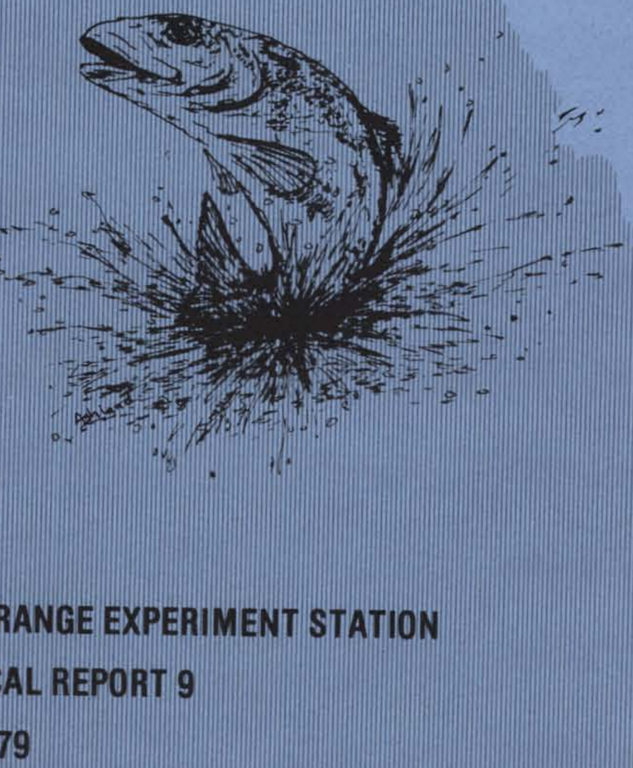
AQUATIC RESOURCES IN THE NATURE CONSERVANCY PORTION OF SILVER CREEK



by

L.J. Francis and T.C. Bjornn

IDAHO COOPERATIVE
FISHERY RESEARCH UNIT

FOREST, WILDLIFE AND RANGE EXPERIMENT STATION
TECHNICAL REPORT 9
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AQUATIC RESOURCES IN THE

NATURE CONSERVANCY PORTION OF SILVER CREEK

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for

The Nature Conservancy

1979

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ABSTRACT

Some of the aquatic resources of Silver Creek, a renowned trout stream in south central Idaho, were studied on the Nature Conservancy section of the stream during 1977.

The temperature range (average 10-12 C, maximum 22C) was found to be good for production and growth of cold-water organisms. Stream discharge at Picabo was relatively stable in 1974-75 and 1975-76 (range 3-13 m^3/sec). Stream discharge in 1976-1977 (low water year) ranged from 2-7.5 m^3/sec.

Stream substrate consists of silt (including fine sands) and gravel with particle size less than 7 cm in diameter. Silt covered from 42 to 56% of the stream bottom during the year.

Twenty-nine species of aquatic plants were found. Vegetation was most abundant in August, and least abundant in March. Chara sp. was the most abundant followed by Potamogeton pectinatus and Veronica anagalis-aquatica. Chara sp. had the greatest biomass per m^2 followed by Elodea canadensis, Potamogeton pectinatus, Veronica anagalis-aquatica, and Rorippa nastertium-aquaticum.

Thirty-one genera of algae which colonized on microscope slides were identified, of which Navicula, Fragillaria, and Gomphonema were the most abundant genera. Cell numbers per mm^2 for each four-week period increased for two or three

weeks and declined during the fourth week. Numbers ranged from 56 to 8266 per mm^2. Chlorophyll a concentrations averaged about 1.3 mg/m^2 during the study period.

Fifty-three families and seventy-eight genera of aquatic insects were identified. Several species identified only to family. In decreasing order of abundance, Diptera, Trichoptera and Ephemeroptera were the dominant orders in benthos samples. Ephemeroptera was the dominant order in drift samples, followed by Diptera and Trichoptera. Midnight drift samples yielded the greatest number of insects, while sunrise samples had the fewest.

Ephemeroptera were the most abundant insects in stomachs of rainbow trout, accounting for 80% of the organisms. Rainbow trout also selected positively for mayflies and negatively against other organisms. Whitefish fed mainly on mayflies, with mayfly adults making up to 50% of the organisms found in their stomachs.

Six species of fish were present in the Nature Conservancy portion of the stream. In decreasing order of abundance these were rainbow trout (Salmo gairdneri), bridgelip suckers (Catastomus columbianus), longnose dace (Rhynichthys cataractae), mountain whitefish (Prosopium williamsoni), Wood River sculpin (Cottus leiopomus) and brook trout (Salvelinus fontinalis). Brown trout (Salmo trutta) and redside shiner (Richardsonius balteatus)were also present below Purdy's irrigation dam.

Age 0 rainbow trout grew 60 mm during their first summer. Age I rainbow trout grew 150 mm from March to November 1977.

Spring and fall spawning rainbow trout are present in Silver Creek. Spring spawners were more numerous in 1977. Spawning of rainbow trout took place from April to early July and in October and November.

ACKNOWLEDGEMENTS

The Nature Conservancy provided the financial support for this study. Idaho Fish and Game conducted a study on the fishery of Silver Creek and our work was coordinated with theirs.

For providing stream discharge and water chemistry data we thank Daryl W. Clapp and Joe A. Moreland of Idaho Department of Water Resources and Idaho Department of Health and Welfare.

We thank Dr. M.A. Brusven and Dr. C.M. Falter for their assistance in formulating research techniques, Dr. Hansen (Utah State University) and Russ Biggam (University of Idaho) for identifying aquatic insects, and Dr. D. Anderegg and Dr. Naskali for identifying the aquatic macrophytes.

Others deserving thanks are Ken Wiley, resident manager of the Nature Conservancy preserve during 1977, for his help in field work, Mr. Bill McMahan, for his hospitality and for providing access to the stream, also Mr. Gardner and Mr. Purdy for providing access to sections of the stream on their properties, and Mr. Bud Bachelder (Hayspur Fish Hatchery Superintendent) for accomodating us and making our stay at the hatchery a pleasant one.

A special thanks to John S. Irving for his encouragement and help during the research.

INTRODUCTION

This report contains the findings of a study funded by The Nature Conservancy of the aquatic ecosystem of Silver Creek, including primary productivity, aquatic vascular plants, insects, and fish within the land owned by The Nature Conservancy.

Silver Creek, a tributary of the Little Wood River in south central Idaho, attracts fishermen from throughout the country. Special angling regulations have been in effect on the headwaters of Silver Creek since 1975 when fly fishing only was started and beginning in 1977, all trout had to be released.

Nature Conservancy personnel, with public and private support, purchased a 479 acre tract of land at the headwaters of Silver Creek in 1976 and set it aside as a special management area. The Nature Conservancy's program for the Silver Creek property is designed "to preserve and enhance the quality of the stream, its environment, and its wild fishery."

STUDY AREA

Silver Creek originates as several springs in a flat, desert valley 10-16 km west of Picabo, Idaho at an elevation of 1490 m (4920 ft, mean sea level), and falls about 95 m (315 ft) in 25 km (15 mi). The creek flows easterly past Picabo and eventually turns south before joining the Little

Wood River about 50 km (30 mi) from the source (Fig. 1). The Nature Conservancy site includes the area along Stalker Creek downstream from the Stalker Creek Bridge and along Silver Creek down to the Kilpatrick Bridge (Fig. 2).

The native vegetation in the area consists of sagebrush and grasses in the hills, and willows, cottonwoods and grasses on the lowland areas. The land adjacent to Silver Creek is used for cattle grazing and irrigated crops; alfalfa, wheat, barley, clover, oats, and potatoes.

The climate in the Silver Creek area is characterized by moderately cold winters and warm summers. The average monthly minimum temperature at Hailey, 32 km northwest of Silver Creek, is -7.4 C in January, with the average monthly maximum being 19.4 C in July. The average annual precipitation at Picabo from 1960 to 1969 was 34.90 cm (Castelin and Chapman 1972).

The water chemistry of Silver Creek partially reflects the geological history of the valley. Fluvioglacial clay, silt and fine to coarse-grained gravel make up most of the Silver Creek-Big Wood River valley floow (Castelin and Chapman 1972), imparting to the river relatively high values of pH, alkalinity, hardness, specific conductance and calcium. The water quality of Silver Creek was analysed by the Department of Health and Welfare during 1976 and 1977 (Table 1).

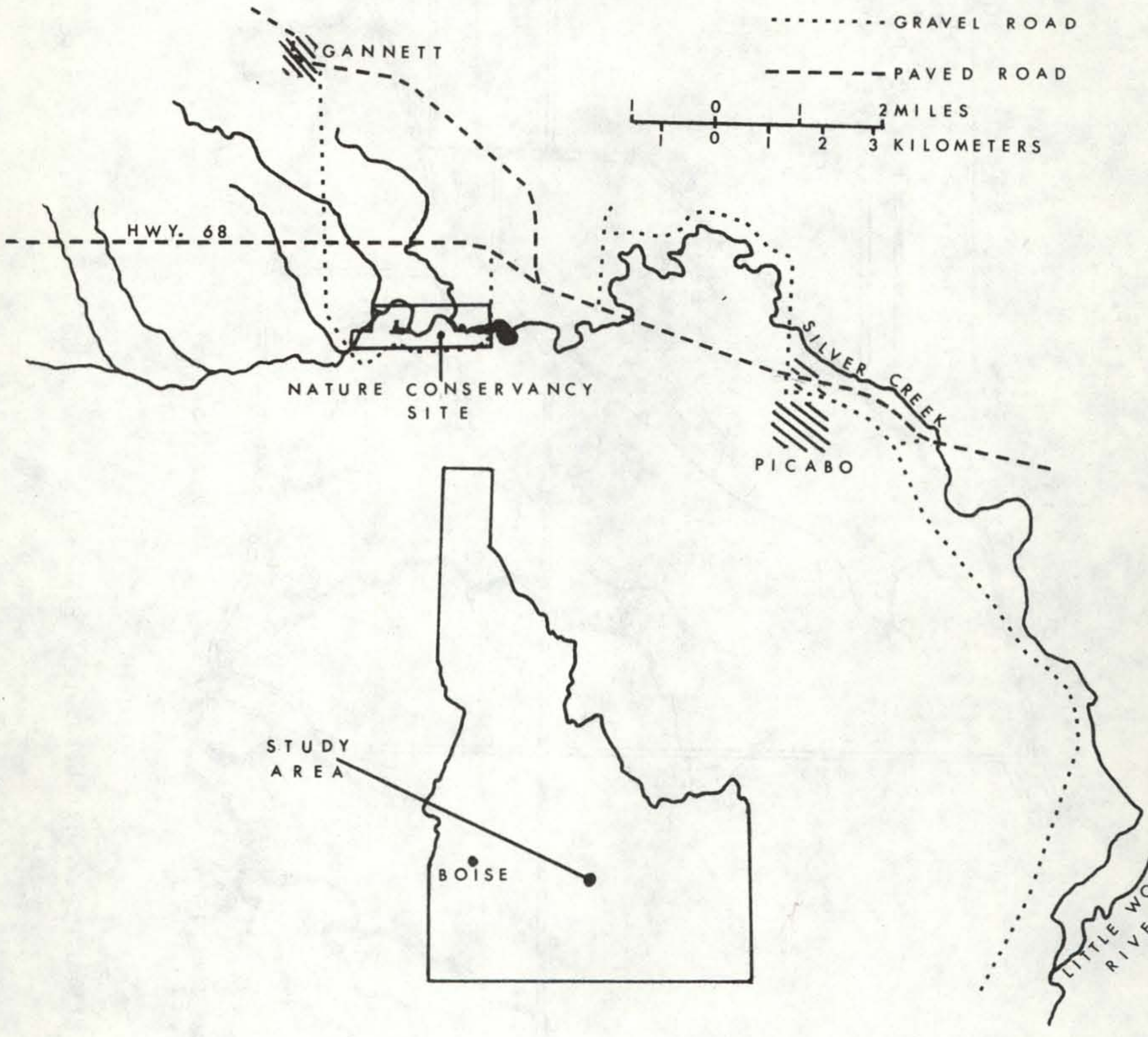

Figure 1. Location of Silver Creek in Blaine County, Idaho.

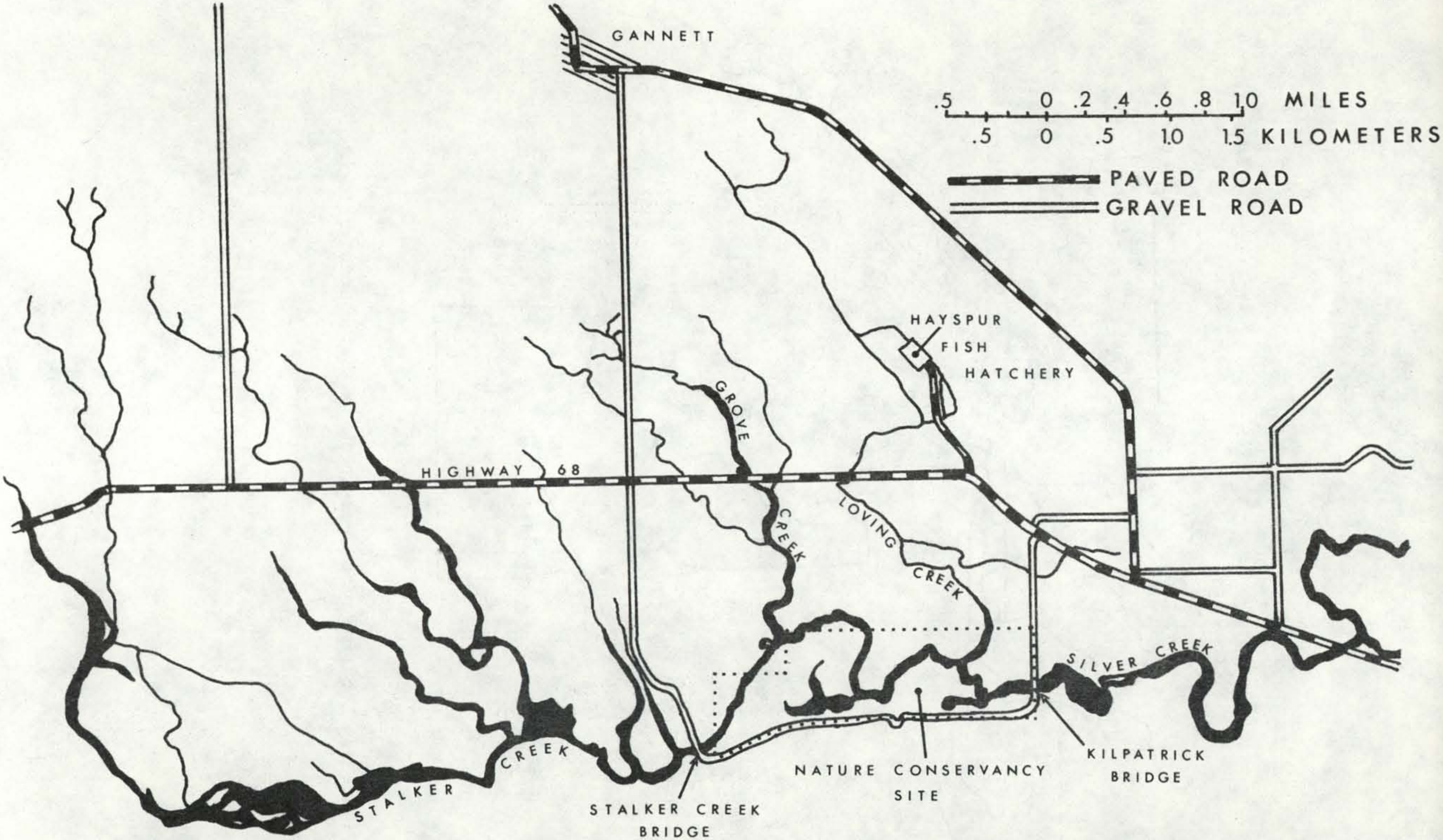

Figure 2. Upper section of Silver Creek with headwater tributaries and The Nature Conservancy site.

TABLE 1. Analyses of Silver Creek water collected at the sportsman's access near Picabo, Idaho by Idaho Department of Health and Welfare, 1976-1977.

	Date of collection			
Parameter	1-06-76	5-05-76	10-21-76	5-17-77
Time of day	1430	2030	1525	1040
Inst. discharge (cfs)	196	148	255	105
Spec. conductance (umhos)	422	365	404	424
pH	7.9	8.2	8.4	8.2
Air temperature (C)	6.0	9.0	17.5	4.5
Water temperature (C)	1.5	13.5	12.0	10.0
Hardness (Ca, Mg, mg/l)	200	190	210	200
Non-carbonate hardness	4	4	13	17
Percentage sodium	5	4	5	5
Sodium adsorption ratio	0.2	0.1	0.1	0.2
Bicarbonate (mg/l)	242	230	235	220
Carbonate (mg/l)	0	0	0	0
Alkalinity-$CaCO_3$ (mg/l)	198	189	193	180
Dissolved				
Calcium (mg/l)	58	54	61	56
Magnesium (mg/l)	14	14	13	14
Sodium (mg/l)	5.0	4.0	4.8	5.2
Potassium (mg/l)	1.4	1.3	1.3	1.1
Sulfate (mg/l)	17	17	16	16
Chloride (mg/l)	2.2	2.1	2.0	2.0
Fluoride (mg/l)	0.3	0.2	0.2	0.3
Silica (mg/l)	14	15	14	13
Solids (mg/l)	235	221	231	218
Solids (tons/ac-ft)	0.32	0.30	0.31	0.30
Solids (tons/day)	124	88.3	159	61.8
Nitrate plus nitrite (mg/l)	0.90	-	0.55	0.36
Total phosphorus (mg/l)	0.17	0.03	0.00	0.02

Specific conductance, hardness, dissolved calcium, alkalinity, dissolved nitrate and total phosphorus are indicators of the productivity of a stream. Specific conductance is a measure of the capacity of water to conduct an electrical current, and is an indicator of total dissolved solids. The specific conductance in Silver Creek ranged from 275 to 424 umhos, with the average being about 380. Since the specific conductance is a measure of the ions in solution, a change in the quantity of ions would cause a change in the specific conductance. From January to May 1976, the specific conductance decreased 14% while at the same time hardness and alkalinity decreased 5% and dissolved calcium 7%. From May to October the specific conductance increased 11% while hardness increased 10%, dissolved calcium 13% and alkalinity 2%.

Calcium and magnesium carbonate, often occurring together, are prominent sources of ions which, in solution, contribute to the hardness of streams. The total hardness in Silver Creek is about 200 mg/l. Spring water where it emerges to the surface is generally rich in calcium bicarbonate. As it flows along it loses carbon dioxide to the atmosphere and by photosynthesis, and after some distance this soll becomes loss of equilibrium CO_2 and deposition of calcium carbonate occurs. This process is also aided by the ability of many plants to make direct use of bicarbonate ions (Hynes 1970). Deposition of calcium carbonate is therefore a common feature of streams in limestone areas, Silver

Creek being a typical example.

Alkalinity refers to the quality and quantity of compounds which bring about a shift in the pH of a solution toward the alkaline side of the pH range. It usually reflects the activity of calcium carbonate (Reid and Wood 1976). The alkalinity in Silver Creek is about 190 mg/l. Potassium, nitrate and phosphate are three important ions needed for plant growth. Potassium is never considered to be a factor limiting plant growht in natural waters (Hynes 1970). Because of the uptake of these ions by plants, they are often present in low concentrations. Phosphorus is often eliminated completely when vegetation is in abundance. When the vegetation dies off in the winter, these nutrients are released back into the water by bacterial action. Nutrients are also entering the stream from bank erosion and overland runoff. In Silver Creek phosphorus levels in January 1976 were 0.17 mg/l but by May had dropped to 0.03, indicating good growth of vegetation already by that time. Comparisons of Silver Creek water quality with other streams in Idaho are shown in Table 2.

TABLE 2. Water quality parameters of selected water basins in Idaho. Sources of information; Wood River - Silver Creek area (Castelin and Chapman 1972, Castelin and Winner 1975), Camas Prairie area (Mitchell 1976), Salmon River (Watts 1971), Pahsimeroi River (Young and Harenberg 1973), Portneuf River area (Norvitch and Larson 1970), Clearwater Plateau (Castelin 1976), and Lemhi River (Halbach 1974). Figures in parentheses indicate number of observations.

Place			Date	Specific conductance	Dissolved solids	Hardness	Calcium	Alkalinity	Nitrate	Phosphorus
Silver Creek			1-06-76	422	235	200	58	198	0.90[1/]	0.17
Silver Creek			5-05-76	365	221	190	54	189	-	0.03
Silver Creek			10-21-76	404	231	210	61	193	0.55[1/]	0.00
Wood River area	above Ketchum		9-20-73	232					0.15	0.00
	at Hailey		9-09-54	324		150	42		1.9	
	groundwater wells (36)	High		605		302	77		13.0	
		Low	1954	247		51	16		0.0	
		Average		388		180	50		3.9	
Camas Prairie area	thermal springs (14)	High		1149	1213		20		0.86	0.03
		Low	1976	206	61		0.8		0.00	0.00
		Average		385	281		3.3		0.20	0.01
Salmon River	below the North Fork	High	1969						7.5	1.40
		Low							1.7	0.04
Pahsimeroi River	near Dicky		6-15-71	217	156	110	29	107	0.20	0
			10-15-71	271	158	140	36	121	0.09	0
	near May		10-13-71	376	227	180	45	190	0.25	0.06
			6-20-71	392	238	180	45	190	0.43	0.15
	groundwater wells (7)	High	Oct.	562	345	250	68	260	0.79	0.18
		Low	11-12,	159	92	67	12	72	0.17	0.03
		Average	1971	369	219	153	39	173	0.46	0.09
Portneuf River	near Pocatello		4-14-60	604	355	260	64		3.1	
			8-03-60	642	391	262	55		2.7	
	groundwater wells (16)	High		1200	757	44	156	458	13.0	0.20
		Low		539	309	0	41	160	0.1	0.03
		Average		817	507	16	82	296	4.6	0.13
	springs (7)	High				424	84	322	6.3	
		Low				166	44	162	0.4	
		Average				284	63	253	2.7	
Clearwater Plateau	surface water sites (8)	High	Oct.-	880			67		4.08	1.22
		Low	Nov.	223			21		0.20	0.11
		Average	1973	388			29		1.40	0.32
	groundwater wells (18)	High	1966-		460	212	58	240	7.0	0.17
		Low	1974		144	48	11	60	0.0	0.01
		Average			309	122	30	142	2.5	0.05
Lemhi River (72)		High			385			258	2.80	0.30
		Low	1973		119			168	0.10	0.00
		Average			239			202(18)	1.05	0.04

1/ nitrate plus nitrite

OBJECTIVES

The specific objectives for the study were:

1. To describe the aquatic ecosystem in Silver Creek at The Nature Conservancy site.
2. To assess the primary productivity of Silver Creek at the site as related to water chemistry, temperature, and aquatic plants and to compare with other streams.
3. To assess the abundance and distribution of aquatic insects and the role they play in the stream ecosystem.
4. To assess the abundance, distribution, movements, age structure and the effects of the fishery on the fish stocks in Silver Creek.

METHODS

Temperature

The temperatures of Silver Creek were monitored with a pocket thermometer in the morning and afternoon on March 17, April 17 and May 23, and a thermograph operated 220 m below the confluence of Grove and Stalker Creeks from June 13 through November 7, 1977. Temperatures of springs at the headwaters of Grove and Loving Creeks and Sullivan Lake were taken on June 20, August 15 and October 17.

Discharge

Stream discharge data collected from October 1974 to September 1977 at a guage near Picabo was made available by the Department of Water Resources. Water level changes during 1977-78 were measured at two bridges spanning Silver Creek in The Nature Conservancy site. One bridge was located approximately 650 m downstream from the confluence of Grove and Stalker Creeks and the other about 450 m below the first bridge. The area downstream from the upper bridge was predominantly gravel with little aquatic vegetation and thus water level changes mainly reflected changes in discharge. The area downstream from the lower bridge had large amounts of aquatic vegetation and thus water level changes were caused by changes in discharge and changes in density of aquatic vegetation.

Stream Substrate

The stream substrate was mapped regularly to monitor the changes in composition of surface sediments and vegetation. Every three weeks from June 26 to October 24, 1977 and on December 10, 1977 and March 17, 1978, we measured sediments and vegetation along three linear transects across Silver Creek every 200 m from a point 200 m upstream from the upper bridge to a point 100 m upstream from the confluence of Loving Creek (Fig. 3). The substrate in Silver Creek was no larger than pebbles (up to 63.5 mm in diameter), and we divided the stream substrate into two classifications. "Silt" consisted of particles up to 1.5 mm in diameter and "gravel" from 1.6 to 63.5 mm. While mapping the substrate we measured the depth of silt so we could estimate the volume of silt present in Silver Creek at various times throughout the year.

Vegetation

The annual succession of algae and macrophytes was monitored while mapping the stream substrate. Plants were identified to genus and the length of each transect line covered by each type of plant was measured and then two 0.093 m^2 samples of each plant at its average height were collected, oven dreid and weighed to calculate standing biomass.

