A CONTRIBUTION TO THE LIMNOLOGY OF THREE LAKES IN THE SOUTHERN INTERIOR HIGHLANDS OF BRITISH COLUMBIA

140 p. plus appendices

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ABSTRACT

Plankton and periphyton studies were carried out on three lakes in the southern Interior Highland limnological region of British Columbia. The phytoplankton of Lily Pad Lake, a small bog lake, was dominated by the desmids, whose fluctuations were dependent chiefly upon interactions with benthic populations. The zooplankton was dominated by the crustaceans, *Diaptomus leptopus*, *Eucyclops agilis*, *Daphnia shodleri*, *D. rosea*, and *Polyphemus pediculus*, and the rotifers, Conochilus unicornis, *Keratella cochlearis* and *K. quadrata*. The periphyton was dominated by the diatoms, *Epithemia turgida* and *Eunotia* spp. Bacteria and detrital organic matter also played a significant role.

The phytoplankton of Nicklen Lake was dominated by *Asterionella formosa*, *Tabellaria fenestrata* and *Dinobryon divergens*. Parasitism, competition and various environmental parameters operated to determine their fluctuations. The periphyton was dominated by the diatoms, especially *Achnanthes minutissima*. *Epithemia turgida* was dominant only in mid-summer. The Cyanophyte, *Aphanocapsa* sp., became dominant at only one station.

Curtis Lake, a dystrophic system, had a paucity of phytoplankton species, with diatoms and greens being the most common. The periphyton was dominated by organic matter and the diatoms, *Achnanthes* spp. and *Eunotia* spp.

L. Bayliss, E. Black April 1977

Plankton and periphyton studies in 3 lakes of the southern Interior highlands of British Columbia

ACKNOWLEDGEMENTS

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We should now like to thank the people who helped at different stages of the analyses; among them, Drs. A. Austin and J. Reynolds for agreeing to be our supervisors; S-D. Brown, S.D. Lang, and J. Reynolds for their invaluable help with taxonomic questions; and A. Ceska for his identifications of the aquatic macrophytes.

INTRODUCTION

The study to be described here is a limnological investigation of three lakes in the southern Interior Highlands of British Columbia. This was undertaken as a contribution to regional limnology since little information exists on lakes in the Okanagan Highlands region. Therefore, the purpose of the research, carried out during the summer of 1976, is to inventory the lakes and to provide fundamental data on their biota in order to help characterize the lakes of the region. Lily Pad Lake (unofficial name) was chosen for detailed study because it is representative of a typical southern Interior Highland lake ~~(Northcote and Larkin, 1~~ which has not been subject to irrigation damming or other human modification (Northcote, unpublished). It forms part of Ecological Reserve #5 (see Figure 1), which was established on May 4, 1971. The Ecological Reserves Act of B.C. was formally passed in 1971 for the special protection of samples of the province's natural diversity. Since no other lake has been selected as an ecological reserve within the southern Interior Highland limnological region, this example is of particular interest. For comparative purposes, Curtis Lake was chosen for similar, though less comprehensive work. It is morphometrically akin to Lily Pad and receives only limited human interference. Though considerably larger than either Lily Pad or Curtis Lake, Nicklen Lake was also selected for study due primarily to its ready accessibility.

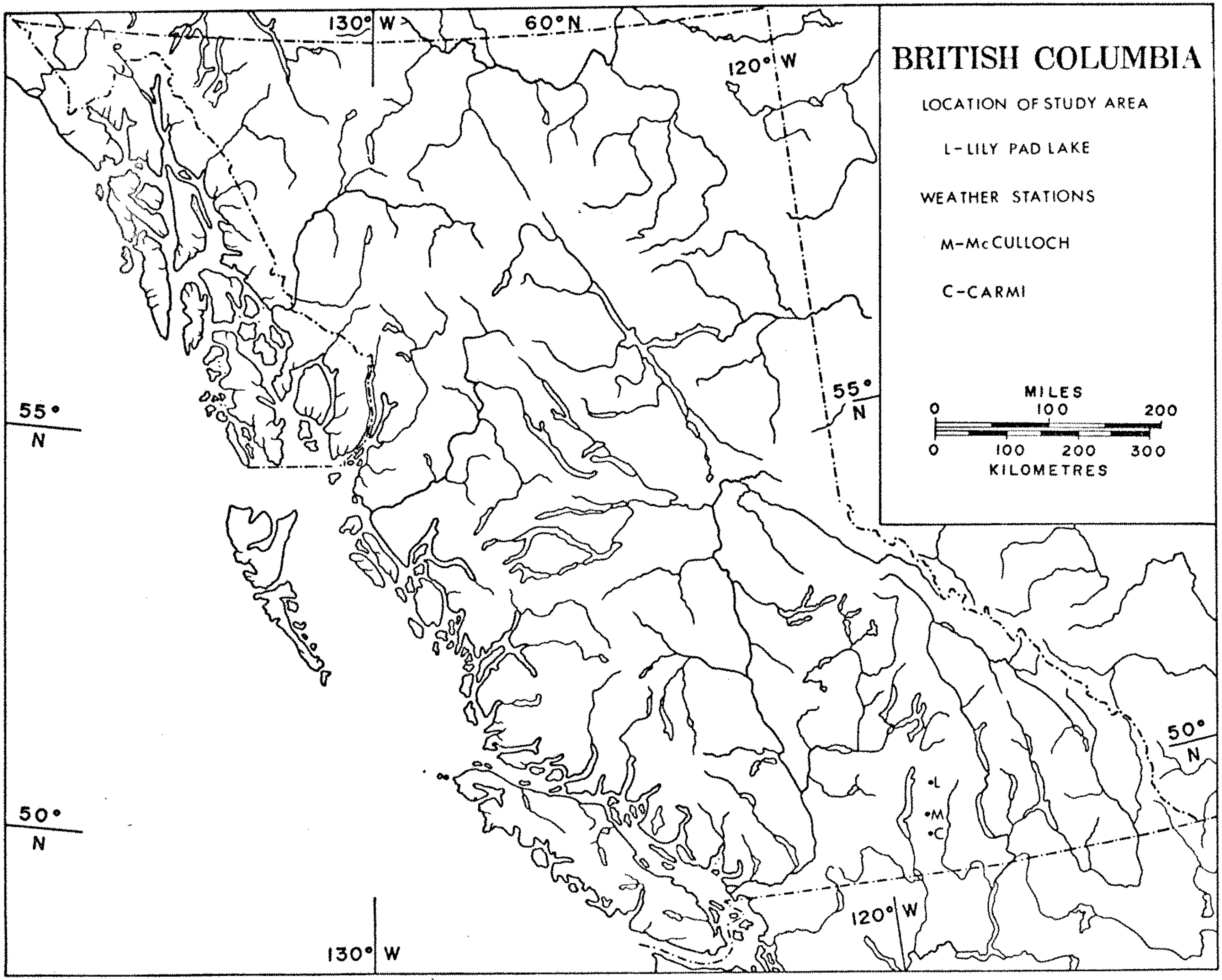


Figure 1 Location of Study Area

DESCRIPTION OF THE STUDY AREA

The topography of the plateau consists mainly of low, rolling hills with gentle slopes. The landform is a ground morraine left by the melting glacier ice of the Pleistocene Age. When the glaciers receded, a blanket of boulder clay over the bedrock of the plateau was left behind. The region has a continental climate with warm, dry summers and cold, snowy winters (Chapman, 1952). Average temperatures at a nearby weather station (McCulloch) are -6°C in winter and 12°C in summer; precipitation is about 720 mm per year.

The vegetation of the drainage basin is composed chiefly of dense stands of *Pinus contorta*. In a few areas, such as along part of the south and west shores of Nicklen Lake and in some of the gullies between Nicklen and Curtis Lake, the climax *Picea englemannii* - *Abies lasiocarpa* is found. Patches of open *Populus tremuloides* - *P. contorta* stands, especially between Nicklen and Herb Lakes, also occur. *Alnus* - *Salix* communities grow in the wetland areas.

The Highland region is dotted with lakes of varying sizes and depths, mostly small and shallow, and with depressions containing marshes, meadows and bogs. Much of the snow melt-water infiltrates the coarse textured soil or is held in the marshy depressions and in small hollows containing temporary pools. Streams in the area are not large and they generally flow slowly due to the gentle slopes. In summer, the low rainfall and warm weather result in a lowering of the stream water, or in a complete drying up of some streams.

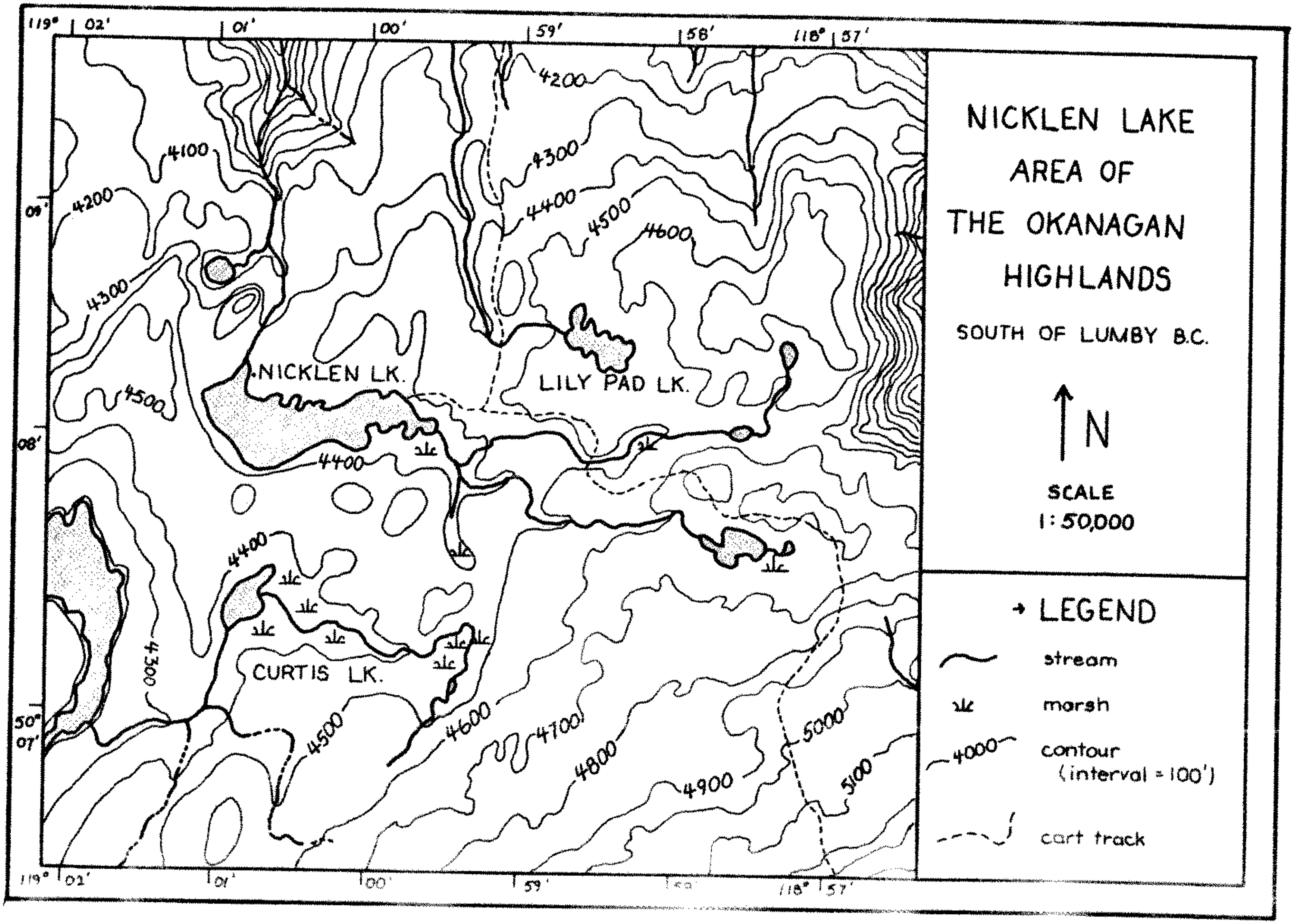
DESCRIPTION AND ORIGIN OF THE LAKES

The lakes, located about 15 miles southeast of Lumby, B.C. (latitude 50°8'20"N, longitude 118°58'5"W) (see Figure 2.) are situated in the southern Interior Highland limnological region of British Columbia (Northcote and Larkin, 1963).

LILY PAD LAKE

Lily Pad Lake is a small ~~acid~~ bog lake with slightly brown stained water, characteristic of lakes in the southern Interior Highland (Northcote and Larkin, 1963). The lake (Figures 3-6) lies at an elevation of about 1364 meters in the Interior Plateau, near the boundary of the Thompson Plateau and the Okanagan Highland (Holland, 1964). Like most of the lakes in the region, it is glacial in origin. It possesses a small, shallow basin which suggests that it may be a kettle lake. The rock outcroppings found at a few places along the shore, especially the mid-eastern and the north-west shores, suggest that ice scouring may have also contributed to the formation of the basin. The large island may represent a piece of bedrock which resisted glacial scouring.

Beaver have played an important role in determining the size and shape of the lake. Originally, there were two small lakes, separated by a vegetated isthmus, in Lily Pad's basin. The subsequent building of a dam at the outlet stream raised the water level about 4 feet and created a single, larger lake. The construction of the dam resulted in extensive marginal tree kill and in the formation (or extension) of the bog areas found at the south end of the lake. It also probably created the floating Sphagnum-Carex mats from vegetation and sod that lined the shores of the original lakes.


NICKLEN LAKE
AREA OF
THE OKANAGAN
HIGHLANDS
SOUTH OF LUMBY B.C.
N
SCALE
1:50,000
LEGEND
stream
marsh
4000 contour (interval = 100')
cart track
NICKLEN LK.
LILY PAD LK.
CURTIS LK.
119° 02' 01' 00' 59' 58' 118° 57'
09'
08'
50° 07'
4100
4200
4300
4400
4500
4600
4700
4800
4900
5000
5100

FIGURES 3-6: Lily Pad Lake.

Lily Pad Lake receives most of its water from seepage and the outlet flow drains to the west and north into Nicklen Creek.

Conductivity measurements, taken in 1969, recorded a specific conductivity of 112.7μmhos/cm (18^{o}C) and a total dissolved solid content of about 102 mg/l, placing it at the upper end of the range of lakes in the Interior Plateau (Northcote and Larkin, 1963). Figure 7 is a contour map of the lake, and Table 1 lists some morphometric parameters.

CURTIS LAKE

Curtis Lake (Figures 8 and 9) lies at an elevation of about 1345 meters in the Interior Plateau. It is a relatively small, shallow lake with highly stained water and a beaver dam at its outlet. Although ground water seepage occurs, it receives most of its water from Heart Creek, which flows through an extensive marshy area. Heart Creek also flows out of Curtis Lake southwest into Aberdeen Lake, and from here drainage is northeast into Harris Creek. As a result of the raising of the water level by the beaver, there are boggy areas at the south end, east of the outlet, and at the north end of the lake. There is no marginal tree kill, though, reflecting the relatively steep sloping sides of the basin.

Curtis Lake (Figure 10) has a maximum depth of about 6.1 meters, a maximum length of 675 meters and a maximum width of 340 meters. Its surface area is about 12.7 ha and there are no islands.

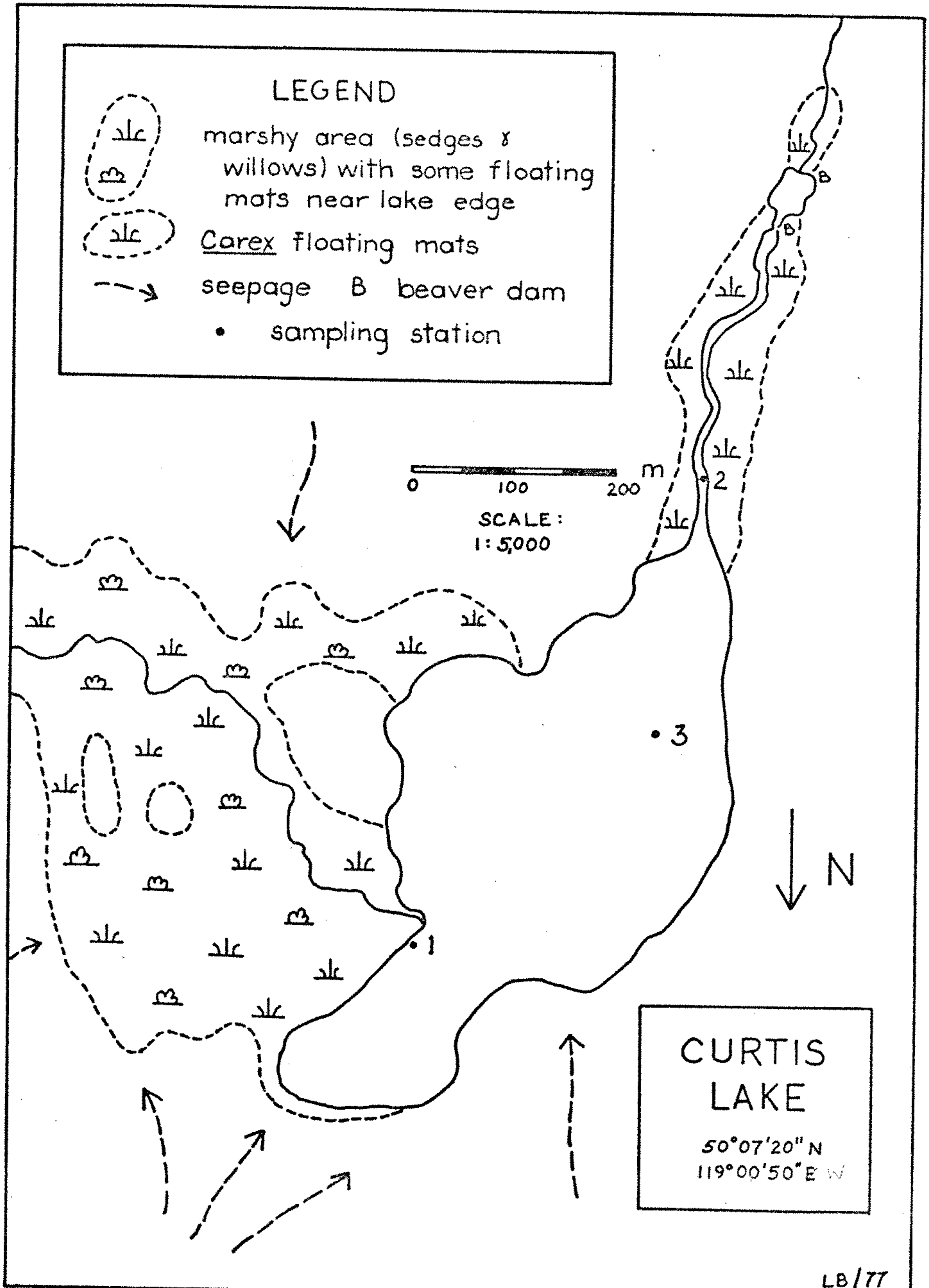
NICKLEN LAKE

Nicklen Lake (Figures 11 and 12), lying at an elevation of about 1308 meters, is a relatively large, deep lake formed as

TABLE 1: Some morphometric parameters for Lily Pad Lake.

Area	118,478 m^2.
Volume	156,297 m^3.
Maximum depth	4.88 m.
Mean depth	1.32 m.
Shoreline length (including large island)	2.87 km.

Figure 8-9 : Curtis Lake.

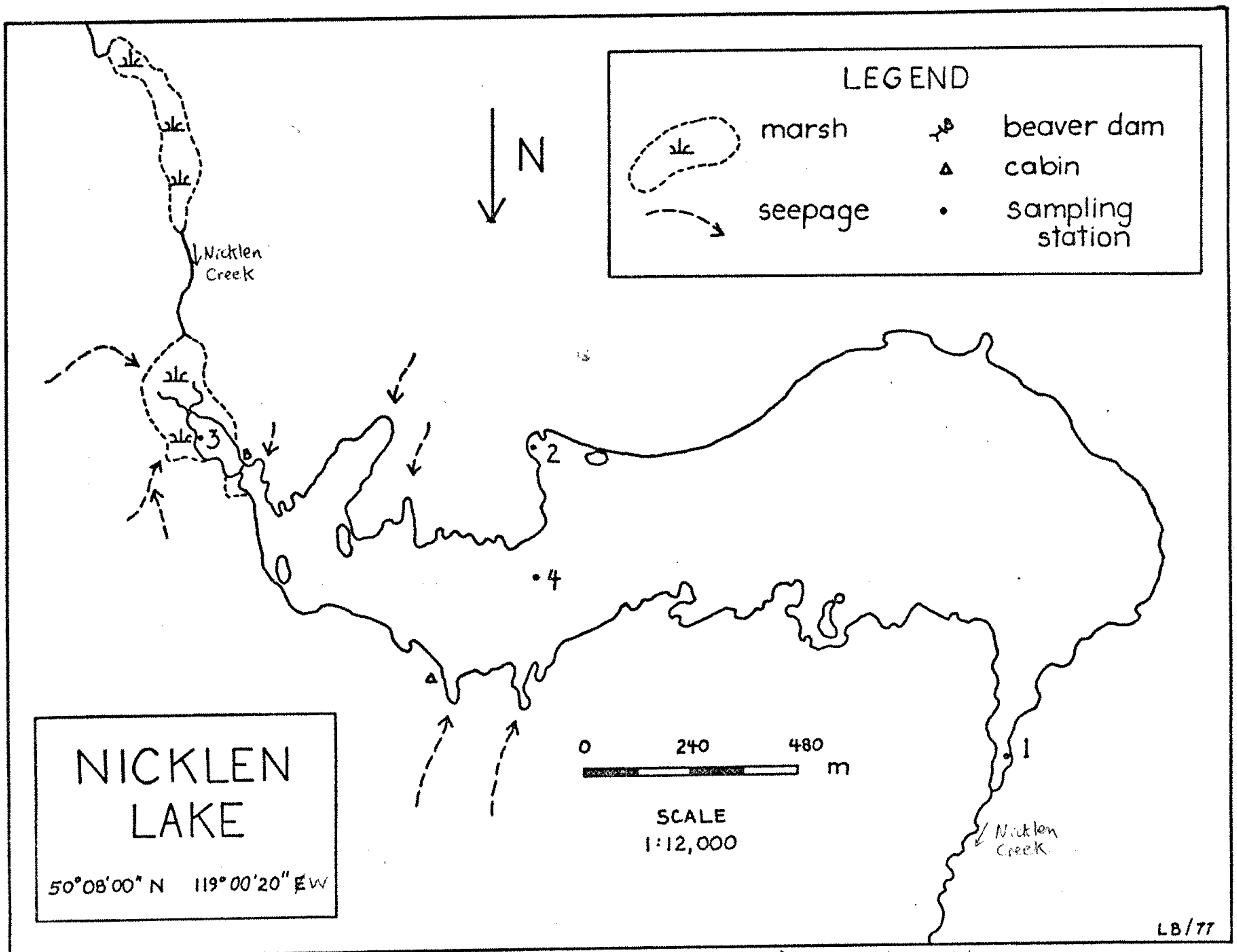


An outline map of Curtis Lake, showing the location of the three sampling stations.

an ice-scoured trough in the bedrock. It is fed by Nicklen Creek, which drains Goat Mountain Lake, about 1.5 miles upstream to the east (Figure 13). Although Nicklen Lake is too large to be affected by beaver, there is an abandoned dam at the east end. This has created a "beaver pond" of about .9 ha, with a marshy area upstream (Figure 13). There is a man-made dam, built in 1946 to store water to feed Harris Creek during the dry summer months when irrigation is needed on Lumby and Coldstream farms, at the (Nicklen Creek) outlet. The water level has been raised about six feet by this dam, and the dead trees along the shoreline reflect this.

Nicklen Lake (Figure 13) has a surface area of about 87.3 ha. Its maximum length is 2000 meters and its maximum length is 660 meters. Its maximum depth has not been determined; it is at least 13.7 meters at Station 1 and depths up to 23 meters have been found (O'Neill, pers. comm.). The Beaver Pond has a maximum depth of 1.2 meters.

Figures 11-12 : Nicklen Lake.



An outline map of Lily Pad Lake showing the locations of the four sampling stations.

Figure 13

DESCRIPTION OF SAMPLING STATIONS

LILY PAD LAKE

Five stations, 3 littoral and 2 pelagic, were established in Lily Pad Lake (Figure 7). Station 1, bounded by a *Sphagnum* mat, supported a moderately dense growth (in mid-summer) of *Potamogeton natans*, some *P. gramineus*, *P. obtusifolius* and *Ceratophyllum demersum*. At Station 2, *P. natans*, *P. gramineus*, *Ceratophyllum* and *Nuphar* were present. Station 3, an exposed littoral station, was located alongside a *Sphagnum* mat in the large open water area of the lake. Scattered *P. gramineus* grew here. Station 4, located near the middle of the small open water area, had *P. natans* as the sole macrophyte. Station 5, located in the larger open water area, was 4.9m in depth. No plants grew on the bottom here.

CURTIS LAKE

Three stations were set up in Curtis Lake (Figure 10). Station 1, located alongside the inlet marsh, was about 1.5m in depth. Aquatic plants growing here were *Nuphar* and some *P. gramineus*. Station 2, located in the channel between the floating *Carex* mats which extended from both shores of the outlet bay, was about 1.8 m deep. *Nuphar* was scattered in the channel. Station 3, an open water station, had a depth of 6.1 m.

NICKLEN LAKE

Four sampling stations were established in Nicklen Lake (Figure 13). Station 1, located at the west end of the lake in the bay leading to the dam, had some *P. gramineus* and was fairly deep. Station 2, a protected littoral station located on the south side of the lake, was also fairly deep. Station 3 was located in the Beaver Pond amongst *Glyceria elata*, *Ranunculus* *flabellaria* and *Salix* spp. An additional mid-lake station, at least 15 meters deep, was established for the purpose of recording temperature profiles and water transparencies.

MATERIALS AND METHODS

Field work took place from the beginning of June until the middle of August. At Lily Pad Lake, sampling began on June 10, after a boat was found and hauled to the lake, ½ mile off a rough, dirt road. Sampling did not commence at Curtis Lake until July 16 due to difficulties, first of all in finding the lake and then in obtaining a boat for it. Since the lake was over an hour's hike away from camp, through woods rarely travelled, except by game and cattle, it was impossible to carry a rowboat in. An attempt was made to build a suitably buoyant log raft, but this was unsuccessful, and finally, a small rubber raft was packed into the lake. Sampling on Nicklen Lake began on June 9 and was conducted from a canoe.

The routine field work consisted of regular plankton and periphyton sampling, temperature and light penetration measurements and general observations of insects and other lake inhabitants. For plankton, each lake was sampled at 3-day intervals on a rotating basis among the three lakes, although during late July and August, Nicklen and Curtis Lakes were visited weekly; the extra time was spent mapping plants at Lily Pad Lake. Plankton samples were taken using a standard No.20 mesh net. Only surface tow net samples were taken of the littoral plankton. At open water stations, vertical and horizontal tows were taken. Each horizontal tow was about 46 meters in length. All samples were preserved in 5% formalin immediately upon collection. Times of plankton sampling were fairly constant from day to day: 12:00 to 2:00 p.m. for Lily Pad, 10:30 a.m. to 12:30 p.m. for Curtis and 8:30 to 11:30 for Nicklen Lake. Periphyton was sampled concurrently, using standard slide boxes, each containing six 3 x 1" glass slides, which were suspended at a depth of one meter from floating, but stationary, logs. Slides were immersed for approximately monthly and overlapping intervals, ranging in duration from 20 to 69 days (Tables 2-4). Upon collection, the slides were placed in jars containing lake water and were also preserved in 5 % formalin.

Weekly light and temperature measurements were taken at the deep station in each lake. Temperature readings were done by submerging a small pool thermometer in water samples taken at various depths with a 1-liter van Dorn bottle. Transparency readings were made using a standard 20 cm Secchi disk. Both temperature and Secchi depth measurements were taken at a similar time on each lake: 2:00 p.m. for Lily Pad, 12:00 p.m. for Curtis and 11:00 a.m. for Nicklen. Due to difficulties with equipment, temperature readings did not begin until July.

Since a field Hach Kit could not be obtained, no water chemistry was done on the lakes. However, dissolved oxygen was determined for Lily Pad Lake on ~~August 2~~ July 23. Water samples were taken at the deep station at depths of 0, 1.5, 3, and 4.5m, and were analyzed according to the methods described for use of a Hach laboratory kit.

Additional field work, for Lily Pad Lake only, included depth measurements and mapping and collecting of aquatic plants. Depth measurements were taken at approximately equal intervals of 5 oar strokes along several transects across the lake ~~(see Appendix II)~~. A calibrated rope, weighted on the end, was used for measuring. Observations on the development of aquatic plants was made throughout the study period, and these plants

TABLE 2 A synopsis of the periphyton experiments in Lily Pad Lake, 1976.

Expt.	Starting Date	Collection Date	Days Exposure	Slides Collected
1	June 10	July 4	25	6
2	July 4	July 22	19	6
3	June 10	July 22	43	6
4	June 10	August 16	68	6
5*	July 22	August 13	24	6
6*	July 22	August 16	27	6
			Total Collected	36

*Due to unforseen circumstances, field sampling had to be abruptly terminated. This prevented the longer exposure of one of these series. Although they were analyzed separately, they are combined in this report since the exposure durations are comparable.

TABLE 3 A synopsis of the periphyton experiments in Nicklen Lake, 1976.

Expt.	Starting Date	Collection Date	Days Exposure	Slides Collected
1	June 9	July 5	27	12
2	July 5	August 5	32	6
3	June 9	August 16	69	6
4	July 5	August 12	39	6
			Total Collected	30

TABLE 4 A synopsis of the periphyton experiments in Curtis Lake, 1976.

Expt.	Starting Date	Collection Date	Days Exposure	Slides Collected
1	July 16	August 4	20	2
2	July 16	August 11	27	2
3	July 16	August 16	32	2
			Total Collected	6

were collected at appropriate times. During late July and early August, a thorough survey was made of the lake and its shore in order to determine distribution patterns of the various plants. A grappling hook was used in the deeper sections of the lake where the plants could not be seen from the boat.

Finally, special plankton samples were taken for detecting vertical migrations of zooplankton in Lily Pad Lake on July 23 and August 3. Sampling times were at four hour intervals, commencing at 8:00 p.m. and ending at 4:00 p.m. the following day. Samples were taken from depths of 0, 1.5, 3 and 4.5m at the deep station, using the van Dorn bottle. At each depth, three 1-liter samples were passed through the plankton net.

During the period from September, 1976 until March, 1977, the collected insects, plants, plankton and periphyton organisms were identified. Little quantitative work was done on the plankton, since it was not felt that the tows were repeatable enough to yield meaningful absolute number comparisons.

Each sample for phytoplankton analysis was examined over 600 random microscope fields at 400x. From these observations, the relative abundances of each identified species in every sample was estimated. Species defying taxonomic identification were given a descriptive name and/or number. However, this quickly became a prohibitive task for the desmids and it was soon abandoned. Consequently, many of the smaller forms were not identified. Even if it had been possible, the multitude of species, particularly desmids, present in some samples, made counting them impractical. Moreover, estimation of frequency and abundance sufficed for the purposes of the present study.

In the laboratory, periphyton slides were scraped using a sharp razor blade. Microscopic examination of these scraped slides showed this to be an effective method for removing the attached organisms. Hyrax mounts were prepared from all slides to facilitate diatom identification. 1200 fields/collected slide were examined and the relative abundances of the species was again expressed by symbols (dominant, abundant, etc.). This is by no means a satisfactory method, since ecologists in other fields (Hope-Simpson, 1940; Smith, 1944) have shown that different observers vary widely in their concepts of eg. "common" as distinct from "abundant" and that a given observer's estimates vary daily. However, this error may have been reduced in this study since only one person analyzed the phytoplankton and periphyton data, a scale of values was used in estimating the degrees of abundance of a species, and a large number of fields were examined.

For Lily Pad Lake crustacean zooplankton, however, counts were made and changes in the populations were described using relative abundance. Aliquots were taken from each sample and the numbers of each species were recorded until a total of at least 100 individuals (cladocerans and copepods) was reached (Appendix I). Since juvenile Daphnia below a certain size were difficult to identify as either D. rosea or D. schodleri, all juveniles were lumped together for counts. Then, twenty, or sometimes more, of the larger individuals were identified to determine a ratio. This ratio was assumed to indicate the proportions of the total juveniles taken up by each of the two species. (This assumption may have resulted in some error in relative abundance determinations). Copepod nauplii were also lumped together due to difficulties in distinguishing the earlier instars. However, in many of the samples, especially later in the study period, positive identifications of the nauplii could be made; these were noted.

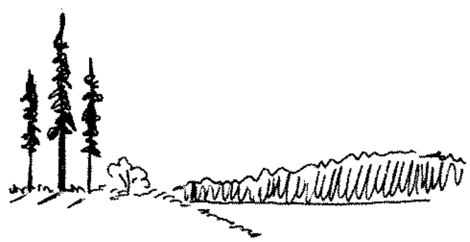
For rotifers, relative abundance was estimated as follows:

approximate number in 10 drops	rating	
<8	NC	not common
8-20	C	common
21-35	VC	very common
36-70	A	abundant
>70	VA	very abundant

Periodically, actual counts were made to check consistency of estimations. Since the rotifer Asplanchna is relatively large, all individuals were counted as for cladocerans and copepods.

RESULTS AND DISCUSSION

LILY PAD LAKE



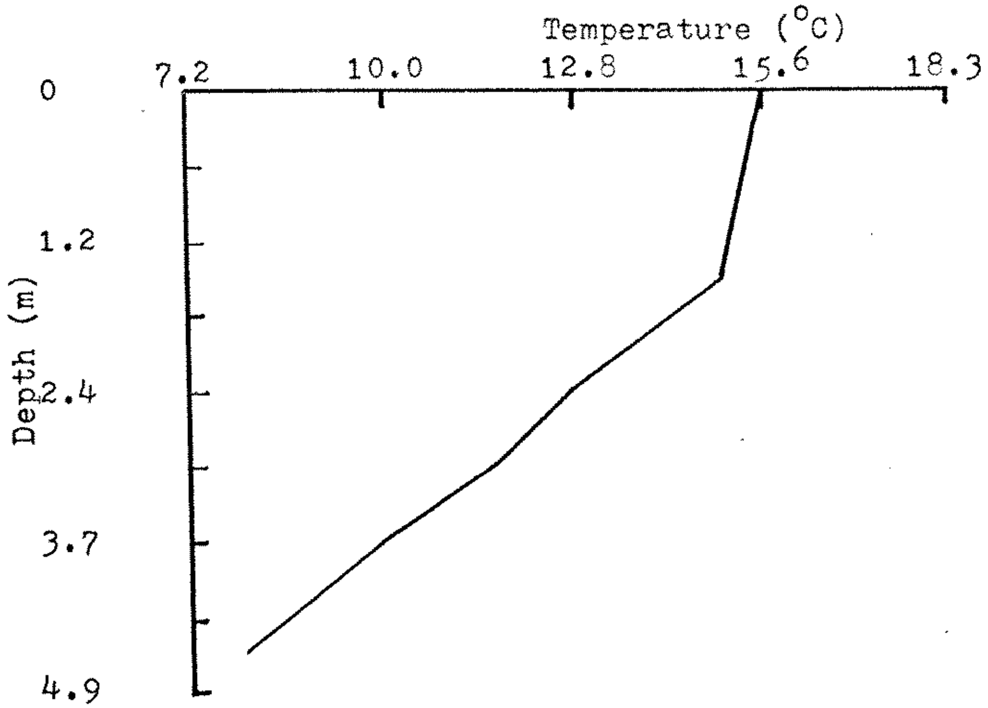
PHYSICAL AND CHEMICAL CHARACTERISTICS

Lily Pad Lake's temperature profiles show no definite epilimnion and hypolimnion (Figures 14a-f). Such diminutive stratification is common in shallow lakes (Wetzel, 1975, p. 76). Light reaches the bottom of most parts of the lake, and even at the deep station, the compensation point (see below) is only a meter from the bottom. Thus some solar heating of the lower waters occurs, discouraging the formation of a hypolimnion. Since the lake is so shallow, and there was invariably some wind action on it, it seems likely that complete circulation might occur, but Lily Pad's small surface area, plus the presence of the vegetation mats, restricts wind action, and the open water was never uniformly warm. The nearly linear profile for July 23 (Figure 14d) reflects the calm state of the lake and the high air temperatures which prevailed at this time.

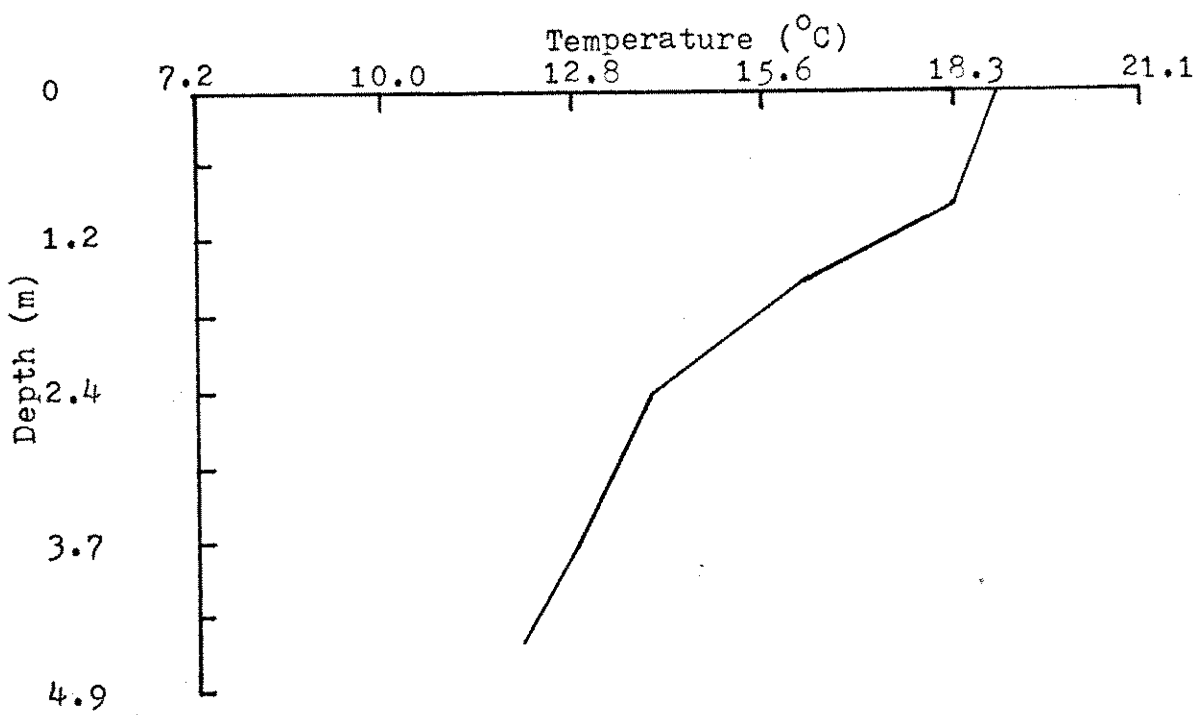
In general, water temperature followed air temperature patterns (~~Appendix I~~ Appendix 3). There was a general warming of the surface waters until late July, after which some cooling took place during cool, rainy weather in August. Temperatures at the protected littoral stations were often warmer than those of the open water, especially on windy days (Table 5).

Secchi depth measurements for Lily Pad were fairly constant at about 3.4 m. (Table 6) The small decrease in late July and early August was probably a result of the increased plankton populations near the surface (eg. <u>Diaptomus</u>)

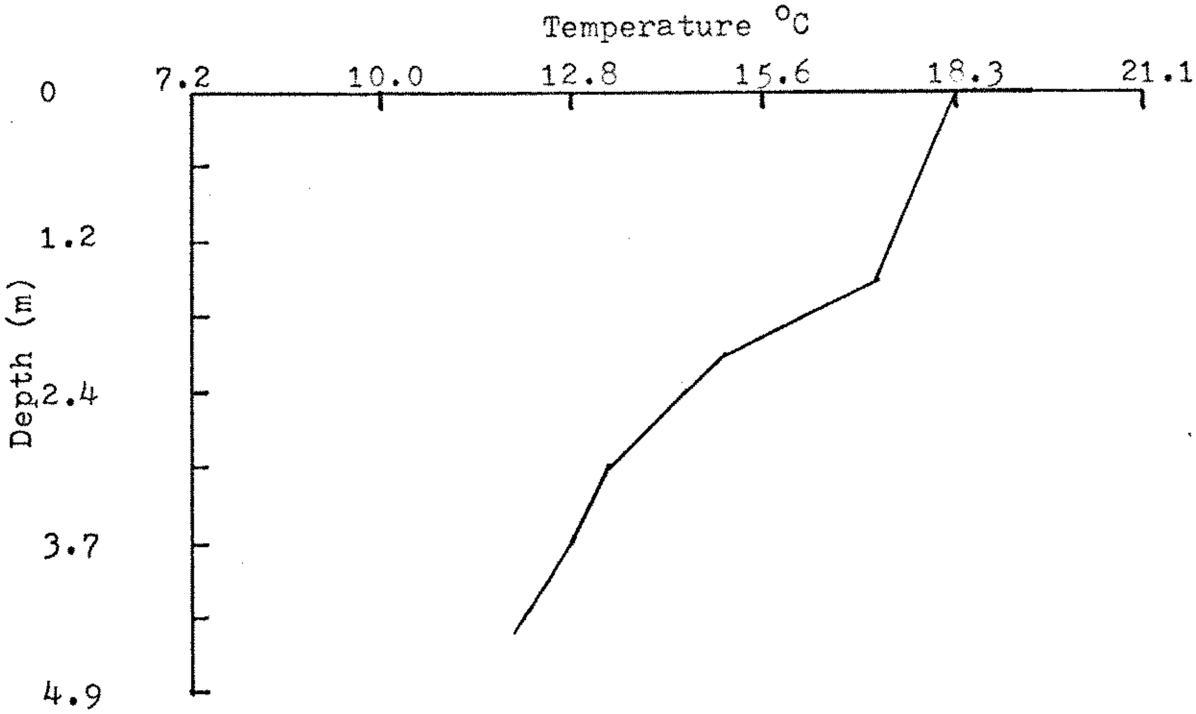
Figure 14 Temperature profiles for Lily Pad Lake, 1976.



