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ANNOTATED INVENTORY OF INVERTEBRATE POPULATIONS OF AN ALPINE LAKE AND STREAM CHAIN IN COLORADO[1]

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ABSTRACT.—Benthic macroinvertebrates were collected during the ice-free season (1 July–20 October) over a five-year period from a chain of alpine lakes and intervening streams in the Green Lakes Valley (3,347–3,615 m) in Boulder County, Colorado. A list of taxa was developed for 1981 and 1982, with taxonomic additions for 1983–1985 and comments on community structure, seasonal and elevational changes in species abundance, and noteworthy occurrences. A total of 111 taxa was collected, of which 84% occurred in streams, 58% being exclusively lotic. Dipterans composed 73–81% of total abundance in streams. The littoral benthic zone of lakes was predominantly trichopterans and dipterans, 44–60% and 24–39%, respectively. Numerically important organisms in various lakes and streams were chironomids, simuliids (particularly *Metacnephia*), oligochaetes, and the bivalve *Pisidium casertanum*. An isolated lake and its outlet stream, with unique characteristics, were the sole locations of *Gammarus lacustris* (Amphipoda) and *Glossiphonia complanata* (Hirudinea). Manipulated lowering of a lake along the main drainage exposed abundant and luxuriant colonies of the bryozoan *Fredericella sultana*. This organism was found on 43% of all rocks sampled, a preponderance heretofore unknown for this, or any, ectoproct in alpine or arctic lakes.

There are few studies of lake chains and their intervening streams for mountainous subalpine regions of the world, and, to our knowledge, there are no such studies for true alpine environments. A general review of relevant published information for Colorado, temperate and subarctic North America, and other continents is given by Bushnell et al. (1982).

We obtained information during an extended study of the aquatic macroinvertebrates of an alpine drainage system in the Colorado Rocky Mountains. During the ice-free season, macroinvertebrates were collected from five of six small lakes, and their intervening streams, in the Green Lakes Valley on the eastern slope of the Continental Divide, Boulder County, Colorado.

This paper is a taxonomic inventory for 1981 and 1982, with additional new data for later years (Chironomidae excluded). Annotations are given on seasonal changes in species abundance, elevational aspects of community structure and abundance, and noteworthy occurrences.

The only directly applicable information on the macroinvertebrates of the Green Lakes drainage is by Elgmork and Saether (1970) and Saether (1970), and it is solely for the streams. These publications discuss taxonomic identifications derived from stream collections made in July 1960. Other publications providing information on a variety of environmental topics are those of Halfpenny (1982), Caine (1984), Bushnell et al. (1984), Bushnell and Butler (1984), Caine et al. (1983), Hoffman et al. (1985), Short et al. (1983), Toetz (1985), and Toetz and Windell (1984).

SITE DESCRIPTION: GREEN LAKES DRAINAGE

The glacially carved Green Lakes Valley is about 40° N latitude and has been closed to the public since 1927 by the City of Boulder because the drainage is a municipal water source (Windell and Foster 1982). The entire study area (Fig. 1) lies above timberline in a 5.46-km^2 drainage basin, of which 0.42 km^2 is occupied by the five Green Lakes (GLs 1–5) and Lake Albion (Caine 1982). GL 5, fed by a stream from the Arikaree Glacier, is the highest lake (3,615 m) and is confluent with GL 4 (3,554 m; Fig. 2) via a connecting stream. The streams were named according to the lake from which they emanate; e.g., Stream 5 leaves GL 5 and flows into GL 4; Stream 2 leaves GL 2 and flows into Lake Albion. Lake Albion (3,347 m) is the lowest lake in the study area, and the greatest eleva-