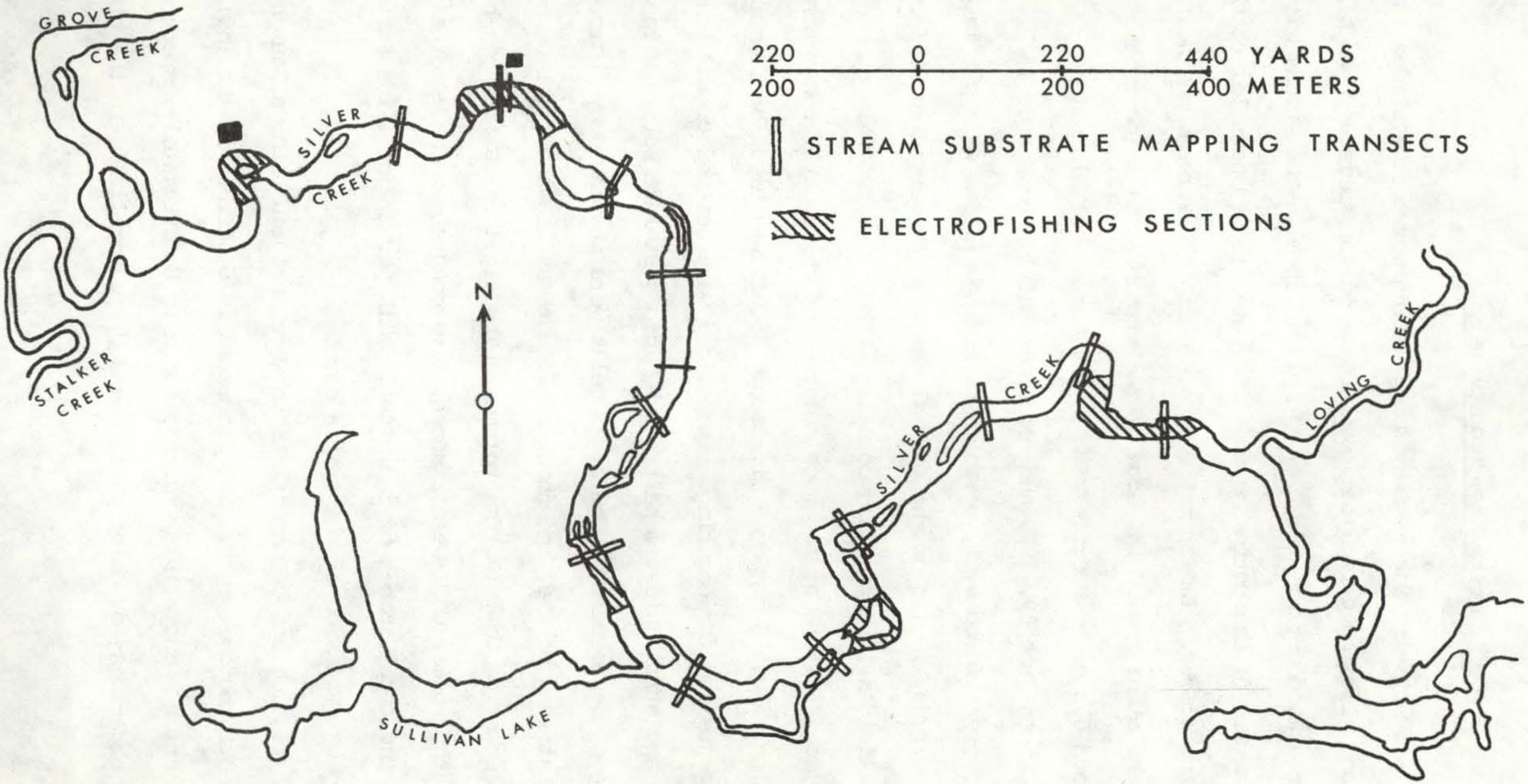

Figure 3. Electrofishing sections and substrate mapping transects on Silver Creek in The Nature Conservancy area.

Primary Productivity

Primary productivity was estimated by placing mocroscope slides in the stream and allowing periphyton to colonize on the surfaces. We placed 16 slides in a wooden frame (Fig. 4) and placed them in the stream within three centimeters of the bottom so that the water flowed parallel to the surface of the slides. Two frames were placed in the stream, one near the center and the other toward the edge of the stream. The velocity and depth (0.5 m/sec and 0.3 m, respectively) were similar at both locations. Sampling began on June 19, 1977 and continued until November 6, 1977. Four slides were removed every seven days, and new slides were put in the frames every 28 days. Two of the four slides were preserved in 5% formalin for later cell identification and counting. The other two were oven dried and then frozen (-20 C) for later calculation of chlorophyll content of the periphyton. A wild compound microscope (500X) was used for identification to genus and for counting. The slides were scraped clean with a razor blade and stiff, plastic-hair brush, into a storage bottle with a known volume of 5% formalin. The algal cells were suspended by thoroughly shaking the storang bottle, and then an aliquot was drawn out for counting in a Palmer Counting Cell (0.1 ml volume). The algal cells from one-half the area on the Palmer Cell were counted, five counts were made for each sample, and the total number of individual cells per mm^2 of slide surface was obtained by expansion of the sample counts.

Chlorophyll a, b and c concentrations were measured using a Bausch and Lomb spectrophotometer 70. The procedure is described in the Environmental Protection Agency (1973) methods manual. Unfortunately, spectrophotometric equations for chlorophyll b and c are unreliable in the presence

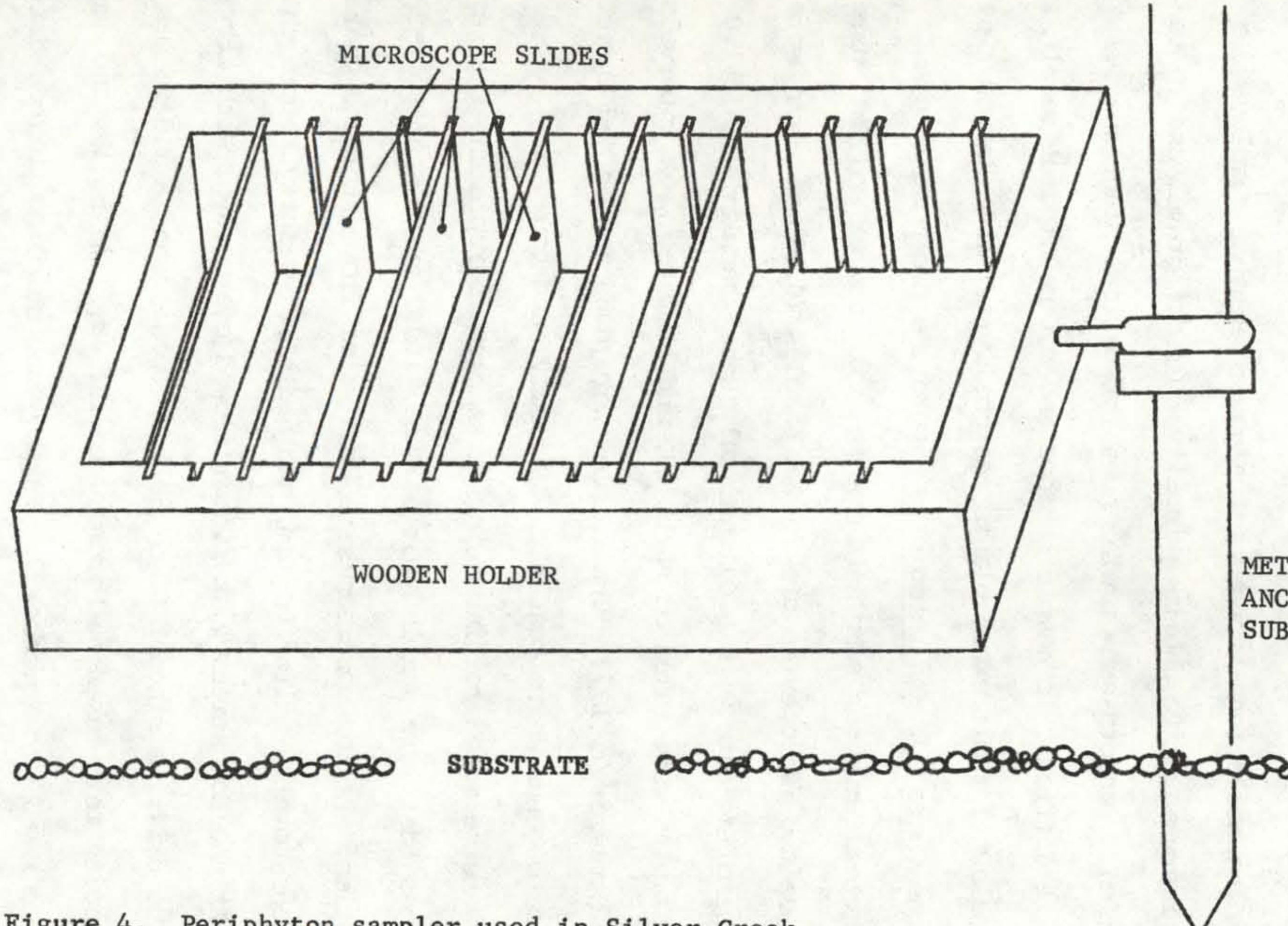

Figure 4. Periphyton sampler used in Silver Creek

of pheophytin (Moss, 1967), which prohibited their use in stream analysis.

Aquatic Insects

Abundance and distribution of aquatic insects was monitored with drift and benthos samples collected throughout the year. Benthos samples were taken from two representative habitats in Silver Creek; gravel and rooted aquatic vegetation. Insects show preferences for various plant species and this makes it difficult to sample benthos and get meaningful results. An insect may select for different plants seasonally as well (Harrod 1964). In April and June Chara sp. and Veronica sp. were the two most abundant aquatic macrophytes, thus our samples throughout the summer and fall were taken where these two macrophytes grew. Two samples (0.093 m^2 each) were taken on each sampling date with a cylindrical "Hess" sampler with a 1.0 mm mesh net. Samples were taken on April 18, and at three week intervals from May 25 to November 7, 1977. The samples were hand sorted and insects were identified to genus where possible, or family, and counted.

Two sites were selected for insect drift samples to represent the same two habitat types that were sampled for benthos, i.e., gravel and rooted aquatic vegetation. At the upstream site, the water flowed through Chara and Veronica beds, over a silted bottom, and had slow velocity before entering the net. At the downstream site, water flowed over gravel with little vegetation. The drift nets had a 61 by 30.5 cm opening and a 1.0 mm mesh net. Drift samples were taken on March 17 to 19, April 17 to 19, and every three weeks from May 23 to November 7. During each sampling period, drifting insects were collected four times daily (at sunset, midnight, sunrise and noon) for two days. The nets were set one half hour before the prescribed time and left for one hour. The current velocity and depth were measured at the mouth of the nets during each sampling period to calculate the volume of water flowing through the nets. The insects cought were identified to genus (aquatic insects) or order (terrestrials) and counted. Qualitative samples of Chara, Veronica, Potamogeton, Roroppa, Ranunculus, Elodea, Berula, Myriophyllum, Hippuris, Fontinalis, Drepanocladus and the duckweeds (Lemnaceae and the Bryophytes) were collected during September to analyse insect-plant relationships.

Food Habits

Stomach samples from rainbow trout and some whitefish were taken periodically at the same time drift samples were collected to relate insects in the drift to utilization by fish. Fish for stomach analysis were collected by angling.

Fish Stocks

Abundance, distribution and age structure of fish in The Nature Conservancy site were assessed by electrofishing five sections of stream. The five sections (Fig. 3) covered about 24% of the stream length in The Nature Conservancy site above the confluence of Loving Creek. The electrofishing gear (a 230 volt generator and variable voltage pulsator) were floated in the stream in a 2.1 m long fiberglass boat. The negative electrode was a cable suspended in the water from the boat. Two dip nets were used as positive electrodes.

Seasonal fish abundance was estimated in March, May, July, September and November using the Seber two-catch method (Seber and LeCren 1967). The stream was too wide to electrofish in one pass up the stream, so we divided the sections lengthwise and electrofished first one side, then the other. The first catch consisted of fish caught while electrofishing upstream and downstream on each side of the stream. The whole procedure was repeated to obtain the second catch. Fish caught in the first catch were held in perforated plastic garbage cans until the second catch was completed. Our estimates are probably smaller than the actual population size because the sample sections had no natural or artificial barriers to prevent fish from leaving the section while we electrofished. Adult fish were seen leaving the sections on a number of occasions. Our estimates of adult fish are probably 10 to 30% low. The fish were identified, counted and the total length of trout and whitefish was recorded by 10 mm length classes. Rainbow trout with jaw tags were measured to the nearest one millimeter and the tag numbers recorded. Scales were taken from some of the rainbow trout, on the left side of the caudal peduncle, to determine age and growth rates.

Movement of trout in Silver Creek was studied by Idaho Fish and Game personnel by jaw tagging all hatchery fish released into Silver Creek in 1976, and wild trout collected by electrofishing.

Spawning activity in The Nature Conservancy site was observed during April, May and June and again in October and November, 1977. Recently hatched fry were observed in May, June and July.

Idaho Fish and Game personnel conducted a creel census during 1975 to 1977 on five sections of Silver Creek (Mallet 1976).

RESULTS

Temperature

The temperature of Silver Creek is affected by the weather and by the temperature of incoming groundwater. The temperature of the water emerging from the ground as springs was between 10.0 and 11.5 C at each sampling time. The temperature of the springs at the Hayspur Fish Hatchery (headwaters of Loving Creek) remains constant, 11 C, throughout the year.

The temperature of the stream is affected more and more by the weather, the farther downstream it flows. Daily maximum temperatures during the summer at the confluence of Grove and Stalker Creeks average about 18.5 C, with a maximum of 22 C recorded on July 24, 1977 (Fig. 5). Daily minimum temperatures in summer were close to those of incoming groundwater. The temperatures of Silver Creek in The Nature Conservancy site drop in late August and September and daily maximum temperatures are close to incoming groundwater during the fall while minimums ranged down to 3 C. Average daily fluctuations were 6 to 10 C during the summer and 2 to 7 C in the fall.

Halbach, 1974, mentioned daily summer temperature fluctuations of 12 C on lower stretches of the Lemhi River, Idaho, while temperatures in the upper stretches of the river fluctuated 4 to 8 C daily. Temperatures in the Teton River near the Teton Dam site had daily fluctuations of 5 to 10C in 1961 and 2 to 8 C in 1974 and 1975 (Irving et al. 1977). The daily fluctuations in 1974-75 were less than in 1961 because the reservoir had begun to fill, thus moderating the water temperature downstream from the dam site. Bithc Creek, a tributary to the Teton River, had daily fluctuations of 5 to 14 C during 1974 and 1975. Temperatures along the St. Joe River, Idaho, during July and August, 1971, ranged from 5 C in the upper

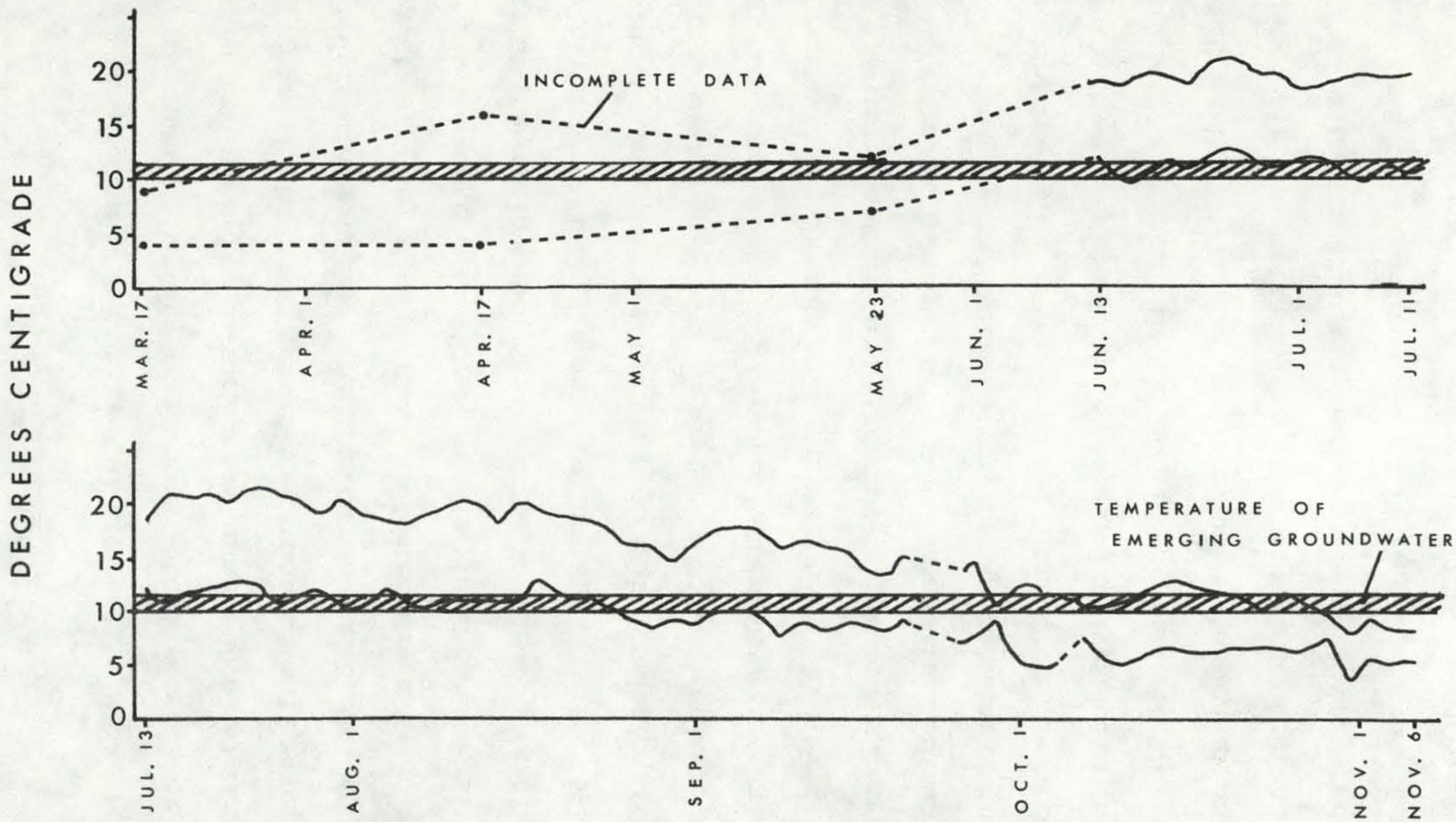

Figure 5. Daily maximum and minimum temperatures of Silver Creek on the upper Nature Conservancy site, 1977.

part of the stream to 21 C in the lower reaches (Hicks, 1971). The upper lethal temperature for rainbow trout is about 28 C (McAfee, 1966) and for brook trout, 21 C (Brett 1944). Since Silver Creek rarely exceeded 21 C in the study area, the stream is well suited, temperaturewise, for the survival of trout.

Discharge

Silver Creek discharge fluctuates less than most streams because of its mostly spring source. During normal water years (1974-76), the flow fluctuated between about 3 and 13 m^3 per second (Fig. 6).

The smallest flows occur during late spring, immediately following spring runoff. The flows then increase gradually, reach a peak in October, and then decrease until spring runoff. The increase in flow during July, August and September is attributed to two major factors. First, spring runoff from the Big Wood River valley entering the groundwater aquifer in the springtime, emerges three to four months later as springs at the headwaters of Silver Creek. Second, water diverted from the Big Wood River near Bellevue for irrigation in the Silver Creek area eventually enters the stream (Moreland, 1977). During 1977, snow did not accumulate on the valley floor because of the drought and there was no spring runoff. With reduced spring runoff in the Big Wood River and reduced irrigation in 1977, there was below average recharge of the groundwater aquifer and water flows in Silver Creek continued to decrease through the summer and fall (Fig. 6).

Water levels were also relatively stable throughout 1977 (Fig. 7). At the upstream bridge the water level fluctuated only 15 cm from March 17, 1977 to March 17, 1978. At the downstream bridge the water level

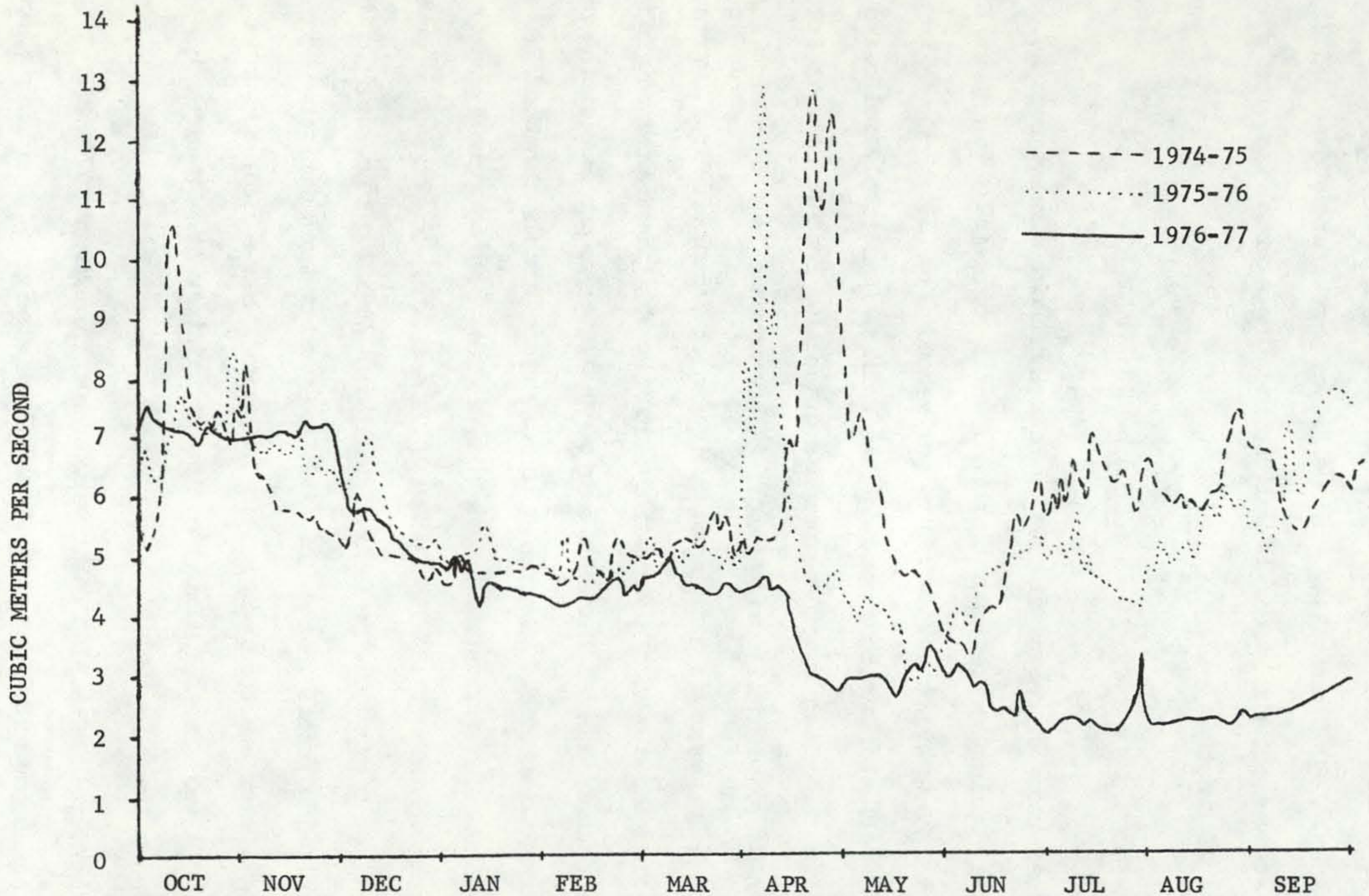

Figure 6. Silver Creek discharge at Picabo, Idaho, October 1974 to September 1977.

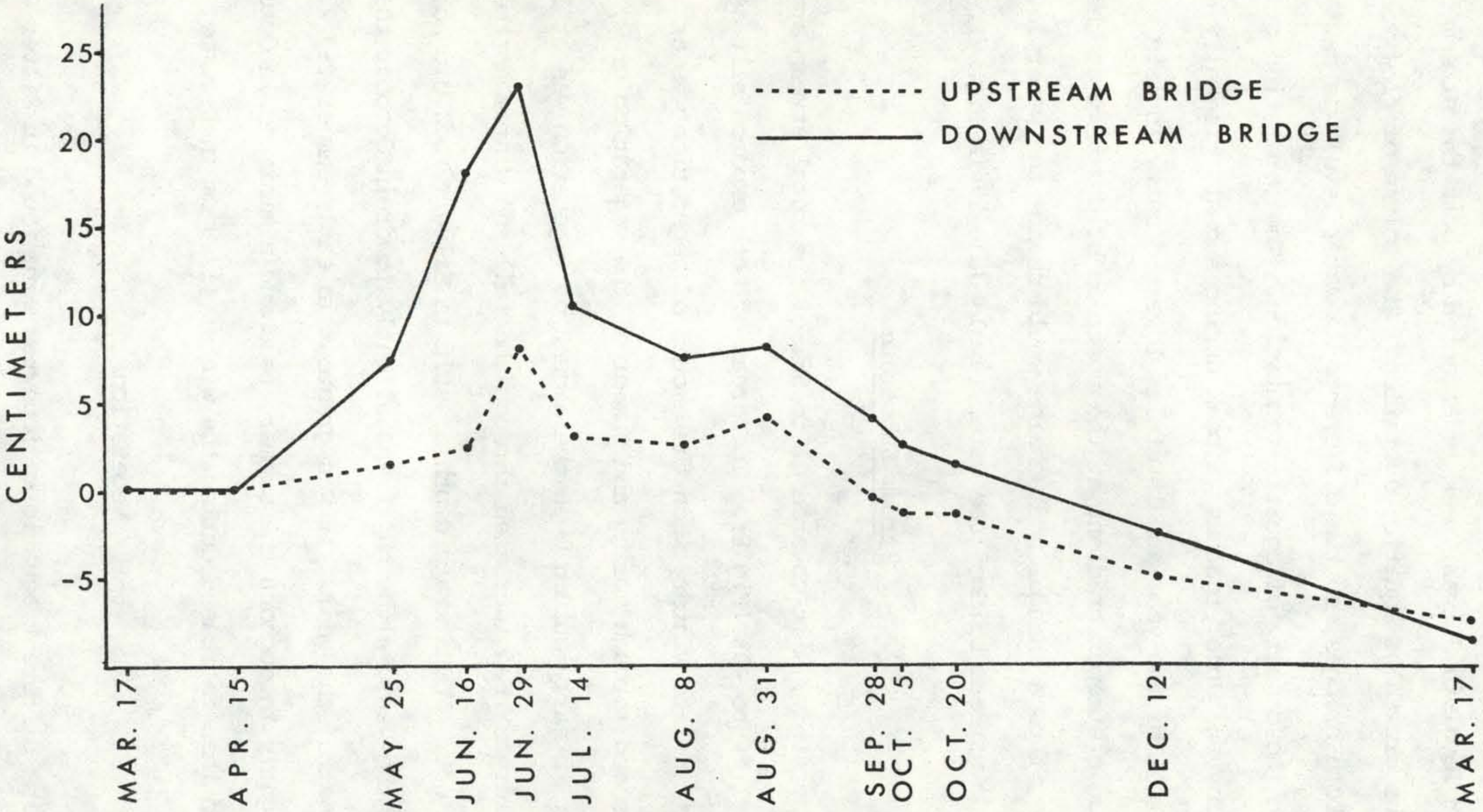

Figure 7. Water level changes of Silver Creek at two stations in The Nature Conservancy site, 1977-78.

fluctuated 31 cm during the same time period.

