

LITTORAL DISTRIBUTION AND DRIFT
OF SELECTED RIFFLE INSECTS

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ABSTRACT

Some factors influencing drift and benthic insects in the littoral^{1/} zone of riffles were studied the summer and fall of 1971 and 1972 in the Clearwater River in north Idaho.

Benthic samples were taken at three water depths (15, 30, and 45 cm) using a $.093 \text{ m}^2$ (1 ft^2) Hess bottom sampler. Insect drift was taken on riffles at three distances from the shoreline in water depths of 30, 45 and 60 cm. Square metal frames $.093 \text{ m}^2$ (1 ft^2) with nylon netting similar to the netting used on the Hess sampler (1.1 mm mesh diameter, 7 meshes cm) were used for drift sampling.

Littoral variation in number and weight of riffle insects was shown to be affected by changes in depth and current velocity, interacting with the date and station of sampling. This differential littoral distribution of riffle insects resulted in variation of the littoral community structure. In the non-fluctuating system, community diversity and diversity per individual decreased with increasing depths to 45 cm and current velocity to 1.1 m/sec. Fluctuating flows appear to reverse the order of community structure, i.e., community diversity and diversity per individual increase with increasing depth to 45 cm and current velocity to 1.1 m/sec.

^{1/} Used in my thesis to mean a shallow, near-shore zone; a zone of water fluctuation in a river.

A flow reduction exponentially increased the number of drifting insects in zones adjacent to the exposed substrate on the shoreline. The mayflies, Baetis spp., were collected in numbers 180 times greater than the normal occurrence in drift and comprised 96% of the total drift. The mayflies Paraleptophlebia sp., Rhithrogenia undulata, and Heptagneia spp.; and the caddisflies Cheumatopsyche sp., Hydropsyche sp., and Brachycentrus sp. had increased drift rates of 10 to 40-fold each. They comprised less than 4% of the total drift.

INTRODUCTION

The study was initiated to assess the effects of diel water fluctuations on the aquatic insects below Dworshak Dam on the Clearwater River. This objective was modified to include basic research on littoral distribution and drift of aquatic insects because the study took place before the river was subjected to diel water fluctuations (July, 1971, to June 1973). This expanded objective has aided in our understanding of: (1) benthic community dynamics downstream from hydroelectric dams, and (2) the resiliency of specific insect species to diel water fluctuations.

The study occurred during a period of transition of flow status, from a naturally controlled flow to a man-regulated flow. Man-regulated flows began with the closure of the diversion tunnels at Dworshak Dam on September 27, 1971. Flows in 1971 were relatively stable, except for the September 27 diversion tunnels closure and subsequent flow reduction. Flows in 1972 were sporadically fluctuated due to man-regulation for various reasons related to completion of construction of Dworshak Dam.

The Clearwater River may be subjected to diel fluctuations of flow if Dworshak Dam is operated as a peaking facility after completion of construction in 1973. In downstream littoral areas, diel fluctuations of flow create a lotic counterpart to the marine "intertidal zone" (Fisher and LaVoy, 1972). The lotic "intertidal zone" will affect the flora and fauna by dewatering, possible desiccation, and other subtle changes. [Neel (1963) considered the main effects of]

hydroelectric dams to be the alteration of: flow patterns, temperature regimes, turbidity, water chemistry, and the resulting aquatic life. He concluded that alterations may be beneficial or deleterious in terms of altering populations of game fish.

~~Several workers have studied the effect of dams on the downstream~~
~~NUMBER AND DISTRIBUTION OF AQUATIC INSECTS.~~
~~insects.~~ Spence and Hynes (1971) reported that stoneflies were absent downstream from a flood control impoundment. Whereas, the mayflies, Baetis and Caenis; the non-biting midges, Chironomidae; the blackflies, Simuliidae; the riffle beetle, Optioservus; the caddisflies, Hydro-
 psychidae; and the freshwater shrimp, Hyalella azteca (Saussure) increased downstream from the impoundment. Pearson, Kramer, and Franklin (1968) reported the disappearance of Baetis and the stonefly, Claasenia sabulosa, below a hydroelectric dam. Powell (1958) noted that mayflies and stoneflies were more abundant upstream from a hydroelectric dam on a western river than downstream. Dipter, Coleoptera, and Trichoptera (Hydropsychidae) were more abundant downstream than upstream from the dam. Radford and Hartland-Rowe (1971) found that the abundance of the stonefly, Nemoura, and the caddisflies, Parapsyche elsis (Milne) and Glossosoma, decreased due to a hydroelectric dam.

Why are certain insect species affected more than others? A complex of factors feasible for study are the living requirements of species, which are collectively expressed in the macro and micro distribution. Another complex of factors feasible for study are the adaptive mechanisms species possess which would aid survival in fluctuating flow re-

gimes. Together with other factors, an endogenous resiliency to environmental changes has developed. The description of the limits of this resiliency is necessary.

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STUDY AREA

The study area lies in north-central Idaho between Lewiston and Greer on the Upper and Lower Clearwater River. The Lower Clearwater River begins at the confluence of the Upper and North Fork of the Clearwater River (Figure 1). Dworshak Dam is located on the North Fork.

Four sampling stations were selected on the basis of similarity in substrate type, slope, and current velocity. Two of the stations were located on the Lower Clearwater River, representing an area below Dworshak Dam. The other two stations were located on the Upper Clearwater River, representing an area not affected by the dam (Figure 1, 3). Drifting insects were sampled from benthic sampling sites 1 and 3 (Figure 1).

Geologically, the Clearwater River flows through basaltic rock from the Columbia River Plateau of Miocene times; but, upstream from Lenore erosion has exposed the Pre-Cenozoic granite of the Idaho Batholith (Gordon, Haber, Michalson and Peebles, 1970).

Within the study area the width of the Clearwater River ranges from 92 to 305 m and averages 152 m. The average gradient is 1.13 m/km.

The North Fork contributes 37% of total annual discharge from the Lower Clearwater River. Peak discharge at Spalding occurs in late May or early June, and averages $1500 \text{ m}^3/\text{sec}$ (Figure 2). Discharge during the period of low flow (August to February) averages $160 \text{ m}^3/\text{sec}$.

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and has been as low as $40 \text{ m}^3/\text{sec}$. Water temperature ranges from 0 to 27 C with highs in August and lows in December or January (Figure 2).

The major recreational uses of the Clearwater River include:
fishing (smallmouth bass and migrating adult steelhead), swimming,
rafting, and sight-seeing.

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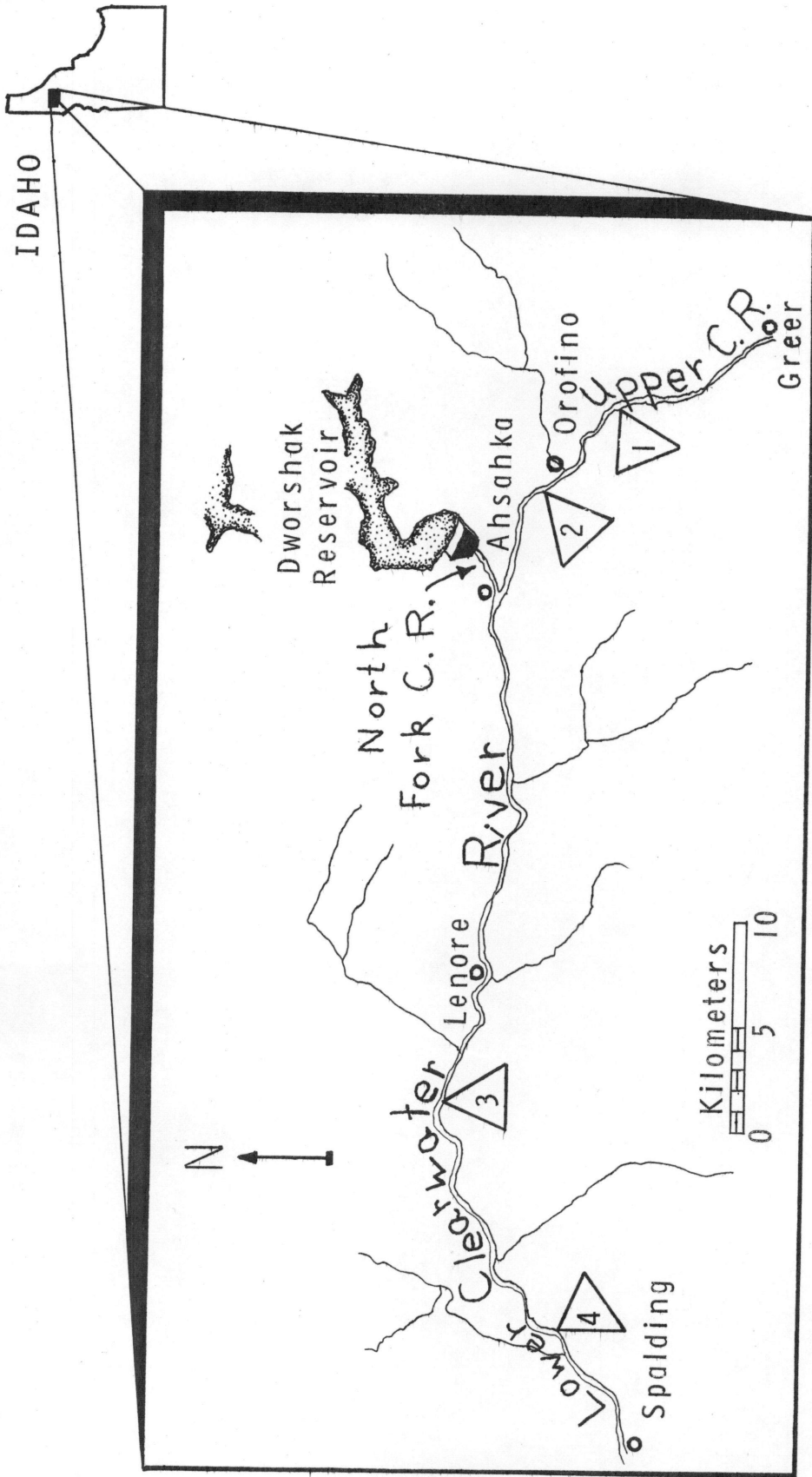


Figure 1. Study area and location of sampling stations (triangle) on the Clearwater River.

