µS/cm. The bottom was covered by a thick spongy sediment, similar to the mats found in the lakes of the Larsemann Hills (Dartnall 1995b). Large paramecium-type Protozoa and smaller spherical ciliates were present, together with a platyhelminth, and 14 species of rotifer including *Cephalodella* spp., *Collotheca ornata cornuta, Encentrum mustela, E. spatitium, Epiphanes senta, Lepadella patella, Notholca* sp., *Ptygura crystallina, Resticula gelida, Adineta barbata, A. grandis, A.* sp., *Habrotrocha constricta* and *Philodina* sp. 2. The cladoceran *Daphniopsis studeri* was present but the copepod *Acanthocyclops mirnyi* was not seen on any of the four visits.

4. Taxonomy

Protozoa: Even though the collecting methods employed were not ideal for collecting Protozoa, specimens were observed in most samples. Generally those seen on the bottom of the freshwater lakes were oval/elliptical, transparent or pale brown, ciliates. Small ciliates with spiky tufts (holotrichia), large solitary 'paramecium-type' ciliates, and a very small number of amoebae were also seen. The freshwater planktonic communities were dominated by three orders of ciliate—Haptorida, Scuticociliatida and Oligotrichida. Of these the haptorids were most common, with *Askenasia, Mesodinium* and to a lesser extent *Monodinium* dominating (Stephen Perriss, pers. comm.).

Small oval ciliates were regularly encounted in the saline lakes. In Ace Lake large tube-dwelling *Magnifolloculina* (Figure 4a) and members of the *Vaginicola* were seen amongst the *Ectocarpus* mats in shallow water. Unoccupied tubes of *Magnifolloculina* were also seen in Hand Lake. Suctoria and vorticellids were observed on the bodies of amphipods from Burton Lake.

Coelenterata: Small ctenophores were seen at the eastern end of Ellis Fjord close to Ellis Rapids. There is a report in the literature of a ctenophore and an anthomedusa—*Rathkea lizzioides* O'Sullivan—in Burton Lake (Bayly 1986; Bayly and Eslake 1989) but neither was observed in the present survey. The presence of a particular species in Burton Lake, which is periodically connected to the sea, is thought to reflect a temporary influx of species present in the inflow at that time, rather than permanent residents of the lake.

Turbellaria: Platyhelminths were observed across the whole range of lakes. There would appear to be at least two species present—an eyed form mainly in the saline lakes (Figure 4b), and a similar-sized species but without eyes, usually in the freshwater lakes.

Tardigrada: At least two species of smooth tardigrade (Figure 4c) were seen in the freshwater lakes—*Hypsibius antarcticus* (Murray) and *Isohypsibius* spp. Both have been reported previously from the Vestfold Hills, from Deep Lake Tarn (Everitt 1981) and are the species commonly reported elsewhere in the Antarctic.

Rotifera: Many of the species recorded from the Vestfold Hills are common rotifers that are regularly encountered, in the Antarctic and elsewhere, and as such require little comment. The section that follows concentrates on problems of identification and distribution.

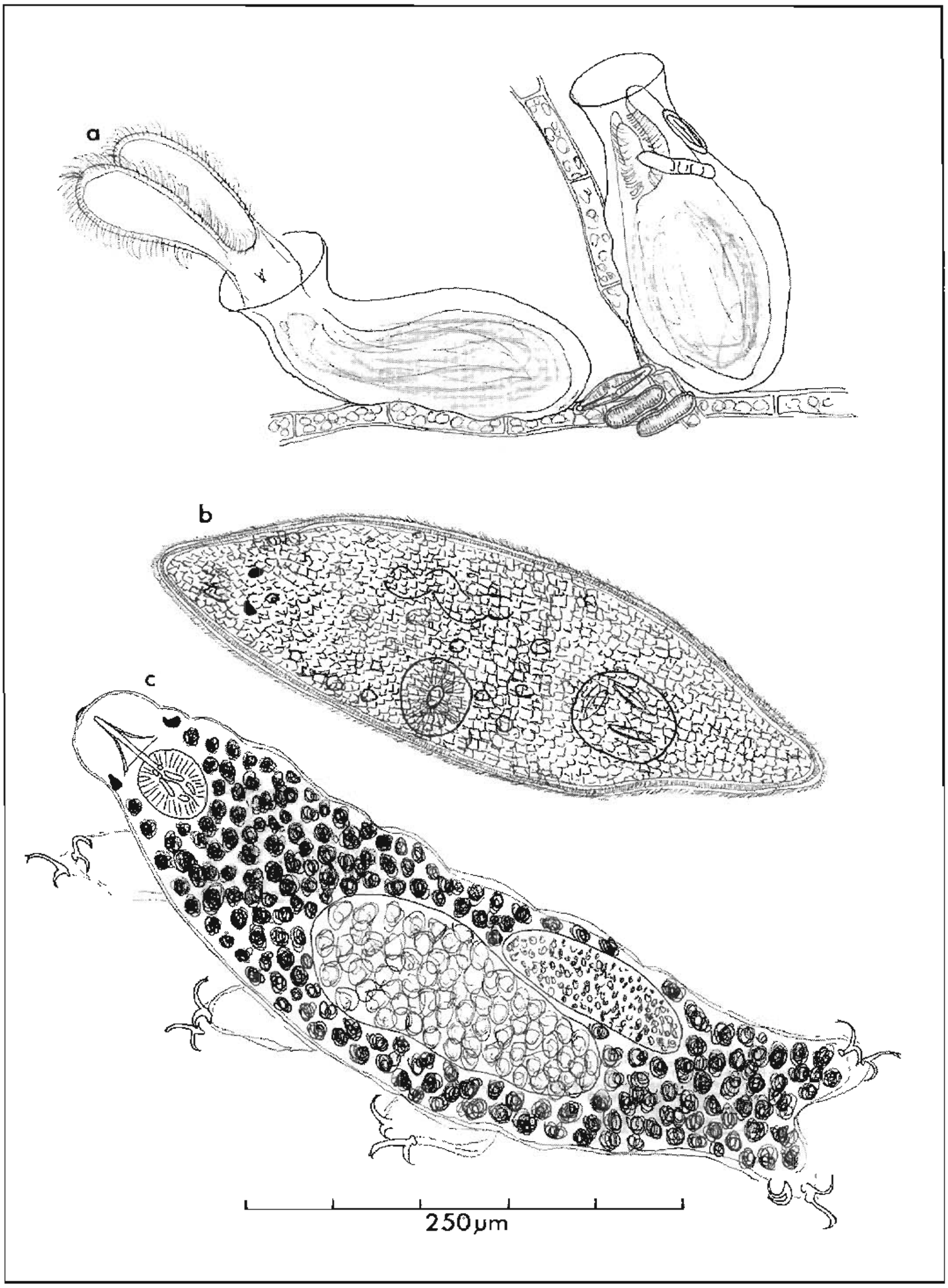

***Figure 4.** Assorted invertebrates: (a)* Magnifolloculina *sp.; (b) platyhelminth; (c) tardigrade.*

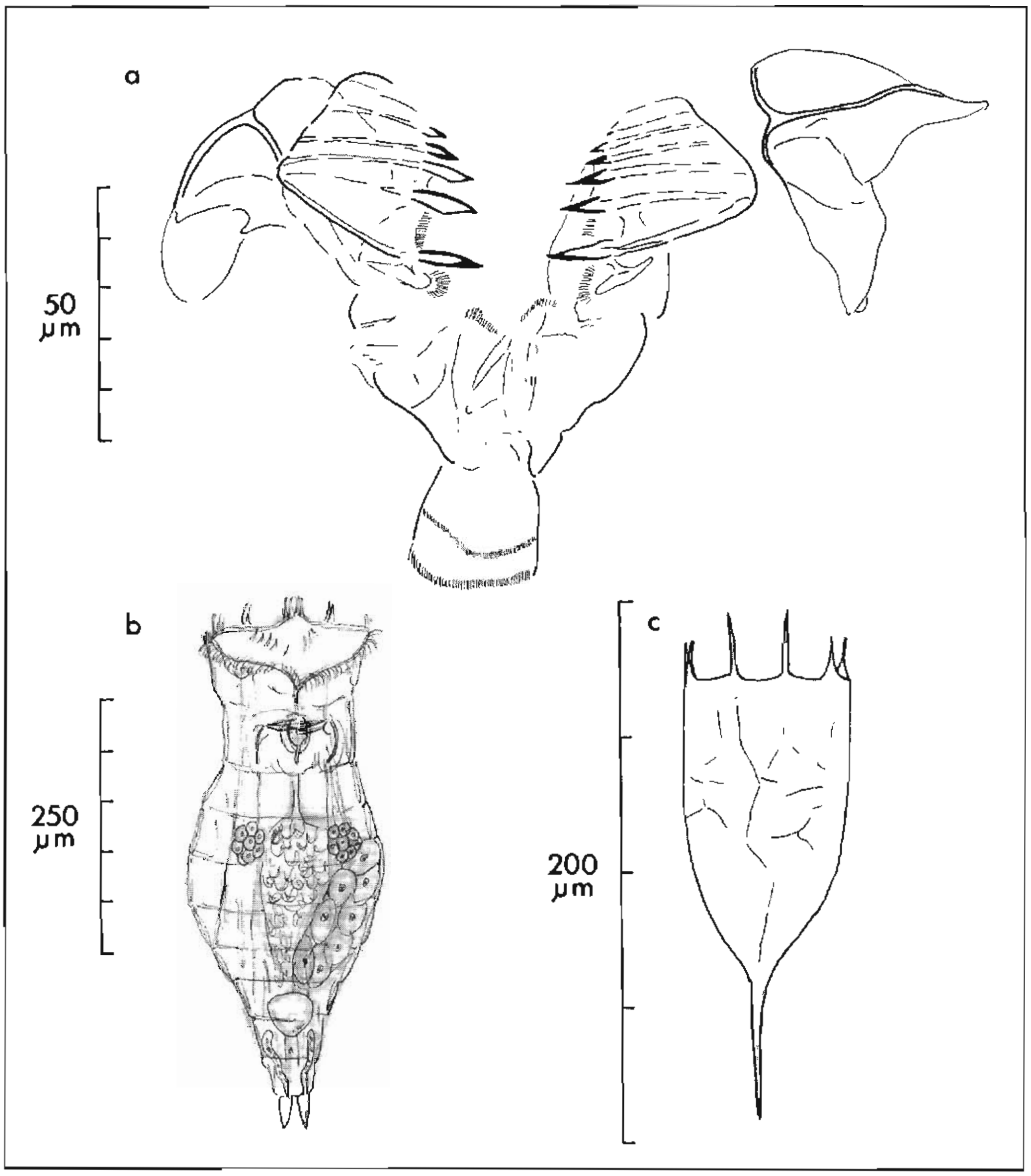

Figure 5. Epiphanes senta: *(a) trophus; (b) ventral view of whole animal.* Keratella cochlearis: *(c) dorsal view of lorica.*

MONOGONONTA

Eighteen species were recognised.

Epiphanes senta (O.F. Müller)
(Figures 5a and 5b)

This species was found in the pools that freeze solid during the winter ('Clear Lake Tarn', Deep Lake Tarn and the melt pool in Lichen Valley) and in the brackish lakes (Waterfall, Depot, Vereteno, the unnamed lakes at grid references 940980 and 944988, and Highway, 'Pointed', Hand, and Grace Lakes). A single specimen was also recovered from Lake Druzhby.

This large soft-bodied (illoricated) rotifer has a cone-shaped body, up to 550 mm long. The broad head bears several tufts of strong cilia (Figure 5b). The mastax has a malleate trophus. The unci are broad, with five major and at least two minor teeth. The rami are broad. sickle-shaped, with many clusters of fine striae on the inner edges (Figure 5a). Only a few males, which are approximately half the size of the females and lack both trophus and digestive tract, were seen in the Highway Lake samples.