The water level in Silver Creek is affected by both the stream discharge and the growth of aquatic vegetation. The volume of flow was about the same at both bridges, so the difference in water level was caused mostly by changes in the density of aquatic vegetation. The vegetation grows rapidly during May and June, reaches a peak during August, gradually dies off through the rest of the year and is at its lowest density in late winter. The stream had a steeper gradient at the upstream bridge than at the downstream bridge, thus a change in discharge would change the water level more at the downstream bridge (see water levels June 29 in Fig. 7).

Stream Substrate

During the study, silt covered 42 to 56% of the total stream area and exposed gravel 24 to 40% (Fig 8). The areas of both exposed silt and gravel were greatest in late winter, when the amount of vegetation was at its lowest, decreased through spring and summer as the vegetation grew, and were smallest in early autumn when the amount of vegetation was at its peak. These areas then increased through the fall and winter as the vegetation died out. The average depth of silt in Silver Creek did not change much through the year, although it was slightly lower in October than during the rest of the year. It was greatest in early summer (13.2 cm), declined slightly throughout the summer, reaching a minimum ; in October (10.7 cm) and then increased during the winter (12.9 cm in December).

Vegetation

Twenty-nine different aquatic macrophytes were found in Silver Creek during 1977 (Table 3). Vegetation covered up to 68% of the total stream

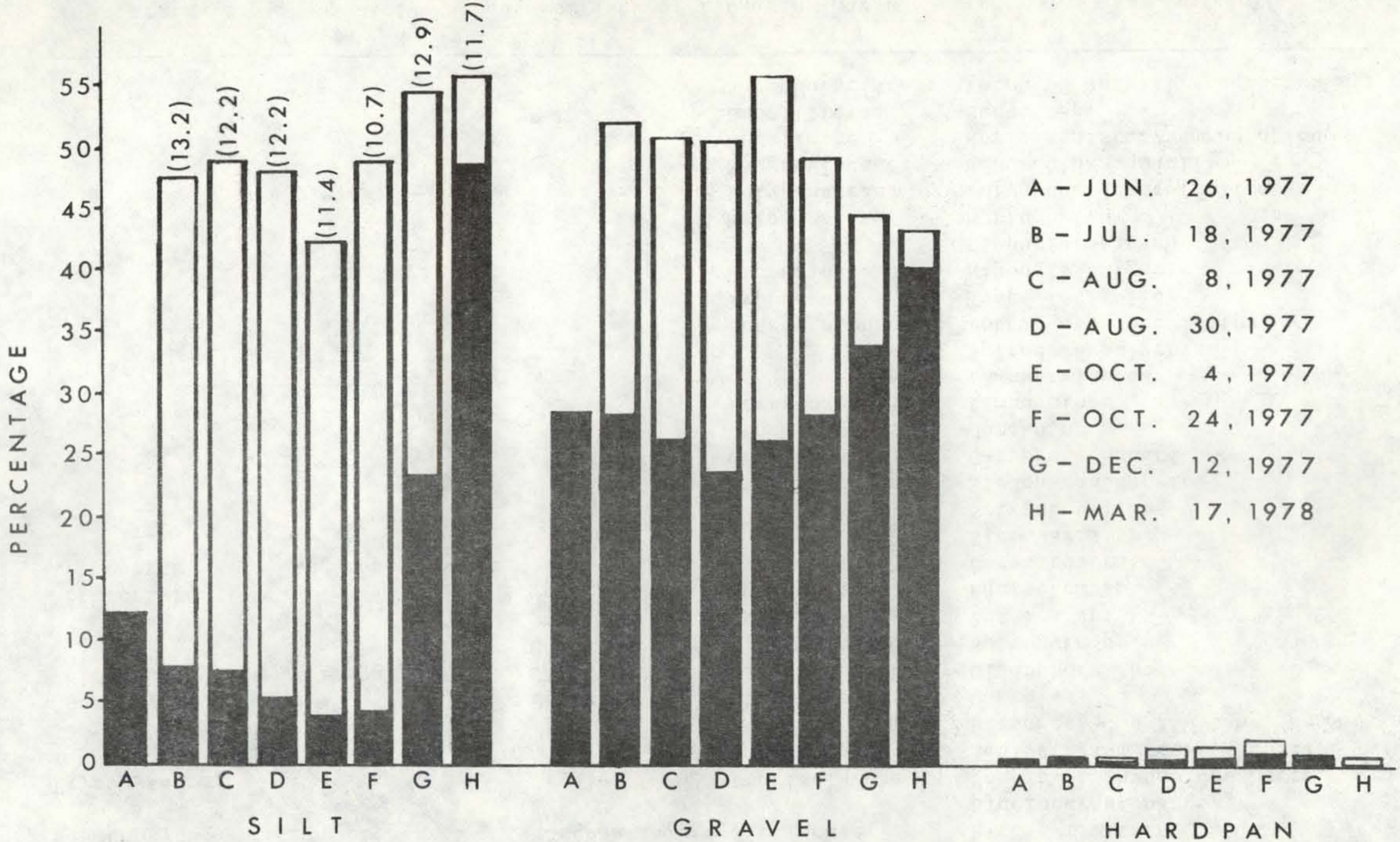

Figure 8. Percentage of stream area covered by substrate types in The Nature Conservancy site. Shaded portion of bar represents the percentage of each substrate type that was bare silt, gravel, etc. and the unshaded area represents the area covered by plants. Figures in parentheses indicate average depth (cm) of silt. Area of gravel and silt underneath plants was not measured on June 26, 1977.

TABLE 3. Aquatic macrophytes found in Silver Creek, 1977.

Division	Class	Order	Family	Genus - species
Hepatophyta	Hepaticae	Marchantiales	Ricciaceae	Riccia fluitans
				Ricciocarpus natans
Bryophyta	Musci	Bryales	Fontinalaceae	Fontinalis hypnoides Hartm.
			Amblystegiaceae	Amblystegium tenax (Hedw.)
				Drepanocladus fluitans (Hedw.)
Charophyta		Charales	Characeae	Chara sp.
Chlorophycophyta	Chlorophyceae	Cladophorales	Cladophoraceae	Cladophora sp.
		Conjugales	Zygnemataceae	Spirogyra sp.
				Zygnema sp.
Arthrophyta			Equisetaceae	Equisetum sp.
Anthophyta	Angiospermopsida		Cyperaceae	Carex rostrate
				Eleocharis sp.
				Scirpus validus
			Hydrocharitaceae	Elodea canadensis
			Gramineae	Catabrosa aquatica[1/]
			Juncaceae	Juncus sp.
			Lemnaceae	Lemna minor
				Lemna trisulca
				Spirodela polyrhiza
			Potamogetonaceae	Potamogeton pectinatus
			Typhaceae	Typha latifolia
			Hippuridaceae	Hippuris vulgaris
				Hippuris montana
			Haloragaceae	Myriophyllum
			Polyganaceae	Polyganum lapathifolium
			Ranunculaceae	Ranunculus aquatilis
			Cruciferae	Rorippa nastertium-aquaticum
			Umbelliferae	Berula sp.
			Scrophulariaceae	Veronica anagallis-aquatica

[1/] Determination not positive because of lack of flowering parts.

area during late summer, 1977, but only 10% during late winter (Table 4). Chara sp. covered the largest area throughout the year, followed by the algae (Spirogyra sp., Zygnema sp. and Cladophora sp.), Potamogeton pectinatus, and Veronica anagalis-aquatica (Fig. 9).

Chara sp. also had the largest biomass per square meter followed by Elodea canadensis, Veronica, Potamogeton and Rorippa nastertium-aquaticum (Fig. 10).

The growth of vegetation helps to keep the gravel clean during much of the summer and fall and plays an important role in the yearly cycle of siltation and silt removal. As the plants grow toward the water surface they force the water through narrow channels between the vegetation beds. This causes an increase in water velocity, sufficient to scour away silt which may be in these channels. Then the vegetation dies off in the fall, the water no longer is forced through narrow channels, and can flow slower again and silt is deposited. The silt biulds up during the winter and is sufficient to allow the plants to establish good root systems again the next spring.

Chara sp. is a freshwater alga, unique in its possession of cylindrical whorled branches. Each joint on the stem consists of a single cell. It almost always occurs in slow or still hard water, and thrives well in Silver Creek where the hardness is around 200 mg/l. It covered 9% of the stream area in late winter and 50% in late summer. The biomass of Chara ranged from 0.9 kg/m^2 in March to 3.2 kg/m^2 in August, and accounted for 89 to 97% of the total biomass of vegetation in the stream. Chara provides the principal habitat for much of the stream's invertebrate population.

Potamogeton pectinatus is a pondweed, commonly found in slow flowing hard water. It is usually recognized by its much branched stems and num-

TABLE 4. Percentage area covered and oven dry weight (kg/m^2) of aquatic macrophytes found in Silver Creek in The Nature Conservancy site, 1977-1978.

	Date sampled															
	June 26, 1977		July 18, 1977		August 8, 1977		August 30, 1977		October 4, 1977		October 24, 1977		December 12, 1977		March 17, 1978	
Macrophyte	Percentage	Weight	Percentage	Weight	Percentage	Weight	Percentage	Weight	Percentage	Weight	Percentage	Weight	Percentage	Weight	Percentage	Weight
Algae	1.1	0.21	1.4	0.09	3.5	0.08	14.6	0.30	36.0	0.04	42.0	0.01	7.6	0.01	-	-
Carex	-	-	-	-	0.1	-	0.3	-	0.3	-	0.3	-	0.2	-	-	-
Chara	36.3	1.42	35.9	2.56	36.0	3.22	42.7	2.89	48.9	2.10	49.8	2.07	32.8	1.77	9.3	0.22
Eleocharis	<0.1	-	0.2	-	0.1	-	<0.1	-	0.1	-	0.2	-	0.3	-	-	-
Elodea	<0.1	0.67	0.2	0.72	0.1	0.81	0.8	0.89	0.3	0.92	0.2	0.60	-	-	-	-
Equisetum	-	-	-	-	-	-	<0.1	-	-	-	-	-	-	-	-	-
Catabrosa	1.1	0.26	0.6	0.29	0.1	0.41	0.6	0.51	0.8	0.30	1.0	0.37	0.6	0.14	-	-
Hippuris	0.1	0.06	0.2	0.10	0.2	0.19	0.2	0.15	0.1	0.11	<0.1	0.08	-	-	-	-
Juncus	-	-	0.2	-	0.1	-	0.2	-	0.2	-	0.2	-	0.3	-	-	-
Duckweeds[1/]	-	-	<0.1	-	<0.1	-	<0.1	-	<0.1	-	<0.1	-	-	-	-	-
Myriophyllum	-	-	-	-	-	-	0.1	-	-	-	-	-	-	-	-	-
Polyganum	-	-	-	-	<0.1	-	0.1	-	-	-	-	-	-	-	-	-
Potamogeton	11.1	0.18	14.6	0.39	17.9	0.41	20.0	0.33	12.4	0.21	9.2	0.16	0.8	0.08	-	-
Ranunculus	0.6	-	0.9	-	0.8	-	1.0	-	0.1	-	<0.1	-	-	-	-	-
Rorippa	0.1	0.32	0.3	0.35	0.2	0.29	0.4	0.26	0.9	0.23	0.6	0.20	0.4	0.11	-	-
Scirpus	0.6	-	0.5	-	0.5	-	0.7	-	0.7	-	0.7	-	0.5	-	0.4	-
Bryales[2/]	0.1	0.44	0.1	0.44	0.3	0.44	0.4	0.44	0.2	0.44	0.2	0.44	0.3	0.44	0.3	0.44
Typha	-	-	<0.1	-	-	-	0.1	-	-	-	-	-	-	-	-	-
Berula	0.2	0.21	0.5	0.12	0.3	0.10	0.6	0.22	0.3	0.21	0.4	0.17	0.7	0.08	-	-
Veronica	7.2	0.10	9.4	0.24	9.8	0.31	8.2	0.37	6.2	0.36	6.7	0.17	5.6	0.24	0.5	-
All plants combined[3/,4/]	57.4	0.96	61.0	1.65	63.8	1.99	67.7	2.05	67.8	1.62	64.7	1.65	40.4	1.48	9.6	0.22

1/ includes the families Lemnaceae and Ricciaceae

2/ Amblestegium made up about 80% of the total area for all mosses. Its oven dry weight was 0.49 kg/m^2 on October 4. Fontinalis, which was 0.31 kg/m^2 and Drepanocaadus, which was 0.15 kg/m^2, were found in equal abundance. Since peak summer growths were not observed with the mosses, it was assumed that their biomass remained relatively constant throughout the year.

3/ The area covered by all plants is less than the total of each individual plant species because plants overlapped each other.

4/ The oven dry weight of all plants combined is derived from the formula $T = \frac{a(w)}{p}$; where a = percentage area covered by each plant, w = oven dry weight of each plant and p = percentage total area covered by all plants.

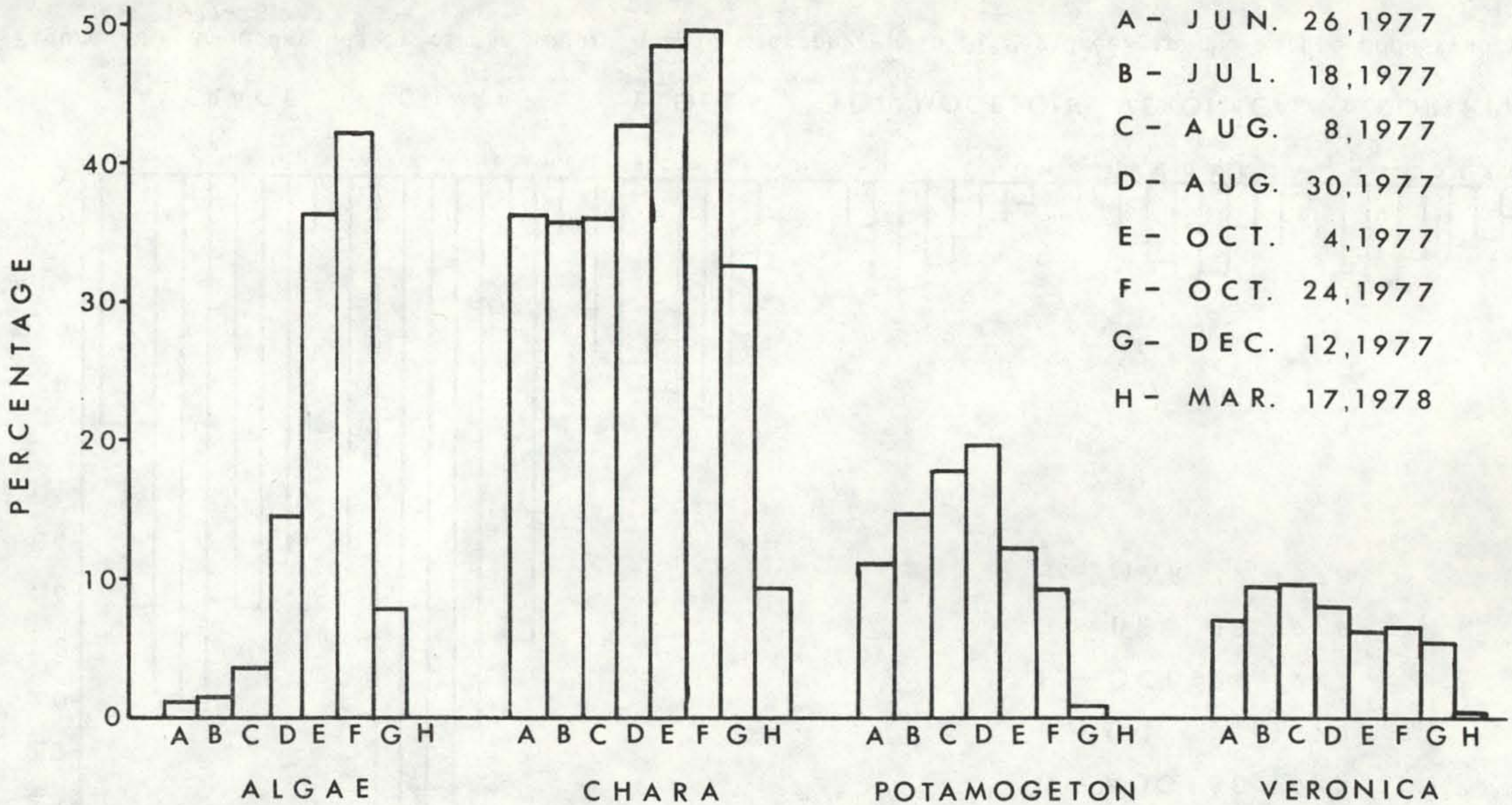

Figure 9. Percentage of Silver Creek surface area covered by the major aquatic macrophytes in The Nature Conservancy area, 1977-78.

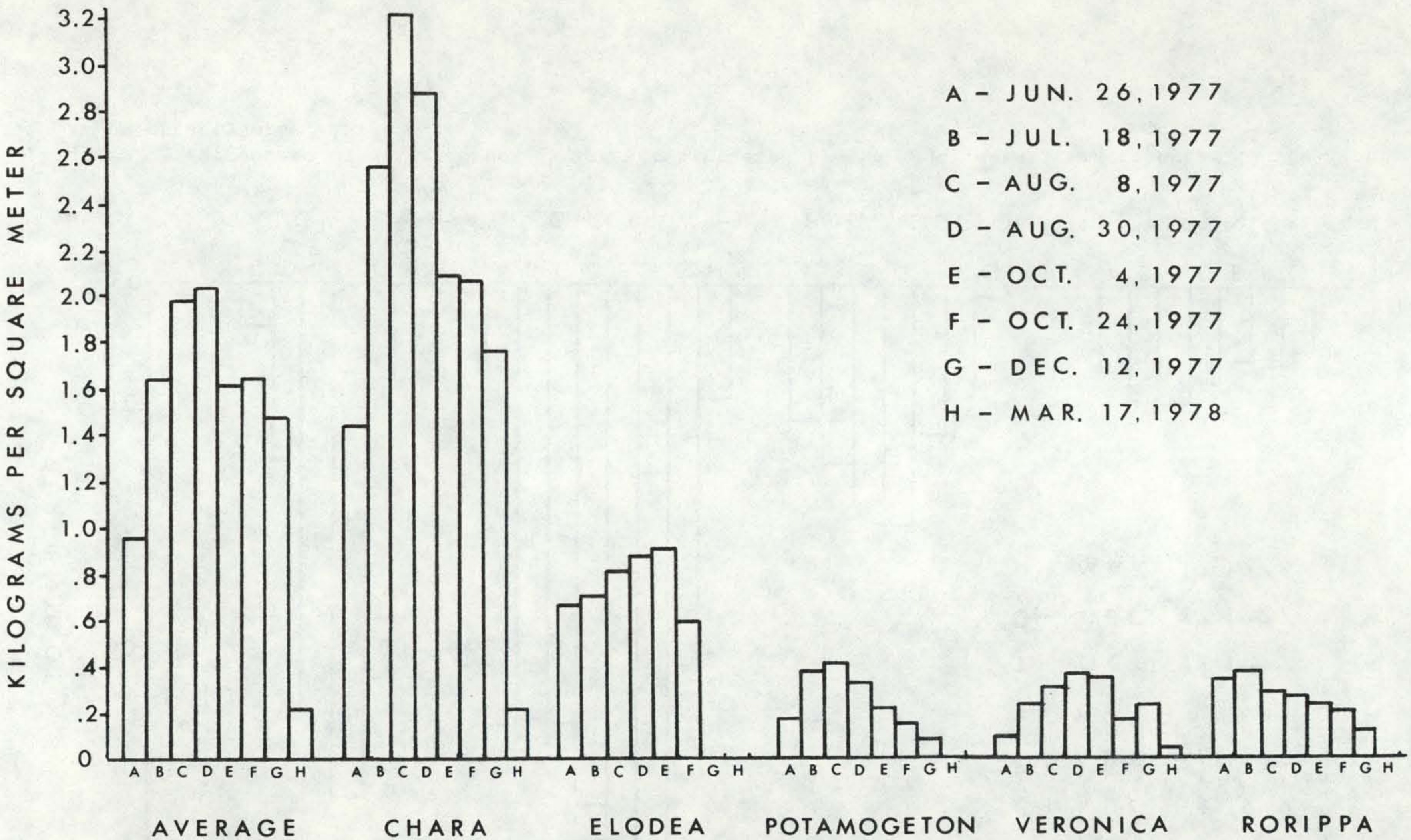

Figure 10. Oven dry weight of the major aquatic macrophytes in Silver Creek in the Nature Conservancy site, 1977-78.

erous threadlike leaves spreading in fan-like fashion. In Silver Creek it grows best in silted areas although it sometimes is found rooted in gravel. Flowers form during late July and August, when the amount of Potamogeton is at its peak (Fig. 9). This plant is a most important food for ducks and provides food and cover for the suckers, dace and trout (Fassett 1957).

Veronica anagalis-aquatica, often called water speedwell, is a biennial or short-lived perenneal common in streams and ditches in eastern North America and in parts of the west (Fassett 1957). Peak growth occurs in early August (Fig. 9). It grows mainly in gravel areas but is sometimes bound in silted areas too. Veronica flowers shortly after it grown above the water's surface. Veronica was seen flowering during every month from June to December, 1977. It provides good habitat for insects and excellent cover for small fish, especially rainbow trout.

Rorippa nastertium-aquaticum, or watercress is the only other aquatic plant of considerable abundance in Silver Creek. Watercress is found mainly in or near the headwater springs, provides cover for fish, and provides habitat for invertebrates used as food by trout.

The algae Spirogyra sp., Zygnema sp. and Cladophora sp. provide food for insects. Because of the relative stability of the water flows, algae thrive in the stream. Peak abundance was reached in October (Fig. 9).

All other plants in the stream were either not very abundant or were plants inhabiting shoreline areas and banks.

Primary Productivity

Algal communities in Silver Creek are composed mainly of epilithic diatoms (Class Bacillariophyceae) and green algae (Class Chlorophyceae). We identified 31 algal genera from the samples taken (Table 5). The most abundant genera were Navicula, Fragillaria, and Gomphonema. Also abundant were Cocconeis, Denticula, Diatomella, Eunotia, Mocrospora, Ourococcus and Scenedesmus.

Cell numbers during the first half of the summer increased rapidly for two or three weeks, then declined during the fourth week, due to sloughing of cells from the slides. During the latter part of the summer and fall this pattern continued with the slides which were near the edge of the stream. The slides in the middle of the stream, however, showed an increase in cell numbers over each four week period, although the increase was not as rapid as at first. Cell numbers in Silver Creek ranged from 56 to 8266 per mm^2 (Table 6). These results are similar to Halbach's (1974) results on the Lemhi River, where his counts ranged from 1.7 to 16,213 cells per mm^2.

During late summer, the filamentous green algae Zygnema, Spirogyra and Cladophora formed extensive mats, covering most of the vegetation in the stream. The microscope slides used did not adequately sample these algae because the long filaments would not attach to their surface. Halbach (1974) found the same thing during his study. Various authors (Tett and Kelley 1975, Hansman 1971) have argued that artificial substrates represent the differential colonization abilities of planktonic species and not true periphyton assemblages. Hayman (1979) found that Ulothrix colonized more abundantly on the slides than on natural substrates, and that Nostoc, Monostroma and certain members of the Zygnematales which

Table 5. -Algae found in Silver Creek in The Nature Conservancy site, 1977.

Division	Class	Family	Genus
Chrysophyta	Bacillariophyceae	Achnanthaceae	Cocconeis
		Coscinodiscaceae	Cyclotella
		Cymbellaceae	Cymbella
			Amphora
		Eunotiaceae	Ceratoneis
			Eunotia
		Fragilariaceae	Fragilaria
			Synedra
		Gomphonemataceae	Gomphoneis
			Gomphonema
		Naviculaceae	Navicula
			Stauroneis
		Nitzschiaceae	Denticula
		Tabellariaceae	Diatomella
	Xanthophyceae	Pleurochloridaceae	Botrydiopsis
Chlorophyta	Chlorophyceae	Cladophoraceae	Cladophora
		Coccomyxaceae	Ourococcus
		Desmidiaceae	Closterium
			Cosmarium
		Hydrodictyaceae	Pediastrum
		Microsporaceae	Microspora
		Oöcystaceae	Ankistrodesmus
		Scenedesmaceae	Scenedesmus
		Zyngemataceae	Mougeotia
			Spirogyra
			Zygnema
			Zygogonium
Cyanophyta	Myxophyceae	Oscillatoriaceae	Oscillatoria
			Spirulina
		Rivulariaceae	Calothrix
		Scytonemataceae	Scytonema

Table 6. -Cell numbers per mm^2 and chlorophyll a concentrations (mg/m^2) from microscope slides in Silver Creek in The Nature Conservancy site, 1977.