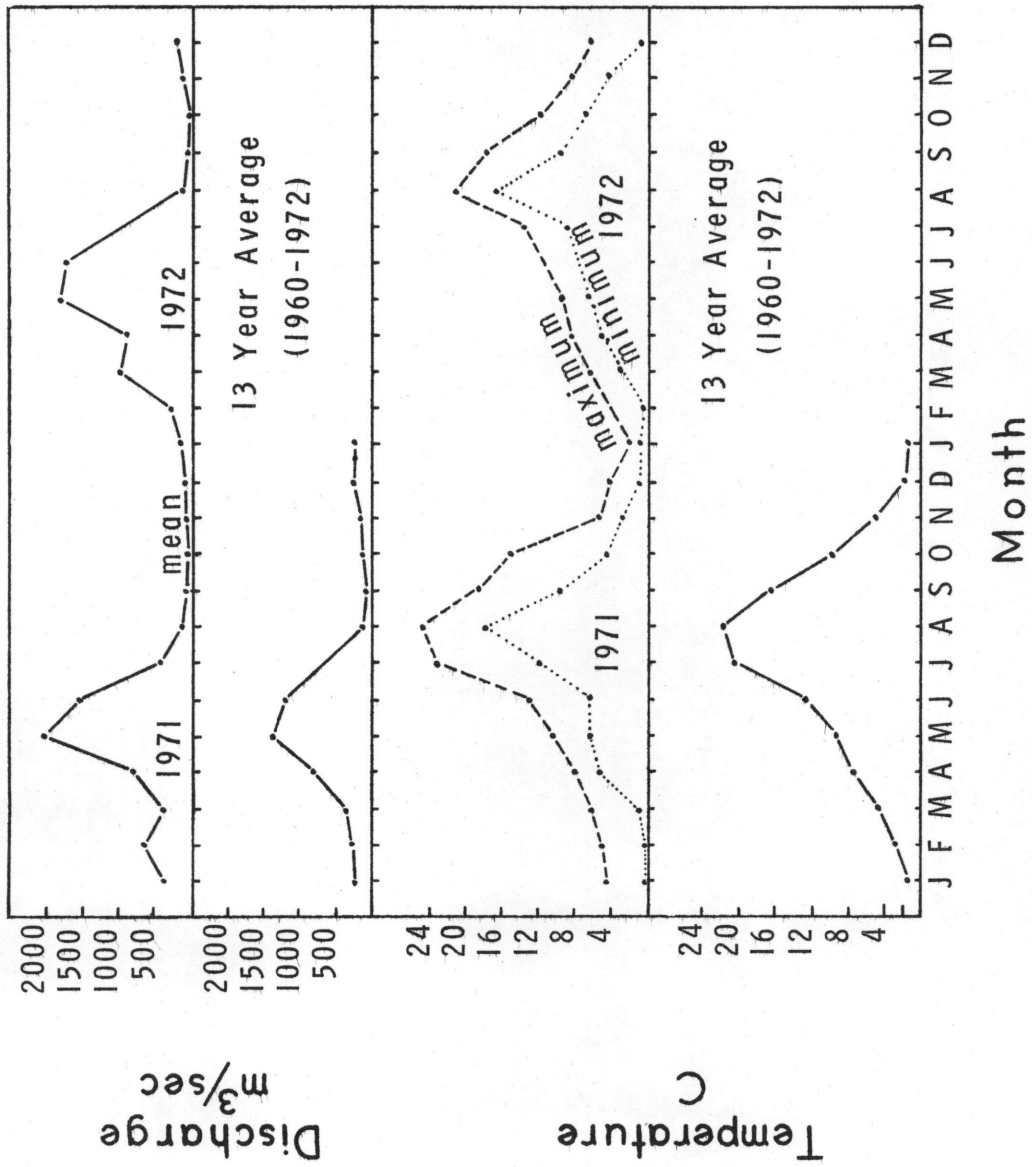


Figure 2. Monthly discharge and water temperature recorded at Spalding for 1971 to 1973, and the 13-year averages (1960-1972) on the Clearwater River. (Data from N.W. Water Resources Data Center, Water Resources Division, U.S.G.S.)

METHODS AND MATERIALS

SAMPLING SITES

Four sampling stations were selected on the basis of similarity in substrate type, slope, and current velocity. Two of the stations were located on the Lower Clearwater River, representing an area below Dworshak Dam. The other two stations were located on the Upper Clearwater River, representing an area not affected by the dam (Figure 1, 3). Drifting insects were sampled from benthic sampling sites 1 and 3 (Figure 1).

Samples were taken at two water depths (15 and 45 cm) in 1971, and three water depths (15, 30, and 45 cm) in 1972. Three random samples were taken at each depth. Current velocities were measured 2 to 5 cm above the substrate over the area sampled.

Benthic samples were preserved in 70% isopropanol in the field, sorted, counted and weighed in the laboratory.

Eight benthos collections were taken during the summer and fall seasons of 1971 and 1972.

Benthic invertebrates were also studied qualitatively by direct observation in water depths of 2 to 8 m with scuba in August and September, 1972.

Drift

The sampling apparatus consisted of $.092 \text{ m}^2 (1 \text{ ft}^2)$ frame fitted with nylon mesh similar to that used for benthic sampling. The nets were set at the surface of the water at three distances from the shoreline in water depths of 30, 45, and 50 cm (Figure 4). Net height was



Figure 3. Benthic sampling on station 3 at a water depth of 30 cm, August, 1972.

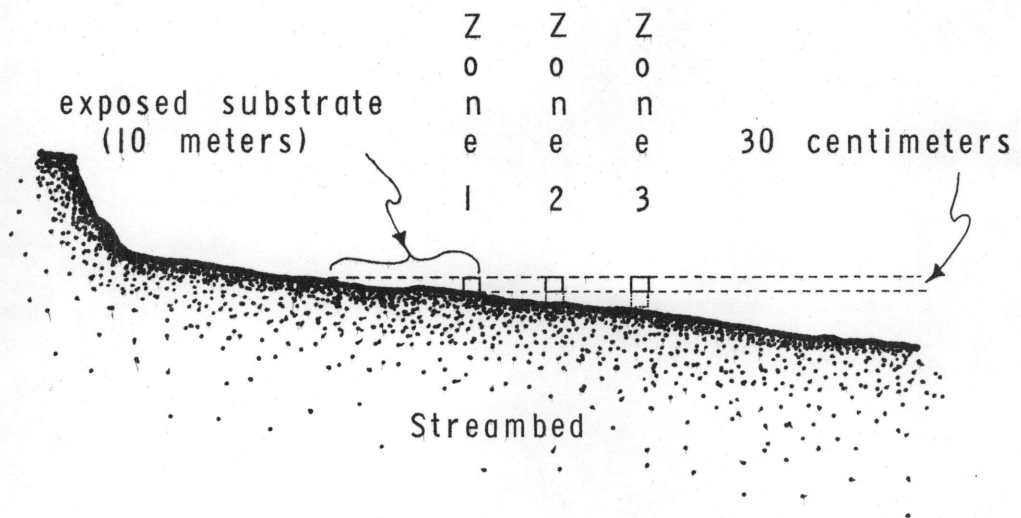


Figure 4. Schematic cross-section of a portion of river channel; and placement of drift nets in the littoral area at three water depths or zones (30, 45, and 60 cm). Broken lines illustrate water level before and after a 30 cm water level reduction.

adjusted at the surface of the water on two metal stakes via wing nuts and metal sleeves. One-hour samples were taken every three hours through a 24-hour period.

Two collections were made in 1971, corresponding closely with the time of benthic sampling.

Closure of the diversion tunnel to begin reservoir filling at Dworshak Dam provided an opportunity to assess the effects of a flow reduction on drifting insects. Drift samples were taken before, during and after the closure. Samples taken before (September 26) represented the control period; samples taken during and after (September 27 and 28) the resultant flow reduction represented the test period of stable flow conditions.

Substrate

Substrate composition was sampled on benthic stations 1, 2, 3 and 4 in August, 1972. A surber $.093 \text{ m}^2$ (1 ft^2) bottom sampler sewn with impermeable cloth was used to collect the samples. The rubble substrate prevented the usage of more efficient core samplers. Samples were randomly taken at water depths of 15, 30, and 45 cm; two samples were taken per depth.

The procedure involved scraping the substrate (to the cemented layer, approximately 5 cm) into the sampler, then seiving the resultant samples through soil screens of specific size (Table 1). Volumes for each size class were determined by liquid displacement. Silt and clay size particles were excluded.

Table 1. Average ^{1/}substrate composition by percent of total volume at three water depths (15, 30 and 45 cm), August, 1972.

Particle Size (mm)	Station 1			Station 2			Station 3			Station 4		
	15	30	45	15	30	45	15	30	45	15	30	45
.56 - 2	1	1	0	2	1	1	6	5	1	6	8	1
2 - 6	1	1	1	4	2	3	6	6	2	4	6	3
6 - 13	2	2	2	6	4	4	5	5	2	3	5	3
13 - 25	5	6	2	6	6	6	6	6	3	7	8	4
25 - 51	9	7	3	8	14	10	12	8	5	11	8	9
51 - 76	5	3	2	6	12	9	2	11	5	6	4	7
> 76	77	80	90	68	61	67	63	59	82	63	61	71

^{1/} Sample size: n = 2

Data Analysis

Community structure was described with diversity indices, derived from information theory by Shannon and Weaver (1963).

$$\text{Community diversity (H)} = -k \left(\sum_{i=1}^m n_i \log_2(n_i/N) \right)$$

$$\text{Diversity per individual } (\bar{H}) = -k \left(\sum_{i=1}^m (n_i/N) \log_2(n_i/N) \right)$$

$$\text{Minimum diversity (H}_{\min}) = k(\log_2 N! - \log_2(N-m+1)!)$$

$$\text{Maximum diversity (H}_{\max}) = k(\log_2 N! - m \log_2(n/m)!)$$

$$\text{Redundance (R)} = (H_{\max} - H) / (H_{\max} - H_{\min})$$

Where: m = the number of species per unit area
 n_i = the number of individuals in the i^{th} species
 N = the total number of individuals per unit area
 $k = 1$

Papers by Margalef (1958), Patten (1962) and Pielou (1967) provided further understanding of the biological applications of information theory.

Community diversity reflects the distribution of individuals among taxa in a population, i.e., community structure.