Epiphanes senta has a world-wide distribution and is usually found in small pools enriched with the excreta of domestic animals. In the Antarctic it is usually, but not always, found in pools enriched by penguins and seals. It has been reported from the McMurdo Sound area (Murray 1910; Armitage and House 1962; Dougherty and Harris 1963); from fresh and brackish pools in eastern Antarctica, in the Bunger Hills (Korotkevich 1958), Haswell Island (Kutikova 1958b; Donner 1972), and the Larsemann Hills (Dartnall 1995b); from the South Shetland Islands (de Paggi 1982), and the South Orkney Islands (Dartnall and Hollowday 1985); from the sub-Antarctic at Macquarie Island (Dartnall 1993), and from Heard Island (Dartnall 1995a). It was therefore no surprise to find it in pools and in a number of the brackish lakes.

Keratella cochlearis (Gosse)
(Figure 5c)

A single specimen of this rotifer was found in a plankton sample taken from the surface waters of Lake Bisernoye (sample taken by Stephen Perriss). This specimen was dead when it was examined—an empty lorica from which the trophus aud body contents were missing. The lorica, which was unadorned, was 189 µm long, with a slim posterior spine 56 µm long and 5.5 µm wide at its base. The body—from the base of the posterior spine to the sulcus between the two median anterior spines—was 107 µm. The six anterior spines were all long and slim. The median pair were 24 µm long while the intermedian and lateral were 17 µm long.

Keratella cochlearis has been reported from the Antarctic twice before—from the South Shetland Islands (de Paggi 1982), and from Molodezhnaya (Kutikova 1991).

Notholca sp.
(Figure 6)

Although this was the most common rotifer found, its identification proved to be the most difficult. From the literature I had expected to find *Notholca verae* Kutikova (Korotkevich 1958; Everitt 1981; Sudzuki 1988), and indeed, the first specimen examined (Figure 6b), from Deep Lake Tarn (where Everitt, 1981, had sampled), was initially thought to be that species.

Notholca specimens from Crooked Lake and Lake Druzhby were similar in all respects but with a much rounder outline (Figure 6f). At this stage it appeared that there were two separate species, *N. verae* in the pools, and *N. squamula* (O.F. Müller) in the freshwater lakes. By the end of the

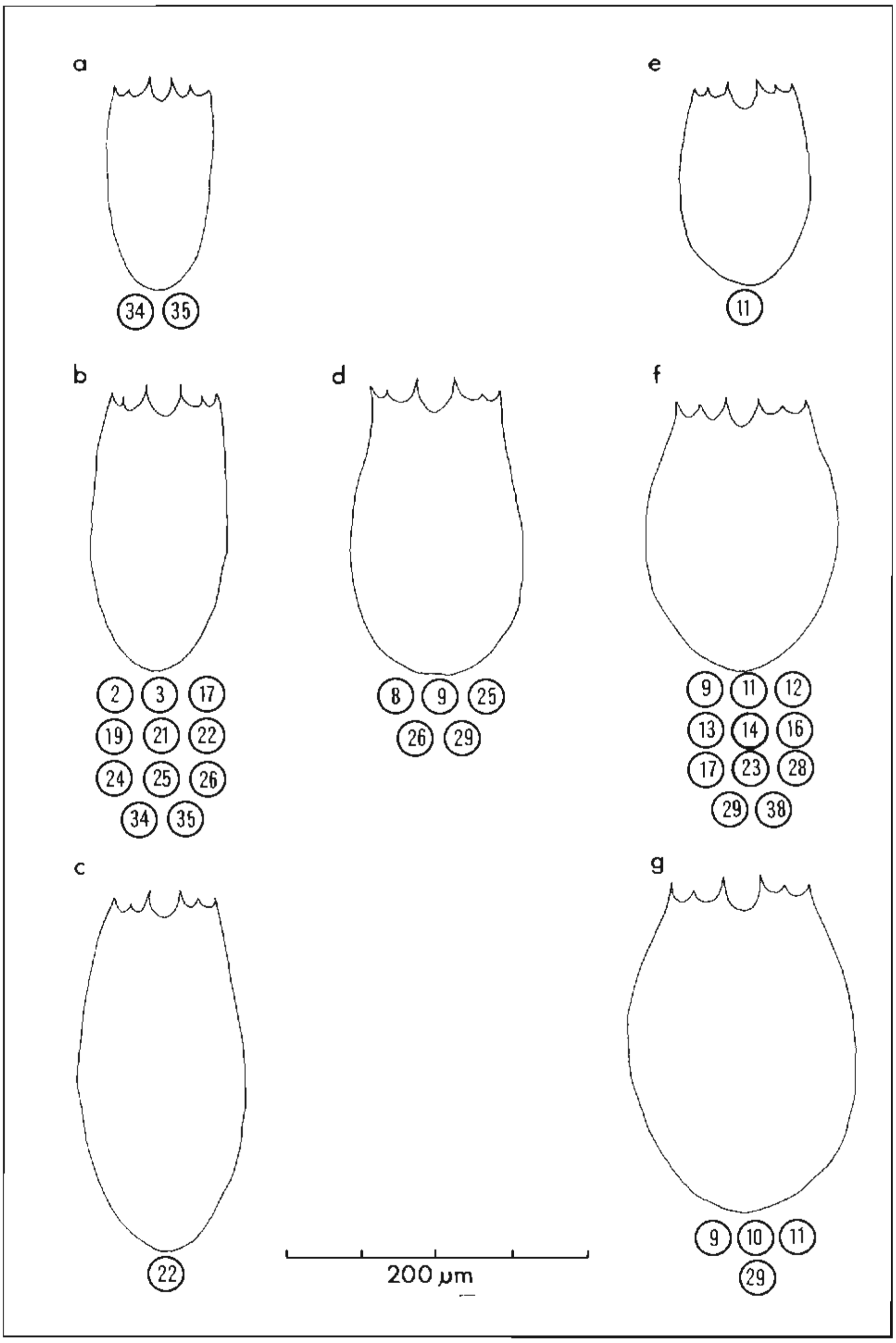

Figure 6. Notholca: *(a, b and c) the 'slim form'; (d) intermediate form; (e, f and g) 'round' form. To identify the circled lake numbers see the chronological list of sampling sites under 'Materials and methods'.*

first summer, intermediate (Figure 6d) as well as giant (Figures 6c and 6g) and dwarf specimens (Figures 6a and 6e) had been collected and it was apparent that the situation was much more complicated.

In the detailed microscopical examination that followed, several significant facts emerged. Firstly the lateral striations, which were present to some degree on the dorsal lorica, had straight rather than serrated edges. As serrated edges are a characteristic of *N. verae* (Kutikova 1958a) their absence must challenge this identification. Secondly the trophi of all the specimens examined, irrespective of where they came from, were identical. And thirdly, all of the ventral plates (lorica) were very similar in size, apparently irrespective of the size of the dorsal plate.

The only distinguishing characteristic was the size and shape of the dorsal lorica. All of the Vestfold Hills specimens had very thin flexible loricas which tended to crumple in polyvinyl lactophenol, the mountant used when making microscope slides. This made breadth measurements difficult. Nevertheless a pattern did emerge with 'round' forms in the freshwater lakes, 'intermediate' forms in the fresh/brackish lakes and 'slim U-shaped' forms in brackish lakes and pools; though there were several anomalies (Figure 6 and Table 1), notably the finding of 'intermediate' and 'round' forms together (Watts and 'little unnamed' lakes) and of the 'slim' form in Lake Bisernoye when a 'round' form was expected.

From all these considerations it has to be concluded that the specimens of Notholca in the Vestfold Hills belong to a single, very variable, species. But further work is necessary to elucidate this problem.

Lepadella patella (Müller)
(Figures 7a, b and c)

One of the more common rotifers, this species was found in the freshwater pools ('Clear Lake Tarn', Deep Lake Tarn (where it had previously been reported by Everitt 1981), and the melt pool in Lichen Valley); in the large freshwater lakes (Druzhby, Crooked, 'Teat', Mossel, Pauk, Bisernoye); and in fresh to brackish ones (Nicholson, Watts, Depot, Vereteno, 'unnamed' and Grace).

Lepadella patella is a small rotifer with a rigid, oval-shaped lorica, a four-segmented foot and two spindle-shaped toes (Figures 7b and c). The mastax has a malleate trophus (Figure 7a). The fulcrum is almost insignificant, the rami small and sickle-shaped. The unci are parmate, with one principal and four secondary teeth.

Lepadella patella has a world-wide distribution, and has been reported from both Macquarie Island and Iles Kerguelen by Russell in 1959. Other locations in the Antarctic include the Obruchev and Bunger Hills (Korotkevich 1958; Kutikova 1958b); the Thalla Hills (Opalinski 1972b); the Larsemann Hills (Dartnall 1995b); Langhovde (Sudzuki 1964); and Heard Island (Dartnall 1995a).

Lepadella sp.
(Figures 7d, 7e and 7f)

A single specimen of this previously-unrecorded species was found in Crooked Lake at a depth of 13 m. The pear-shaped lorica was nearly 350 μm long and 225 μm wide with, in the living specimen, a shallow anterior sulcus. Its cross-section was of a flat arrowhead but no keel was apparent when the specimen was mounted on a microscope slide. The toes were oval, 42 μm long by 20 μm broad, and with a hint of a small posterior protuberance. The malleate trophus was 70 μm broad and 35 μm deep. The unci were 20 μm long and bore three teeth, and the hammer-headed manubria were 25 μm long. The rami were as broad as they were tall, with a fringe of

Table 1. The distribution of Notholca *in the Vestfold Hills lakes, with* x *indicating presence.*

		Type of *Notholca*						
		slim			intermediate	round		
Lake Ref. No.	**Name**	**small**	**<--->**	**large**		**small**	**<--->**	**large**
2	'Clear Lake Tarn'		x					
19	Deep Lake Tarn		x					
Freshwater Lakes								
11	Lake Druzhby					x	x	x
12	Crooked Lake						x	
13	'Teat' Lake						x	
14	Mossel Lake						x	
16	Pauk Lake						x	
23	Lake Zvezda						x	
24	Lake Bisernoye		x					
Freshwater and Brackish Lakes								
28	unnamed lake						x	
22	Waterfall Lake		x	x				
29	little unnamed lake				x		x	x
8	Nicholson Lake				x			
38	Grace Lake						x	
17	Depot Lake		x				x	
9	Watts Lake				x		x	x
Brackish and Marine Lakes								
25	Lake Vereteno		x		x			
26	'Pointed' Lake		x		x			
34	Highway Lake	x	x					
21	Hand Lake		x					
3	Clear Lake		x					
34	Ace Lake	x	x					
Unclassified								
10	Ellis Fjord							x