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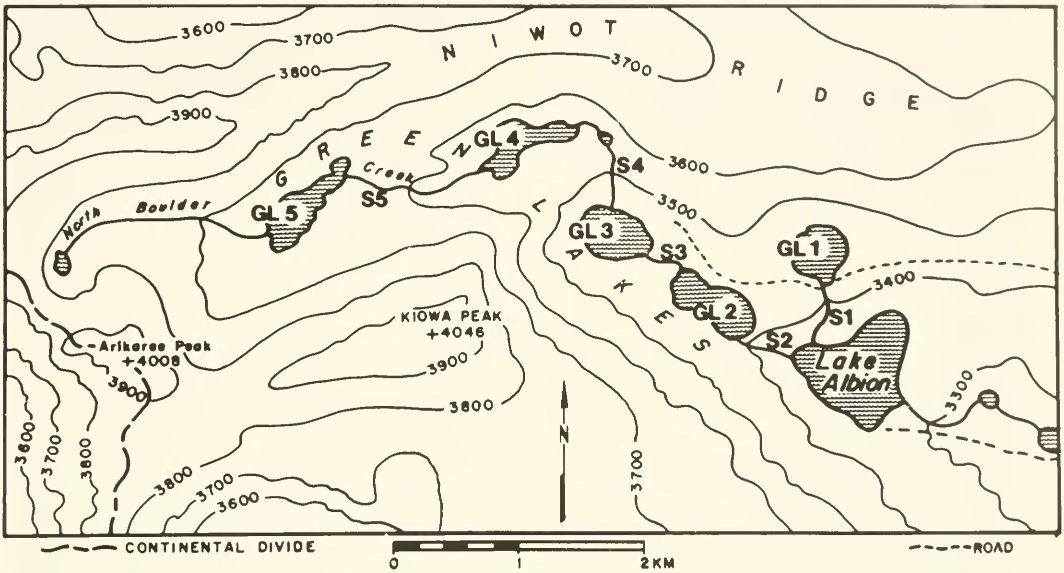

Fig. 1. The Green Lakes (GLs 1–5), Lake Albion, and intervening stream segments of North Boulder Creek (Ss 1–5) located in an alpine valley on the east slope of the continental divide, 42 km west of the city of Boulder, Colorado.

Fig. 2. Photograph of Green Lake 4 taken from an aspect facing north in late August 1985.

tional descent between any pair of connecting lakes is 104 m between GL 4 and GL 3. Most of this vertical decline occurs via a steep waterfall near the outlet of GL 4, from the base of which the main stream and small tributaries follow a more gradual decline to GL 3 (Fig. 3). The linear distance between the inlet of GL 5 and the outlet of Lake Albion is 5 km.

Only GL 1 (3,426 m) is apart from the main flowage system. This lake has no inlet, but it has a subterranean seepage that surfaces as a small stream (Stream 1), ultimately draining into Lake Albion. GL 1 (Fig. 4) has an open, south-facing exposure with a steep talus slope to the north and less-steep rises to the east and west.

The maximum depths of the lakes are 8 m for GLs 1 and 5, 13 m for GL 4, 16 m for GLs 3 and 2, and 14 m for Lake Albion. The bottom composition of most littoral zones of lakes, and of streams, is a mixture variously dominated by one or more of the following: boulders, large to small stones, and sometimes patchy areas of coarse to fine sand and silt. The bottom of the central and deeper portions of the lakes is almost entirely silt-clay (McNeely 1983). The lower lakes had a longer ice-free season in all years. Lake Albion and GL 1 reached maximal temperatures of 13 and 14 C, respectively, in August and early September of 1981 and 1982. Lakes 4 and 5 never experienced maxima much above 9 C. Data published by Caine (1984) indicate that pH values of the flowage water were nearly always between 6 and 7.

Fig. 3. Photograph of Green Lake 3 taken from an aspect facing west. Waterfall in background is part of Stream 4 below outlet from Lake 4, August 1985.

Fig. 4. Photograph of Green Lake 1 taken from an aspect facing north in early October 1986. Green Lake 1 is the only lake separated from the main drainage and with a full southern exposure.

Lake Albion, GL 2, and GL 3 support populations of brook trout (*Salvelinus fontinalis*) (Nelson 1976, Windell, unpublished data). Green Lakes 1, 2, 3, and Lake Albion have been enhanced in volume by the construction of dams. Repair of these dams during the summer of 1985 necessitated a lowering of water levels by opening conduits near the bottom of lake basins. Water levels returned to normal in 1986 except in GL 2 where barrier damage was greatest.

METHODS

Benthic macroinvertebrates were collected between 1 July and 20 October 1981 at two-week (sometimes three-week) intervals, with later beginning dates in succeeding years. Specimens were collected from three predetermined and regularly sampled lake sites (except GL 2) and at intervening stream sites.

The benthos was sampled using a rock-picking technique in the lakes and the Surber-sampling method in the intervening streams. The rock-picking involved turning over randomly selected rocks within the range of the sampling site. Organisms on the rocks (sometimes on finer bottom sediments) were then removed with fine forceps. All picking times were standardized to 15 minutes. In addition to rock-picking, vegetation samples were taken from several lakes and streams. As all of the lakes have a generally narrow littoral zone, rock-picked (or bottom-picked) samples were most often obtained up to 3 m (infrequently as much as 6 m) from shore.