Diversity per individual represents the mean diversity each individual contributes to the community structure, and is equated to the uncertainty which exists regarding the species of an individual selected at random from a population. Both community diversity and diversity per individual indicate the relative stability of a community; generally the more stable communities are associated with more complete utilization of the available niches.

Redundancy represents the position of a community between maximum and minimum diversity. Maximum diversity occurs when all individuals are equally divided among the species. Minimum diversity occurs when one species has $N-m$ individuals and all other species represented have one individual each. The unequal abundance of individuals per species in a population constitutes repetition for common species, i.e., redundancy.

All diversity calculations were performed on data converted to a square-meter from the mean of three $.093 \text{ m}^2$ samples at each depth.

On selected taxa, I tested the hypothesis that no significant difference in numbers or weight of insects per $.093 \text{ m}^2$ occurred among depths, stations, and dates of sampling. The taxa were selected on the basis of abundance and order representation. These tests were made with and without adjustment of the means for current velocity, using a $4 \times 4 \times 3$ factorial design with three replicates. A square-root transformation on weight and a base ten logarithm transformation on the number + 1 [$\log (\text{number} + 1)$] was used to normalize the distributions and equalize the variances.

RESULTS

Physical Parameters

Substrate composition was relatively homogeneous at stations 2, 3 and 4; station 1 differed slightly in having substantially less sand (.2 - 2 mm) and small pebbles in the size range of 2 to 13 mm (Table 1). The substrates at stations 1, 2, 3 and 4 are characteristically loosely held (not embedded and predominately "fist-size" (76 - 130 mm)).

I found no consistent difference in substrate composition among the three sampling depths (Table 1).

Discharge during the peak flow period in 1971 and 1972 was above the 13-year average (Figure 2); flooding occurred in 1972 in the study area. Flows in 1971 were relatively stable excluding the water level reduction due to the closure of Dworshak Dam diversion tunnel in September, 1971. Flows in 1972 below Dworshak Dam were sporadically fluctuated with a minimum of five short-duration fluctuations. The amplitude of the water level fluctuations ranged from 45 to 100 cm and generally occurred within 1 hr (personal communication, Idaho Fish and Game Department personnel).

Water Chemistry

The chemical parameters pH, turbidity, dissolved oxygen, carbon dioxide, alkalinity, and hardness apparently varied with time of the year, but not significantly with flow (Table 2). Phos-

Table 2. Monthly water chemistry ^{1/} for the Clearwater River at Lenore, 1971.

	pH	O ₂ (mg/l)	CO ₂ (mg/l)	Turb (mg/l)	Alkalinity (mg/l)	Hardness (mg/l)	Phosphate (mg/l)
Month							
Jan	7.2	13.2	nd ^{2/}	nd	nd	34.2	nd
Feb	7.3	9.0	5	2.5	51.3	34.2	0.20
Mar	7.2	12.0	5	5.0	51.3	34.2	0.20
Apr	7.3	13.0	5	4.0	27.4	34.2	0.08
May	7.2	10.0	5	7.0	27.4	34.2	0.08
Jun	7.0	11.2	5	3.7	13.7	17.1	0.06
Jul	7.2	9.9	5	2.0	17.1	34.2	0.22
Aug	7.2	8.8	5	0.0	34.2	34.2	-
Sep	7.1	9.8	0	-	34.2	34.2	0.20
Oct	7.2	9.8	5	0.0	41.2	34.2	0.29
Nov	7.1	12.4	5	8.5	20.0	20.0	0.02
Dec	7.2	-	1	8.5	30.0	20.0	0.10

^{1/}

Taken from Dworshak Fisheries Studies, Idaho Fish and Game Department Annual Report, 1971. DSS-29 Jobs 1, 2 and 3; Ball, K. and W. Cannon.

^{2/}

nd = no data

phate levels followed a bimodal annual cycle with peaks in late-winter or early-spring and summer (Table 2).

Littoral Community Structure

In 1971 community diversity (H) was greater at the 45 cm water depth than the 15 cm depth for stations 1 and 2; at stations 3 and 4 the 15 cm water depth had a greater H than the 45 cm depth (Figure 6). In 1972 H at the 15 cm depth was consistently lower than the 30 and 45 cm depths were apparent during 1972. At all stations and depths H was consistently greater in 1971 than 1972 (Figure 5 and 6).

H showed a fall cycle of increasing values from late summer to late fall (Figure 6).

Diversity per individual (\bar{H}) at the 45 cm depth was consistently less than the 15 cm depth for all stations in 1971 and 1972 (Figure 7). In 1972 \bar{H} for the 30 cm depth at stations 1 and 2 was consistently similar to the 45 cm depth; although, at stations 3 and 4 no definite trend was observed. 1972 samples showed greater variability in \bar{H} among the three water depths (15, 30 and 45) than the 1971 samples.

Redundancy (R) was generally greatest for 1971 and 1972 at the 45 cm depth with increasing values as depth increased (Figure 5). R appeared to have a fall cycle; R increasing into early fall and decreasing in late fall (Figure 8).

The average number of taxa taken per sample in 1971 and 1972 stayed constant at the three sampling depths for each year; they were 22 and 18 respectively for the two years (Figure 5).

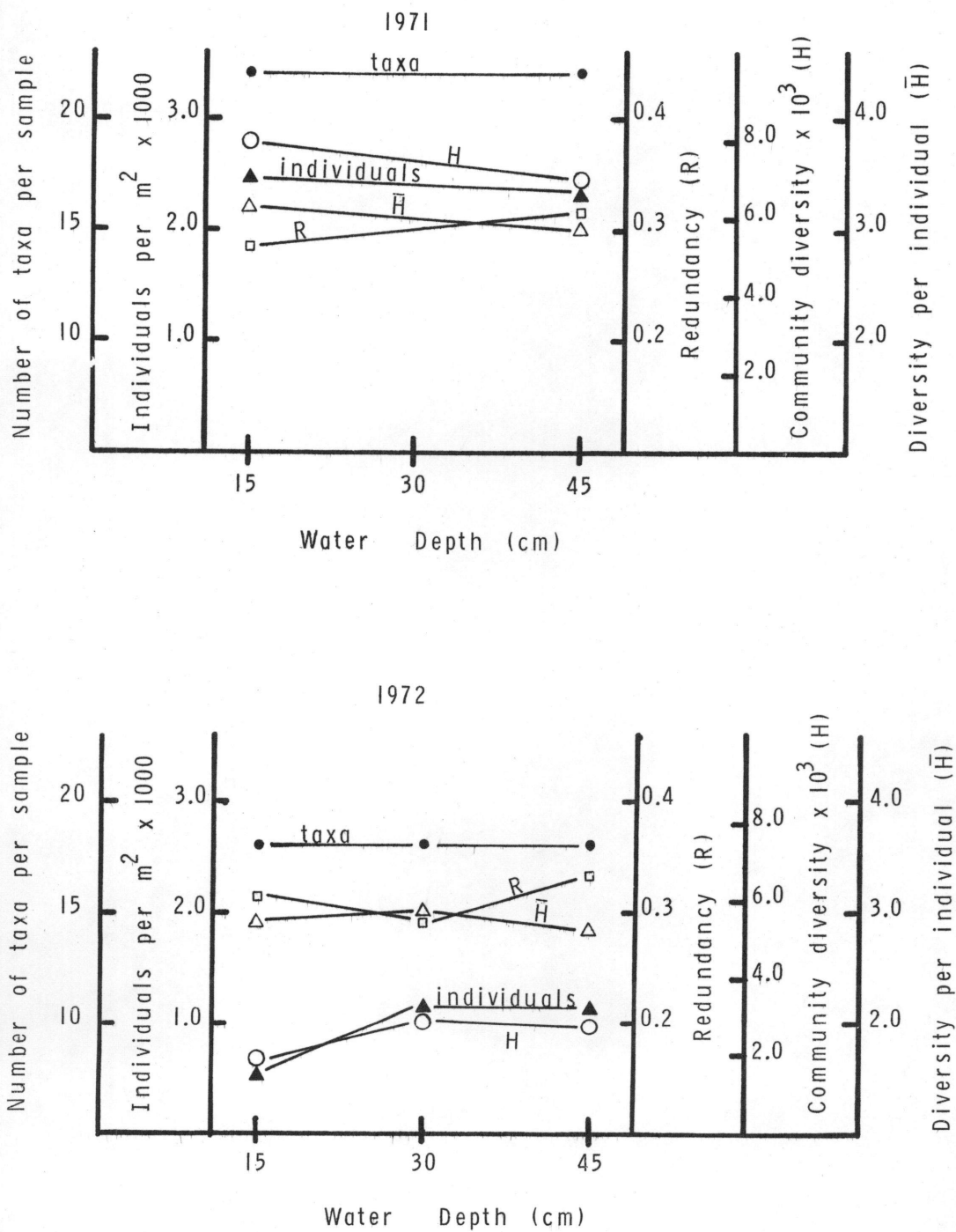


Figure 5. Community structure at three water depths (15, 30 and 45 cm), at stations 1, 2, 3 and 4 for August to November, 1971, and July to October, 1972.