Date	Middle of stream		Edge of stream	
	Cell counts	Chlorophyll a	Cell counts	Chlorophyll a
6-26	268.9	0.39	218.4	0.49
7-04	1670.4	0.52	3622.2	0.90
7-09	8266.3	1.05	6747.8	0.36
7-16	3787.5	0.91	2870.8	0.50
7-25	172.3	0.08	306.0	0.48
8-02	2957.4	0.54	2488.1	1.10
8-08	2983.0	0.34	1995.4	1.28
8-15	1255.1	1.79	1908.0	1/
8-22	114.6	0.78	273.6	0.82
8-29	716.6	0.83	676.5	2.18
9-05	1508.5	1.48	1173.9	2.48
9-12	2177.8	2.59	1391.6	2.39
9-19	56.4	2.32	71.9	1.66
9-26	504.2	1.38	226.2	0.60
10-03	950.6	1.75	518.6	0.96
10-10	1789.2	1.46	257.2	1.06
10-17	243.3	1.59	193.3	1.39
10-24	850.0	2.72	377.7	1.32
10-31	1607.8	1.83	282.6	0.89
11-07	1832.7	3.53	142.8	0.99

1/ Microscope slides broke.

were present in the stream were not recorded on the slides.

Chlorophyll a concentrations from those algae which attached to the microscope slides average about 1.3 mg/m^2 during the study period (Table 6). Chlorophyll a concentrations on the Henry's Fork averaged about 3.4 mg/m^2, while other areas along the Snake River ranged from 1.6 mg/m^2 at Burbank (RM4) to 33.8 mg/m^2 at Rupert (RM666) (Falter et al 1976). Chlorophyll a concentrations on several tributaries of the Gallatin and Madison Rivers ranged from 1.9 to 17.0 mg/m^2 (Hayman 1979).

Aquatic Insects

Aquatic insects from 78 genera, plus representatives from 14 families not keyed to genus, and several aquatic non-insect invertebrates were found in Silver Creek in 1977 (Table 7).

Ephemeroptera (mayflies), Trichoptera (caddisflies), and Diptera (true flies) were the dominant orders of invertebrates found in benthos samples (Table 8). Trichopterans made up 29 to 50% of the total genera and Diptera 17 to 35% (Fig. 11). Trichopterans made up the largest percentage of the insects collected in gravel benthos samples (21 to 82%) while dipterans and ephemeropterans made up the largest percentages of insects found in benthos samples collected from areas covered with vegetation (29 to 93% and 2 to 59%, respectively) (Fig. 11).

Insects drifting downstream in Silver Creek had a definite diel periodicity in all sample periods (Fig. 12). Drift samples collected at midnight had the largest number of insects with sunrise samples usually having the fewest. The number of insects drifting downstream also varied seasonally with the largest numbers in late winter and late summer and the smallest in spring and fall. *Baetis* spp., *Ephemerella* spp.,

TABLE 7. Invertebrates found in Silver Creek, 1977.

Class	Order	Family	Genus - species
Insecta	Collembola	Isotomidae	
		Entomobryidae	
		Podouridae	
	Ephemeroptera	Baetidae	Baetis spp.
			Callibaetis sp.
			Centroptilum sp.
			Ephemerella grandis
			Ephemerella spp. (Invaria grp)
			Leptophlebia sp.
			Paraleptophlebia sp.
			Pseudocloeon sp.
			Siphlonurus sp.
			Tricorythodes minutus
		Heptageniidae	Cinygmula sp.
			Rithrogena sp.
			Stenonema sp.
	Odonata	Gomphidae	Ophiogomphus sp.
		Coenagrionidae	Enallagma sp.
			Ischnura sp.
	Orthoptera	Tetrigidae	
	Plecoptera	Nemouridae	Nemoura sp.
		Perlidae	Acroneuria californica
		Perlodidae	Isogenus sp.
			Isoperla sp.
	Hemiptera	Corixidae	Cenocorixa bifida
		Gerridae	Gerris sp.
			Trepobates sp.
		Notonectidae	Notonecta sp.
		Saldidae	Saldula comatula
	Trichoptera	Hydroptilidae	Agraylea sp.
			Hydroptila sp.
			Orthotrichia sp.
			Oxyethira sp.
		Rhyacophilidae	Rhyacophila acropedes
			Glossosoma sp.
			Protoptila sp.
		Philopotamidae	Chimarra sp.
		Psychomyiidae	Polycentropus sp.
		Hydropsychidae	Hydropsyche sp.
		Limnephilidae	Chyranda sp.
			Amphicosmoecus sp.
			Limnephilus sp.
		Leptoceridae	Triaenodes sp.
			Oecetis sp.
		Lepidostomatidae	Lepidostoma sp.
		Brachycentridae	Brachycentrus sp.
		Helicopsychidae	Helicopsyche borealis

TABLE 7. continued.

Class	Order	Family	Genus - species
Insecta	Hymenoptera	Brachonidae	
		Diapriidae	
		Mymaridae	
		Pteromalidae	
		Scelionidae	
	Coleoptera	Chrysomelidae	Donacia sp.
		Dytiscidae	Agabus sp.
			Hygrotus sp.
			Illybius sp.
			Oreodytes sp.
		Elmidae	Heterlimnius sp.
			Optioservus sp.
		Gyrinidae	Gyrinus sp.
		Heteroceridae	
		Helodidae	Cyphon sp.
		Hydrophilidae	Helophorus sp.
			Laccobius sp.
			Sphaeridium sp.
		Noteridae	Pronoterus sp.
		Haliplidae	Brychius sp.
			Haliplus sp.
	Diptera	Tipulidae	Elliptera sp.
			Polymeda sp.
			Prionocera sp.
			Tipula sp.
		Anthomyiidae	Fannia sp.
		Chironomidae	
		Culicidae	
		Dolichopodidae	Dolichopus sp.
		Empididae	Chelifera sp.
			Clinocera sp.
			Hemerodromia sp.
		Ephydridae	1/
			Notiphila sp.
		Heleidae	1/
			Bezzia sp.
			Palpomyia sp.
			Parabezzia sp.
		Psychodidae	Psychoda sp.
		Rhagionidae	Atherix sp.
		Sciomyzidae	Tetanocera sp.
		Simuliidae	Simulium sp.
		Stratiomyidae	Euparypus sp.
			Stratiomys sp.
		Syrphidae	Myiolepta sp.

TABLE 7. continued.

Class	Order	Family	Genus - species
Crustacea	Amphipoda	Talitridae	Hyalella azteca
		Gammaridae	Gammarus lacustrus
	Cyclopoida		
	Cladocera	Chydoridae	
Arachnoidea	Hydracarina		
Gastropoda			
Oligochaeta			
Hirudinea			

1/ some organisms not identified to genus.

TABLE 8. Abundance of invertebrates per 0.093 m^2 sample found in Silver Creek in gravel (G) and vegetation (V) benthos samples within The Nature Conservancy site, 1977.

	April 18		June 3		June 18		July 9		July 29		August 18		September 8		September 28		October 17		November 7	
	G	V	G	V	G	V	G	V	G	V	G	V	G	V	G	V	G	V	G	V
Ephemeroptera	87	1090	137	1104	95	1557	82	2336	41	638	57	482	23	770	47	445	10	95	26	555
Baetis	43	90	37	95	14	407	12	178	14	171	35	98	23	365	47	205	10	70	11	195
Cinygmula			1		18		2													
Ephemerella	42	1000	92	973	60	1119	68	1982	26	322	20	289		265		115		25	12	310
Paraleptophlebia				13		2						44		95		70				
Tricorythodes	2		7	23	3	28		176	1	145	2	51		45		55			3	50
Odonata		10						10		5		1		10		5		40		75
Enallagma/Ischnura		10						10		5				10		5		40		71
Ophiogomphus												1								4
Plecoptera	14		9	13	6	23	7	23	6	14	6	10	12	10	13	25	7	5	11	42
Acroneuria	1			1	3		2		2	2	4		9	5	12	5	7		11	27
Isogenus/Isoperla	13		9	10	3	22	5	23	2	10	1	10		5		10		5		15
Nemoura				2		1			2	2	1		3		1	10				
Trichoptera	613	195	363	58	706	140	289	234	113	138	77	34	37	345	164	395	529	160	497	693
Brachycentrus	151	25	18	13	10	70	23	53	14	38	10	12	6	20	5	40	2	10	9	46
Glossosoma	11				1														1	
Helicopsyche	3	50	72	15	63	49	3	22	13	10	12	4	1	195	22	230	379	40	63	225
Hydroptila	4	5	4	1		4		118		60		2		5	2	30	3	20	9	70
Hydropsyche	120	30	11		33	10	18	24	11	18	14	1	13	75	52	40	57	10	57	111
Lepidostoma			1																	
Oecetis		50		22		3		6		3		7		35		5		65		151
Oxyethira															2	35	4	15		
Polycentropus							1													
Protoptila	315	30	252	5	589	1	220	10	69	6	30		12		78	15	81		336	5
Rhyacophila	9		5	2	10	3	24	1	6	3	11	8	5	15	3		3		22	75
Triaenodes		5																		10
Coleoptera	73	5	33	159	26	126	135	51	119	72	98	222	77	155	105	435	193	35	170	716
Agabus						1														
Optioservus/Heterlimnius	73	5	33	159	26	125	135	51	119	72	98	222	77	155	105	435	193	35	170	716
Diptera	492	3145	104	550	28	1150	61	3316	62	2606	26	661	31	4240	39	2325	103	4240	706	4297
Chironomidae	301	3030	89	480	19	1116	46	3290	50	2568	21	559	20	3955	23	2150	20	4170	665	4006
Chelifera	17	20	8	16	5		3	3	2	3		4	2	40	4	25	2	10	3	
Clinocera		25		20	1					2		8				15		5		
Lymyridae						1													1	
Euparypus	2		2	7	1	2	1	6		5		2		20		5	79	30	9	75
Fannia						1														
Hemerodromia	5	5	3	1	2	22	11		10	1	4	2	2	75	1	45	2	10	26	161
Simulium	167	45		23		8		12		27	1	77	7	150	11	85		15	2	55
Non-insects	9	475	44	648	15	141	16	254	15	251	18	291	24	335	38	685	160	900	131	1342
Amphipods		5	3	44	2	45		44		41		22		50	1	150	2	220	3	101
Hirudinea	1	30	3	20		5		13		10		15		5		5		5	6	21
Gastropods		50	16	67	10	7	1	4	3	21	6	44	17	135	22	230	143	675	76	253
Oligochaets	7	390	21	517	1	77	13	192	10	175	12	207	7	105	15	280	13		39	826
Hydracarina	1		1		2	7	2	1	2	4		3		40		20	2		7	141
Total	1283	4925	690	2533	876	3111	590	6224	356	3724	282	1697	204	5865	406	4420	1002	5475	1541	7720

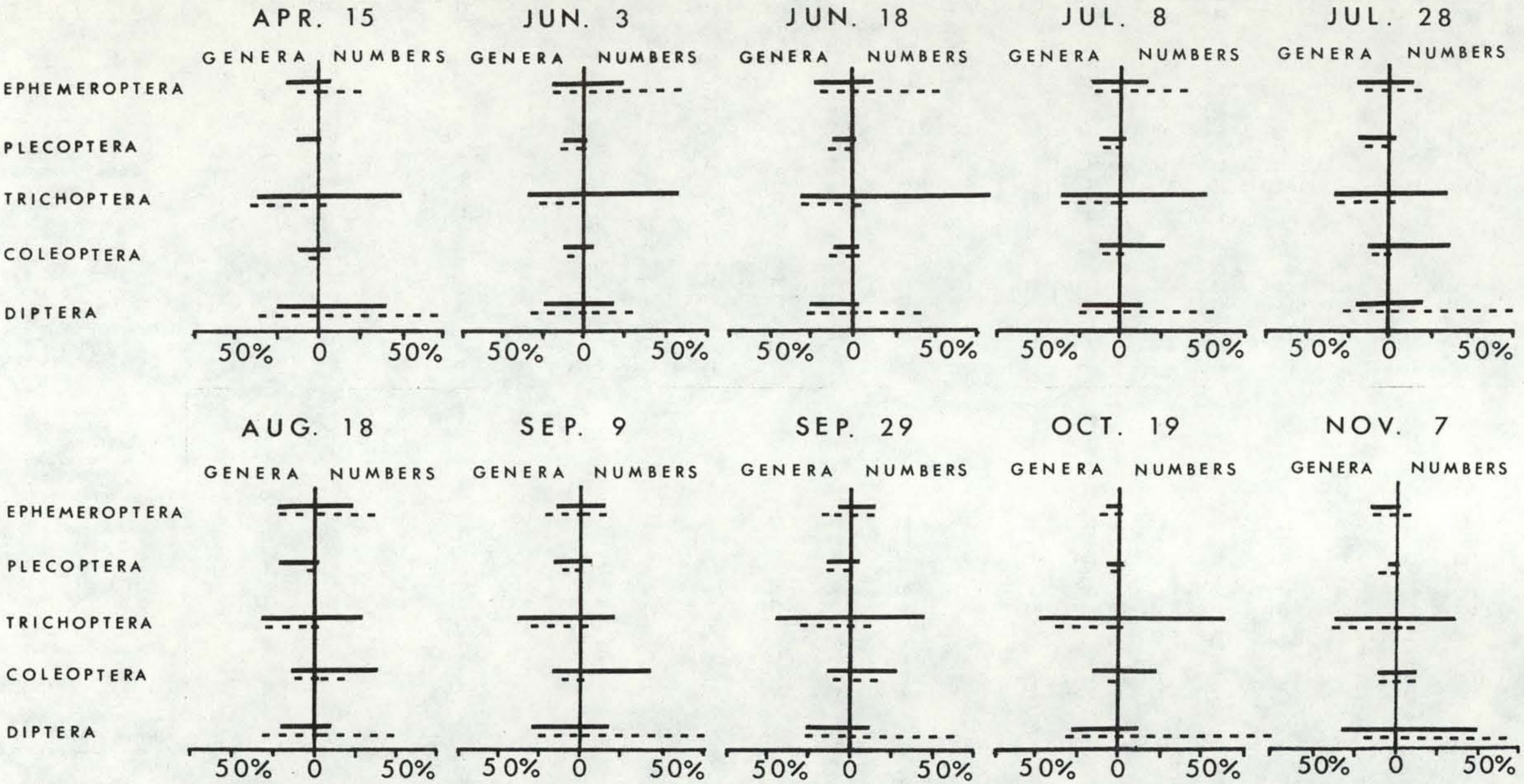

Figure 11. Percentage of total genera and numbers of insects in benthos samples collected during 1977 in The Nature Conservancy site in Silver Creek that came from the five orders listed. Chironomidae considered as one genus.

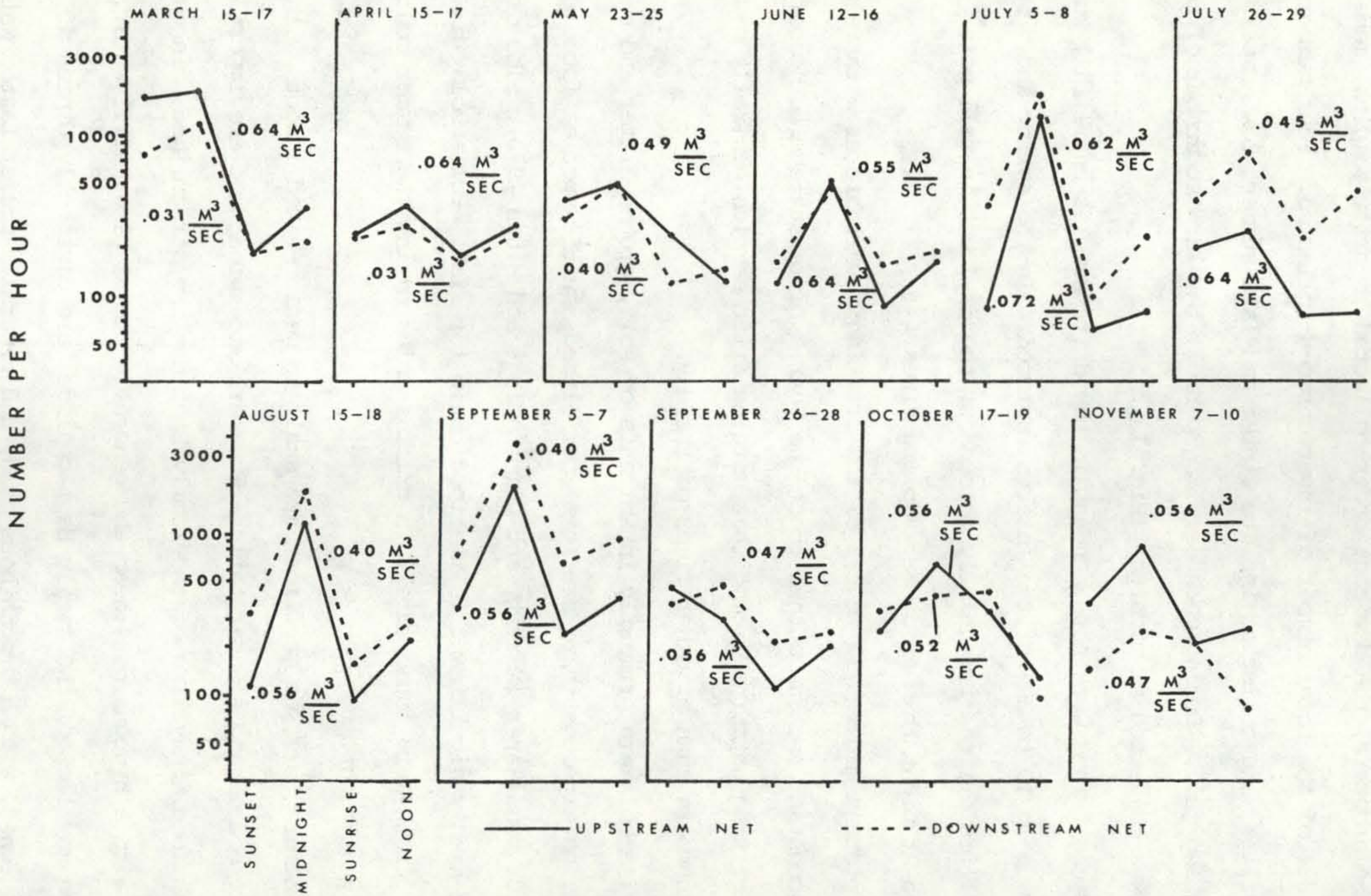

Figure 12. Diel abundance of all drifting invertebrates at the collection sites in Silver Creek in The Nature Conservancy site, 1977. The upstream site was located immediately below large beds of aquatic macrophytes and the downstream site was at the lower end of a gravel riffle. Numbers on figures indicate volume of water flowing through the drift nets.

and Chironomida were the most abundant insects in the drift samples throughout the year.

Ephemeroptera, the dominant order collected in drift samples, made up 24 to 83% of the total number of invertebrates collected. Peak numbers of mayflies were collected in late winter and late summer, low numbers in spring and fall. During each sampling period, the largest number of mayflies was collected at midnight (Fig. 13).

Trichopterans were not abundant in the drift samples until fall when they made up 10 to 20% of the insects captured. In the spring and summer, caddisflies drifted irregularly throughout the day, but in fall more drifted at night than at other sampling times.

Dipterans made up 11 to 38% of the drifting invertebrates with relatively constant abundance throughout the year. Dipterans showed no definite diel drifting patterns except that morning drift samples generally had fewer numbers than at other times of the day.

Collembola are primarily inhabitants of soil, ground litter and moist vegetation although there are some specialized aquatic species found in slack or pond water (Merritt and Cummins 1978 and Hicks 1970). The order is not highly significant in the food chain for fish. Collembola in Silver Creek were found rarely in drift samples during the summer months, usually at night.

Ephemeropters, or mayflies, are small to medium-sized insects with fragile bodies and slender tails. They are widespread and are important as fish food. Mayflies of the family Baetidae are streamlined, minnow-like, with a hypognathous head and generally prefer slow, still water, whereas mayflies of the family Heptageniidae are distinctly depressed or flattened, with a prognathous head, and generally prefer faster water

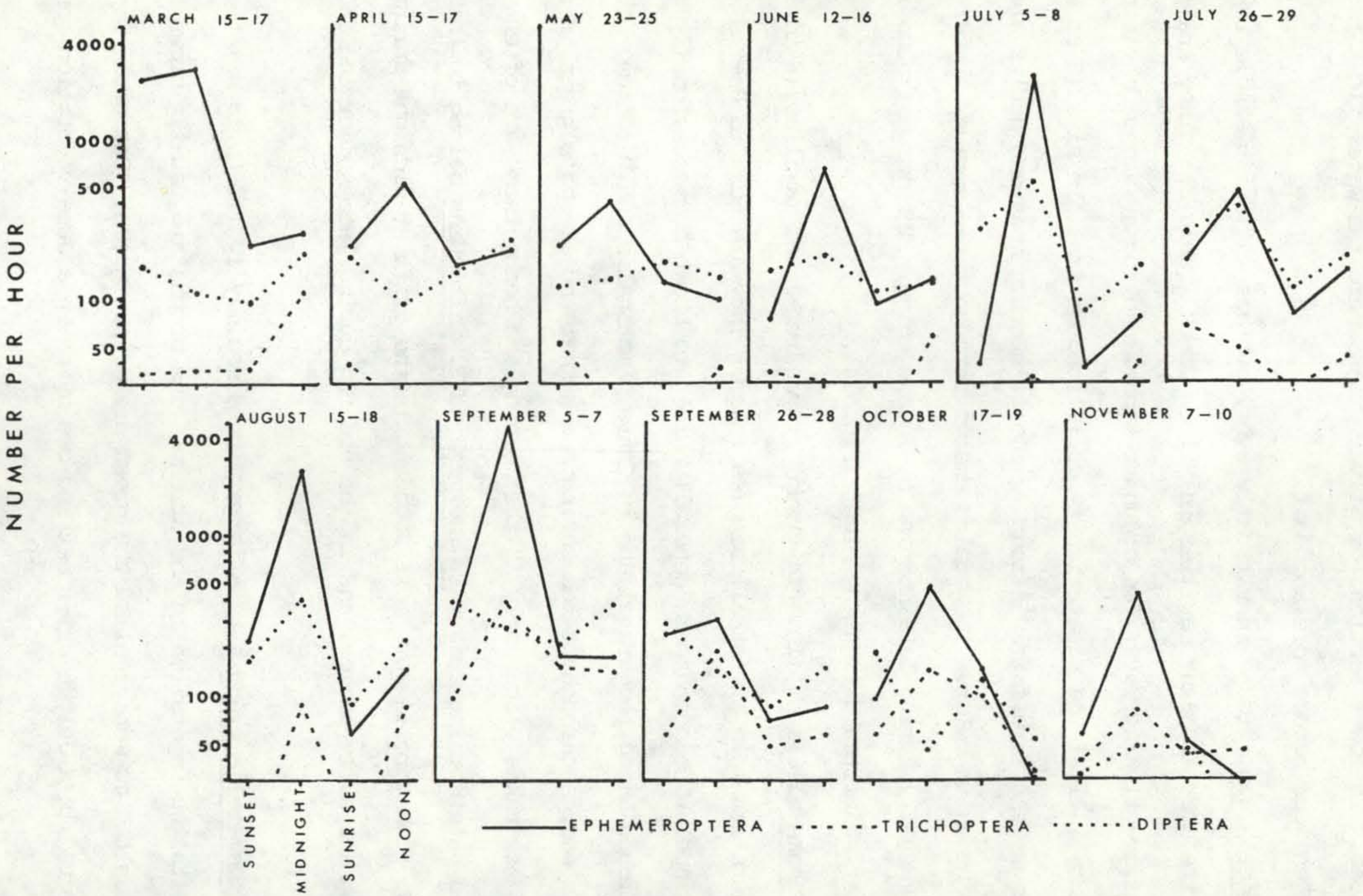

Figure 13. Diel abundance of the three major orders of insects drifting in Silver Creek in The Nature Conservancy site (both stations combined), 1977.

(Hicks 1970). With the exception of Cinygmula sp., and Rithrogena sp., the mayflies in The Nature Conservancy area are exclusively of the family Baetidae. In lower sections of Silver Creek where the water flows faster, Heptageniidae become more abundant.

Baetis spp., found in virtually every benthos and drift sample taken, were the most abundant mayflies in Silver Creek (Table 8). They are found in shallow flowing water, on or under stones and rocks, among debris and on almost all of the vegetation types. Although small in size (3 to 8 mm long), they are fairly strong swimmers. Both numphs and adults are olive green in color. The adults emerge througout the spring, summer and fall, usually during late morning or late evening. The largest numbers of Baetis drifted during the night (Fig. 14).

Ephemerella spp. (Invaria group) are medium-sized mayflies (8 to 14 mm) and were found in almost all samples taken. They are next to Baetis in abundance. The numphs are generally green to brown but occasionally black, were found among the gravel and in Chara, Fontinalis and Veronica. The adults emerge throughout the spring and summer and are pale green in color. Emergence takes place early in the morning and hence these are often called pale morning duns. E. inermis and E. infrequens belong to this group. Ephemerella were most abundant in the drift at midnight during spring and early summer, and in the evening during late summer and fall (Fig. 15).

