A STUDY OF THE EFFECTS OF SEASONAL CHANGES ON BENTHIC INVERTEBRATES IN PRICKLY PEAR CREEK, JEFFERSON COUNTY, MONTANA

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ABSTRACT

Total number and generic diversity of benthic insects in Prickly Pear Creek, Jefferson County: T9N, R3W, Sections 23 and 26, were investigated during July and October. Quantitative studies showed that the invertebrate population was greatly increased in the summer to fall transition. Trichoptera was the most numerous order during both July and October sampling periods. In the seasonal transition it was noted that the total number of Trichoptera, Plecoptera, and Diptera increased, while that of Ephemeroptera and Coleoptera decreased. The generic diversity of Plecoptera increased, Ephemeroptera decreased and the remaining orders remained relatively constant.

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INTRODUCTION

Benthic invertebrates are essential in the ecosystem of streams and serve as early indicators of unfavorable disturbances within the system. Prickly Pear Creek has been the subject of various studies, none of which included an intensive invertebrate survey. The morphology of Prickly Pear Creek has been extensively altered in the past and there presently exists the possibility that placer mining and water use by the Diehl Development Corporation will produce future major disruptions.

A study by Bishop and Peck (1962) indicated that 51% of the stream's original length of 65.97 km had been altered. Channel relocations and dredging resulted in 30.57 km of meandering stream channel being directed into a straight 25.74 km channel. Diking, channel clearance, and riprapping altered an additional 3.22 km of channel.

Construction of Interstate Highway 15 near Montana City in 1968 resulted in a continuous 1.006 km channel change to Prickly Pear Creek. To mitigate the loss of the original channel the stream was artificially meandered in the flood plane which resulted in the lengthening of the stream by 3% (960.12 m to 990.6 m). No effort was made to duplicate the physical parameters of the natural channel except length (Workman 1974).

A study by Elser (1970) showed that the average stream depth and average thalweg depth were reduced by 28.6% (0.43 m to 0.30 m) and 21.7% (0.70 m to 0.55 m), respectively. Prior to construction there was a pool every 54.86 m of stream for a periodicity of 6.6 times the average stream width. Following the relocation of the stream in 1968 the spacing of successive pools was increased to a pool every 115.82 m or a periodicity of 15.7 widths. Two years following construction of the highway the periodicity had adjusted to 8.8 widths or a pool every 64.0 m. The standard spacing of pools is ordinarily in the magnitude of from five to seven stream widths (Leopold and Langbein 1966).

Willow shoot plantings were made in May 1968 to compensate for woody vegetation removed during the construction of Interstate Highway 15. The total survival of the shoots was low: 36.8% for willows planted in double rows and 8.7% for shoots planted in single rows (Elser 1969). In 1969, 1,723 additional willow shoots were planted in single rows. The success of these plantings was not quantitatively evaluated, however streamside observations indicated poor survival (Elser 1969). As a result erosion was extensive.

Fish population estimates done by Elser (1969) indicated that before construction the suckers made up 62.1% of the total number and 78.6% of the total weight. Trout comprised 37.9% and 21.5% of the total numbers and weight, respectively. The sucker:trout ratio of 2:1 by numbers and 3:1 by weight remained unchanged immediately following construction; however brown trout became the most abundant game fish in weight and numbers per 4047 m^2 (one acre) in 1968, whereas rainbow trout predominated in 1967. The most significant change in the fish population came in a reduction of the total standing crop. Numbers and weight of fish per 4047 m^2 were reduced by 45.8% (432 to 234) and 51.2% (76.1 kg to 37.1 kg), respectively, between 1967 and 1968. Population estimates in 1969 were 228 fish per 4047 m^2 weighing 35.3 kg. A study by Workman (1974) stated that population estimates in 1972 indicated that trout numbers returned to preconstruction (1967) levels with 79 rainbow trout and 90 brown trout per 4047 m^2. The total weight of trout (13.6 kg per 4047 m^2) was still below preconstruction levels (16.3 kg per 4047 m^2). Sucker populations remained at a level 59% below the preconstruction numbers. All estimates were made at the 80% confidence interval. In July 1976 an attempt was made to estimate the fish population, but the electroshocking only produced one rainbow trout. This poor result could be attributed to mechanical failures with the electroshocking equipment.

Prickly Pear Creek has been a victim of many man-caused alterations and is in danger of further damage caused by man. This survey of the invertebrates during the summer and autumn will serve as baseline data for further ecological studies.

The location of the study was in Jefferson County, T9N, R3W, Sections 23 and 26 (Fig. 1). The study areas of Elser and Workman were limited to Section 23.