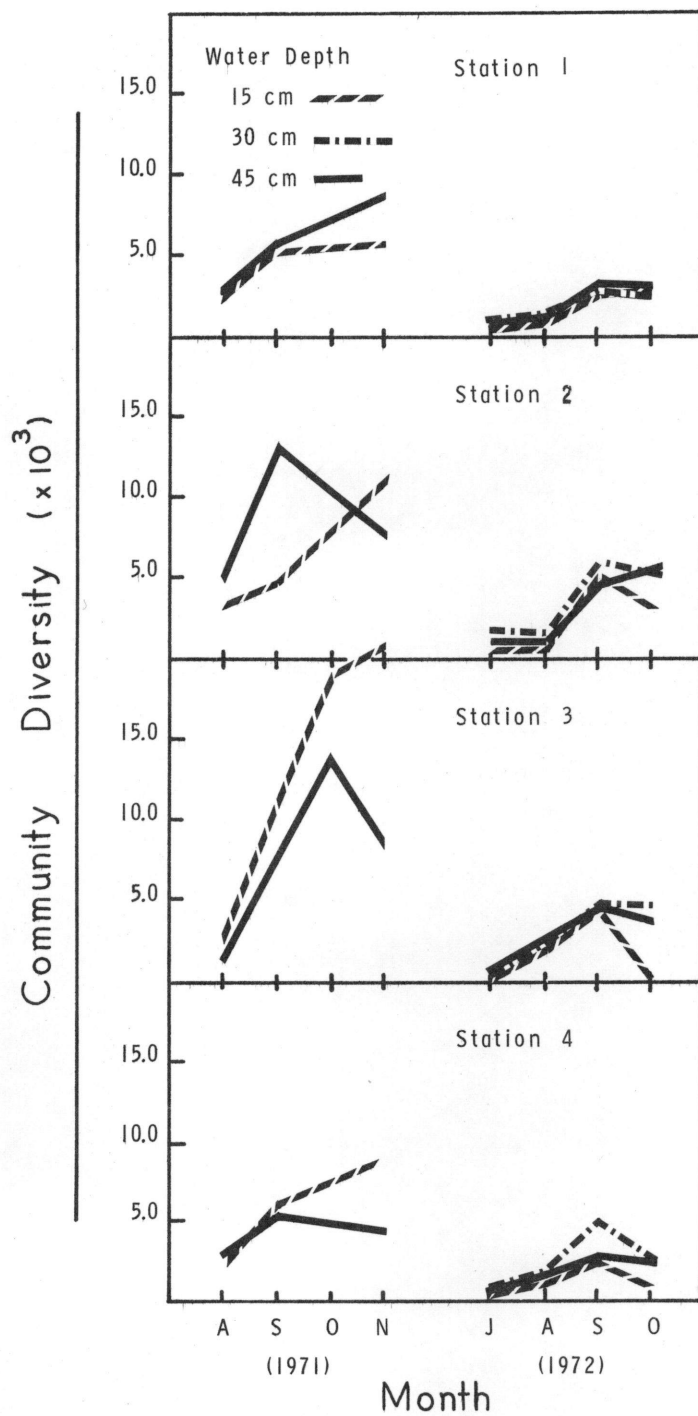


Figure 6. Community diversity at three water depths (15, 30, and 45 cm), at stations 1, 2, 3 and 4 for August to November, 1971, and July to October, 1972.

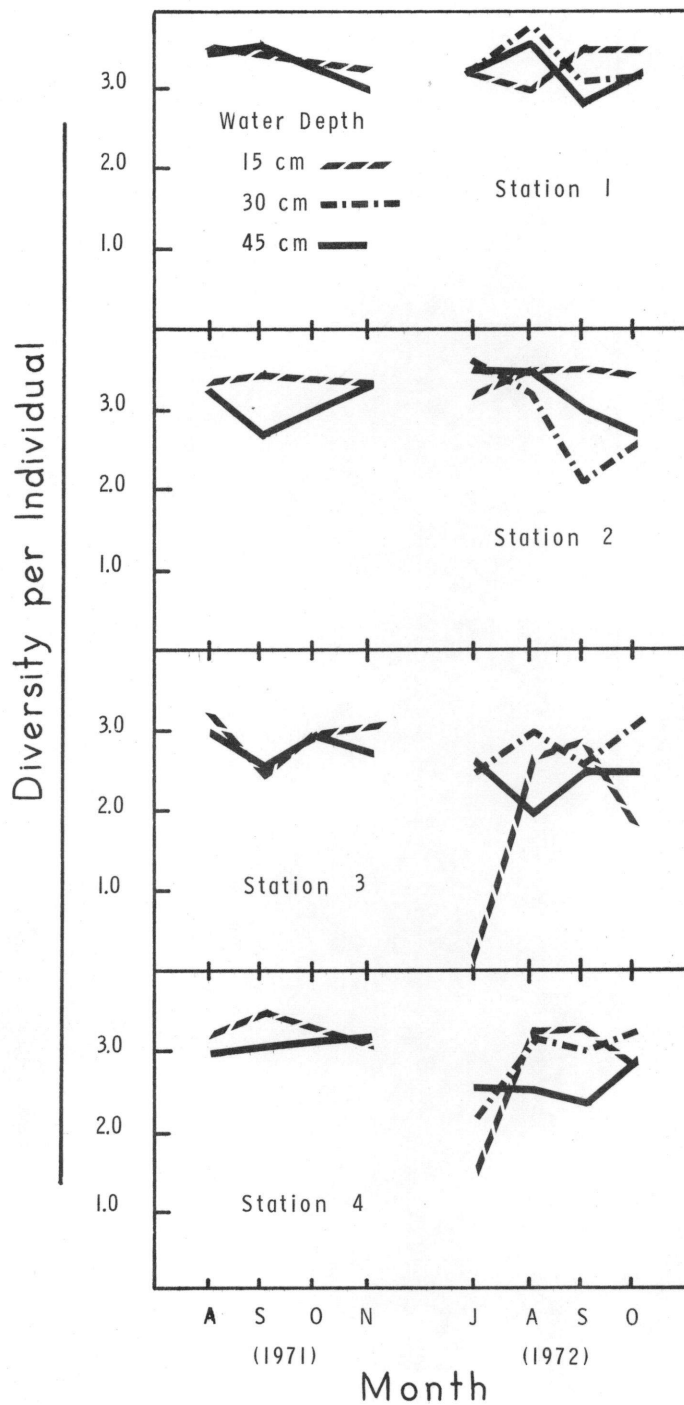


Figure 7. Diversity per individual at three water depths (15, 30 and 45 cm), at stations 1, 2, 3 and 4 for August to November, 1971, and July to October, 1972.

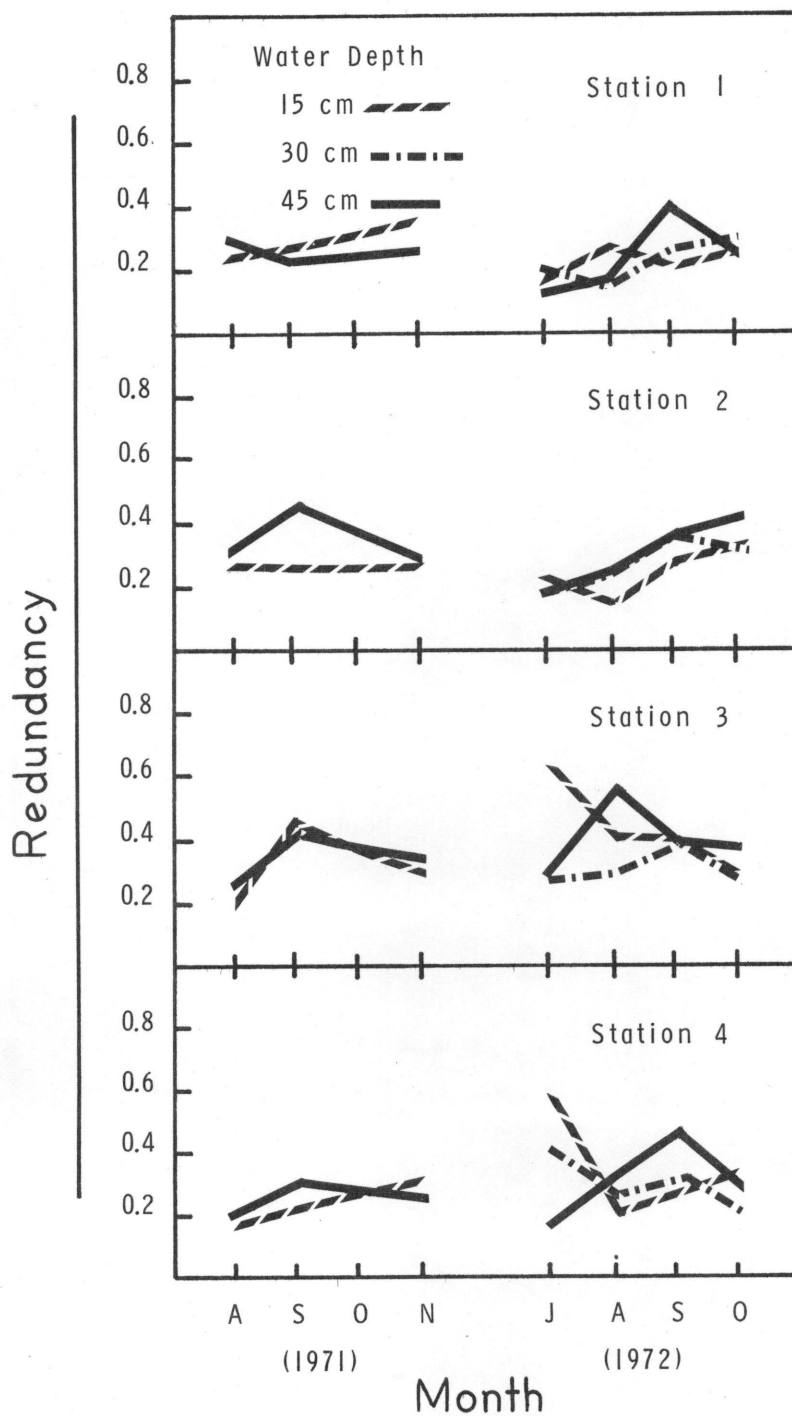


Figure 8. Redundancy at three water depths (15, 30 and 45 cm), at stations 1, 2, 3 and 4 for August to November, 1971, and July to October, 1972.

Littoral Distribution

The littoral distribution of the mayflies, Baetis spp. and Ephemera margarita (Needham); the caddisflies, Hydropsyche sp., Cheumatopsyche sp., and Brachycentrus sp.; and, the non-biting midges Tendipedidae was significantly affected (5% level) by depth (or some factor associated with depth) and current velocity; and significantly (5% level) depending upon date and station of sampling (Table 3 and 4).

Baetis spp. abundance and biomass increased with increasing depth to 45 cm and current velocity to 1.1 m/sec (Table 5); the magnitude of variation among the depths was affected by the station (Table 3 and 4). The abundance and biomass were more variable at stations 1 and 3 than stations 2 and 4.

Ephemera margarita abundance and biomass increased with increasing depth to 45 cm and current velocity to 1.1 m/sec (Table 5); although, the date of sampling tempered the magnitude of increase along the depth gradient (Table 3 and 4). The abundance and biomass of E. margarita in July and September were significantly less than the August and October samples at all three depths.

Hydropsyche sp. and Brachycentrus sp. abundance and biomass increased with increasing depth to 45 cm and current velocity to 1.1 m/sec (Table 5), depending upon the date and station of sampling. Hydropsyche sp. showed no depth preference in the July samples. Furthermore, the abundance of Hydropsyche sp. at the three depths for stations 1 and 2 was less than the abundance at stations 3 and 4. Brachycentrus sp. abundance and biomass

at all depths increased during the July to October sampling period (Table 3 and 4). Stations 1 and 4 had less biomass of Brachycentrus sp. than stations 2 and 3 for all depths.