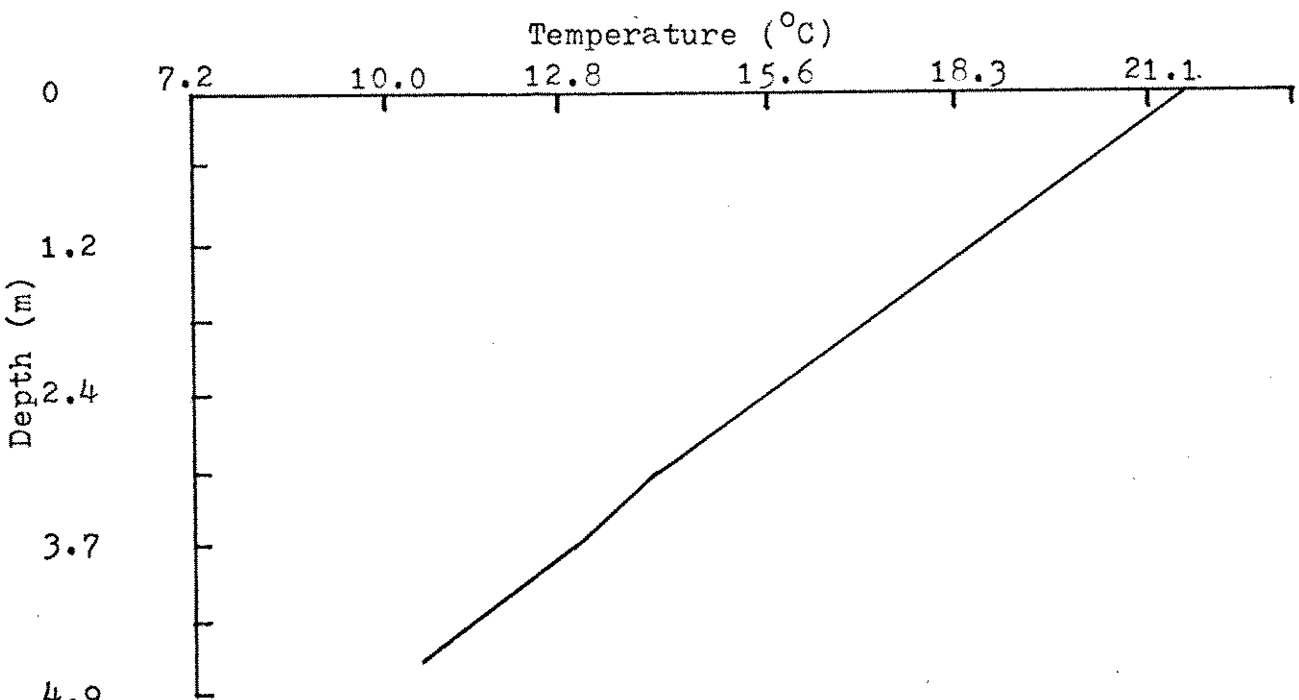
a) July 4 Air Temperature 20°C



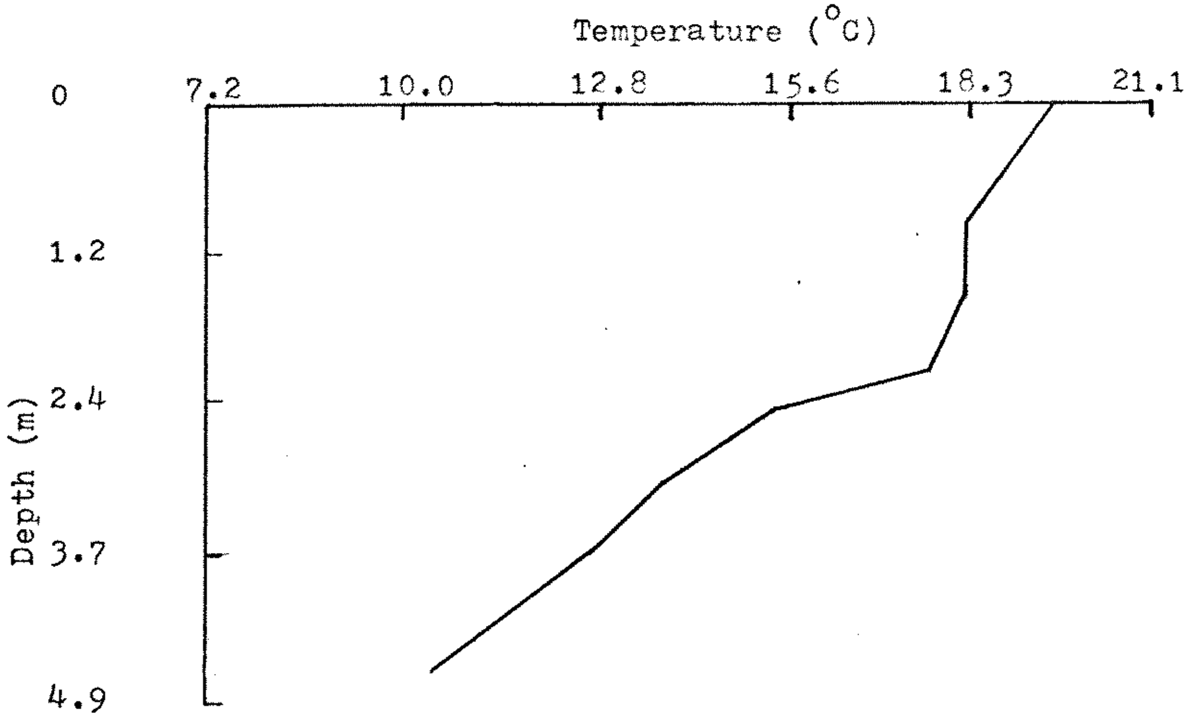
b) July 11 Air Temperature 18°C



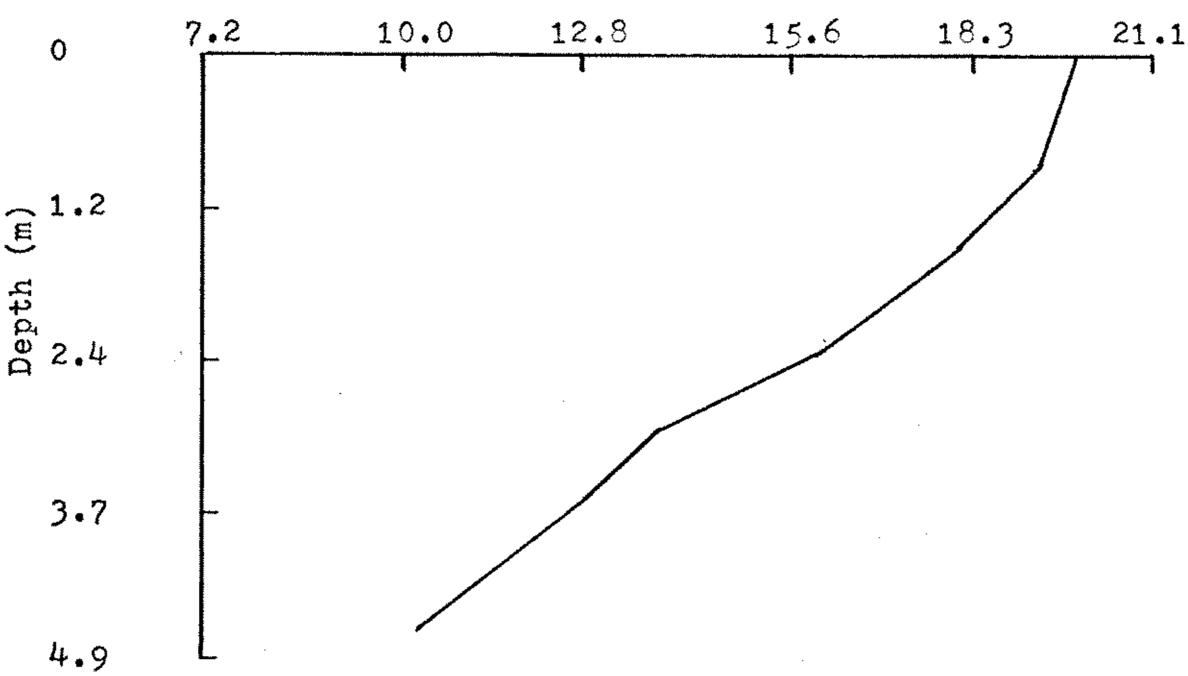
c) July 14 Air Temperature 19°C



d) July 23 Air Temperature 22°C



e) August 3 Air Temperature 22°C



f) August 13 Air Temperature 16°C

TABLE 5 Surface water temperatures (°C) at the three littoral stations in Lily Pad Lake, 1976.

	July 10	July 14	July 18	July 22	Aug 2	Aug 6	Aug 10	Aug 13
Station 1	18.3	18.9	17.8	22.2	18.9	21.9	18.9	18.9
Station 2	18.3	18.9	17.8	22.8	18.9	21.7	18.9	18.9
Station 3	16.1	17.8	17.2	22.8	19.4	20.0	21.9	19.7

TABLE 6 Secchi Depth measurements for Lily Pad Lake, 1976.

DATE	SECCHI DEPTH	GENERAL WEATHER DESCRIPTION
June 29	3.4 m	sunny
July 11	3.4 m	partially cloudy
July 14	3.6 m	partially cloudy
July 22	3.0 m	cloudy
Aug 13	3.0 m	cloudy

The results for dissolved oxygen for Lily Pad Lake on July 23 were as follows:

depth (m)	D.O. (mg/l)
0	9.2
1.5	7.0
3.0	3.5
4.5	1.6

Although the surface water had a high oxygen concentration, probably due to photosynthetic activity, oxygen conditions were appreciably unsaturated throughout much of the water column, even though light penetrated nearly to the bottom. In general, this is characteristic of lakes high in dissolved organic matter (Wetzel, 1975; p. 136). Chemical oxidation assumes a significant role in consuming oxygen in such lakes (Gjessing and Gjerdahl, 1970)(in Wetzel, 1975; p. 127). However, benthic decomposition is also important, especially in shallow lakes; in Lily Pad Lake, the water near the sediments was quite low in oxygen. This may have affected the activities of some of the zooplankton.

One would expect the oxygen content to vary among the different bays, and areas confined by vegetation mats, due to variations in depth and densities of aquatic macrophytes. The oxygen conditions of the open water may be affected by those of the littoral areas to some extent, especially later in the year when the macrophytes are decomposing.

MACROPHYTES

Since Lily Pad Lake is shallow (most areas being 1.2m or less in depth), it had abundant aquatic vegetation. The following is a list of the aquatic and shoreline plants found. The notes on the distribution of each refer to the conditions in early August, when the plants were most prominent.

ROOTED SUBMERGED COMMUNITY

Potamogeton natans L.

This was the most abundant rooted submergent and was found in water from .6 to 3m in depth. Its best growth was in water less than 1m deep, and it was especially abundant in the Station 2 bay (see Figure 7), where its stems were tangled and its floating leaves covered most of the water surface. No other plants grew in such areas. Figure 15 shows the distribution of P. natans, along with the three other major plants in the lake.

The floating leaves of P. natans first reached the surface, at the shallowest areas, in late June and flowered in early July. In the deeper water, floating leaves reached the surface much later, if at all, and no flowering had occurred by August 15.

Potamogeton gramineus L.

This plant was generally found in water .6m or less, but apparently was capable of growing in deeper water, since scattered plants were found in the large open water area, in depths up to about 2.4m. Perhaps its near absence from most waters between .6 and 1.2m was due to the superior competitive abilities of P. natans at these depths. P. gramineus was often found in a zone between P. natans and shore emergents, such as Polygonum, Sparganium and Carex, and sometimes between Nuphar plants. Its distribution is also shown in Figure 15. Its floating leaves appeared later than those of P. natans, but flowering was earlier. (In P. gramineus, flowering spikes reached the surface before the floating leaves).

Potamogeton foliosus Raf.

This plant was found in shallow water, less than .6m deep, often scattered among P. gramineus, Ceratophyllum demersum and Chara, but it also formed relatively dense patches by itself. This plant was fairly common, especially along the west shores of the lake. No flowers were seen.

Potamogeton berchtoldii Fieb.

This plant was also fairly common in shallow water and was found in small patches, or scattered among P. gramineus, Ceratophyllum, and Chara. It was not abundant where P. foliosus was most abundant. P. berchtoldii was also found with P. obtusifolius on the bottom alongside the floating Sphagnum-Carex mats.

Potamogeton obtusifolius Mert. & Koch

This plant was found mainly alongside the Sphagnum-Carex mats, in water about 1-1.5m in depth, but, sometimes, it also grew in shallower water, scattered among P. gramineus.

Ceratophyllum demersum L.

This plant was present in many areas of the lake, in water up to about 2.4m in depth. In the shallower areas, it was often found with Chara, if the latter was not too dense. It was invariably found alongside or on the sides of the floating vegetation mats.

Vallisneria americana Michx.

This plant was most often found alongside the vegetation mats, with Ceratophyllum, P. obtusifolius and P. berchtoldii, but it sometimes grew in shallow water just outside the Carex band near shore.

Chara spp.

Chara covered much of the lake bottom at depths of .6m or less, sometimes forming dense submerged hummocks and mounds. These mounds were most prominent near Station 1 (see Figure 7) and along the west shore north of the beaver dam. It was also found in deeper water (up to about 1.2m) at the south end of the small open water area, near the vegetation mats (see Figure 15).

Nitella sp.

Nitella was found only in an area at the west end of the large open water section of the lake at depths from about 1.4 to 2.4m.

ROOTED FLOATING

Nuphar polysepalum Engelm.

This plant was abundant in Lily Pad Lake, and in many places, its leaves covered most of the water surface. It was found mainly in water .6m or less, but in one area, it grew entirely across the lake (see Figure 15). *Nuphar* was often associated with standing dead trees, and formed a zone between the *Carex* band next to shore and the submerged plants farther out. Usually no other plants grew beneath *Nuphar*. The leaves first appeared above the water surface in late May, and flowering began in late June and had almost ended by mid-August. The maintenance of a constant water level by the beaver dam probably favoured prolonged growth and flowering.

EMERGENTS

Eleocharis palustris (L.) R. & S.

Eleocharis was found in scattered patches or bands, usually in water 15-30 cm deep. It was present along all parts of the shore, especially at the eastern end of the lake.

Typha latifolia L.

One small group of *Typha* was found on the south shore opposite the largest *Sphagnum* mat, and a smaller group was present on a nearby mat. Only one or two flowering spikes were seen.

Polygonum amphibium L.

This plant was found near the shore, generally in water less than 20 cm deep, and in scattered patches, often where the *Carex* band was broken. Flowers were first noted

Sparganium eurycarpum Engelm.

Sparganium was also found in scattered patches in shallow water, and was often found with, or near, *Polygonum*. Flowers were first noted in mid-July.

Hippuris vulgaris L.

This was a rare plant, which was found in patches along the south shore in water 15 cm deep or less and was usually associated with *Polygonum* and *Sparganium*.

Carex rostrata Stokes
Carex lasiocarpa Ehrh.
Carex aquatilis Wahl.
Carex kellogii (*Carex lenticularis* Michx.)
Carex diandra Shrank
Carex vesicaria L.

These six plants grew in water about 4-15 cm in depth and formed a band of varying width (usually about 2-4 m) along almost all of the lake's shore. Narrow bands (about .5 m) were found along the steeper parts of the shore, such as the island shore, whereas the seepage areas had broad bands (Figure 15). All of the above species appeared to grow intermixed, although in a few places the band consisted of only *C. diandra*. *C. kellogii* seemed to be the most common, and often grew in clumps in the shallow water portions of the lake, such as the northwest bay. Carex spp. also formed clumps at the east end of the lake, where the sedge meadow graded into a bog.

Glyceria elata (Nash) Jones

This grass formed narrow bands along parts of the far west shore, and in water to a depth of about 15 cm.

SEDGE MEADOW

Carex canescens L.

This *Carex* was common on damp soil, or in very shallow water, inshore from the emergent *Carex* band. It also occurred on decaying wood.

Alopecurus aequalis Sobol.

This was fairly common along the north shore of the eastern half of the lake, sometimes in 2-3 cm of water. It was found with *Carex canescens*.

Potentilla palustris (L.) Scop.

This plant was common along most of the lake shore and up to depths of 2 cm in the water.

Agrostis scabra Willd.

This grass was common on the shore, with *Carex canescens*, or, more often, on slightly drier ground.

Calamagrostis canadensis (Michx.) Beauv.

These plants were found as scattered individuals with *Agrostis scabra* and *Carex canescens* along most of the shore.

Other plants found near the water's edge include: *Veronica americana* *Galium trifidum*, *Epilobium glandulosum*, *Deschampsia caespitosa*, and a small *Carex* that was often found with *Carex canescens*. (This *Carex* was collected too young and could not be identified). Less common were *Carex pachystachya*, found with *C. canescens* at the end of a bay in the southwest corner of the lake, *Puccinellia pauciflora*, found at the north seepage area, and *Trisetum canescens*. *Alnus incana* sometimes grew almost to the water's edge at the seepage areas.

VEGETATION MATS

Most of the plants on the floating *Sphagnum* mats were also found along the shore. The main plant on the mats, besides *Sphagnum*, was a member (or members) of the group of emergent shoreline *Carex* species, possibly *C. kellogii*. *Carex canescens* was also common on the mats, and, mostly along the edges, *Carex diandra*, the unidentified small *Carex* and *Potentilla palustris* were found. *Potentilla* often extended off the mat into the water. Scattered *Calamagrostis canadensis* were found on most mats; these individuals were smaller than those of the same species on shore, and flowered earlier. On one mat bordering the small open water area, small groups of *Scirpus hudsonianus* were found. Unfortunately, *Sphagnum* samples were not taken; there may have been several species making up the mats. There were at least two other mosses present, one was submerged along the mat edges and the other was found on top of the mats. In places, *Utricularia* was found submersed among the mosses along the edges.

PHYTOPLANKTON*

The waters of Lily Pad Lake support a predominantly Chlorophyte-Cyanophyte phytoplankton assemblage, characteristic of acid bog lakes (Prescott, 1939: Ruttner, 1952; Woelkerling, 1976). Of the Chlorophyta, desmids, often numbering several hundred species, are, by far, the most conspicuous element in euplanktonic collections from *Sphagnum* bogs (De Graaf, 1957; Brook, 1959; Wetzel, 1975). Table 7 contains a complete species list of the plankton organisms recorded from Lily Pad Lake.

DESMIDIALES

As recorded by Gough and Woelkerling (1976) from acid bog lakes, *Staurastrum* was the most prevalent genus in Lily Pad Lake. Only 23 taxa, though, were distinguished or given a descriptive name. Many desmid species were neither identified nor described (see below for a discussion). This was particularly true for the genus *Cosmarium*, very common in acid bog lakes (De Graaf, 1957; Woelkerling and Gough, 1976). Only 20 species of *Cosmarium* were identified from the plankton. This is not at all representative of the myriad of forms, particularly very small taxa, encountered. Station 1 and, to a lesser extent, Station 2 were, almost consistently, astonishingly rich in members of this genus. Since *Cosmarium* spp. are largely restricted to non-planktonic habitats (Brook, 1959), their relatively high occurrence in the plankton here is probably only incidental. Ten *Closterium* species were distinguished. *Closterium* also occurs commonly in acid bog lakes, but to a lesser extent than *Cosmarium* or *Staurastrum* (Woelkerling and Gough, 1976).

*Since there was extreme heterogeneity in the environment and no forms showed a seasonal pattern of dominance, it is not felt that a tabular presentation of the species to be discussed is required.

TABLE 7 A list by taxonomic category of the plankton net organisms recorded from Lily Pad Lake Ecological Reserve (June, 1976 to August, 1976).

BACILLARIOPHYTA

Achnanthes spp.
Amphora ovalis Kutz.
Asterionella formosa var. *formosa* Hass.
Cocconeis placentula Ehr.
Cyclotella spp.
Cymbella spp.
Epithemia spp.
Eunotia spp.
Fragilaria brevistriata Grun.
Fragilaria capucina Desm.
Fragilaria construens (Ehr.) Grun.
Fragilaria crotonensis Kitton
Fragilaria virescens Ralfs
Fragilaria sp. #1
Frustulia rhomboides (Ehr.) De T.
Gomphonema acuminatum Ehr.
Gomphonema acuminatum var. *coronata* (Ehr.) W. Sm.
Gomphonema spp.
Melosira spp.
Navicula spp.
Neidium spp.
Nitzschia spp.
Pinnularia spp.
Rhopalodia gibba (Ehr.) O. Mull.
Stauroneis phoenicenteron (Nitz.) Ehr.
Stauroneis spp.
Surirella linearis W. Sm.
Surirella linearis var. *constricta* (Ehr.) Grun.
Surirella spp.
Synedra spp.
Tabellaria fenestrata (Lyngb.) Kutz.
Tabellaria flocculosa (Roth) Kutz.

CHLOROPHYTA (except DESMIDIALES)

Actinastrum Hantzschii Lag.
Ankistrodesmus falcatus (Corda) Ralfs
Ankistrodesmus spiralis (Turner) Lemmer.
Apiocystis brauniana Nageli
Botryococcus-like sp.
Characium spp.
Chlorococcum spp.
Coelastrum microporum Naegeli
Coleochaete orbicularis Pringsheim
Coleochaete scutata Breb.
Coleochaete soluta-like sp.
Crucigenia quadrata Morren
Crucigenia rectangularis (A. Braun) Gay

Dactylococcopsis raphidiodes-like sp.
Dictyosphaerium pulchellum Wood.
Ekalatothrix-like sp.
Eudorina elegans Ehr.
Geminella-like sp.
Glaucocystis sp.
Hydrodictyon reticulatum (Linn.) Lagerheim
Lagerheimia ciliata (Lag.) Chodat
Microspora spp.
Microthamnion-like sp.
Mougeotia spp.
Oedogonium spp.
Oocystis spp.
Pandorina morum (O. Mull.) Bory
Paulschulzia pseudovolvox (Schulz) Skuja
Pediastrum araneosum (Racib.) Racib.
Pediastrum Boryanum (Turp.) Menegh.
Pediastrum Boryanum var. longicorne Reinsch.
Pediastrum duplex Meyen.
Pediastrum ovatum (Ehr.) A. Braun
Pediastrum tetras (Ehr.) Ralfs
Pleodorina californica Shaw
Protosiphon botryoides (Kutz.) Klebs.
Quadrigula-like sp.
Scenedesmus abundans (Kirchner) Chodat
Scenedesmus acutiformis Schroeder
Scenedesmus arcuatus (Lemmer.) Lemmer.
Scenedesmus armatus (Chodat) G.M. Smith
Scenedesmus bijugatus Lag.
Scenedesmus platydiscus (G. M. Smith) Chodat
Scenedesmus quadricauda (Turp.) de Brebisson
Scenedesmus quadricauda var. bicaudatus Hansgirg
Scenedesmus serratus (Corda) Bohlin
Schroederia spp.
Selenastrum westii G.M. Smith
Sphaerocystis Schroeteri Chodat
Spirogyra spp.
Tetraedron minimum (A. Braun) Hansgirg
Tetraedron trigonum (Naegeli) Hansgirg
Tetraspora sp.
Zygnema spp.

DESMIDIALES

Arthrodesmus octocornis Ehr.
Arthrodesmus sp. #1 (Incus var. Ralfsii-like sp.)
Closterium cornu Ehr. var. cornu f. cornu
Closterium dianae Ehr. var. dianae f. dianae
Closterium gracile de Brebisson
Closterium kuetzingii de Brebisson var. kuetzingii
Closterium libellula Focke var. libellula f. libellula
Closterium striolatum Ehr. var. striolatum f. striolatum
Closterium venus Kutz. var. venus f. venus
Closterium sp. #1 (dianae var. brevius-like)
Closterium sp. #2 (parvulum-like)
Closterium sp. #3 (ralfsii-like)

Cosmarium Botrytis Menegh.
Cosmarium granatum Breb.
Cosmarium humile (Gay) Nordst.
Cosmarium moniliforme (Turp.) Ralfs
Cosmarium Portianum Arch.
Cosmarium punctulatum Breb.
Cosmarium undulatum Corda.
Cosmarium sp. #1 - sp. #11
Cosmarium sp. #12 (angulosum-like)
Cosmarium sp. #13 (subprotumidum-like)
Desmidium sp. #1 (Aptogonum-like)
Euastrum binale (Turp.) Ehr.
Euastrum dubium Nag.
Euastrum elegans (de Breb.) Kutz.
Euastrum elegans var. Novae Semliae Wille.
Euastrum insulare
Euastrum sp. #1 (denticulatum-like)
Gonatozygon aculeatum Hastings
Gonatozygon Brebissonii De Bary.
Gonatozygon Kinahani (Arch.) Rabenh.
Gonatozygon monotaenium De Bary.
Gonatozygon monotaenium var. pilosellum Nordst.
Gonatozygon pilosum Wolle.
Gymnozyga moniliformis Ehr.
Hyalotheca dissiliens (Sm.) de Breb.
Micrasterias apiculata (Ehr.) Menegh.
Micrasterias denticulata de Breb.
Micrasterias rotata forma evoluta Turn.
Micrasterias Sol (Ehr.) Kutz.
Neitrium Digitus (Ehr.) Itzigs. & Rothe.
Sphaerozosma excavatum Ralfs
Sphaerozosma vertebratum (de Breb.) Ralfs
Spondylosium planum (Wolle) W. & G.S. West
Spondylosium pygmaeum (Cooke) West
Spondylosium secedens (De Bary) Arch.
Staurastrum anatinum Cooke & Wills
Staurastrum apiculatum de Breb.
Staurastrum Arctiscon (Ehr.) Lund
Staurastrum Avicula de Breb.
Staurastrum brachiatum Ralfs
Staurastrum dejectum de Breb.
Staurastrum denticulatum (Nag.) Arch.
Staurastrum Dickei var. circulare Turn.
Staurastrum dubium West
Staurastrum furcigerum de Breb.
Staurastrum gladiosum Turn.
Staurastrum gracile Ralfs
Staurastrum grande var. parvum West
Staurastrum inflexum de Breb.
Staurastrum megacanthum Lund
Staurastrum mucronatum Ralfs
Staurastrum muticum de Breb.
Staurastrum paradoxum Meyen.
Staurastrum pelagicum W. & G. S. West
Staurastrum polymorphum de Breb.

Staurastrum sp. #1
Staurastrum sp. #2 (var. gracile-like)
Staurastrum sp. #3 (paradoxum-like)
Penium sp. #1 (margaritaceum-like)
Pleurotaenium trabecula (Ehr.) Nag. var. trabecula f. trabecula
Pleurotaenium sp. #1
Xanthidium antilopaeum var. polymazum Nordst.

CYANOPHYTA

Anabaena flos-aque (Lyngb.) Breb.
Anabaena limnetica G.M. Smith
Anabaena spp.
Aphanizomenon flos-aque (Lyngb.) Ralfs
Aphanocapsa spp.
Aphanothece spp.
Arthrospira Jenneri (Kuetz.) Stizenberger
Calothrix-like sp.
Chroococcus spp.
Coelosphaerium naegelianum
Coelosphaerium sp. #1 (pallidum-like)
Gloeothece spp.
Gloeotrichia echinulata (J.E. Sm.) P. Richt.
Gomphosphaeria lacustris Chodat
Lyngbya aerugineo-caerulea (Kuetz.) Gomont
Lyngbya limnetica Lemmer.
Lyngbya spp.
Merismopedia convoluta (de Breb.) Kuetz.
Merismopedia elegans (A. Braun) Kuetz.
Merismopedia glauca (Ehr.) Naegeli
Merismopedia tenuissima Lemmer.
Microcystis spp.
Nostoc paludosum Kuetz.
Nostoc spp.
Oscillatoria Agardhii Gomont
Oscillatoria limosa (Roth) C.A. Ag.
Oscillatoria nigra Vaucher
Oscillatoria rubescens De Candolle
Oscillatoria tenuis C.A. Ag.
Oscillatoria spp.
Palmodictyon viride-like sp.
Rhabdoderma-like sp.
Spirulina princeps (West & West) G.S. West
Tolypothrix tenius (Kutz.) J. Schmidt

EUGLENOPHYTA

Euglena acus Ehr.

PYRROPHYTA

Ceratium carolinianum (Bailey) Jorgensen
Ceratium hirundinella (O. Mull.) Duj.

CHRYSOPHYTA

Dinobryon divergens Imhof
Dinobryon sertularia Ehr.
Ducellieria-like sp.
Epipyxis sp.
Peridinium spp.
Unidentified Chrysophyte (?)

CILIOPHORA

Vorticella sp. #1
Vorticella sp. #2
Vorticella sp. #3
Zooflagellate sp. #1
Zooflagellate sp. #2

RHIZOPODA

Difflugia sp.

Since desmids, unlike diatoms, have few quantifiable characteristics, careful drawings of the cell form in its entirety must be relied upon for identifications. However, it is very difficult to make a good reproduction of complex, and even simple, cell forms. Consequently, much confusion has arisen as a result of an insufficient diagnosis or an indistinct type-figure (Heimans, 1969). Polymorphism has also been noted with some frequency among desmids (Bicudo and Carvalho, 1969). The environmental conditions (not yet known) existing in certain lakes seem to lead to the production of considerable variation in the semicells (Brook, 1959). This contributes to the overburdening with synonymy of desmid nomenclature. Also, because of the variation in symmetry in different views, it is necessary to see the cell from the top, front and side for taxonomic applications. However, this is not always possible and, since misidentifications can be made based upon incomplete viewing of the cells, such cases were not recorded in this study. In addition, the limits of species, even for the desmid specialist, are often difficult to define, especially in the case of the genus Staurastrum, the taxonomy of which shows considerable confusion, owing to two opposing tendencies. Firstly, too much attention has been paid to minor details of shape and ornamentation, with the result that many species have been founded on very variable characters; secondly, many good species, possessing only one good character, have all been placed in one poorly-delimited species (Brook, 1959). Cosmarium also shows tremendous variability, which hinders the recognition of described taxa (Heimans, 1969). The problem with the taxonomy of Closterium is quite different. Here, the difficulty lies in proper expression via words and illustrations of the distinctions used eg. degree of curvature and shape of the apex (Heimans, 1969). From the preceding discussion of the problems encountered in desmid taxonomy and my limited experience with these algae, the rendering of safe identifications was not always possible. In naming the desmids in this project, as much care as possible was taken. However, due to the great variability in the expression of form, a small amount of deviation was allowed for some species. Because of the many transitional forms between the variational and the typical species, varieties were not named unless the distinction was clear. The reader should bear this in mind when comparing these lists with others.

Some desmids in the macrophytic zone may be closely bound to their hosts but a considerable number appear to lead an almost free-floating existence in the water surrounding the plants so that they are frequently washed into the open water of the lake. There is also a group of truly planktonic forms (Brook, 1959). In the littoral collections, in particular, and even in those from the open water, species, which are not strictly planktonic, but which can survive in the open water for a short time, were probably collected in the net tows from Lily Pad Lake. For example, the normal habitat for Micrasterias spp. is in bogs and amongst the weeds of small lakes. Frequently, however, they may be carried into the open water and thus occur in plankton collections eg. Micrasterias Sol (Brook, 1959). This species was recorded only from the plankton samples in Lily Pad Lake and should be regarded as only a facultative plankter. The occurrence of a similar phenomenon in Cosmarium has already been mentioned.

Spondylosium planum, frequently recorded in low abundance in Lily Pad plankton, is the only regularly planktonic member of this genus. It is suggested that the filamentous habit and mucilage-secreting propensities of this species are characters which have contributed to its success as a plankter (Brook, 1959). A few species of Cosmarium and Staurastrum were also observed to possess gelatinous investments. Prescott (1948) and Ruttner (1952) recorded a similar event in Sphagnum bog pools. Woelkerling and Gough (1976) listed Gonatozygon as a rare genus. However, in Lily Pad Lake, six members of this genus occurred regularly, although the individuals never became common.

The desmids in Lily Pad Lake showed erratic fluctuations, both among stations on the same day and on consecutive sampling dates. The phytoplankton in bog lakes is highly unstable; its formation has been correlated with abundance on the sediments and its removal is due to washing out by turbulence and rainfall (Duthie, 1965). Hutchinson (1967) also stated that recruitment of the phytoplankton from littoral benthos is a common occurrence in desmids. The sediments in Lily Pad Lake may be a rich algal habitat since the shallow water allows most of the incident light to reach the surface of the sediments, and many of the products of organic decomposition must be available to the algae. In general, the algal periodicity in a bog pool bears little relation to variations in nutrients; individual species exhibit independent periodicity of development; and there is some connection between total population and rainfall (Duthie, 1965). Therefore, the very changeable weather experienced during the sampling period must have had an effect on the extreme variability observed for the various algal groups (particularly desmids) in Lily Pad Lake.

Rather than tediously comparing the habitats of the species recorded from Lily Pad Lake with the numerous data in the literature on their ecology, let it suffice to say that most of the desmid species have been previously found in acid bog lakes (please see West and West (1904, 1905, 1908, 1911); West and Carter (1923); Kreiger (1933/1939); van Oye (1941, 1944); De Graaf (1957); Brook (1959); Prescott et al (1975),among others, for a discussion).

OTHER CHLOROPHYTA

Other Chlorophyte species were also common in the plankton. Ten species of *Scenedesmus* and six species of *Pediastrum* were recorded. *Scenedesmus* spp. occurred commonly at Stations 1 and 2 throughout the sampling period. *Pediastrum* spp., although occurring constantly, were much rarer. De Graaf (1957) recorded these two species as being very common in quaking bogs. De Graaf (1957) also documented the common occurrence of other members of the Chlorococcales, which were well represented in Lily Pad Lake.

The most common Chlorophyte taxa (excluding the desmids) were species of *Mougeotia* and *Spirogyra*. The numbers of these two genera were underestimated since only sterile species were found; they have been included as one unidentified species. Abdin (1949) showed a peculiar feature exhibited by *Spirogyra*. He found that conjugating filaments occurred at lower depths in June; at this time, the alga was present in great numbers and formed numerous zygospores. This was never shown in any other month and may indicate a special degree of sensitiveness to the conditions of the environment. Both *Mougeotia* and *Spirogyra* have been recorded from quaking bogs (De Graaf, 1957). Filamentous Chlorophytes appear to be summer species in expressing their maxima (Klarer and Hickman, 1975), possibly correlated with an increase in temperature (Goddard, 1937; Young, 1945). Spirogyra and Mougeotia were rare or absent at all stations until July 10, when both became common at all stations. On July 18, Spirogyra was abundant at Station 1, common at Station 2, and rare at Station 3. On July 22, Mougeotia was the dominant component of the plankton tow at Station 3. Thereafter, both genera declined. However, in mid-August, Mougeotia became abundant at Station 3 again. From Table 5, it can be seen that the maximum temperature recorded from Lily Pad Lake was 22.8°C at Station 3 on July 22, the day on which Mougeotia attained dominance. However, Klarer (1973) has shown that temperatures above 20°C are detrimental to the growth of Mougeotia. Spirogyra may also respond to temperature, but no references were found to support this.

Lily Pad Lake did show a "patchy" bloom of Mougeotia spp., which began in early July and which was still present in mid-August, and in obvious good health, at the cessation of sampling. Irregular light-green masses, 1-2 meters in diameter, were formed on the surface of the lake, mostly in the protected areas behind the vegetation mats. These masses were buoyed up by the gas bubbles which they had produced. A similar phenomenon for Spirogyra in northern ponds and small lakes in the United States was cited by Bradley and Beard (1969). These authors also recorded a bloom of Spirogyra which occurred only on the bottom of a very shallow (45-85 cm.) alkaline bog lake. It was moved about by gentle currents and was often rolled up by the wind-driven helices which formed in the lake water, but it never formed large aggregates on the surface. Davies (1970) found *Mougeotia* in dense mats over the bottom ooze in shallow waters but he did not report its occurrence at the surface. In contrast to the summer *Mougeotia* bloom in Lily Pad Lake, the *Spirogyra* inflorescence peaked in February and had disappeared by May (Bradley and Beard, 1969). In Lily Pad Lake, the floating mats of *Mougeotia* trapped small animals, such as corixids and notonectids, and macroscopic plant fragments. Many smaller algae were also caught up in the entanglement, as revealed by microscopic examinantion. Bradley and Beard (1969) found no apparent correlation between their bloom and seasonal changes in composition or in temperature of the lake water. It was speculated that the great blooms might be due to decreased light intensity in the winter (Bradley and Beard, 1969), since the photosynthesis of algae is inhibited by light in natural waters (Goldman et al, 1963). What effect the atypical summer and consequently frequent cloud cover had on the development of the *Mougeotia* bloom in Lily Pad Lake is not known. The initial survey crew in 1969 mentioned the presence of much filamentous algae at the edges of the lake, although they were not described as floating rafts of filaments.

CYANOPHYTA

De Graaf (1957) also found that colonial blue-greens eg. *Aphanocapsa elachista* were very common in bogs. In the current study, a variety of both filamentous and colonial Cyanophytes occurred regularly. *Merismopedia* spp. occurred frequently at the protected littoral stations as did the filamentous species, *Oscillatoria* and *Lyngbya*. *Anabaena flos-aque*, a filamentous blue-green, was also a common planktonic species. On June 26, there was a sudden, brief increase in trichomes of *Arthrospira jenneri* in the vertical haul from Station 5. Such a dramatic increase and decline might be due to resuspension from the sediments. Prescott (1952) recorded this species as inhabiting the mud and the organic sediments.

BACILLARIOPHYTA

Diatoms have also been recorded from bogs (De Graaf, 1957). They were not a conspicuous group in the phytoplankton of Lily Pad Lake. *Tabellaria fenestrata* was the most constantly recorded species. However, Duthie (1965) found this alga to be only spasmodically abundant in the plankton of bogs, particularly during periods of turbulence. He found that *T. flocculosa* (rare in Lily Pad Lake plankton) had a greater tendency to become planktonic, whereas colonies of *T. fenestrata* were always more abundant on the sediments. Frequent, wind-induced turbulence in Lily Pad Lake may have contributed to the regular planktonic occurrence of *T. fenestrata*. A curious, single-day increase of very small species of *Navicula*, *Synedra* and *Nitzschia* species, was recorded in the horizontal tow from the open water Station 4 on July 18. Such a rapid dominance and decline might also be due to an interaction with benthic populations.

PYRROPHYTA

Ceratium hirundinella, a common constituent of Lily Pad Lake phytoplankton has been recorded by De Graaf (1957). However, Woelkerling (1976) did not find the dinoflagellates to be common in acid bog lakes. In Lily Pad Lake, there is considerable heterogeneity in the horizontal distribution of *Ceratium*. It became abundant on June 19 and remained moderately common, though patchy, thereafter. It is generally a summer species (Edelstein, 1966; Hutchinson, 1967). Heaney (1976) also observed a contagious distribution in this alga, in contrast to Dottne-Lindgren and Ekbohm (1975), who concluded that the horizontal distribution of Ceratium in Lake Erken was uniform. Horne et al (1971) also stated that blooms of dinoflagellates, which occur commonly in lakes, are often patchily distributed over the lake surface. Edelstein (1966) found C. hirundinella to be so abundant from June to September that additional colour was imparted to the water. However, C. hirundinella never approached "bloom" conditions in Lily Pad Lake.

CHRYSOPHYTA

Dinobryon divergens was a common early summer constituent of the phtoplankton assemblage. De Graaf (1957) found D. divergens to be associated with C. hirundinella in quaking bogs. Dinobryon was also heterogeneously distributed. It became abundant on June 16, declined gradually and was rarely observed after July 1. Since periodicity in Dinobryon appears to be related to the nutrient content of the water (Hutchinson, 1967), no further consideration can be given to this alga here.

A bloom of an unidentified colonial flagellate was also recorded. As a result of the method of preservation, identification was impossible. Ruttner (1952) has listed delicate forms, such as chrysomonads and heterokonts, as being characteristic of bog flora. In Table 7, this species is listed as an Unidentified Chrysophyte(?). The bloom, present on the first sampling date, had disappeared by mid-July.

CILIOPHORA

Vorticella spp. were periodically abundant in the plankton samples. Vorticella sp. #1 was almost always associated with Anabaena flos-aque, although no direct relationship between their population fluctuations was observed. Davis (1972) found Vorticella sp. to be almost exclusively attached to coenobia of Anabaena flos-aque; both reached their maxima on the same date, however.

PERIPHYTON

Sixteen taxonomic divisions were recorded from the slides collected in Lily Pad Lake (Table 8). The periphyton community consisted mainly of algae, diatoms and filamentous greens, bacteria and detritus. In the following discussion, the term periphyton or Aufwuchs refers primarily to the organisms growing upon glass slides but is used in the general sense to include all organisms growing upon submerged objects in water (Young, 1945).

Test slides immersed for a week revealed the initial bacterial colonization documented by other researchers in both freshwater and marine environments (Henrici, 1939; Cooke, 1956; Aleem, 1957; Sladeckova, 1962). However, bacteria did dominate some of the periphyton slides exposed for longer periods of time (see below). Resting and germinating zygospores of desmids were also recorded and, like bacteria, they have been shown to be primary colonizers of bare substrata (Sladeckova, 1962). A rather diverse and variable diatom assemblage was also recorded during the first week of immersion. Principal colonizing diatoms were *Nitzschia* spp., *Navicula* spp., *Epithemia* spp., *Gomphonema* spp., *Gomphonema acuminatum*, *Fragilaria crotonensis*, *Achnanthes* spp., and *Cymbella* spp. The stalked diatoms (*Cymbella*, *Gomphonema* and *Synedra*) were loosely attached to the substrate by mucilaginous pedicels. *Achnanthes* was attached by the whole of one surface. The remaining species had no visible means of attachment and were entangled among other algae.

According to Brown and Austin (1973a), bacteria never dominate the periphyton and are quickly succeeded in abundance by algae. However, bacteria were common on all slides examined from Lily

TABLE 8 A list by taxonomic category of the periphyton organisms recorded from Lily Pad Lake Ecological Reserve during the sampling period June - August, 1976.