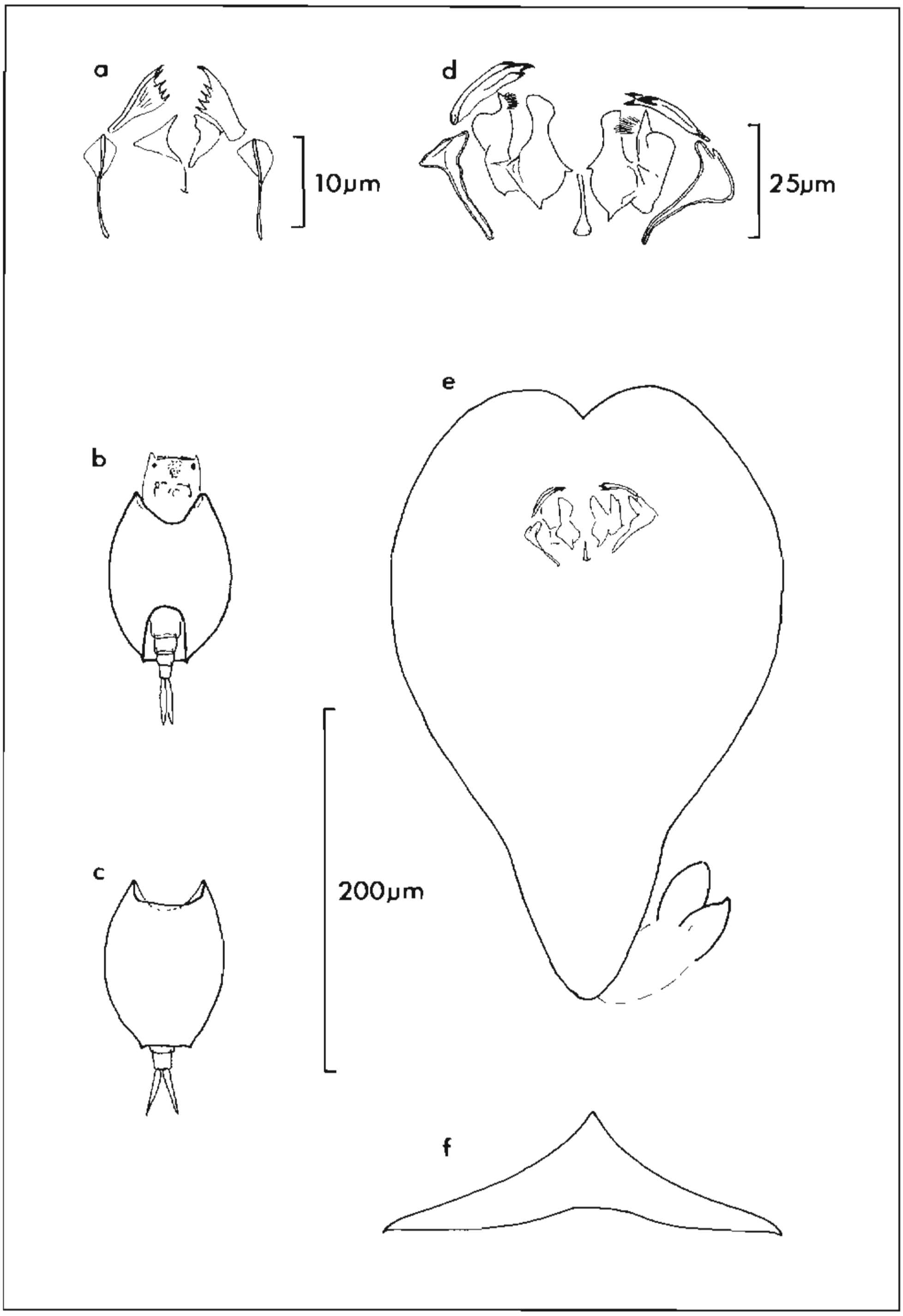

Figure 7. Lepadella patella: *(a) trophus; (b) ventral view of lorica; (c) dorsal view of lorica.* Lepadella *sp.: (d) trophus; (e) dorsal view of lorica; (f) cross-section.*

ancillary teeth on the outer edges. The fulcrum was small (Figure 7d).

This species of *Lepadella* is unlike any previously described. Only one specimen was found and further specimens are required before a new species can be described.

Proales reinhardti (Ehrenberg)
(Figures 8a and 8b)

Seven specimens of *Proales reinhardti* were found during one summer visit to the eastern end of Ellis Fjord. They ranged from 275 to 360 µm long. The head, which bears a single red eyespot on the brow, is clearly separated from the body. The mastax has a malleate trophus with large curved manubria. The rami have two prominent teeth and two ancillary ones, and the fulcrum is small and oval with a forward-pointing spiue. There is a conspicuous pair of progastric glands. The foot is composed of two segments and a pair of large toes. The second foot segment, which is approximately three times longer than the basal segmcnt, can be withdrawn into the body cavity. The pedal glands run the whole length of the foot.

Proales reinhardti has been reported from the Antarctic before by Korotkevich (1958) and by Kutikova (1958b) who recorded it from Crooked Lake (Lake Krukvatuet) in the Vestfold Hills. At first glance these reports are at odds with the present record, for while Crooked Lake is one of the purest freshwater lakes, the salinity of the sampling point in Ellis Fjord, where the present samples were taken, was 22‰. The specimens, which were somewhat moribund when examined about two hours after capture, had been taken from a point in the bay in direct line with the outflow from Lake Druzhby. A number of other freshwater invertebrates including *Daphniopsis studeri* were also found. They had presumably been washed out from Lake Druzhby.

Lindia torulosa Dujardin
(Figures 8c and 8d)

This species was found at five locations—in Watts, Druzhby, Mossel, Waterfall and 'unnamed' lake. Only six specimens were obtained and they ranged in size from 250 to 425 µm long, though this was difficult to determine because of the flexibility of the body. The corona consisted of a simple ciliated band. Two cihated tufts (auricles) are present when swimming, though these were rarely seen as the animal spends most of its time browsing on the bottom where it is a cyanobacterial feeder. A large red eyespot is present on the brain and the mastax has a cardate trophus. Although the pedal glands were large, the toes were very small aud appeared to have a small button-shaped tip. The Vestfold Hills specimens are in close agreement with the published descriptions of this species (Koste 1978).

Lindia torulosa has a world-wide distribution and is now known from two sub-Antarctic and two Antarctic locations. Ou the Antarctic Peninsula, Beauchamp (1913) recorded it at Jenny Island, and Heywood (1977) reported a new form, *L. torulosa antarctica*, from the nearby Alexander Island. Since then it has been found at Macquarie (Dartnall 1993) and Heard Islands (Dartnall 1995a).

Cephalodella spp.
(Figure 9)

Cephalodellids were found in eight locations—iu Deep Lake Tarn, in Bisernoye, Crooked, Druzhby, Grace and Waterfall Lakes and in the two uunamed lakes (28 and 29). Only a few specimens were found at each location. Although small, the specimens examined showed a

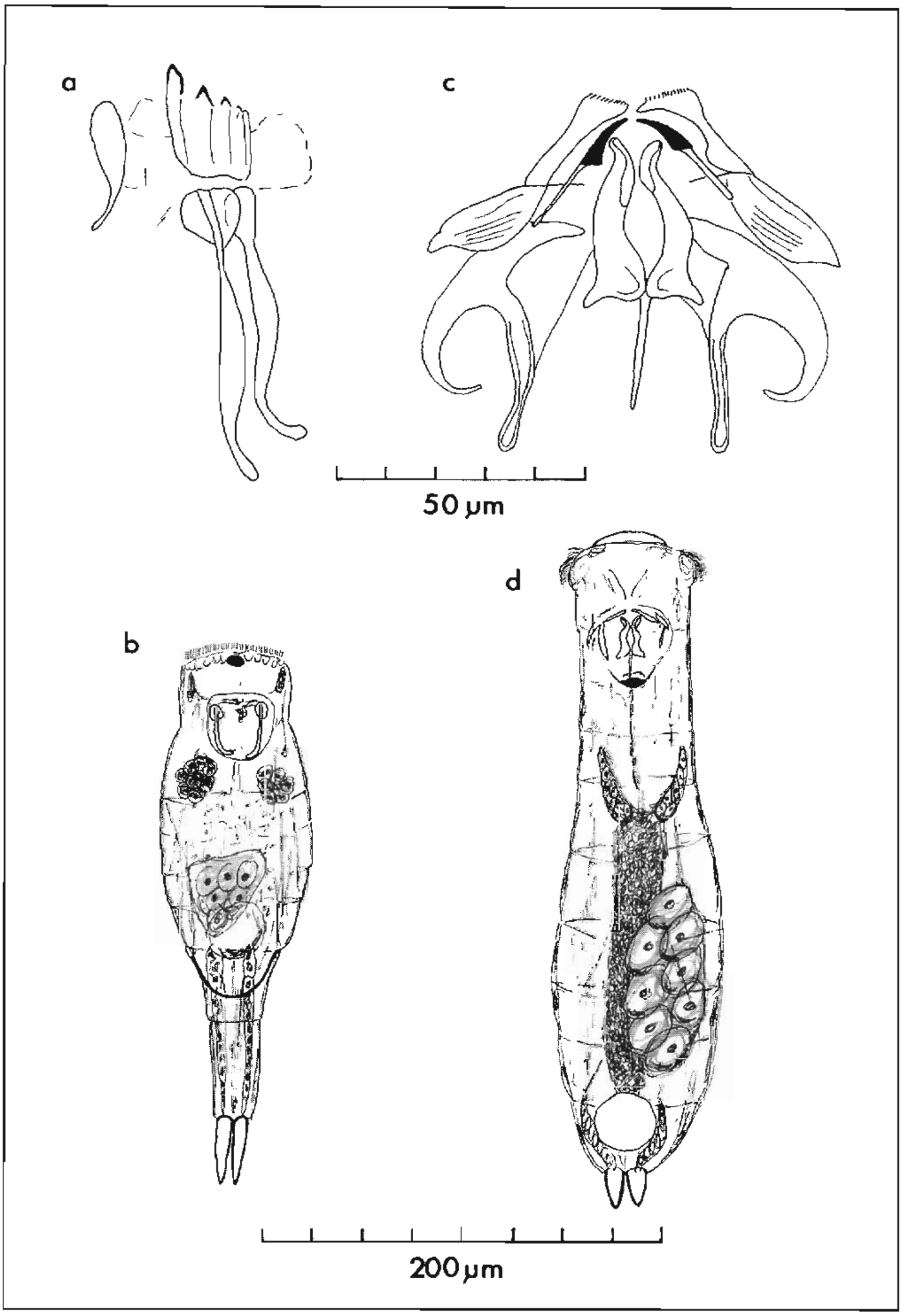

Figure 8. Proales reinhardti: *(a) trophus, lateral view; (b) dorsal view of whole animal.* Lindia torulosa: *(c) trophus; (d) dorsal view of whole animal.*

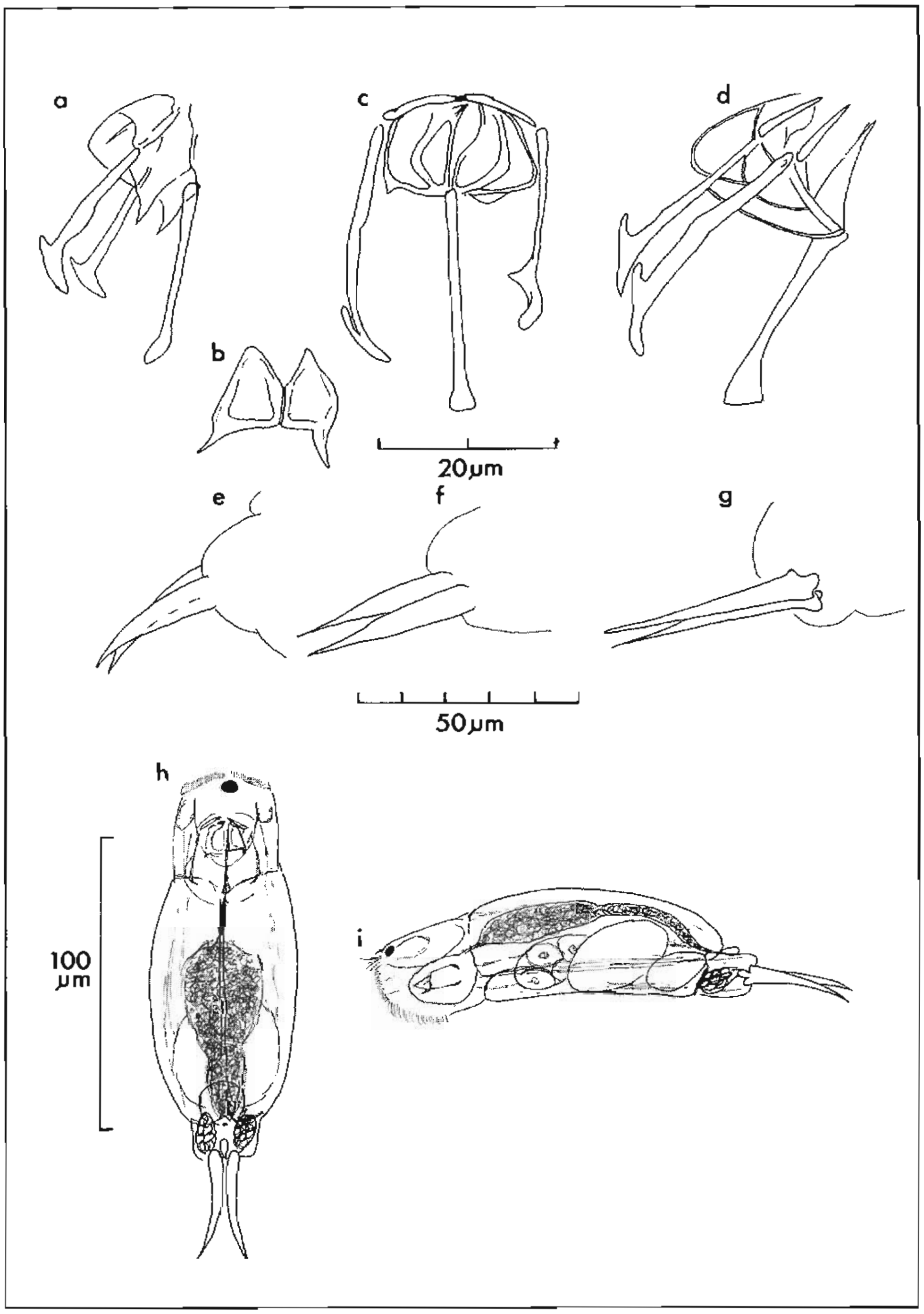

Figure 9. Cephalodella *spp.: (a) lateral view of trophus; (b) ventral view of rami; (c) ventral view of trophus; (d) lateral view of trophus; (e, f and g) various toe shapes; (h) dorsal view of whole animal; (i) lateral view of whole animal.*