Cheumatopsyche sp. abundance and biomass at each depth than the September and October samples (Table 3 and 4); although, the depth-current velocity related increase still prevailed. *Incomplete*

Tendipedidae decreased in numbers and biomass with increasing depth to 45 cm and current velocity to 1.1 m/sec (Table 5); biomass also depended upon the station of sampling (Table 3 and 4). Stations 1 and 2 had less biomass of Tendipedids than stations 3 and 4.

The variation in littoral distribution of the stonefly Arcynopteryx sp.; the mayflies Paraleptophlebia bicornuta (McDonnough), Rhithrogenia undulata (Banks), Heptagenia solitaria (McDonnough), and Ameletus sp.; and, the riffle beetle Zaitzevia sp. was only partially accounted for in the main effects of depth and current velocity, although significantly (5% level) depending upon the date and station of sampling (Table 3 and 4).

Arcynopteryx sp. increased in abundance and biomass per sample from July to October. In August and September Arcynopteryx sp. numbers and biomass were greatest at the 30 cm depth, with the 15 and 45 cm depths being equal to each other, but less than the 30 cm depth. The peak abundance of Arcynopteryx sp. at the 30 cm depth was at stations 1 and 3 (Table 5); station 2 had no apparent depth differential and station 4 had increasing biomass and abundance with increasing depth to 45 cm and current velocity to 1.1m/sec.

Table 3. Mean squares of the significant^{1/} main effects, interaction effects, and error term for number and weight (weight in parenthesis) of selected taxa, without mean adjustment for current velocity, July to October, 1972.

Degrees of Freedom	Main effects			Interaction terms			Error
	3	3	2	9	6	6	142
Taxa	Date	Station	Depth	Station x Date	Depth x Date	Station x Depth	Error
Ephemeroptera							
<u>Ameletus</u> sp.	.374 (.010)		.275 (.008)	.107 (.004)	(.001)		.024 (.001)
<u>Baetis</u> spp.	.260		.589 (.009)			.131	.054 (.001)
<u>Rhithrogenia</u> <u>undulata</u>	14.016 (.344)		.235 (.018)		.448 (.028)		.069 (.003)
<u>Heptagenia</u> <u>solitaria</u>	.872 (.030)	.766 (.022)	(.006)	.214 (.005)	(.003)		.059 (.001)
<u>Ephemerella</u> <u>margarita</u>	3.326 (.103)	.740 (.022)	.951 (.020)	.279 (.007)	.246 (.005)		.053 (.001)
<u>E. grandis</u>	.435 (.007)	.334 (.006)		.132 (.003)			.022 (.001)
<u>Paraleptophlebia</u> <u>bicornuta</u>	1.056 (.031)	.232 (.008)	.622 (.024)	.104 (.004)	.241 (.013)	.120 (.004)	.028 (.001)
Plecoptera							
<u>Arcynopteryx</u> sp.	1.778 (.237)	.283 (.029)	.223 (.025)	.247 (.012)	.145 (.025)	.131 (.015)	.047 (.006)
<u>Claassenia</u> sp.	.121	.462			.080 (.055)		.035 (.019)
Trichoptera							
<u>Hydropsyche</u> sp.	6.157 (.936)	2.402 (.535)	3.409 (.492)	1.032 (.133)	.356 (.072)	.409 (.102)	.082 (.014)
<u>Cheumatopsyche</u> sp.	10.501 (.750)	.495 (.068)	3.728 (.220)	.349 (.022)	.270 (.042)		.106 (.010)
<u>Brachycentrus</u> sp.	4.120 (.592)	2.984 (.262)	1.544 (.134)	1.181 (.162)	.192 (.040)	(.020)	.076 (.007)
Diptera							
Tendipedidae	.689 (.004)	1.143 (.014)	.899 (.011)	.323 (.003)		(.002)	.102 (.001)
Tipulidae	.576 (.130)	.121					.044 (.010)
Coleoptera							
<u>Zaitzevia</u> sp.	.170 (.001)	.075 (.001)	.099 (.0007)				.026 (.0001)
Lepidoptera							
<u>Paragyraetis</u> sp.	.468 (.013)	.073 (.003)		.059 (.002)			.026 (.0005)

^{1/}

P ≤ 0.05

Table 4. Mean squares of the significant^{1/} main effects, interaction effects, and error term for number and weight (weight in parenthesis) of selected taxa, with mean adjustment for current velocity, July to October, 1972.

Degrees of freedom	Main effects			Interaction terms			Error
	3 Date	3 Station	2 Depth	9 Station x Date	6 Depth x Date	6 Station x Depth	142 Error
Taxa							
Ephemeroptera							
<u>Ameletus</u> sp.	.353 (.010)			.108 (.004)			.024 (.001)
<u>Baetis</u> spp.	.263		.168				.054
<u>Rhithrogenia</u> <u>undulata</u>	13.594 (.336)				.434 (.028)		.069 (.003)
<u>Heptagenia</u> <u>solitaria</u>	.810 (.026)	.752 (.022)		.208 (.004)		.003	.059 (.001)
<u>Ephemerella</u> <u>margarita</u>	3.112 (.096)	.751 (.023)	.187	.212 (.004)	.243 (.006)		.053 (.001)
<u>E. grandis</u>	.380 (.006)	.185 (.003)		.120 (.003)			.022 (.001)
<u>Paraleptophlebia</u> <u>bicornuta</u>	.952 (.031)	.192 (.007)		.083 (.004)	.202 (.012)	.120 (.004)	.028 (.001)
Plecoptera							
<u>Arcynopteryx</u> sp.	1.074 (.223)	.224 (.019)		.226 (.012)	.147 (.024)	.131 (.014)	.047 (.006)
<u>Claassenia</u> sp.	.136	.470					.035
Trichoptera							
<u>Hydropsyche</u> sp.	5.964 (.873)	2.132 (.460)	.396 (.096)	.530 (.096)	.374 (.074)	.312 (.066)	.081 (.014)
<u>Cheumatopsyche</u> sp.	10.053 (.707)	.339 (.061)	.913 (.061)	.260 (.020)	.268 (.038)		.107 (.010)
<u>Brachycentrus</u> sp.	3.687 (.572)	2.371 (.199)	.480 (.034)	1.069 (.147)	.189 (.039)	.017	.077 (.007)
Diptera							
Tendipedidae	.688 (.004)	1.156 (.013)	.356	.326 (.003)		.002	.102 (.001)
Tipulidae	.578 (.132)						.045 (.010)
Coleoptera							
<u>Zaitzevia</u> sp.	.162 (.001)	.076 (.001)					.026 (.0002)
Lepidoptera							
<u>Paragyraetis</u> sp.	.431 (.012)			.059 (.002)			.026 (.0005)

^{1/} P ≤ 0.05

Table 5. Mean^{1/} number and weight (mg in parenthesis) of selected benthic insects per m² of substrate, at the 15, 30 and 45 cm water depths of stations 1, 2, 3 and 4, July to October, 1972.

Taxa	Water depth (cm)		
	15	30	45
<u>Ephemeroptera</u>			
<u>Ameletus</u> sp.	6.14 (11.72)	2.45 (2.76)	1.29 (.53)
<u>Baetis</u> spp.	1.07 (.27)	5.49 (3.86)	8.91 (11.02)
<u>Rhithrogenia undulata</u>	23.04 (45.48)	32.38 (95.11)	35.05 (111.99)
<u>Heptagenia solitaria</u>	(19.90)	(14.74)	(4.75)
<u>Ephemerella margarita</u>	4.80 (5.21)	16.59 (32.56)	16.77 (38.75)
<u>Paraleptophlebia bicornuta</u>	9.32 (25.84)	3.76 (3.11)	1.15 (.39)
<u>Plecoptera</u>			
<u>Arcynopteryx</u> sp.	5.53 (31.39)	11.57 (97.14)	9.23 (95.11)
<u>Trichoptera</u>			
<u>Hydropsyche</u> sp.	22.58 (232.60)	56.84 (733.25)	59.22 (843.89)
<u>Cheumatopsyche</u> sp.	21.97 (127.88)	78.56 (525.72)	87.18 (569.41)
<u>Brachycentrus</u> sp.	7.99 (52.74)	26.47 (242.19)	28.95 (279.01)
<u>Diptera</u>			
Tendipedidae	64.39 (57.36)	57.94 (37.47)	31.02 (19.90)
<u>Coleoptera</u>			
<u>Zaitzevia</u> sp.	4.40 (1.55)	3.30 (.87)	1.34 (.17)

^{1/} Sample size: n = 12

In July and October Paraleptophlebia bicornuta numbers and weight per sample were equal at the 15 and 45 cm depths, with the 30 cm depth having less number and weight. August and September abundance and biomass of P. bicornuta decreased with increasing depth to 45 cm and current velocity to 1.1 m/sec (Table 5). At stations 1, 3 and 4 numbers and weight of P. bicornuta decreased with increasing depth. At station 2 all depths were approximately equal in abundance and biomass.

Rhithrogenia undulata (Banks) abundance and biomass along the littoral area increased with increasing depth to 45 cm and current velocity to 1.1 m/sec in July, August, and October (Table 3, 4 and 5); in September no depth differential was apparent.

The date of sampling affected the distribution pattern of Hep- tagenia solitaria. July, August, and September samples had a decreasing abundance and biomass with increasing depth to 45 cm (Table 5), and October samples had greatest abundance and biomass at the 30 cm depth.

Ameletus sp. and Zaitzevia sp. abundance and biomass decreased with the increasing depth and current velocity (Table 5).

The mayfly, Ephemerella grandis (Eaton); the stonefly, Claas- senia sp.; and the true crane fly, Tipulidae had no significant difference in abundance and/or biomass in the sampled littoral zone.

Qualitative observations with scuba in water depths of 2 to 8 m indicated the deep riffle areas of the Clearwater River have substantially less biomass and abundance of insects than the shallow zones (15 to 45 cm).

Littoral Drift

I found no apparent difference in drift rate of immature insects among the three sampled zones during stable flow conditions in September (Figure 9) and November, 1971.