BACILLARIOPHYTA

Achnanthes exigua Grun.
Achnanthes lanceolata (Breb.) Grun.[1]
Achnanthes linearis (W. Sm.) Grun.[1]
Achnanthes microcephala (Kutz.) Grun.[1]
Achnanthes minutissima Kutz.[1]
Amphipleura pellucida
Amphora ovalis
Amphora spp.
Cocconeis placentula
Cyclotella meneghiniana (?)
Cyclotella spp.
Cymbella caespitosa (Kutz.) Grun.
Cymbella cistula-complex[2]
Cymbella gracilis (Rabh.) Cl.
Cymbella heteropleura (?)
Cymbella naviculiformis Auersw.
Cymbella ventricosa Kutz.
Cymbella spp.
Diploneis finnica (Ehr.) Cl.
Diploneis oblongella (Naeg.) A. Cl.
Epithemia argus Kutz.
Epithemia sorex Kutz.
Epithemia turgida (Ehr.) Kutz.
Epithemia zebra (Ehr.) Kutz.
Eunotia curvata (Kutz.) Lagerst.[3]
Eunotia diodon Ehr.[4]
Eunotia flexuosa (Breb.) Kutz.[3]
Eunotia flexuosa var. eurycephala Grun.[3]
Eunotia incisa Greg.[4]
Eunotia major (W. Sm.) Rabh.[4]
Eunotia monodon Ehr.[4]
Eunotia naegelii Migula[3]
Eunotia pectinalis (Kutz.) Rabh.[4]
Eunotia praerupta Ehr.
Eunotia serra var. diadema

[1]These species comprise Achnanthes spp. referred to in the discussion.

[2]Cymbella cistula is a very variable species and intergrades with other taxa such as C. lanceolata and C. hungarica (Brown, pers. comm.)

[3]These species comprise Eunotia complex #1

[4]Since most of the cells in this complex were observed only in girdle view accurate identification was impossible. This group is referred to as Eunotia complex #2 in the text.

Fragilaria brevistriata Grun.
Fragilaria capucina Desm.
Fragilaria construens
Fragilaria crotonensis
Fragilaria pinnata Ehr.
Fragilaria virescens
Frustulia rhomboides var. capitata (A. Mayer) Patr.
Frustulia rhomboides var. crassinervia (Breb. ex W. Sm.) Ross
Gomphonema acuminatum
Gomphonema acuminatum var. coronata
Gomphonema constrictum Ehr.
Gomphonema lanceolatum Ehr.
Gomphonema monatum (?)
Gomphonema olivaceum (Lyngb.) Kutz.
Gomphonema subtile (?)
Melosira spp.
Navicula radiosa
Navicula tuscula Ehr.
Navicula spp.
Neidium iridis (Ehr.) Cl.
Neidium spp.
Nitzschia acicularis W. Sm.
Nitzschia fonticola Grun.
Nitzschia linearis W. Sm.
Nitzschia spp.
Pinnularia spp.
Rhopalodia gibba
Stauroneis phoenicenteron
Stauroneis spp.
Stenopterobia intermedia (Lewis) Fricke
Stephanodiscus spp.
Surirella robusta
Surirella spp.
Synedra capitata
Synedra ulna (Nitz.) Ehr.
Synedra ulna var. obtusa (?)
Synedra spp.
Tabellaria fenestrata
Tetracyclus lacustris

CHLOROPHYTA (except DESMIDIALES)

Ankistrodesmus falcatus
Ankistrodesmus spiralis
Aphanochaete-like sp.
Apiocystis brauniana
Binuclearia tatrana Wittrock
Botryococcus Braunii
Bulbochaete spp.
Chaetopeltis orbicularis Berth.
Chaetosphaeridium-like sp.
Characium spp.
Chlorococcum spp.
Coelastrum microporum

Coleochaete orbicularis
Coleochaete scutata
Coleochaete soluta-like sp.
Coleochaete sp. (Juvenile)
Crucigenia crucifera (Wolle) Collins
Crucigenia quadrata
Crucigenia rectangularis
Draparnaldia sp. #1 (Judayi-like)
Geminella-like sp.
Hydrodictyon reticulatum
Microspora spp.
Mougeotia spp.
Oedogonium undulatum (Breb.) A. Braun
Oedogonium spp.
Oocystis spp.
Pandorina morum
Paulschulzia pseudovolvox
Paulschulzia tenera (Korsch.) Lund.
Pediastrum araneosum
Pediastrum angulosum (Ehr.) Menegh.
Pediastrum Boryanum
Pediastrum Boryanum var. longicorne
Pediastrum duplex var. clathratum (A. Braun) Lag.
Pediastrum tetras
Pediastrum tetras var. excisum (Rabh.) Hansgirg
Pediastrum tetras var. tetraodon (Corda) Hansgirg
Protosiphon botryoides
Scenedesmus abundans
Scenedesmus acutiformis
Scenedesmus arcuatus
Scenedesmus armatus
Scenedesmus bijugatus
Scenedesmus denticulatus
Scenedesmus hystrix Lag.
Scenedesmus obliquus
Scenedesmus platydiscus
Scenedesmus quadricauda
Scenedesmus serratus
Schroederia spp.
Spirogyra spp.
Stigeoclonium spp.
Tetraedron caudatum (Corda) Hansgirg
Tetraedron minimum
Tetraedron trigonum forma gracile (Reinsch) De T.
Tetraspora sp.
Zygnema spp.

DESMIDIALES

Arthrodesmus octocornis
Closterium cornu var. cornu f. cornu
Closterium cynthia De Notaris var. cynthia
Closterium gracile
Closterium incurvum (Breb.) f. incurvum

Closterium intermedium var. hibernicum West & West
Closterium kuetzingii var. kuetzingii
Closterium libellula var. libellula f. libellula
Closterium navicula var. navicula
Closterium parvulum Nag. var. parvulum
Closterium rostratum Ehr. var. rostratum
Closterium setaceum var. setaceum f. setaceum
Closterium venus var. venus f. venus
Closterium spp.
Cosmarium anceps Lund
Cosmarium Botrytis
Cosmarium granatum
Cosmarium obliquum Nordst.
Cosmarium Portianum
Cosmarium sp. #1, #4-#8
Cosmarium sp. #15 (margaritiferum-like)
Cosmarium sp. #16 (ovale-like)
Cosmarium sp. #17 (subprotumidum var ?-like)
Cosmarium sp. #18 (venustum-like)
Desmidium Aptogonum
Desmidium pseudostreptonema W. & G.S. West
Euastrum binale
Euastrum dubium
Euastrum elegans
Euastrum insulare
Euastrum sp. #1
Euastrum sp. #3 (crassangulatum var. ornatum-like)
Euastrum sp. #4 (pectinatum-like)
Euastrum sp. #5 (pulchellum-like)
Gonatozygon aculeatum
Gonatozygon Brebissonii
Gonatozygon Kinahani
Gonatozygon monotaenium
Gonatozygon monotaenium var. pilosellum
Gymnozyga moniliformis var. gracilescens Nordst.
Micrasterias pinnatifida (Kutz.) Ralfs.
Neitrium Digitus
Onychonema filiforme (Ehr.) Roy & Biss.
Pleurotaenium trabecula var. trabecula f. trabecula
Pleurotaenium sp. #2 (minutum var. crassum-like)
Sphaerozosma excavatum
Sphaerozosma vertebratum
Spinoclosterium cuspidatum (Bailey) Hirano
Spondylosium planum
Staurastrum anatinum
Staurastrum Arctiscon
Staurastrum Avicula
Staurastrum dejectum
Staurastrum Dickei var. circulare
Staurastrum furcigerum
Staurastrum glabrum (Ehr.) Ralfs.
Staurastrum gracile
Staurastrum grande var. parvum
Staurastrum inflexum
Staurastrum megacanthum

Staurastrum mucronatum
Staurastrum paradoxum
Staurastrum pyramidatum West.
Staurastrum sp. #1
Staurastrum sp. #2
Staurastrum sp. #7 (*grande*-like)
Xanthidium aculeatum Ehr.
Xanthidium antilopaeum var. *hebridarum*
Xanthidium antilopaeum var. *polymazum*
Xanthidium cristatum

CYANOPHYTA

Aphanizomenon flos-aque
Aphanocapsa spp.
Gloeotrichia echinulata
Gomphosphaeria aponina Kuetz.
Gomphosphaeria lacustris
Lyngbya spp.
Merismopedia elegans
Merismopedia glauca
Merismopedia tenuissima
Merismopedia spp.
Microcystis aeruginosa Kutz.
Nostoc paludosum
Oscillatoria Agardhii
Oscillatoria nigra
Oscillatoria rubescens
Oscillatoria spp.
Tolypothrix tenius

EUGLENOPHYTA

Euglena acus

PYRROPHYTA

Ceratium carolinianum
Ceratium hirundinella
Glenodinium spp.
Gymnodinium spp.

CHRYSOPHYTA

Dinobryon bavaricum
Dinobryon divergens
Dinobryon sertularia
Dinobryon sociale
Ducillieria-like sp.
Epipyxis sp.

ROTIFERA

Colurella sp.
Conochilus unicornis
Keratella cochlearis
Lecane sp.
Lepadella sp.
Tetrasiphon sp.
Trichocera sp.

CLADOCERA

Daphnia schodleri

COPEPODA

Diaptomus leptopus

CILIOPHORA

Unidentified Protozoan
Vorticella sp. #1
Vorticella sp. #3

TRICHOPTERA

Trichopteran larvae

DIPTERA

Chaoborus sp.
Chironomid larvae

HIRUDINEA

Helobdella stagnalis (L.)

AMPHIBIA

Salamander eggs

Pad Lake and even achieved dominance on one series. Henrici (1939) stated that bacteria are more characteristically a part of the periphyton than of any other ecologic group. Bacterial periphyton can be defined as that part of the bacterioplankton which is able to attach to firm substrata (Sladeck and Miskovsky, 1976). It should be noted here that, since it is difficult to distinguish microscopically between bacteria and suspended debris (Sykes and Skinner, 1971), both detritus and bacteria probably contribute to the "bacterial" component on the glass slides. They will not be separated in this study. For a discussion of the role of detritus and organic matter in aquatic ecosystems the reader is referred to Wetzel (1975; pp. 538-621).

An inert surface like glass is sufficient to cause an increase in bacteria. This increase is probably due to the concentration of organic matter absorbed onto the surface. That such a concentration of organic matter from the water on submerged surfaces actually occurs has been demonstrated (Stark et al, 1938). It is clear, therefore, that the occurrence of surfaces either as support for the bacteria, or in concentrating their food elements, is a factor of fundamental importance in the growth of aquatic bacteria (Henrici, 1939; McCoy and Sarles, 1969).

There was a considerable difference among stations in the degree to which bacteria occurred on the slides. They were consistently abundant only at Station 3. Experiment #5 at this station yielded bacteria as the dominant component. Consequently, the number of species enumerated from these slides was very low -- 26 species were recorded with only Mougeotia being abundant. In contrast, the finding of over 100 species per slide was not uncommon in some series. The large amount of debris on the slides in Expt. #5 at Station 3 reduced the amount of substrate potentially available for colonization by the algae. As an aside, it is interesting to note that the bacterial contribution to the slides in Expt. #6 (combined with Expt. #5 for this report) at the same station was not high, even though the slides had been exposed over a similar time period (Table 2). Reasons for this are unknown.

There is a positive correlation between the occurrence of aquatic plants and the numbers of bacteria. Mere shallowness of the water is not a factor. It is probable that the increase of bacteria in the vicinity of larger aquatic plants is due to larger amounts of dissolved organic matter, derived from these plants, in the water. Henrici (1939) recorded, in a eutrophic lake in central Minnesota, high counts of periphytic bacteria at the three protected littoral stations with abundant aquatic plants. His exposed littoral station, similar to Station 3 in openess, showed a development of periphytic bacteria intermediate between the littoral and open water stations. This is completely opposite to that recorded in Lily Pad Lake. However, the data from Henrici (1939) originated from a eutrophic lake. Since no references were found regarding bacterial distribution in bog lakes, reasons for the bacteriological observations in Lily Pad Lake are not immediately obvious.

The "detrital" component of the periphyton also included pollen grains originating from the Pinus contorta stands surrounding the lake. From mid-July to August, pollen was abundant on many of the slides. Nutrient input from pollen sources may be significant in the nutrient budget of a small subalpine or alpine lake with a limited nutrient inflow (Richerson et al, 1970). Smirnov (1964) found that pollen spores were eaten by numerous inshore invertebrates, including zooplankton and chironomid larvae, which were very common in Lily Pad Lake. Alnus incana, abundant around the shoreline, may also contribute to the nutrient budget of Lily Pad Lake. Goldman (1961) found that Alnus tenuifolia made a significant contribution to the primary productivity of a lake in California. Allochthonous detritus can play an important role in the economy of aquatic systems. In fact, Marshall (1967) has shown that the total contribution of allochthonous materials in a stream community was many times that of the aufwuchs community. However, in Lily Pad Lake, it is more likely that the periphyton make the greatest contribution to the total primary productivity.

SUCCESSION OF PERIPHYTON SPECIES AND SPECIES INTERACTIONS

There were marked differences among stations in periphyton species succession and between monthly and successional slides over the sampling period (Tables 9 and 10).

In the monthly samples, the three filamentous Chlorophytes, Mougeotia, Spirogyra and Oedogonium, showed a general increase in July and a decrease in August (Table 10). While studying the effects of thermal effluent on epiphytic algae, Klarer and Hickman (1975) found that, at the unheated stations, there was an influx of large-celled menbers of the Chlorophyta, particularly Oedogonium and Mougeotia, in late July. During early August, these two species virtually disappeared. Davies (1970) found that the periphyton was dominated by Mougeotia in the summer. In Lily Pad Lake, a similar pattern was observed, although the three species did not quite disappear by mid-August. The relationship between Mougeotia and temperature has already been discussed. As in the case of Mougeotia and Spirogyra, Oedogonium was found only in the vegetative

TABLE 9 Succession of the dominant Lily Pad Lake periphyton taxa on those slides of Expts. 1, 3 amd 4 which were immersed for increasing exposure durations of 25, 43 and 68 days respectively between June 10 and August 16, 1977. Data is recorded in relative abundance. D=Dominant A=Abundant C=Common R=Rare.

Species	Expt. 1			Expt. 3			Expt. 4		
Station	1	2	3	1	2	3	1	2	3
Mougeotia	R	R	A	C-A	C-A	D	A	A	C
Oedogonium	R	C	C	C	C	C-A	C-A	C	C-A
Spirogyra	R	R	C	C-A	C	C-A	C	R-C	C
Achnanthes	A	A	A	A	A	R-C	A	A	R-C
C. cistula	A	A	A	A	A	R-C	R-C	R-C	R-C
E. turgida	A	A	A	A	A	R-C	D	D	D
Eunotia #2	C	A	A	A	A	R-C	D	D	D

TABLE 10 Succession of the dominant Lily Pad Lake periphyton taxa at the three sampling stations on those slides of Expts. 1, 2 and 5, samples immersed for successive approximately monthly intervals from June 10 to August 16, 1977. Data is recorded in relative abundance. D=Dominant A=Abundant C=Common R=Rare.

Species	Expt. 1			Expt. 2			Expt. 5		
Station	1	2	3	1	2	3	1	2	3
Mougeotia	R	R	A	A	C	D	C	C	C
Oedogonium	R	C	C	A	C	A	C	C	C
Spirogyra	R	R	C	A	A	A	C	R	R-C
Achnanthes	A	A	A	A	A	A	A	A	C
C. cistula	A	A	A	A	A	A	R-C	C	C
E. turgida	A	A	A	C	A	A	A	A	D
Eunotia #2	C	A	A	C	A	A	A	A	D

condition. Prescott (1952) observed that Oedogonium, often abundant in the vegetative condition in the open water portion of acid bog lakes, rarely reproduced sexually there. However, he recorded that fruiting plants were found in the pools and ditches of the marginal mats, where there was a concentration of organic matter. Abdin (1949) found that strong illumination brought Oedogonium to its maximum, although this occurred at depths of 2 to 5 meters. However, Hickman and Klarer (1975) suggested that temperature is perhaps more important than light intensity in affecting these species. Zygnema was common on most monthly slides examined, except at Station 1. Klarer and Hickman (1975) found Zygnema to be common in early June samples collected from heated stations.* Bulbochaete was only rarely encountered in these monthly collections.

Table also lists the third clearly distinguishable "community type", namely the diatoms. Many investigators have documented an abundance of diatom taxa in periphyton communities (Patrick et al, 1954; Castenholz, 1960; Stockner and Armsrong, 1971; Brown and Austin, 1973b). Species of Eunotia and Epithemia turgida were the dominant diatoms encountered in Lily Pad Lake periphyton. Species of Eunotia are reported to live under acid conditions and in streams known to receive drainage from acid bogs (Williams and Scott, 1962). Ruttner (1952), De Graaf (1957) and Patrick and Reimer (1966) have recorded species of Eunotia as characteristic representatives of acid bog flora. Although two complexes of this genus were distinguished, only Eunotia complex #2 became dominant. No references were found in the English literature (though they may exist) which reported on the seasonal ecology of any of the species

* However, direct comparisons between artificial periphyton and epiphyton must be viewed with reservation as Tippett (1970) has shown that the two are often not compatible.

which comprised this complex. However, Whitford and Schumacher (1968) reported that E. pectinalis was most abundant at cool seasons in brown waters and that it could tolerate low light conditions. In the present study, this complex was abundant at Stations 2 and 3 and common at Station 1 in Expts. 1 and 2. In Expt. #5 it became abundant at Station 1, remained abundant at Station 2 and became dominant at Station 3 (Table 10). Possible reasons for these observations will be considered later when interstation variability is discussed. The other diatom which became dominant was Epithemia turgida, although the available literature did not document this alga as characteristic of bog waters. Castenholz (1960) reported that E. turgida was a major summer species with an autumnal maximum. Klarer and Hickman (1975) showed that E. turgida increased in late July, but declined in early August. However, the following year, Epithemia did not become dominant until the end of August. Klarer (1973) found that E. turgida experienced optimal growth between 10 and 20°C and occurred in the non-heated areas as a major summer species with a late summer/ early autumn maximum. This was also generally observed in Lily Pad Lake. Curiously, it was only at Station 3 that this species became dominant in the monthly samples, similar to Eunotia complex #2. Two other diatom genera were also recorded as abundant. Cymbella cistula complex was abundant in Expts. 1 and 2 but declined in Expt. #5 (Table 10). Cymbella has been recorded as an abundant diatom in a quaking bog (De Graaf, 1957). However, Castenholz (1960) has stated that, although Cymbella cistula is widespread throughout the world, little has been said about its seasonal periodicity. Its decline on the slides immersed in late July to mid-August could be due to a seasonal decline or to competition with other species (see below). Achnanthes (chiefly A. minutissima) was abundant on all monthly slides examined, except those at Station 3, where it declined in August (Table 10). Reasons for its decline may be comparable to those for Cymbella.

Table 9 shows the succession of the same periphyton taxa on slides immersed for increasing exposure durations of 25, 43 and 68 days. The succession of the periphyton species in Expts. 1, 3 and 4 differed somewhat from that expressed in the monthly samples. These differences may have been due in part to seasonal effects and physiological condition of the colonizing cells, "sloughing-off", and the availability of potentially colonizing populations (Brown and Austin, 1973b). However, these dissimilarities could also be due to competition for dwindling substrate space. Brown (1973) recorded a decrease in diversity with time of colonization in periphyton communities due to increased competition or other interspecific interaction which led to the elimination of some species as the total population increased towards substrate saturation. Since all the sampling in the current study was conducted during the summer season, it is not strictly valid to differentiate the effects of length of slide immersion from "seasonal" effects (eg. seasonal population changes). It is probable that both "seasonal" effects and length of slide immersion are important but the relationship would be complicated.

At Stations 1 and 2, Mougeotia became more abundant as time of exposure increased, whereas at Station 3, it became dominant on those slides immersed for 48 days and received a "common" rating on those slides immersed for 68 days.(Table 9). Spirogyra increased in importance at all stations in Expts. 1 to 3 but declined on those slides immersed for 10 weeks (Table 9). It declined when the diatoms, Epithemia and Eunotia achieved dominance. Spirogyra might not be as capable of efficiently competing with the rapidly growing diatoms for the colonizable substrate area. The reason might also be seasonal (see the following section). The decline of Mougeotia at Station 3 is more probably due to a local effect (see below), since it remained abundant at Stations 1 and 2, even when the diatoms were dominant. At Station 1, Oedogonium increased in importance with lengthening exposure duration. At Station 2, it remained constantly common with increasing exposure duration. At Station 3, it increased in importance but received the same rating for Expts. 3 and 4 (Table 9). Oedogonium did not show any effects of competition with the diatoms as it retained a high rating on the slides immersed for 68 days. Although Bulbochaete spp. became abundant at Station 3 on the 10 weeks' slides, it was clearly additional and did not replace others, since it was only rarely encountered on those slides of less exposure duration. There was no succession involved in the colonization of this species. Klarer and Hickman (1975) recorded Bulbochaete as present throughout October at heated stations, although it never became a common member of the population. The reasons for its sudden appearance in this study are not known. Zygnema was common on most successional slides except at Station 1, similar to the monthly series.

The diatoms, Eunotia complex #2 and Epithemia turgida increased in abundance with lengthening exposure duration until, in Expt. #4, they attained dominance on all slides examined. (Table 9) During this increase, though, there was a curious decline in the abundance of both species at Station 3 in Expt. #3 (Table 9). Achnanthes remained abundant at Stations 1 and 2 throughout the study period. Its rarity with increasing exposure at Station 3 might be due to unknown local factors at this station, since it showed a similar pattern in the monthly (August) series (Tables 9 and 10). Competition with the two dominant diatoms would not appear to be the reason for the decline since Achnanthes was abundant at Stations 1 and 2 when Eunotia and Epithemia were dominant. Cymbella also became more rare as length of exposure increased (Table 9). The latter two species also exhibited a decline comparable to Eunotia and Epithemia at Station 3 in Expt. #3. This rather dramatic decrease of the four diatom species might be attributed to competition for substrate space since the large-celled Mougeotia became dominant at this time. However, a similar pattern in these diatoms was not observed in the monthly (July) series, even though Mougeotia was also dominant here. Explanations for these observations are probably complex and beyond the scope of this study. However, they would appear to be localized since such an observation was made only at Station 3. The already mentioned decline of Cymbella coincided with the achievement of dominance by Eunotia and Epithemia. Cymbella may be a species less capable than the two other diatoms in competing for decreasing substrate area as Epithemia and Eunotia increase. Since Cymbella also declined on all monthly slides exposed during August (Expt. #5), the reason may also be partially seasonal. There was a sudden increase of Cocconeis placentula at Station 2 in Expt. #3. This species occurred only rarely on all other slides examined. Douglas (1958) found that C. placentula was patchy in its distribution in a small English stream and that erratic variations in species populations were not uncommon. Some diatoms, such as Gomphonema and Nitzschia, showed little change in relative abundance throughout the sampling period. Frustulia was also a constant species and has been found to be a common alga in acid bog lakes (Ruttner, 1952).

Desmids were also constant, though only occassionally common, constituents of the periphyton. Euastrum, Cosmarium and Staurastrum were the most common periphytic species. Brook (1959) has listed the first two as being restricted to nOn-planktonic habitats. According to Gough and Woelkerling (1976), there is a greater diversity of desmid taxa in the aufwuchs than in the plankton. However, they sampled macrophytic hosts, which may harbour a richer desmid flora than that settling on the glass slides. Competition for available substrate space is probably detrimental to the development of desmids on the slides. They were common only on those slides exposed for short durations of time.

There was a variety of fauna present in Lily Pad Lake periphyton. The presence of invertebrate fauna in periphyton communities is dependent upon environmental and experimental conditions, such as trophic status, substratum, exposure position and depth of substrata etc. (Brown and Austin, 1973a). In the present study, there was no clear relationship between the occurrence of these organisms and the afore-mentioned controlling factors, although rotifers were more abundant as length of exposure increased.

Reasons for the interstation differences will be considered only in a general way. In addition to the reasons already mentioned, many possibilities exist to explain the variability.

The importance of invertebrate grazing as a controlling factor in attached algal distribution has been illustrated (Douglas, 1958). *Keratella cochlearis*, abundant in Lily Pad Lake plankton throughout June and July, is a known periphyton feeder and has been shown to be positively correlated with population changes in phyco-periphyton (Foerster and Schlichting, 1965). Several other rotifers were also recorded from Lily Pad Lake periphyton, along with the crustaceans, *Daphnia schodleri* and *Diaptomus leptopus*. Grazing by larval stages of *Rana* and *Bufo*, both common in Lily Pad Lake, has been shown to be an important regulator of accumulated periphytic biomass and can lead to sharp, irregular fluctuations in periphyton populations (Dickman, 1968; Stockner and Armstrong, 1971). The latter authors have also shown that grazing by caddisfly larvae and herbivorous gastropods is another biological factor affecting attached algal distribution. Castenholz (1960), however, rarely observed grazing by gastropods. In Lily Pad Lake, there ~~were~~ was a variety of small gastropod species; their effect on the periphyton is not known. Caddisfly larvae were common on the slide boxes and were occasionally collected from the slides. Brook (1955) found that fluctuations in the attached populations between March and October were mainly caused by the depredations of aquatic insect larvae. Chironomids and *Chaoborus* were sometimes recorded from the periphyton slides. Brook (1955) found that chironomid larvae feed quite heavily on diatoms. Castenholz (1960) cited loss by wave action as the main factor after the thickness of the attached material increased. At Station 3, water currents and turbulence might be important in affecting species distribution by inhibiting the colonization of species lacking a suitable attachment. This might also help to explain the strange happenings at this station, which have already been mentioned. Differences in chemical parameters among stations might also be a possible factor, although several authors have observed that fluctuations in attached algal populations could not be correlated with changes in water chemistry (Douglas, 1958; Brown and Austin, 1973b; Woelkerling, 1976). However, as concluded by Castenholz (1960) and Brown and Austin (1973b), it is probable that the observed station differences result from an interplay of many factors.

In order to make a casual comparison between the periphyton settling on natural and artificial substrates, a single-day collection was made of the rooted macrophytes growing at various places in the lake. Only qualitative observations were made of these samples. There exists in the literature an antithetical view of the usefulness of artificial substrates in collecting a truly representative proportion of the natural populations. Some authors have found that artificial substrates are not highly selective for any particular group of organisms and that the algae attached to such substrates provide a reasonable characterization of the attached algal flora occurring on natural substrates in the lake (Patrick et al, 1954; Neal, 1967; Brown and Austin, 1971, 1973; Stockner and Armstrong, 1971). However, other authors have found that the substrate does influence the community composition and the population density (Young, 1945; Foerster and Schlichting, 1965; Tippett, 1970; Ertl, 1971; Woelkerling, 1976). From the very cursory examinations made of the macrophytic hosts growing close to the location of the slide boxes in Lily

Pad Lake, there appeared to be significant differences in the species present. Rhopalodia gibba, although not very common in the artificial periphyton, was abundant on several hosts. According to De Graaf (1957), it is a species widely distributed in quaking bogs. Eunotia, dominant on the artificial substrata, was not common on the macrophytes sampled. On the other hand, Epithemia turgida was dominant in both habitats. As a group, Cyanophytes were more common as epiphytes than as slide colonizers. Superficially, there appeared to be considerable differences in species composition from one host to another growing in close proximity to one another. Woelkerling (1976) recorded a similar phenomenon. For example, Potamogeton natans harboured an overwhelmingly rich epiphytic flora dominated by Epithemia turgida and various Chlorophytes. On the other hand, Nuphar polysepalum, growing in the same bay, had Tabellaria fenestrata as one of the dominant epiphytes. This species was never regularly common on the slides. Although no collections were made from Utricularia or Sphagnum, Sphagnum has long been recognized as possessing a diverse desmid flora. Sphagnum has the ability to reduce the pH of the surrounding water (Gorham, 1957), thereby increasing the availability of free CO_2, which favours desmid development (Moss, 1973a,b). It is not yet known if Utricularia, which consistently has the richest desmid flora (Heimans, 1969; Gough and Woelkerling, 1976) also possesses a mechanism favouring desmid development. Hence, although artificial substrates may be an unreliable ecological indicator of changes occurring within a natural community (Tippett, 1970), their use is preferable for the base-line intentions of this study.

INTERACTION BETWEEN PHYTOPLANKTON AND PERIPHYTON POPULATIONS

Brown and Austin (1973b) found a striking relationship between species common to the plankton and periphyton whereby a decrease in cell numbers and % abundance in the planktonic populations coincided with their increase in the periphyton. Although several species were common to both habits in Lily Pad Lake, only two filamentous Chlorophytes -- Mougeotia and Spirogyra -- showed any kind of relationship. Contrary to the inverse relationship recorded by Brown and Austin (193b), a positive correlation was evident in Lily Pad Lake, which likely signifies seasonal and/or physico-chemical reasons for the observed fluctuations. The periphytic dominance of Mougeotia on both monthly and successional slides picked up on July 22 coincided with its preeminent status in the plankton on this date. It would seem that, at Station 3, there was some environmental factor (unknown) perhaps temperature critical for the full development of this taxon in July. It appeared that there was only one very large-celled species of Mougeotia which was responsible for the dominance of this genus in both the periphyton and phytoplankton. Spirogyra showed a decline from the end of July through mid-August in the plankton, and in the monthly and successional periphyton samples. Therefore, its decline is undoubtedly of a seasonal nature.

ZOOPLANKTON

CLADOCERANS AND COPEPODS

Crustacean zooplankton communities

The following crustacean zooplankton species were found in Lily Pad Lake:

Daphnia schodleri Sars
Daphnia rosea Sars
Polyphemus pediculus Linné
Sida crystallina O.F. Muller
Acroperus harpae Baird
Chydorus sphaericus (O. F. Muller)
Simocephalus vetulus Schødler
Ceriodaphnia reticulata (Jurine)
Streblocerus serricaudatus (Fischer)
Scapholeberis kingi Sars
Graptoleberis testudinaria (Fischer)
Eurycercus lamellatus (O.F. Muller)
Lathonura rectirostris (O.F. Muller)
Diaptomus leptopus S A Forbes
Eucyclops agilis (Koch)
Macrocyclops albidus (Jurine)

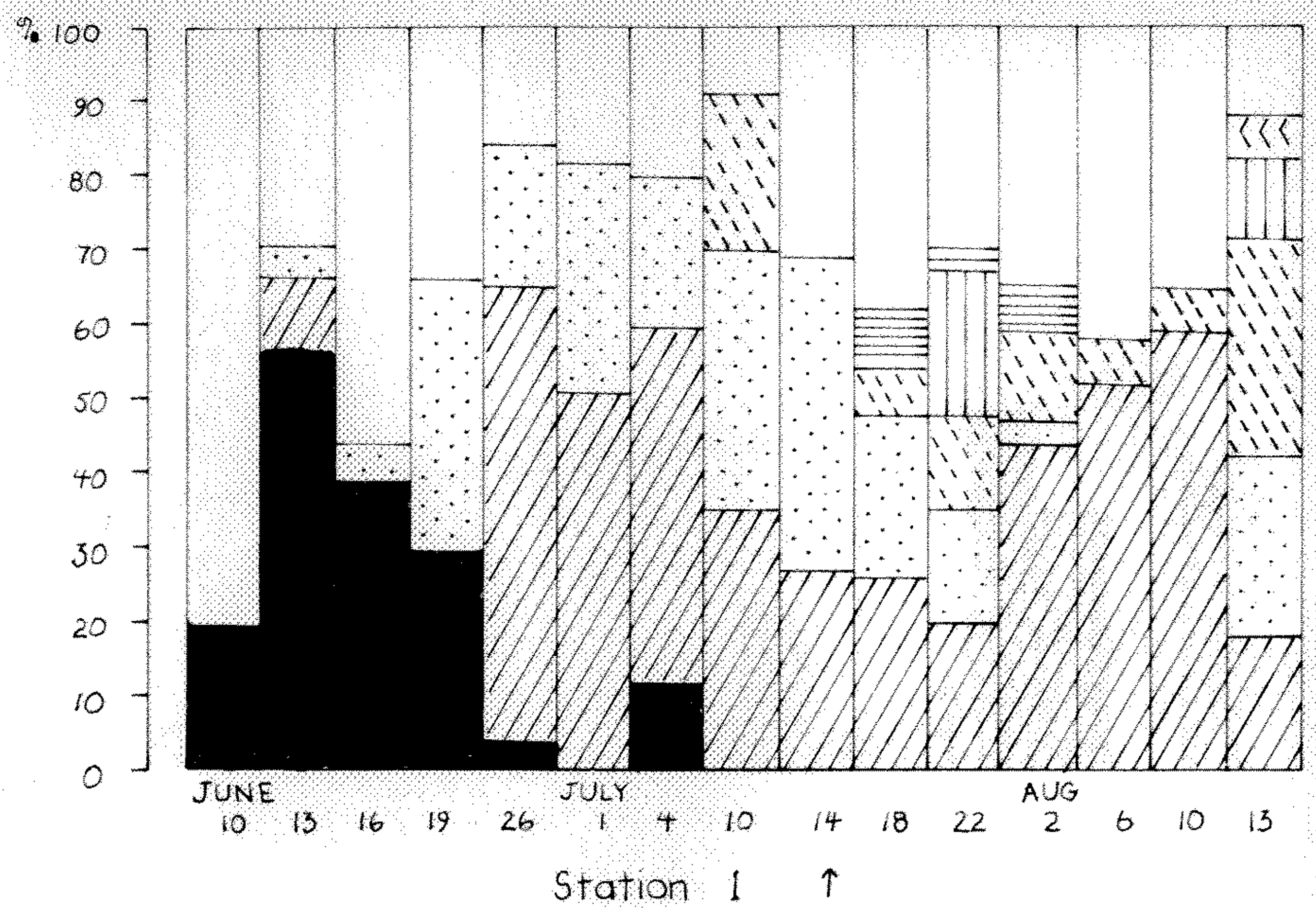
Although little work has been done on lakes in the Interior Highland region, most of these species have been found in other parts of western Canada. Anderson(1971) lists the following as common pond and shallow lake forms at montane elevations: *Daphnia schodleri*, *D. rosea*, *Polyphemus pediculus*, *Diaptomus leptopus*, *Macrocyclops albidus*, and *Eucyclops agilis*. *Chydorus sphaericus*, *Simocephalus vetulus*, and *Scapholeberis kingi* are commonly present at all elevations(Anderson 1971, Carl 1940). Anderson grouped his 340 Canadian Rocky Mountain lakes according to the kind of diaptomid present. Group IV lakes, characterized by *Diaptomus leptopus*, contained the majority of Lily Pad's crustacean zooplankton species, and there were only two species frequently present in these lakes which were not collected from Lily Pad. (These were *Acanthocyclops vernalis* and *Bosmina longirostris*.) Lakes belonging to group IV were described by

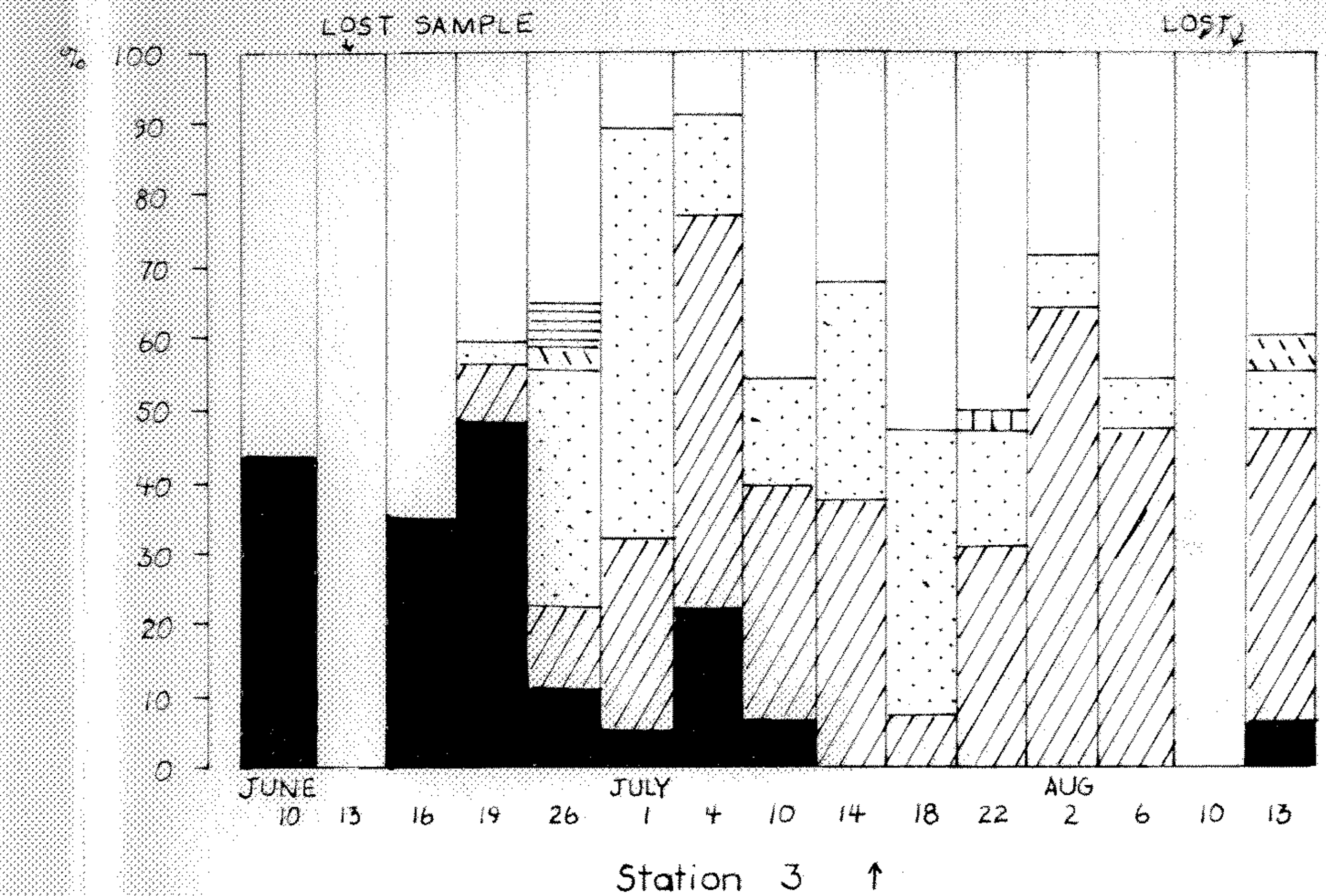
Anderson as "mostly montane ($\bar{x}$=1328m elevation), small($\bar{x}$=15.2 ha), and moderately deep, and having low salinity and moderate heat accumulation in summer." Lily Pad Lake appears to fit fairly well into the group, apart from the fact that it is shallow rather than "moderately deep". It may differ from the Rocky Mtn. Lakes, though, since it contains the floating Sphagnum-Carex mats and is fed by seepage through a bog area. Thus its water may be somewhat acidic in nature (although not likely extremely acidic , judging from the presence of several kinds of mites, ostracods, sponges ,and molluscs, all of which are absent or poorly represented in very acidic waters,(see Wetzel 1975 p658). Considering the similarities between the composition of Lily Pad's zooplankton communities and that of western Canadian lakes in general (Anderson 1974), it appears that Lily Pad's pH probably does not assume a significant role in determining the zooplankton species present. Many of the above mentioned species have been found in waters known to be acidic; Eucyclops agilis, Macrocyclops albidus, Polyphemus pediculus, Chydorus sphaericus, Scapholeberis kingi, and Streblocerus serricaudatus occurred in an acid marsh (Daggett and Davis,1974), while Sida crystallina, Scapholeberis kingi, Simocephalus vetulus, and Graptoleberis testudinaria were found in a bog pond (same authors). In addition, Daphnia rosea has occurred in a slightly dystrophic small pond with bog surroundings (Dodson,1972). Sprules(1975) concluded that pH has only a slight effect on the zooplankton species composition of lakes (and also total number of species present), as long as it is not below 5.0.

Of the 16 cladoceran and copepod species occurring in Lily Pad Lake, those found in highest abundance were: Diaptomus leptopus, Eucyclops agilis, Daphnia schodleri, D. rosea, and

Polyphemus pediculus. These were not all abundant at once in any given habitat (see below). Eurycercus lamellatus, Graptoleberis testudinaria, and Lathonura rectirostris were only found once or twice, and Scapholeberis kingi and Streblocerus serricaudatus occurred occasionally, as did Ceriodaphnia reticulata. The remaining species composed intermediate proportions of the zooplankton at certain times during the study period.