Ephemerella grandis is a larger, uncommon mayfly (12 to 15 mm) that inhabits the vegetation in the stream. The numphs are usually brown and the adults, commonly called the green drake, are green. One adult was collected in a July 6 drift net and one nymph in a June vegetation sample.

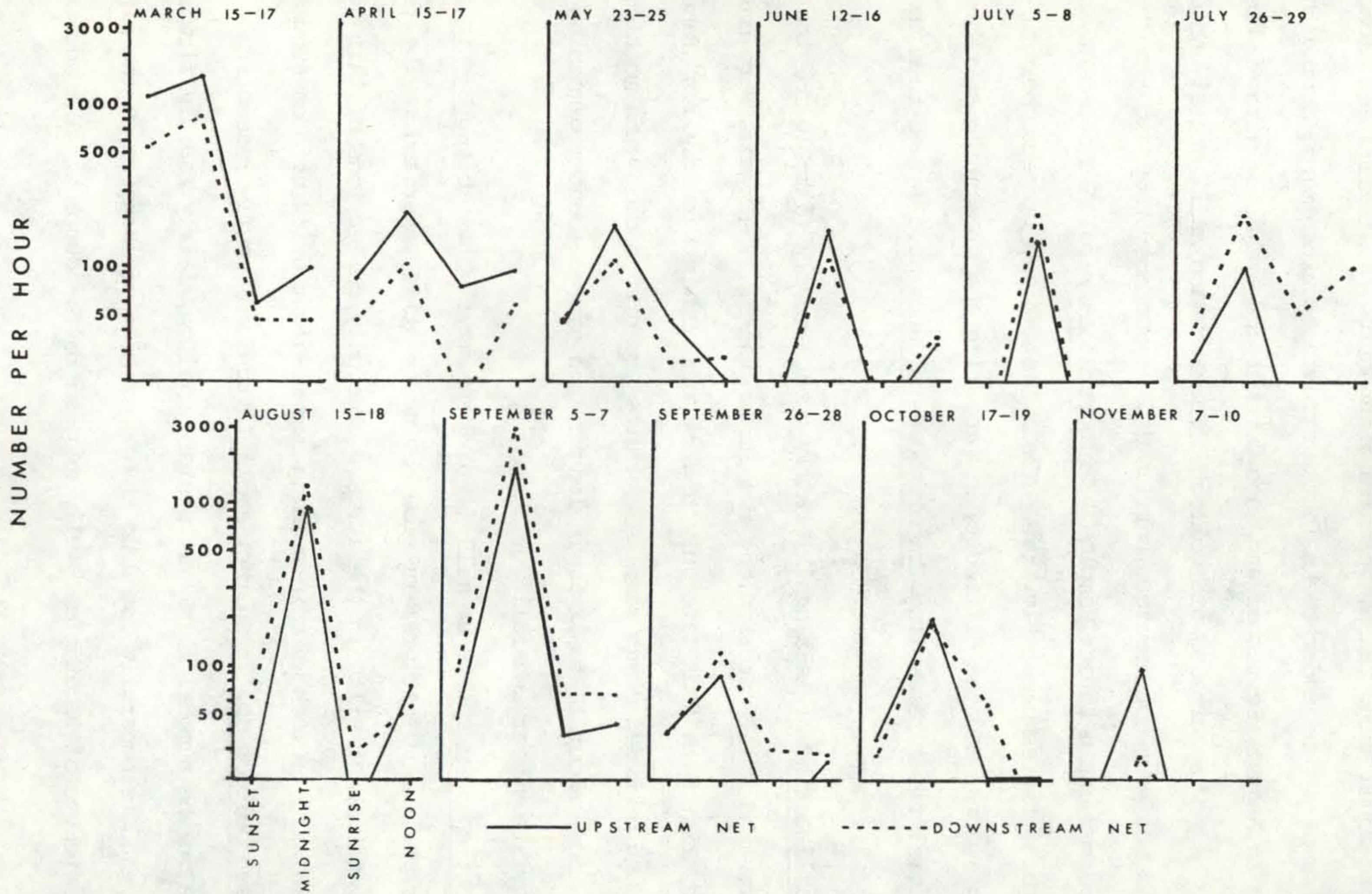

Figure 14. Diel abundance of Baetis spp. drifting in Silver Creek in The Nature Conservancy site, 1977.

Tricorythodes minutus is a small (3 to 6 mm) mayfly next in abundance to Ephemerella in The Nature Conservancy area. The nymphs are green and were found among Chara, Veronica, Ranunculus, Fontinalis and Elodea plant samples, and under rocks in the stream. Adults emerge during the moring in August, September and into October and are black with whitish wings. A few specimens were collected in March and April gravel and drift samples but were not numerous until July. By October they had almost disappeared again in our samples. Tricorythodes were most abundant in midnight drift samples (Fig. 16). Their small size, large numbers in mating swarms, and the difficulty of preparing and presenting suitable artificial flies resembling Tricorythodes minutus have earned them the name of "fisherman's curse."

Callibaetis sp. is a small, fairly common mayfly (6 to 10 mm) that inhabits the still waters along the stream banks. The nymphs were collected in drift nets from late July to November and in Myriophyllum, Ranunculus and duckweed plant samples. Adults are gray-bodied with mottled gray wings, about 10 to 12 mm in length, and emerge about mid-morning during late summer and fall.

Centroptilum sp. is a small (4 to 8 mm) mayfly resembling Baetis in the nymphal form. It prefers slow moving or still water and may be found on vegetation or silt in the stream. The only collections of this genus made in Silver Creek were in evening and midnight drift nets on August 18.

Pseudocloeon sp. is another small (3 to 6 mm) mayfly resembling Baetis in the nymphal form. It prefers shallow, fairly rapidly flowing water, and is generally found on the upper side of rocks or on the tips of the leaves of vegetation, fully exposed to the current. The adults,

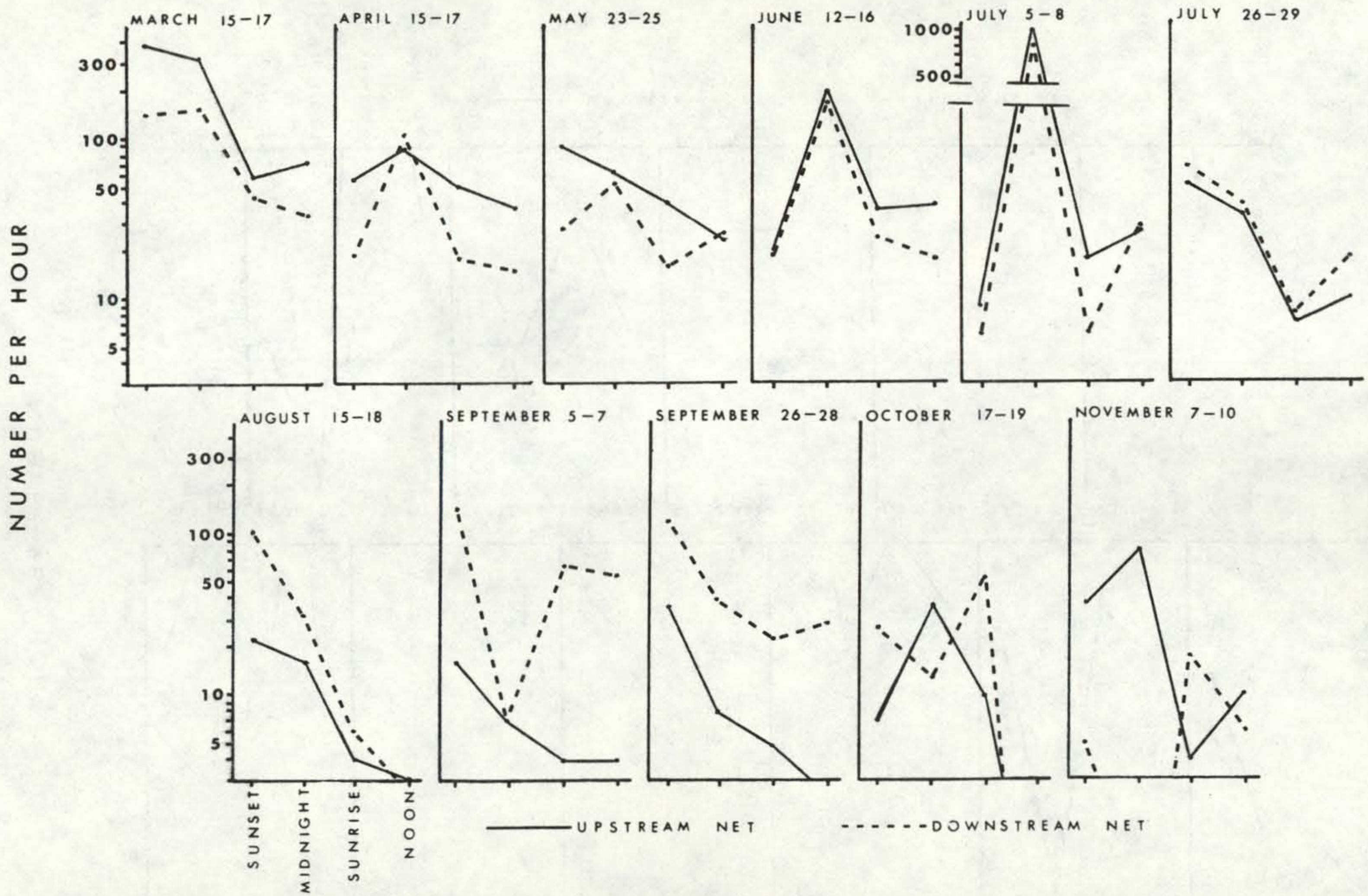

Figure 15. Diel abundance of Ephemerella spp. (Invaria group) drifting in Silver Creek in The Nature Conservancy site, 1977.

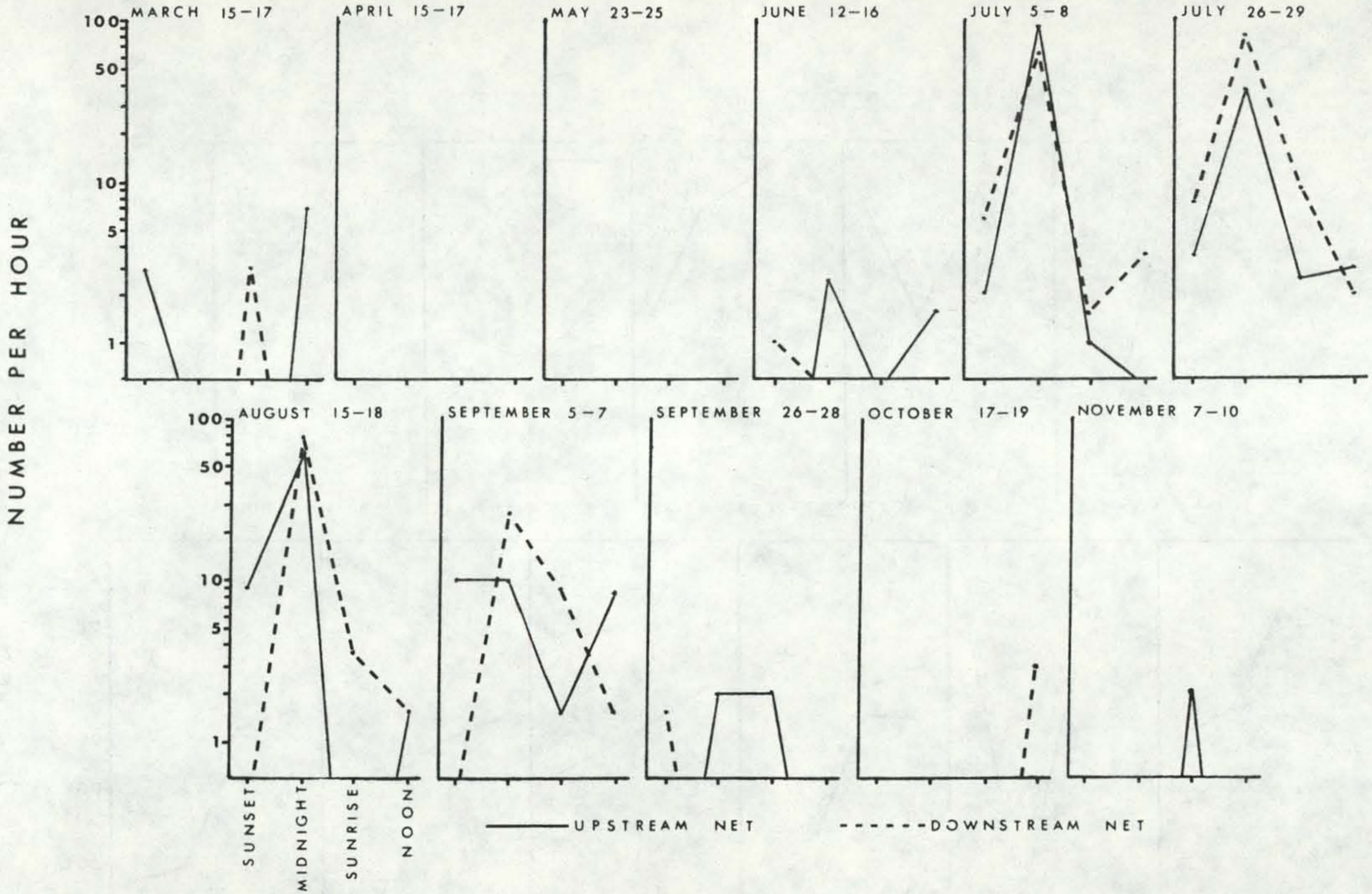

Figure 16. Diel abundance of Tricorythodes minutus drifting in Silver Creek in The Nature Conservancy site, 1977.

which lack hind wings, emerge during late afternoon during August and September. Only a few specimens of this genus were collected in Silver Creek; in August, September and November.

Siphlonurus sp. is a large mayfly (9 to 25 mm) that inhabits the still water along the edge of the stream. Nymphs were found occasionally in midnight drift nets from June to August. They were seen swimming in back-water areas along the stream during the summer. The nymphs spend most of their time on silty bottoms although they are able swimmers. To emerge, the nymphs crawl out of the water onto the banks, usually during the morning or early afternoon, from April to July.

Leptophlebia sp. is a small (7 to 12 mm) mayfly, poorly adapted for swift water, and thus it is found in the quiet portions of the stream. It seeks the dark underside of any material available during the day and moves to the upper surfaces at night. Emergence takes place usually in the afternoon during late winter and early spring. One nymph was coll-ected in a May 23 midnight drift net, and adults were seen emerging on March 17, 1978.

Paraleptophlebia sp. is a small (6 to 10 mm) mayfly that prefers slow to moderately swift water. Nymphs were found in coarse gravel and with the plants, Chara, and Fontinalis. Collections of this genus were made from June to October in drift and vegetation benthos samples. The nymphs crawl out of the water to emerge as adults, with emergence occur-ring during the summer and early fall months. The adult males have a brownish head, thorax and tip of abdomen, with the middle abdominal seg-ments being white. The females are reddish-brown. Mating swarms occur in midafternoon on sunny days.

Cinygmula sp. is a small (7 to 11 mm) mayfly that lives in the crevices and under rocks on the stream bottom. The nymphs can move fairly rapidly across stones but are poor swimmers. The adults emerge in the spring and mating flights occur in the ebenings or earlier on cloudy days. Nymphs of this genus were collected in May, June and July in drift and gravel benthos samples.

Stenonema sp. and Rithrogena sp. are small, flat mayflies (6 to 10 mm) that were rarely collected in The Nature Conservancy area but are abundant further downstream in Silver Creek where the water flows swifter. They cling to the under surface of rocks and sticks. Like Cinygmula, they are poor swimmers but can crawl in almost any direction with ease. The adults may emerge throughout the spring, summer or fall.

The damselflies and dragonflies (order Odonata) are uncommon in Silver Creek in slow moving or still water. They are territorial in nature and highly predaceous on other insects and small fish when they can catch them. Dragonfly nymphs from the genus Ophiogomphus were collected in August 18 and November 7 vegetation samples. Several damselfly nymphs from the genera Enallagma and Ischnura were collected during the year, mostly from September to November. Damselfly nymphs were found in Chara, Hippuris, Ranunculus, Myriophyllum and Fontinalis plant samples.

The grasshoppers and crickets (order Orthoptera) are generally not aquatic although some forms inhabit stream banks and lake shores. The Tetrigidae, or pygmy locust, is one of these. One specimen of this family was found in a rainbow trout stomach on September 28. Another one was found in a September 26 noon drift net.

Plecoptera or stoneflies are found frequently in Silver Creek. The nymphs are found in the gravel and under sticks, while the adults are usually found in vegetation near the stream. Both forms are important food for fish. The four genera found, in decreasing order of abundance were Isogenus sp., Acroneuria californica, Isoperla sp. and Nemoura sp. Isogenus sp. and Isoperla sp. are both small (10 to 15 mm) very similar stoneflies, common in Silver Creek. The nymphs are yellowish to green in color, as are the adults. The adults emerge during June and July. Nymphs were collected from April to August in drift and gravel benthos samples, while adults were found in fish stomachs collected during July through September. Drift samples collected at midnight had the highest numbers of these stoneflies (Fig. 17). Acroneuria californica is a large stonefly (up to 45 mm) found wherever large rocks, submerged branches or other suitable substrate occurs. Because of the lack of large rock in The Nature Conservancy site, these are rare in that area, but are abundant in lower sections of the creek. Nymphs were found throughout the study period but no adults were collected. Nemoura sp. is uncommon in Silver Creek, being collected only from late July to September. It is the smallest of the stoneflies in Silver Creek, reaching about 12 mm during late instar stages.

Hemiptera are true bugs, and these are also uncommos in Silver Creek. Only five genera of Hemiptera were found in Silver Creek; Cenocorixa bifida, Gerris sp., Trepobates sp., Notonecta sp. and Saldula comatula. Cenocorixa is a fairly common water boatman that inhabits the calm water along the edges of the stream. These were generally found in the drift during July and August, but none in benthos samples. They were also common in fish stomachs during July, September and October. Gerris sp. and Trepobates sp. are water striders that were infrequent along the edges of Silver Creek. Gerris are usually found on top of the water, whereas

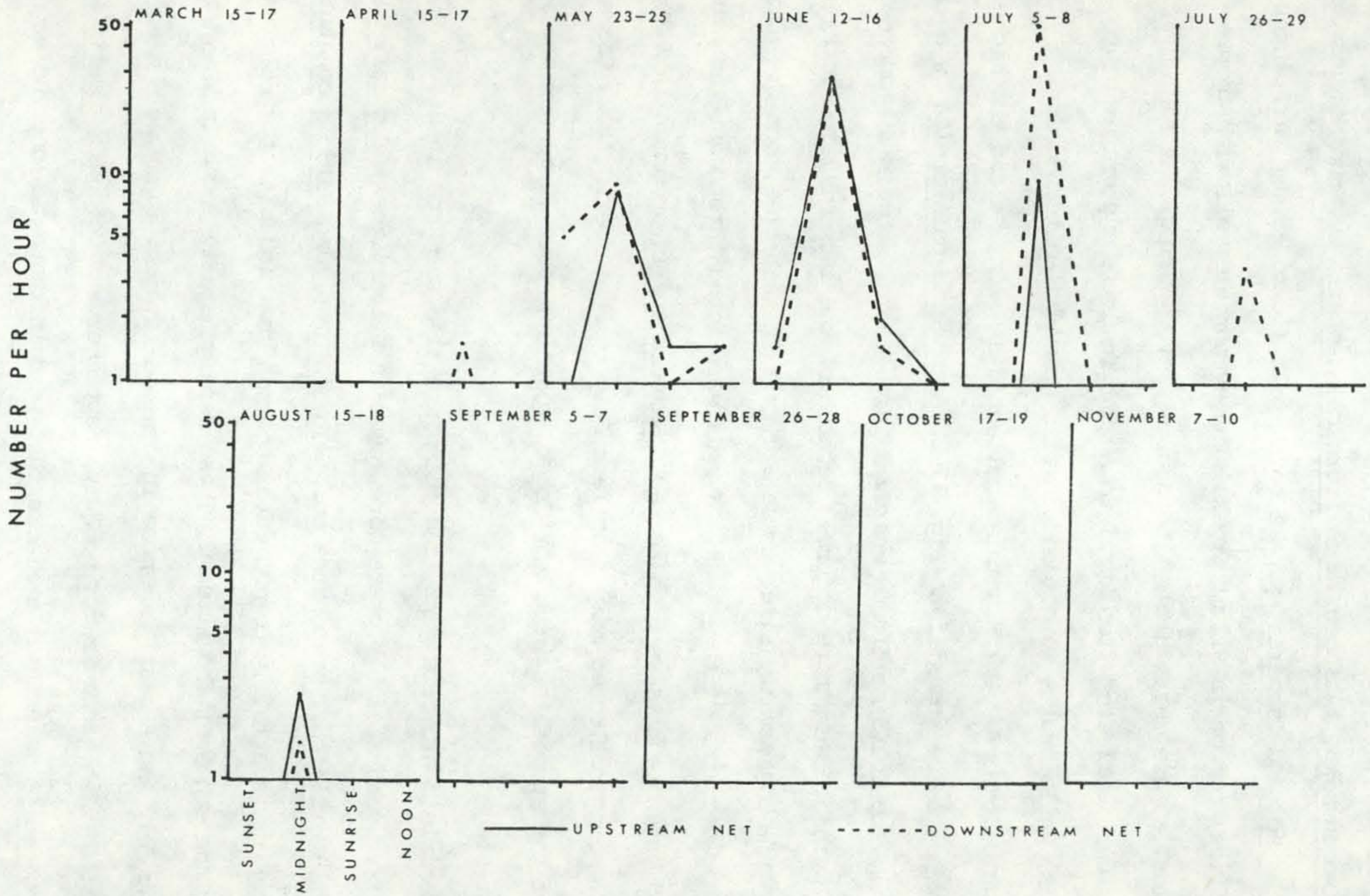

Figure 17. Diel abundance of Isogenus sp. and Isoperla sp. drifting in Silver Creek in The Nature Conservancy site, 1977.

Trepobates are usually found on top of algal mats. One Gerris adult was found in a rainbow trout stomach on October 18. The only collection of the backswimmer, Notonecta, was made on November 10 in a morning drift net. Saldula comatula is a shore bug which, as the name implies, inhabits the banks of the stream. The only specimen collected was in an April 15 noon drift sample.

Trichoptera, or caddisflies are, next to mayflies, the most abundant insects in Silver Creek. Eighteen different genera were found during the study period. The nymphs are found in virtually all types of vegetation and gravel in the stream and are very important food items for fish.

Brachycentrus sp. is a medium-sized (up to 12 mm) caddisfly that prefers running water. It was found among the gravel, and in Rorippa, Fontinalis, Veronica and Potamogeton plant samples. Its case is generally four-sided and tapered but sometimes is circular and tapered. They were collected throughout the year in most of the samples, with adults appearing during July and August. They were the most numerous in the drift in early spring (Fig. 18).

Glossosoma sp. and Protoptila sp. are small caddisflies that build saddle-like (or tortoise-shell-like) cases of small bits of rock. Glossosoma, which grow to about 10 mm, were infrequently collected from April to July. Protoptila, which only grow to about 3.5 mm, were collected on all sampling dates in gravel benthos samples and were commonly found in the drift from May to July.

Helicopsyche borealis is a small caddisfly (6 to 8 mm) that builds a snail-like case of sand grains. It is abundant in Silver Creek and was collected on all sampling dates in all benthos samples and most drift samples (Fig. 19). It was also found in Fontinalis, Potamogeton, Chara and Berula plant samples. Adults emerge from spring to early August.

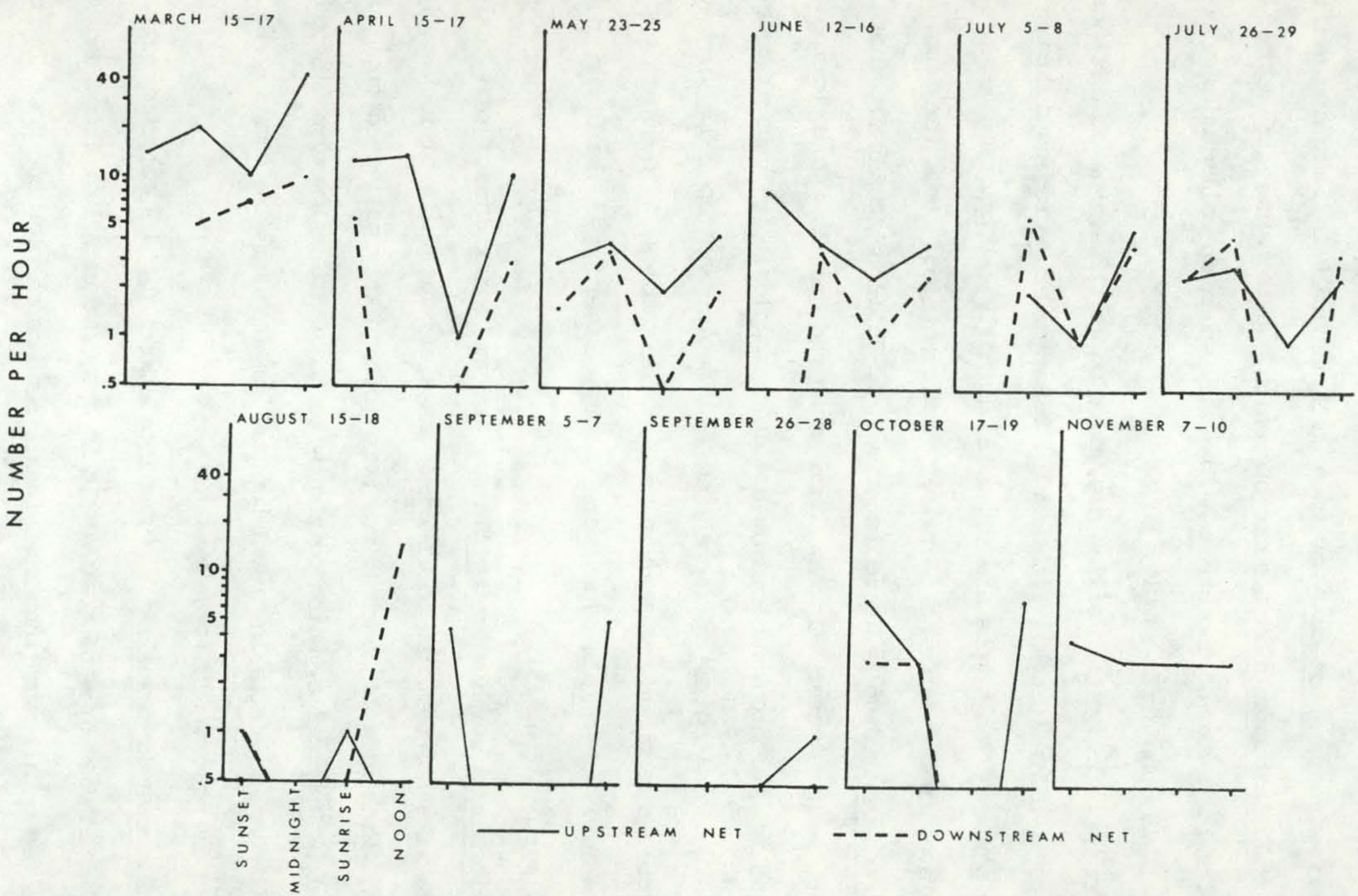

Figure 18. Diel abundance of Brachycentrus sp. drifting in Silver Creek in The Nature Conservancy site, 1977.