Surber-sampling stations in the streams generally were located either close to the outlet of one lake or the inlet of the succeeding lake, but the station between Green Lakes 3 and 2 was situated approximately equidistant from each lake. Two 1-min samples were taken 1–3 m apart at each station. Because of their proximity, these two samples were combined to give numbers of organisms per 0.09 m^2. The net mesh was 1024 um. When samples were unusually dense or confounded with excessive amounts of entangling vegetation, aliquots were taken. The sample was first poured into an enameled pan and agitated either manually or with a magnetic stirrer. Then an aliquot, the volume of which was determined by the nature of the sample, was taken. A total of three aliquots was used from each sample. Specimens were preserved in 70% ethanol prepared with 5% glycerine. If field samples were placed in 5% formalin, they were later changed to the alcohol-glycerine solution.

Taxonomic Identification

Identification of aquatic insects was done by us almost exclusively from the immature aquatic stages, with samples confirmed by the taxonomic specialists cited below in the Acknowledgments. A large body of literature was used for identification (Allen and Edmunds 1962, Arnett 1960, Baumann et al. 1977, Beck 1976, Bode 1983, Brinkhurst and Cook 1966, Brinkhurst and Jamieson 1971, Dodson 1982, Edmunds et al. 1976, Elgmork and Saether 1970, Fiance 1977, Harmston 1963, Hiltunen and Klemm 1980, Klemm 1982, Lepneva 1966, Mason 1973, Merritt and Cummins 1984, Morihara and McCafferty 1979, Oliver et al. 1978, Pennak 1978, Peterson 1970, Roback 1957, Saether 1970, 1975, 1976, 1977, Simpson and Bode 1980, Smith 1968, Soponis 1977, Steyskal and Knutson 1981, Stone 1981, Surdick 1981, Szczytko and Stewart 1979, Usinger 1956, Ward 1985, Wiggins 1977, Wilson and McGill 1982, Wu 1978).

Results

The 1981 and 1982 collecting seasons (July–October) of the current study produced a total of 111 taxa, 93 of which occurred in streams (Table 1). Stream samples obtained by Elgmork and Saether (1970) in the first two weeks of July 1960 included 71 taxa of benthic macroinvertebrates. Of the 111 taxa included in our study, 64 were exclusively lotic, 18 were restricted to lentic sites, and 29 were both lentic and lotic in occurrence. At any particular collecting site the Chironomidae accounted for 31–51% of taxa in streams and 22–67% in lakes during 1981. Many taxa (30%) of the Green Lakes Valley flowage system were represented by a single specimen. About half of these were dipterans, thus underscoring the contribution of these insects to community diversity.

Species richness in the littoral-benthic zone of these lakes ranged from 9 to 19 taxa. Dredge samples from deeper water presumably would raise these values by contributing additional chironomids, oligochaetes, and nematodes. Mean Shannon-Weiner species diversity was 2.15 ± 1.08 for all lakes sampled in 1981 and 1982. In lotic habitats, species richness ranged from 24 to 40 taxa, and mean species diversity was 2.33 ± 0.75. Species diversities of Green Lake 1 and Stream 1 were both higher than mean diversities of all lakes and streams. While community composition changed with elevation, there was no trend in actual species number.

Discussion

NUMERICAL ABUNDANCE AMONG SUPRAGENERIC TAXA.—Distribution of organisms among major taxonomic groups remained comparatively stable over the 21-year period between the 1960 collections and the present study. The benthos of streams and lakes of Green Lakes Valley was predominantly dipterans. The Diptera constituted 81% of total macroinvertebrate organisms in streams in 1960, and 79% and 73% in 1981 and 1982, respectively. Worms (Nematoda, Oligochaeta, Turbellaria, and Hirudinea), Ephemeroptera, Plecoptera, Trichoptera, and other taxa (Coleoptera, Mollusca, and Crustacea) individually accounted for less than 10% of total abundance in 1960, 1981, and 1982, with the exception of worms in 1982, which constituted 15% of lake and stream abundance.