Only a few of the zooplankton species were found together in any one habitat at a given time. At the open water stations, there was a range of 3-7 species found, and a mean of 4.59(see appendix 2). Of these, only 2, or sometimes 3, occurred in abundance; usually one copepod and one cladoceran (sometimes 2) composed the majority of the individuals in the samples. Such relatively simple zooplankton communities are characteristic of the limnetic zone of lakes (Pennak 1957, and others). Lily Pad Lake possessed more zooplankton species in its open water communities than the average of lakes that Pennak studied. This is probably due to littoral influence. Littoral samples contained more species; a range of 2-11 and a mean of 6.22 was calculated for them (see appendix 2). This is to be expected, since the rooted plants and bottom debris, and also the floating Sphagnum-Carex mats, of the littoral areas provide many additional habitats for the zooplankton and it is likely that some bottom-inhabiting and plant-loving forms would be taken with the more characteristically planktonic ones in the net. Generally most of the individuals in the littoral samples belonged to only 3 species, usually one copepod, and 2 (sometimes 3) cladocerans. In total, there was a mean of 9.27 cladoceran and copepod species found in Lily Pad Lake on any one sampling day. This relatively high number, in comparison





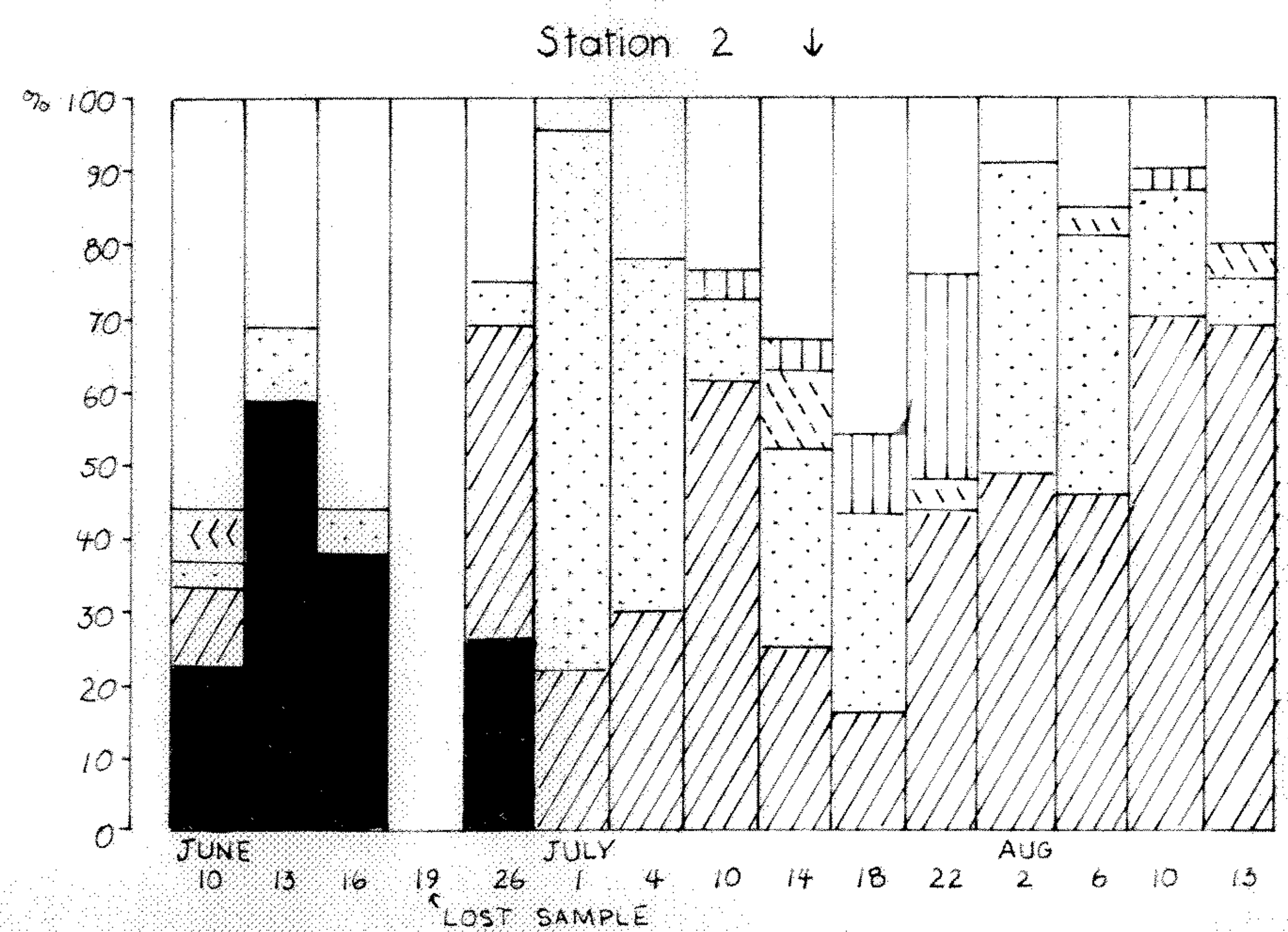
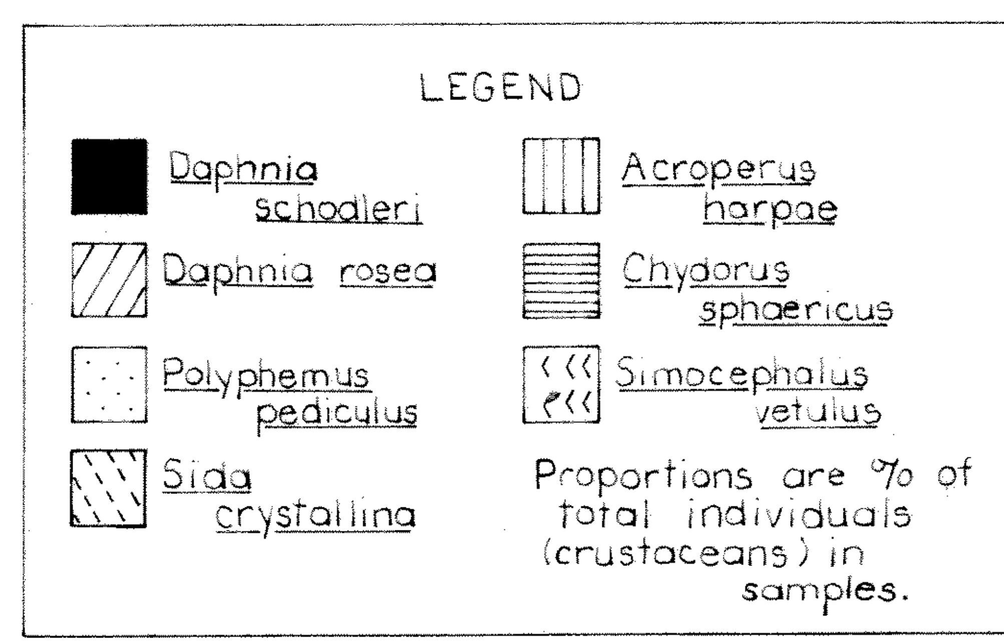
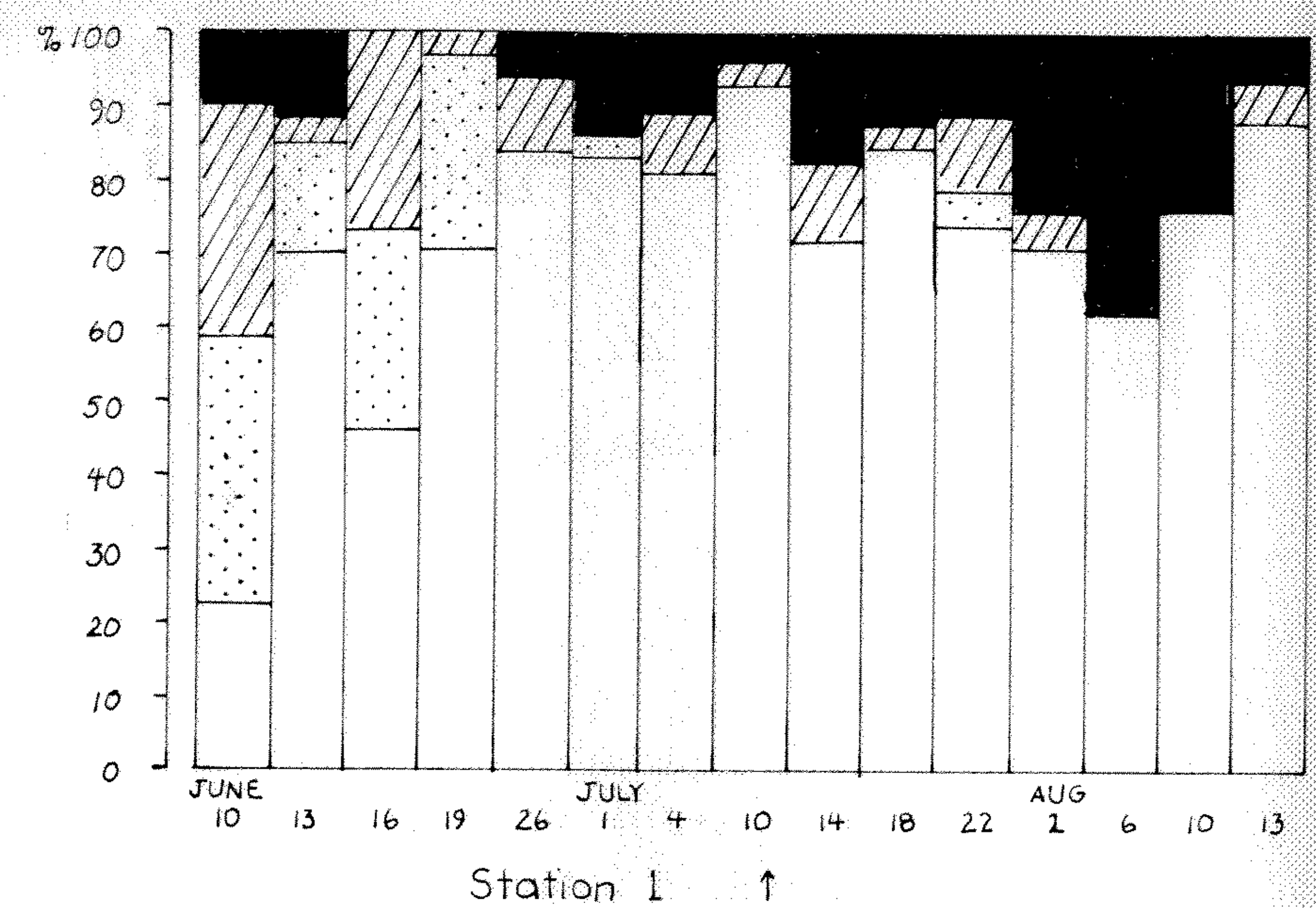


FIGURE 17 Composition of the crustacean zooplankton of Lily Pad Lake at littoral stations 1976.
A) CLADOCERANS.





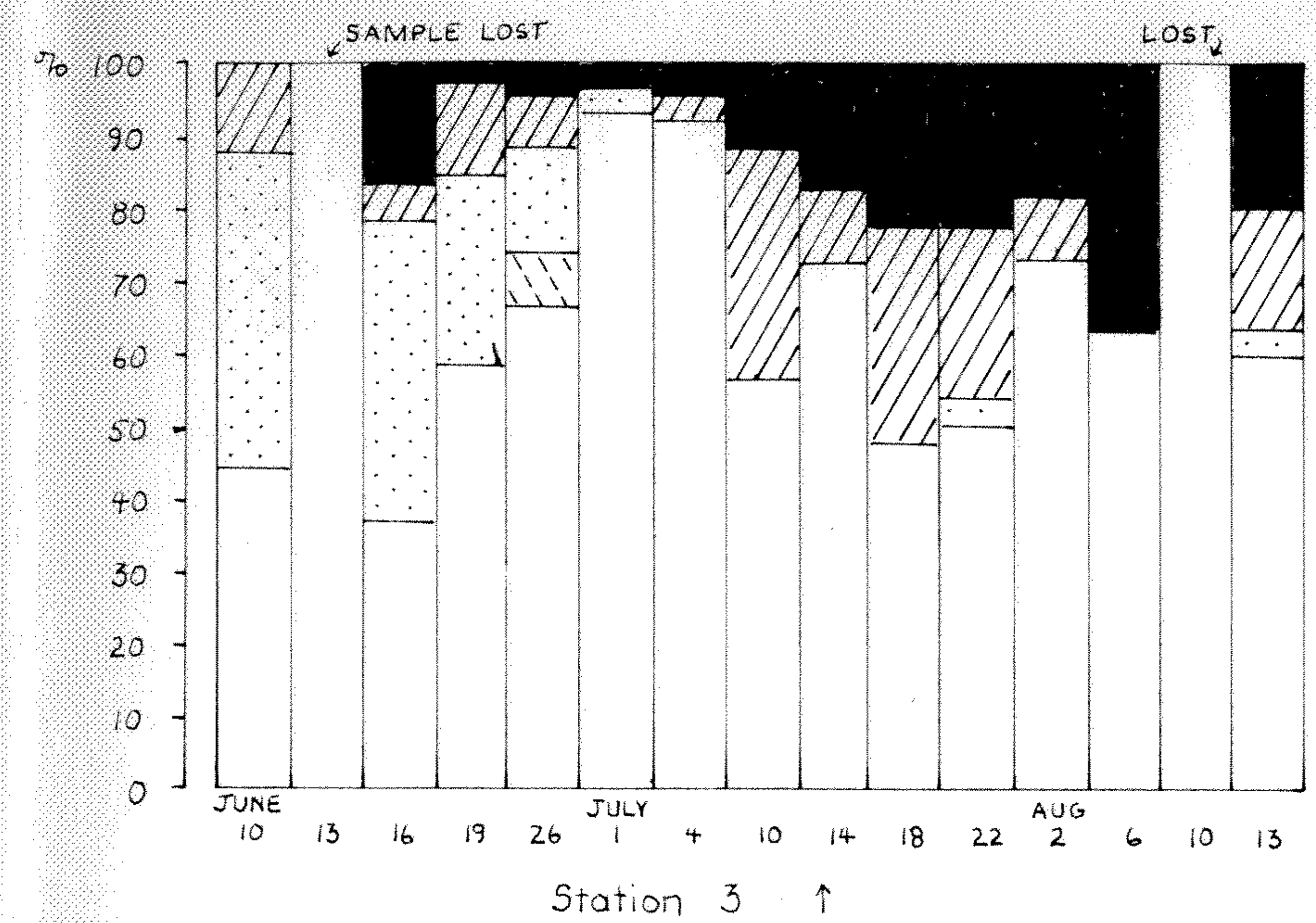
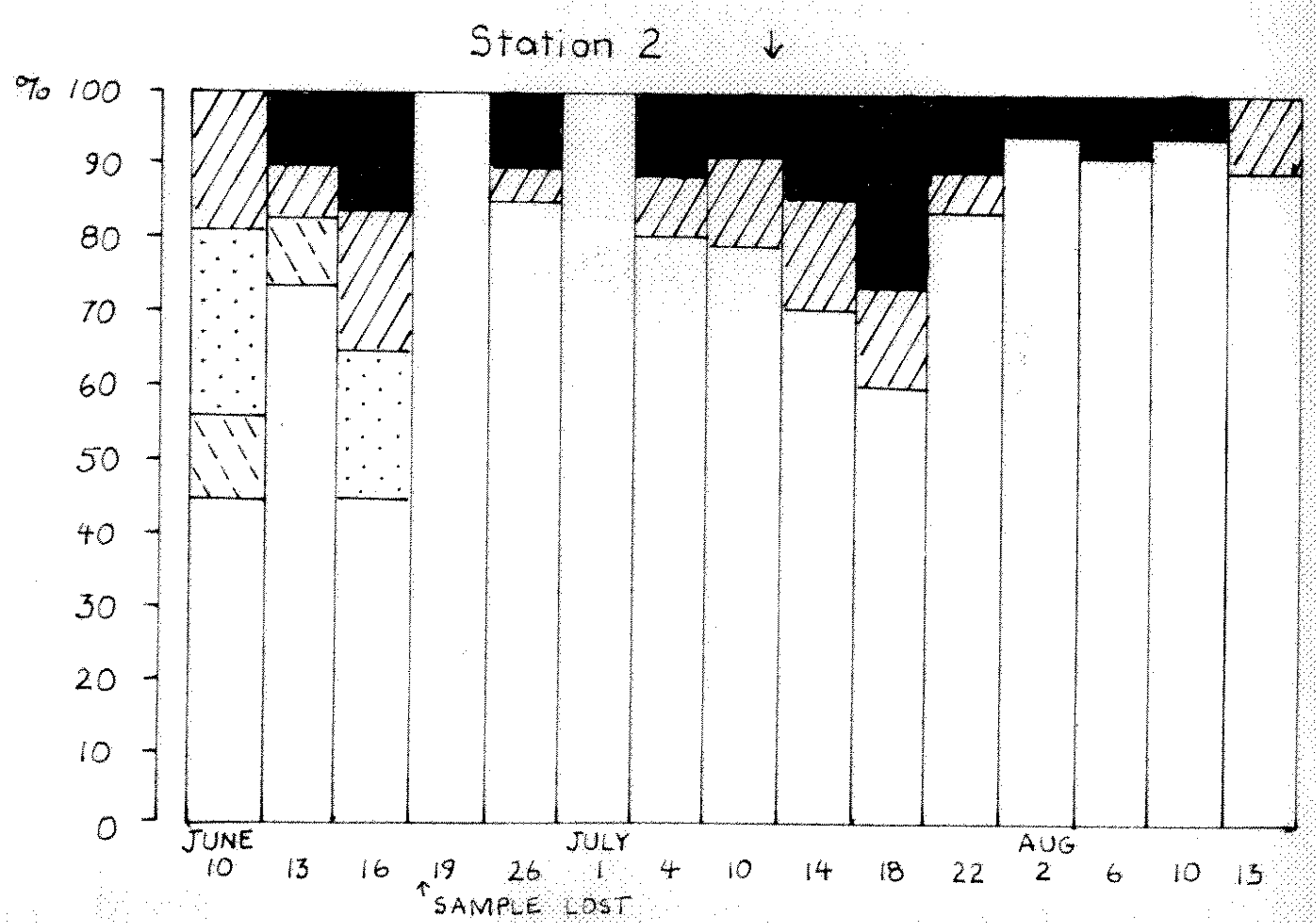
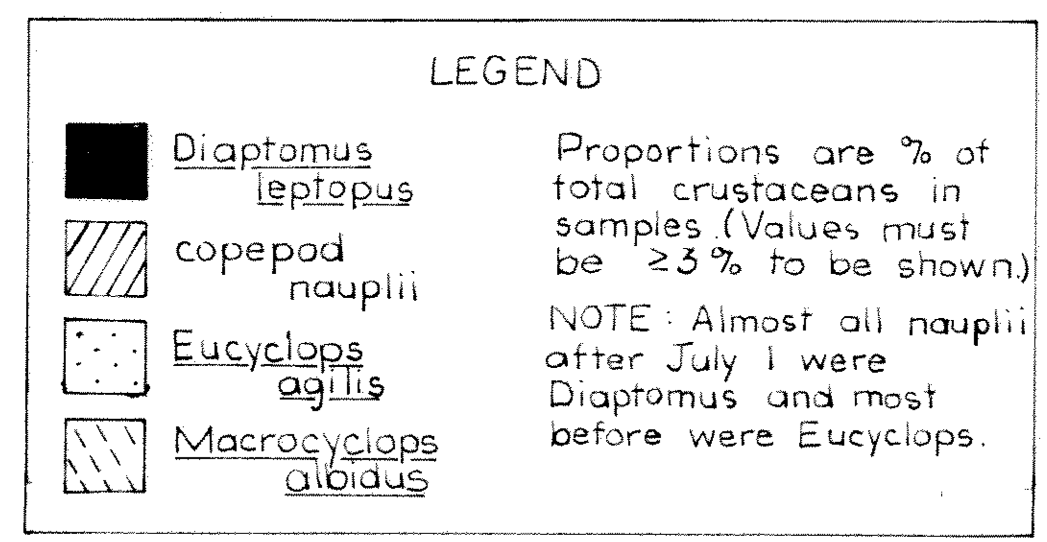


FIGURE 17 Composition of the crustacean zooplankton of Lily Pad Lake at open water stations.
B) COPEPODS.





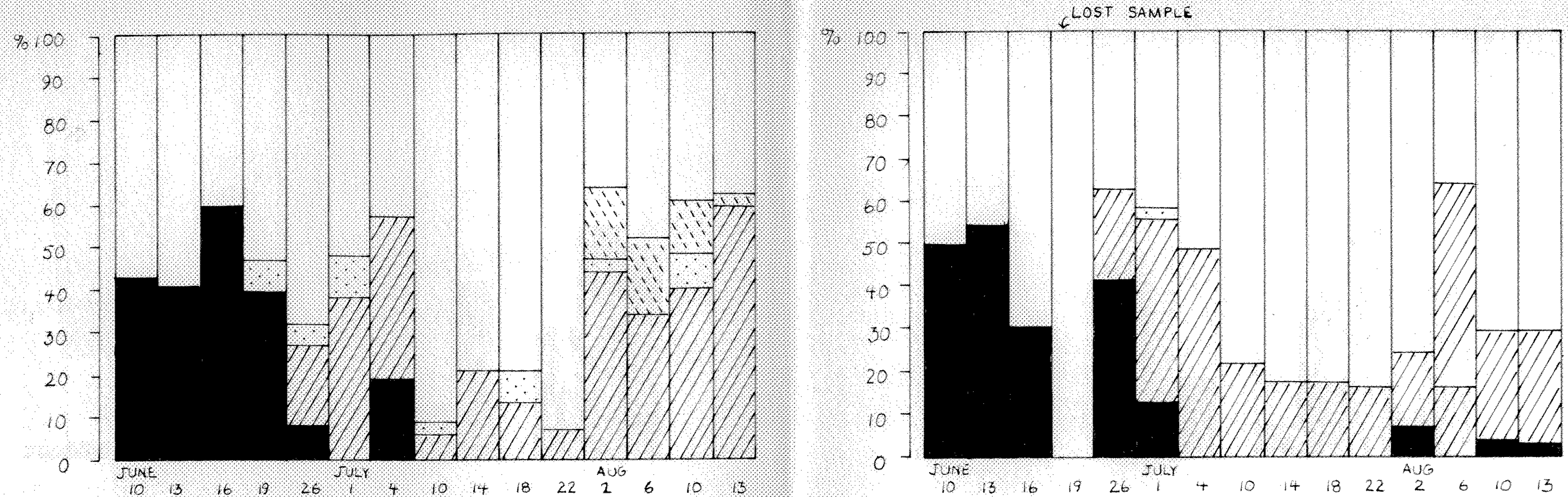
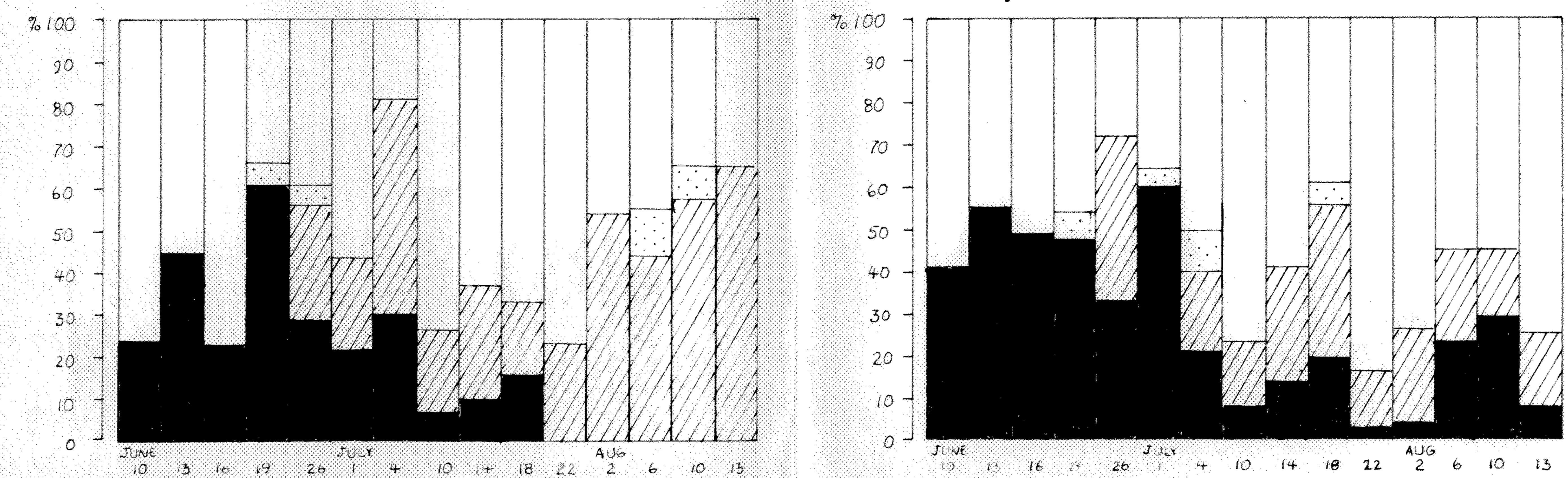
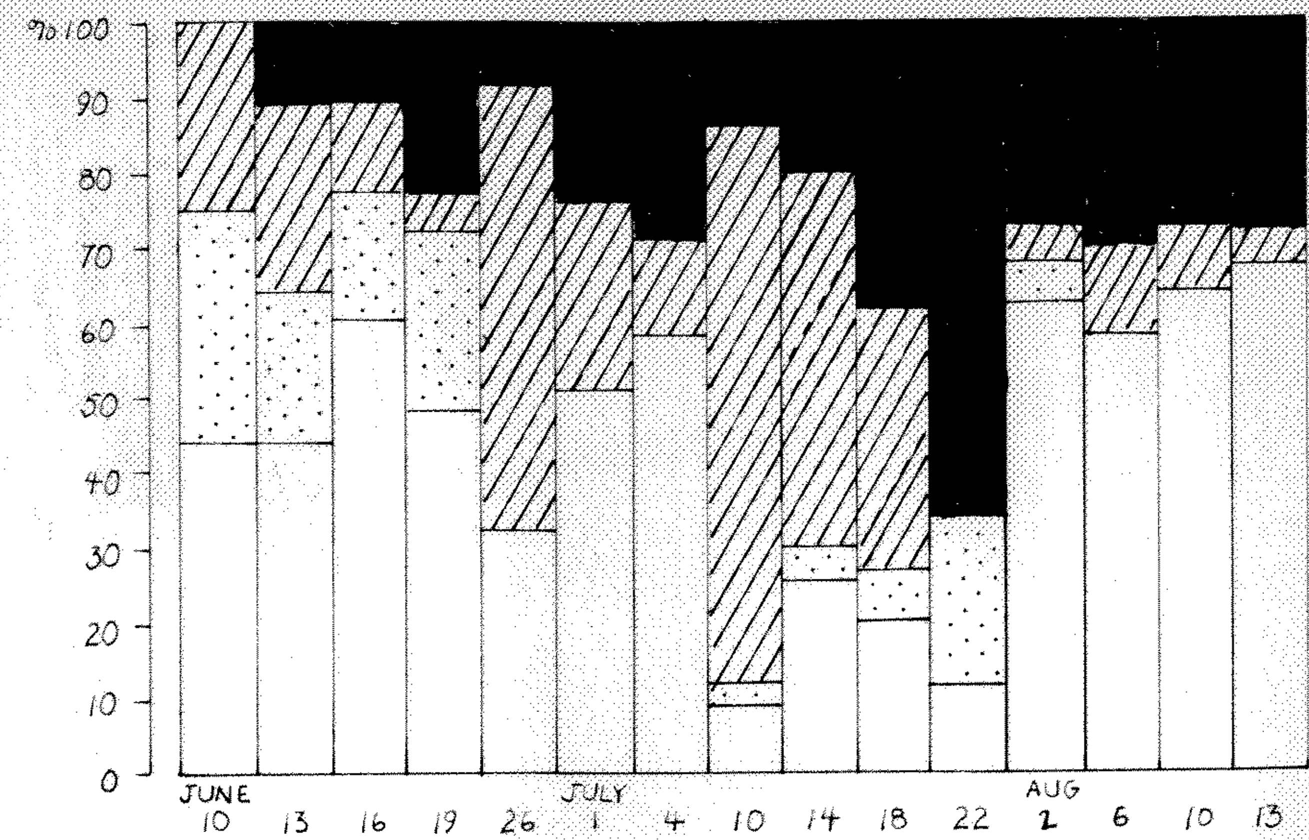
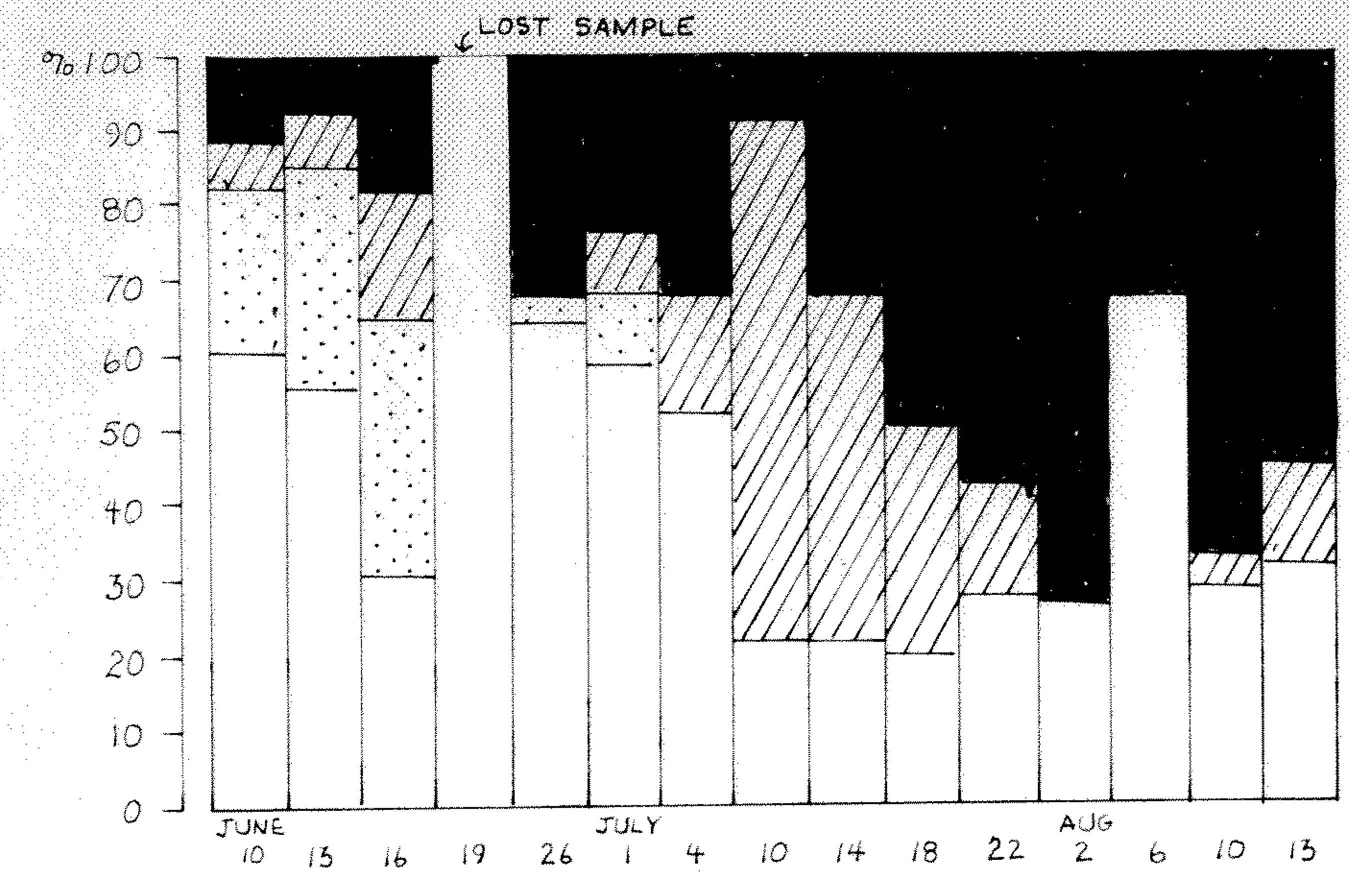


FIGURE 18 Composition of the crustacean zooplankton of Lily Pad Lake at open water stations. A. CLADOCERANS. (Legend as for Figure A.)





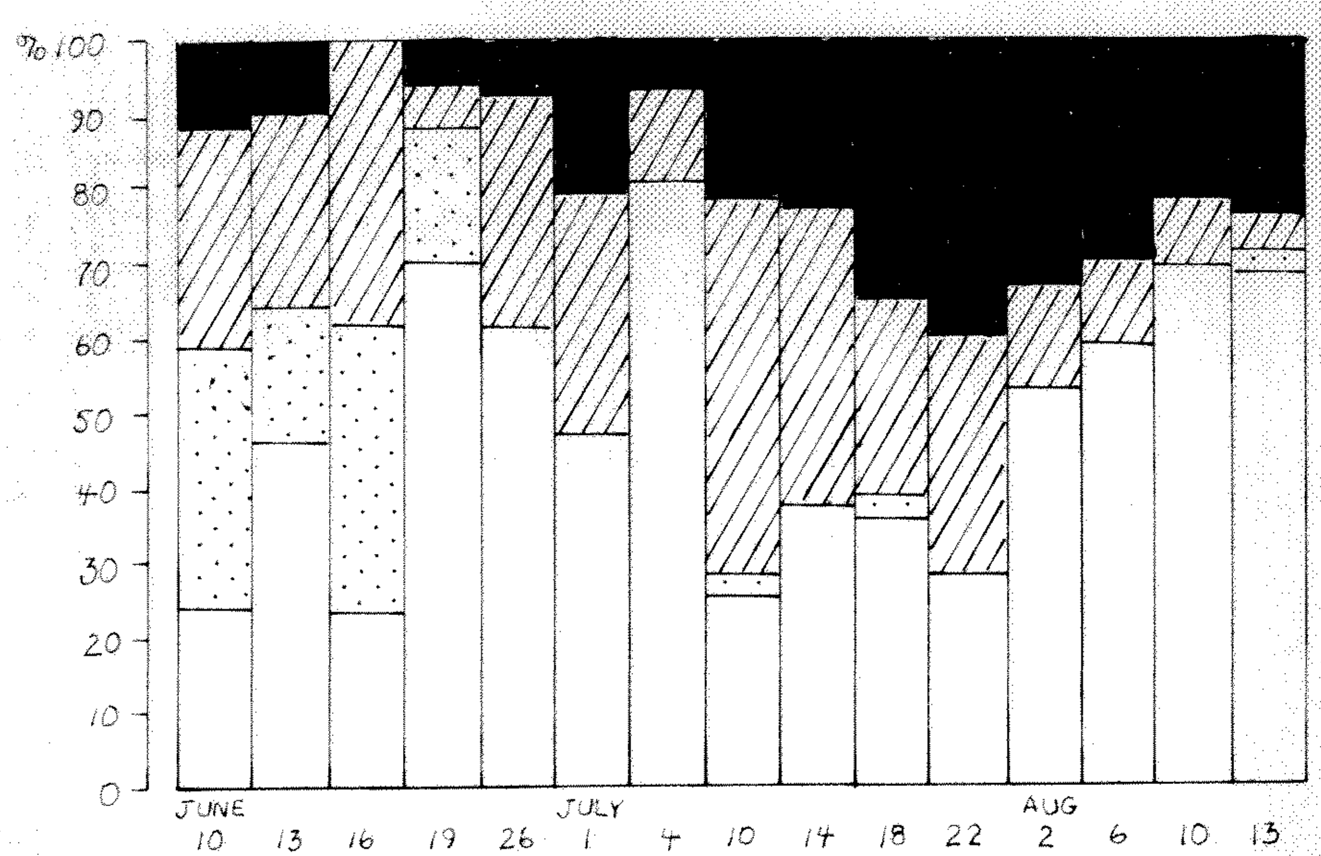
Station 4 horizontal tow ↑



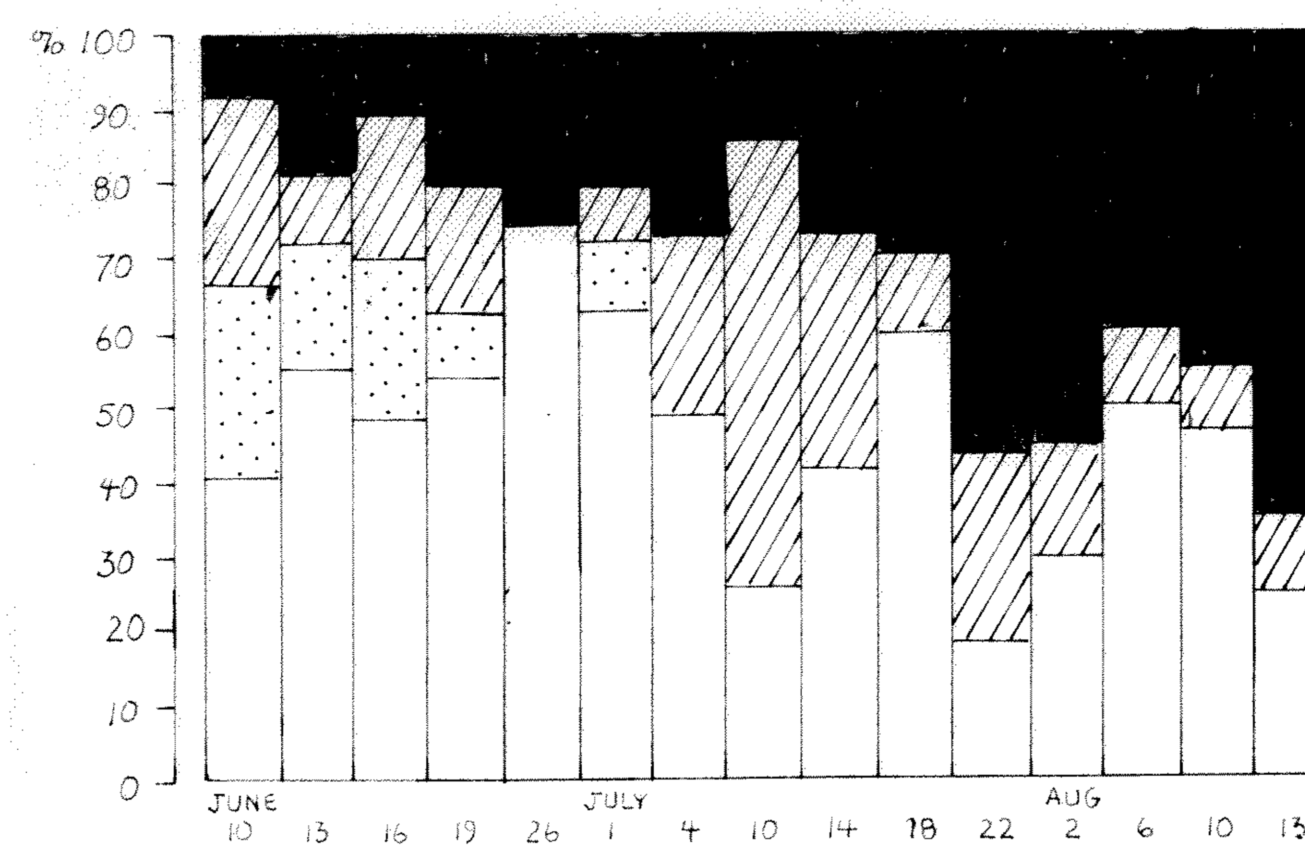
Station 5 horizontal ↑

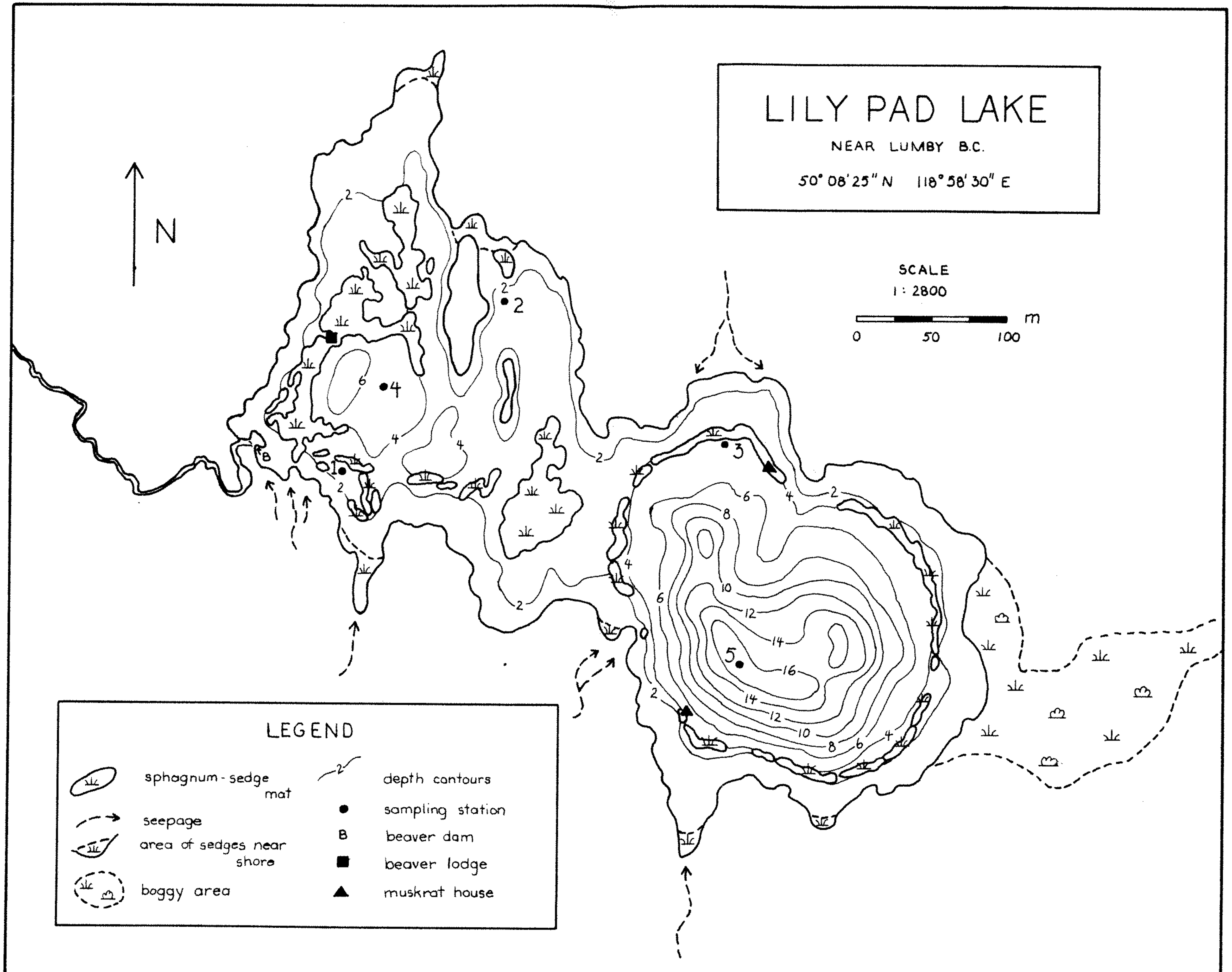
FIGURE 18 Composition of the crustacean zooplankton of Lily Pad Lake at open water stations.
B. COPEPODS. (LEGEND AS FOR FIGURE B)

vertical tow ↓



vertical ↓




LILY PAD LAKE
NEAR LUMBY B.C.
50° 08' 25" N 118° 58' 30" E
N
SCALE
1 : 2800
0
50
100
m
LEGEND
sphagnum - sedge mat
seepage
area of sedges near shore
boggy area
depth contours
sampling station
B beaver dam
beaver lodge
muskrat house

to Anderson's (1974) mean of 5.27 species for the Rocky Mountain lakes, possibly reflects Lily Pad Lake's small size and relatively great complexity, and perhaps also the fairly extensive littoral sampling that was conducted in this study.

Habitats

There appeared to be some habitat preferences among the crustacean zooplankton. *Sida crystallina*, *Acroperus harpae*, *Simocephalus vetulus*, and *Macrocyclops albidus* all preferred the littoral areas (see Appendix 2 and Figures 17 A-B and 18 A-B). Although not occurring often, *Eurycercus lamellatus*, *Graptoleberis testudinaria*, *Lathonura rectirostris*, *Streblocerus serricaudatus*, and *Scapholeberis kingi* were collected in littoral tows as well. All of the above zooplankters have been described as inshore and shallow water species by others (Anderson, 1974; Carl, 1940; Brooks, 1966). Both *Graptoleberis* and *Eurycercus*, for example, are bottom-loving, and *Lathonura* remains attached to aquatic plants much of the time (Brooks, 1966). *Sida* also prefers this latter habit. (Reynolds, pers. comm.).