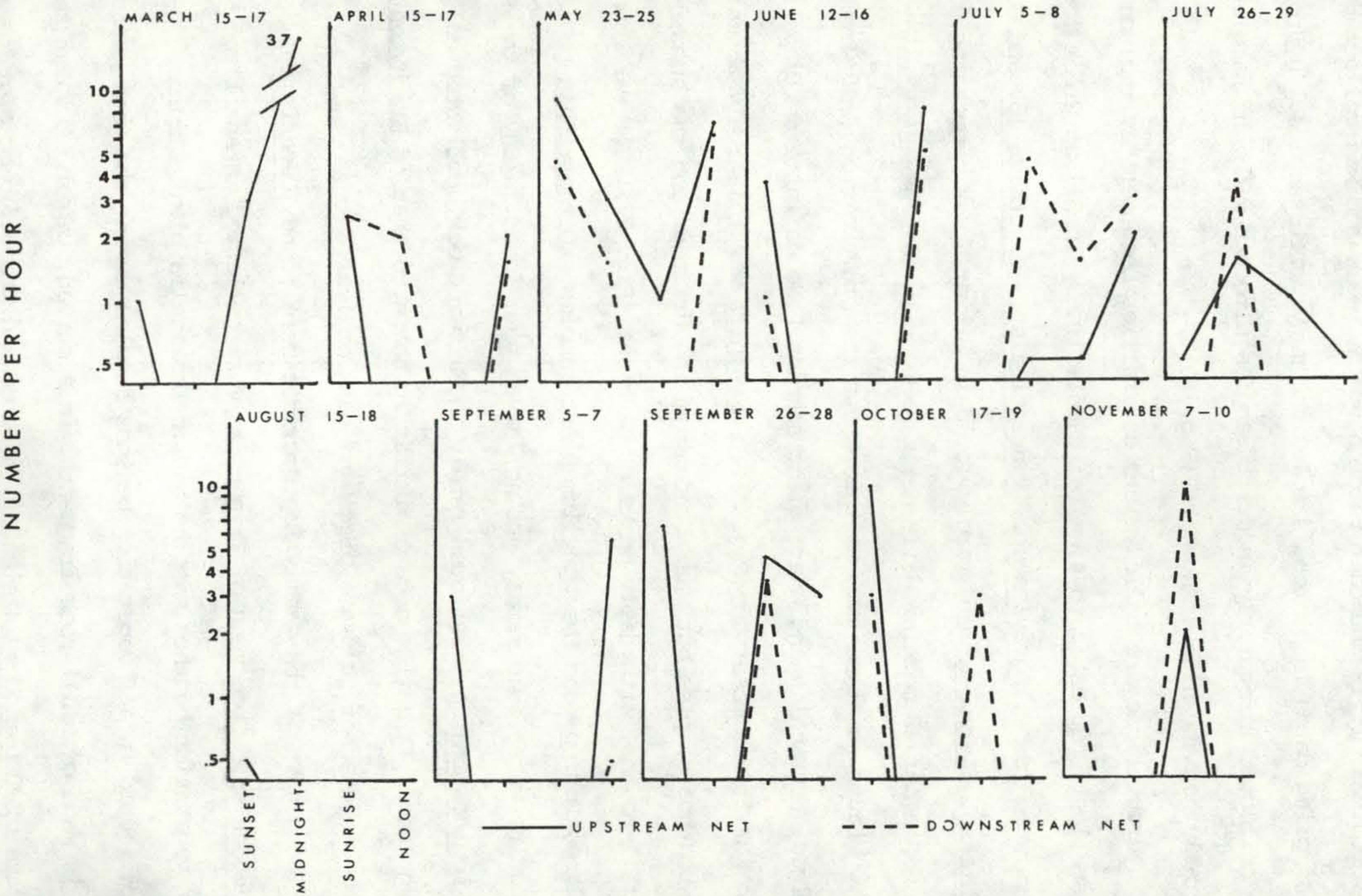

Figure 19. Diel abundance of Helicopsyche borealis drifting in Silver Creek in The Nature Conservancy site, 1977.

Hydropsyche sp. is a fairly large (up to 17 mm) net-spinning caddisfly that dwells among the gravel, and in Fontinalis, Berula, Rorippa and Veronica. It is abundant throughout the year, and was collected on all sampling dates in benthos samples and many drift samples. Hydropsyche were collected irregularly in drift samples although midnight samples generally had the highest numbers (Fig. 20).

Hydroptilidae are called micro caddisflies because they include the smallest species (2 to 4 mm) of caddisflies. In Silver Creek four genera were found; Agraylea sp., Hydroptila sp., Oxyethira sp. and Orthotrichia sp. Agraylea were rarely found in Silver Creek, appearing only in a September 28 morning drift net. Hydroptila were abundant in drift and vegetation benthos samples throughout the study period, and were found in algae, Fontinalis and Chara plant samples. No definite daily pattern in the drift was observed (Fig. 21). Oxyethira was relatively absent from benthos samples but was abundant in the drift during the summer and fall months, with daily peaks at midnight (Fig. 22). It was found in algae, Rorippa and Myriophyllum plant samples. Orthotrichia pupae and adults were found rarely but no larvae were found in any of the samples.

Lepidostoma sp. was found rarely in Silver Creek, collected only during June. It builds a case similar in shape to that of Brachycentrus but constructed of quadrate pieces of bark or leaf.

Two genera of the family Leptoceridae were found, Oecetis sp., and Triaenodes sp. Specimens of Triaenodes were collected in April and November vegetation benthos samples and in Fontinalis plant samples. Oecetis was collected in all vegetation benthos samples during the year. Its case is made of small rock fragments, in a curved, tapered tubular shape. The case of Triaenodes is slender, tapered and made of pieces of green plants arranged spirally.

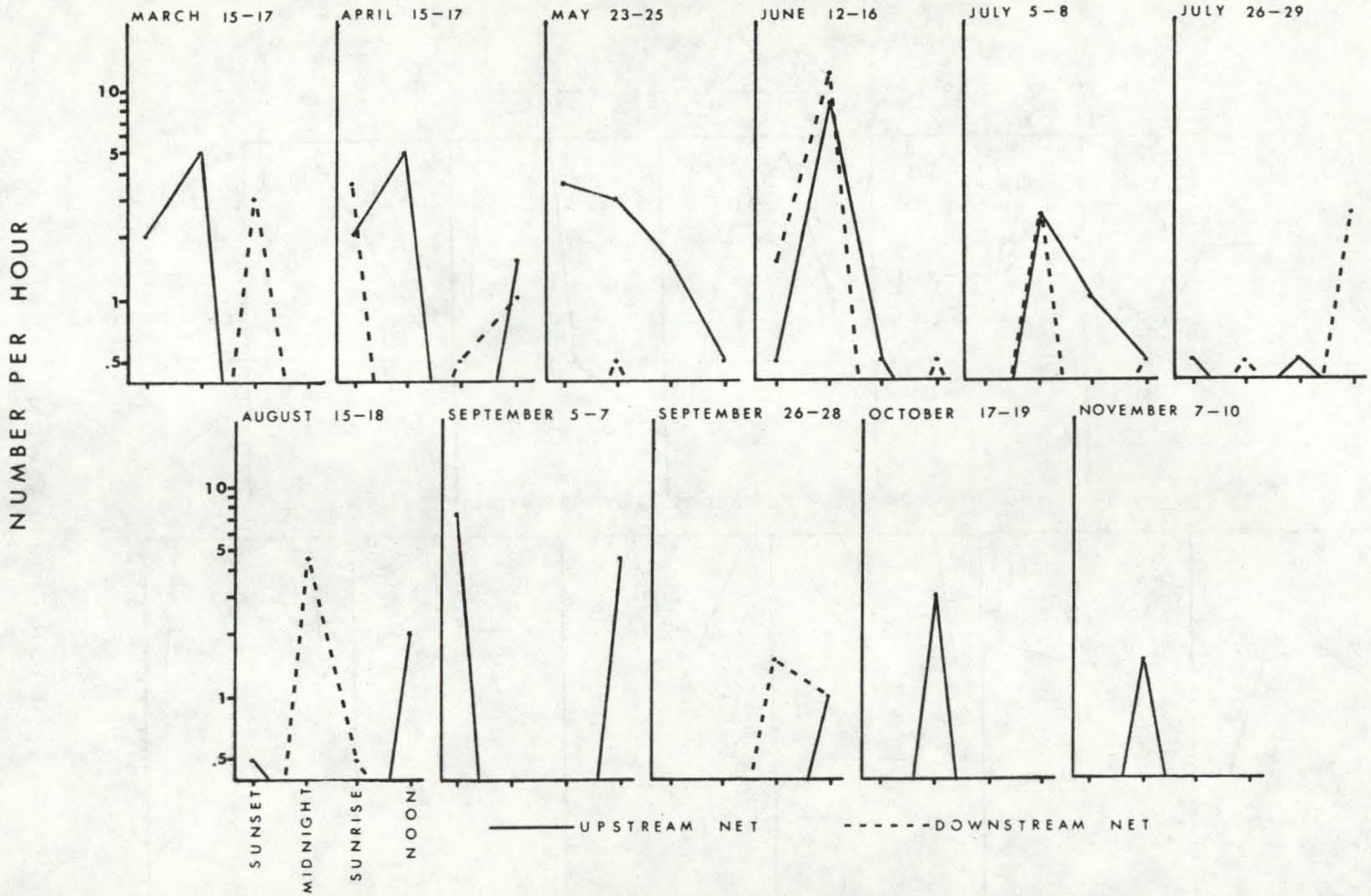

Figure 20. Diel abundance of Hydropsyche sp. drifting in Silver Creek in The Nature Conservancy site, 1977.

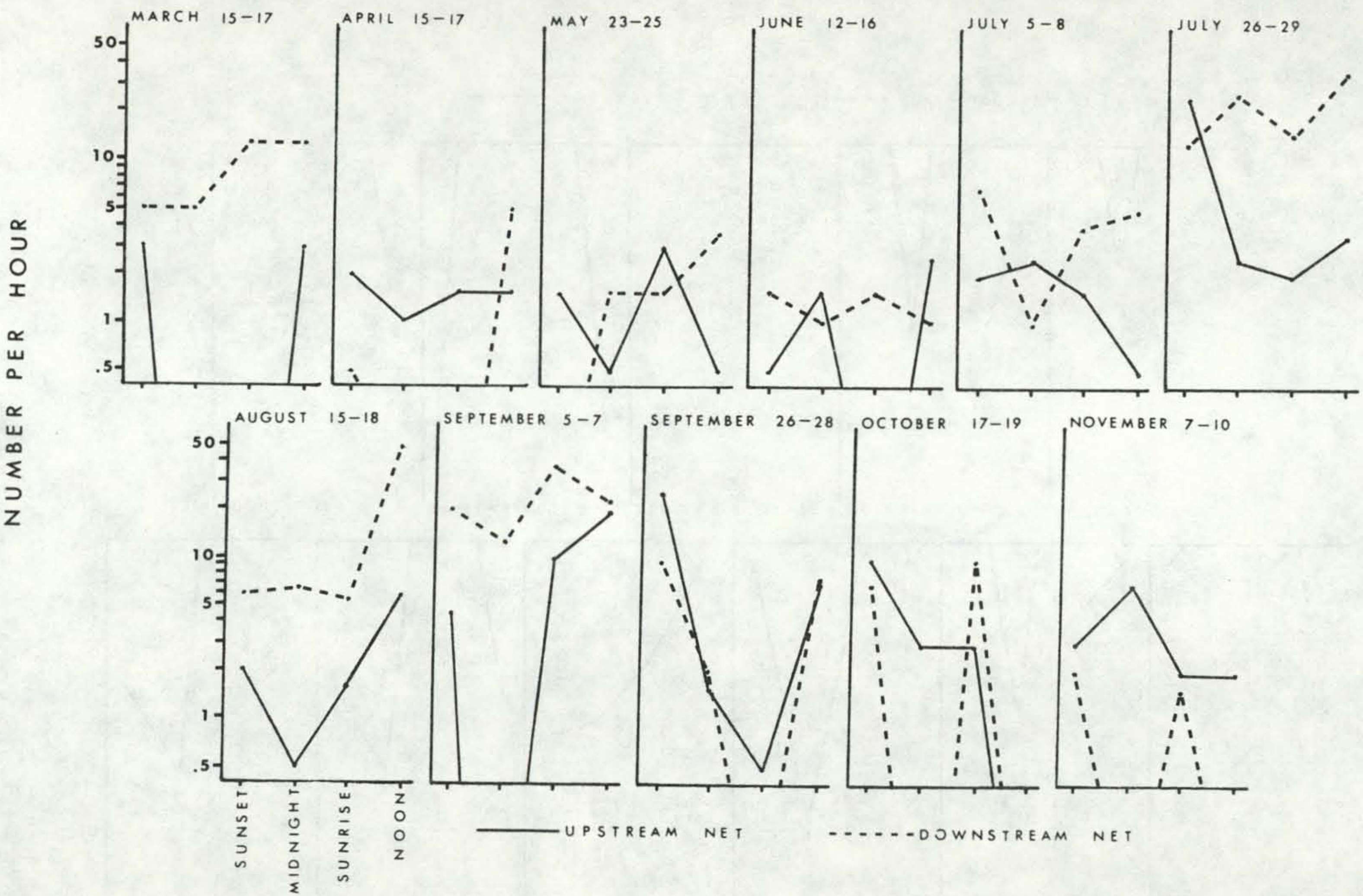

Figure 21. Diel abundance of Hydroptila sp. drifting in Silver Creek in The Nature Conservancy site, 1977.

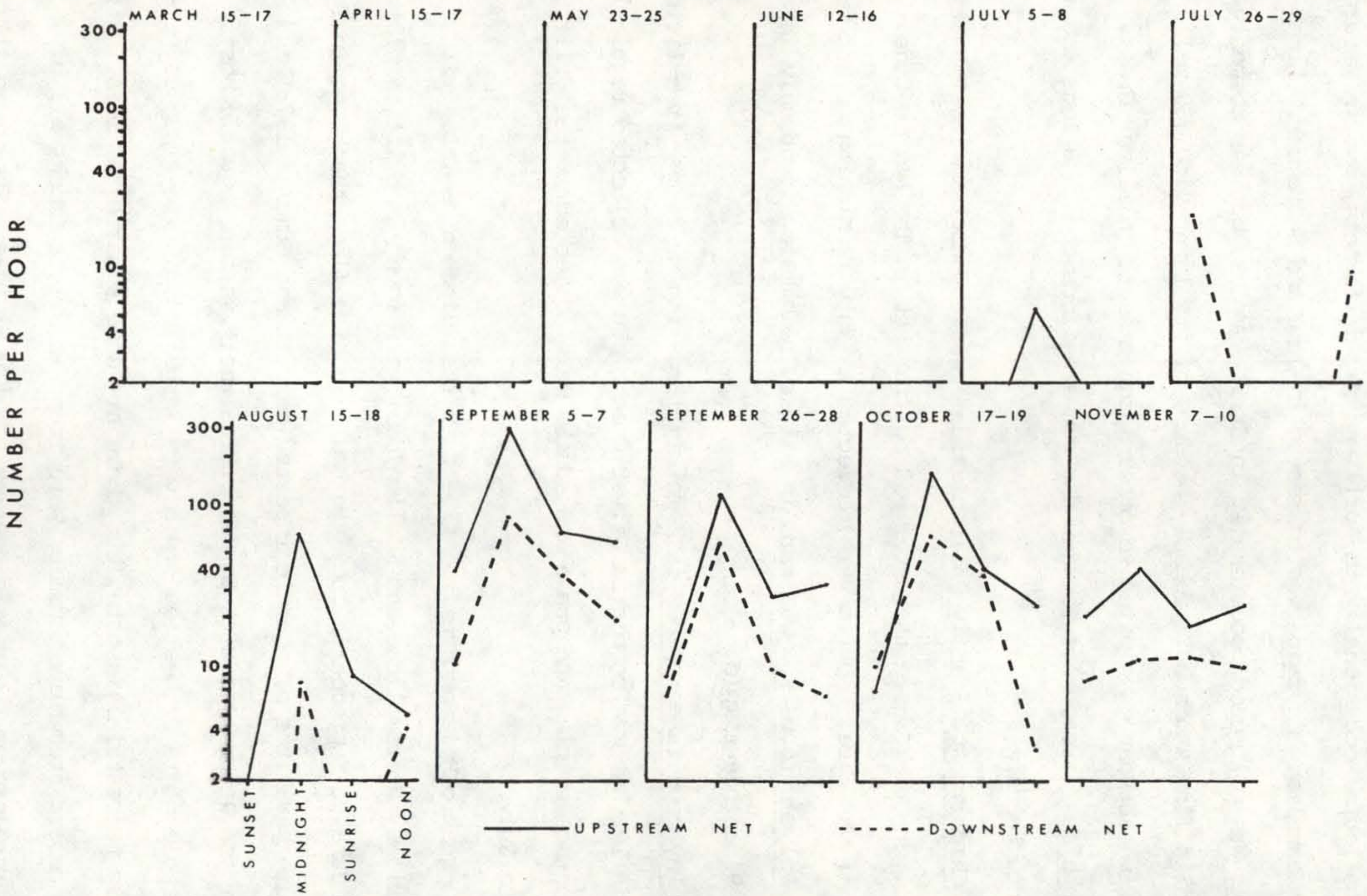

Figure 22. Diel abundance of Oxyethira sp. drifting in Silver Creek in The Nature Conservancy site, 1977.

There were three genera of Limnephilidae found in Silver Creek, Amphicosmoecus sp., Chyranda sp., and Limnephilus sp. Amphicosmoecus was collected occasionally in April and May drift nets, and in Berula plant samples. Chyranda was collected in June and September. Limnephilus was collected occasionally in drift samples, but was commonly found in fish stomachs, probably because of its large size (30 mm) and relative abundance compared to other large insects in Silver Creek. Limnephilus larvae were found under submerged branches and logs and among the duckweeds.

Chimarra sp. (family Philopotamidae) was abundant in lower sections of Silver Creek where the water was swifter but in The Nature Conservancy area it was rare. Adults were collected in July in midnight drift nets.

Polycentropus sp. was rare in Silver Creek being found only in a July 9 benthos sample.

Rhyacophila acropedes is a fairly large (up to 23 mm) free-living caddisfly that was common in Silver Creek. It was collected regularly in benthos samples and pupae and adults were collected in the drift from May to July.

Aquatic Hymenoptera from five families (Brachonidae, Diapriidae, Mymaridae, Pteromalidae and Scelionidae) were found in drift samples from June to September. They are small in size (less than 2 mm in length) and are parasites of aquatic insects (Merritt and Cummins 1978) and enter the water as adults to parasitize their various aquatic hosts.

Coleoptera or beetles are a very large and diverse group of primarily terrestrial insects, but there are some aquatic families. Sixteen genera from nine families were found in Silver Creek, all of which were rare except the riffle beetles, family Elmidae. They were all relatively unimportant as fish food. Agabus sp., Hygrotus sp., Illybius sp. and Oreodytes sp. (family Dytiscidae), Helophorus sp., Laccobius sp. and Sphaeridium sp. (family Hydrophilidae) and Brychius sp. and Haliplus sp. (family Haliplidae) all inhabit the calm water along the stream edges. Both the larvae and adults live in the water but must come to the surface periodically for air. Mature larvae crawl onto the banks and burrow into damp places to pupate. Agabus were collected in a June 18 vegetation benthos sample and in an October 17 drift sample. Hygrotus were found in June drift samples. Hydrophilidae were found in drift samples during May and June. Helophorus was also found on July 6 and September 5 in drift samples. Brychius were found in August and September drift samples whereas Haliplus were found in April, June, August and September. The riffle beetles, Heterlimnius sp. and Optioservus sp. are small (5 to 7 mm) but abundant in Silver Creek, with Optioservus the more numerous of the two in our samples. Larvae breath with gills that are retractable into a caudal chamber. Adults carry an air bubble under their elytra but depend largely on diffusion of exygen from the water, rather than ascending to the water surface to replenish the supply. Riffle beetles were found in all benthos samples and most drift samples during the year, and were found in Berula, Fontinalis and Chara plant samples. Drift samples collected at midnight had the highest numbers of riffle beetles (Fig. 23).

Diptera is one of the largest and most diverse orders of insects. Twenty identified genera plus representatives from four families not identified to genus were found in Silver Creek. They are also very numerous and important in the diet of fish.

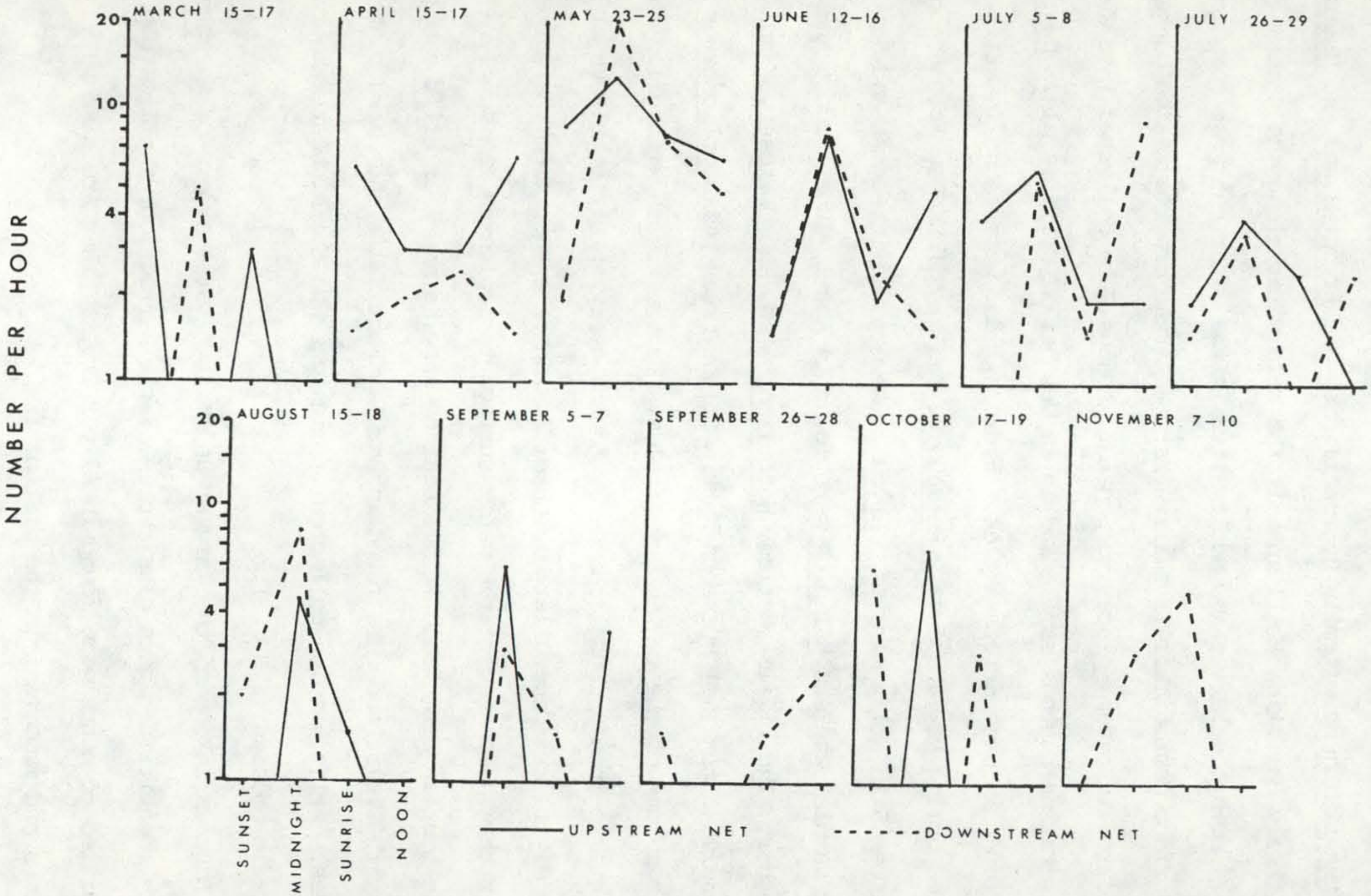

Figure 23. Diel abundance of the riffle beetles <u>Heterlimnius</u> <u>sp</u>. and <u>Optioservus</u> <u>sp</u>. drifting in Silver Creek in The Nature Conservancy site, 1977.