considerable variation in overall size, and in the shape of the toes and trophus. The specimens were 135 to 270 μm long. Downwardly curved toes were normally encountered (Figure 9e) but straight toes with a markedly delineated point (Figure 9f), and longer, slimmer examples (Figure 9g) were also seen. The greatest variation, however, was found in the shape of the rami. Most had a smooth lower margin (Figure 9d) but many had tiny points on one or both edges (Figure 9c) and a few had quite massive projections (Figures 9a and 9b). The latter specimens resemble *C. dentata* Wulfert. The specimens with the smooth lower margin to the rami, and downwardly pointed toes (Figures 9h and 9i), were identical with specimens from the Larsemann Hills (Dartnall 1995b) and from Heard Island (Dartnall 1995a) that had been identified as *Cephalodella sterae* (Gosse). None of these specimens had a small dagger-like heel on the manubria at its point of termination with the rami, so this identification is now considered qnestionable. This species has been reported from the Obruchev Hills (Korotkevich 1958).

At least two species of small Cephalodellid were present in both the pools and freshwater lakes of the Vestfold Hills but further work is required on their identification.

Resticula gelida (Harring and Myers)
(Figures 10a and 10b)

Solitary individuals of *Resticula gelida* were found in five locations—in the melt pool in Lichen Valley, in Mossel Lake, in the two unnamed lakes (Lakes 28 and 29) and in Grace Lake. This species has a world-wide distribution and has been reported from Adelaide Island (Dartnall 1980), from brackish pools at Signy Island (Dartnall and Hollowday 1985), from the Larsemann Hills (Dartnall 1995b) and from Heard Island (Dartnall 1995a). The closely related *R. nyassa* has been reported from Macquarie Island (Dartnall 1993).

ENCENTRUM SPECIES

Six species of *Encentrum* including three that have been described as new (Dartnall 1997) were recognised from the Vestfold Hills lakes. They all looked alike, were highly active, and had transparent illoricate bodies and a protrusible forcipate trophus. Being predominantly predatory they were never very abundant; nevertheless, they were present in more than half the lakes examined (Table 2). In this table the lakes have been loosely arranged in groups of 'similar environments' so that the three pools (Deep Lake Tarn and 'Clear Lake Tarn' and the melt pool in Lichen Valley) have been brought together and have been separated from the freshwater lakes (Crooked Lake, etc.), which have in turn been separated from the brackish/marine ones. The Ellis Fjord results, which do not fit into any of these groupings, have been added at the foot of the table. Two species dominate this table—*Encentrum mustela* which is found in the pools and freshwater lakes, and *E. spatitium* which occurs in the freshwater and brackish lakes. Increasing salinity would appear to he the separating factor, with an overlap in just four of the lakes. The remaining species were very rare and little can be made of their distribution. The six species are differentiated by the shape of the trophus.

Encentrum brevifulcrum Dartnall
(Figures 11a and 11b)

This species was found in just three lakes (Clear Lake, Highway Lake, and the 'unnamed' lake at grid reference 940980). Perhaps the largest of the Vestfold Hills species of *Encentrum*, it has a sac-like body 150–350 μm long, and tiny insignificant toes. Although the trophus was relatively

Table 2. The distribution of six species of Encentrum *in the Vestfold Hills lakes, with* x *indicating presence.*

Lake Ref. No.	Name	Species of *Encentrum*					
		forcipatum	*mustela*	unknown	*brevifulcrum*	*spatitium*	*salinum*
2	'Clear Lake Tarn'		x				
19	Deep Lake Tarn		x				
30	Lichen Valley		x				
Freshwater Lakes							
12	Crooked Lake	x	x				
11	Lake Druzhby		x				
14	Mossel Lake		x				
16	Pauk Lake		x				
13	'Teat' Lake		x				
Freshwater and Brackish Lakes							
28	'unnamed' lake		x	x	x	x	
29	'little unnamed'		x			x	
22	Waterfall Lake		x				
38	Grace Lake		x			x	
9	Watts Lake		x				
17	Depot Lake					x	
35	Highway Lake		x		x	x	
Brackish and Marine Lakes							
25	Lake Vereteno					x	x
26	'Pointed' Lake					x	
3	Clear Lake				x	x	x
4	Lake McCallum					x	
34	Ace Lake					x	x
Unclassified							
10	Ellis Fjord		x			x	x

large (35 µm), the rami dominated the space between the unci and manubria, and the fulcrum at 7 µm long was quite tiny by comparison. Each gently curving ramus (17.5 µm long) was crowned by two small teeth. The unci were very thin (10 µm long) and without any perceivable midpoint swelling at the point of articulation with the rami. The intramallei were small. The manubria were gently curved, 24 µm long and with a slightly bulbous head.

Encentrum sp.
(Figure 11c)

Figure 11c is a drawing of a trophus from a living specimen of *Encentrum* from the unnamed lake (Lake 28). This was first thought to be another example of *E. brevifulcrum*, but the fulcrum is even smaller than in that species, being only 5 µm long. Only one tooth was present on each ramus, and the posterior ends of the manubria were slightly swollen. This is almost certainly a new species but unfortunately the specimen was lost when being removed from the temporary drawing mount prior to making a permanent slide.

Encentrum forcipatum Dartnall
(Figure 11d)

Just two specimens of this species were found in Crooked Lake. Virtually identical in size, shape and overall structure to *E. mustela*, the two species could only be separated by a high-powered (oil immersion) microscopical examination of their trophi; and even then the general shape and

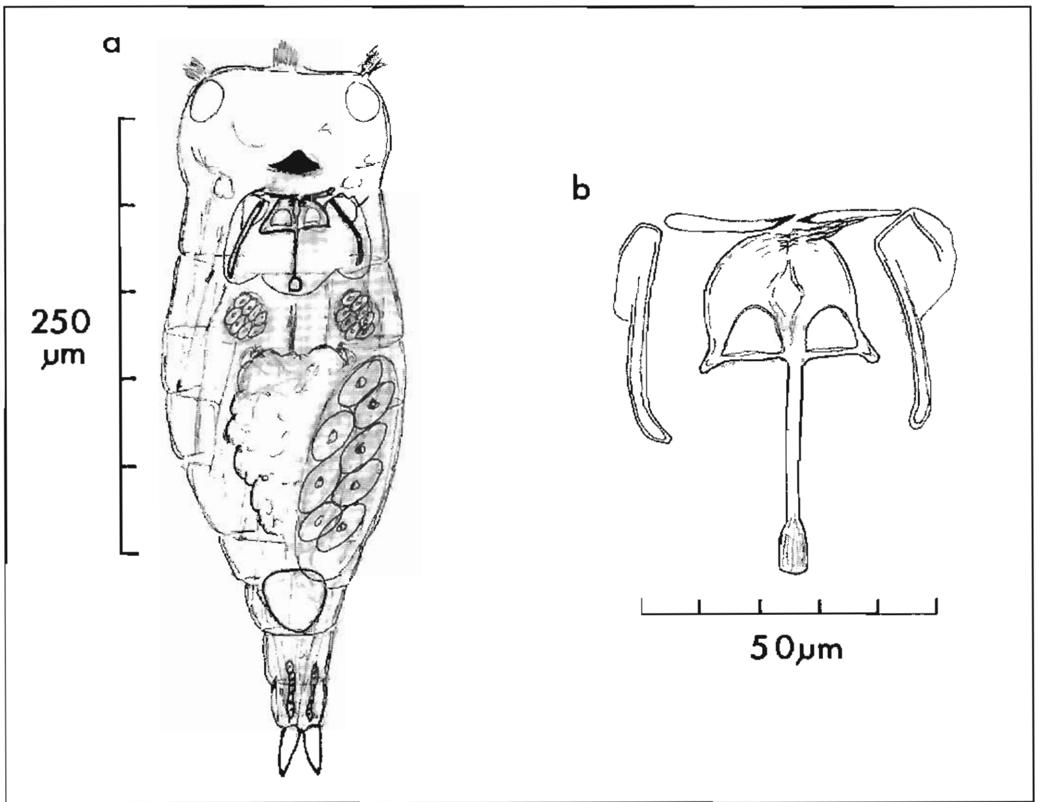

Figure 10. Resticula gelida: *(a) ventral view of whole animal; (b) trophus.*

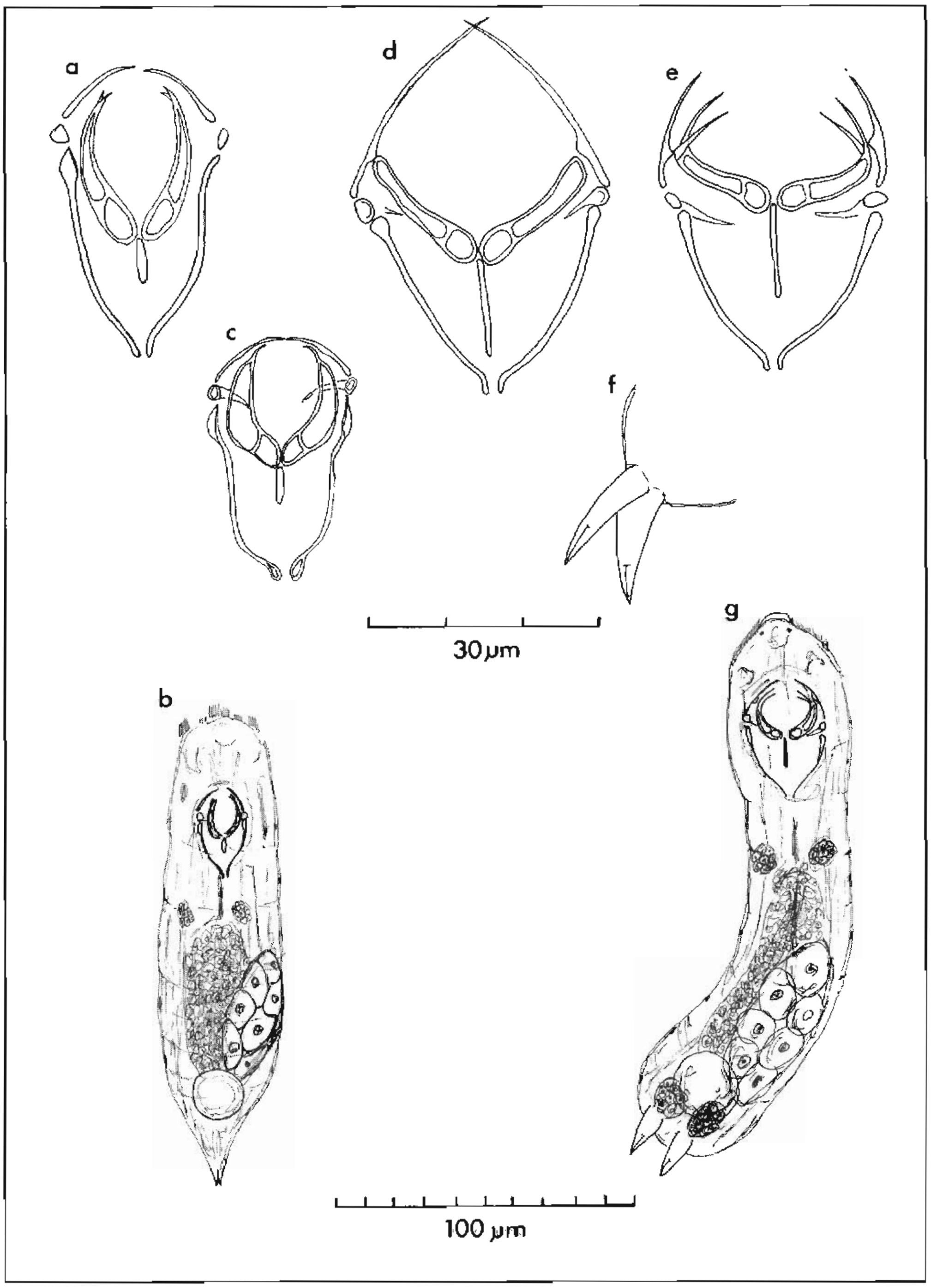

Figure 11. Encentrum brevifulcrum: *(a) trophus; (b) ventral view of whole animal.* Encentrum *sp.: (c) trophus.* Encentrum forcipatum: *(d) trophus.* Encentrum mustela: *(e) trophus; (f) toes; (g) ventral view of whole animal.*

arrangement were similar. *E. forcipatum* differs from *E. mustela* in the absence of teeth on the rami, and in the size of the unci. In *E. forcipatum* each uncus, at 30 µm long, is twice the length of that of *E. mustela*. They both pivot at a point just 8 µm from their bases, so the plane of operation of the 'long-nosed pincered' *E. forcipatum* is well forward and in a position where ramal teeth (if present) would be of little use.