Of the more common crustaceans in Lily Pad Lake, *Polyphemus pediculus*, also described as a shallow water species (Anderson, 1974; Carl, 1940), definitely seemed to prefer the littoral areas, and was most abundant at Station 2 (Figures 17 A and 18 A). *Daphnia rosea*, although it was abundant in all parts of the lake during much of the study period, generally composed a slightly greater percentage of the total individuals in the littoral samples. Together with *Polyphemus*, this plankter took up the major portion of the zooplankton communities at the littoral stations. On the other hand, *Daphnia schodleri* exhibited some preference for the open water, at least in mid-summer; individuals of this species were most abundant in Station 5 vertical samples during July and August and it was in these samples that essentially all the adults occurring during this time were found. This implies a preference by D. schodleri for lower temperatures, also suggested by this species' population changes during the study period (see below). Diaptomus leptopus definitely preferred the open water, especially the larger open water area of the lake; this plankter usually made up about 10-30% of the individuals in littoral samples, while in the samples from the open water, at least during July and August, it invariably composed more than 40%, and often as much as 70-80%. (These proportions include nauplii. See Figure 17B~~A-C~~ and 18B and accompanying note). The low relative abundance of Diaptomus in the littoral areas, where Polyphemus was abundant, suggests that Polyphemus may have been preying upon Diaptomus. However, Anderson (1970) found no evidence of such activity by this cladoceran in his experiments; other prey was preferred. Competitive interactions between copepodids and Daphnia rosea is a second possibility (see below). Most adults of Diaptomus were found in open water samples, and they occurred somewhat more abundantly in vertical tows than in horizontal tows. In contrast, nauplii and copepodids apparently somewhat preferred the surface waters (see Appendix I). Perhaps this is a consequence of greater oxygen availability at the surface, as suggested by Hazelwood and Parker (1961). Temperature and light may play a role in the distribution of the adults. ~~(see discussion on vertical migrations).~~

Some zooplankton species did not seem to show any appreciable habitat preference during their periods of occurrence in the lake. Eucyclops agilis, though listed as a littoral copepod by Anderson (1971) and others, was one of these. Chydorus sphaericus was also found as often in open water as near shore; this cladoceran is perennial in the littoral and develops in the limnetic zone in summer (Wetzel, 1975; p. 454).

Anderson (1974) found that, although many crustacean species were more common either in littoral or limnetic waters, none seemed to be exclusive to one habitat. Since Lily Pad Lake is small and shallow, one would expect movement from habitat to habitat to occur quite extensively, and that several "littoral" forms would be present in the open water. Since the smaller open water area (Station 4) is only about 1.2 - 1.8m deep and has Potamogeton natans growing in it, it is actually more like a littoral station rather than a limnetic one, and the zooplankton communities of this area would be expected to include more "littoral" forms than those of the much deeper large open water area. In fact, it is in Station 4 samples that appreciable numbers of Sida and Polyphemus were found (see Figure 18A).

Among littoral stations, numbers 1 and 2 resembled each other in species composition. This is to be expected since the water depth was the same and similar plants were growing in both areas. Both stations were well protected from wind action, since they were bordered by mats, islands, or juts of land in the direction of prevailing winds, and both were located on the NNE side of land, and thus received similar amounts of sunshine. Zooplankton communities at littoral Station 3 differed from the other two, however; They were similar to those from open water stations in that such species as Sida and Acroperus never made up a significant proportion ot the total individuals, and, in general, there were fewer species present. Two possible reasons for this are: 1) water was over twice as deep at Station 3 as at other littoral stations, and there was no abundant plant growth on the bottom, and 2) the station was exposed to wind blowing acrøoss the large open water area, and thus must have received many individuals from the open water community. One noticeable similarity between this station and the other littoral stations, however, was the occurrence of Polyphemus in relatively high abundance. The presence of the floating mat was probably important in determining the littoral character of this station.

Changes in the crustacean zooplankton communities during the summer

Because Lily Pad Lake's crustacean zooplankton communities were described by means of relative abundance rather than absolute numbers, it is a little difficult to show numerical changes in the populations during the study period, and to attribute these changes to environmental factors such as temperature, competition and predation. In addition, the study period was rather short. Nevertheless, some trends may be interpreted from the data. Figures and show changes in relative abundance of the four major crustacean zooplankton species found at the open water stations.

Diaptomus leptopus (Figure 19) was present, as copepodids, at a fairly constant relative abundance in late spring. Adults appeared on June 26, and gravid females were present on July 1. (see Appendix 1). Then a great increase in nauplii occurred during the period from July 4 - 14 (see Figure 19 and the note below it), and, following, an increase in numbers of copepodids. Adults were most abundant during late June and early July, just before the increase in nauplii occurred, but were present in low numbers throughout the rest of the study period, too; some of these were females with egg sacs. It is difficult to say whether the later adults were all from the same late spring - early summer generation

LEGEND

Diaptomus leptopus
adults
copepodids

copepod nauplii

Eucyclops agilis

NOTES

1) Essentially all nauplii present before July 1 were *Diaptomus* and most occurring before this were (appeared to be) *Eucyclops*.

2) *Eucyclops* adults and copepodids were lumped together, but adults never made up more than 1% of total crustaceans in samples.

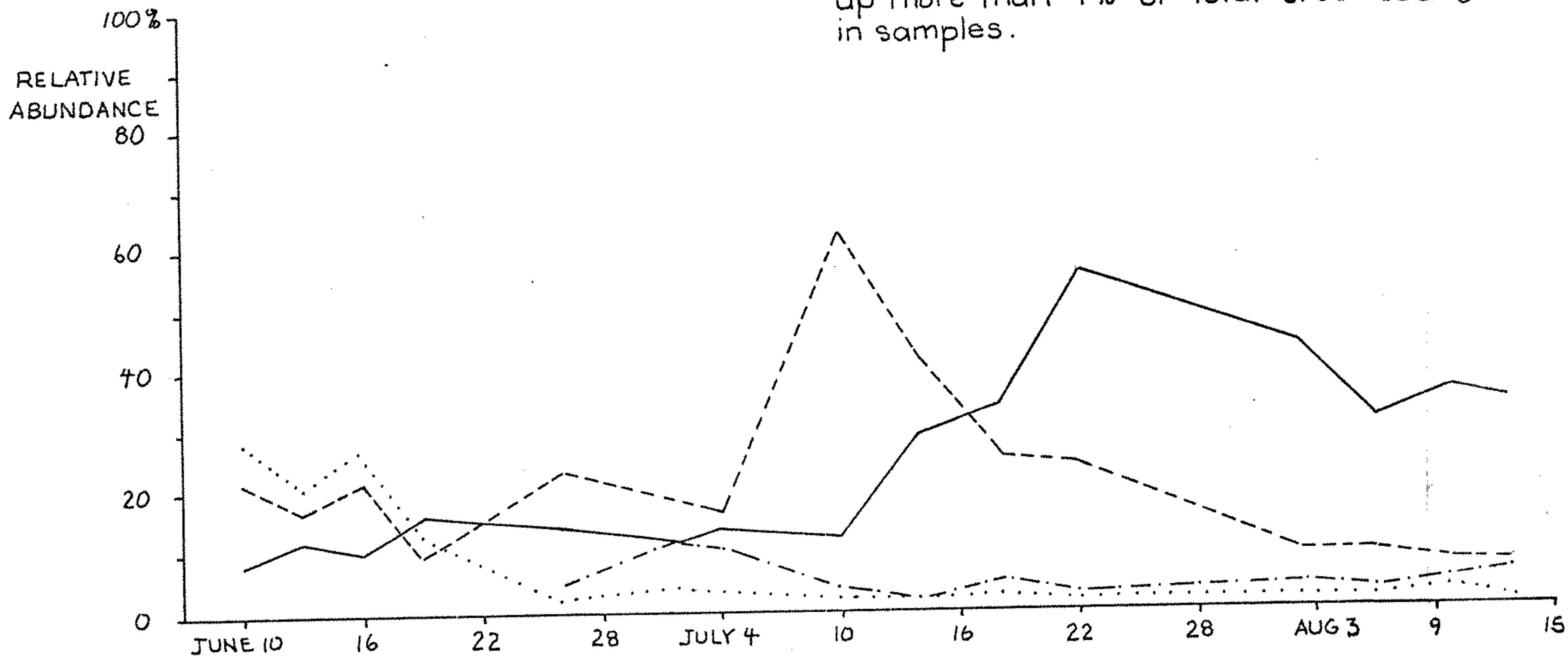


FIGURE 19 Relative abundance of 2 copepods in Lily Pad Lake 1976. (Values are a mean for open water stations on each date.)

or not, but since it takes some time for development to adults (probably about 4-6 weeks judging from Carter's (1974) results for *Diaptomus ashlandi*), it seems likely that they were. However, the slight increase in relative abundance of adults on the last sampling date may represent the maturing of the summer copepodids. It appears, then, that the individuals of *Diaptomus leptopus* found in Lily Pad Lake during the study period belonged to one of two generations: late spring - early summer or mid-summer. According to Wetzel (1975, p. 463), most species of calanoid copepods in temperate regions exhibit prolonged reproductive periods, with several generations per year. Carter (1974) found that, in a shallow beaver pond in Ontario, *Diaptomus ashlandi* hatched from resting eggs early in May and produced four complete generations, the last maturing in late autumn. I would suspect that, in Lily Pad Lake, the first *Diaptomus leptopus* individuals collected represent the first generation of the year, judging from the apparent generation time (see Figure 19). There would most likely have been at least one, and maybe two, generations during late summer and autumn, subsequent to those present during the study period.

Eucyclops agilis was fairly abundant only in the late spring samples (Figure 19). Copepodids were most abundant in June 16 samples (see Appendix 1) and it was in these samples that adult females were first present. Shortly after, during late June, there appeared to be a small increase in nauplii, and an accompanying decline in copepodids and adults. Occasional copepodids and adults, including females with egg sacs, were found in samples for the remainder of the study period, but the population apparently remained very small. Perhaps summer conditions in the lake were unfavourable for reproduction of *Eucyclops*, or competition from Diaptomus nauplii and copepodids was great. Eucyclops agilis, like Diaptomus, is herbivorous (Fryer, 1957). Alternatively, individuals may have aestivated. A number of cyclopoid copepods are known to enter periods of dormancy, as either eggs or copepodids, in the sediments (Wetzel, 1975; p. 462). The resting stage may occur in winter or mid-summer. (Anderson, 1970b) found that in some ponds in western Canada cyclopoids had reproductive maxima shortly after ice break-up, and then again in autumn, and, in a bog pond studied by Daggett and Davis (1974), the maxima for Eucyclops (adults) were in March and August. Perhaps, then, Eucyclops prefers cooler temperatures, and is better able to compete for resources when the water is cool.

Daphnia schodleri populations exhibited a trend somewhat similar to that of Eucyclops; it was relatively abundant during early summer and was rather sparsely represented later on in the study period (Figure 20). Juveniles were very high in relative abundance in mid-June, when they composed 35-45 % of the zooplankters present, and adults, although never as abundant, also showed a maximum around June 19. During the latter part of June, ephippial adults appeared, suggesting that conditions were becoming unfavourable for this cladoceran; the first ephippial adult was seen in a June 16 sample, and peak production of ephippial eggs occurred around June 26. Thereafter, numbers of both adults and juveniles decreased and remained low for the rest of the study period. Because this decrease in abundance occurred at a time when water temperatures were generally highest (Figure 14), and since those remaining individuals, especially adults, were usually collected from vertical tows at the deep station (see Appendix 1), it appears that D. schodleri may prefer cooler temperatures. The apparent

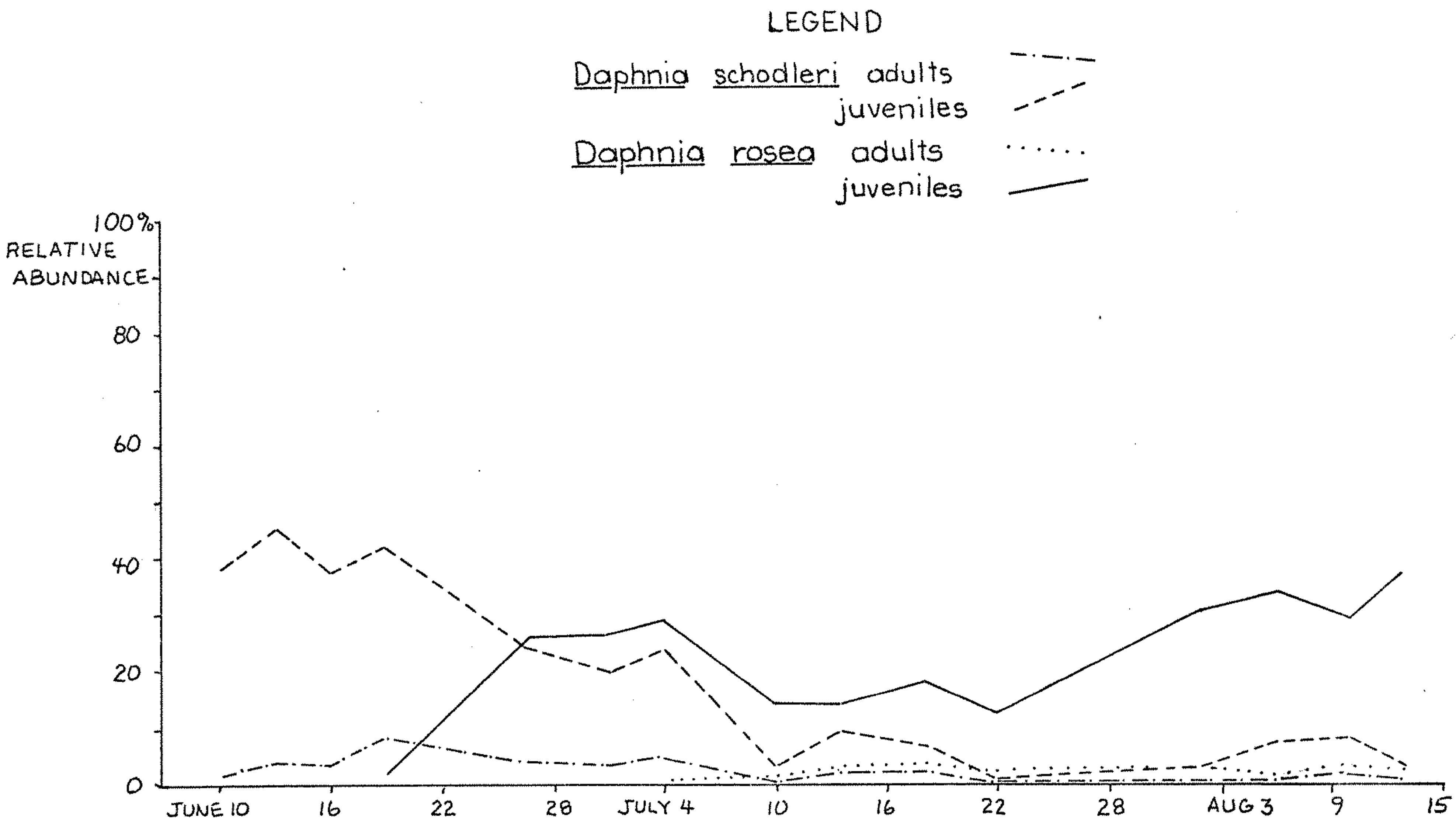


FIGURE 20 Relative abundance of 2 major cladocerans in Lily Pad Lake 1976. (Values are means for open water samples for each date.)

increase in juveniles at the end of the study period, when weather was cool and water temperature was decreasing somewhat (Figure 14), supports this idea, and suggests that a second population maximum may occur in autumn. However, Hazelwood and Parker (1961) found that higher temperatures resulted in larger populations of *Daphnia schodleri* in shallow Kepple Lake, B.C. Perhaps, the *Daphnia* recorded from Lily Pad Lake is a physiological race, adapted to lower temperatures. In general, temperature increases the reproductive rate in *Daphnia*, by increasing the frequency of moulting, and thus the frequency of production of young (Hall, 1974). Other factors are involved in zooplankton population regulation, though, besides temperature. In Kepple Lake, *D. rosea* was not present; perhaps in Lily Pad Lake competition between the two *Daphnia* species took place (see below). Alternatively, selective predation of the relatively large *D. schodleri* may have been important (also see below). Possibly individuals escaped predation to some extent by remaining in the deeper water.

Daphnia rosea was abundantly present during the warmest part of the study period (Figure 20). During the cooling trend in mid-August males and then ephippial females appeared (see Appendix I). Thus this species seems to be a warm-water species in Lily Pad Lake. It is possible that, under mid-summer conditions, *D. rosea* is better able to efficiently utilize its environment than *D. schodleri*, since the former appears to dominate during this time. Competition between two species of the same genus, due to similar food requirements, has often been suggested to occur, and generally in limnetic zooplankton communities, each genus is represented by only one species at any given time (Pennak, 1957). If two congeneric species do occur in a lake, some means of separation, reducing competition, may occur: differences in body size (which results in utilization of different sized food), differences in habitat, and/or differences in optimal conditions corresponding to the seasons (Pennak, 1957; Sandercock, 1967). Although D. schodleri adults are considerably larger than D. rosea adults (~~Figure~~), and thus may filter out larger food particles from the water, the juveniles of these two species most likely compete for food. There seem to be no significant habitat differences between the two Daphnia species in Lily Pad Lake since, when abundant, the individuals occur in all parts of the lake (although D. rosea composed a slightly greater proportion of the total in littoral samples than open water samples, as mentioned above). Thus, it appears that D. schodleri and D. rosea in Lily Pad Lake are separated mainly temporally. However, this separation may not illustrate differences in optima for certain conditions (such as temperature) and consequent "avoidance" of competition, but rather may be a result of competition; as mentioned before, D. schodleri has exhibited a mid-summer maximum in other lakes, and perhaps would have remained abundant in Lily Pad Lake if D. rosea was not present.

It is also possible that Diaptomus leptopus may have affected Daphnia populations. The reduction in relative abundance of D. schodleri during mid and late July seemed to be correlated with the increase in numbers of Diaptomus copepodids (see Figures 19-20). This may of course not reflect the actual numerical behaviour of the population, since collections contained unusually high numbers of organisms during this time. ~~Per contra,~~ Anderson (1971) found few co-occurrences of large cladocerans and non-predaceous diaptomids (of which D. leptopus is one) in alpine and subalpine ponds and lakes in western Canada, and Hazelwood and Parker (1961) found a negative correlation between numbers of *Diaptomus leptopus* and *Daphnia schodleri* in Kepple Lake. These results suggest that competition may occur between these two zooplankters. The relative abundance of *Daphnia rosea* also dropped during the time when high numbers of *Diaptomus* nauplii and copepodids became present, which implies competition between the copepod and this smaller cladoceran as well. However, the drop in *D. rosea* abundance also appears in the littoral station results, too, and since *Diaptomus* was never as abundant in the littoral areas, other factors must be working (see below).

The above discussion has concentrated on the major crustaceans of the open water habitats, but trends in some littoral zooplankton populations were present also. It can be seen in Figure 17A ~~A-C~~ that *Polyphemus pediculus*, although somewhat patchy in occurrence, was abundant from late June through to early August, with a maximum around July 1. Other investigators (Daggett and Davis, 1974) have recorded a single summer maximum for this cladoceran. *Sida crystallina* was significantly abundant on several days from mid July until the end of the study period. (Its sporadic pattern of abundance may be attributed in part to the path of the plankton net on the sampling day; on days that many plants intercepted the net, more individuals of this species would be collected than on days when the net traversed few plants). Occasional individuals of *Sida*, mostly large adult females with broods or eggs, were also found earlier in the summer (June 26 to July 4), but apparently conditions were not favourable for successful development of young until mid-July. Seasonal trends for such species as *Sida* may correspond to periods of plant growth (Daggett and Davis, 1974), and, in Lily Pad Lake, aquatic plants were reaching peak biomass at the time of Sida's population increase. Acroperus harpae also appeared in appreciable numbers in mid-summer samples, suggesting it is a warm water species. Like other littoral forms, this cladoceran may have spent much of its time on the bottom during periods when it was absent or occasional in samples. Simocephalus seems to show an opposite trend; it was found in mid-June samples, then was absent until mid-August. Perhaps it prefers cooler temperatures, or is unable to compete with Daphnia rosea. Finally, the cyclopoid copepod Macrocyclops albidus was found only in mid-June littoral samples. This copepod, like Eucyclops agilis, has shown early spring and autumn maxima in other lakes (Daggett and Davis, 1974).

So far, the dynamics of Lily Pad's zooplankton communities have been discussed without considering predation to any great extent. Populations of crustacean zooplankton are significantly influenced by predators (Dodson, 1972; Daggett and Davis, 1974; Brooks and Dodson, 1965 and others). If one population can avoid predation more efficiently than another, its competitive ability is enhanced, just as it is if one population can reproduce faster at the given temperature and light conditions, or can utilize the food source better than another. Although there are no fish in Lily Pad Lake, there are other organisms that prey upon crustaceans. Chaoborus larvae, which were quite abundant throughout the study period in littoral and open water areas, is one of these. Dodson (1972) found that Chaoborus accounted for 90% of the total mortality of Daphnia rosea in a shallow boggy pond in Colorado; it tended to eat the smaller non-reproductive daphnids. Although no counts were made, there appeared to be an increase in numbers of Chaoborus during mid and late July in Lily Pad Lake, and, if it selectively preyed upon Daphnia, this insect may have been important in causing the apparent decrease in abundance of Daphnia rosea, and perhaps also D. schodleri, during this time. However, some Chaoborus species have been found to prefer young copepods to Daphnia (Wetzel, 1975; p. 525). A second predator in Lily Pad Lake was the large amphipod Gammarus limnaeus, which was abundant, especially in the open water, during June. Although most amphipods are omnivorous scavengers (Pennak, 1953), individuals of this species were observed eating large Daphnia schodleri adults in Lily Pad Lake. Anderson (1974) also reports that some Gammarus species are selectively predaceous. Thus, Gammarus may have played a role in regulating numbers of D. schodleri in the lake. Larvae of the predaceous diving beetles Dysticus spp. and Asilius spp. were also present in all parts of Lily Pad Lake, and were most abundant during late June and early July. These insects reached a fair size (the largest collected was about 40 mm long) and therefore may have chosen to eat other insects rather than zooplankton; they were seen eating Gammarus and dragonfly nymphs. Nevertheless, some of the larger zooplankters, such as adult D. schodleri and Diaptomus, may have been taken by them. Finally, many leeches are carnivorous, and there were several species in the lake. They were extremely abundant, and, although most common in the littoral benthos during much of the study period, they were very active from mid-July through to early August, and were frequently noticed swimming about even in the large open water area during this time. They may have affected zooplankton dynamics, too. Additional predators of crustacean plankters, in the littoral areas only, include the backswimmer Notonecta, which was very common in mid-July and thereafter; dragonfly and damselfly nymphs, also abundant; water striders and mites. The cladoceran Polyphemus itself is predaceous, and may have affected the abundance of *Daphnia rosea* in littoral areas.

A final aspect to note about changes in Lily Pad's zooplankton communities during the study period involves the total number of species present at a time. Pennak (1957) found that the number of species present did not vary markedly from one season to another. He was referring to limnetic zooplankton communities. In Lily Pad Lake, there was no apparent increase in species numbers at open water stations, in accord with Pennak; there were, however, appreciable increases at the littoral stations during late July and early August (see Figure 17A ~~A-G~~ and B and Appendix2). In addition, dominance was less definite during this time; up to 5 species made up 15% or more of the total numbers in some samples, such as, for example, the July 22 Station 1 sample (see Appendix2). This increase in species richness may be due to the full development of aquatic plant communities at this time, providing a maximum number of habitats and thereby allowing several species to be relatively abundant at once.

Notes on total density

In general, Lily Pad Lake seemed to be moderately densely populated with crustacean zooplankton. One might not expect this to be so, since, due to its bog characteristics, the lake has relatively low phytoplankton productivity, and, also, since pH has been found to be a limiting factor of population sizes for some entomostracans (Hazelwood and Parker, 1961 (in Ward, 1940)). However, cladocerans and copepods do not need to feed on live algae; they are generally capable of utilizing detritus effectively (Pennak, 1967, and others), and Lily Pad's water had plenty of particulate matter in it, some of which must have been a possible food source for zooplankton. And the lake's pH is most likely not extremely low.

The total numbers of crustacean zooplankton found in Lily Pad varied with time. Although numerical densities were not calculated for the different samples, there was a noticeable increase in density in mid-July and numbers remained somewhat higher than before throughout the rest of the study period. This increase was especially, and nearly constantly, found to occur in horizontal tow samples from open water stations, especially Station 5; the most abundant plankter was Diaptomus. Littoral samples were very irregular with respect to density; sometimes, many individuals were collected from a station on one sampling day, and hardly any the next day at the same station (and, in addition, different littoral stations often differed greatly in density on any given day). The littoral phytoplankton also showed similar patchiness, suggesting possible interactions between food and feeders. Some irregularities probably occurred in the open water samples, too, but they appeared to be small. Other authors (for example, Sandercock, 1967) found horizontal clumping to be insignificant.

ROTIFERS

The following rotifers were found in Lily Pad Lake: (~~see figures~~)

Keratella quadrata
Keratella cochlearis
Conochilus unicornis
Asplanchna priodonata
Kellicottia longispina
Synchaeta sp.
Polyarthra sp.
Euchlanis sp.
Gastropus stylifer
Brachionus sp.
Lecane sp.
unidentified rotifer

Keratella cochlearis, *K. quadrata*, *Conochilus*, and *Asplanchna* were those that became most abundant in the lake. Others that were fairly common at some time during the study period were; *Kellicottia*, *Synchaeta*, *Euchlanis*, and *Polyarthra*.

There was an average of 5.2 species of rotifers (range 3-8) found in open water samples. Of these, usually only one was abundant; the dominant rotifer was either *Keratella quadrata*, or *Conochilus*. However, *Asplanchna* was abundant with *Conochilus* during the latter part of the study period, and *K. cochlearis* was nearly as abundant as *K. quadrata* in June 10 samples. These four rotifers are among those termed "characteristic" of limnetic zooplankton communities in the 27 Colorado lakes studied by Pennak (1957). Littoral waters contained an average of 4.4 species, with a range of 1 to 9, at any one time. These numbers, of course, refer to planktonic rotifers; there are doubtlessly many more attached ones in the littoral zone.

Of the rotifers occurring in the lake, several appeared to somewhat prefer the open water areas to the littoral: *Kellicottia*, *Synchaeta*, *Keratella quadrata*, *K.cochlearis*, and *Conochilus*. This is reflected in the higher average number of species in the open water zooplankton communities, noted above, and also in the higher abundances, in general (see appendix 2), of those species present there. Possibly the greater amount of water movement in the limnetic areas, allowing the rotifers to remain suspended more easily and also moving them about to new grazing waters, is favorable. *Euchlanis*, however, appeared to favor the littoral areas (also see appendix 1).

There were some trends in population dynamics of Lily Pad rotifers during the study period (figure 21). *Keratella quadrata* was abundant to very abundant for most of June, whereafter dominance appeared to be assumed by *Conochilus*. *K. quadrata* has been characterized by George and Fernando (1969, in Wetzel 1975 p.432) as a cold water form; in the two small southern Ontario lakes they studied, this rotifer occurred in the upper layers in winter, moved to the cooler hypolimnion as water warmed, and then declined in midsummer. The behavior of populations of *K. quadrata* in Lily Pad Lake also suggest that it prefers cooler water. It was present in low numbers throughout July and August, too, however, and produced eggs at this time as well as during its period of maximum abundance. Competition from *Conochilus* may have contributed to *K. quadrata's* decline(and also to the decrease in numbers of other June rotifers.)

Conochilus unicornis was the most abundant rotifer in the lake for most of the study period (figure 21). It has been described as a summer and autumn species. (George and Fernando, 1969, in Wetzel 1975, p. 433). It apparently became the major food source of the predaceous rotifer *Asplanchna priodonata*, which became very abundant during late July and August; *Conochilus* was seen inside many *Asplanchna* individuals in samples taken during this time, and *Asplanchna*

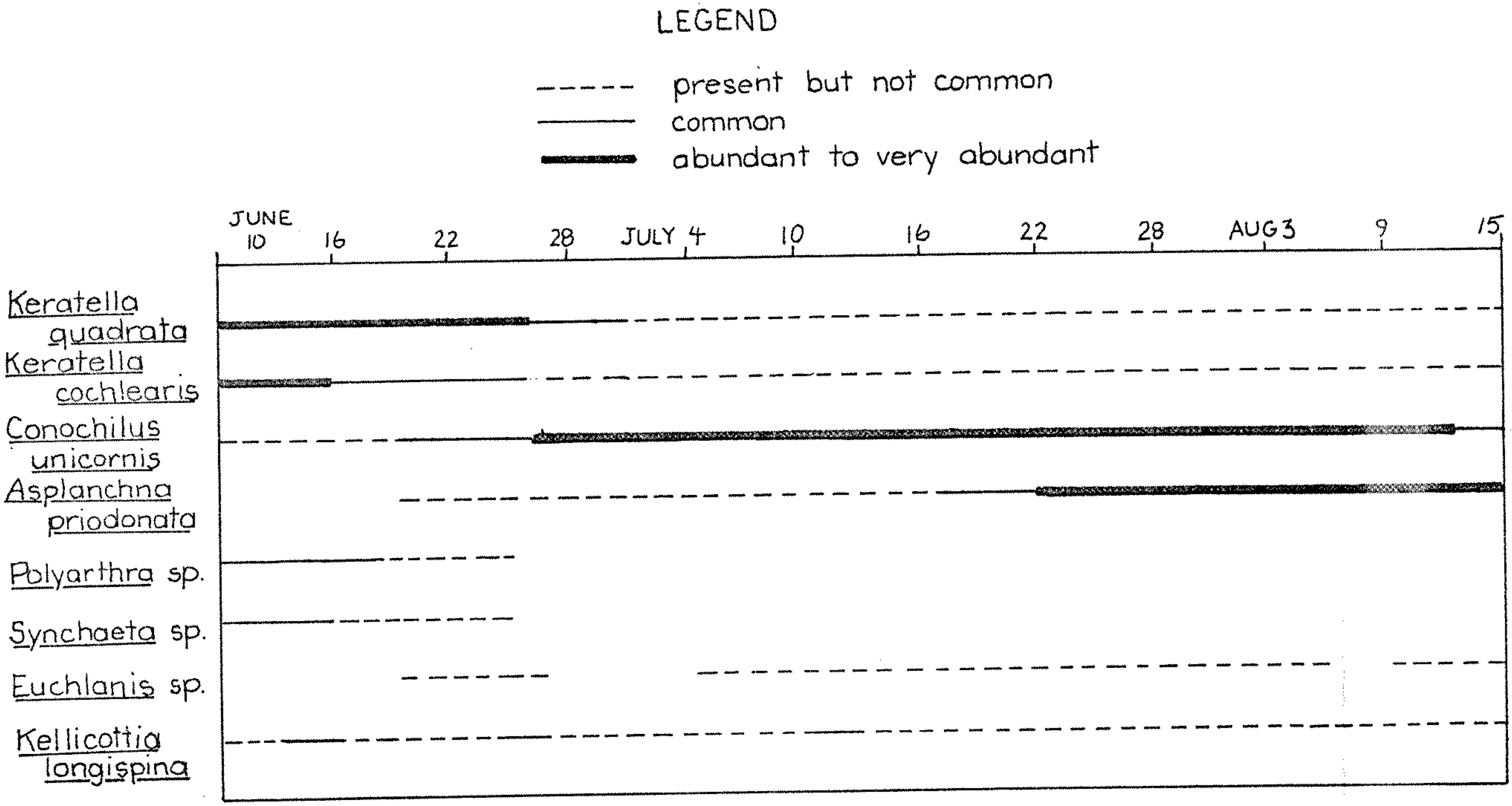


FIGURE 21 Abundance of rotifers in open water stations in Lily Pad Lake 1976.

was most abundant in samples containing mainly individuals of *Conochilus*. Predation most probably was the cause of the decline of *Conochilus* in mid-August.

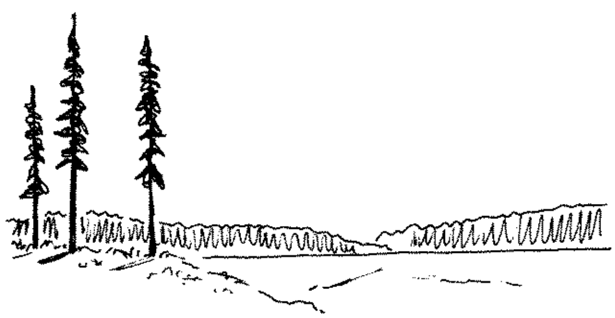
One rotifer which was present fairly consistently throughout the study period and did not show a maximum was *Kellicottia longispina*. This rotifer was perennial in the two Ontario lakes studied by George and Fernando (1969, in Wetzel 1975, p.433) and was uniformly distributed with depth all year; it thus apparently has a wide temperature tolerance range, at least in some lakes. In the Ontario lakes, *Kellicottia* showed a summer maximum.

Of the remaining Lily Pad rotifers, both *Polyarthra* and the predaceous *Synchaeta* were common, but never abundant, for the first half of June, and then disappeared completely. *Euchlanis* was occasional in samples from mid-June until late July, and was essentially absent in August. In most June samples, *Gastropus* was present in low numbers, as was the unidentified rotifer. Finally, *Brachionus* appeared occasionally in July and August, and *Lecane* occured once or twice in June and July (appendix 2).

In contrast to the crustacean zooplankton, the rotifer communities of Lily Pad Lake were greater in species richness in June than they were later on in the study period (see appendix 1). The great abundance of *Conochilus* may have left less "space" in the habitats of the lake for other species. The general increase in numbers of crustaceans, specifically *Diaptomus*, during July and August may have played a role; copepod nauplii are of a size such that they might compete with some rotifers for food.

According to Wetzel (1975 p. 658), acid waters contain many species and relatively few individuals. The proliferation of *Keratella quadrata* and *Conochilus* populations suggest again that Lily Pad Lake must not be extremely acidic. There was a general decrease in total numbers of rotifers in August. Possibly this is a reflection of predatory activities of *Asplanchna*, but other factors may have affected this trend.

NICKLEN LAKE



PHYSICAL CHARACTERISTICS

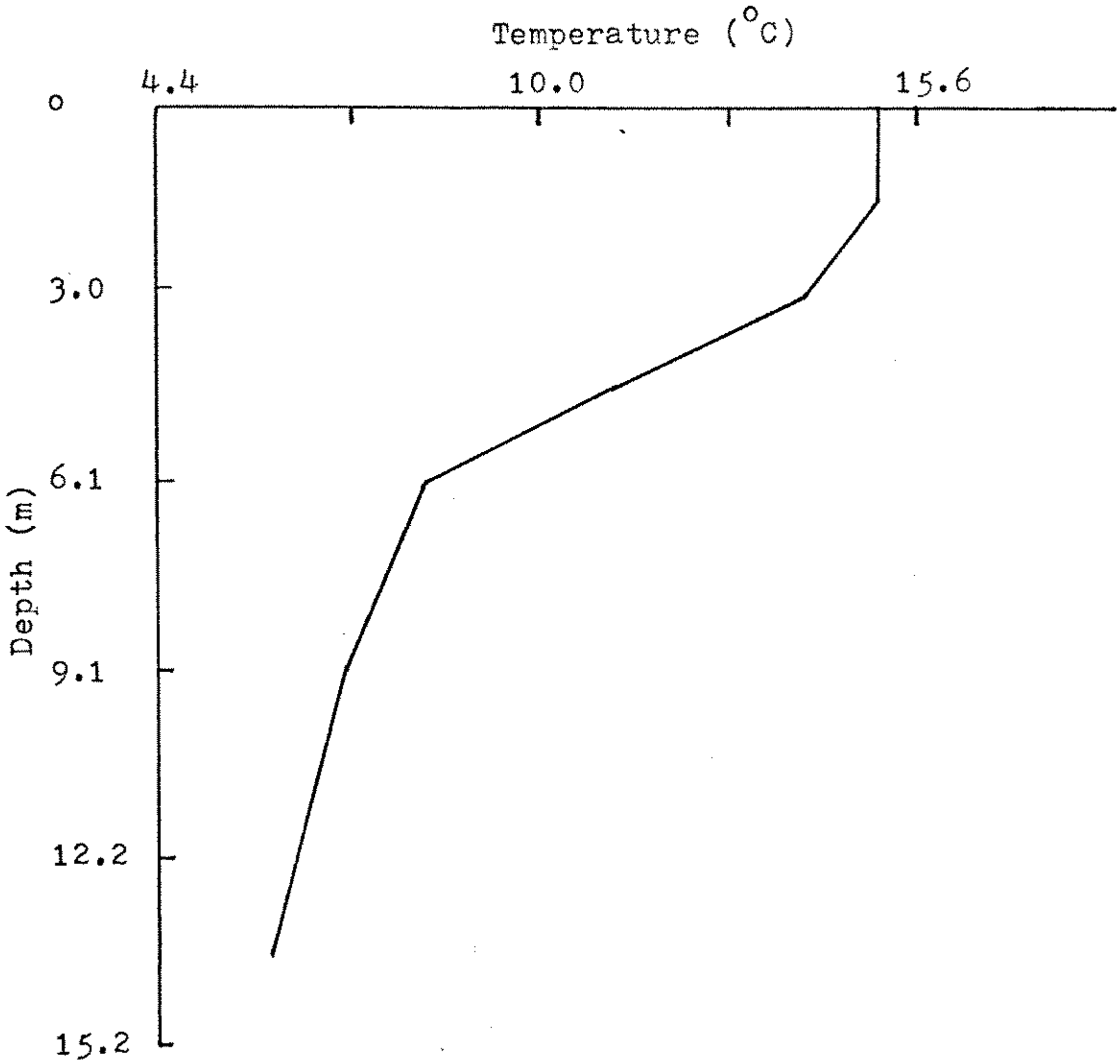
Nicklen Lake, being relatively large and deep, had a fairly well developed stratification (Figure 22 a-d). The lake was rarely calm, but apparently only the top few meters circulated; the epilimnion was only about 2.5 - 3.0 m thick. Littoral surface temperatures, shown in Table 11, were similar to those of the open water surface, with the exception of Station 3, the Beaver Pond. Lower temperatures here during the latter part of the study period are most likely the result of cool inflowing water from Nicklen Creek following heavy rains.

Nicklen Lake's Secchi depth was fairly constant during the study period (Table 12). Its water is also brown-stained.

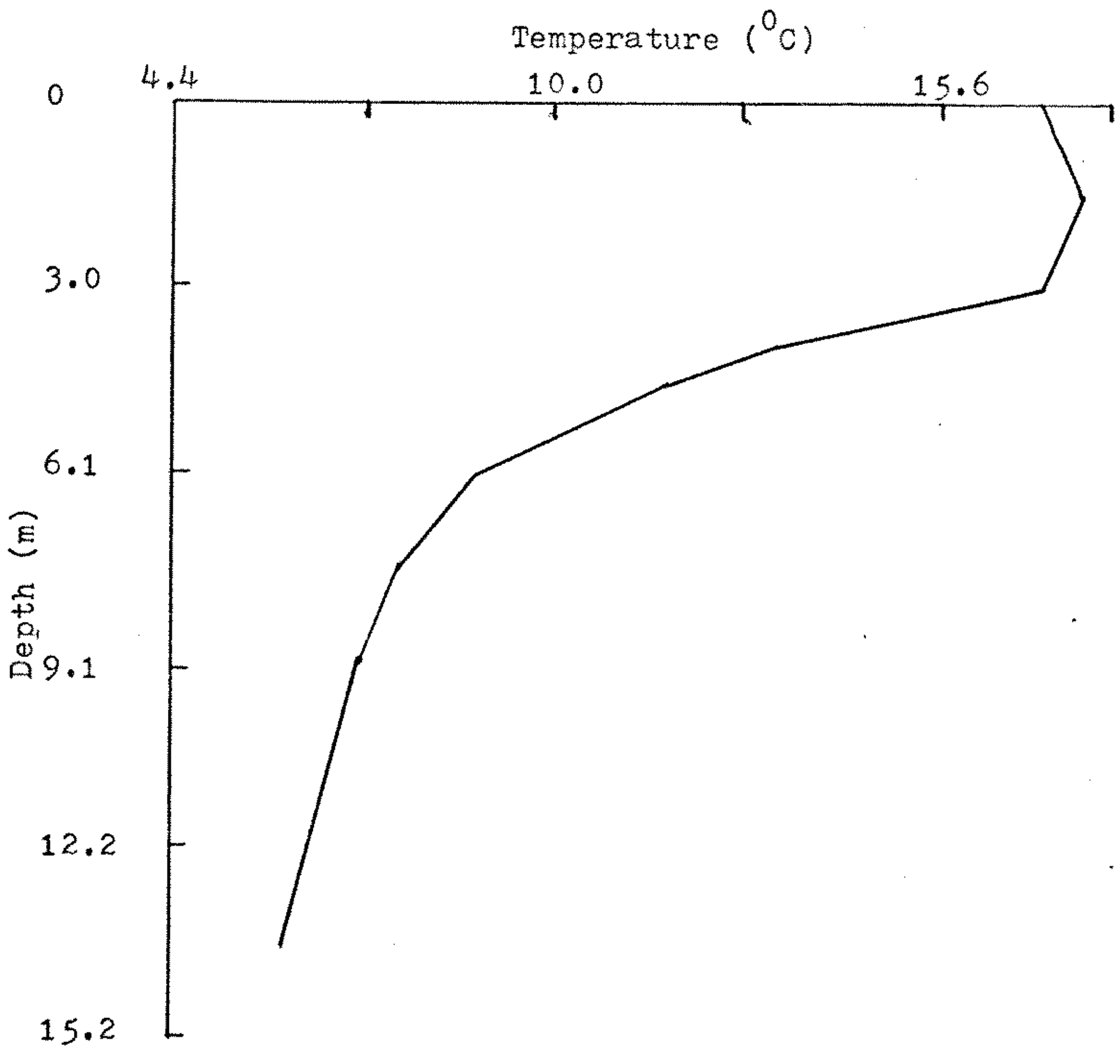
TABLE 11 Surface water temperatures (°C) at the three littoral stations in Nicklen Lake, 1976.