A similar preponderance of dipterans became evident when abundances of organisms for streams alone were compared. However, lake organisms were predominantly trichopterans (44–60% of total abundance) and dipterans (24–39%). Worms, Ephemeroptera, Plecoptera, and other organisms independently constituted less than 10% of organisms collected in both 1981 and 1982. Again, deep-water dredge samples from lakes would likely increase the proportions of the dipterans, oligochaetes, and nematodes. Therefore, the somewhat contrasting importance of dipterans in lakes and streams is explained, in

TABLE 1. Benthic organisms of lakes and streams in the Green Lakes Valley, Boulder County, Colorado, for 1960 and 1981–1982. (New occurrences for later years: *1983, **1984, ***1985).

Organism	Relative abundance (1960)[1]	Relative abundance Present study	Location Present study
CNIDARIA			
Hydra sp.	less ab.	ab.	L(3,A), S(1)
PLATYHELMINTHES (Turbellaria)			
Polycelis coronata	ab.	ab.	L(A,3,4,5), S(1,2,3,5)
NEMATODA sp.	ab.	less ab.	L(A), S(1,5)
BRYOZOA			
Plumatella sp. statoblast	less ab.	—	—
Plumatella repens	—	rare	L(A)
Fredericella sultana	—	ab.***	L(3)
HIRUDINEA			
Glossiphonia complanata	—	rare	L(1)
OLIGOCHAETA			
Analycus sp.	—	ab.	L(3), S(1)
Chaetogaster cf. *Diastrophus*	ab.	—	—
Mesenchytraeus sp.	ab.	—	—
Nais variabilis	ab.	ab.	L(3), S(1,2,4,5)
Tubificidae sp.	—	rare	L(A), L(5)
Lumbriculus variegatus	—	less ab.	L(3)
AMPHIPODA			
Gammarus lacustris	less ab.	ab.	L(1), S(1)
ACARINA			
Atractides sp.	—	rare**	S(1)
Aturus fontinalis	ab.	—	—
Lebertia atelodon	less ab.	less ab.*	S(1)
Limnochaetes americana	—	rare	L(3)
Sperchon coloradensis	less ab.	less ab.	L(A), S(1)
COLLEMBOLA			
Podura aquatica	less ab.	rare	S(5)
EPHEMEROPTERA			
Siphlonuridae			
Ameletus sp.	—	ab.	L(3,4), S(4,5)
Siphlonurus sp.	—	rare	L(A), S(5)
Baetidae			
Baetis bicaudatus	ab.	ab.	S(1,2,3,4,5)
Baetis intermedius	less ab.	—	—
Baetis rusticans	less ab.	—	—
Baetis tricaudatus	—	ab.	S(5)
Heptageniidae			
Cinygmula mimus	ab.	ab.	L(3,4), S(1,3,4)
Ephemerellidae			
Drunella coloradensis	ab.	ab.	S(2,3)
PLECOPTERA			
Nemouridae			
Nemouridae sp.	—	less ab.	S(1,4,5)
Malenka sp.	—	rare	S(2)
Nemoura sp.	less ab.	—	—
Nemoura arctica	—	less ab.	S(5)
Zapada cinctipes	—	less ab.	S(1,2)
Zapada haysi	less ab.	—	—
Zapada oregonensis	—	less ab.	S(1)
Leuctridae			
Paraleuctra or *Perlomyia* sp.	—	less ab.	L(5)
Capniidae			
Bolshecapnia, *Capnia*, *Mesocapnia*, or *Utacapnia* sp.	—	less ab.	L(5)

Table 1 continued.