Encentrum mustela Milne
(Figures 11e, 11f and 11g)

This species was found in 15 locations—in two of the pools, the freshwater lakes and some of the brackish ones (see Table 2). It is a small-to-medium sized rotifer (up to 200 µm long), with a pair of short stubby toes.

In Europe *Encentrum mustela* is regarded as a cold stenotherm. In the Antarctic it has been reported from Signy Island (Dartnall and Hollowday 1985), from Heard Island (Dartnall 1995a) and from the Larsemann Hills (Dartnall 1995b), and probably has a circumpolar distribution.

Encentrum salinum Dartnall
(Figures 12a, 12b and 12c)

Experiences of this species were found from four locations (Ace Lake, Clear Lake, Lake Vereteno and in Ellis Fjord). They were all small (maximum length about 170 µm, though this is very difficult to measure accurately owing to the 'elastic' nature of the body). A pair of small stubby toes (13 µm long) situated on the ventral surface close to the posterior were present. The trophus was relatively narrow (28 µm long), the manubria long, relatively straight (18 µm) and slender, the intra-mallei small (2 µm across), and each uncus short (8 µm) and srubby. The fulcrum was short (9 µm) and thin. The rami were small and curved (with an outside diameter of 10 µm), with each ramus bearing two small teeth.

Although described as a new species (Dartnall 1997) *Encentrum salinum* has been seen before. An identical set of trophi was found in the digestive tract of a predatory nematode from Macquarie Island (Dartnall 1990, 1993). The Macquarie Island specimen was then tentatively identified as *E. mustela* but is now revised as *Encentrum salinum*.

Encentrum spatitium Wulfert
(Figures 12d, 12e and 12f)

This species was found in 11 of the brackish lakes (Table 2). It is a medium-sized rotifer (upwards of 300 µm), with long pointed toes (25 µm) that have swollen bases. The trophus is large (40 µm) and the fulcrum is 18 µm long with an enlarged knob at the posterior end. The rami are strong, slightly curved and tipped by two strong teeth. The unci are similarly shaped, 13 µm long with a sharp point and mid-point swelling at the point of articulation with the rami. The intra-mallei are especially large, 10 µm tall with a conspicuous 'tail' that extends almost to the middle of the trophus.

Until recently *Encentrum spatitium* has only been reported from European inland saline waters (Koste 1978). Now, in addition to the saline lakes of the Vestfold Hills, it has been found in the Larsemann Hills (Dartnall 1995b) and in coastal pools on South Georgia (Dartnall unpub. report).

Ptygura crystallina (Ehrenberg)
(Figure 13a)

Ptygura crystallina was found in the melt pool in Lichen Valley, in Bisernoye, Crooked, Druzhby,

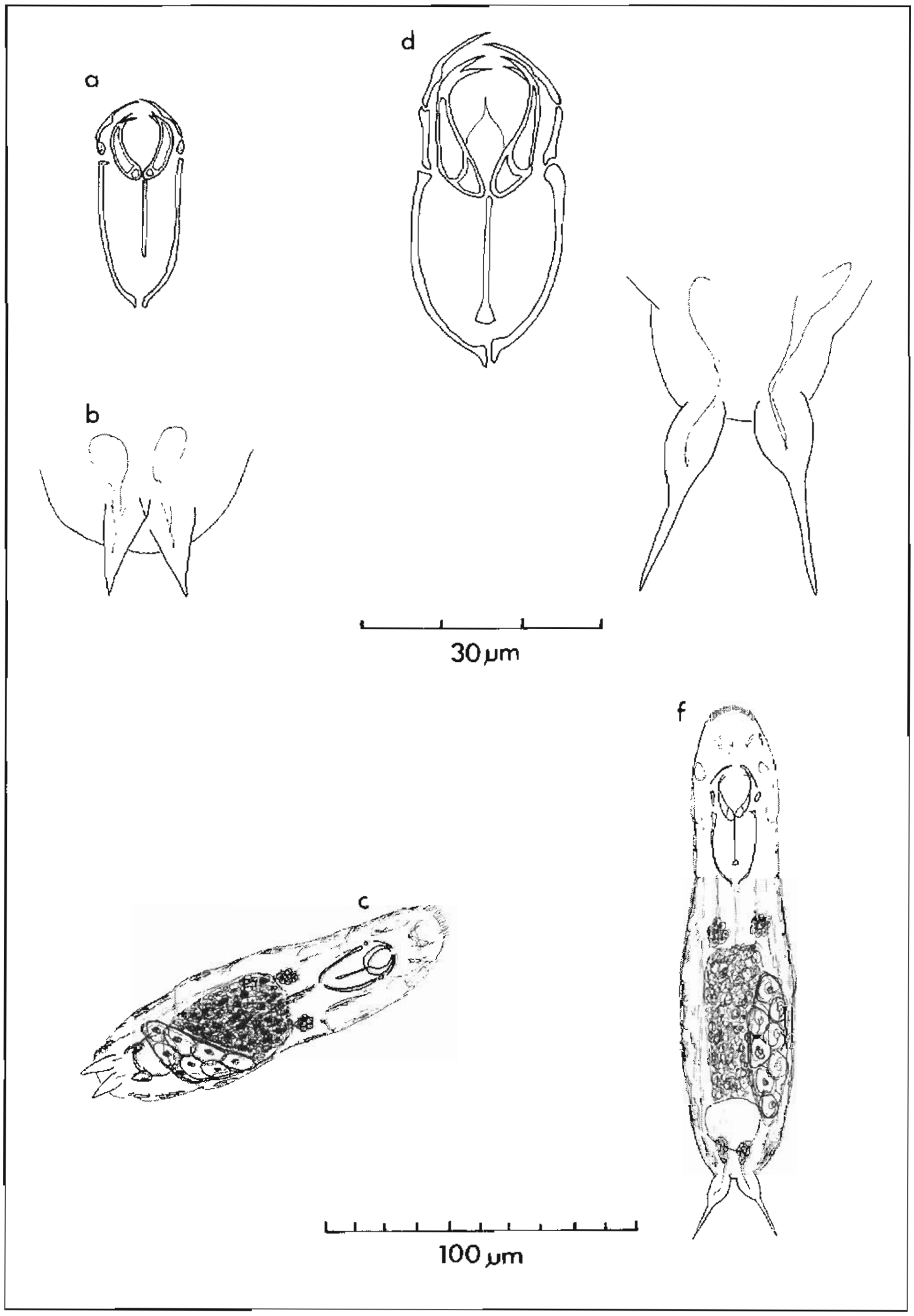

Figure 12. Encentrum salinum: *(a) trophus; (b) foot; (c) ventral view of whole animal.*
Encentrum spatitium: *(d) trophus; (e) foot; (f) ventral view of whole animal.*

Grace, Mossel, Pauk, Waterfall and Watts Lakes, and in the unnamed lake at grid reference 940980. A tube-dwelling species, it was found attached to the benthic mats but was never very common.

Ptygura crystallina has a world-wide distribution. It has been reported from the Antarctic and sub-Antarctic three times before: from Signy Island (Dartnall and Hollowday 1985); from the Larsemann Hills (Dartnall 1995b); and from Macquarie Island (Dartnall 1993). In addition, Everitt (1981) reported a *Ptygura* sp. from from Deep Lake Tarn in the Vestfold Hills—which was presumably this species.

Collotheca ornata cornuta (Dobie)
(Figure 13b)

This species was found in the pools (Deep Lake Tarn and the pool in Lichen Valley), and in Crooked, Depot and Grace Lakes and in Lake Druzhby. Although by far the largest rotifer found—some specimens were in excess of 1100 µm long—it was sometimes difficult to spot when the large coronal hood with the characteristic finger-like projection on the superior knob was withdrawn and contracted. Up to five large oval (60 by 50 µm) eggs were seen attached to the stem.

Collotheca ornata cornuta has a world-wide distribution. It has been reported from the Antarctic region several times and undoubtedly has a circumpolar distribution. It was first recorded in 1910 by Murray (reporting it as *Floscularia cornuta*) who found it at Cape Barne and Cape Royds, and it has subsequently been reported from these locations, and nearby, by Armitage and House (1962), though their record is for *C. ornata*, and by Dougherty and Harris (1963). It has been reported from eastern Antarctica from pools in the Obruchev Hills (Korotkevich 1958; Kutikova 1958b). from the Wilkes Coast (Dartnall unpub.), and from the Larsemann Hills (Dartnall 1995b), from Signy Island (Dartnall and Hollowday 1985), from Macquarie Island (Dartnall 1993), and from Heard Island (Dartnall 1995a).

BDELLOIDEA

Eight species of bdelloid rotifer were recognised. Four of these (*Adineta grandis, A. barbata, Habrotrocha constricta* and *Philodina gregaria*) are commonly found in the Antarctic and require no additional comment other than that they were rarer here than elsewhere. The as yet unidentified *Philodina* sp. 1 was the most common bdelloid found. Large numbers were found in the early spring, distributed throughout the water column when the lakes were still ice-covered. At other times they were normally found on or near the bottom amongst the benthic vegetation.

Two species of bdelloid rotifer not found in the present survey have been reported from the Vestfold Hills (Everitt 1981). These are *Macrotrachela quadricornifera* (Milne) and *Mnobia russeola* Zelinka. Both are normally found in mosses (Bartos 1951), so their presence in Deep Lake Tarn is not altogether surprising.

Adineta barbata Janson
(Figure 14a)

This species was found in 'Clear Lake Tarn' (Lake 2), the melt pool in Lichen Valley (Lake 30) and in Grace Lake (Lake 38). A medium-sized bdelloid (to 325 µm long), it was greyish-brown in colour. The spurs were particularly long and heavy.