	July 13	July 17	July 21	July 24	Aug 5	Aug 12
Station 1	17.2	20.0	19.4	18.9	18.9	18.3
Station 2	17.2	20.0	19.4	18.9	18.9	18.3
Station 3	16.7	17.2	18.9	17.2	15.6	12.2

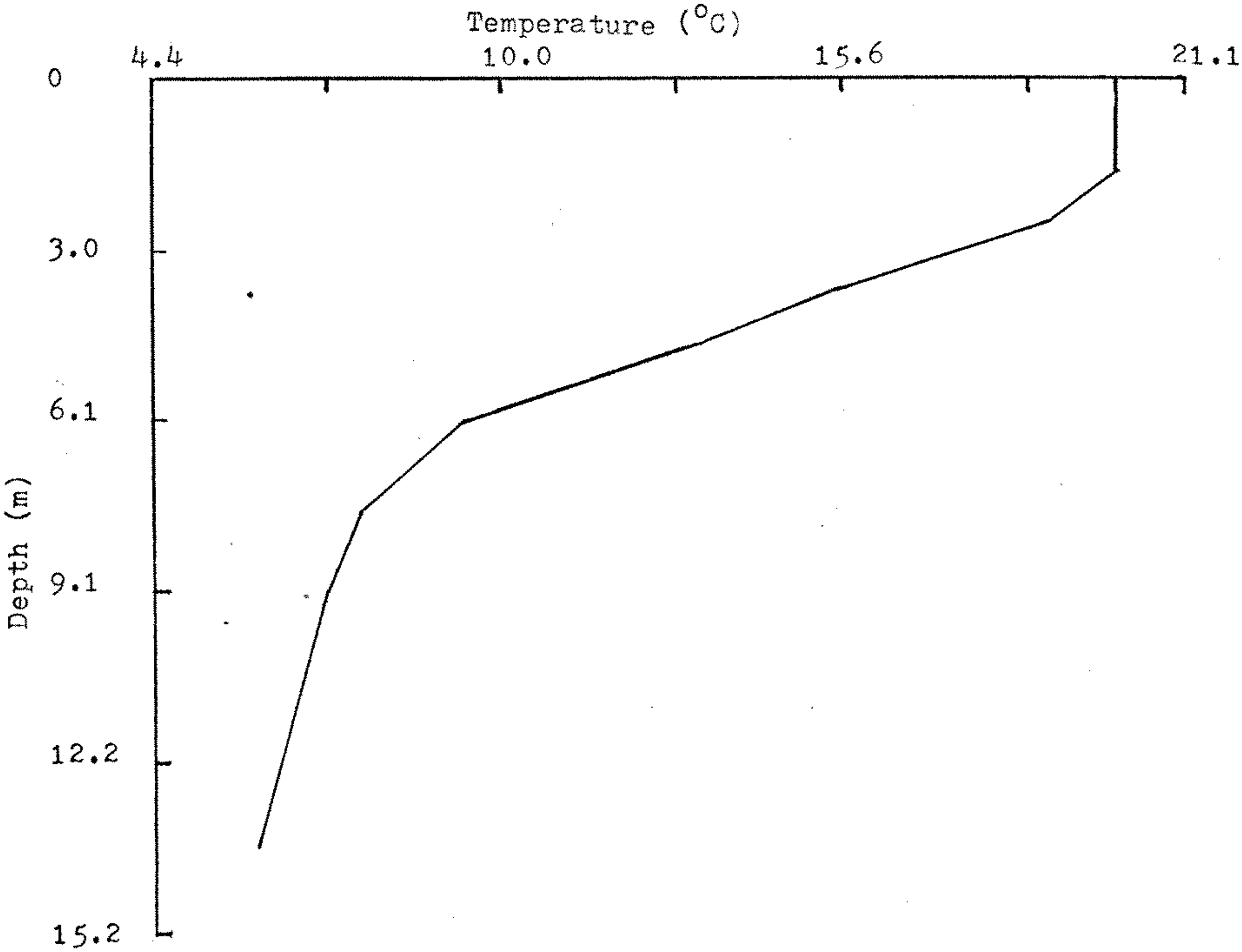
FIGURE 22 Temperature profiles for Nicklen Lake, 1976.



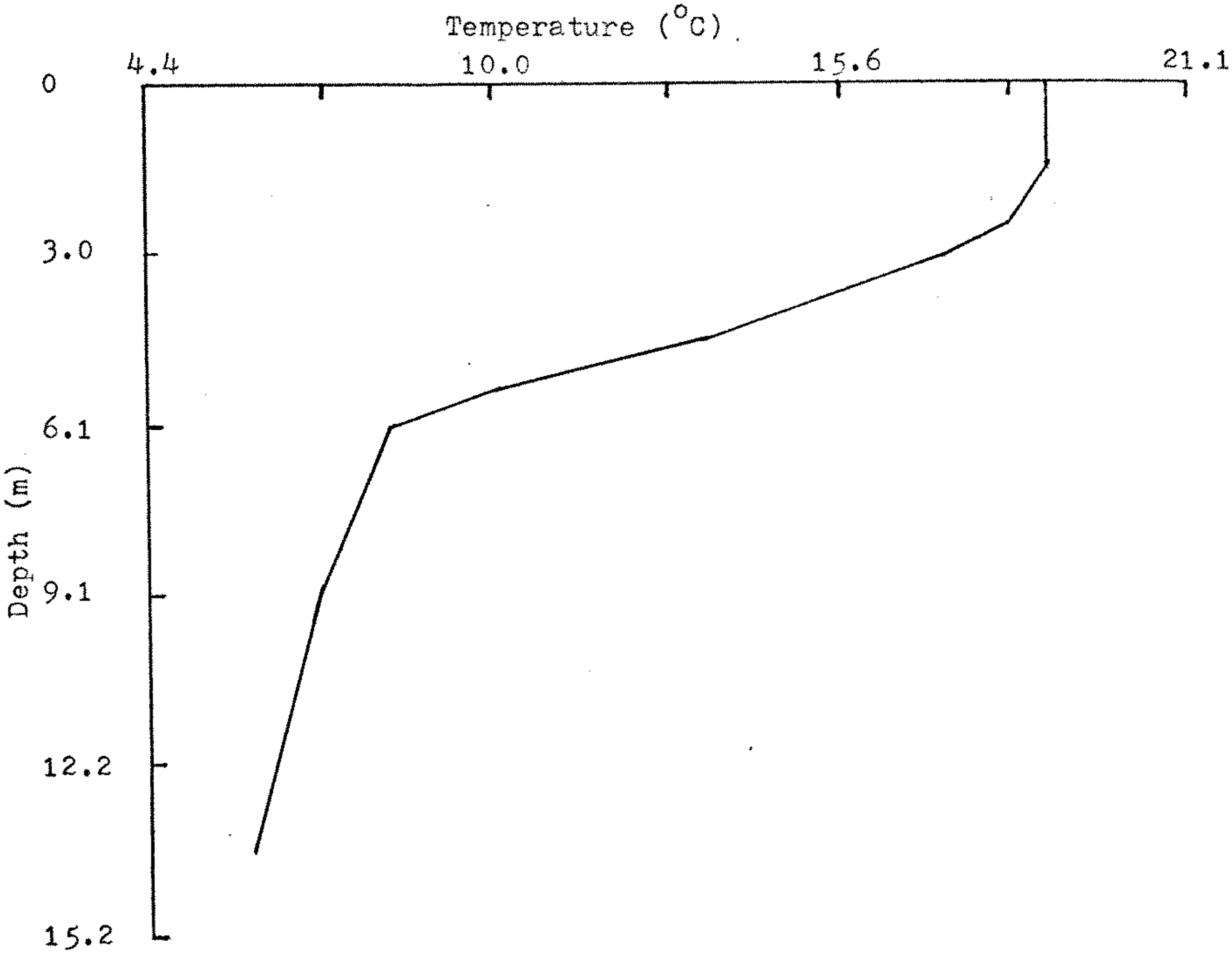
a) July 2 Air Temperature 14°C



b) July 13 Air Temperature 12°C



C) July 21 Air Temperature 10°C



d) August 5   Air Temperature 14°C

TABLE 12 Secchi Depth measurements for Nicklen Lake, 1976.

DATE	SECCHI DEPTH	GENERAL WEATHER DESCRIPTION
July 2	4.2 m	mostly cloudy
July 13	3.9 m	sunny
July 21	3.7 m	cloudy
Aug 5	3.7 m	cloudy and rainy

SUCCESSION OF PLANKTON SPECIES

The diatom - chrysophyte phytoplanktonic association found in Nicklen Lake is characteristic of oligotrophic waters (Rawson, 1956; Hutchinson, 1967). A report by Schindler and Holmgren (1971) on the phytoplankton of lakes in northwestern Ontario indicates that Nicklen Lake can be classified as a chrysophyte lake, with Dinobryon, Asterionella and Tabellaria among the most important genera. To effect brevity, only these three taxa, which dominated the net plankton assemblage, will be considered here. Table is a complete list of the phytoplankters identified from Nicklen Lake.

The pattern of succession in the dominant net phytoplankton species illustrated in Figure 23 represents their relative abundance at Station 4 only. However, there was considerable variability among the four stations, particularly Station 3. The latter, located in the "Beaver Pond", seemed to operate quite distinctly from the rest of the lake. This will become even more evident in the following section. To simplify the following discussion, only the data from the open water Station 4 will be used.

The dominant phytoplankters were the colonial diatoms, Asterionella formosa and Tabellaria fenestrata, and the arborescent Chrysophyte Dinobryon divergens. Planktonic populations of Asterionella formosa usually develop large spring and lesser autumnal maxima in the more productive lakes of the English Lake District (Lund, 1949, 1950). Davis (1972) recorded the massive development of Asterionella only in the late winter and early spring. In Nicklen Lake, Asterionella reached its maximum in mid-July and had disappeared almost completely by the beginning

TABLE 13 A list by taxonomic category of the phytoplankton net organisms recorded from Nicklen Lake (June, 1976 to August, 1976).

BACILLARIOPHYTA

Achnanthes spp.
Amphora ovalis
Amphora spp.
Asterionella formosa var. *formosa*
Asterionella formosa var. *gracillima* (Hantz.) Grun.
Caloneis spp.
Cocconeis placentula
Cyclotella spp.
Cymbella spp.
Epithemia spp.
Eunotia spp.
Fragilaria brevistriata
Fragilaria capucina
Fragilaria construens
Fragilaria crotonensis
Fragilaria virescens
Fragilaria sp. #1
Gomphonema acuminatum
Gomphonema acuminatum var. *coronata*
Gomphonema spp.
Melosira spp.
Meridion circulare (Grev.) Ag.
Navicula spp.
Neidium spp.
Nitzschia spp.
Pinnularia spp.
Rhopalodia gibba
Rhopalodia sp.#1
Stauroneis phoenicenteron
Stauroneis spp.
Stephanodiscus spp.
Surirella linearis var. *constricta*
Surirella robusta Ehr.
Synedra spp.
Tabellaria fenestrata
Tabellaria flocculosa

CHLOROPHYTA (except DESMIDIALES)

Actinastrum Hantzschii
Ankistrodesmus falcatus
Ankistrodesmus spiralis
Bulbochaete spp.
Chlorococcum spp.
Crucigenia quadrata
Crucigenia rectangularis

<u>Eudorina elegans</u>
<u>Kirchneriella lunaris</u> (Kirch.) Moebius
<u>Microspora</u> spp.
<u>Mougeotia</u> spp.
<u>Oedogonium</u> spp.
<u>Oocystis</u> spp.
<u>Pediastrum araneosum</u>
<u>Pediastrum Boryanum</u>
<u>Pediastrum Boryanum</u> var. <u>longicorne</u>
<u>Pediastrum duplex</u> var. <u>gracillimum</u> W. & G.S. West
<u>Pediastrum duplex</u> var. <u>subgranulatum</u> Racib.
<u>Pediastrum muticum</u> var. <u>longicorne</u> (?) Reinsch
<u>Pediastrum tetras</u>
<u>Protosiphon botryoides</u>
<u>Quadrigula closterioides</u> (Bohlin) Printz
<u>Quadrigula-</u>like sp.
<u>Scenedesmus arcuatus</u>
<u>Scenedesmus bijugatus</u>
<u>Scenedesmus obliquus</u> (Turp.) Kuetz.
<u>Scenedesmus platydiscus</u>
<u>Scenedesmus quadricauda</u>
<u>Schroederia</u> spp.
<u>Spirogyra</u> spp.
<u>Tetraedron minimum</u>
<u>Tetraspora</u> sp.
Unidentified Chaetophorales (?)
<u>Volvox aureus</u> Ehr.
<u>Zygnema</u> spp.

<u>DESMIDIALES</u>

<u>Arthrodesmus octocornis</u>
<u>Arthrodesmus triangularis</u> Lagerh.
<u>Closterium acerosum</u> (Schrank) Ehr. var. <u>acerosum</u>
<u>Closterium dianae</u> var. <u>dianae</u> f. <u>dianae</u>
<u>Closterium kuetzingii</u> var. <u>kuetzingii</u>
<u>Closterium moniliferum</u> (Bory) Ehr. var. <u>moniliferum</u> f. <u>moniliferum</u>
<u>Closterium setaceum</u> Ehr. var. <u>setaceum</u> f. <u>setaceum</u>
<u>Closterium</u> sp. #3 (<u>ralfsii</u>-like)
<u>Closterium</u> spp.
<u>Cosmarium Botrytis</u>
<u>Cosmarium</u> sp. #5
<u>Cosmarium</u> sp. #14 (<u>elengatissimum</u>-like)
<u>Desmidium Swartzii</u> Ag.
<u>Euastrum binale</u>
<u>Euastrum elegans</u>
<u>Euastrum</u> sp. #2 (<u>bidentatum</u>-like)
<u>Gonatozygon aculeatum</u>
<u>Gonatozygon Brebissonii</u>
<u>Gonatozygon Kinahani</u>
<u>Gonatozygon monotaenium</u> var. <u>pilosellum</u>
<u>Gymnozyga moniliformis</u>
<u>Micrasterias apiculata</u>

Micrasterias denticulata
Micrasterias Sol
Pleurotaenium trabecula var. trabecula f. trabecula
Spondylosium planum
Staurastrum anatinum
Staurastrum Arctiscon
Staurastrum gracile
Staurastrum grande Bulnh.
Staurastrum grande var. parvum
Staurastrum paradoxum
Staurastrum polymorphum
Staurastrum sp. #3
Staurastrum sp. #4 (erasum-like)
Staurastrum sp. #5 (gracile var. bulbosum-like)
Staurastrum sp. #6 (subgracillimum-like)
Staurastrum sp. #7
Xanthidium antilopaeum var. hebridarum W. & G.S. West

CYANOPHYTA

Anabaena flos-aque
Anabaena spp.
Aphanizomenon flos-aque
Arthrospira Jenneri
Chroococcus spp.
Gloeotrichia echinulata
Lyngbya spp.
Merismopedia convoluta
Merismopedia elegans
Merismopedia tenuissima
Merismopedia spp.
Nostoc paludosum
Rhabdoderma-like sp.
Tolypothrix tenuis

EUGLENOPHYTA

Euglena acus

PYRROPHYTA

Ceratium hirundinella

CHRYSOPHYTA

Dinobryon bavaricum Imhof
Dinobryon cylindricum Imhof
Dinobryon divergens
Dinobryon sertularia
Dinobryon sociale Ehr.
Ducillieria-like sp.

Epipyxis spp.
Unidentified Chrysophyte (?)

of August (Figure 23). Since data for only three months is available here, it is not known if this is the annual maximum expressed by Asterionella for this lake. However, Lund (1949) stressed that there were many irregularities to be expected (eg. the spring growth period may continue into the period normally characterized by low numbers or may not be clearly delimited at all) and that every algal species and lake must be considered separately (Lund, 1950). Lund (1949) has shown that relatively large populations in the plankton of some sheltered bays may precede those in the open water. In Nicklen Lake, Station 2, a protected littoral spot, was the first to show an increase in Asterionella. However, it does not appear that these are the "inoculum" for the production of the open water maximum (Lund, 1949). Although littoral and profundal deposits receive cells from the plankton, there is no evidence that these deposits are reciprocally returned. Live cells of Asterionella are always present in the open water and are able to increase in numbers if sufficient nutrients and light are available (Lund, 1949). The close of the spring maximum for Asterionella is frequently due to depletion of available silica, rather than light and temperature (Lund, 1950). The decrease in its autumnal maximum has been found to be associated with a number of factors eg. decrease in light and temperature, loss to bottom sediments, and chytrid parasitism (Canter and Lund, 1948, 1951). In Nicklen Lake, temperature rose during the Asterionella increase but dropped only slightly during the decline of Asterionella. Due to the atypical weather experienced during the sampling period, correlations with light intensity are not obvious. Parasitism, particularly by chytrid

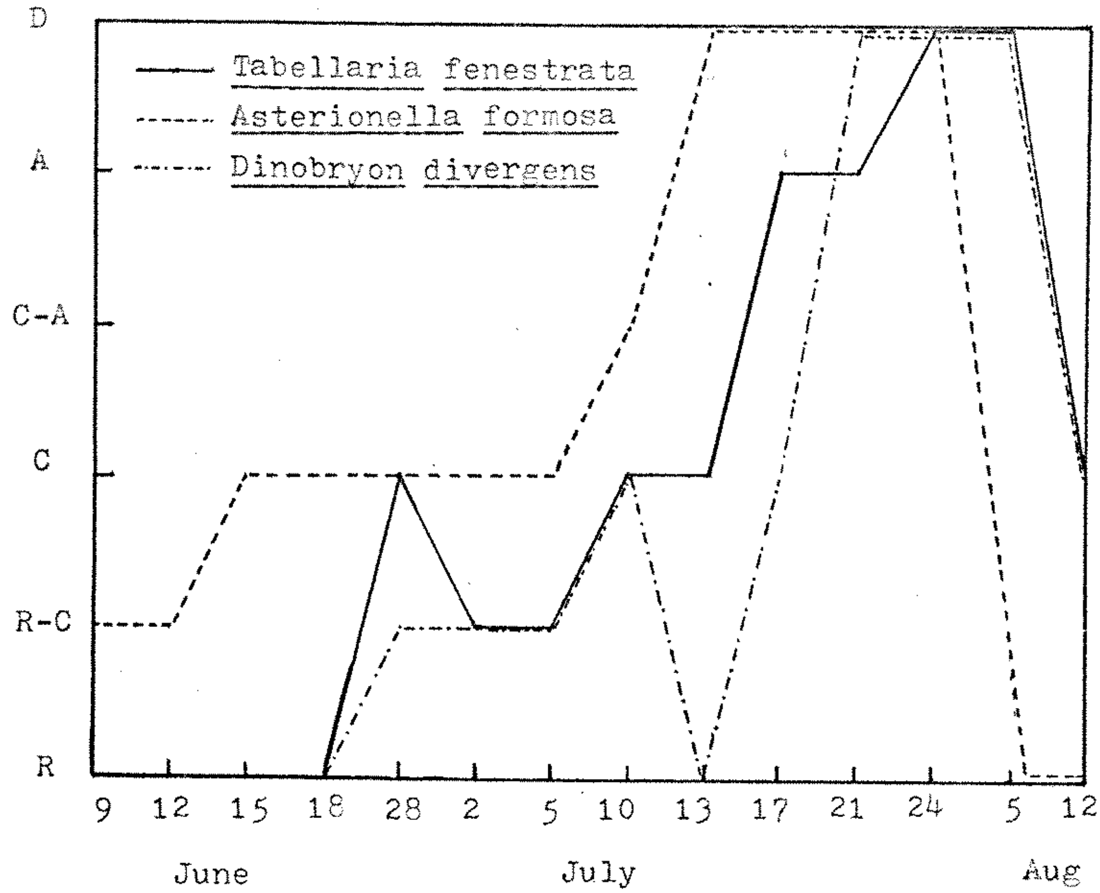


Figure 23 The successional patterns of the three dominant phytoplankton taxa in Nicklen Lake during the period June to August, 1976. Data is recorded in relative abundance. D=Dominant A=Abundant C=Common R=Rare

fungi, clearly can reduce the population of a dominant (Hutchinson, 1967). Although Lund (1950) stated that the common fungal parasite, Rhizopidium planktonicum Canter, is almost completely destroyed by formalin preservation, Asterionella cells in Nicklen Lake were obviously heavily parasitized by at least three species -- Dinobryon utriculus var. tabellariae Lemm., Bicoeca sp. (?), and chytrids (Rhizopidium ?). Canter and Lund (1948, 1951) found that parasitism was heavy when Asterionella was increasing and that the diatom population crashed shortly afterwards, even though nutrients were not limiting. Apparently, this has been recorded only from eutrophic lakes (Hutchinson, 1967). However, in Nicklen Lake, an oligotrophic water body, parasitism was heaviest when Asterionella attained dominance. The possible control of the Asterionella population in Nicklen Lake by available nutrients, particularly silica, cannot be commented upon. Loss to the sediments is also a possible explanation ~~for the decline~~ for the decline of Asterionella. Davis (1972) concluded that the elimination of this species from the surface waters under ice could only be explained by sinking towards the bottom. In Nicklen Lake, most or all of these factors probably contributed to the pattern observed in Asterionella.

As recorded in Nicklen Lake, several authors have found the increase of Tabellaria to be subsequent to that of Asterionella (Pearsall, 1932; Lund, 1950; Hutchinson, 1967; Davis, 1972). It attained dominance toward the end of July and declined by mid-August (Figure 23). Davis (1972) found that Tabellaria "bloomed" in late spring and early summer and that it declined by early August. Parasitism may play a role in determining the seasonal succession of *Tabellaria*. Although Lund (1950) stated that most of the fungi parasitizing planktonic algae affect only one species, *Tabellaria* was observed to possess a parasitic flora similar to that of *Asterionella*. Hutchinson (1967) reported that a species reduced by parasitism was often replaced by another species which sometimes suffered an epidemic itself. Competition with *Asterionella* for available nutrients may also explain why *Tabellaria* showed a later maximum. Lack of water chemistry data prevents further examination of this problem. No references were found in the literature which alluded to the possible role of temperature and/or light in controlling populations of *Tabellaria*.

The Chrysophycean flagellate, *Dinobryon*, has been shown, along with *Tabellaria*, to follow the spring pulse of *Asterionella* (Hutchinson, 1967; Davis, 1972). In Nicklen Lake, the same general pattern was observed (Figure 23). The sudden decrease in surface cells on July 13 might be due to microstratification at a lower depth (Baker, 1970), since *Dinobryon* was common in the vertical haul, or to plankton patchiness. Four days later it achieved dominant status. In *Dinobryon divergens*, powerful chemical influences operate to determine its seasonal occurrence. Hutchinson (1967) noted that *Dinobryon* did not develop until the major spring species had reduced the nutrient concentration and were themselves about to disappear. Although different races in different lakes may have slightly different requirements, a remarkable correlation has been found between the appearance of *D. divergens* and a decrease in phosphorous concentration (Lund, 1965; Hutchinson, 1967). Hutchinson (1967) stated that the incidence of *D. divergens* does not appear to be thermally determined within the range of 5-21°C, which is within the limits recorded in Nicklen Lake. However, Asmund (1955) found that D. divergens showed a very considerable maximum in August and September. He postulated that unusually cold weather may have inhibited some species but favoured D. divergens, perhaps by diminishing the competition from other organisms, which are more sensitive to low temperatures than Dinobryon divergens. Although the unusual weather may have affected Dinobryon in Nicklen Lake, chemical data is needed to properly explain the fluctuations. However, Hutchinson (1967) stated that a substance produced by Asterionella stimulates Dinobryon. In addition, Dinobryon can exist at low silica concentrations (Lund, 1965) and can therefore survive when Asterionella is dominant. Tabellaria and Dinobryon have also been noted to co-dominate the plankton (Davis, 1972).

From the preceding discussion, the occurrence of all three species at the same time of year and the dominance of all three in late July seems somewhat anomalous. In Nicklen Lake, the cycles of all three were compressed into a much shorter span of time than the accessible literature documented. Since only a single season's sampling data is available, it is not known if this is a typical occurrence in Nicklen Lake or a reflection of the unusual meteorological conditions.

SUCCESSION IN PERIPHYTON SPECIES

Twelve taxonomic divisions were recorded from Nicklen Lake periphyton (Table 14). Diatoms were clearly dominant overall but "bacteria" and cyanophytes were dominant at one station. As recorded in Lily Pad Lake, there were differences in the successional patterns between the samples of monthly and cumulative exposure periods and also differences among stations. However, there were no "monthly" slides for August and thus little mention will be made of the differences here.

Bacteria and detritus were a dominant component of the periphyton only at Station 3. The larger amounts of organic matter recorded from the slides at Station 3 are probably due to the much higher incidence of aquatic plants found here (Henrici, 1939). Pollen grains were again common on many slides, particularly during July.

Diatoms were the dominant component on all slides examined (Table 15). Achnanthes (chiefly A. minutissima), the most dominant diatom, is a representative of the "true periphyton" (Sladeckova, 1962) and appears to be confined almost exclusively to the aufwuchs community (Goddard, 1937; Brook, 1955; Douglas, 1958; Stockner and Armstrong, 1971; Brown and Austin, 1973b). The conclusion of Stockner and Armstrong (1971) that, from its observed distribution, A. minutissima can de considered a reliable character form of the littoral zone of oligotrophic lakes seems premature since it has been recorded as a dominant in the periphyton of a small eutrophic lake (Brown and Austin, 1973b). Instead, it would appear to be an extremely versatile species, since it can also adapt itself to unusually high temperatures (up to 35°C) (Klarer, 1973; Stockner, 1967), and has been recorded as abundant from an acid bog lake (Lily Pad Lake) and a dystrophic lake (Curtis Lake) in the current

TABLE 14 A list by taxonomic category of the periphyton organisms recorded from Nicklen Lake during the sampling period June - August, 1976.

BACILLARIOPHYTA

Achnanthes exigua
Achnanthes linearis[1]
Achnanthes microcephala[1]
Achnanthes minutissima[1]
Amphipleura pellucida
Amphora ovalis
Amphora spp.
Asterionella formosa var. formosa
Asterionella formosa var. gracillima
Biddulphia sp.
Capartogramma crucicula (Grun. ex Cl.) Ross
Cocconeis placentula
Cocconeis pediculus Ehr.
Cyclotella bodanica Eulenst.
Cyclotella spp.
Cymbella caespitosa
Cymbella cistula-complex
Cymbella Ehrenbergii Kutz.
Cymbella gracilis
Cymbella heteropleura (?)
Cymbella spp.
Diatoma hiemale var. mesodon (Ehr.) Grun.
Diploneis oblongella
Diploneis finnica
Epithemia argus
Epithemia turgida
Epithemia zebra
Eunotia complex #1
Eunotia complex #2
Eunotia serra var. diadema
Fragilaria brevistriata
Fragilaria capucina
Fragilaria construens
Fragilaria crotonensis
Fragilaria pinnata
Fragilaria virescens
Frustulia rhomboides (Ehr.) De T.
Frustulia rhomboides var. capitata
Frustulia rhomboides var. crassinervia
Gomphonema acuminatum
Gomphonema acuminatum var. coronata
Gomphonema constrictum
Gomphonema monatum (?)
Gomphonema olivaceum
Gomphonema subtile (?)
Melosira italica
Melosira spp.
Navicula cuspidata (Kutz.) Kutz.
Navicula radiosa Kutz.
Navicula spp.

[1] These species comprise Achnanthes spp. referred to in the text.

Meridion circulare
Neidium affine (Ehr.) Pfitz.
Neidium bisculatum (Lagerst.) Cl.
Neidium productum (W. Sm.) Cl.
Neidium spp.
Nitzschia acicularis
Nitzschia linearis W. Sm.
Nitzschia (Lanceolata) sp.
Nitzschia spp.
Pinnularia abaujensis (Pant.) Ross
Pinnularia maior (Kutz.) Rabh.
Pinnularia nobilis (Ehr.) Ehr.
Pinnularia nodosa (Ehr.) W. Sm.
Pinnularia spp.
Rhopalodia gibba
Stauroneis anceps f. *gracilis* Rabh.
Stauroneis phoenicenteron
Stauroneis spp.
Stephanodiscus spp.
Surirella linearis
Surirella linearis var. *constricta*
Surirella robusta
Synedra ulna
Synedra spp.
Tabellaria fenestrata
Tabellaria flocculosa
Tetracyclus lacustris

CHLOROPHYTA (except DESMIDIALES)

Actinastrum Hantzschii
Ankistrodesmus falcatus
Ankistrodesmus spiralis
Aphanochaete-like sp.
Apiocystis brauniana
Binuclearia tatrana
Botryococcus Braunii
Bulbochaete spp.
Chaetopeltis orbicularis
Chlorococcum spp.
Coleochaete orbicularis
Coleochaete scutata
Coleochaete soluta-like sp.
Crucigenia rectangularis
Dictyosphaerium pulchellum
Draparnaldia sp. #1
Draparnaldia spp.
Geminella-like sp.
Microspora spp.
Mougeotia spp.
Oedogonium spp.
Oocystis spp.
Pediastrum araneosum
Pediastrum Boryanum
Pediastrum Boryanum var. *longicorne*

Pediastrum duplex var. subgranulatum
Pediastrum muticum var. longicorne (?)
Pediastrum tetras
Schroederia spp.
Scenedesmus acutiformis
Scenedesmus arcuatus
Scenedesmus bijugatus
Scenedesmus platydiscus
Scenedesmus quadricauda
Spirogyra spp.
Tetraedron minimum
Tetraedron trigonum
Tetraspora sp.
Zygnema spp.

DESMIDIALES

Arthrodesmus octocornis
Arthrodesmus triangularis
Arthrodesmus sp. #1 (Incus var. Ralfsii-like)
Arthrodesmus sp. #3 (octocornis-like)
Arthrodesmus sp. #4 (subulatus-like)
Closterium dianae var. dianae f. dianae
Closterium gracile
Closterium kuetzingii var. kuetzingii
Closterium libellula var. libellula f. libellula
Closterium lunula (Müll.) Nitzsch var. lunula f. lunula
Closterium moniliferum var. moniliferum f. moniliferum
Closterium navicula var. navicula
Closterium setaceum var. setaceum f. setaceum
Closterium venus var. venus f. venus
Closterium sp. #3
Closterium sp. #5 (cornu-like)
Closterium sp. #6 (angustatum-like)
Closterium spp.
Cosmarium sp. #1, #5, #8, #9, #11
Cosmarium sp. #19 (trachypleurum-like)
Cosmarium sp. #20 (laeve-like)
Cosmarium sp. #21 (orbiculatum-like)
Desmidium Aptogonum
Desmidium Swartzii
Euastrum binale
Euastrum dubium
Euastrum elegans
Euastrum insulare
Euastrum sp. #2
Euastrum sp. #5
Euastrum sp. #6 (sinuosum-like)
Euastrum sp. #7 (gemmatum-like)
Gonatozygon Brebissonii
Gonatozygon monotaenium
Gonatozygon monotaenium var. pilosellum
Micrasterias pinnatifida
Neitrium Digitus
Pleurotaenium trabecula var. trabecula f. trabecula

Staurastrum anatinum
Staurastrum Arctiscon
Staurastrum dejectum
Staurastrum dejectum var. *patens* Nordst.
Staurastrum Dickei var. *circulare*
Staurastrum glabrum
Staurastrum gladiosum
Staurastrum gracile
Staurastrum grande var. *parvum*
Staurastrum megacanthum
Staurastrum mucronatum
Staurastrum paradoxum
Staurastrum sp. #2
Staurastrum sp. #5
Staurastrum sp. #8 (*pilosum*-like)
Staurastrum sp. #9 (*teliferum*-like)
Spondylosium planum
Xanthidium antilopaeum var. *polymazum*

CYANOPHYTA

Anabaena spp.
Aphanocapsa sp.
Calothrix-like sp.
Chroococcus spp.
Gloeocapsa spp.
Gloeotrichia echinulata
Gloeotrichia spp.
Hapalosiphon hibernicus W. & G.S. West
Lyngbya major Menegh.
Merismopedia elegans
Merismopedia glauca
Merismopedia tenuissima
Merismopedia spp.
Nostoc spp.
Tolypothrix tenuis
Unidentified "Rivulariaceae (?)"

EUGLENOPHYTA

Euglena acus
Phacus sp.

PYRROPHYTA

Ceratium hirundinella

CHRYSOPHYTA

Dinobryon divergens
Dinobryon sertularia

Ducillieria-like sp.
Epipyxis sp.
Unidentified Chrysophyte (?)

ROTIFERA

Conochilus unicornis
Keratella cochlearis
Kellicottia longispina
Lecane sp.

DIPTERA

Chaoborus sp.
Chironomid larvae

CILIOPHORA

Unidentified Protozoan
Vorticella sp. #1
Vorticella sp. #3

AMPHIBIA

Salamander eggs

TABLE 15 Succession of thedominant Nicklen Lake periphyton taxa for all four experiments. Slides were immersed for 27, 32, 39 and 69 days between June 10 and August 16, 1977. Data is recorded in relative abundance. D=Dominant A=Abundant C=Common R=Rare

Species	Expt. 1			Expt. 2			Expt. 4			Expt. 3		
Station	1	2	3	1	2	3	1	2	3	1	2	3
Mougeotia		C	R-C	C	C	C	C-A	A	C	C-A	A	A
Achnanthes	D	D	D	D	D	D	D	D	D	D	D	D
Eunotia #1	C	C	R-C	C-A	C-A	R	C-A	C-A	R	C-A	C-A	R
E. turgida	C	C	R	D	D	R-C	D	D	R	C	C	R

study. Achnanthes showed no change in its dominant status throughout the sampling period. Epithemia turgida was the other diatom which achieved dominant status, although this occurred only in the mid-summer monthly series, which is consistent with its seasonal distribution (Castenholz, 1960) (Table 15). Interestingly, E. turgida, which became dominant in Lily Pad Lake after the long exposure period, was only common over a similar duration of time in Nicklen Lake. Although several reasons could account for this, eg. differences in chemical and/or other environmental conditions between the lakes, perhaps there is some measure of competition between Epithemia and Achnanthes, since the latter never achieved dominant status in Lily Pad Lake. In addition, E. turgida was never common at Station 3 in Nicklen Lake. The slides at this station were overwhelmingly dominated by Achnanthes. In Nicklen Lake, Eunotia complex #1 was the more common of the two complexes distinguished for this genus (cf. Lily Pad Lake). It increased throughout June and received the same rating at Stations 1 and 2 in July and August and on the slides exposed for 10 weeks (Table 15). Curiously, this complex was rare at station 3 in June, whereas Eunotia complex #2 was abundant only at Station 3 in June. This illustrates a possible intrageneric competition since Eunotia complex #2 was dominant in Lily Pad Lake, whereas Eunotia complex #1 was only rarely encountered. Cyclotella bodanica showed an increase in July only at Station 1 in Expt. #2. Cyclotella is often found in association with the dominant planktonic algae recorded from Nicklen Lake and is also considered an indicator of oligotrophic conditions (Rawson, 1956). However, it was never common in the plankton in this study. Melosira was abundant on the slides immersed during July only at Station 3. Seasonal fluctuations in Melosira italica are due mainly to its relatively high sinking rate and its ability to remain alive on the deposits in the dark even under anaerobic conditions (Lund, 1954). Its periodicity is directly related to thermal stratification. Its rate of sinking is such,that when the water stratifies in summer, the population passes rapidly into the hypolimnion and onto the sediments, where a large part of the crop remains alive until re-suspended by turbulent mixing currents during autumnal circulation (Lund, 1954, 1955). Although a temperature profile was not available until July, when the lake was thermally stratified, the rareness of Melosira in the summer plankton is in accord with Lund (1954, 1955). Its abundance in the periphyton at Station 3 is probably due to the fact that the slide box was resting only about .2 meters above the sediments and hence, colonization of the slides by Melosira would be easily accomplished by slight turbulence in the water. Rhopalodia gibba showed a sudden increase in Expt. #4 at Station 2. Klarer and Hickman (1975) recorded R. gibba as a common alga during August, although the reasons for its sudden abundance at only Station 2 in the present study are not known. Fragilaria brevistriata and Fragilaria pinnata were common on all slides at Station 3 only. Both are common in a wide variety of freshwater habitats (Patrick and Reimer, 1966). Likewise, species of Gomphonema and Nitzschia were common throughout the sampling period. Cocconeis placentula showed a sudden increase, similar to that recorded in Lily Pad Lake, at Station 2 in Expt. #2. Douglas (1958) found that erratic variations in this species were not uncommon. Asterionella was absent or rare on all slides examined except at Station 1. Here, it was rare-common in the June series, common-abundant in Expt. #2, and common in Expts. #3 and #4. Its increase in the periphyton is coincident with its decline from the plankton, although not all cells of the planktonic Asterionella population settled out on the slides following its pulse in the plankton (see Brown and Austin, 1973b). Reasons for the local occurrence in this study are not known.

Of the Chlorophyta, Mougeotia spp. and Coleochaete scutata were the only common genera. The former increased in July and August and was abundant on the slides exposed for a long period of time. Its correlations with temperature have already been discussed. Coleochaete was common on many slides, although its occurrence did not follow any recognizable pattern and it is probably only an additional species. It showed extensive growth on the slides and often measured hundreds of microns in diameter. Brook (1955) found that Coleochaete, abundant in May, was densely overgrown by Achnanthes within two weeks. Chaetophorales, such as Coleochaete, with a feebly developed or absent erect system, were most frequently covered by Achnanthes and probably suffered most in competition for space (Brook, 1955). Such a successional ~~correlation~~ pattern was not evident in Nicklen Lake.

Cyanophytes formed a more conspicuous element in Nicklen Lake periphyton than in Lily Pad Lake periphyton. Several species of blue-greens were common even after a month of exposure (cf. Brown and Austin, 1973a). Hapalosiphon and Tolypothrix were common constituents of the periphyton in Expt. #2 at Stations 1 and 2. Klarer and Hickman (1975) recorded Tolypothrix as a common epiphyte in mid-June. Gloeotrichia echinulata, a more common planktonic species (Prescott, 1952; Brown, 1969), was recorded as common on the slides in Expt. #4 at Station 2, where it formed macroscopic globular colonies on the surface of the slides. Aphanocapsa (*elachista* ?) formed enormous macroscopic blobs on the surface of the long-term slides only at Station 3. Although Brown and Austin (1973a) found that Cyanophytes were only initial colonizers, Neal et al (1967) and Cattaneo et al (1975) recorded that blue-greens were dominant after longer periods of colonization. Brook (1955) recorded *Microcystis*, an alga which often appears with *Aphanocapsa* in water blooms, to be dominant on 4 weeks' slides. The dominance of *Aphanocapsa* was clearly additional, as recorded by Brook (1955) for *Microcystis*, since it did not occur on any previous slide series i.e. no succession was involved in its achievement of dominance.

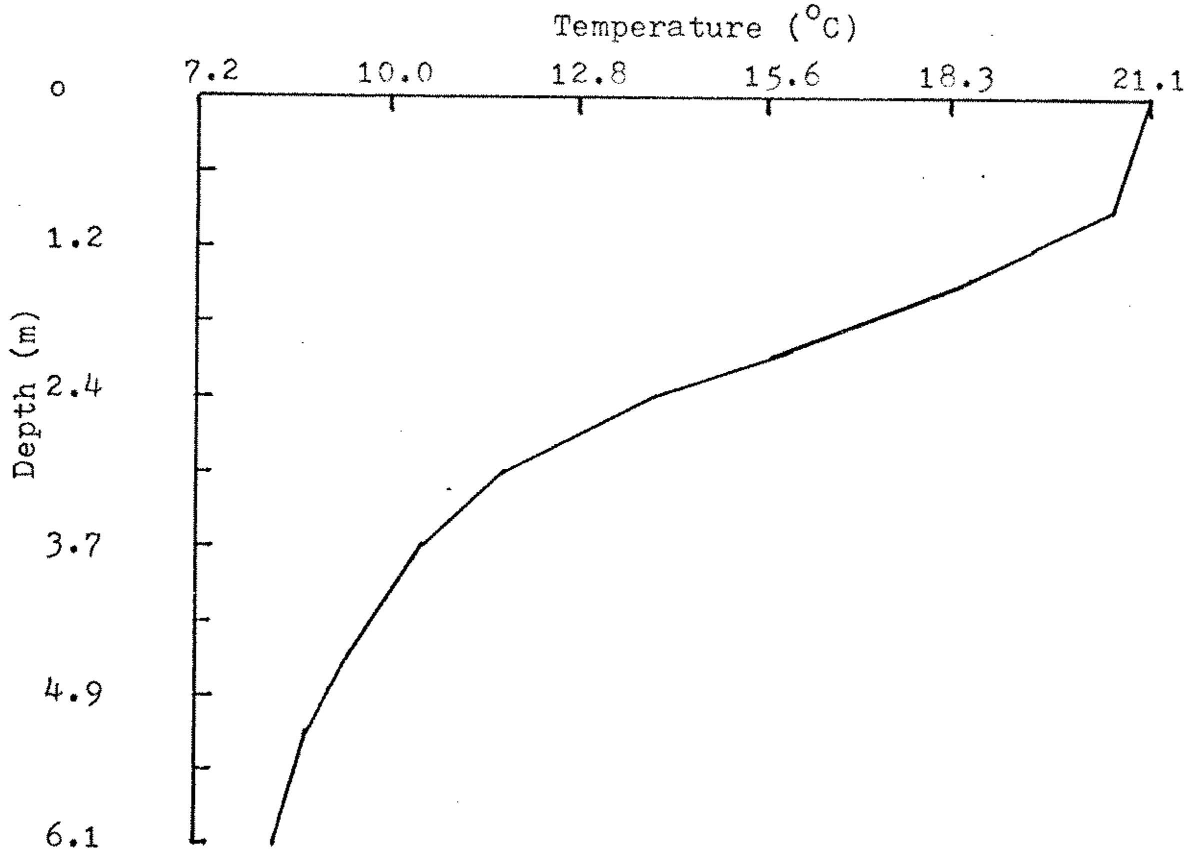
CURTIS LAKE

PHYSICAL CHARACTERISTICS

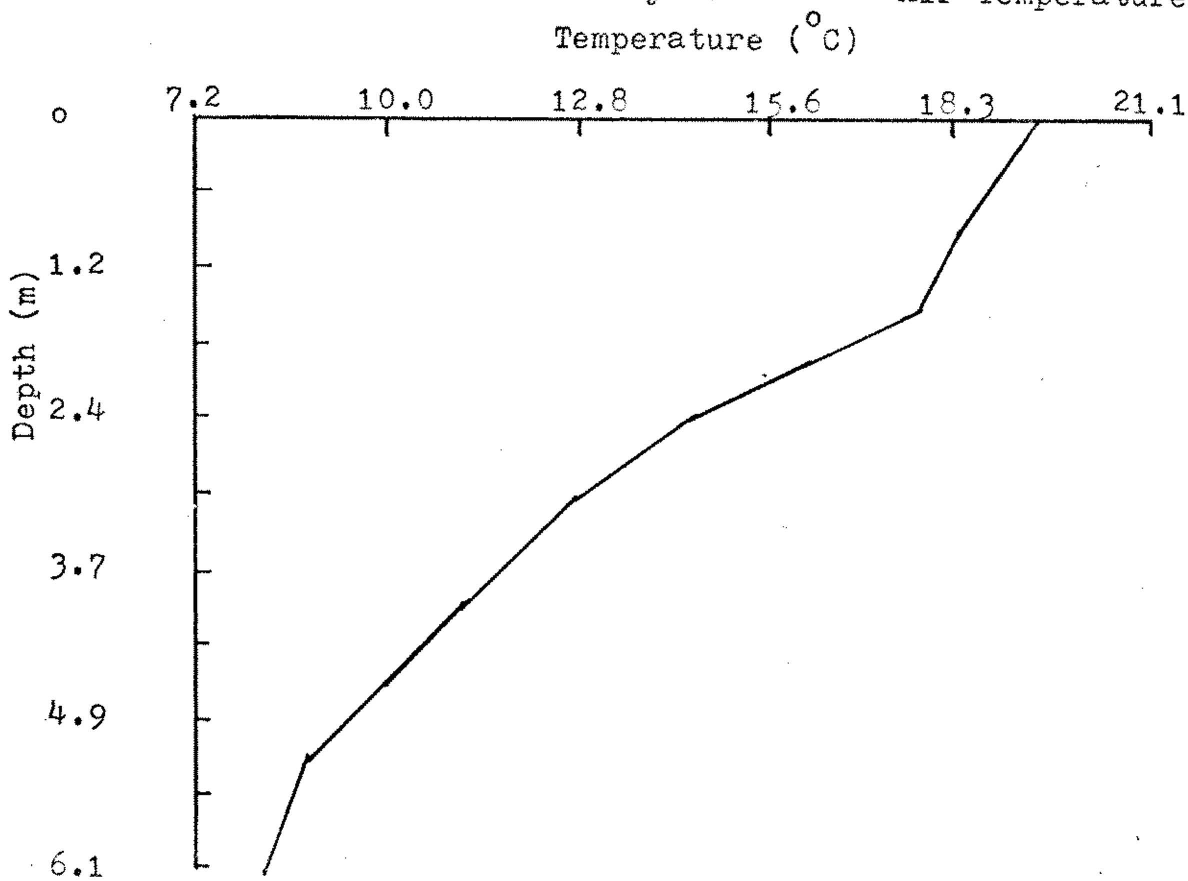
Similar to Lily Pad, Curtis Lake showed little development of a definite epilimnion or hypolimnion (Figure 24 a-c). Since light penetrated to only about 1.4 m in Curtis Lake (Table 16), one might expect little heating of lower waters and therefore possibly a sharp thermocline (Cole, 1975). However, the temperature profile was nearly a straight line on two of the three days. Curtis Lake is exposed to wind action (it was always windy at the lake), and so lack of mixing does not explain these profiles as it may for Lily Pad. According to Wetzel (1975, p. 76), inflow - outflow relationships are important in affecting thermal stratification of lakes; cool inflow from streams may cause turbulence which reduces the thermal gradient appreciably. Because water flow through Curtis Lake appeared to occur at a relatively fast rate -- outflowing Heart Creek was running fairly rapidly throughout July and August-- this kind of turbulence may play a part in this lake's thermal pattern.