Prionocera sp. is a crane fly that was found occasionally in Silver Creek. Larvae were found in drift samples and fish stomachs in July and September, and in the moss, Drepanocladus. Elliptera sp., Polymeda sp. and Tipula sp. were collected rarely in Silver Creek.

Psychoda sp. (family Psychodidae) is a small, hairy, mothlike fly. Only two specimens of this genus were collected, both adults, in drift samples in June and July.

Mosquitoes (family Culicidae) are common along Silver Creek although none were collected in benthos or drift samples. They inhabit the still water areas along the stream, and in lakes and ponds.

Simulium sp. (family Simuliidae) is a black fly that was abundant in Silver Creek. The larvae prefer fast water where they attach themselves to rocks. They were also found in the Berula, Hippuris, Rorippa, Veronica, Potamogeton and Elodea plant samples. They spin a cocoon ot pupate, attaching it to the rock or plant surface on which it rests. Pupae were found in March, April and July in Silver Creek. Adults were most numerous in April, May, August and September. Although no definite daily drift pattern was observed, black flies were generally most abundant in evening drift samples (Fig. 24).

Chironomidae were the most numerous of all insects in Silver Creek. Several species live in the creek and they inhabited a wide variety of habitats. They were found in virtually every drift and benthos sample taken throughout the year, in all plant samples, and in most fish stomachs. Their diel drift patterns are quite irregular although evening samples generally had more Chironomids than at other times (Fig. 25).

Heleidae, often called biting midges or "no-see-ums" are found frequently in Silver Creek. Although a couple of Heleids were not ident-

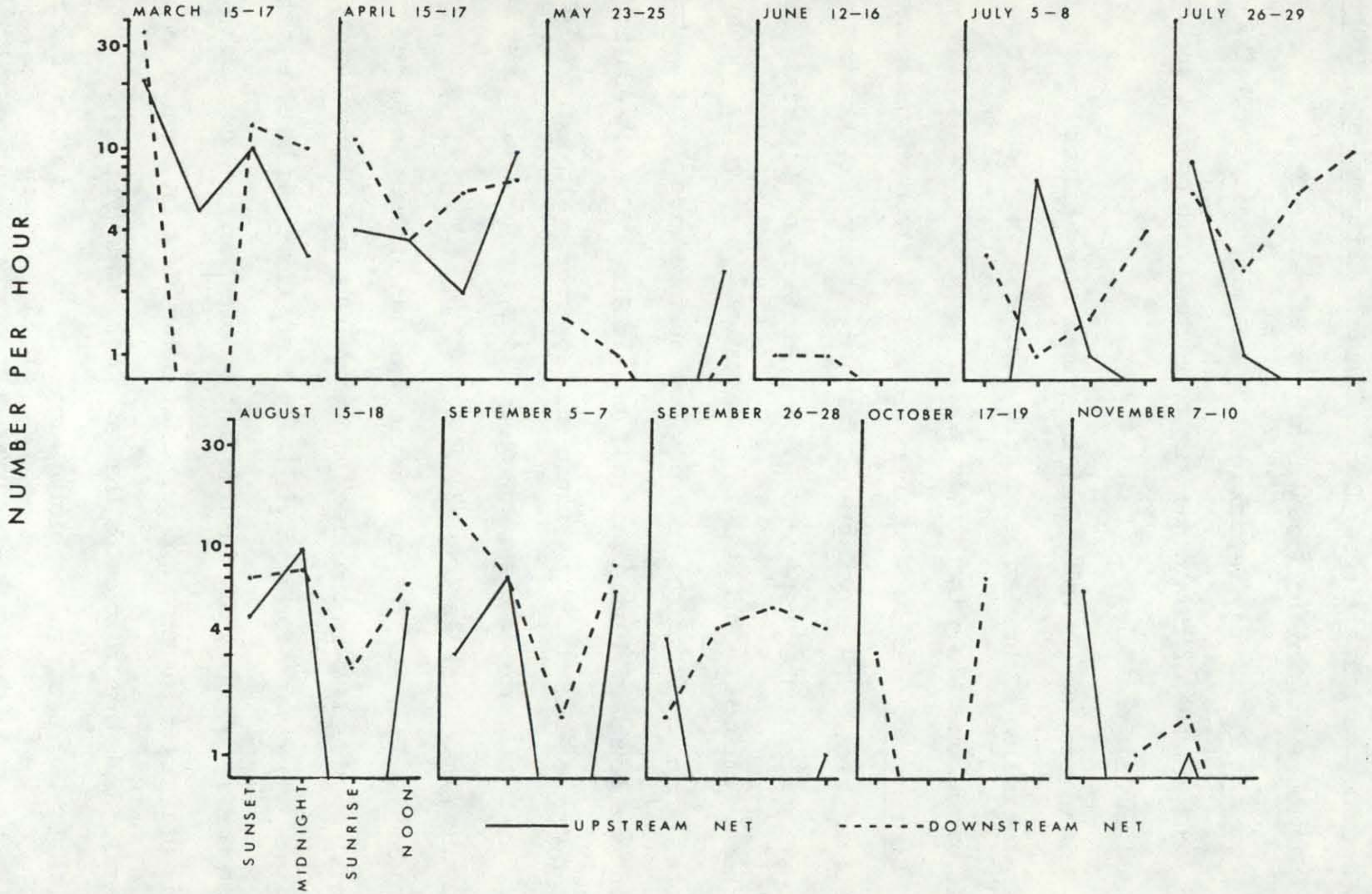

Figure 24. Diel abundance of Simulium sp. drifting in Silver Creek in The Nature Conservancy site, 1977.

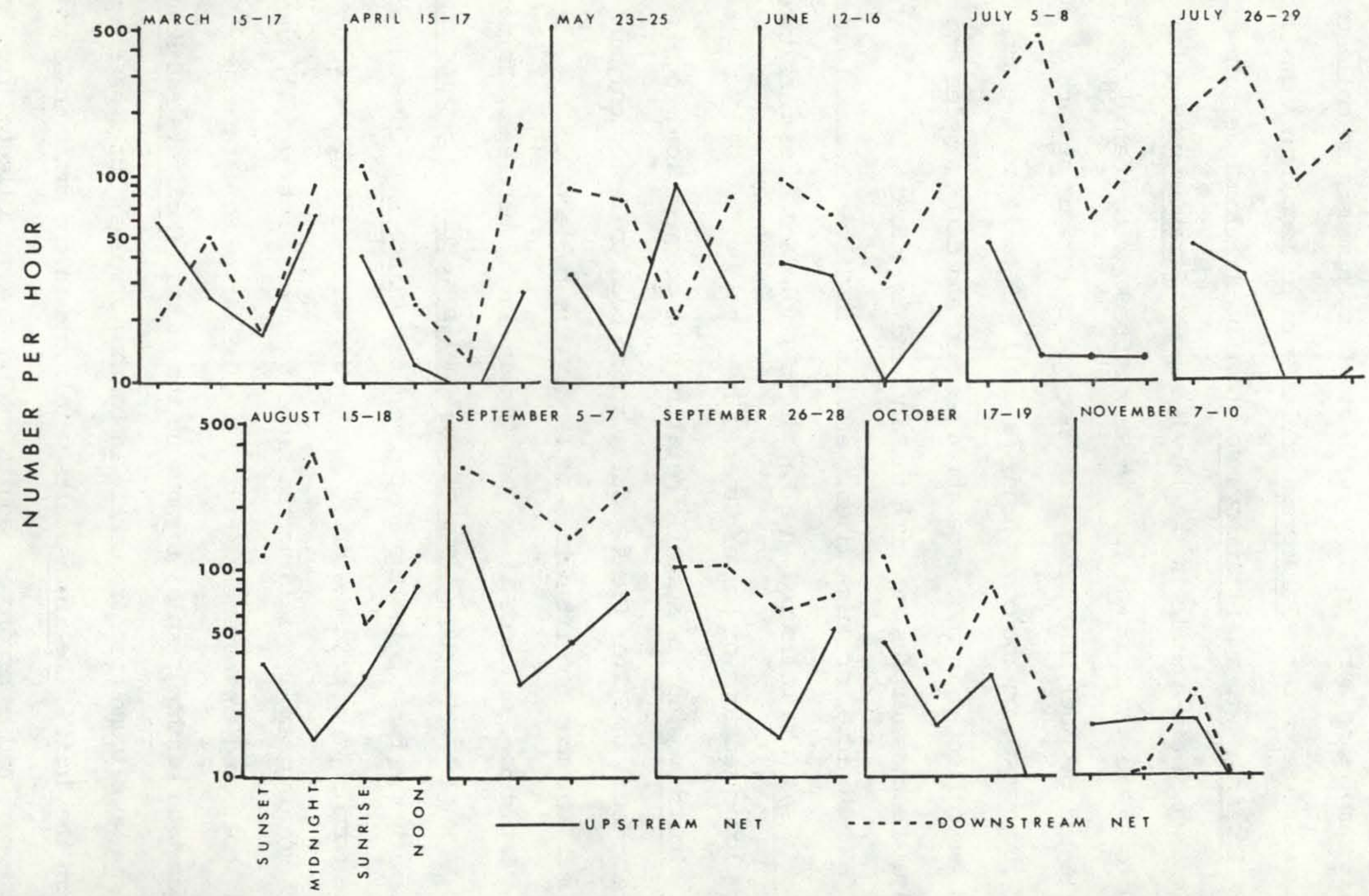

Figure 25. Diel abundance of Chironomidae drifting in Silver Creek in The Nature Conservancy site, 1977.

ified to genus, three genera were identified, Bezzia sp., Palpomyia sp. and Parabezzia sp. The first two were found frequently in benthos and drift samples in April to July, with single specimens also collected in August and September. Parabezzia adults were collected in August.

Euparypus sp. and Stratiomys sp. (family Stratiomyidae) are soldier flies, which are aquatic in the larval stage. Stratiomys is a large (40 to 45 mm) fly that was rare in Silver Creek, with the only specimens collected in a July 6 evening drift net and in a trout stomach on July 29. Euparypus, on the other hand, is small (10 to 14 mm) but abundant and was collected in most vegetation benthos and drift samples and in gravel benthos samples in April to July, and in October.

Rhagionidae, or snipe flies, were rare in Silver Creek. Larvae of Atherix sp. were collected in a May drift sample and in samples taken from lower sections of Silver Creek.

Dolichopus sp. is a small, metallic blue or green long-legged fly, rarely found in Silver Creek, adults having been collected only in July 26 and September 5 drift nets. No larvae were collected.

Empididae, or dance flies, were common in Silver Creek. Three genera were identified, Clinocera sp., Chelifera sp. and Hemerodromia sp. with the first being the most numerous. Clinocera pupae and adults were commonly found in the drift during the early part of the year, with morning samples yielding the highest numbers, but by fall, they were only collected infrequently (Fig. 26). The larvae were infrequent in vegetation benthos samples throughout the study. Chelifera and Hemerodromia were found more frequently in benthos samples, but less frequently in the drift. Chelifera adults were found in the drift in August and September, and Hemerodromia adults and pupae were collected from May

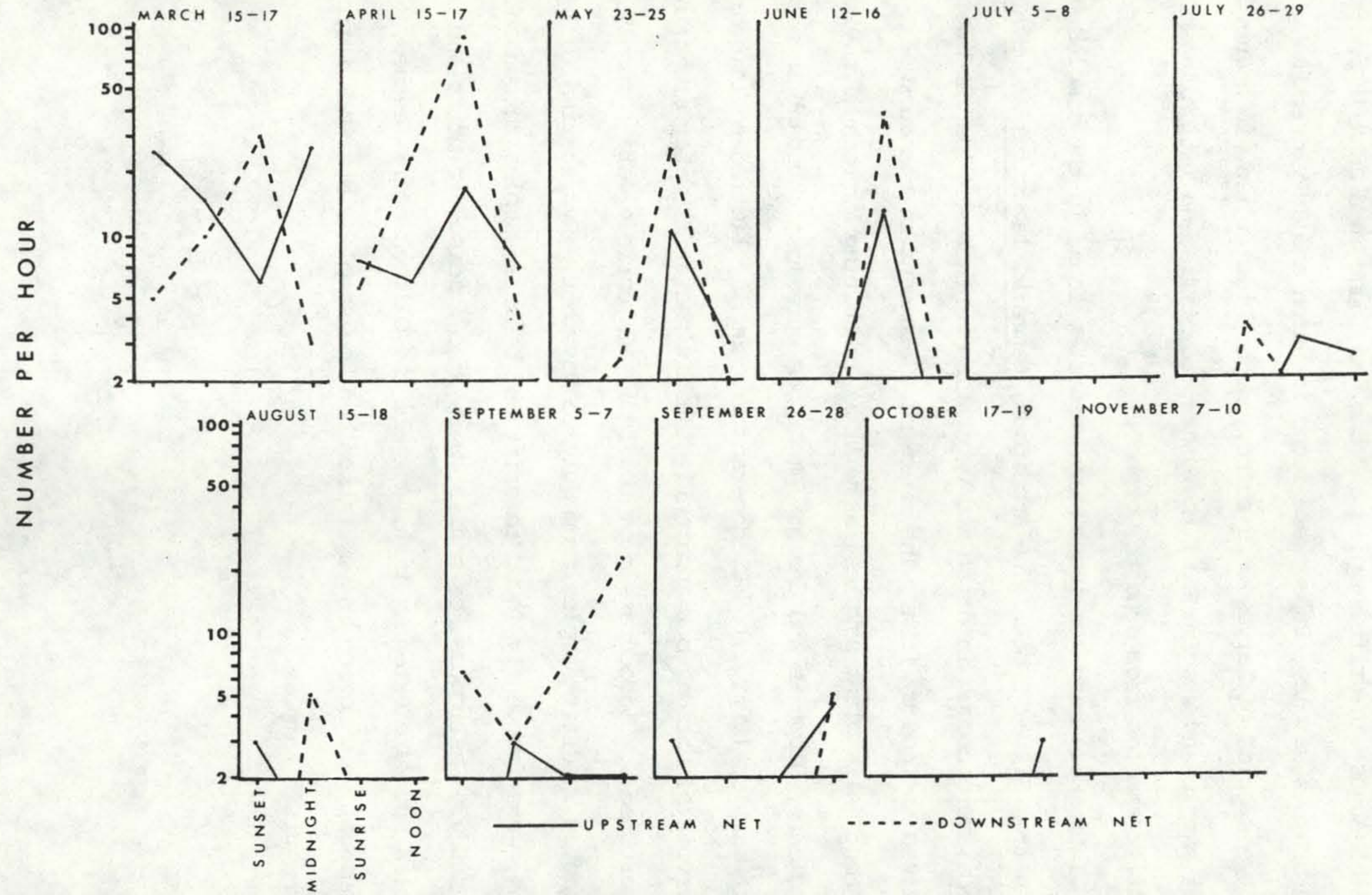

Figure 26. Diel abundance of Empididae drifting in Silver Creek in The Nature Conservancy site, 1977.

to July. Hemerodromia larvae were found with the plant Rorippa.

Ephydridae are rare in Silver Creek. Adults were collected in March, May and August in drift samples and one was found in a June 18 vegetation benthos sample. Pupae were found in March and July drift samples and two species of larvae were found, one not identified, in a July drift sample and specimens of the other, identified as Notiphila sp., in drift samples from June to October.

There were many non-insect invertebrates found in the samples taken from Silver Creek. The amphipods, Gammarus lacustrus and Hyalella azteca, were common in drift and vegetation benthos samples, and were utilized as food by fish. They were most abundant in the duckweeds and Fontinalis plant samples, as well as inhabiting Myriophyllum, Drepanocladus, Hippuris and Chara. Amphipods were most abundant in midnight drift samples (Fig. 27). Cladocerans are usually limited to lake or reservoir situations but apparently inhabit the still water areas in Silver Creek. Cladocerans from the family Chydoridae were commonly collected in drift samples from July to November. Hydracarina, or water mites, were frequently found in drift and benthos samples throughout the study. Gastropods, or snails, were also numerous in drift and benthos samples and were eaten by fish, as were the Oligochaets. Leeches (Class Hirudinea) were common in vegetation benthos samples, but were infrequent in the drift samples.

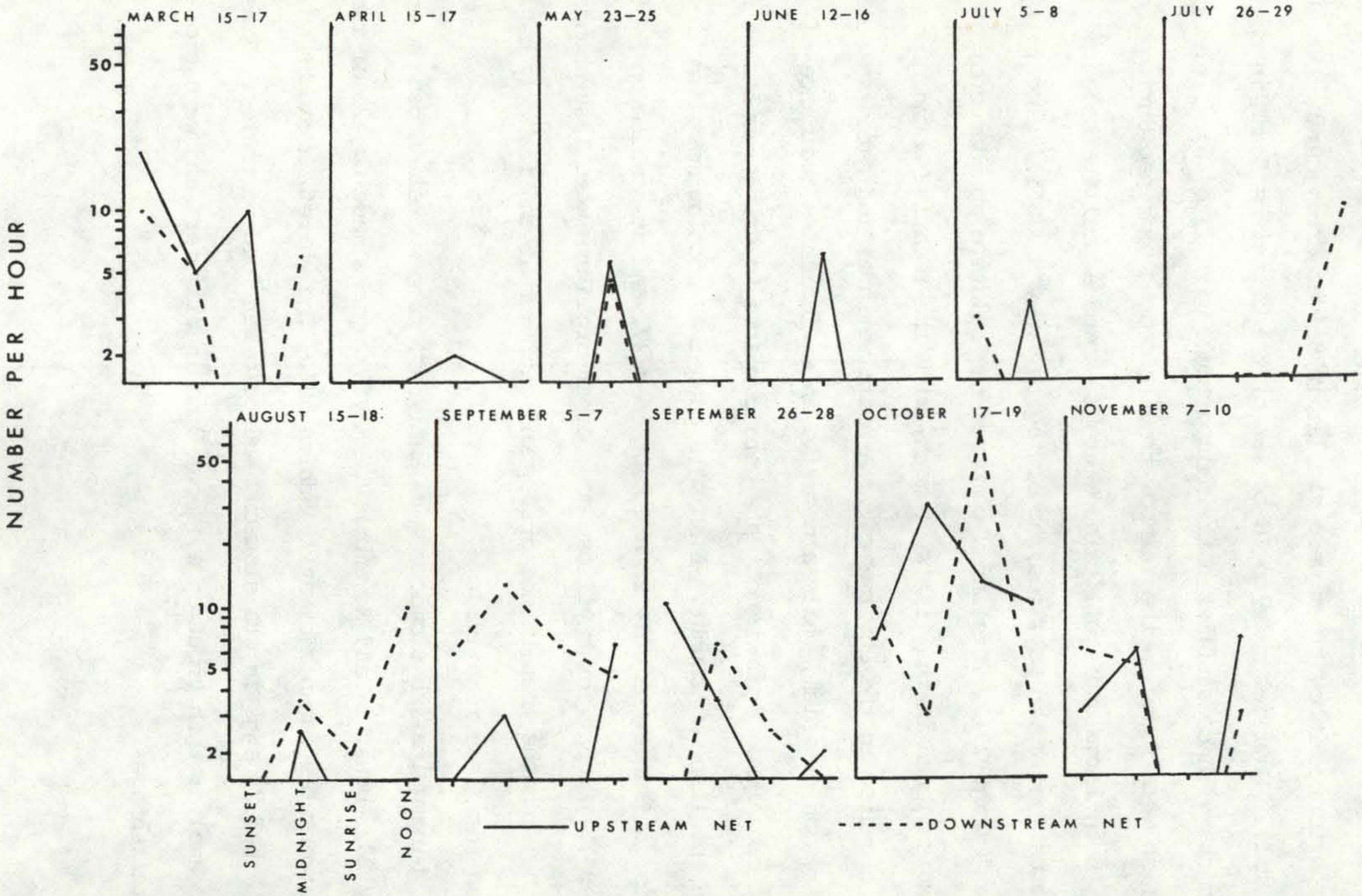

Figure 27. Diel abundance of Amphipods drifting in Silver Creek in The Nature Conservancy site, 1977.

Food Habits

The diets of both large (longer than 250 mm) and small (250 mm long or shorter) rainbow trout were similar in Silver Creek during the summer and fall. Mayflies made up 10 to 96% of the organisms found in the stomachs with caddisflies next in importance with 1 to 46% (Fig. 28). No fish were found in the rainbow trout stomachs examined during the study.

Both large and small rainbow trout showed a positive selectivity towards feeding on mayflies, according to Ivlev's (1961) "electivity index" (Fig. 29). This index compares the relative abundance of an organism found in the fish's stomach, with the relative abundance of the organism in the environment. A positive index indicates selectivity towards an organism, while a negative index indicates avoidance of that organism. Stomach contents were compared to drift samples at the time the fish was caught. Fish were caught at noon on most sampling dates, at sunset on July 28 and September 27, and at sunrise on September 7. Except for mayflies, most other organisms were less abundant in the stomachs than in the drift, indicating that the fish may have eaten them less readily.

Nine whitefish stomachs were analysed, from whitefish caught on July 28, August 17 and November 7. Mayfly nymphs made up 42% of the invertebrates eaten and mayfly adults 50%. The whitefish caught on November 7 had 28 eggs in its stomach, and no other food particles. These eggs were smaller than trout eggs (about 2 mm in diameter) and were probably whitefish eggs.

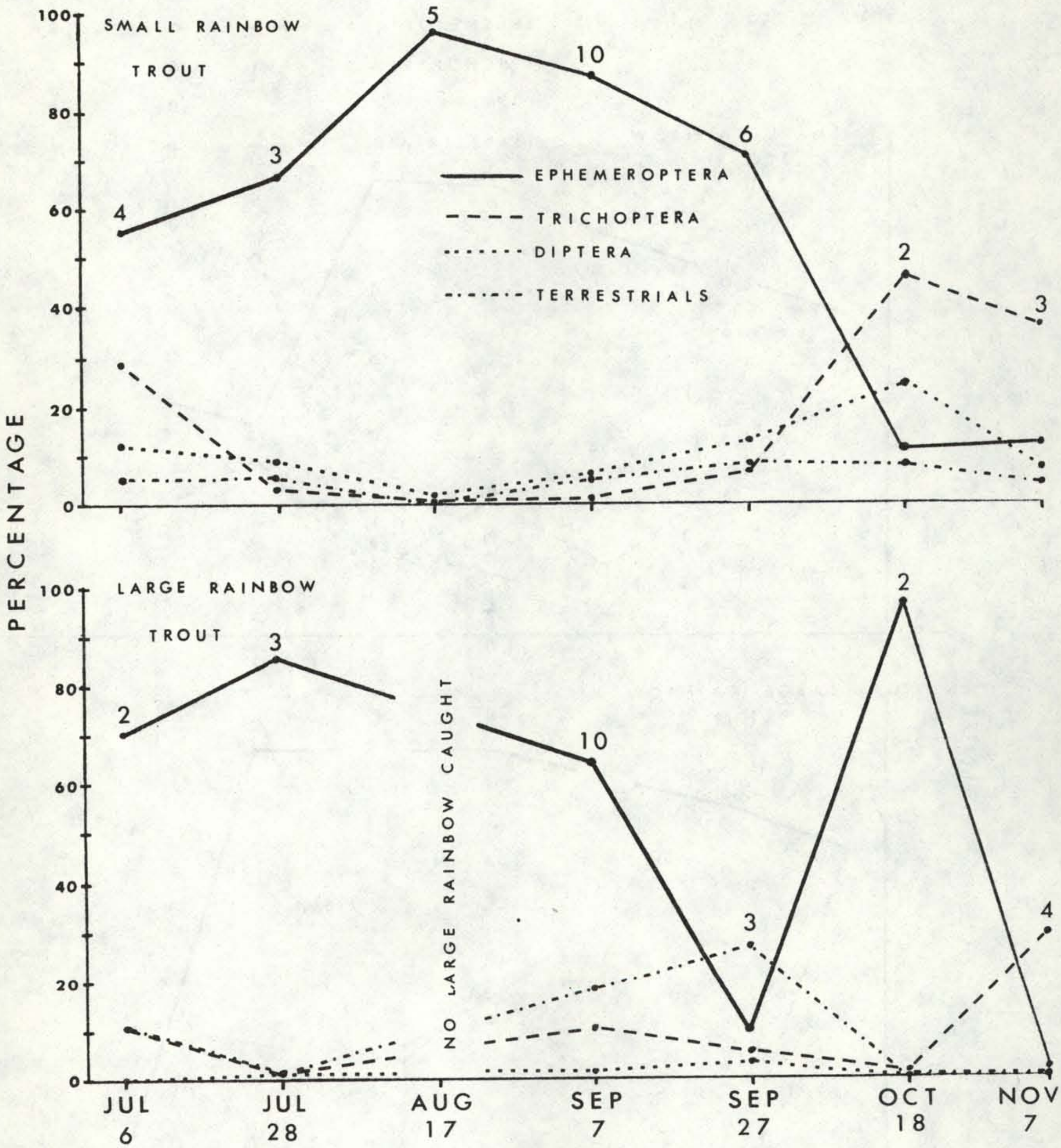

Figure 28. Percentage composition, by number, of insects found in stomachs of rainbow trout from Silver Creek in The Nature Conservancy site, 1977. The number of fish stomachs examined on each date is shown by the number next to the line.