Closure of the diversion tunnel at Dworshak Dam resulted in a water level reduction of 30 cm at station 3. The water level reduction took place during daylight hours (1620 to 1700 hr). Total drift rate of immature insects while the water level was receding did not differ from the controls (Figure 9). However, after darkness the total drift rate of immature insects was respectively 5 and 95 times greater than the controls at zones 3 and 2 of station 3.

Drift rates were suppressed during early evening after the flow reduction for Paraleptophlebia sp., Heptagenia spp., Brachycentrus sp., Hydropsyche sp., and Cheumatopsyche sp. at zone 2 (Table 6). No suppression of drift for the above species occurred at zone 3 (Table 7). Rhithrogenia undulata and Baetis spp. drift did not show any suppression early in the evening at zone 2, respectively exhibiting 10 and 180 times greater drift than the controls (Table 6). At zone 3 Baetis spp. was 10 times greater than the control, while R. undulata did not differ from the control (Table 7).

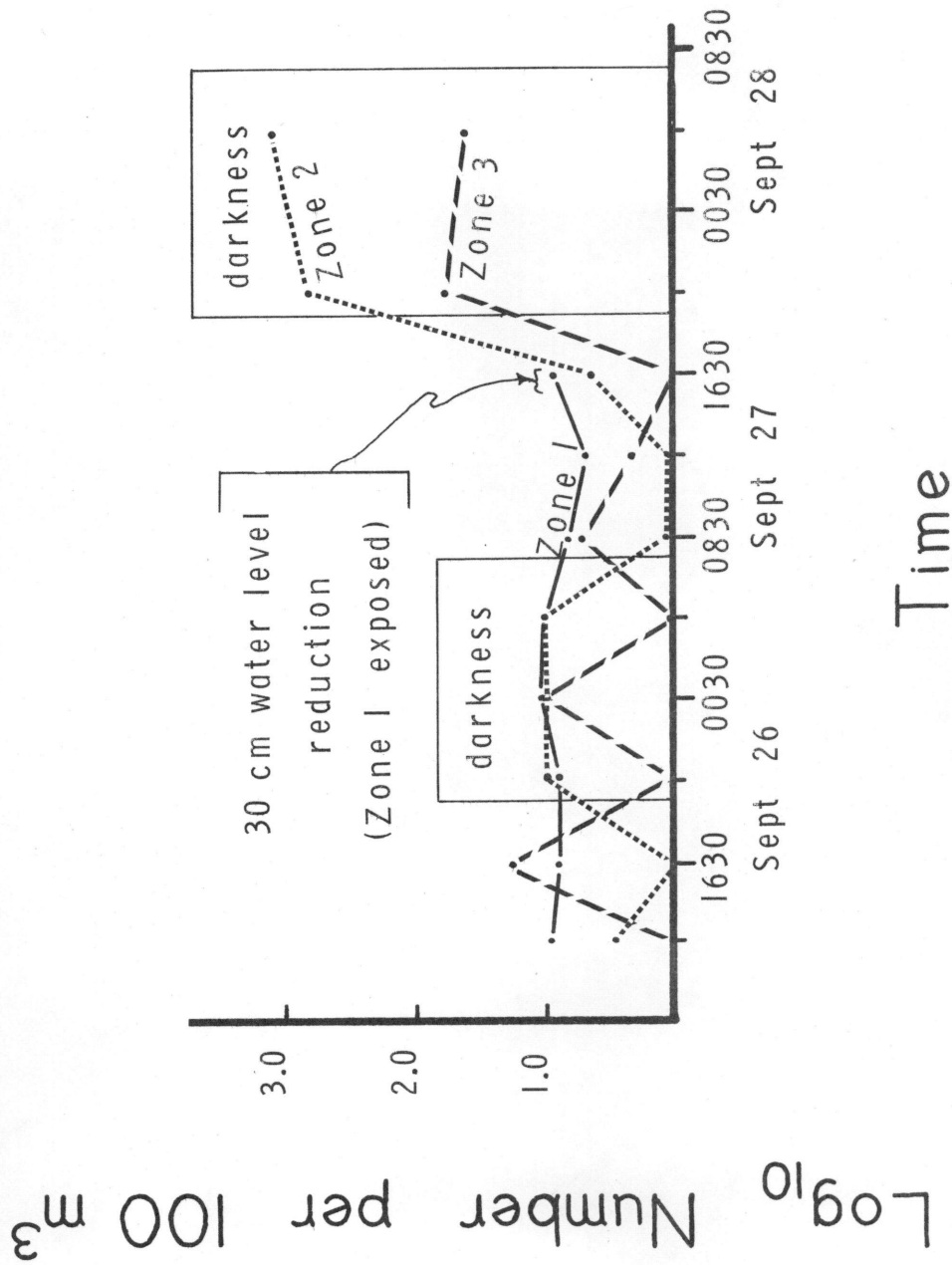


Figure 9. Immature insect drift in \log_{10} of the number per 100 m³ of water at station 3, before, during and after a 30 cm water level reduction (September 26, 27 and 28, 1971).

Table 6. Drift of immature insects among frequently occurring taxa at station 3, zone 2. The values given are in terms of number and weight (mg in parenthesis) per 100 m³ of water, for periods before, during and after a 30 cm water level reduction (September 26, 27 and 28, 1971).

Taxa	Sept 26			Sept 27			Sept 28					
	1230	1630	2030	0030	0430	0830	1230	1630	2030	0030	0430	
Ephemeroptera												
<u>Baetis</u> spp.	0	0	4	7	10	0	0	0	686	nd ^{1/}	1237	
	(0)	(0)	(8)	(13)	(24)	(0)	(0)	(0)	(1477)	(nd)	(2262)	
<u>Rhithrogenia</u>	0	0	0	0	1	0	0	1	5	nd	12	
<u>undulata</u>	(0)	(0)	(0)	(1)	(0)	(0)	(0)	(0)	(5)	(nd)	(20)	
<u>Heptagenia</u> spp.	0	0	0	0	0	0	0	0	0	nd	12	
	(0)	(0)	(0)	(1)	(1)	(0)	(0)	(0)	(0)	nd	(65)	
<u>Paraleptophlebia</u> sp.	0	0	3	2	1	0	0	0	0	nd	12	
	(0)	(0)	(12)	(16)	(8)	(0)	(0)	(0)	(0)	(nd)	(70)	
Trichoptera												
<u>Hydropsyche</u> sp.	0	0	0	1	0	0	0	0	0	nd	23	
	(0)	(2)	(0)	(5)	(0)	(0)	(1)	(0)	(0)	(nd)	(126)	
<u>Cheumatopsyche</u> sp.	0	0	2	1	0	0	0	2	0	nd	18	
	(1)	(0)	(8)	(4)	(2)	(0)	(0)	(4)	(0)	(nd)	(35)	
<u>Brachycentrus</u> sp.	0	0	0	0	0	0	0	0	0	nd	6	
	(2)	(0)	(0)	(2)	(2)	(0)	(0)	(0)	(0)	(nd)	(4)	
Diptera												
Tendipedidae	1	0	0	1	0	1	0	0	0	nd	0	
	(0)	(0)	(0)	(0)	(0)	(1)	(0)	(0)	(0)	(nd)	(0)	

^{1/}

nd: no data available

Table 7. Drift of immature insects among frequently occurring taxa at station 3, zone 3. The values given are in terms of number and weight (mg in parenthesis) per 100 m³ of water, for periods before, during and after a 30 cm water level reduction (September 26, 27, and 28, 1971).

Taxa	Sept 26			Sept 27			Sept 28					
	1230	1630	2030	0030	0430	0830	1230	1630	2030	0030	0430	
Ephemeroptera												
<u>Baetis</u> spp.	0 (0)	6 (15)	0 (0)	6 (6)	1 (1)	2 (6)	0 (1)	0 (0)	0 (0)	55 (109)	nd ^{1/} (nd)	28 (39)
<u>Rhithrogenia</u> <u>undulata</u>	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)	nd (nd)	2 (0)
<u>Heptagenia</u> spp.	0 (0)	1 (2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	nd (nd)	1 (2)
<u>Paraleptophlebia</u> sp.	0 (0)	8 (57)	0 (0)	3 (19)	0 (0)	1 (8)	0 (0)	0 (0)	0 (0)	0 (0)	nd (nd)	0 (0)
Trichoptera												
<u>Hydropsyche</u> sp.	0 (0)	1 (4)	0 (0)	2 (7)	0 (0)	1 (2)	0 (0)	0 (0)	0 (0)	0 (0)	nd (nd)	2 (8)
<u>Cheumatopsyche</u> sp.	0 (1)	1 (5)	0 (0)	0 (3)	0 (2)	0 (0)	1 (3)	0 (0)	0 (0)	1 (1)	nd (nd)	5 (10)
<u>Brachycentrus</u> sp.	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (3)	nd (nd)	2 (3)
Diptera												
Tendipedidae	1 (0)	0 (0)	0 (0)	1 (0)	0 (0)	1 (1)	0 (0)	0 (0)	0 (0)	0 (0)	nd (nd)	0 (0)

^{1/} nd: no data available

Drift of Baetis spp. at zones 2 and 3 just prior to dawn was respectively 100 times and 30 times greater than the controls (Table 6 and 7).

Late evening and early morning samples at zone 2 for Paraleptophlebia sp., Rhithrogenia undulata, Cheumatopsyche sp., and Brachycentrus sp. showed a 10-fold increase over the controls (Table 6). At zone 2 Heptagenia spp. increased 40-fold and Hydropsyche sp. 20-fold during the same period.

I found no apparent difference between controls and tests at zone 3 during late evening and early morning for Paraleptophlebia sp., Rhithrogenia undulata, Heptagenia spp., Hydropsyche sp., Cheumatopsyche sp. and Brachycentrus sp. (Table 7).

Relationship of Benthos and Drift at Zone 2

At zone 2 (water depth 45 cm) on the day prior to the flow reduction, Baetis spp. comprised 53% of the 24-hour drift sample and increased to 96% the day of the flow reduction (Figure 10). Although Baetis spp. comprised most of the drift samples, the percentage in benthos was only 0.5% (Figure 10). Hydropsyche sp. and Cheumatopsyche sp., respectively, contributed 15% and 50% of the benthos, and 7% of the drift on the control day (September 26) and 2% during the day of the flow reduction. Paraleptophlebia sp. accounted for 16% of the drift on the control day and 0.5% the day of flow reduction with 2% of the total benthic composition (Figure 10).