The low Secchi depth readings for Curtis Lake reflect the high humic organic content of the water.

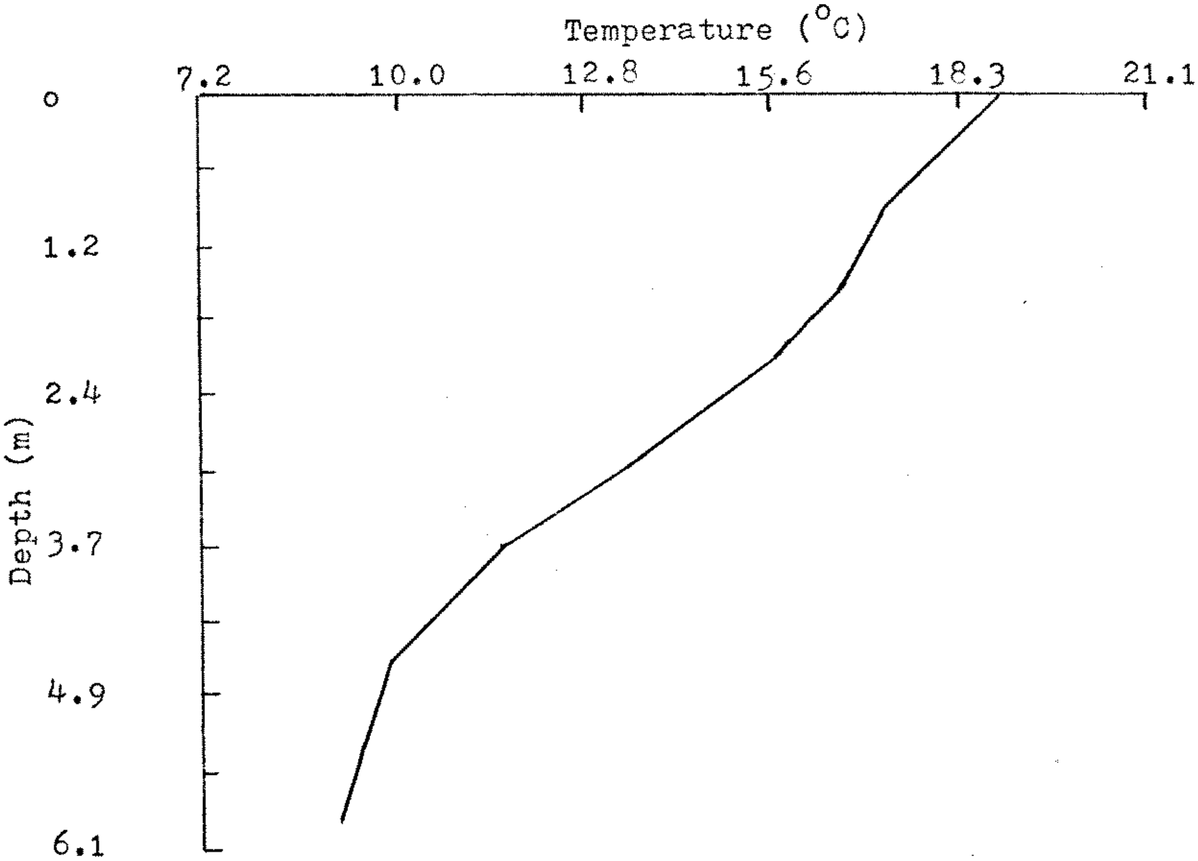
FIGURE 24 Temperature profiles for Curtis Lake, 1976.



a) July 20 Air Temperature 18°C



b) August 4 Air Temperature 21°C



c) August 11 Air Temperature 21°C

TABLE 16 Secchi Depth measurements for Curtis Lake, 1976.

DATE	SECCHI DEPTH	GENERAL WEATHER DESCRIPTION
July 20	1.4 m	cloudy
Aug 4	1.4 m	sunny
Aug 11	1.2 m	partially cloudy

PHYTOPLANKTON AND PERIPHYTON

The paucity of phytoplankton recorded from Curtis Lake is characteristic of acid "oligo-dystrophic" waters (Prescott, 1939; Ruttner, 1952; Cole, 1975), and obviates the inclusion of a list of the common forms. Table shows that chlorophytes and diatoms were the most common groups encountered, although the occurrence of many species was only incidental. A bloom of a flagellate, which appeared identical to that recorded from Lily Pad and Nicklen Lakes, was present on the last sampling date. As already mentioned, Curtis Lake can probably be considered an acid dystrophic system. The main characteristics of the dystrophic lake-type are the brown water, the content of acid humus and the dy or tyrfopel as profundal sediment. They may be either eutrophic or oligotrophic (Hansen, 1962). The phytoplanktonic productivity of dystrophic systems exhibits several general control characteristics. Photosynthetic rates are generally low, but there is a large quantity of organic matter in the water from allochthonous and littoral sources which is not easily decomposed by bacteria (Henrici, 1939; Ruttner, 1952; Hutchinson, 1967; Cole, 1975). There is still no agreement on the biological significance of such allochthonous colour except in its reaction in reducing light penetration (Hutchinson, 1967), which consequently affects phytoplankton production.

The periphyton of Curtis Lake was dominated by bacteria and organic matter on all three sets of slides, which is in agreement with their role in the littoral of a dystrophic lake (Wetzel, 1975). A complete species list is included in Table 18.

The algae of small dystrophic lakes survive primarily in the benthos, but some detach themselves from the bottom or from the stems of submerged plants and float in the water like true planktonic organisms (Fott and Novakova, 1965). The diatoms were the dominant algae present on Curtis Lake slides. *Eunotia serra* var. *diadema*, *Gomphonema* spp., and *Tetracyclus lacustris*, all became common on the slides immersed for 32 days. *E. serra* var. *diadema* is common in dystrophic waters, whereas, *T. lacustris*, although not recorded as being common in such waters, prefers cool waters with little or no current (Patrick and Reimer, 1966). *Achnanthes* spp. (chiefly *A. linearis* (cf. Nicklen and Lily Pad Lakes)), and *Eunotia* complex #2 were the dominant algae on the slides exposed for a month. Their successional patterns have already been considered. The filamentous Chlorophytes, *Oedogonium* and *Bulbochaete*, were abundant in Expts. 1 and 2. When the diatoms became dominant, both these species declined, probably due to competition for available substrate space. Prescott (1939) has recorded mats of filamentous Chlorophyceae as being present in dystrophic lakes.

From cursory examinations of the faunal component in the plankton of Curtis Lake, the rich development of rotifers (*Conochilus unicornis* in Curtis Lake) and crustaceans (both cladocerans and copepods), despite the poor growth of phytoplankton, is not uncommon in dystrophic lakes (Lang, 1931).

TABLE 17 A list by taxonomic category of the phytoplankton net organisms recorded from Curtis Lake (July, 1976 to August, 1976).

BACILLARIOPHYTA

Amphipleura pellucida Kutz.
Amphora spp.
Asterionella formosa var. *formosa*
Cymbella spp.
Diploneis finnica (Ehr.) Cl.
Eunotia serra var. *diadema* (Ehr.) Patr.
Eunotia spp.
Fragilaria brevistriata
Fragilaria crotonensis
Fragilaria sp. #1
Frustulia rhomboides
Gomphonema acuminatum var. *coronata*
Gomphonema spp.
Melosira spp.
Navicula spp.
Neidium spp.
Nitzschia spp.
Pinnularia spp.
Rhopalodia gibba
Stauroneis spp.
Surirella biseriata var. *constricta* Grun.
Surirella ovata Kutz.
Surirella spp.
Tabellaria flocculosa
Tabellaria fenestrata
Tetracyclus lacustris

CHLOROPHYTA (except DESMIDIALES)

Actinastrum Hantzschii
Apiocystis brauniana
Bulbochaete spp.
Chlorococcum spp.
Crucigenia rectangularis
Microspora spp.
Mougeotia spp.
Oedogonium spp.
Pediastrum tetras
Scenedesmus bijugatus
Schroederia spp.

DESMIDIALES

Arthrodesmus Incus var. ?

Arthrodesmus triangularis
Arthrodesmus sp. #2 (Incus var. validus-like)
Closterium costatum Corda var. costatum f. costatum
Closterium kuetzingii var. kuetzingii
Closterium navicula (Breb.) Lutk. var. navicula
Closterium setaceum var. setaceum f. setaceum
Closterium sp. #4 (nematodes/archerium-like sp.)
Closterium spp.
Desmidium Aptogonum Breb.
Desmidium Swartzii
Docidium baculum Breb. f. baculum
Euastrum binale
Euastrum elegans
Gonatozygon monotaenium var. pilosellum
Gymnozyga moniliformis
Micrasterias apiculata
Micrasterias apiculata var. fimbriata (Ralfs) Nordst.
Micrasterias Sol
Pleurotaenium coronatum var. nodulosum (Breb.) West
Pleurotaenium trabecula var. trabecula f. trabecula
Sphaerozosma vertebratum
Spondylosium planum
Staurastrum megacanthum
Staurastrum paradoxum

CYANOPHYTA

Anabaena flos-aque
Anabaena spp.
Nostoc spp.
Tolypothrix tenuis

PYRROPHYTA

Ceratium hirundinella

CHRYSOPHYTA

Dinobryon divergens
Dinobryon sertularia
Epipyxis spp.
Unidentified Chrysophyta (?)

TABLE 18 A list by taxonomic category of the periphyton organisms recorded from Curtis Lake during the sampling period July-August, 1976.

BACILLARIOPHYTA

Achnanthes linearis[1]
Achnanthes microcephala[1]
Achnanthes minutissima[1]
Amphora ovalis
Amphora spp.
Ceratoneis arcus Kutz.
Cocconeis placentula
Cyclotella bodanica
Cyclotella spp.
Cymbella aspera var. genuina-like sp.
Cymbella cistula complex
Cymbella cuspidata Kutz.
Cymbella Ehrenbergii
Cymbella gracile
Cymbella naviculiformis
Cymbella spp.
Diploneis finnica
Eunotia complex #2
Eunotia perpusilla Grun.
Eunotia serra var. diadema
Fragilaria brevistriata
Fragilaria capucina
Fragilaria virescens
Fragilaria sp. #1
Frustulia rhomboides var. capitata
Frustulia rhomboides var. crassinervia
Gomphonema acuminatum
Gomphonema acuminatum var. coronata
Gomphonema constrictum
Gomphonema spp.
Melosira spp.
Navicula radiosa
Navicula spp.
Neidium productum
Nitzschia linearis
Nitzschia spp.
Pinnularia socialis (T.C. Palm.) Hust.
Pinnularia spp.
Rhizoselenia eriensis H.L. Sm.
Stauroneis anceps f. gracilis
Stauroneis phoenicenteron
Stauroneis spp.
Stenopterobia intermedia
Surirella linearis
Surirella linearis var. constricta
Surirella robusta
Synedra ulna
Synedra spp.

[1] These species comprise Achnanthes spp refered to in the text

Tabellaria fenestrata
Tabellaria flocculosa
Tetracyclus lacustris

CHLOROPHYTA (except DESMIDIALES)

Ankistrodesmus falcatus
Ankistrodesmus spiralis
Aphanochaete-like sp.
Apiocystis brauniana
Bulbochaete spp.
Chaetophora-like sp.
Coleochaete orbicularis
Coleochaete scutata
Mougeotia spp.
Oedogonium undulatum
Oedogonium spp.
Oocystis spp.
Palmodictyon-like sp.
Scenedesmus arcuatus
Scenedesmus quadricauda
Unidentified Chaetophorales (Juvenile)
Zygnema spp.

DESMIDIALES

Closterium ehrenbergii
Closterium kuetzingii var. kuetzingii
Closterium lunula var. lunula f. lunula
Closterium setaceum var. setaceum f. setaceum
Closterium venus var. venus f. venus
Closterium sp. #2
Closterium sp. #3
Closterium sp. #7 (libellula-like)
Cosmarium spp.
Euastrum binale
Euastrum dubium
Euastrum elegans
Euastrum insulare
Euastrum sp. #8 (ansatum-like)
Gymnozyga moniliformis
Micrasterias rotata
Staurastrum paradoxum
Staurastrum spp.

CYANOPHYTA

Hapalosiphon hibernicus (?)
Nostoc spp.
Tolypothrix tenuis

CHRYSOPHYTA

Epipyxis sp.
Dinobryon sertularia

EUGLENOPHYTA

Euglena acus

ROTIFERA

Rotifer sp. #1
Rotifer sp. #2

CILIOPHORA

Vorticella sp. #1
Vorticella sp. #3

DIPTERA

Chironomid larvae

SUMMARY

1. On the basis of the morphometry and the biota Lily Pad Lake is a small, slightly acidic bog lake.

2. The aquatic vegetation is dominated by Nuphar polysepalum, the submergents Potamogeton natans, P. gramineus, Chara spp., and Ceratophyllum demersum. The shoreline vegetation is dominated by species of Carex.

3. Lily Pad Lake phytoplankton is composed chiefly of desmids, which showed erratic fluctuations in their populations, probably due to interactions with the sediments and the unusual weather patterns experienced during the sampling period. Other members of the Chlorophyta were also very common and their incidence is correlated with water temperature. Filamentous and colonial Cyanophyta occurred regularly, particularly at the littoral stations. Diatoms were not common in the plankton. The most common planktonic species was Ceratium hirundinella, which showed considerable heterogeneity in its horizontal distribution. Dinobryon divergens was common only in the early summer samples.

4. Lily Pad Lake periphyton was dominated by diatoms, filamentous greens, bacteria and detritus. The most common diatoms were Epithemia turgida, Eunotia complex #2, Achnanthes spp. and Cymbella cistula. Mougeotia, Oedogonium and Spirogyra were the most common Chlorophytes. For all species there were marked differences among stations in periphyton species succession and between monthly and successional slides over the sampling period. Bacteria and detritus also played a significant role in the periphyton of Lily Pad Lake, particularly at the exposed littoral station. A positive correlation was found between the planktonic and periphytic populations of Mougeotia and Spirogyra, which likely signifies

seasonal and/or physico-chemical reasons for the observed fluctuations.

5. Nicklen Lake is a relatively large oligotrophic lake, characteristic of the Southern Interior Highland limnological region.

6. Asterionella formosa, Dinobryon divergens and Tabellaria fenestrata were the dominant components of the net plankton assemblage. Asterionella reached its maximum in mid-July and had disappeared almost completely by the beginning of August, perhaps due to loss to bottom sediments, chytrid parasitism, and decreased light or temperature. Dinobryon followed Asterionella in attaining dominance. Since powerful chemical influences operate to determine its seasonal occurrence, chemical data is needed to properly explain the pattern observed in Nicklen Lake. Tabellaria became dominant towards the end of July and declined by mid-August. Parasitism and competition with Asterionella might explain its fluctuations.

7. The periphyton was dominanted by diatoms, especially Achnanthes minutissima, which was dominant throughout. Epithemia turgida achieved dominance only in the mid-summer series. Some measure of competition for available substrate space between these two species was evident. The blue-green,Aphanocapsa, was dominant at the shallow littoral station over the long exposure period and would appear to be strictly additional. Other diatoms and cyanophytes showed only local increases in abundance. Of the Chlorophyta, Mougeotia and Coleochaete scutata were the only common genera and also showed only local increases in abundance.

8. Curtis Lake is a dystrophic lake, with the highly brown-stained water characteristic of such systems.

9. The most common phytoplankton groups were the greens and the diatoms, although no species became common. The periphyton was

dominated by bacteria and organic matter. The diatoms, *Achnanthes* and *Eunotia* complex #2, were the dominant algae. The filamentous greens, *Oedogonium* and *Bulbochaete*, declined when the diatoms became dominant.

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Appendix 1 Zooplankton counts for Lily Pad Lake 1976.

LILY PAD LAKE ZOOPLANKTON — DATE: JUNE 10

SPECIES	ABUNDANCE AT LITTORAL STATIONS L1	L2	L3
CLADOCERANS			
Daphnia pulex-schodleri, A	1	1	
Daphnia rosea, A		-	
juvenile Daphnia	19	31	38
Polyphemus pediculus A		1	
J	2	3	
Simocephalus vetulus		7	
Chydorus sphaericus		2	
COPEPODS			
Diaptomus leptopus adults			
copepodids	10	1	
Eucyclops agilis adults		1	
cyclopoid copepodids	36	36	37
~~Macrocyclops agilis albidus~~			
nauplii	31	19	11
ROTIFERS			
Keratella cochlearis	C	C	VC
Keratella quadrata	C	VC	A
Kellicottia longispina	NC	NC	NC
Polyarthra	NC	C	C
Synchaeta	NC	NC	NC
Conochilus unicornis	NC		NC
~~Filinia longiseta~~ Lecane		NC	
	30	30	30

NOTES

embryos in brood chamber

largest Daphnia about 3mm long, found in L1 & L2

tiny Daphnia with bud-like appendages
1-H, 2-H

ratio of D. schodleri / D. rosea

L1 = 20/0   L2 = 6/14   L3 = 20/0

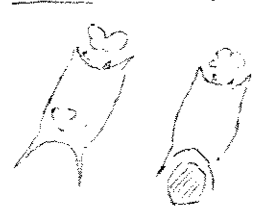
ratio of Macrocyclops / Eucyclops copepodids

L1 = 0/20   L2 = 6/14   L3 = 0/20

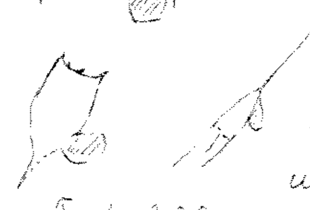
one ♂ cyclopoid in L2 (Eucyclops)

Filinia longiseta
2-V

Keratella with eggs



about 25µ



about 20µ

Kellicottia with egg
1-H, 2-H

LILY PADLAKE ZOOPLANKTON

DATE : JUNE 10

SPECIES	ABUNDANCE AT OPEN WATER STATIONS 1-H	1-V	2-H	2-V	NOTES
CLADOCERANS					
Daphnia pulex-schodleri, A	4		2	1	 Tiny Daphnia with bud-like appendages seen in 1-H, 2-H
Daphnia rosea, A					
juvenile Daphnia	50	24	75	52	
~~Polyphemus pediculus~~, A					
J					most Daphnia in 1-H are medium-sized; ratio D schodleri / D rosea: 1-H = 18/2, 1-V = 20/0, 2-H = 30/0, 2-V = 2/(
COPEPODS					
Diaptomus leptopus, A					
copepodids	2	12	18	10	
Eucyclops agilis, A					
cyclopoid copepodids	39	36	49	34	cyclopoid copepodids are Eucyclops
nauplii	31	30	9	33	* nauplii small & medium-sized 15-20μ & 25-30μ
ROTIFERS					
Keratella cochlearis	A	C	A	C	
Keratella quadrata	VA	A	VA	VA	
Kellicottia longispina	NC	NC	C	C	
Polyarthra	C	NC	C	C	
Synchaeta	C	NC	C	C	
Conochilus unicornis		NC	NC	NC	 Conochilus unicornis
	30	60	10	30	

LILY PAD LAKE ZOOPLANKTON — DATE: JUNE 13

SPECIES	ABUNDANCE AT LITTORAL STATIONS		
	L1	L2	L3
CLADOCERANS			
Daphnia pulex-schodleri A	5	5	
Daphnia rosea A			
juvenile Daphnia	60	74	
Polyphemus pediculus A			
I	4	1	
Bosmina haepae		3	
~~Chydorus sphaericus~~			
COPEPODS			
Diaptomus leptopus A			
copepodids	12	11	
Eucyclops agilis		1	
cyclopoid copepodids	15	13	
nauplii (copepod)	3	9	
ROTIFERS			
Keratella cochlearis	C	A	
Keratella quadrata	VC	VA	
Kellicottia longispina	NC	NC	
Polyarthra		NC	
Conochilus unicornis	NC	NC	
~~Brach.~~ Synchaeta		NC	
Euchlanis		NC	
Ouchropus stylifer		NC	
unidentified rotifer		NC	
~~Asplanchna~~			

NOTES

cladoceran embryos present in the sample (free)

one giant D. pulex with brood in L2

ratios D. schodleri / D. rosea

L1 = 17/3   L2 = 17/3

several cladoceran embryos

adult Eucyclops was a O⁷

Macrocyclops copepodid ratios : Eucyclops

L1 = 0/10   L2 = 9/1   L3 = ↗

Euchlanis

Synchaeta

kellicottia & both keratellas spp still with eggs

20   26

LILY PAD LAKE ZOOPLANKTON — DATE: JUNE 13

SPECIES	ABUNDANCE AT OPEN WATER STATIONS 1-H	1-V	2-H	2-V	NOTES
CLADOCERANS					
Daphnia pulex-schodleri A	3	2	3	6	one giant D pulex (schodleri) with brood, 2-V
Daphnia rosea A					
juvenile Daphnia	44	43	44	52	D schodleri / D rosea ratios: 1-H = 20/0, 1-V = 20/0, 2-H = 20/0, 2-V = 20/0
Polyphemus pediculus A					
J		1			
Chydorus sphaericus	3				
					embryos in water
COPEPODS					
Diaptomus leptopus A	13 ↓	10 ↓	7 ↓	20 ↓	
copepodids					
Eucyclops agilis A					
cyclopoid copepodids	23	18	25	18	all cyclopoid copepodids are Eucyclops
copepod nauplii	29	26	6	10	large + small nauplii (some probably diaptomid) ← mostly 25-30μ
ROTIFERS					
Keratella cochlearis	VC	C	VC	C	
Keratella quadrata	A	VC	A	A	
Kellicottia longispina	NC	C	C	NC	
Polyarthra	C	NC	C	C	
Conochilus unicornis	C	NC	NC	NC	
Synchaeta	C	C	C	NC	
Mastiopus stylifer	NC	NC	NC	NC	
unidentified rotifer		NC		NC	
Asplanchna	1				Asplanchna about 60μ
	50	20	30	20	

Asplanchna
about 60μ

LILY PAD LAKE ZOOPLANKTON

DATE : JUNE 16

SPECIES	ABUNDANCE AT LITTORAL STATIONS L1	L2	L3
CLADOCERANS			
Daphnia pulex-schodleri A	1	2	2
Daphnia rosea A			
juvenile *Daphnia*	38	61	36
Polyphemus pediculus A	2		
J	3	1	1
COPEPODS			
Diaptomus leptopus A			
copepodids	2	22	19
Eucyclops agilis A			1
cyclopoid copepodids	27	29	47
copepod nauplii	27	27	6
ROTIFERS			
Keratella cochlearis	NC	C	C
Keratella quadrata	C	VA	VA
Kellicottia longispina		NC	C
Polyarthra	NC	C	NC
Conochilus unicornis		C	C
Synchaeta	NC	NC	NC
Mastigopus stylifer		NC	NC
Philodina	NC		
	120	30	60

NOTES

D schodleri / D rosea ratios

L1 = 10/0 L2 = 20/0 L3 = 17/3

↖ most were very small + hard to identify

some *Diaptomus* are larger now (about ½ field)

adult *Eucyclops* are ♀♂, no egg sacs, but are fairly large (as large as those seen later with egg sacs) ⅓ medium ↖ field

all cyclopoid copepodids seen were *Eucyclops*

Philodina

LILY PADLAKE ZOOPLANKTON DATE: JUNE 16

SPECIES	ABUNDANCE AT OPEN WATER STATIONS 1-H	1-V	2-H	2-V	NOTES
CLADOCERANS					
Daphnia pulex-schodleri A	9	3	7	3	some adult Daphnia with broods & there are free embryos 1-H, 2-H, 2-V
Daphnia rosea A					
juvenile Daphnia	59	23	45	49	one Daphnia pulex (schodleri) with ephippial egg seen in 1-H
					
					all juveniles seem to be D schodleri
COPEPODS					
Diaptomus leptopus A	127 ↓				
copepodids		1	27	12	
Eucyclops agilis A					
cyclopoid copepodids	19	43	51	23	all are Eucyclops
copepod nauplii	14	42	25	20	
ROTIFERS					
Keratella cochlearis	C	C	C	C	
Keratella quadrata	A	A	VA	VA	
Kellicottia longispina	NC	NC	NC	C	
Polyarthra	NC	NC	C	C	
Conochilus unicornis	NC	NC	C	C	
Synchaeta	C	NC	NC	NC	
Gastropus stylifer		NC	NC		
Asplanchna	2				
	20	60	50	50	

LILY PAD LAKE ZOOPLANKTON — DATE: JUNE 19

SPECIES	ABUNDANCE AT LITTORAL STATIONS L1	L2	L3	NOTES
CLADOCERANS				
Daphnia pulex schodleri A	2		7	embryos in water
Daphnia rosea A	1			ratios for D schodleri / D rosea
juvenile Daphnia	38		50	L1 = 19/1 L2 = 7/[illegible] L3 = 17/3
Polyphemus pediculus A	5			
J	40		3	
Sida crystallina A	1			Daphnia schodleri with
J				epiphippial eggs L1 = 1
Chydorus sphaericus	1			L3 = 1
COPEPODS				
Diaptomus leptopus A			1	adult Diaptomus was a ♂
copepodids	1		2	
Eucyclops agilis				
cyclopoid copepodids	32		27	← Eucyclops
copepod nauplii	4		13	
ROTIFERS				
Keratella cochlearis	C		A	keratella still with eggs
Keratella quadrata	C		A	
Kellicottia longispina			NC	
Conochilus unicornis	NC		A	
Synchaeta	NC			
Euchlanis	NC		NC	
				Asplanchna with K quadrata + Conochilus inside
Asplanchna			3	
	20	20 →		

LILY PADLAKE ZOOPLANKTON DATE: JUNE 19

SPECIES	ABUNDANCE AT OPEN WATER STATIONS 1-H	1-V	2-H	2-V	NOTES
CLADOCERANS					
Daphnia pulex-schodleri A	5	6		10	cladoceran embryos in water
Daphnia rosea A					
juvenile *Daphnia*	45	65		41	ratio for juvenile *Daphnias* rosea / pulex
Polyphemus pediculus A	3			1	
J	5	6		5	1-H = 19/1 1-V = 19/1 2-V = 20/0
					2 of the adult D pulex have ephippia for 1-V, 1 in 1-H, 2-V
COPEPODS					cyclopoid copepodids are *Eucyclops*
Eucyclops agilis A		2			< ♂'s
cyclopoid copepodids	28	5		10	
Diaptomus leptopus A					some *Diaptomus* are quite large & have purplish antennae
copepodids	27	7		22	
copepod nauplii	6	7		17	most nauplii seem to be cyclopoid (are small) but a few larger
ROTIFERS					
Keratella quadrata	A	A		A	still some *Keratella* with eggs
Keratella cochlearis	C	C		C	
Kellicottia longispina	NC	NC		C	
Conochilus unicornis	C	NC		C	
Polyarthra	NC	NC		NC	
Euchlanis		NC			
Gastropus stylifer	NC	NC		NC	
unidentified rotifer		NC			
Synchaeta				NC	
	20	30		30	

RECOMMENDATIONS FOR FUTURE STUDY ON LILY PAD LAKE

With the baseline data provided here, future investigations of Lily Pad Lake might include estimates of the primary production of the periphyton community. Analyses of water chemistry should also be carried out. In addition, since the successive development of bogs is mirrored not only in the sharply marked succession of the higher flora and changes in the chemical composition of the water but also in the community composition of the microorganisms, the opportunity exists for future studies in Lily Pad Lake on the successional changes taking place in the micro-biocoenoses. The lake is also very suitable for the study of aquatic insects; members of many groups, especially Odonata, were abundant.

LILY PAD LAKE ZOOPLANKTON — DATE: JUNE 26

SPECIES	ABUNDANCE AT LITTORAL STATIONS L1	L2	L3
CLADOCERANS			
Daphnia schødleri A	1	4	2
Daphnia rosea A	1		
juvenile *Daphnia*	122	95	26
Polyphemus pediculus A	5	3	3
J	31	21	40
Sida crystallina A	1		
~~*Ceriodaphnia reticulata* J~~			4
Chydorus sphaericus			8
Ceriodaphnia reticulata			3
Acroperus harpae			2
Simocephalus vetulus			1
COPEPODS			
Diaptomus leptopus A	2	1	1
copepodids	10	15	6
Eucyclops agilis			5
Macrocyclops albidus			2
cyclopoid copepodids			20
copepod nauplii	19	6	9
ROTIFERS			
Keratella quadrata	C	A	NC
Keratella cochlearis	C	VA	A
Kellicottia longispina		NC	
Polyarthra	NC		C
Conochilus unicornis	NC	NC	C
Euchlanis	NC		
Diurella stylifer	NC		C
Lecane			NC
Synchaeta			NC

NOTES

one large Simocephalus in L3 ½ field of view

new cladocerans found

Sida crystallina about ¾ field & full of embryos in brood pouch

Acroperus harpae ♀ both have broods; some of

Ceriodaphnia reticulata

one with embryos

Chydorus

ratios for *D. schødleri* / *D. rosea*

L1 = 1/19 L2 = 7/13 L3 = 9/11

D. schødleri with ephippia in L2 & L3

some fairly large purplish diaptomid copepodids

adults are 1♂ & 1♀ L1

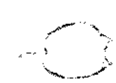
1♀ in L2 & L3

Eucyclops adults in L3 were 3♂ & 2♀

one ♂ *Macrocyclops* & one ♀ with egg sacs!

cyclopoid copepodid ratios for L3

20 E / 12 M



Lecane

LILY PADLAKE ZOOPLANKTON DATE: JUNE 26

SPECIES	ABUNDANCE AT OPEN WATER STATIONS			
	1-H	1-V	2-H	2-V
CLADOCERANS				
Daphnia schodleri A	2	3		17
Daphnia rosea A				1
juvenile *Daphnia*	35	53	99	78
Polyphemus pediculus A	4			
J	3	5		
Lathonura rectirostris	1			
COPEPODS				
Diaptomus leptopus A			14	12
copepodids	12	8	38	22
Eucyclops agilis				
cyclopoid copepodids	[illegible]	1	5	3
copepod nauplii	82	31	2	
ROTIFERS				
Keratella quadrata	A	C	C	A
Keratella cochlearis	A	C	C	C
Conochilus unicornis	A	C	VA	A
Kellicottia longispina	NC	NC	C	C
Polyarthra	NC	NC	NC	C
Gastropus stylifer	NC	NC	NC	NC
[illegible]	2	2		

NOTES

new cladoceran *Lathonura rectirostris*

cladoceran embryos in water, and many small Daphnias

D. schodleri / D. rosea ratios

1-H = 4/16 1-V = 10/10

2-H = 15/5 2-V = 1/13

D. schodleri with ephippia 5/17 in 2-V

adult *Diaptomus* taken by purple color on cerci

♂/♀ ratios

2-H = 3/11 2-V = 5/7

adults also have last ½ of antennae purplish

cyclopoid copepodids are *Eucyclops*

most nauplii small

LILY PAD LAKE ZOOPLANKTON — DATE: JULY 1

SPECIES	ABUNDANCE AT LITTORAL STATIONS L1	L2	L3	NOTES
CLADOCERANS				
Daphnia schodleri A				D. schodleri / D. rosea ratios
Daphnia rosea A				L1 = all rosea ↑ hard to identify because they were all small; L2 = 0/20 ↗; L3 = 3/17
juvenile Daphnia	60	21	37	
Polyphemus pediculus A	2	18	7	
J	34	52	60	
Streblocerus serricaudatus	1			
Sida crystallina A	1			
Acroperus harpae		1	1	one loose ephippium in L2, & several in L3
				lots of pine pollen
COPEPODS				
Diaptomus leptopus A			1	= ♀
copepodids	16	2	4	
Eucyclops agilis A	1		1	= adult ♀ in L1, ♀ with egg sacs in L3
cyclopoid copepodids	3		2	↖ copepodids are Eucyclops
copepod nauplii		1	2	
ROTIFERS				
Conochilus unicornis	A	NC	C	
Keratella quadrata	NC	NC	NC	
Keratella cochlearis	NC			
Kellicottia longispina	NC	NC	NC	

30 100 110

LILY PAD LAKE ZOOPLANKTON DATE: JULY 1

SPECIES	ABUNDANCE AT OPEN WATER STATIONS			
	1-H	1-V	2-H	2-V
CLADOCERANS				
Daphnia schodleri A		1	1	13
Daphnia rosea A				
juvenile Daphnia	39	41	87	56
Polyphemus pediculus A	5			
I	5	1	4	4
Chydorus sphaericus		1		
COPEPODS				
Diaptomus leptopus A	12	15	15	15
copepodids	13	5	23	19
Eucyclops agilis			2	2
cyclopoid copepodids	3		13	7
copepod nauplii	20	30	11	8
ROTIFERS				
Conochilus unicornis	VA	C	VA	A
Keratella quadrata	2	C	NC	NC
Keratella cochlearis	NC	NC	NC	NC
Kellicottia longispina	NC	NC	NC	NC
Asplanchna	2		4	
	40	[illegible]	[illegible]	[illegible]

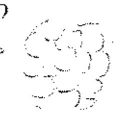
NOTES

D. schodleri / D. rosea ratios
1-H = 0/20 1-V = 10/10
2-H = 5/18 2-V = 20/0

some D. schodleri with ephippia in 2-V
a few embryos in water

♂/♀ for Diaptomus adults
2-H = 8/7 2-V = 5/15
1-H = 6/6 1-V = 4/11
← one ♀ with egg sac in 2-H, 1-V & 1-H

egg sac seen free in 2-V →



↑ from Diaptomus

← Eucyclops copepodids

← 7 are diaptomid late nauplii in 2-V
9 in 2-H, all in 1-H & 1-V

Daphnia schodleri with hump seen in 2-V !