Organism	Relative abundance (1960)[1]	Relative abundance Present study	Location Present study
Perlodidae			
Cultus sp.	—	ab.	S(1,3)
Isogenus sp.	ab.	—	—
Isoperla fusca	—	rare	S(2)
Isoperla quinquepunctata	—	less ab.	S(3)
Kogotus modestus	—	rare	S(3)
Megarcys signata	—	ab.	S(3)
Skwala parallela (?)	—	rare	L(4)
Sweltsa sp.	—	ab.	L(A), S(1,2,3,4)
HEMIPTERA			
Notonectidae			
Notonecta sp.	—	rare	L(1)
TRICHOPTERA			
Trichoptera spp., early instars	—	ab.	L(1,A), S(1)
Rhyacophilidae			
Rhyacophila sp.	ab.	—	—
Rhyacophila acropedes (e)	—	rare	S(1,5)
Rhyacophila angelita	—	less ab.***	S(2,3)
Rhyacophila hyalinata (e)	—	rare	L(3), S(2,3)
Rhyacophila tucula	—	less ab.	S(1,2,3,4,5)
Lepidostomatidae			
Apatania sp.	—	ab.	L(1,A), S(2)
Brachycentridae			
Brachycentrus sp.	ab.	—	—
Limnephilidae			
Hesperophylax sp.	ab.	—	—
Hesperophylax occidentalis	—	ab.	L(1–5), S(1–4)
Hesperophylax oreades (c)	ab.	—	—
Psychoglypha subborealis	—	less ab.	L(A,1)
Psychoronia costalis (c)	—	ab.	L(A,1,4,5), S(4)
Leptoceridae (adult)	—	rare	S(1)
LEPIDOPTERA			
Pyralidae sp.	—	rare	S(1)
COLEOPTERA			
Dytiscidae			
Agabus sp.	—	rare	L(1), S(5)
Dytiscus sp.	—	rare	S(1)
Hydrophilidae			
Helophorus sp.	—	less ab.	S(3)
Staphylinidae			
Staphylinidae sp.	—	rare	S(2)
Elmidae			
Heterolimnius corpulentus	—	rare	S(1)
Zaitzevia sp.	—	less ab.	S(1)
Heteroceridae			
Heterocerus sp.	—	rare	S(5)
Georhyssidae			
Georhyssus sp.	—	less ab.	S(4)
DIPTERA			
Sciaridae			
Sciaridae sp. A	less ab.	—	—
Sciaridae sp. B	less ab.	—	—
Lycoriella (*Hemineurina*) sp.	less ab.	—	—

Table 1 continued.

Organism	Relative abundance (1960)[1]	Relative abundance Present study	Location Present study
Empididae			
Atalanta sp.	ab.	—	—
Clinocera (Hydromia) sp.	—	less ab.	S(2,4,5)
Tipulidae			
Antocha sp.	—	less ab.	S(3)
Dicranota sp.	—	ab.	S(1,2,3,4,5)
Erioptera (trimicra) sp.	—	less ab.	S(1)
Limnophora torreyae (e)	—	less ab.	L(1), S(5)
Ormosia sp.	—	less ab.	S(1)
Tipula sp.	—	less ab.	S(5)
Culicidae			
Culicidae sp.	—	rare	L(5)
Aedes spp.	—	less ab.	S(2)
Aedes (Ochlerotatus) impiger	less ab.	—	—
Simuliidae			
Metacnephia sp. near *jeanae*	—	dom.	S(4,5)
Prosimulium (Prosimulium) hirtipes	ab.	rare	S(4)
Prosimulium (Prosimulium) travisi	ab.	less ab.	S(4)
Prosimulium (Prosimulium) ursinum (d,4)	ab.	—	—
Prosimulium (Prosimulium) sp. near *frohnei*	—	ab.	S(4,5)
Prosimulium n. sp. (d)	—	ab.	S(4,5)
Simulium hunteri	—	ab.	L(A), S(1)
Ephydridae			
Philygria debilis	—	rare	S(4)
Cressionella montana	less ab.	—	—
Thaumaleidae			
Thaumaleidae sp.	—	less ab.*	L(3 or 4)
Thaumalea sp.	less ab.	—	—
Chironomidae			
Chironomidae spp., larval bodies	—	less ab.	L(4), S(2,4,5)
Chironomidae spp., pupae	—	less ab.	L(3,5,A), S(4,5)
Chironomus anthracinus group	less ab.	—	—
Cardiocladius sp.	ab.	less ab.	S(5)
Chaetocladius	—	less ab.	L(A)
Corynoneura sp.	less ab.	—	—
Corynoneura taris	—	less ab.	S(5)
Cricotopus sp. 9	—	less ab.	L(3)
Cricotopus sp. B	—	rare	L(3)
Diamesa sp. A (4)	ab.	—	—
Diamesa sp. B	ab.	—	—
Diamesa sp. C	ab.	less ab.	S(3,4)
Diamesa sp. D	ab.	—	—
Diamesa sp. E	less ab.	less ab.	S(4,5)
Diamesa sp. F	ab.	less ab.	S(2,4,5)
Diamesa sp. G	ab.	less ab.	S(3,4)
Diamesa (Pseudokiefferiella) sp. H(4)	ab.	—	—
Diamesa (Pseudokiefferiella) sp. J	less ab.	—	—
Diamesa latitarsis gr.	—	ab.	S(3,5)
Diplocladius sp.	—	less ab.	L(3)
Eukiefferiella sp. A	less ab.	—	—
Eukiefferiella sp. (subtype bavarica) sp. B (a,4)	ab.	—	—
Eukiefferiella sp. C	less ab.	—	—
Eukiefferiella sp. D	less ab.	—	—
Eukiefferiella (type longicalcar) sp. E (b)	ab.	—	—
Eukiefferiella sp. F	less ab.	—	—
Eukiefferiella (subtype minor) sp. G (b)	ab.	—	—
Eukiefferiella sp. H	less ab.	—	—