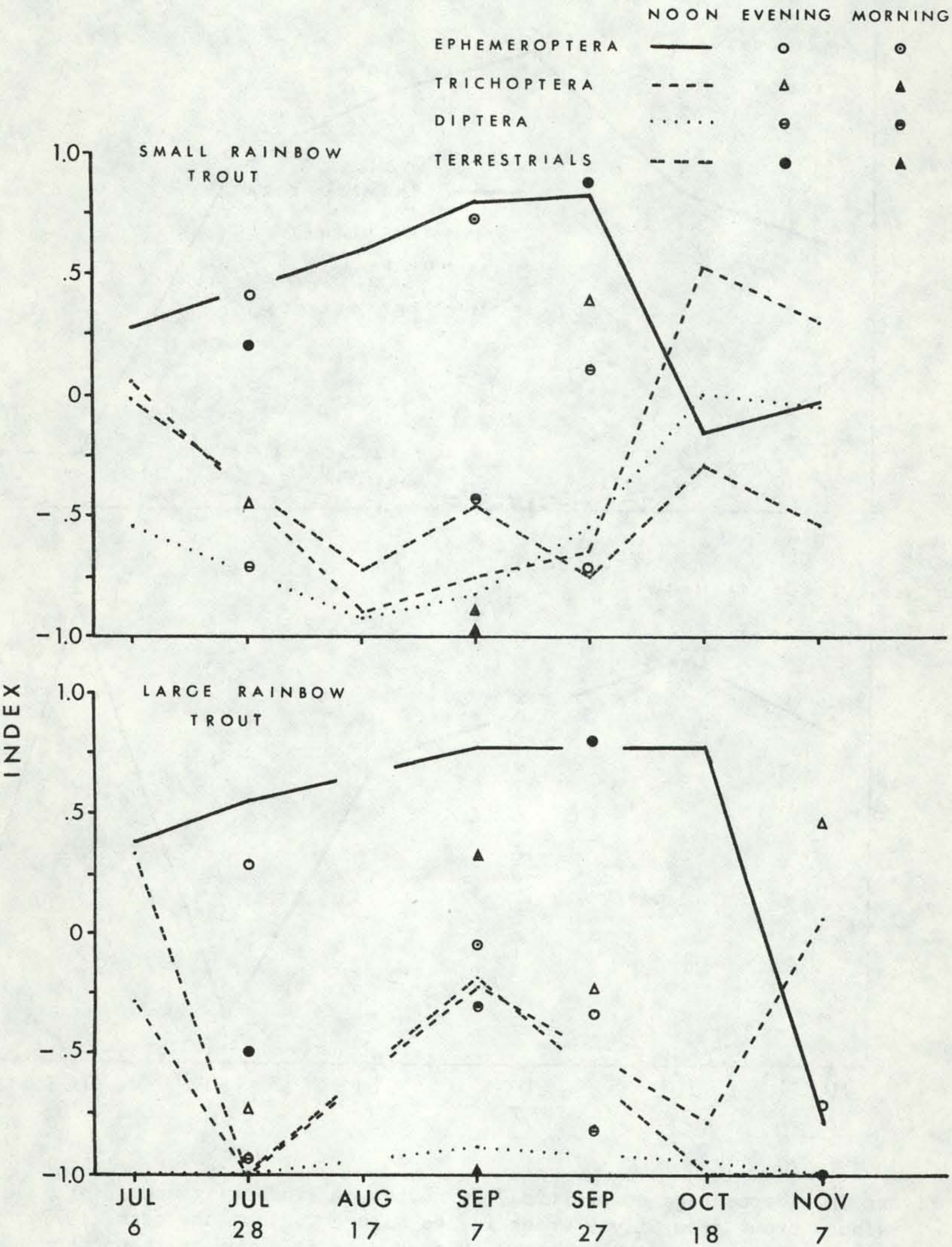

Figure 29. Ivlev's "electivity index" for four major groups of insects found in stomachs of rainbow trout from Silver Creek in The Nature Conservancy site, 1977.

Fish Stocks

Six species of fish were found in The Nature Conservancy section of Silver Creek upstream from the confluence of Loving Creek. These were; rainbow trout (Salmo gairdneri), brook trout (Salvelinus fontinalis), mountain whitefish (Prosopium williamsoni), Wood River sculpin (Cottus leipomus), bridgelip sucker (Catastomus columbianus), and longnose dace (Rhynichthys cataractae). Below Purdy's irrigation dam brown trout (Salmo trutta) and redside shiner (Richardsonius balteatus) were also present.

Rainbow trout were the most abundant species in The Nature Conservancy portion of Silver Creek (Table 9). These made up 17 to 75% of the fish present throughout the year, followed by suckers and dace. Rainbow trout made up 57% (28 to 69%) of the catchable size (longer than 150 mm) game fish, whitefish 40%(27 to 71%) and brook trout 3% (1 to 4%).

The age composition of the rainbow trout and whitefish populations in The Nature Conservancy section of Silver Creek changed throughout the year (Fig. 30). We caught the largest number of age I or older rainbow trout and whitefish in March, July and September, with the fewest caught in May and November.

Age 0 and I rainbow trout are the only age classes easily discernable from length-frequency data (Fig. 31). In March we caught several yearling rainbow trout that ranged from 50 to 140 mm in length. By May, these age I fish had grown to 90 - 170 mm and some recently emerged trout fry less than 50 mm long were present. In July, age 0 rainbow trout were up to 110 mm, and yearlings ranged from 130 to 240 mm. By September some age 0 trout had reached 150 mm and yearlings were up to 260 mm. In November age 0 trout still ranged up to 150 mm and it had become difficult to

TABLE 9. Estimated number of fish in the sample sections of Silver Creek in The Nature Conservancy site, catches with electrofishing gear, 95% confidence intervals of estimates and number of fish per 100 m of stream length, 1977.

	Rainbow trout			Brook trout		Whitefish		Sucker	Dace	Sculpin
	Age			Age		Age				
Date	0	I	II and older	0	I and older	0	I and older			
March 15-17										
Catch 1	0	21	284	3	15	0	267	24	1	1
Catch 2	0	11	22	0	6	0	25	9	11	9
Estimated	0	44	308	3	25	0	295	38	12[1/]	10[1/]
95% confidence intervals	-	32-70	306-311	-	21-35	-	293-299	33-49	-	-
Number per 100 m	0	7	49	1	4	0	47	6	2	2
May 23-25										
Catch 1	100	46	45	12	2	0	76	84	315	20
Catch 2	38	19	10	2	0	0	43	26	224	32
Estimated	161	78	58	14	2	0	175	122	1090	52[1/]
95% confidence intervals	138-184	65-97	55-63	14-15	-	-	121-239	110-135	703-1477	-
Number per 100 m	26	12	9	2	1	0	28	19	172	8
July 14-16										
Catch 1	3070	233	129	34	17	108	202	101	314	68
Catch 2	531	57	26	14	3	112	30	27	123	41
Estimated	3712	308	162	58	21	220[1/]	237	138	516	171
95% confidence intervals	3682-3742	294-322	155-170	48-74	20-23	-	232-243	128-149	473-559	109-249
Number per 100 m	587	49	26	9	3	35	38	22	82	27
September 13-15										
Catch 1	3151	268	70	8	5	73	141	1080	207	174
Catch 2	950	44	21	4	4	43	23	262	83	100
Estimated	4511	321	100	16	25	178	168	1426	346	409
95% confidence intervals	4433-4589	313-329	91-111	12-30	9-143	116-252	164-174	1396-1456	309-383	306-512
Number per 100 m	714	51	16	2	4	28	27	226	55	65
November 1-3										
Catch 1	2508	101	61	19	4	39	58	1025	100	26
Catch 2	673	24	5	6	2	20	67	459	127	34
Estimated	3428	132	66	28	8	80	125[1/]	1856	227[1/]	60[1/]
95% confidence intervals	3372-3484	125-141	66-68	25-35	6-18	59-112	-	1745-1967	-	-

[1/] Catch 1 plus catch 2. Catch 2 was larger than catch 1.

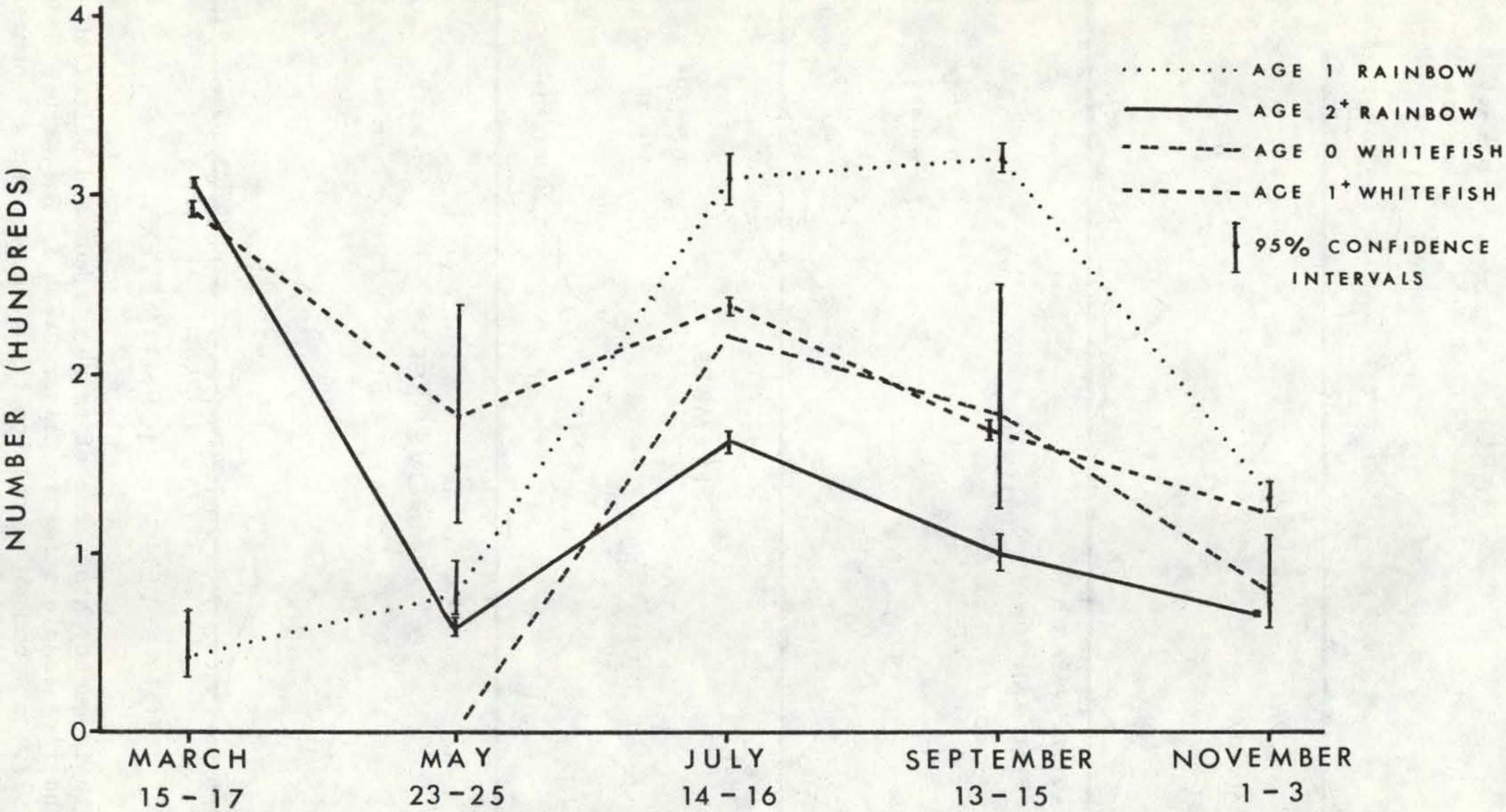

Figure 30. Abundance of rainbow trout and whitefish in the five sample sections in The Nature Conservancy portion of Silver Creek upstream from the confluence of Loving Creek, 1977. Where no confidence intervals are shown, the second catch exceeded the first catch.

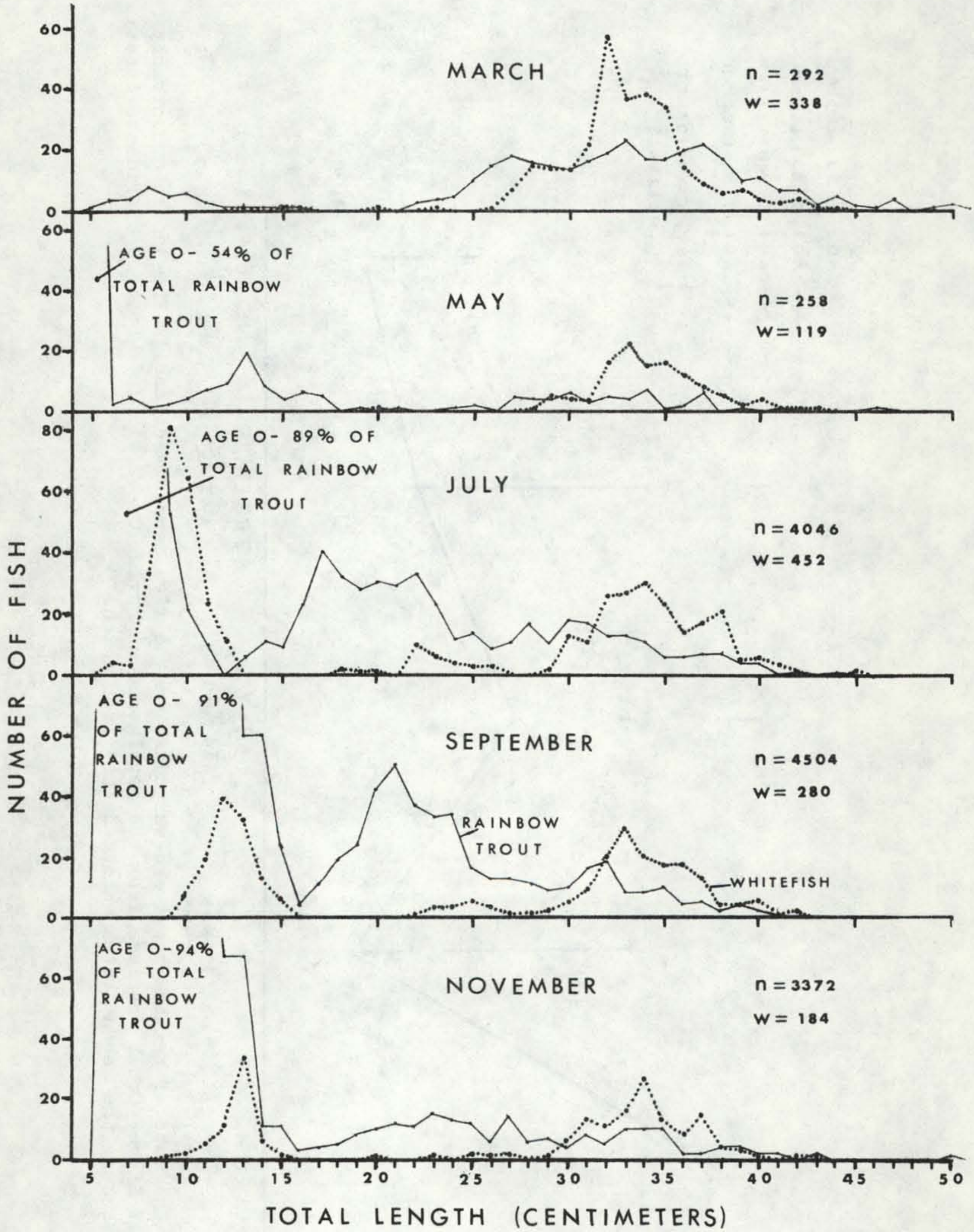

Figure 31. Length-frequency histogram of rainbow trout and whitefish collected from the five sample sites in Silver Creek in The Nature Conservancy site, 1977. n = number of rainbow trout in sample; w = number of whitefish.

separate large age I trout from small age II fish.

Age I rainbow trout grew 150 mm from March to November 1977 (Fig. 31). The average length of age I rainbow trout in March was 84.7 mm and in November 235.1 mm. Age 0 rainbow trout averaged 85.3 mm in November, a gain of 60 mm during their first summer.

Both spring and fall spawning rainbow trout were present in Silver Creek in 1977. Spring spawning rainbow trout were introduced many years ago and are not abundant in Silver Creek. Fall spawners are currently being stocked from the Hayspur Fish Hatchery. Prior to 1977, they were stocked throughout the Silver Creek drainage. Since 1977 they have not been stocked in The Nature Conservancy area. Trout that are released into Loving Creek from the hatchery do, however, have access to The Nature Conservancy site. From observations during April, May, June and July and again in October and November we believe there were more spring than fall spawning rainbow trout. Spring spawning occurred during April, May, June and early July of 1977. Fall spawning started in mid-October and was still active in mid-November when observations were discontinued. Cutthroat trout were probably the original inhabitants of Silver Creek but no cutthroat trout were found in 1977. There were some cutthroat x rainbow trout hybrids found.

DISCUSSION

The chemical composition and temperature of Silver Creek is good for the growth and survival of cold-water organisms. Markus (1962) and Morton (1962) report that rainbow trout fingerlings grow best at about 13 C, and have lower mortality rates at that temperature. In general, the temperature range for rainbow trout is 0 to 28 C with an optimum below 21 C (McAfee 1966). The temperature of Silver Creek fluctuated above and below the 10 to 11.5 C of the headwater springs with maximum temperatures up to 22 C for short periods on warm summer days (Fig. 5).

The area of exposed gravel was largest in Silver Creek in March because the amount of vegetation that covers and traps silt in the stream was at a minimum at that time (Figs. 8 and 9). Water discharge is low in March and hence velocities are also slow and silt accumulates. The smallest area of exposed gravel occurred in late August when vegetation was near maximum. The vegetation that grew in the spring and summer on much of the substrate trapped the silt that settled out during the winter. The only exposed gravel areas that persisted in late summer were on riffles and where the water was forced through channels between the silt and vegetation beds. The increased velocity in the channels scoured silt from the stream substrate. Silt was also scoured from the stream in fall because the water discharge increased (Fig. 6) and vegetation died and drifted out of the stream. Reduced discharge during the winter allowed silt to settle out on the stream bottom again.

A certain amount of silt is necessary in Silver Creek for Chara to establish good root systems and form large beds. Chara does not grow well in gravel. Chara was the most abundant macrophyte in the stream and provides good habitat for much of the stream's invertebrate populations.

Veronica, on the other hand, grows well in gravel, provides habitat for insects, especially Baetis spp., Ephemerella spp. and Simulium sp., and provides good cover for small fish. If there were less silt, Veronica would probably be more abundant than in 1977, but this increase in abundance would probably not make up for the decrease in abundance of Chara which would occur with the decrease in silt.

According to some fishermen who have fished Silver Creek for many years, Chara has a 5 to 7 year growth cycle in the creek. Chara increased in abundance each year over a 5 to 7 year period, then most of it is washed out in one year. Supposedly the Chara begins washing out in local areas and rolls into large mats damming the water behind it. The water depths and velocities increase and the vegetation is washed out in larger and larger sections of stream. Wood and Imahori (1966) report that Chara beds sometimes live up to 50 years in reservoirs. We could not find other documented evidence of several year cycles for Chara in the literature.

In 1977-78, Chara had an annual cycle of abundance in Silver Creek with peak densities in August and minimum in late winter (Figs. 10 and 11). However, Chara does not die back completely in the winter as do many plants and the possibility exists that it may build up over a period of years until the water washes most of it out. We doubt, however, that a regular cycle of 5 to 7 years would develop. In the fall and winter of 1977-78, discharge in Silver Creek was abnormally low (Fig. 6), a condition that would seem to favor the retention of Chara, yet both biomass and area covered decreased markedly.

A change in vegetation upstream from the drift net sites may explain why fewer insects were caught in the lower net during March, April, May and October and November than in the upper net, but more in the lower net during the summer (Fig. 12). When the sites to collect insect drift samples were selected in March 1977, the upper site was downstream from a section of silted stream with Chara beds directly upstream from the net. As the season progressed, much of the silt was scoured leaving some exposed gravel, but the Chara beds remained intact. The lower site was downstream from an area that was mainly gravel with little vegetation in March. As the season progressed, Veronica grew profusely over the gravel and algae became abundant. The vegetation died leaving bare gravel again in the fall.

It appears from Chlorophyll a analysis that Silver Creek is not very productive compared to other streams. Chlorophyll a concentrations in Silver Creek were slightly less than in the Henry's Fork and much less than most other areas of the Snake River. However, most of the nutrients in Silver Creek and the Henry's Fork are tied up in the abundant vegetation which grows there, and the diatoms and algae which colonized the microscope slides did not account for much of the total productivity of the stream. Most other areas of the Snake River do not have as much vegetation and nutrients are taken up more by diatoms and algae.

Mayfly hatches and mating swarms that occurred regularly during the year began about two hours after sunrise and were completed by late morning. Our sampling with drift nets occurred before and after such activity. The apparent selectivity of rainbow trout for mayflies (Fig. 29) may result from fish feeding on the emerging mayflies rather than an actual selectivity for mayflies. Only 57 rainbow trout stomachs were analysed during the study so we have limited confidence in the food selectivity data.

Mountain whitefish were abundant in Silver Creek. They prefer pools where water depths exceed three feet, and feed primarily on bottom organisms (Daily 1971). However, in Silver Creek they also fed heavily on Baetis, Ephemerella and Tricorythodes adults on the water surface. Although the whitefish diet was similar to that of rainbow trout, we should not conclude on this alone that the two species compete with each other. Some biologists (McHugh 1940, Sigler 1951) have suggested that mountain whitefish possess many qualities of a game and food fish but that they compete for food with, and at times take the eggs and young of other salmonid species. Thompson and Davies (1976), on the other hand, found that at no time during their study did they find that mountain whitefish had consumed eggs or young of other fish species.

Abundance of trout in Silver Creek within The Nature Conservancy section may vary as fish leave to or return from spawning and as the abundance of cover provided by vegetation changes. In March there were many fish in the stream. In May, relatively few fish were collected. Many fish may have gone upstream to the tributaries to spawn. As the vegetation increased in June, fish abundance increased, but then decreased again in the fall when the vegetation died off. Age I fish that spent their first year in the tributaries and then came down into The Nature Conservancy section made up a large part of the increased summer abundance (Figs. 30 and 31). Some changes in our estimates of fish abundance may have resulted from changes in electrofishing effectiveness. The conductivity was similar throughout the year, but in March the water was more turbid than during the rest of the year. The turbid water allowed us to approach closer to the fish and thereby increased our chance of capturing them.

There is some concern that a continuous influx of fall spawning trout from the hatchery (via Loving Creek) into The Nature Conservancy site may eventually lead to mostly fall spawning trout. Survival of fall-spawned fry may be lower than spring-spawned fry, however, and prevent the shift to fall spawners. Fry from fall spawners emerge in Silver Creek in January and February (75 to 100 days hatching time at 3 to 4 C, Embody 1934). At this time of year, there is little vegetation in the stream and thus little cover or food. Predation on fry emerging in winter may be high because of the lack of cover and slow growth. Spring-spawned fry, on the other hand, emerge in late spring and early summer, when there is an abundance of cover and food. No fish were found in the stomachs of fish caught during the summer and fall, even though fry were abundant at these times.

There have been several different stocks of trout introduced into Silver Creek in the past. The original rainbow trout introductions were of McCloud River, California trout in the nineteenth century (Thurow 1978). Since 1907 rainbow trout from several sources have been reared at the Hayspur Fish Hatchery and introduced into Silver Creek. These sources include Neosho, Mo.; Soap Lake, Wash.; Hat Creek Calif.; Henry's Fork Snake River, Idaho; Williams Lake, Idaho; and Roaring River, Oregon. In addition, between 1955 and 1970 Idaho Department of Fish and Game personnel annually salvaged fish from Richfield Canal and planted them in Silver Creek. Richfield Canal introductions included trout from the original Big Wood River stock and trout from stocks reared in Hayspur Hatchery and introduced into Richfield Canal. Hayspur Hatchery currently maintains its own brood stock and these fish exhibit considerable variation in external characteristics due to their complex genetic makeup. The mixing of these stocks with the trout in Silver Creek may have altered their overall size, life span and survivability. Hatchery fish over the years have been selected to spawn at younger ages than wild fish. If the trout in Silver Creek now spawn at younger ages than 20-30 years ago because of the repeated infusions of hatchery fish, the average size of fish in the stream would be smaller. Although death of trout is not obligatory after spawning, as it is in Pacific salmon, many trout do not survive after spawning, so spawning at an early age reduces the time a fish is in the stream and thus the ultimate size that can be attained.

RECOMMENDATIONS FOR FUTURE STUDY

Mapping of vegetation should be continued on a twice a year basis, at the high (August) and low (March) points of vegetation abundance, to see if Chara does follow a several year cycle. Since abundance of fish and insects is associated with the vegetation, a knowledge of the vegetation cycle would help in understanding the predicting changes in fish abundance.

A population estimate of the fish in The Nature Conservancy site should be taken annually to assess the effects of the catch-and-release regulations on the fish stocks. By electrofishing sections of Silver Creek, one can estimate both the abundance of the fish and the average size of fish. Scales could also be obtained for age and growth studies.

If fishing mortality was the cause of the smaller overall size of trout in Silver Creek, then the catch-and-release regulations should allow the trout to live longer and grow larger. However, if the size of trout in Silver Creek has declined because of other factors, such as introduction of stocks that changed the genetic makeup of the population, resulting in a slower growing or shorter-lived trout, then catch-and-release regulations alone would not return the fish to the larger reported size of yesteryears. If the overall size of the trout does not increase, as is hoped with the special regulation, then other stocks of trout should be investigated for possible introduction into Silver Creek.

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