Eucyclops adults
1 ♀/10 ♂ in 2-H, ♀ with egg sacs

LILY PAD LAKE ZOOPLANKTON DATE: JULY 4

SPECIES	ABUNDANCE AT LITTORAL STATIONS L1	L2	L3
CLADOCERANS			
Daphnia schodleri A			
Daphnia rosea A			2
juvenile *Daphnia*	80	40	102
Polyphemus pediculus A	5	13	2
J	22	51	16
Sida crystallina A		5	
Acroperus harpae		2	
COPEPODS			
Diaptomus leptopus A	3	5	3
copepodids	12	12	3
copepod nauplii	11	11	4
ROTIFERS			
Conochilus unicornis	A	NC	VA
Keratella quadrata	NC	NC	NC
Keratella cochlearis	NC	NC	
Kellicottia longispina	NC		NC
Euchlanis		NC	
Asplanchna priodonta	1		1

NOTES

D. schodleri / D. rosea ratios:
L1 = 4/16 L2 = 5 L3 = 8/22
all D. rosea, I think, although they are very small

free ephippia in L3 sample
embryos in samples, especially L3

adult Diaptomus ♂/♀
L1 = 0/3 L2 = 2/2 L3 = 2/1

♂ with spermatophores

nauplii are diaptomid

some Keratella & Kellicottia still with eggs

x-section of lorica of Euchlanis

LILY PADLAKE ZOOPLANKTON DATE: JULY 4

SPECIES	ABUNDANCE AT OPEN WATER STATIONS				NOTES
	1-H	1-V	2-H	2-V	
CLADOCERANS					
Daphnia schodleri A	4	25	3	3	D schodleri / D rosea ratios:
Daphnia rosea A	2		1		1-H = 19/21 1-V = 20/0
juvenile Daphnia	79	60	67	40	
Polyphemus pediculus A				2	2-H = 0/20 2-V = 10/10
I	1		1	19	c small
					15/25 of adult D schodleri were giants in 1-H, 4 had ephippia
					embryos in samples
COPEPODS					
Diaptomus leptopus A	23	5	14	14	adult ♂/♀ ratios:
copepodids	20	2	32	16	1-H = 10/13 1-V = 2/3
					2-H = 7/7 2-V = 4/10
					♀'s with egg sacs 1-H = 1, 2-H = 1
copepod nauplii	20	13	20	26	loose egg sacs in samples
					nauplii are diaptomid
ROTIFERS					
Conochilus unicornis	VA	A	VA	VC	Kellicottia with eggs
Keratella quadrata	NC	NC	NC	C	
Keratella cochlearis	NC	NC	NC	NC	
Kellicottia longispina	NC	C		NC	
Asplanchna priodonta	1		2		
	40	80	20	40	

LILY PAD LAKE ZOOPLANKTON — DATE: JULY 10

SPECIES	ABUNDANCE AT LITTORAL STATIONS		
	L1	L2	L3
CLADOCERANS			
Daphnia schodleri A			
Daphnia rosea A		2	8
juvenile Daphnia	43	63	42
Polyphemus pediculus A	1	2	3
J	42	10	16
Sida crystallina A	10		
J	16		
Acroperus harpae	1	4	
Chydorus sphaericus		3	1
COPEPODS			
Diaptomus leptopus A		1	3
copepodids	5	8	12
Eucyclops agilis			2
cyclopoid copepodids	1		
copepod nauplii	4	13	39
ROTIFERS			
Conochilus unicornis	VC	VC	VC
Keratella quadrata		NC	NC
Keratella cochlearis		NC	
Euchlanis	NC	NC	NC
Brachionus	NC		
Asplanchna priodonta		2	2

NOTES

ratios for Daphnia L1 = ♀ ; L2 = small, but seem to be D rosea ; L3 = 4/16

empty carapaces from Acroperus

some giant Sidas (3 mm) with broods

lots of pine pollen

embryos in samples, probably Polyphemus

adult Diaptomus L2 = ♀ ; L3 = 2♂ / 1♀

Eucyclops: 2 ♀'s

nauplii in L2 & L3 seem to be diaptomid nauplii (are large & bluish)

LILY PAD LAKE ZOOPLANKTON DATE: JULY 10

SPECIES	ABUNDANCE AT OPEN WATER STATIONS 1-H	1-V	2-H	2-V
CLADOCERANS				
Daphnia schodleri A				2
Daphnia rosea A		3	1	2
juvenile Daphnia	7	28	27	24
Polyphemus pediculus A				
J	<	3		1
COPEPODS				
Diaptomus leptopus A		10		4
copepodids	17	16	11	13
cyclopoid copepodids	4	3	2	2
copepod nauplii	88	61	89	71
ROTIFERS				
Conochilus unicornis	VA	A	VA	
Keratella quadrata	NC	NC	NC	
Kellicottia longispina	NC →		NC	
Synchaeta sp.	NC →			
[illegible]	NC	1	NC	
Asplanchna priodonta		1	6	

NOTES

D schodleri / D rosea ratios:
1-H = 1-V = $\frac{4}{16}$
2-H = $\frac{0}{7}$ 2-V = $\frac{7}{13}$
small

all seen in 1-H were D schodleri (2) but most were too small to identify these may be D rosea

some giant Daphnia in 2-V (seem to like bottom waters)

embryos in 2-V

adult ♂/♀ ratios
1-H = 1-V = $\frac{2}{8}$
2-H = 2-V = $\frac{2}{2}$

loose diaptomid eggs some [illegible] eggs

nauplii probably Diaptomus

[illegible] in vertical samples but things there are large

LILY PAD LAKE ZOOPLANKTON

DATE: JULY 14

SPECIES	ABUNDANCE AT LITTORAL STATIONS		
	L1	L2	L3
CLADOCERANS			
Daphnia schoedleri A			2
Daphnia rosea A		1	9
juvenile *Daphnia*	31	27	35
Polyphemus pediculus A		1	9
J	48	29	29
Acroperus harpae	1	4	
Sida crystallina A	1	3	
~~*Chydorus sphaericus* J~~		9	2
Chydorus sphaericus		1	
COPEPODS			
Diaptomus leptopus A			
copepodids	21	17	22
Eucyclops agilis		1	1
cyclopoid copepodids	2	2	
copepod nauplii	11	17	12
ROTIFERS			
Conochilus unicornis	VC	VC	A
Keratella quadrata	NC	NC	NC
Keratella cochlearis			NC
Kellicottia longispina	NC		NC
Euchlanis	NC	C	NC
Asplanchna priodonta		2	1
	50	[illegible]	40

NOTES

ratios for *Daphnia*:
L1 = ♀ L2 = 1/5 L3 = 0/20
all *rosea* (small, though) ? small

humps on *D. rosea* (medium-sized ones)

only one or 2 seen, though

some larger *Acroperus* now

Acroperus carapaces in L1 = 2, L2 = 5, L3 = 1

embryos in water may be *Sida*

pine pollen

adult *Eucyclops* ♀'s

cyclopoid copepodids are *Eucyclops*

nauplii seem to be mostly *Diaptomus*

LILY PADLAKE ZOOPLANKTON DATE : JULY 14

SPECIES	ABUNDANCE AT OPEN WATER STATIONS				NOTES
	1-H	1-V	2-H	2-V	
CLADOCERANS					
Daphnia schodleri A				7	ratios for *Daphnia*:
Daphnia rosea A				9	1-H = 18/2 1-V = ↗
juvenile *Daphnia*	23	32 →		35	2-H = 2/18 2-V = 5/15
Polyphemus pediculus A					
J	1			2	
Sida crystallina A					some humped *D. rosea*
J	2				juveniles
Campocercus harpae	1				(only 1 or 2)
Ceriodaphnia reticulata			1		embryos in 2-V
COPEPODS					
Diaptomus leptopus A				6	← 10♂, 5♀
copepodids	20		54	28	
cyclopoid copepodids	4		4		← *Eucyclops*
copepod nauplii	50		78	39	← diaptomids
ROTIFERS					
Conochilus unicornis	VC		VA	VA	
Keratella quadrata	NC		NC	NC	
Keratella cochlearis	NC		NC	NC	
Kellicottia longispina	NC		C	C	
Euchlanis	NC			NC	
Asplanchna priodonta			3		
	50		90	52 (30)	

LILY PAD LAKE ZOOPLANKTON DATE: JULY 18

SPECIES	ABUNDANCE AT LITTORAL STATIONS			NOTES
	L1	L2	L3	
CLADOCERANS				
Daphnia schodleri A				ratios for *Daphnia*
Daphnia rosea A	2	1		L1 = D.rosea / J L2 = 1/9 L3: 2/8
juvenile *Daphnia*	28	21	10	
Polyphemus pediculus A	5	1	2	
J	20	32	45	new cladoceran =
Sida crystallina A	2	1		*Scapholeberis kingi*
J	5	2		
Acroperus harpae	17	13		
Simocephalus vetulus	2			
Chydorus sphaericus	9	2		*Chydorus* + *Acroperus* large & small
Streblocerus serricaudatus	3			
Scapholeberis kingi				embryos in samples
				pine pollen
COPEPODS				
Diaptomus leptopus A				
copepodids	15	34	27	
Eucyclops agilis	1			♀ with egg sac in L1
cyclopoid copepodids	2	1	1	← *Eucyclops*
copepod nauplii	3	16	34	← diaptomids
				free egg sac in L2 of *Diaptomus*
ROTIFERS				
Conochilus unicornis	VC	VA	C	
Euchlanis	NC	NC		
Kellicottia longispina		NC	NC	
Keratella cochlearis		NC	NC	*Keratella* seen with eggs
Asplanchna priodonta		4	2	
	[illegible]	50	40	

LILY PAD LAKE ZOOPLANKTON

DATE: JULY 18

SPECIES	ABUNDANCE AT OPEN WATER STATIONS				NOTES
	1-H	1-V	2-H	2-V	
CLADOCERANS					
Daphnia schødleri A				13	males of Daphnia:
Daphnia rosea A	2	4	3	9	1-H = 0/7 1-V = 11/9
juvenile Daphnia	13	37	38	47	2-H = 1/9 2-V = 6/19
Polyphemus pediculus A	4	1			
J	5	1	1	7	embryos in samples
Chydorus sphaericus	1				
Acroperus harpae		2			
					(one ♀ with egg sac)
					♂/♀ ratios 1-V = 5/2 2-H = 2/0 2-V = 5/13
COPEPODS					
Diaptomus leptopus A		7	2	18	
copepodids	45	37	104	19	free egg sac from Diaptomus in 1-H, 1-V, + 2-V
cyclopoid copepodids	8	4	1		← Eucyclops
copepod nauplii	43	32	63	12	← almost all are diaptomid (or all?) late nauplii in 1-H, 2-H, 2-V; 1-V has small + large + could be both cyclopoid + calanoid
ROTIFERS					
Conochilus unicornis	VC	C	VA		
Euchlanis	NC				
Keratella cochlearis	NC	NC	NC		
Polyarthra		NC			
Keratella quadrata		NC	NC		Kellicottia with egg
Kellicottia longispina			C		
Asplanchna priodonta	4	2	19		
	211	40	10	40	

LILY PAD LAKE ZOOPLANKTON — DATE: JULY 22

SPECIES	ABUNDANCE AT LITTORAL STATIONS L1	L2	L3
CLADOCERANS			
Daphnia schødleri A			
Daphnia rosea A	2		
juvenile Daphnia	21	1	43
Polyphemus pediculus A	5	4	3
J	11	47	19
Sida crystallina A	3	2	
J	12	3	
Acroperus harpae A	7	9	1
J	15	23	3
Chydorus sphaericus	3	3	1
Simocephalus serrulatus	4		
Eurycercus lamellatus	1	1	
Scapholeberis kingi		1	
Ceriodaphnia reticulata		1	
COPEPODS			
Diaptomus leptopus A		4	
copepodids	13	9	31
Eucyclops agilis	1		
cyclopoid copepodids	5	3	5
copepod nauplii	11	6	31
ROTIFERS			
Conochilus unicornis	A	C	VC
Kellicottia longispina	NC		NC
Euchlanis	NC	NC	
Keratella quadrata			NC
Asplanchna priodonta		1	4
	50	60	40

NOTES

some D. rosea (1 or 2) with embryos

Daphnia ratios:
L1 = all D. rosea = L2 = L3

embryos in water

Acroperus carapaces L1 = 4

one Chydorus large with embryo (or ephippium)

new cladoceran:
Eurycercus lamellatus

adult Diaptomus ♂/♀ ratios
L2 = 0/4 & 2 with eggs

adults L1: ♀ with egg sacs

0 diaptomid nauplii

LILY PAD LAKE ZOOPLANKTON

DATE: JULY ~~18~~ 22

SPECIES	ABUNDANCE AT OPEN WATER STATIONS 1-H	1-V	2-H	2-V
CLADOCERANS				
Daphnia schodleri A				1
Daphnia rosea A		6	1	4
juvenile Daphnia	24	19	23	15
Polyphemus pediculus A	1		1	
J	2	1		3
Sida crystallina A	1			
J	5			
Graptoleberis testudinaria				1
COPEPODS				
Diaptomus leptopus A	1	5		9
copepodids	215	42	100	61
cyclopoid copepodids	4	2	1	7
copepod nauplii	73	36	23	31
ROTIFERS				
Conochilus unicornis	A	C	VA	VA
Euchlanis	C			
Keratella quadrata	NC	NC	NC	NC
Keratella cochlearis	NC	NC	NC	NC
Kellicottia longispina	NC	NC		C
Brachionus	NC	NC		
Asplanchna priodonta	13	2	30	9
([illegible])	5''	60	10	20

NOTES

Daphnia ratios:
1-H = all D rosea = 1-V
2-H = all D rosea   2-V = 1/2 ← probably mostly rosea

new cladoceran = Graptoleberis testudinaria

some giant D schodleri present (hard to pick up with dropper)

adult ♂/♀ ratios:
1-H = 0/1   1-V = 3/2 ← one with egg sac
2-V = 3/6 ← some free egg sacs

← diaptomid

← a couple of cyclopoid nauplii maybe (there are a couple of small nauplii in 1-V, 2-H)

keratellas & kellicottia with eggs

some Asplanchnas with small Asplanchnas inside of them

LILY PAD LAKE ZOOPLANKTON DATE: AUG 2

SPECIES	ABUNDANCE AT LITTORAL STATIONS			NOTES
	L1	L2	L3	
CLADOCERANS				
Daphnia schodleri A			1	juvenile Daphnias
Daphnia rosea A	1	2	25	L1 = all D. rosea = L2 = L3
juvenile Daphnia	56	64	43	broods of D. rosea usually of
Polyphemus pediculus A		27	2	2 or 3
J	4	29	5	
Sida crystallina A	6	1		
J	6			embryos in samples
Acroperus harpae A				
J	4			Acroperus carapace L1 = 1 = L2
Simocephalus vetulus	3			
Chydorus sphaericus A	2			
J	6			
Streblocerus serricaudatus	2			
COPEPODS				
Diaptomus leptopus A				
copepodids	31	8	20	
Eucyclops agilis	1			* ♀ with egg sacs
cyclopoid copepodids	1	1	2	
copepod nauplii	6	2	8	* most nauplii large
ROTIFERS				
Conochilus unicornis	C	NC	C	
Euchlanis	NC			Euchlanis nearly as big as
Kellicottia longispina		NC	NC	Asplanchna now
Keratella cochlearis		NC	NC	
				many Asplanchnas! seem to be
				feeding on Conochilus
Asplanchna priodonta	6	76	7	

LILY PAD LAKE ZOOPLANKTON

DATE: AUG 2

SPECIES	ABUNDANCE AT OPEN WATER STATIONS 1-H	1-V	2-H	2-V
CLADOCERANS				
Daphnia schodleri A		2		2
Daphnia rosea A	2	11	5	
juvenile *Daphnia*	86	52	49	25
Polyphemus pediculus A	3		1	
J	2			2
Sida crystallina A	4			
J	31		1	
Eurycercus lamellatus	1			
Scapholeberis kingi	1			1
Ceriodaphnia reticulata			1	1
Scapholeberis kingi				✓
COPEPODS				
Diaptomus leptopus A	4	7	7	5
copepodids	50	33	158	54
Eucyclops agilis	2			
cyclopoid copepodids	7	1		1
copepod nauplii	9	17	3	16
ROTIFERS				
Conochilus unicornis	A	VC	VC	A
Keratella quadrata	NC	NC		NC
Keratella cochlearis	NC	NC		NC
Kellicottia longispina	NC	NC	C	NC
Asplanchna priodonta	60	5	5	3
	101	60	5	70

NOTES

most *Daphnia rosea* of a certain size have hump > 1/3 - 1/4 size

Daphnia juveniles:
1-H = all *D. rosea*
1-V = $\frac{1}{24}$ 2-H = $\frac{5}{15}$
2-V = $\frac{1}{10}$

quite a few medium *D. rosea* with humps (many)

embryos in water

several giant *D. schodleri* in 2-V

↓ free egg sacs 1-V, 2-H

adult *Diaptomus* ♂/♀ ratios:
1-H = $\frac{1}{4}$ 1-V = $\frac{0}{7}$ 2-H = $\frac{0}{7}$
2-V = $\frac{0}{5}$

adult *Eucyclops* ♂/♀ ratios:
1-H = $\frac{1}{1}$

2-H & 2-V
∞ diaptomid in 1-H, but $\frac{11}{17}$ in 1-V are small

rotifer seen only once, on 2-H

LILY PAD LAKE ZOOPLANKTON — DATE: AUG 6

SPECIES	ABUNDANCE AT LITTORAL STATIONS			NOTES
	L1	L2	L3	
CLADOCERANS				
Daphnia schødleri A				
Daphnia rosea A	1	3	14	
juvenile Daphnia	85	67	37	
Polyphemus pediculus A		12		
J		41	8	
Sida crystallina A	1	2	1	
J	8	6	2	
Acroperus harpae A	1			
J	1	2		
Chydorus sphaericus A	1	1	1	← with eggs
J		2		
Graptoleberis testudinaria			1	
Ceriodaphnia reticulata			1	
COPEPODS				
Diaptomus leptopus A	1		1	
copepodids	61	13	40	
Eucyclops agilis	1			← ♀
cyclopoid copepodids		2	1	
copepod nauplii	3	3	3	
ROTIFERS				
Conochilus unicornis	NC	C	NC	← Conochilus eaten!
Keratella quadrata			NC	
Keratella cochlearis		NC		
Kellicottia longispina				
Asplanchna priodonta		157	14	

Daphnia males:
L1 = all D rosea, mostly medium? & lots with humps
L2 = 0/20 ↑ all rosea again

one ♂ D rosea! with hump, in L

♀'s with 1 or 2 embryos in brood pouch

embryos in water in all samples

adult Diaptomus L1 = ♀
L2 = ♂♀
L3 = ♂

Asplanchna eating Conochilus & Keratella

LILY PADLAKE ZOOPLANKTON

DATE: AUG 6

SPECIES	ABUNDANCE AT OPEN WATER STATIONS 1-H	1-V	2-H	2-V
CLADOCERANS				
Daphnia schødleri A		1		6
Daphnia rosea A		7	3	
juvenile Daphnia	63	39	155	43
Polyphemus pediculus A	2	1	1	
J	1		2	
Sida crystallina A	2	1		
J	28	10		
Acroperus harpae A		1		
J				
Ceriodaphnia reticulata				2
COPEPODS				
Diaptomus leptopus A	5	2		8
copepodids	45	29	78	35
Eucyclops agilis		2		
cyclopoid copepodids	2		1	2
copepod nauplii	20	11	5	11
ROTIFERS				
Conochilus unicornis	VA	A	VA	A
Keratella cochlearis	NC	NC		
Keratella quadrata	NC	NC	NC	
Kellicottia longispina	NS	NC	NC	NC
Asplanchna priodonta	63	10	24	10
	[illegible]	50	[illegible]	40

NOTES

some giant D schødleri in 2-V

giants — 2 D schødleri medium with hump

Daphnia ratios:

1-H = 2/18   1-V = all D rosea

2-H = 4/16   2V = 12/15

some very small embryos in water

medium D roseas with humps

D rosea ♂/♀ ratios:

2-H = 1/2

1-V = 0/7

adult ♂/♀ ratio:

1-H = 0/5   1-V = 0/2

2-V = 2/6

adult Eucyclops 1-V = 2♂

some nauplii are small in 1-V

Asplanchna eating Conochilus & Keratella

LILY PAD LAKE ZOOPLANKTON DATE: AUG 10

SPECIES	ABUNDANCE AT LITTORAL STATIONS		
	L1	L2	L3
CLADOCERANS			
Daphnia schodleri A			
Daphnia rosea A	4	13	
juvenile Daphnia	77	108	
Polyphemus pediculus A		7	
J	3	22	
Sida crystallina A	2		
J	6	1	
Acroperus harpae A	2	1	
J	1	4	
Chydorus sphaericus A	1	1	
J	1	2	
Ceriodaphnia reticulata	1		
Simocephalus vetulus	1	1	
COPEPODS			
Diaptomus leptopus A	1		
copepodids	32	10	
Eucyclops agilis	2	1	
cyclopoid copepodids	1		
copepod nauplii	3	1	
ROTIFERS			
Conochilus unicornis	NC	NC	
Euchlanis	NC		
Asplanchna priodonta	1	1	

NOTES

Daphnia ratios:
L1 = all D rosea = L2 = L3

adult D rosea ♂/♀ ratios:
L1 = 2/2 L2 = 4/9

Acroperus carapaces
L1 = 4

♂/♀ ratio for Diaptomus:
L1 = 0/1

adult Eucyclops ♂/♀ ratio:
L1 = 0/2 (↑ with egg sacs) L2 = 0/1

L3 sample kind of decomposed, but saw Polyphemus, D rosea, Diaptomus & Acroperus also Macrocyclops adult ♀!

LILY PADLAKE ZOOPLANKTON DATE: AUG 10

SPECIES	ABUNDANCE AT OPEN WATER STATIONS			
	1-H	1-V	2-H	2-V
CLADOCERANS				
Daphnia schoedleri A		2		6
Daphnia rosea A	3	11	2	2
juvenile Daphnia	45	50	51	61
Polyphemus pediculus A	5	1	1	
J	4	1		
Sida crystallina A				
J	15	8	1	
Ceriodaphnia reticulata	2		1	
Acroperus harpae	1			
COPEPODS				
Diaptomus leptopus A	2	9	3	12
copepodids	30	15	122	56
Eucyclops agilis	1			
cyclopoid copepodids	1			3
copepod nauplii	11	10	7	12
ROTIFERS				
Conochilus unicornis	VA	VC	VA	A
Brachionus	NC			
Keratella cochlearis		NC		NC
Keratella quadrata		NC		NC
Kellicottia longispina		NC	NC	NC
Asplanchna priodonta	16	6	14	4
	10	30	13	(20)

NOTES

one D rosea with [illegible]

Daphnia ratios:

1-H = all D rosea = 1-V

2-H = $\frac{2}{13}$ 2-V = $\frac{21}{13}$

$\frac{♂}{♀}$ ratios for D rosea

1-H = $\frac{1}{2}$ 1-V = $\frac{0}{11}$ c all ♀ in 2-H, 2-V

∽ one adult Ceriodaphnia with brood

D roseas seem to have bigger broods (3 + 4)

giant D schoedleri in 2-V

adult $\frac{♂}{♀}$ ratio for Diaptomus

1-H = $\frac{1}{1}$ 1-V = $\frac{3}{6}$

2-H = $\frac{2}{1}$ 2-V = $\frac{4}{8}$

Eucyclops $\frac{♂}{♀}$ ratios:

1-H = $\frac{1}{0}$

∗ a couple of small nauplii

∗ Eucyclops ♂'s smaller than ♀'s

free egg sacs of Diaptomus in 2-H

in 2-V, several D schoedleri with humps (medium size

young inside Asplanchna

LILY PAD LAKE ZOOPLANKTON | DATE: AUG 13

SPECIES	ABUNDANCE AT LITTORAL STATIONS			NOTES
	L1	L2	L3	
CLADOCERANS				
Daphnia schodleri A			1	Daphnia ratios:
Daphnia rosea A		24	10	L1 = D rosea all = L2
juvenile Daphnia	20	100	42	L3 = 3/17
Polyphemus pediculus A	2	8		
J	24	3	9	♂/♀ ratio for D rosea
Sida crystallina A	9	1		L2 = 13/11 ← one with ephippium.
J	23	8	5	L3 = 8/2 ←
Acroperus harpae A	6	1		Acroperus carapace L1 = 3
J	6	2		embryos in samples
Simocephalus vetulus	6	3		big + small Simocephalus
Chydorus sphaericus A		1		
J		2		D rosea seems to be increasing
Ceriodaphnia reticulata			1	in size now
COPEPODS				adult Microcyclops = ♀ in L2 with eggs
Diaptomus leptopus A				
copepodids	6	4	22	adult Eucyclops = ♀'s in L2 + L1 ← with egg sacs
Microcyclops albidus		1		
Eucyclops agilis		2	1	cyclopoid egg sacs present
cyclopoid copepodids	1	1	4	
copepod nauplii	6	19	18	both small + big nauplii in L1, L2; big in L3 (2/4, 14/5)
ROTIFERS				
Conochilus unicornis	NC	C	VC	
Keratella cochlearis			NC	L2 poorly preserved sample
Kellicottia longispina			NC	
				copepodids in L3 = 1/3 M/E
Asplanchna priodonta		26	14	

[illegible]

LILY PAD LAKE ZOOPLANKTON

DATE: AUG 13

SPECIES	ABUNDANCE AT OPEN WATER STATIONS 1-H	1-V	2-H	2-V
CLADOCERANS				
Daphnia schødleri A		1	4	2
Daphnia rosea A	3	11	1	3
juvenile Daphnia	80	63	40	21
Polyphemus pediculus A	1			
J	2			
Sida crystallina A				
J	4	2		
Ceriodaphnia reticulata			1	
COPEPODS				
Diaptomus leptopus A	5	7	3	18
copepodids	34	20	79	51
Eucyclops agilis	3			
cyclopoid copepodids	1	3	3	1
copepod nauplii	7	4	19	11
ROTIFERS				
Conochilus unicornis	—	NC	VA	VC
Kellicottia longispina	NC	NC	C	NC
Keratella cochlearis	[illegible]	NC	NC	NC
Keratella quadrata				NC
Asplanchna priodonta		8	80	3
	20	70	80	(80) 100

NOTES

D. rosea still with (humps that fuse)

Daphnia ratios:
1-H = all rosea = 1-V ← 1/29 really
2-H = 5/15   2-V = 4/10

♂/♀ ratio for D. rosea
1-H = 1/2   1-V = 4/7
2-V = 1/2

embryos in water

not many small Daphnias in 2-V

adult Diaptomus ratios ♂/♀:
1-H = 0/5   1-V = 3/4
2-H = 0/3   2-V = 8/10 ↑ free egg sac in 1-H + 2-V

Eucyclops ♂/♀ ratios: (one with eggs)
1-H = 2/1

nauplii of 1-V are big + small; others all big

Conochilus not seen in 1-H but sample was poorly preserved, & I expect it was probably VC or A

← cyclopoid copepods probably Eucyclops

small Asplanchnas in 2-H large ones

APPENDIX 2 : Prescence and relative abundance of crustacean zooplankton species at the 5 sampling stations on Lily Pad Lake 1976.

	June 9	13	16	19	26	July 1	4	10	14	18	22	Aug 2	6	10	13
Diaptomus	10.1	10.1	P	P	6.3	13.6	11.3	4.1	18.3	13.2	11.4	24.0	37.8	23.9	5.5
Eucyclops	36.4	15.2	27.0	25.6	–	3.4	–	P	P	P	5.3	P	P	P	P
Nauplii	31.3	3.0	27.0	3.2	9.9	–	8.3	3.3	9.6	2.6	9.6	4.7	P	P	5.5
D. schodleri	20.0	56.6	39.0	30.4	3.6	–	12.0	–	–	–	–	–	–	–	–
D. rosea	–	9.1	–	P	60.9	30.8	48.1	35.0	27.0	26.3	20.2	44.2	52.4	58.7	18.3
Polyphemus	P	4.0	5.0	36.0	18.8	30.5	20.3	35.0	41.7	21.9	14.9	3.1	–	P	23.9
Sida	–	–	–	P	P	P	–	21.1	P	6.1	13.2	9.3	5.5	5.8	29.4
Acroperus	–	–	–	–	–	–	–	P	P	14.9	19.3	3.1	P	P	11.0
Chydorus	–	–	–	P	–	–	–	–	–	7.9	2.6	6.2	P	P	–
Streblocerus	–	–	–	–	–	P	–	–	–	P	3.5	P	–	–	–
Simocephalus	–	–	–	–	P	–	–	–	–	P	–	P	–	P	5.5
Lathonura	–	–	–	–	P	–	–	–	–	–	–	–	–	–	–
Eurycercus	–	–	–	–	–	–	–	–	–	–	P	–	–	–	–
Ceriodaphnia	–	–	–	–	–	–	–	–	–	–	–	–	–	P	–
Total No of Spp	4	5	4	6	6	6	4	6	6	9	9	9	6	9	7
	Range 4-9 Mean 6.40 Species														

Table A: Presence and Relative Abundance of Crustacean Zooplankton at Station 1

P = Present

	June					July						Aug			
	10	13	16	19	26	1	4	10	14	18	22	2	6	10	13
Diaptomus	P	9.5	15.5		11.0	P	11.9	8.5	15.2	27.4	11.1	6.0	8.6	5.8	P
Nauplii	15.6	6.9	19.0		4.1	P	8.2	12.3	15.2	12.9	5.1	P	P	P	10.6
Eucyclops	25.5	P	20.4		—	—	—	P	P	P	P	P	P	P	P
Macrocyclops	10.8	8.6	—		—	—	—	—	—	—	—	—	—	—	—
D. Schodleri	22.5	58.6	38.0		25.5	—	—	—	—	P	—	—	—	—	—
D. Rosea	9.8	9.5	6.3		42.8	22.1	29.8	61.3	25.0	16.1	P	47.3	46.1	70.3	68.9
Polyphemus	3.9	P	P		16.6	73.7	47.8	11.3	26.8	26.6	43.6	41.8	34.9	16.9	6.1
Sida	—	—	—		—	—	P	—	10.7	P	4.3	P	3.9	P	5.0
Acroperus	—	P	—		—	P	P	3.8	3.6	10.5	27.4	—	P	2.9	P
Chydorus	P	—	—		—	—	—	P	P	P	P	—	P	P	P
Simocephalus	6.9	—	—		—	—	—	—	—	—	—	—	—	P	P
Eurycercus	—	—	—		—	—	—	—	—	—	P	—	—	—	—
Scapholeberis	—	—	—		—	—	—	—	—	—	P	—	—	—	—
Ceriodaphnia	—	—	—		—	—	—	—	—	—	P	—	—	—	—
Total SPP	8	7	5		4	4	5	5	7	8	10	5	7	8	8

Range 4-10 Mean 6.50 SPP

Table B: Presence and Relative Abundance of Crustacean Zooplankton at Station 2.

Proportions are % P = Present

	June					July						Aug			
	10	13	16	19	26	1	4	10	14	18	22	2	6	10	13
DIAPTOMUS	—		16.7	2.9	5.3	4.4	4.5	11.9	18.2	22.7	22.6	18.9	37.3		19.5
NAUPLII	12.8		5.3	12.6	6.8	P	3.0	31.0	7.9	28.6	22.6	7.5	—		15.9
EUCYCLOPS	43.0		47.2	26.2	13.6	2.9	—	P	P	P	3.6	P	P		4.4
MACROCYCLOPS	—		—	—	6.8	—	—	—	—	—	—	—	—		—
D. SCHOEDLERI	44.2		35.1	47.6	10.6	5.2	22.0	6.4	P	P	—	P	—		6.2
D. ROSEA	—		—	7.8	10.6	26.9	55.3	33.3	36.4	6.7	31.4	64.2	46.4		40.7
POLYPHEMUS	—		P	P	32.6	57.4	13.6	15.1	31.4	37.5	16.1	6.6	7.3		8.0
SIDA	—		—	—	3.0	—	—	—	P	—	—	—	P		4.4
CHYDORUS	—		—	—	6.1	—	—	P	—	—	P	—	P		—
CERIODAPHNIA	—		—	—	P	—	—	—	—	—	—	—	P		P
ACROPERUS	—		—	—	P	P	—	—	—	—	2.9	—	—		—
SIMOCEPHALUS	—		—	—	P	—	—	—	—	—	—	—	—		—
GRAPTOLEBERIS.	—		—	—	—	—	—	—	—	—	—	—	P		—
TOTAL SPP	2		4	5	11	6	4	6	6	5	6	5	8		7
	RANGE 2-11 MEAN 5.75 SPP														

TABLE C: PRESENCE AND RELATIVE ABUNDANCE OF CRUSTACEAN ZOOPLANKTON AT STATION 3.

PROPORTIONS ARE %   P = PRESENT

	June 10	13	16	19	26	July 1	4	10	14	18	22	Aug 2	6	10	13
Diaptomus	P	11.3	10.6	22.7	8.6	24.3	28.9	14.3	19.8	37.5	66.3	26.7	29.8	26.7	27.9
Nauplii	24.6	25.2	12.4	5.0	59.0	25.2	13.4	73.9	49.5	35.0	22.4	4.5	11.9	9.2	5.0
Eucyclops	31.0	20.0	16.8	23.5	—	P	—	3.4	4.0	6.7	P	4.5	P	P	P
D. Schedleri	42.9	40.9	60.2	40.3	7.9	—	18.8	—	P	—	—	—	3.6	—	—
D. Rosea	—	—	—	P	18.7	37.9	38.2	5.9	20.8	12.5	7.4	43.6	33.9	40	59.3
Polyphemus	—	—	—	6.7	5.0	9.8	P	2.5	P	7.5	P	2.5	P	7.5	P
Sida		—	—	—	P	—	—	—	P	—	P	17.3	18.0	12.5	2.9
Acroperus	—	—	—	—	—	—	—	—	P	—	—	P	—	P	—
Chydorus	—	P	—	—	—	—	—	—	—	P	—	—	—	—	—
Lathonura	—	—	—	—	P	—	—	—	—	—	—	—	—	—	—
Ceriodaphnia	—	—	—	—	—	—	—	—	—	—	—	—	—	P	—
Scapholeberis	—	—	—	—	—	—	—	—	—	—	—	P	—	—	—
Total spp	3	4	3	5	5	4	4	4	7	5	5	7	6	7	5

Range 3–7 Mean 4.93 spp.

Table D: Presence and Relative Abundance of Crustacean Zooplankton at Station 4, Horizontal Tows.

Proportions are % P = Present

	June 10	13	16	19	26	July 1	4	10	14	18	22	Aug. 2	6	10	13
Diaptomus	11.8	10.0	P	6.3	7.9	21.3	6.7	21.5	23.0	35.2	40.2	32.5	29.8	22.4	24.3
Nauplii	29.4	26.0	37.8	6.0	30.7	31.9	12.4	50.4	40.0	25.6	32.4	13.8	10.6	9.3	3.6
Eucyclops	35.3	18.0	37.8	18.0	P	—	—	3.3	P	3.4	P	P	P	P	3.2
D. schoedleri	23.5	45.0	23.4	61.3	28.7	22.3	30.0	6.6	10.2	16.0	P	3.2	P	P	P
D. rosea	—	—	—	P	26.7	22.4	51.0	19.0	26.8	16.8	22.5	49.6	44.3	57.0	65.4
Polyphemus	—	P	—	5.4	5.0	P	—	—	P	P	P	—	—	P	—
Sida	—	—	—	—	—	—	—	—	—	—	—	—	10.6	7.5	P
Chydorus	—	—	—	—	—	P	—	—	—	—	—	—	—	—	—
Acroperus	—	—	—	—	—	—	—	—	—	—	—	—	P	—	—
Total spp	3	4	3	5	5	5	3	4	4	6	5	4	6	6	5

Range 3-6 Average 4.57 spp

Table E: Presence and Relative Abundance of Crustacean Zooplankton at Station 4, Vertical Tows.

Proportions are % P = Present

	June					July						Aug.			
	10	13	16	19	26	1	4	10	14	18	22	2	6	10	13
DIAPTOMUS	11.8	8.2	18.1		32.9	24.1	33.3	8.5	32.0	50.0	67.1	73.3	31.6	66.5	54.7
NAUPLII	5.9	7.1	16.8		P	7.0	14.5	68.5	46.2	29.7	15.4	P	P	3.7	12.7
EUCYCLOPS	22.0	29.4	34.2		3.2	9.5	—	P	P.	P	P	—	P	P	—
D. SCHOEDLERI	50.3	55.3	30.9		41.8	12.7	P	—	P	P	—	7.1	15.8	3.7	3.2
D. ROSEA	—	—	—		20.9	43.0	49.3	21.5	17.1	16.9	16.1	16.9	48.2	24.5	26.4
POLYPHEMUS	—	—	—		—	2.5	P	—	—	P	P	P	P	P	—
CERIODAPHNIA	—	—	—		—	—	—	—	P	—	—	P	—	P	P
ACROPERUS	—	—	—		—	—	—	—	P	—	—	—	—	—	—
SIDA	—	—	—		—	—	—	—	—	—	—	P	—	P	—
TOTAL SPP	3	3	3		4	5	4	3	5	6	4	6	5	7	4
	RANGE 3-7				MEAN 4.43 SPP.										

TABLE F: PRESENCE AND RELATIVE ABUNDANCE OF CRUSTACEAN ZOOPLANKTON AT STATION 5, HORIZONTAL TOW.

PROPORTIONS ARE %

P = PRESENT

	June 10	13	16	19	26	July 1	4	10	14	18	22	Aug. 2	6	10	13
Diaptomus	7.7	18.9	11.2	20.8	25.6	20.5	27.3	14.3	27.0	29.6	56.6	55.1	40.2	44.7	64.5
Nauplii	23.4	9.4	18.7	16.0	—	6.7	23.6	59.7	31.0	9.6	25.0	15.0	10.3	7.9	10.3
Eucyclops	26.2	17.0	21.5	9.4	P	9.5	—	P	—	—	P	P	P	P	P
Daphnia schoedleri	40.8	54.7	48.6	48.1	33.1	59.5	29.9	8.4	13.5	19.2	3.2	3.7	23.4	29.0	7.5
D. rosea	—	—	—	—	39.1	—	18.2	15.1	27.0	36.0	12.9	21.5	22.4	16.4	16.8
Polyphemus	—	—	—	5.6	—	3.5	10.0	P	P	5.6	P	P	—	—	—
Ceriodaphnia	—	—	—	—	—	—	—	—	—	—	—	P	P	—	—
Scapholeberis	—	—	—	—	—	—	—	—	—	—	—	P	—	—	—
Graptoleberis	—	—	—	—	—	—	—	—	—	—	P	—	—	—	—
Total spp	3	3	3	4	4	4	4	5	4	4	6	7	5	4	4

Range 3–7 Average 4.43 spp

Table G: Presence and Relative Abundance of Crustacean Zooplankton at Station 5, Vertical Samples.

Proportions are %

P = Present

APPENDIX 3: Weather data June - August 1976.
Nicklen Lake.

TEMPERATURES (°F) MAY 22 - AUGUST 16, 1976.

DATE		AM MIN	AM MAX	PM MIN	PM MAX
MAY	22	36	54	47	62
	23	38	59	42	54
	24	36	46		
	25	29	43	31	47
	26	32	43	37	54
	27	31	53	43	54
	28	27	43	27	68
	29	29	42	34	46
JUNE	8			52	68
	9	42	54	45	62
	10	38	53	44	58
	11	29	51	41	49
	12	32	44	33	46
	13	31	44	46	58
	14	30	50	44	59
	15	44	50	45	49
	16	43	47	44	55
	17	31	47	42	69
	18	38	59	48	70
	19			42	60
	20	31	50	42	64
	21	32	51	44	60
	22	36	39	36	46
	23	38	47	48	48
	24	38	48	36	48
	25	36	36	36	42
	26	35	40	38	58
	27	31	42	43	71
	28	38	63	48	76
	29	50	73	54	79

DATE		AM MIN	AM MAX	PM MIN	PM MAX
JULY	2	30	44	41	58
	3	35	50	43	58
	4	38	50	50	68
	11	43	50	49	65
	12	44	58	46	65
	13	36	57	45	61
	14	34	45	45	66
	15	42	58	51	81
	16	36	45	45	82
	17	45	64	59	77
	18	40	65	53	80
	19	43	70	54	81
	20	46	70	53	67
	21	38	55	44	55
	22	34	48	49	52
	23	38	58	46	78
AUGUST	2	51	60	56	64
	3	44	58	49	72
	5	50	65	52	60
	6	46	57	49	74
	7	51	65		63
	8	46		57	56
	9	49	53		64
	10	39		43	70
	11	43	60	48	71
	12			46	74
	13	47	60	43	62
	15	44		47	53
	16	35	52	41	46

WEATHER STATION AT SOUTH END OF NICKLEN LAKE, NEAR LUMBY, B.C.

LATITUDE: LONGITUDE: ELEVATION:

RAINFALL (INCHES) NICKLEN LAKE WEATHER STATION

DATE		AM	PM
MAY	22	-	TR
	23	.01	.36
	24	.32	.11
	25	-	.10
	26	.04	-
	27	-	.42
	28	-	-
	29	-	-
JUNE	8		.07
	9	.06	-
	10	-	.03
	11	-	.11
	12	-	.25
	13	.11	-
	14	-	TR
	15	.30	.40
	16	.12	.04
	17	-	-
	18	-	-
	19		.18
	20	-	-
	21	-	-
	22	.69	.30
	23	.02	TR
	24	-	TR
	25	.03	TR
	26	TR	-
	27	-	-
	28	-	-
	29	-	-

DATE		AM	PM
JULY	2	-	-
	3	-	.03
	4	TR	-
	11	-	TR
	12	.07	-
	13	-	-
	14	-	-
	15	-	-
	16	-	-
	17	-	-
	18	-	-
	19	-	-
	20	-	.22
	21	.34	-
	22	-	-
	23	-	-
AUG	2	.02	.05
	3	-	-
	5	.14	.46
	6	-	-
	7	.25	TR
	8	-	.28
	9	.02	-
	10	-	-
	11	-	-
	12		.03
	13	.07	.02
	15		
	16	.13	.29

WEATHER DESCRIPTIONS

MAY 22	Large cumulus clouds, with a short cloudburst midday. Almost clear by dusk. Gentle breeze SW in evening.
MAY 23	Thunderstorm early A.M. (during night). ~~Day~~ Morning mostly cloudy with some clearing periods. Light rain near noon with cool SW fresh breeze. Rain for most of the rest of the day.
MAY 24	Periodically windy and rainy all morning and afternoon. Gentle to fresh breeze, SW. Thunderstorm late evening.
MAY 25	Nearly clear in morning, but soon clouding over. Snow flurries. Gusty winds periodically, especially late afternoon and evening. Clearing by dusk late afternoon.
MAY 26	Stratocumulus clouds and calm in morning. Rain showers throughout day, and mostly calm. Clearing by evening.
MAY 27	Clouds and rain during day and clearing again in evening. Calm.
MAY 28	Clouds with some sunny breaks, and cool gentle SW breeze most of day. Snow flurries in afternoon.
MAY 29	Large cumulo-nimbus clouds. Gusty fresh breeze. Snow flurries.
JUNE 8	Heavily overcast most of day, with some rain. Sunny periods late afternoon. Mostly calm. Heavy rain in evening.
JUNE 9	Sunny with a few distant cumulus clouds. Winds moderate to strong most of day, light to calm by evening.
JUNE 10	Clear in morning, but clouding over. Some sunny breaks and rain showers. Gentle SW breeze. Cirrostratus in evening.
JUNE 11	Light clouds in morning, rain mid day and afternoon. Clearing by evening. Rainbow. Gentle SW breeze most of day.

JUNE 12	Much rain in morning, turning to snow around noon. Some breaks in afternoon, then more showers and snow, stopping by evening. Calm.
JUNE 13	Very overcast during morning and calm. Clearing in afternoon with gentle breeze from ~~north~~ west (at Lily Pad Lake, not Nicklen). Calm and clear in evening.
JUNE 14	Clear in morning, by noon light clouds (alto-stratus). Sunny breaks throughout afternoon. Light breeze to moderate in afternoon, SW. Showers in evening
JUNE 15	Rain all day!
JUNE 16	Heavily overcast in morning with some rain about noon. Gradually breaking with gentle breeze. Clear by late evening.
JUNE 17	Sunny all day! Mostly calm.
JUNE 18	Sunny in morning, clouding over late afternoon.
JUNE 19	Strong ~~northerly~~ southerly winds accompanying a thunderstorm in the morning, giving way to clear skies and light breeze.
JUNE 20	Mainly cloudy in morning, almost clear by afternoon with scattered clouds. Light winds in morning. Overcast by evening again.
JUNE 22	Raining & overcast most of day.
JUNE 23	Overcast with a few breaks and occasional showers. Moderate S breeze.
JUNE 24	Generally overcast. Gusty SW winds.
JUNE 25	Clear early morning, then clouding over. Snow and hail in afternoon. Gusty strong SW winds.
JUNE 26	Overcast in morning with light SW breeze. Breaking up early afternoon. Late afternoon and evening mostly sunny with large cumulus clouds and calm
JUNE 27	Clear, sunny and warm all day. Winds light to from SW periodically.
JUNE 28	~~Our~~ Warmest day so far. Clear most of day, light clouds in evening (altostratus & some cumulus) Felt stormy in evening.
JUNE 29	Some altostratus & moderate SW breeze to strong breeze (very warm). Sunny mostly.

JULY 1	Rain in morning, starting to break up early afternoon. Light SW breeze. Almost clear by evening.
JULY 2	Mostly cloudy throughout day, large cumulus and cumulo-nimbus. Light breeze SW but also SE at times. Evening calm and partly sunny.
JULY 3	Altostratus clouds turning to low stratus bringing rain in mid-afternoon. Breaking by early ~~evening~~ evening. Calm.
JULY 4	Mainly sunny, but cumulus and cumulonimbus clouds going by all day. Winds light from ~~south~~ west. (Winds were often from the west at Lily Pad Lake, while at Nicklen and Curtis they were generally south or southwest). All clear by late evening.
JULY 11	Cloudy most of day and calm. Some sunny breaks in afternoon. Showers early evening.
JULY 12	Cloudy with sunny periods most of the day. Clear by late afternoon and evening. Light SW breeze increasing to moderate in evening.
JULY 13	Winds SW moderate to strong most of day. Mostly sunny.
JULY 14	Clear in morning, but mostly cloudy in afternoon. Light breeze to calm in evening. Clear again by evening.
JULY 15	Sunny, clear, hot day. Mostly calm.
JULY 16	Another hot, sunny day. SW breeze light until late afternoon, when it increased to moderate.
JULY 17	Clear and sunny again with a light breeze.
JULY 18	Clear and sunny with light air to light breeze during day and no wind in evening.
JULY 19	Sunny with some ~~cirrostratus~~ and cirrocumulus clouds. Calm.
JULY 20	Overcast all day. Few sunny breaks in afternoon, then a late afternoon thunderstorm. Heavy rain and also hail (hailstones up to ¼" across). In about 1½ hours, .22" of rain fell. Storm continuing with bursts of precipitation all evening.

JULY 21	Cool and cloudy day, with a few sunny breaks. Wind a gentle to fresh breeze SW all day, gusty. Almost clear by late afternoon.
JULY 22	Mostly clear in morning but soon clouding over. Cool SW light breeze but calm late afternoon and evening. Some late afternoon showers. Clear again by evening.
JULY 23	Sunny with some cumulus clouds passing by. Calm.
AUGUST 2	Cloudy and calm. Mist for a short while midday. Heavy clouds, thunder + lightning in afternoon. Rain. Clearing late afternoon.
AUGUST 3	Cloudy in morning, then sunny with a few cloudy periods. Calm. Evening mostly clear.
AUGUST 5	Heavy rain in morning, and light showers in early evening. Then clearing, with a few distant cumulus. Calm.
AUGUST 6	Mostly sunny, with cumulus clouds passing by all day. Short shower late afternoon. Evening clear.
AUGUST 7	Thunderstorm during night. Cloudy and calm in morning, then breaking up.
AUGUST 8	Heavy clouds and rain. Calm. No rain in late afternoon or evening, but still cloudy.
AUGUST 9	Sunny with cloudy periods.
AUGUST 10	Again sunny with some cumulus clouds.
AUGUST 11	Mostly sunny in morning + early afternoon. Short thundershower in mid-afternoon and then mostly cloudy. Light SW breeze.
AUGUST 12	Sunny with cloudy periods and an afternoon shower. Calm.
AUGUST 13	Clear in morning, gradually clouding over. Calm. Heavy rain in evening.
AUGUST 14	Not at lake, but rainy and overcast in Coldstream.
AUGUST 15	Rain and fog!
AUGUST 16	Rainy. Periodic gentle to moderate breeze.