Table 1 continued.

Organism	Relative abundance (1960)[1]	Relative abundance Present study	Location Present study
Eukiefferiella coerulescens group	—	ab.	L(3), S(4,5)
Eukiefferiella devonica group	—	rare	S(2)
Eukiefferiella gracei group, sp. 1 (b)	—	ab.	S(4,5)
Eukiefferiella gracei group, sp. 2 (b)	—	less ab.	S(1,3,4)
Eukiefferiella rectangularis group, Type J	ab.	dom.	S(1,2,4,5)
Glyptotendipes (Phytotendipes) lobiferus (?)	—	ab.	L(1), S(1)
Heptagyia sp.	ab.	—	—
Heterotrissocladius hirtapex	—	rare	S(1)
Hydrobaenus fusistylus	—	dom.	L(3), S(4,5)
Metriocnemus sp. A	less ab.	—	—
Metriocnemus sp. B cf. *Epoiicladius* sp.	less ab.	—	—
Microcricotopus sp. *parvulus* type	less ab.	—	—
Micropsectra sp.	ab.	—	—
Micropsectra sp. 1	—	dom.	L(3,A), S(1,3,4,5)
Micropsectra sp. 2	—	rare	L(5)
Nanocladius (Nanocladius) spiniplenus	—	rare	S(2)
Orthocladiinae spp.	—	less ab.	L(A), S(5)
Orthocladius sp.	—	rare	S(2)
Orthocladius (Eudactylocladius) sp. A	less ab.	less ab.	S(4)
Orthocladius (Eudactylocladius) sp. B	ab.	ab.	L(3), S(1,2,4,5)
Orthocladius (Euorthocladius) sp.	ab.	—	—
Orthocladius (Euorthocladius) type III	—	ab.	L(3,4), S(1,3,4,5)
Orthocladius (Orthocladius) obumbratus	—	rare	S(2)
Pagastia sp. 1	—	less ab.	S(2,3,5)
Parakiefferiella sp.	ab.	rare	S(1)
Parametriocnemus graminicola	—	less ab.	S(2,3)
Paraphaenocladius sp.	less ab.	—	—
Phaenopsectra sp.	—	less ab.	L(3,5), S(5)
Procladius sp.	—	less ab.	S(1)
Psectrocladius sp.	—	less ab.	L(3,A)
Psectrocladius octomaculatus	less ab.	—	—
Pseudodiamesa pertinax	ab.	ab.	L(4,A), S(5)
Rheocricotopus sp. *atripes* type	less ab.	—	—
Rheocricotopus sp. *effusus* type	less ab.	less ab.	S(2)
Synorthocladius sp.	—	ab.	L(3), S(4,5)
Theinemannia cf. *gracilis*	less ab.	—	—
Trichotanypus sp.	—	rare*	L(5)
Tvetania bavarica group (a)	—	ab.	L(3), S(1)
Mollusca			
Sphaeriidae			
Pisidium sp.	less ab.	—	—
Pisidium casertanum	—	ab.	S(1,4)
Pisidium nitidum	—	rare	S(1,4)
Pisidium variable	—	rare	S(1)

[1]Elgmork and Saether (1970) Collections from 1960: ab. = 38 most abundant taxa based upon individuals sampled per 10-minute interval. less ab. = all other taxa.

[2]Present study. rare = 1. less ab. = 2–19. ab. = 20–299; dom. = >300 organisms collected during field season.

[3]Distribution data are given for present study only: S = stream (1,2,3,4,5). L = lake (A,1,2,3,4,5). See Fig. 1.

[4]Found by Elgmork and Saether (1970) outside of present study area.

[a]*Eukiefferiella* (subtype bavarica) sp. B (Elgmork and Saether 1970) is equivalent to *Tvetania bavarica* group in present study (Peterson 1983, personal communication).