Adineta barbata is normally found in drying mosses and has a world-wide distribution (Bartos 1951). It has been reported from the Antarctic before: from the McMurdo Sound area by Murray

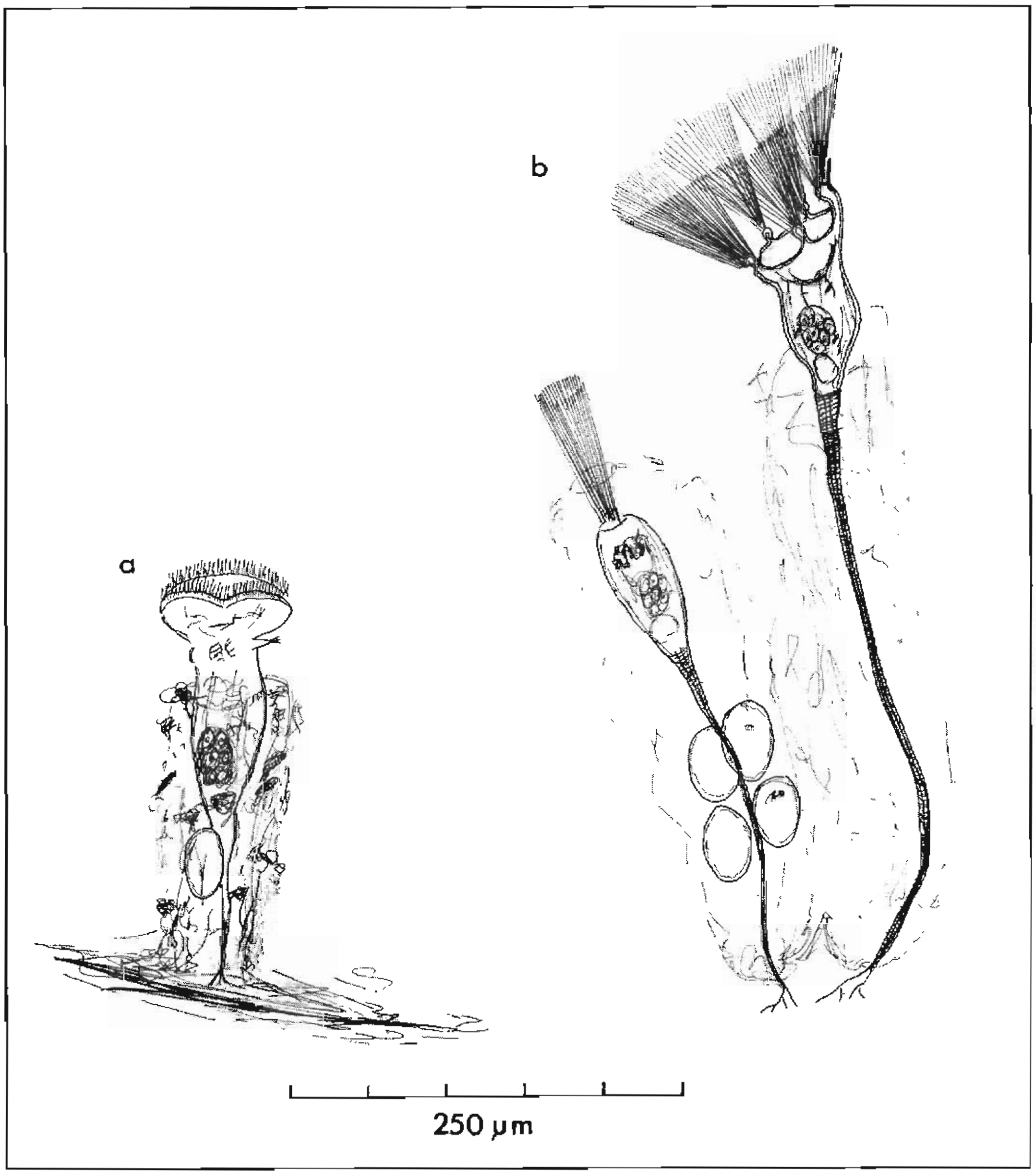

Figure 13. Ptygura crystallina: *(a) whole animal.* Collotheca ornata cornuta: *(b) whole animal.*

(1910) and Dougherty and Harris (1963), and from Signy Island (Dartnall and Hollowday 1985).

Adineta grandis Murray
(Figure 14b)

This species was found most abundantly in the pools (Deep Lake Tarn and the melt pool in Lichen Valley). It was also found in large numbers in some of the brackish lakes (Watts, Vereteno, Highway and Grace). In addition 10 specimens were recovered from Crooked Lake.

This is a large brown rotifer up to 700 µm long. It is a viviparous species—some specimens were observed to have five developing young in their bodies. The mastax has a ramate trophus and, as with all members of this genus, has a 2/2 dental formula. The head lacks the wheel organ typical of bdelloid rotifers and so all the members of this genera cannot swim but creep caterpillar-fashion, or glide, over the bottom. The foot is narrow, with two spurs and three small toes.

Adineta grandis is only found in the Antarctic and probably has a circumpolar distribution. So far it has been reported from the McMurdo Sound area by Murray (1910), Dougherty and Harris (1963) and Spurr (1975); from Wilkes Land (Dartnall unpub.), Haswell Island (Donner 1972; Opalinski 1972a), the Larsemann Hills (Dartnall 1995b), and from Signy Island (Dartnall and Hollowday 1985).

Adineta sp.
(Figure 14c)

Only a few specimens of this species were found in the following lakes—Druzhby (Lake 11), the unnamed lake (Lake 28), and Grace (Lake 38). Small (250 µm), transparent, and with no distinguishing marks, it is possibly a juvenile. Similar specimens were found in Lake Scandrett and Discussion Lake in the Larsemann Hills (Dartnall 1995b).

Habrotrocha constricta Dujardin
(Figure 15a)

This pellet-forming bdelloid was regularly encountered, though never very common. It was found creeping on the bottom of the pools ('Clear Lake Tarn', Deep Lake Tarn and the melt pool in Lichen Valley) in Lake Druzhby, the unnamed lake (Lake 28) and Grace Lake. Most of the specimens encountered were medium/large, though a few larger ones (>450 µm) were seen. The body was smooth and pale yellow-brown in colour. The wheel organ in this species is small—not much larger than the neck—and the upper lip is large and triangular with an m-shaped apex. The ramate trophus is covered with fine striae and has a dental formula of 8/8. The foot is short, with a pair of small blunt spurs which touch at the base, and three small toes. A number of oval eggs (80 x 50 µm) were seen.

According to Bartos (1951) *Habrotrocha constricta* has a world-wide distribution. It has been reported from the Antarctic several times, including the Vestfold Hills (Everitt 1981). It was first reported by Murray (1910) from the McMurdo Sound area and has subsequently been reported at Signy Island (Jennings 1976; Donner 1980; Dartnall and Hollowday 1985), from Wilkes Land (Thomas 1965, 1972), and the Larsemann Hills (Dartnall 1995b).

Philodina gregaria Murray
(Figure 15b)

This species was found in the pools—'Clear Lake Tarn', Deep Lake Tarn (where Everitt 1981, also reported it) and in the melt pool in Lichen Valley. It was also found in two of the lakes—Watts and Depot.

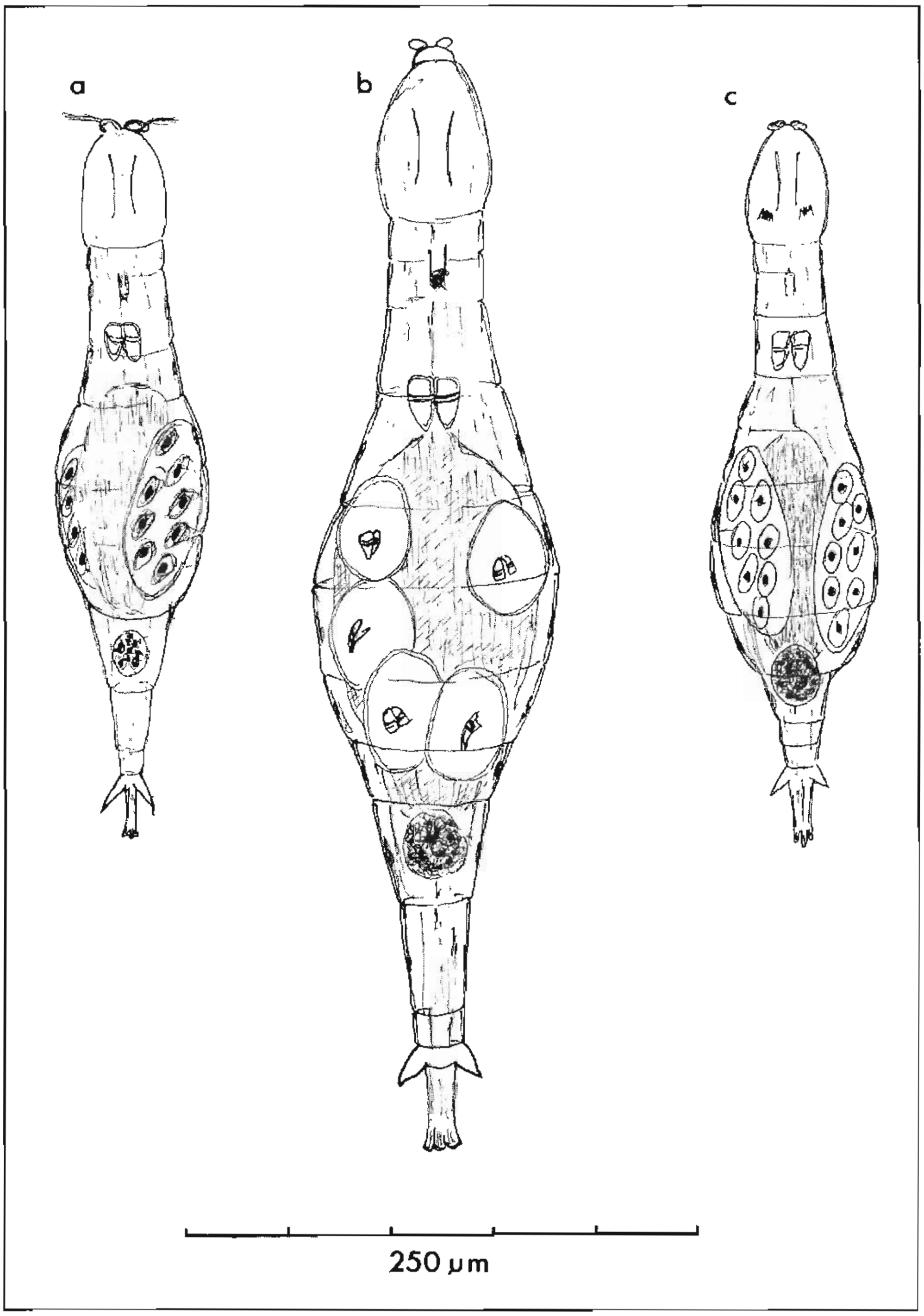

Figure 14. Adineta barbata: *(a) ventral view.* Adineta grandis: *(b) ventral view.*
Adineta *sp.: (c) ventral view.*

It is a very large viviparous bdelloid with a total length in excess of 600 µm. The body is bright red, and the head and foot are a clear/pale red colour. The ciliary discs of the wheel organ are large and there is a pair of conspicuous orange eyespots. The teeth on the ramate trophus have a dental formula of $2_{+1}/2_{+1}$. The spurs are moderately long and widely separated.

Like *Adineta grandis*. *Philodina gregaria* is only found in the Antarctic and has been reported from the Vestfold Hills (Everitt 1981). Originally descibed by Murray in 1910 from the lakes and pools at Cape Royds and Cape Barne, it has subsequently been reported there by Armitage and House (1962), Dougherty and Harris (1963), Spurr (1975) and Cathey et al. (1981). In addition it has been reported from the Wilkes Land Coast (Dartnall unpub.), from Haswell Island (Donner 1972; Opalinski 1972a), the Larsemann Hills (Dartnall 1995b), on the Antarctic Peninsula at Red Rock Ridge, Stonnington (Schmitt 1945) and Ablation Point, Alexander Island (Heywood 1977), and at Signy Island (Dartnall and Hollowday, 1985).

Philodina sp. 1
(Figures 15c, 15d, 15e and 15f)

This large (>400 µm) brown bdelloid was the commonest bdelloid found and it occurs in Crooked Lake, Depot Lake, Lake Druzhby, Mossel Lake, Nicholson Lake, Pauk Lake, 'Teat' Lake, both of the unnamed lakes, Waterfall Lake, Watts Lake and Lake Zvezda. It was normally on the bottom, associated with the benthic vegetation, but in the spring when the ice had begun to melt large numbers were distributed throughout the compact water column. It is a very chunky species with a large pair of ciliary discs. A pair of orange eyespots were present and the trophi had a dental formula of 3/3 or $3_{+1}/3_{+1}$. The dorsal antennae appeared to be made of two segments. An oviparous species, it lays pale brown oval-shaped eggs with a single polar knob (100 x 75 µm).