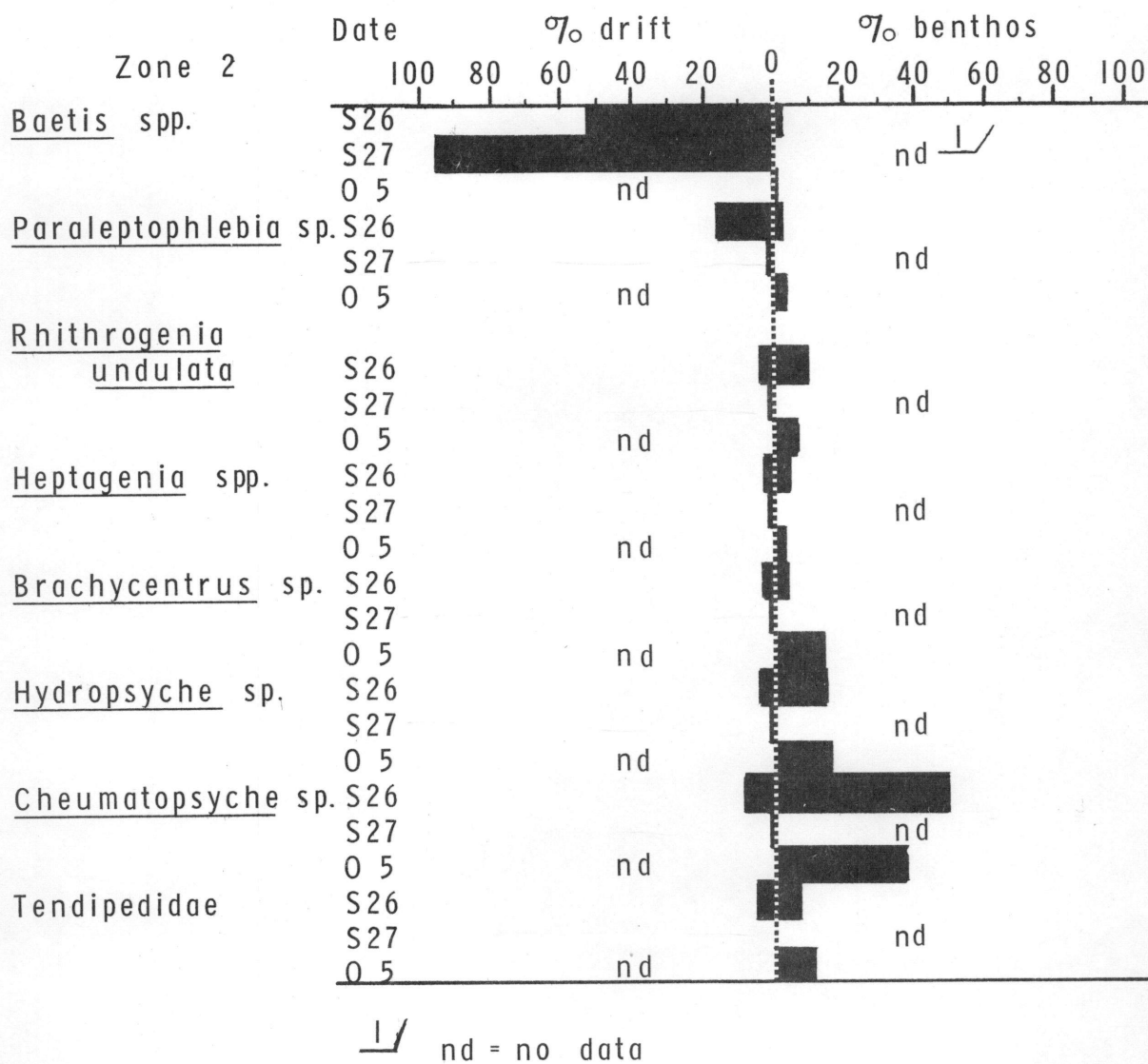


Figure 10. Percentage of total benthic and drifting insects among frequently occurring taxa at station 3, zone 2, on September 26 (S26), 27 (S27), and October 5 (O 5), 1971.

Table 8. Mean^{1/} number and weight (mg in parenthesis) of selected benthic insects per m² of substrate at the 45 cm water depth of station 3 before and after a flow reduction (September 26 and October 5, 1971).

Taxa	Date	
	September 26	October 5
Ephemeroptera		
<u>Baetis</u> spp.	22 (37)	36 (82)
<u>Rhithrogenia undulata</u>	412 (451)	639 (1341)
<u>Heptagenia</u> spp.	190 (552)	172 (825)
<u>Paraleptophlebia</u> sp.	93 (67)	65 (51)
Trichoptera		
<u>Hydropsyche</u> sp.	617 (4758)	1245 (7270)
<u>Cheumatopsyche</u> sp.	2074 (7278)	1510 (7294)
<u>Brachycentrus</u> sp.	161 (726)	165 (1065)
Diptera		
Tendipedidae	287 (183)	402 (86)

^{1/}

Sample size: n=3

The relative abundance of Rhithrogenia undulata, Heptagenia spp., Brachycentrus sp. and Tendipedidae decreased to less than 1% of the total insect abundance in drift as a result of exponential increase in Baetis spp. (Figure 10). Prior to the flow reduction these taxa showed relatively equal representation in drift and benthos: Rhithrogenia undulata (5%), Heptagenia spp. (4%), Brachycentrus sp. (4%), and Tendipedidae (6%).

Benthic samples taken eight days after the flow reduction (water level remained at the reduced level for eight days) revealed that changes in relative abundance were not consistent among the taxa (Figure 10). The relative abundance of Brachycentrus sp. and Tendipedidae, respectively, increased 400% and 100% over the eight-day period. The relative abundance of Cheumatopsyche sp. and Baetis sp., respectively, showed a decrease of 26% and 500%. Paraleptophlebia sp., Rhithrogenia undulata, Heptagenia sp., and Hydropsyche sp. did not appear to change in relative abundance (Figure 10).

After the flow reduction at the 45 cm water depth, density and biomass of Paraleptophlebia sp., Brachycentrus sp., Hydropsyche sp., Cheumatopsyche sp., and Tendipedidae increased; Heptagenia spp. and Baetis spp. decreased in density and biomass; and, Rhithrogenia undulata remained unchanged in density and biomass (Table 8).

CONCLUSIONS AND DISCUSSION

Littoral Community Structure and Insect Distribution

Community structure in the littoral area of riffles varied with depth. In non-fluctuating conditions of 1971, community diversity and diversity per individual decreased and redundancy increased with increasing depth to 45 cm (maximum sampling depth). The sporadic fluctuating flows of 1972 apparently resulted in a reversal of the 1971 community diversity and diversity per individual along the depth gradient. Community diversity and diversity per individual increased with increasing depth to 45 cm. Diversity per individual increasing with depth is corroborated by Fisher and LaVoy (1972). They reported that diversity per individual increased with increasing depth in a river subjected to daily water fluctuations. Redundancy was not different from the non-fluctuating situation. I feel that redundancy did not show a significant difference from the non-fluctuating situation because benthic communities were still in a state of transition from the non-fluctuating to the fluctuating system. I suspect that redundancy will decrease with increasing depth in the fluctuating system, a reversal from the non-fluctuating system. This situation should occur because of the near reciprocal relationship between community diversity or diversity per individual and redundancy.

The loss of community diversity and diversity per individual in the shallow-littoral zone means the community has changed to a more unstable form (Patten, 1962), resulting in: (1) fewer species; (2) changes in the dominance relationships among the species; (3) changes

in the energy entering the trophic level of insects; (4) changes in energy utilized by the insect trophic levels; and (5) changes in the available energy for higher trophic levels (fish) socially desirable to man.

Community structure on the littoral area of streams is a result of the interaction of all factors affecting the distribution of aquatic insects. Current velocity has been shown to be an important factor affecting insect distribution by Needham and Usinger (1956), Armitage (1961), Cummins (1964), Scott (1958), Allen (1959), and Hynes (1970). Cummins (1964) also included substrate particle size, distribution of food, and oviposition site as possible factors affecting distribution. Armitage (1961) added that temperature affects may also contribute to faunal distribution. Philipson (1954) demonstrated that dissolved oxygen concentration affected the distribution of some aquatic fauna. In this study the homogeneity of substrate type, temperatures among depths, nymphal age, and dissolved oxygen at the three sampling depths precluded the analysis of these effects on the littoral distribution of aquatic insects.

My results indicate that depth or some factor associated with depth, along with current velocity, contributed significantly to the littoral distribution of species in terms of numbers and biomass. Needham and Usinger (1956) reported similar results in Prosser Creek, California.

I found that three basic types of species specific distribution occurred along the littoral zone in the Clearwater River:

- (1) decreasing abundance and weight per sample with increasing depth (current velocity).
- (2) increasing abundance and weight per sample with increasing depth (current velocity).
- (3) no difference in abundance and weight per sample with increasing depth (current velocity).

The data and location of sampling interacted with the depth (current velocity) effects, resulting in alterations of these basic distribution patterns, e.g., Ameletus sp., Rhithrogenia undulata, Emphemerella margarita, and Paraleptophlebia bicornuta exhibited movements into and out of the sampling depths throughout the fall. The mechanism involved in these movements may be linked to ecdysis, pupation, emergence, or other behavioral adaptations. Diel flow fluctuations may interact either negatively or positively on aquatic species as a result of superposition on natural behavior rhythms depending upon location and timing of fluctuations.

Other factors which could contribute to variation in littoral distribution which I did not include, but may be of importance are: predator abundance, life history stage, seasonal discharge variations, and seasonal behavioral patterns.

Littoral distribution of the caddisflies, Hydropsyche sp., Cheumatopsyche sp., and Brachycentrus sp.; and, the mayflies Baetis spp.

and Ephemerella margarita having greater abundance in deep zones may provide pre-adaptive resiliency to diel flow fluctuations. Although loss of shallow zone populations, if it were to occur, would constitute a considerable drop in total insect biomass on riffles. Selective mortalities on species which prefer shallow water or low current velocities could result from flow fluctuations. I found that the mayfly, Ameletus sp.; the riffle beetle, Zaitzevia sp.; and the non-biting midge, Tendipedidae preferred low current velocity and shallow water conditions.

Littoral Drift

There was no apparent difference in drift rate at the three zones in the littoral area during stable flow conditions.