[b]*Eukiefferiella* (subtype minor) (type longicalcar) sp. E + G (Elgmork and Saether 1970) are equivalent to *E. gracei* group in present study (Peterson 1985, personal communication).

[c]*Hesperophylax oreades* (Elgmork and Saether 1970) is equivalent to *Psychoronia costalis* in present study (Wiggins 1983, personal communication).

[d]*Prosimulium (Prosimulium) ursinum* (1970) is equivalent to *Prosimulium* n. sp. in present study (Peterson 1983, personal communication).

[e]Species designation tentative.

part, by the restriction of lake sampling to the narrow littoral zone.

Numerical abundance among species.— The most abundant organism in 1981, the simuliid, *Metacnephia* sp. near *jeanae*, comprised 35.5% of all organisms collected. The absence of *Metacnephia* in 1960 may be due to the early sampling time in that year. Peak abundance in 1981 and 1982 was in late July and again in early September. In 1985 it was during August.

The most abundant stream species in 1960, the chironomid *Eukiefferiella* sp. G, may have been present in 1981 and 1982 as *E. gracei* species 1 and 2. A new taxon, *E. rectangularis*, a species first found in 1981, was fourth in abundance and was distributed throughout the same range of streams as was *Eukiefferiella* sp. G 21 years earlier. Perhaps these latter two organisms are temporally separated conspecifics.

Simuliids generally were dominants in 1960, 1981–1982, and 1985. *Prosimulium hirtipes* and *P. travisi* together formed the second most abundant group in 1960. Their dominance was replaced in 1981–1982 by *Prosimulium (Prosimulium)* near *frohnei* and *Prosimulium* n. sp. B., both of which were abundant. *Prosimulium* was concentrated in both studies in Streams 4 and 5, and also below Lake Albion in 1960 (outside the present study area). The recent manipulations of water levels in the lower lakes appear to have greatly reduced *Prosimulium* in Streams 3, 2, and 1.

Subdominants in 1960 included the chironomid *Diamesa* sp. A. in streams above Lake 5 (outside present study area), oligochaete *Mesenchytraeus* sp. extending down into Stream 5, the chironomid *Cardiocladius* sp., and *Eukiefferiella* sp. J., ranging throughout Streams 4 and 5. In 1981, subdominants were chironomids *Hydrobaenus fusistylus* in lentic and lotic situations above Stream 3; *Micropsectra* sp. 1, distributed throughout the study area; and the bivalve *Pisidium casertanum*, restricted to Streams 1 and 4 (GL 3, 1985).

ELEVATIONAL DISTRIBUTION.—Elevational trends were apparent for several major taxonomic groups in lakes, but not in streams. Ephemeroptera and Trichoptera were more abundant in upper lakes (GLs 5 and 4) than in lower ones (Lake Albion and GL 1). These groups consisted mainly of shredders and scrapers. Dipterans were most abundant in lower lakes where rocks in the littoral zone were more often coated with a thin film of fine sediment and micro-Aufwuchs.

Several taxa showed elevational range affinities in both 1981 and 1982. The blackfly *Metacnephia* (a filter-feeder) was especially numerous in Stream 5 (just below the GL 5 outlet) and extended in small numbers down to Stream 3. It is possible that GL 5 serves as a catchment for coarse and fine particulate organic matter derived from extensive *Kobresia*-alpine avens wetlands in the surrounding alpine basin. Studies of suspended particulate organic matter in the waters of Green Lakes Valley are not yet completed but possibly will have a bearing on this contention. Little is known about the physiology or aerodynamic suitability of the adults of this genus that may contribute to its successful breeding in this harsh environment.

Baetis bicaudatus (an ephemeropteran collector-gatherer) and *Hesperophylax* (a trichopteran shredder) were distributed throughout the watershed in both years, but they were particularly abundant during the summer of 1982 in Stream 5. This may be attributable to an especially long growing season on the high tundra in 1981, resulting in large allochthonous detrital food reserves in the stream the following year.