Philodina sp. 2
(not illustrated)

This species is much smaller (300 µm long) and slimmer than *Philodina* sp. 1. It is pale red in colour and has a 2/2 dental formula. Only a few specimens were found in 'Clear Lake Tarn' and Grace Lake. This species was also found in the Larsemann Hills (Dartnall 1995b).

Macrotrachela spp.
(not illustrated)

A small number of specimens belonging to this genus were found in Watts Lake and the unnamed lake (Lake 28) during the summer. The Watts Lake specimens were pale brown, large (425 to 675 µm long), and very slim, with a smooth cuticle. The wheel organ was large, the trochal discs widely separated and with a dental formula of 2/2. A number of developing eggs were present. These were oval in shape (100 x 80 µm). The specimens from the unnamed lake, which may be of a different species, were orange-brown, less than 400 µm long and with a faint 3/3 dental formula. The small foot with three toes, and two small pointed spurs that touch at their base, were similar.

NEMATODA

Nematodes were found in the benthic sediments of a number of lakes. Several species appeared to be present. At least two species were present in the freshwater lakes and at least two more in the saline lakes.

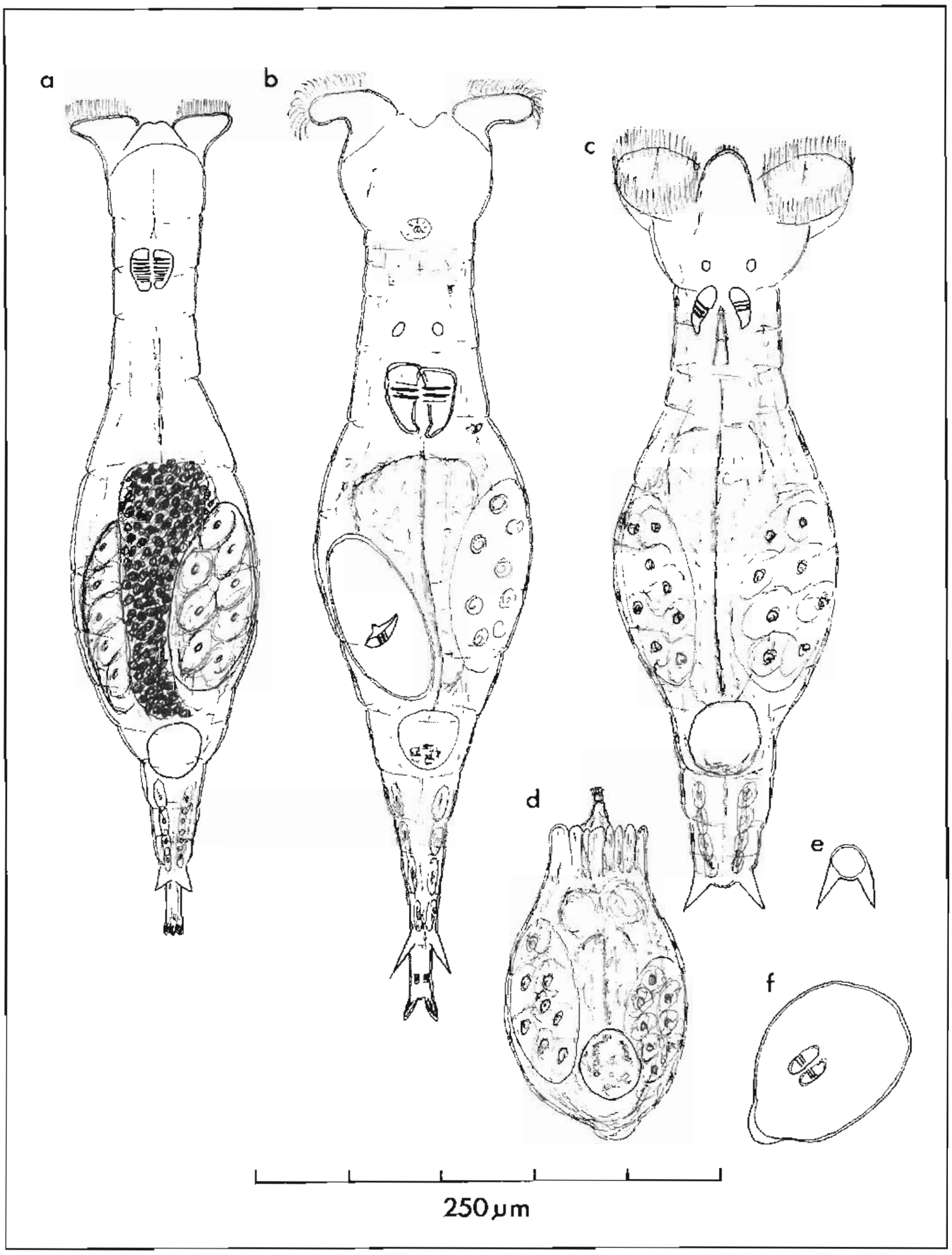

Figure 15. Habrotrocha constricta: *(a) ventral view.* Philodina gregaria: *(b) ventral view.* Philodina *sp. 1: (c) ventral view; (d) contracted specimen; (e) cross-section through spurs; (f) egg.*

ANNELIDA

Although Oligochaete worms have been reported from a number of Antarctic and sub-Antarctic locations before, none was found in the Vestfold Hills. Veliger larvae of several unidentified marine worms, however, were seen in the marine samples taken from the eastern end of Ellis Fjord.

ARTHROPODA

One cladoceran, three copepods, two harpacticoids and an amphipod were found in the Vestfold Hills lakes.

Daphniopsis studeri Rühe
Figure 16(a)

This cladoceran was present in the large freshwater lakes (Druzhby, Crooked, 'Teat', Mossel, Chelnok, Pauk and Bisernoye), and in some of the fresh/brackish lakes (Watts, Nicholson, Waterfall, Pointed, Vereteno, the unnamed lake, the little unnamed lake, and Highway and Grace) where it was the most conspicuous species found. Males were not seen at any of these locations (cf. Lake Scandrett in the Larsemann Hills, Dartnall 1995b) though they were obviously present since females with overwintering eggs or, more usually, discarded brood pouches were found in the benthos of Druzhby, Grace and Watts Lakes during the winter and early spring.

Originally described from the freshwater lakes at Iles Kerguelen (Rühe 1914) *Daphniopsis studeri* has been reported from the sub-Antarctic islands of Marion (Smith and Sayers 1971; Kok and Grobbelaar 1978), Crozet (Dreux 1970) and Heard (Dartnall 1995a), as well as from the Larsemann Hills (Dartnall 1995b).

Acanthocyclops mirnyi Borutsky and Vinogradov
(Figure 16b)

This small copepod was present in the large freshwater lakes (Druzhby, Crooked, 'Teat', Mossel, Chelnok, Pauk, Zvezda and Bisernoye); and the fresh/brackish (Watts, Depot, Waterfall, Vereteno and Grace and the unnamed lake).

Acanthocyclops mirnyi was first described from the Bunger Hills (Borutsky and Vinogradov 1957). It has subsequently been reported from there by Borutsky (1962), and Brodsky and Zvereva (1976). It has also been recorded from the Vestfold Hills—in Lake Krutvatnet (now known as Crooked Lake) and in Lebed' Lake (Korotkevich 1958; Borutsky 1962) but the Lebed' Lake records have been discredited on account of the salinity of the water there. *A. mirnyi* has also been reported from the nearby Larsemann Hills (Dartnall 1995b) and is now known to be in the Falkland Islands (Dartnall unpub.).

Drepanopus bispinosus Bayly
(Figure 16c)

This small calanoid copepod was found in Burton Lake, Fletcher Lake, and in some of the Ellis Fjord samples. Normally an inhabitant of the inshore marine environment (Tucker and Burton, 1988), it has been reported from Burton Lake and Fletcher Lake by Eslake et al. (1988), Wang (1988) and Wang et al. (1990). Both these lakes are periodically connected to the sea and this is presumably where the animal came from.

Paralabidocera antarctica (I.C. Thompson)

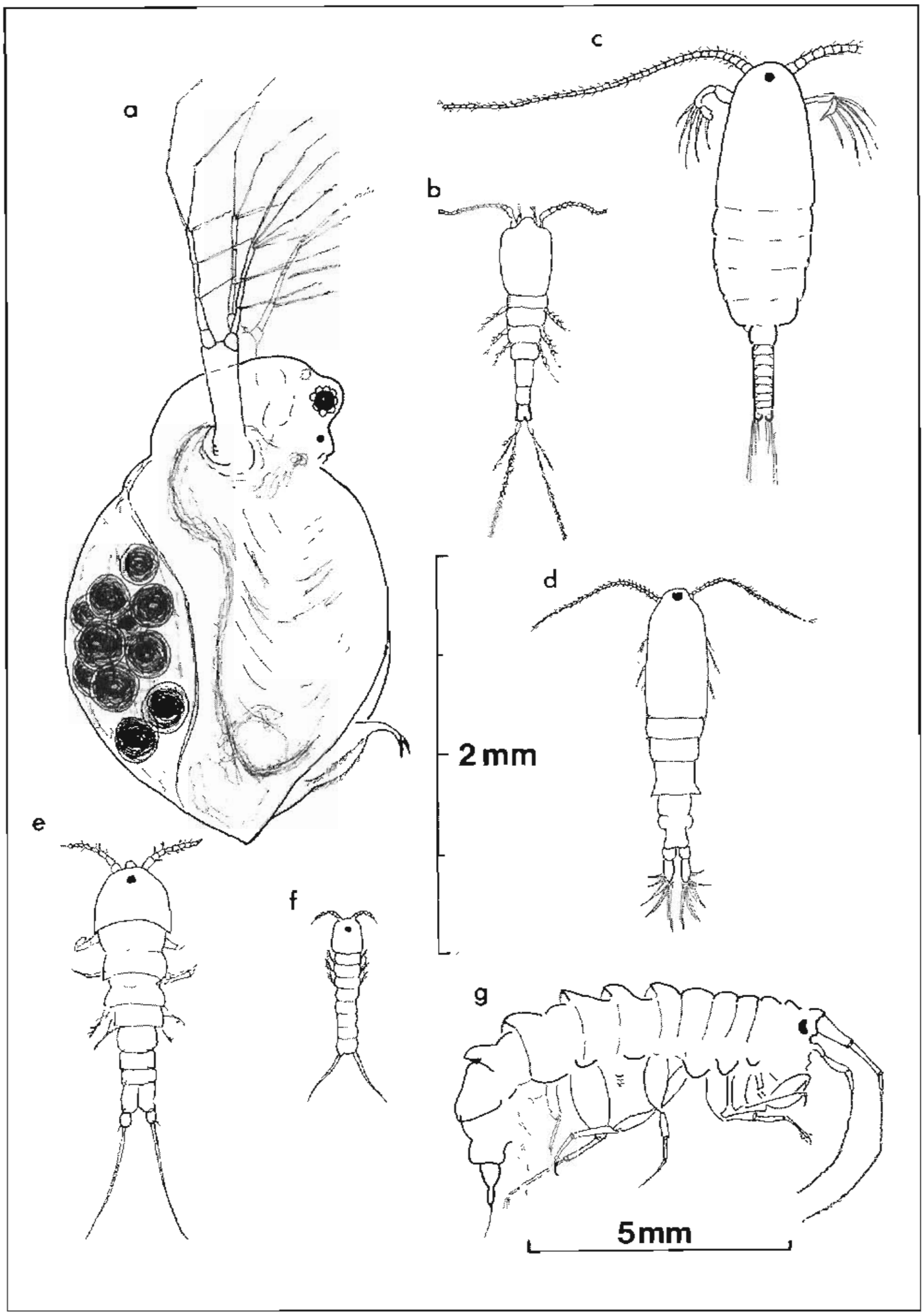

Figure 16. Arthropoda (Cladocera) Daphniopsis studeri: *(a) lateral view.* (Copepoda) Acanthocyclops mirnyi: *(b) dorsal view.* Drepanopus bispinosus: *(c) dorsal view.* Paralabidocera antarctica: *(d) dorsal view.* (Harpacticoida) *(e) Fletcher Lake specimen; (f) Ace Lake specimen.* (Amphipoda) *(g) lateral view of specimen from Burton Lake.*

(Figure 16d)

This small calanoid copepod was found in Lake Ahraxas, Fletcher Lake, Ace Lake and Pendant Lake, and in some of the Ellis Fjord samples. Normally an inhabitant of the inshore marine environment (Tucker and Burton 1988), it has been reported from these lakes variously by Bayly (1978, 1986), Burton and Hamond (1981), Wright and Burton (1981), Bayly and Burton (1987), and Bayly and Eslake (1989). Burton and Fletcher Lakes are periodically connected to the sea and this link is undoubtedly the source of the fauna of these lakes. The specimens found in Ace Lake and in Lake Abraxas were slightly smaller than those from the sea—an observation previously noted by Bayly (1978).