Flow reductions were shown to stimulate exponential increases in the diel drift pattern of insects; Pearson and Franklin (1968) and Minshall and Winger (1968) reported similar drift increases with fluctuating flows.

Increased drift rates of Baetis spp. and Paraleptophlebia sp. could provide resiliency to flow fluctuations if lateral movements to deeper water habitats accompanies increased drift. I was unable to determine the existence of lateral movements to depths greater than 45 cm due to the physical difficulty involved in sampling.

Normally, light intensity is the key factor in the phase-setting of drift periodicity; the drift amplitude is affected by current velocity, discharge, and water temperature (Waters, 1972). Pearson and

Franklin (1968) substantiated the light phase-setting and discharge-amplitude hypothesis; however, Minshall and Winger (1968) found normal light intensity phase-setting was overridden during flow fluctuations. Explanations for the divergence in results could be the different effects the flow reductions had on the streambed, size of stream, survival adaptation in the area of study, and the taxa studied. Taxa in all three studies were similar, so probably of minimal importance. Minshall and Winger's test streams were less than 1 m wide and had no extensive littoral areas exposed as a result of flow reduction. My streams, as well as those which Pearson and Franklin worked on, were generally large rivers with extensive littoral areas exposed after flow reductions. Behaviorally speaking, survival adaptation to rapid flow fluctuations could be more endogenous to insect populations from small streams because of the naturally occurring fluctuations due to precipitation. On large rivers, day to day flows are more consistent, possibly resulting in a lack of survival adaptation for resident fauna, i.e., to move toward the receding water line during a rapid flow reduction in daylight hours. Supportive evidence that survival adaptation may have occurred is: (1) Minshall and Winger's observation of directed movements of insects toward deep water during flow reduction on their small test creek, (2) my failure to observe directed movements to deep water in a large river during or directly after a flow reduction, (3) my failure to collect substantially more insects during or directly after the flow reduction than similar times the day before flow reduction.

Uneven increases in drift among different taxa after flow reductions, that I found, indicate differential abilities to move off of the exposed areas and susceptibility to flow reductions.

Waters (1965) categorized total drift into three subcategories: catastrophic (forceful entrainment into water column), constant (random displacement), and behavioral (directed movement off of the substrate). The nature of the increases I observed strongly suggest that behavioral drift was involved, a result of overcrowded conditions occurring as insects moved off the exposed areas after flows were reduced and corresponding to light-phase setting.

On low gradient littoral areas, increased drift rates after flow reductions apparently result from insects moving off the exposed areas and/or shallow zones adjacent to the exposed substrate.

Some factors I feel are important in affected the increase in drift rates after flow reductions are: the longitudinal gradient of the stream which would affect the current velocities; slope of the banks which would affect the amount of exposed substrate; and the diel and seasonal timing of the flow reduction affecting the phase-setting mechanism of drift and the distribution of the taxa.

Relationship of Drift and Benthos

The relationship between benthic and drifting insects was variable among different species in both the non-fluctuating and fluctuating systems. In the non-fluctuating system Baetis spp. and Para-

leptophlebia sp. comprised less than 1% of the total benthos each, yet comprised 50% and 16% of the total drift. The percentage of total drift for other taxa was below their respective percentages in benthos.

After a rapid flow reduction, Baetis spp. increased from 53% to 96% of the total drift. The effects of the rapid flow reduction on benthic composition are difficult to interpret due to the limitations imposed on sampling in deep water areas. I found that a slight amount of crowding occurred (based on samples taken eight days after the flow reduction) in the shallow areas for: Hydropsyche sp., Brachycentrus sp., Paraleptophlebia sp., and Tendipedidae. The crowding of insects in deeper water could provide temporary adaptation to sporadic water fluctuations; although, the crowding was insignificant compared to the large biomass which was unaccounted for after the flow reduction. The hyporheic habitat, the area under the streambed where the water percolates slowly between the stone and the gravel, Hynes (1970) described may provide some survival habitat for exposed organisms; but the cemented substrates I sampled may exclude such possibilities. Therefore, organisms which have slow terrestrial movements and lack high drift rates after flow reductions will most likely suffer high mortalities on exposed areas during unfavorable atmospheric conditions. The abundance of Baetis spp., Heptagenia spp., Rhithrogenia undulata, and Cheumatopsyche sp. either remained stable or decreased slightly over the eight days of reduced flow. This indicates that crowding did not occur for some taxa, which may have resulted in mortality or movement to deeper water.

Research on the duration of water level fluctuations, along with the diel and seasonal timing of fluctuations, and the differential adaptability of insects to periodic exposure may provide answers for questions involving the optimization of the relationship between aquatic productivity and hydroelectric power production.

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APPENDIX

Table 9. Checklist of insect taxa in the Clearwater River at sampling stations 1, 2, 3 and 4 for August to November, 1971, and July to October, 1972.

Taxa	Station			
	1	2	3	4
TRICHOPTERA				
<u>Leucotrichia</u> sp.	R ^{1/}	R	C ^{1/}	R
<u>Unknown</u> sp.	R	R	R	R
<u>Parapsyche</u> sp.	X ^{1/}	X	X	X
<u>Arctopsyche</u> sp.	X	X	R	X
<u>Hydropsyche</u> sp.	C	C	C	C
<u>Cheumatopsyche</u> sp.	C	C	C	C
<u>Macronemum</u> sp.	R	R	R	R
<u>Dolophilodes</u> sp.	R	C	R	X
<u>Wormaldia</u> sp.	R	R	R	R
<u>Polycentropus</u> sp.	R	C	C	R
<u>Athripsodes</u> sp.	X	X	R	X
<u>Oecetis</u> sp.	C	C	C	C
<u>Helicopsyche</u> sp.	R	R	R	X
<u>Brachycentrus</u> sp.	C	C	C	C
<u>Micrasema</u> sp.	C	C	C	C

^{1/}

Occurrence is based on the mean number of individuals collected per taxa during the 1971 and 1972 sampling periods.

R = Rare, less than 1 specimen per m².

C = Common, greater than 1 specimen per m².

X = No occurrence.

Table 9 (cont)

Taxa	Station			
	1	2	3	4
<u>Lepidostoma</u> sp.	R	X	X	X
<u>Dicoecomecus</u> sp.	R	R	X	X
<u>Glossosoma</u> sp.	C	C	C	C
<u>Rhyacophila</u> sp.	R	X	X	R
EPHEMEROPTERA				
<u>Paraleptophlebia bicornuta</u> (McDonnough)	C	C	C	C
<u>P. heteronea</u> (Walker)	C	C	C	C
<u>P. debilis</u> (McDonnough)	X	X	X	X
<u>Leptophlebia</u> sp.	X	X	R	X
<u>Ephemerella grandis</u> (Eaton)	C	C	C	R
<u>E. doddsi</u> (Needham)	X	C	C	C
<u>E. inermis-infrequens</u> (Eaton)	C	C	C	C
<u>E. hecuba</u> (Eaton)	X	C	X	R
<u>E. hetercaudata</u> (McDonnough)	X	X	X	R
<u>E. margarita</u> (Needham)	C	C	C	C
<u>E. tibialis</u> (McDonnough)	C	C	C	C
<u>Epeorus albertae</u> (McDonnough)	R	C	C	C
<u>Rhithrogenia undulata</u> (Banks)	C	C	C	C
<u>Stenonema</u> sp.	R	R	R	R
<u>Cinygmula</u> sp.	R	X	R	R
<u>Heptagenia solitaria</u> (McDonnough)	C	C	C	C

Table 9 (cont)

Taxa	Station			
	1	2	3	4
<u>H. simpliciodes</u> (McDonnough)	X	R	R	X
<u>H. criddlei</u> (McDonnough)	X	R	C	X
<u>Ameletus</u> sp.	C	C	C	C
<u>Baetis</u> sp.	C	C	C	C
<u>Ephemera simulans</u> (Walker)	X	X	R	X
<u>Caenis latipennis</u> (Banks)	R	R	R	X

PLECOPTERA

<u>Pteronarcys</u> sp.	R	R	X	R
<u>Peltoperla</u> sp.	R	X	X	X
<u>Brachyptera</u> sp.	X	X	R	X
<u>Nemoura</u> sp.	X	X	X	X
<u>Acroneuria</u> sp.	C	C	X	R
<u>Clasassenia</u> sp.	C	C	C	C
<u>Arcynopteryx</u> sp.	C	C	C	C
<u>Isogenus</u> sp.	R	C	C	R
<u>Isoperla</u> sp.	X	R	X	X
<u>Chloroperla</u> sp.	X	R	X	X
<u>Alloperla</u> sp.	R	R	C	C
<u>Paraperla</u> sp.	R	X	X	X

Table 9 (cont)

Taxa	Station			
	1	2	3	4
COLEOPTERA				
<u>Narpus</u> sp.	R	C	X	R
<u>Rhizelmis</u> sp.	R	R	X	X
<u>Zaitzevia</u> sp.	C	C	C	C
<u>Optioservus</u> sp.	X	C	R	R
<u>Heterlimnius</u> sp.	X	X	X	X
<u>Ampumixis</u> sp.	X	R	X	X
<u>Cleptelmis</u> sp.	R	C	R	R
<u>Heterelmis</u> sp.	X	R	R	X
<u>Microcylloepus</u> sp.	X	R	X	X
<u>Elsianus</u> sp.	R	X	X	X
<u>Hydrophilus</u> sp.	X	R	X	X
<u>Psephenus</u> sp.	R	C	X	R
<u>Oreodytes</u> sp.	C	C	C	C
DIPTERA				
Tipulidae	C	C	C	C
<u>Protoplasa</u> sp.	X	X	X	X
<u>Philorus</u> sp.	X	X	R	X
Tendipedidae	C	C	C	C
Heleidae	X	X	X	X
Simuliidae	X	X	X	X
<u>Deuterothlebia</u> sp.	X	X	X	X
<u>Atherix variagata</u>	C	C	R	X

Table 9 (cont)

Taxa	Station			
	1	2	3	4
ODONATA				
<u>Ophiogomphus</u> sp.	R	C	R	X
<u>Gomphus</u> sp.	X	X	R	X
LEPIDOPTERA				
<u>Paragyraetis</u> sp.	C	C	C	C
HEMIPTERA				
Veliidae	X	X	X	X
ANNELID				
Oligochaeta	C	C	C	C
Hirudinea	R	X	X	X
MOLLUSCA				
Gastropoda	C	C	C	C