Ephemeropterans are microhabitat specialists sensitive to subtle differences in stream substrates and water velocities (Edmunds et al. 1976). The abundance of *Cinygmula mimus* (a scraper) in Stream 4, *Drunella coloradensis* (an engulfer and scraper) in Stream 3, and *Ameletus* (a scraper) in upper streams and lakes (i.e., Ss 5 and 4, GLs 5 and 4) may be the result of such microhabitat partitioning. *Ameletus* and *Cinygmula* are genera with usually lotic species, but they are found in lentic habitats in Green Lakes Valley. However, hydrological studies indicate that these lakes are constantly flushing systems and have currents in some locations throughout the summer months (Caine 1984).

UNIQUENESS OF LAKE 1, STREAM 1.—Green Lake 1 and its outlet, Stream 1, are isolated from the main flowage of North Boulder Creek and have certain unique characteristics. Tributaries of this spur on the main drainage carry higher solute loads than other tributaries in the valley (Hoffman et al. 1985). Green Lake 1 is also the only lower lake in the valley without a fish population. The amphipod *Gammarus lacustris* and the leech *Glossiphonia complanata* were restricted to this lake and stream. A longer ice-free season because of shallowness and full southern exposure, higher solute values, and a lack of fish predators may contribute to the success of these species here. During a draw-down of GL 1 in the summer of 1985, *G. lacustris* mortality was very high (estimates average 2/cm^3) in evaporation pools at the receding lake edge. This species may well be the greatest producer of animal biomass in GL 1.

Three species of fingernail clams (Sphaeriidae: *Pisidium casertanum*, *P. nitidum*, and *P. variabilis*) are sympatric in Stream 1. *Pisidium casertanum* was the fifth most abundant organism in the 1981 field season, abundant in Stream 1, and less so in Stream 4 (three dried specimens were found on the lake bottom of GL 3 in 1985 after the lowering of the water level). *Pisidium variabilis* was represented by only one specimen collected in Stream 1. The geographical distribution of most freshwater bivalves is limited by water chemistry, as more alkaline water with elevated calcium carbonate favors larger numbers of individuals and species. However, Sphaeriidae construct shells in remarkably low concentrations of calcium carbonate (Pennak 1978). It is not uncommon to find *Pisidium* in alpine waters with very low dissolved solute concentrations, but its abundance in Stream 1 in 1981 and 1982 may reflect higher solute concentrations in this region of the Green Lakes Valley, consonant with a more efficient detrital trap (dictated by slow seepage into Stream 1 from GL 1). The three clam species can coexist in habitats only as low as pH 5.5–6.0 (Okland 1980, Okland and Kuiper 1980), which overlaps the lowest reading for Green Lakes flowage.

In 1985 there was a notable decline of the *Pisidium* population in Stream 1. The lowered water level in GL 1 reduced the flow in Stream 1 to a trickle. This stressful condition and a pH near the known lower tolerance level for *Pisidium* species are probably important factors contributing to the decline.

Bryozoa.—Only a single statoblast of an unidentified species of *Plumatella* was found by Elgmork and Saether (1970). A colony of *Plumatella repens* with only five zooids was obtained from Lake Albion in 1982. However, the surprise during the 1985 season was the preponderance of *Fredericella sultana* on the rocks in Green Lake 3. The water level in this lake was lowered approximately 6.4 m for dam repair. This change in water level exposed a considerable, normally submerged, rocky benthic area. Inspection of several rocks found to have dry colonies of *F. sultana* suggested that we should take radial transects (from the former lake margin to the lowered water line). Easily dislodged small- to medium-sized rocks along seven transects were examined. Forty-three percent (91 of 212 rocks) had one or more dried *F. sultana* colonies attached. Many of these colonies were large, i.e., > 75–100 zooids, a few up to several hundred. Subsequently, numerous luxuriant living colonies were observed on submerged rocks at the water line and deeper down. Large colonies grow away from a surface as easily seen, loose tufts. *Fredericella sultana* has been reported from high-elevation Swiss lakes by Forel (1884). Bushnell (1966) found this species surviving and slowly growing under lake ice all winter in Michigan. In GL 3 no colonies were found above the 1.3-m depth; thus, the species was below the level of the winter ice thickness. Since this species does not produce floating statoblasts, the primary means of settling on near-surface substrates is via the sexually produced larvae. If colonies had been seasonally established on such substrates in GL 3, freezing and ice abrasion likely obliterated them.

The most striking aspect of the Green Lake 3 fauna is that the largely rocky benthic regions, to as far down as we have observed, are dominated by a bryozoan macroinvertebrate. Such dominance is not commonly encountered in warmer eutrophic lakes and was heretofore unknown for a truly alpine or arctic lake.

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