Harpacticoid species
(Figures 16e and 16f)

Two species of harpacticoid were found in the present survey—different species in Fletcher Lake (Figure 16e) and Ace Lake (Figure 16f). The specimens from Ace Lake have been identified as *Idomene scotti* Lang (Dr R. Hamond, pers. com.). Two species of harpacticoids have been reported from the Vestfold Hills lakes before—notably *Harpacticus furcatus* Lang and *Amphiascoides* sp. from Lake Abraxas (Burton and Hamond 1981; Bayley and Eslake 1989).

Amphipod species
(Figure 16g)

A single specimen of a large amphipod was found in Burton Lake. This is a new record for the Vestfold Hills lakes. Amphipods were seen in the marine samples from the eastern end of Ellis Fjord. (Two species of amphipod—*Paramoera walkeri* Stebbing and *Orchomene* cf. *plebs* (Hurley)—have been found in Davis Bay (Tucker and Burton 1988)).

MOLLUSCA

A number of small bivalve molluscs (several species) were present in the benthic samples taken from the eastern end of Ellis Fjord. These are inshore marine species that were not present in any of the lakes. (For a list of the molluscs that have been found from marine inshore locations in the Vestfold Hills see Tucker and Burton 1988.)

Fossilized shells of marine bivalve molluscs (principally *Laternula elliptica* (King and Broderip) and some *Pecten* sp.) were found around the shore, and in the marine terraces of a number of lakes, notably from Laternula Lake (Lake 1), Watts Lake (Lake 9) and in the marine terraces round the lakes in Death Valley.

VERTEBRATA

A number of dead and decaying fishes were found washed up on the shore of Deprez Basin (Lake 33). They were found farthest from the opening into Long Fjord. In addition, fish scales were seen in benthic samples from both Burton Lake (Lake 5) and on two separate occasions in Lake Druzhby (Lake 11). Fish have been reported in Burton Lake (Williams 1988) but they do not occur in Lake Druzhby. The scales found here are believed to have been deposited with bird faecal droppings.

5. Discussion

The lakes of the Vestfold Hills are a product of their topography, geology and climate. Isostatic uplift, now and in the recent past, has tilted the land and lifted it out of the sea. This has isolated some of the fjords from the sea, land-locking them as a series of natural depressions.

Those 'isolated fjords' that are close to the Plateau or Sørsdal Glacier and receive copious quantities of melt water will have had any residual seawater flushed out, leaving behind ultra-pure freshwater lakes (for example Crooked Lake); those that have small catchment areas, and receive little or no melt, will become more saliue as evaporation concentrates the salt ions into an ever-decreasing volume of water (the lakes in Death Valley). Between these two extremes there is a variety of intermediate conditions that have been variously affected by glacial retreat, evaporation, drainage, inundation by the sea, wind-deposited sea spray, and freshwater flooding (Adamson and Pickard 1986).

This process is still continuing and a number of changes—some of them quite catastrophic—can be anticipated for the future. For example, the ice-dam of Pineapple Lake (grid reference 865815) will eventually be breached by the sea and this basin will become an arm of Crooked Fjord thereby losing its freshwater status.

Isostatic uplift will complete the isolation of Burton Lake from the sea. At present this lake is linked to Crooked Fjord across ice-dammed shallows and during the summer there is a small interchange of water between the two, which tops up not only the water level but the flora and fauna as well. Complete isolation will see this lake becoming shallower and more saline and probably with a reduced flora and fauna.

Ellis Fjord will also become isolated from the sea. Some stratification has already occurred in the deepest troughs of this fjord (Gallagher et al. 1989) and left alone these could eventually become individual lakes of increasing salinity. However, at present, copious quantities of freshwater flow into the eastern end of this fjord during the summer. Should this continue, then these 'saline lakes' would be 'freshened' with the through-flow of water. Isostatic uplift and glacial retreat, however, may affect the freshwater inflow. and instead of flowing over the Ellis Rapids this water could be diverted to Watts and Lebed' Lakes. Another possible scenario could have the water diverted away before it reaches there—westward from Chelnok Lake, and alongside the Sørsdal Glacier and into Crooked Fjord, resulting in an isolation of the Tierney River Lakes system.

Elsewhere the water level in closed lakes, that is those lakes without an appreciable through-flow of melt water, will fluctuate dependent upon the climate and the catchment area. When the gain due to snowfall exceeds the loss by evaporation (positive water balance) the depth of water will increase. When there is a negative water balance the freshwater lakes will tend to dry up, while the saline lakes will become saltier as they also tend to dry up.

The fauna of the Vestfold Hills lakes is more varied than in other Antarctic locations of a similar latitude. This is primarily due to the wide range of habitats; not only is there a freshwater component but a brackish/marine one as well. The 'freshwater component' is virtually identical with that found in the Larsemann Hills (Dartnall 1995b). but the 'brackish/marine component' has no parallel.

It was apparent that similar habitats had similar faunas, and that the species found in the pools, for example, were very different from those in the saline lakes. By grouping together similar habitats—developing further the distribution ideas that came about from Tables 1 and 2—and then collating them according to the presence or absence of the commoner species it has been possible to arrange the lakes into six categories each of which has its own characteristic fauna (Table 3). The six categories are:

Pools. Pools are shallow bodies of water (less than 2 m deep) that freeze solid during the winter. During the summer they have a pH around 7.5, and a salinity range of 300 μS/cm to 2.25 μS/cm. They are highly productive, with abundant protozoa, rotifers, tardigrades and nematodes. The rotifers include all those species that are usually found in Antarctic pools—*Adineta grandis, Epiphanes senta, Habrotrocha constricta, Philodina gregaria* and *Resticula gelida* (Dartnall 1992). plus a number of others, including *Encentrum mustela* and *Lepadella patella*, that are usually considered lake species (Dartnall and Hollowday 1985). Deep Lake Tarn is typical of the Vestfold Hills pools and has been the subject of a detailed study (Everitt 1981).

Freshwater Lakes. Freshwater lakes are large bodies of freshwater with a pH around 7.1 and conductivity of 50 μS/cm or less. They are characterised by the presence of the cladoceran *Daphniopsis studeri*, the copepod *Acanthocyclops mirnyi*, and the rotifers *Lindia torulosa* and *Philodina* sp. 1. The rotifers normally found in Antarctic pools (*Adineta grandis, Epiphanes senta, Habrotrocha constricta, Philodina gregaria* and *Resticula gelida*) are for the most part absent—there are just a few isolated specimens. Mosses (*Bryum pseudotriquetrum*) were found in four of the lakes (Chelnok, 'Teat', Crooked and Druzhby).

Freshwater/Brackish Lakes. The freshwater/brackish lakes are of small to medium size with pH from 7.2 to 8.7 and salinity from 550 μS/cm to 5.5‰. These lakes have a predominantly freshwater flora and fauna, but with increasing salinity the species found in the pools and freshwater lakes are lost and replaced by three species of brackish *Encentrum*. Tufts of moss (*Bryum pseudotriquetrum*) were found in four of the lakes (the unnamed lake and Waterfall, Depot and Hand Lakes).

Brackish Lakes. The brackish lakes are of small to medium size. with a pH of 8.1 to 8.8 and salinity of 9.7–18‰. They have a very limited fauna. None of the pool and freshwater lake species are present, just the brackish *Encentrum* species and a few marine copepods and harpacticoids.

Marine Lakes. The marine lakes are of small to medium size with pH from 8.0 to 8.5 and salinity up to 77‰. A number of these, such as Ace and Ekho Lakes, are meromictic. They can support a varied, albeit limited, flora and fauna in shallow, oxygenated and less saline waters. Some still retain a link to the sea—Deprez Basin, Burton Lake and Fletcher Lake—and here the fauna can be topped up and added to.

Hypersaline Lakes. These are highly saline lakes (>250‰) and with pH of 7.4 to 7.7. The most saline do not freeze during the winter. They have a very limited flora (Wright and Burton 1981) and appear to be devoid of invertebrates.

Table 3. Distribution of invertebrates in the Vestfold Hills lakes. Key: x = present

	pools			freshwater lakes								freshwater/brackish lakes											brackish lakes				marine lakes					hypersaline lakes			
	'Clear Lake Tom'	Deep Lake Tom	'melt pool'	Chelnok Lake	Lake Zvezda	'Teot' Lake	Pouk Lake	Lake Bisernoye	Massel Lake	Crooked Lake	Lake Druzhby	'unnamed lake'	'little unnamed'	Nicholson Lake	Waterfall Lake	Grace Lake	Watts Lake	Depot Lake	Lake Vereteno	'Pointed' Lake	Highway Lake	Lake Hand	Clear Lake	Pendant Lake	Lake McCollum	Lake Abraxas	Ace Lake	Burton Lake	Fletcher Lake	Ekho Lake	Anderson Lake	Latemulo Lake	'Lebed' Lake	Dingle Lake	Deep Lake
Hebrotrocha constricta	x	x	x								x	x	x			x																			
Resticula gelida			x						x			x	x			x																			
Adineta barbata	x		x													x																			
Philodina gregaria	x	x	x									x	x				x	x																	
Adineta grandis	x	x	x							x			x			x	x		x		x	x													
Epiphanes senta	x	x	x								x	x	x		x	x		x	x	x	x	x													
Cephalodella spp.		x						x		x	x	x	x		x	x																			
Ptygura crystallina			x				x	x	x	x	x	x			x	x	x																		
Collotheca ornata cornuta		x	x						x	x	x	x	x		x	x		x																	
Encentrum mustela	x	x				x	x		x	x	x	x	x		x	x	x				x														
tardigrades	x	x	x			x			x	x	x	x	x				x		x																
Lepadella patella	x	x	x			x	x	x	x	x	x	x	x	x	x	x	x	x	x																
Acanthocyclops mirnyi				x	x	x	x	x	x	x	x	x			x		x	x	x																
Daphniopsis studeri				x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x														
Philodina sp. 1					x	x	x		x	x	x	x	x	x	x		x	x																	
Lindia torulosa									x		x	x			x		x																		
Adineta sp.											x	x				x																			

Group	Lake	*Encentrum brevifulcrum*	*Encentrum spatiatum*	*Encentrum salinum*	*Paralabidocera antarctica*	harpacticoids	*Drepanopus bispinosus*	miscellaneous species	platyhelminths	*Notholca* sp.	nematodes
hypersaline lakes	Deep Lake										
	Dingle Lake										
	Lebed' Lake										
	Laternula Lake										
marine lakes	Anderson Lake										
	Ekho Lake										x
	Fletcher Lake				x	x	x				
	Burton Lake				x		x				x
	Ace Lake		x	x	x	x			x	x	x
brackish lakes	Lake Abraxas				x	x					x
	Lake McCallum		x								
	Pendant Lake				x						
	Clear Lake	x	x	x					x	x	x
freshwater/brackish lakes	Lake Hand								x	x	
	Highway Lake	x	x							x	
	'Pointed' Lake		x							x	
	Lake Vereteno		x	x						x	
	Depot Lake		x						x	x	
	Watts Lake									x	x
	Grace Lake		x						x	x	
	Waterfall Lake									x	
	Nicholson Lake									x	x
	'little unnamed'		x						x	x	x
	'unnamed lake'	x	x						x	x	x
freshwater lakes	Lake Druzhby								x	x	x
	Crooked Lake								x	x	x
	Massel Lake									x	x
	Lake Bisernaye									x	x
	Pauk Lake									x	
	'Teat' Lake									x	x
	Lake Zvezda									x	
	Chelnak Lake										
pools	'melt pool'								x		
	Deep Lake Tarn									x	x
	'Clear Lake Tarn'								x	x	x

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