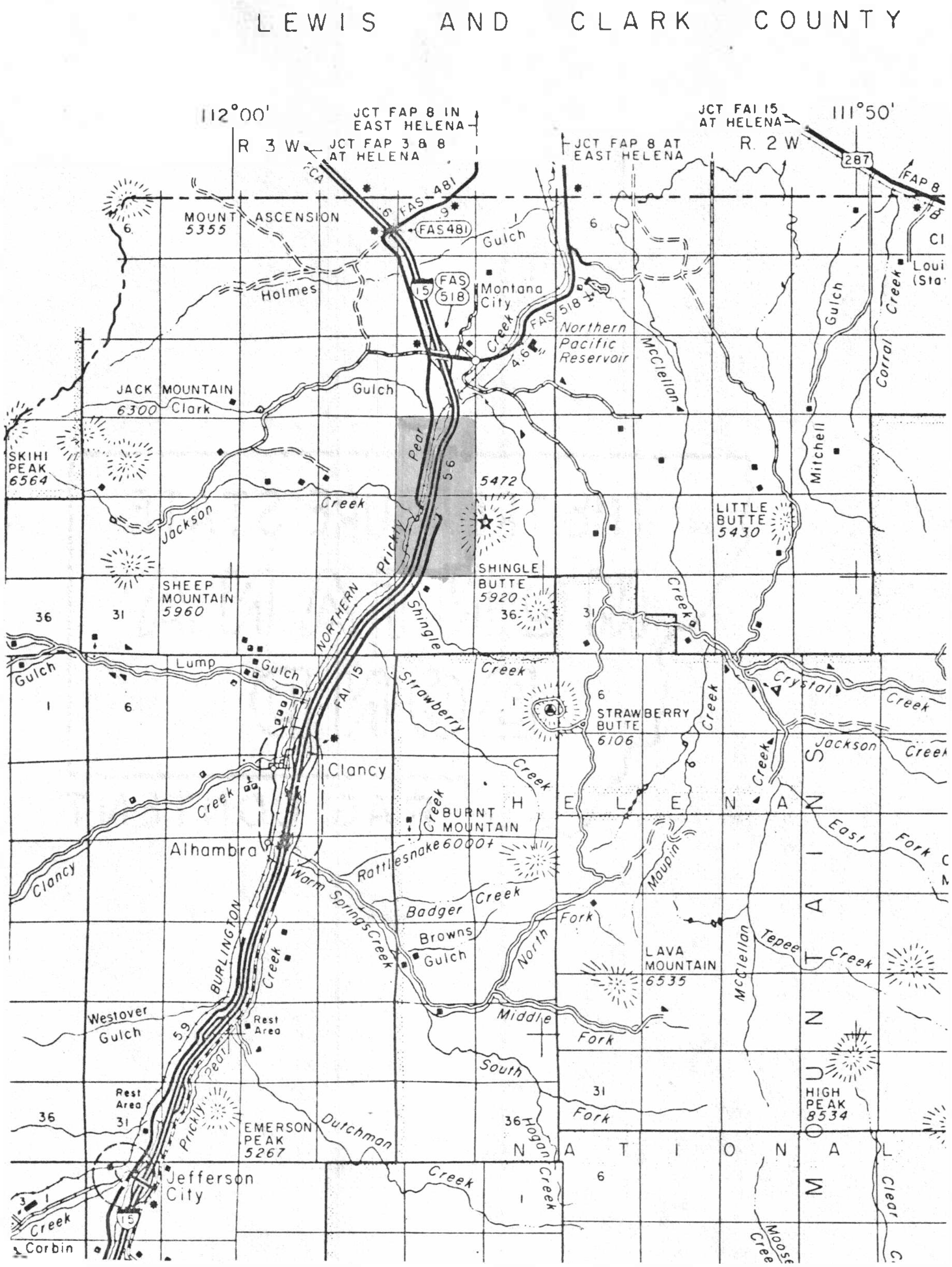

Fig. 1. Location of study area: Jefferson County, T9N, R3W, Sections 23 and 26.

METHODS AND PROCEDURES

Collecting Techniques

Sampling was done from 13 July to 20 July 1976 and repeated 14 October to 22 October 1976 at six sites containing similar flow and substratum and established within the stream. The relative location of these stations is illustrated in Fig. 2. Six Surber samples 0.093 m^2 in area were taken at each station across the width of the stream during the July and October sampling periods. Flow and velocity (Table 1) were measured by a gage station maintained by the Montana Department of Natural Resources and Conservation. This station was located 100 m upstream of station E (Fig. 2). Temperature readings were recorded during collection of the first and final samples at each station for both sampling periods. Table 1 shows the average of these two readings for July and October.

The Surber bottom sampler with a netting aperture of 1.0 mm was placed in the stream with the net opening upstream (Fig. 3). The foundation frame was securely worked into the stream bottom outlining the area to be worked and then stabilized be kneeling on both knees behind it. The mean depth of the stream at each sample was 0.25 m. The larger stones within the sample area were removed, washed free of organisms at the opening of the net, then discarded. Th insects were carried into the net by the current. The area was then gently churned up by hand to a depth of approximately 0.05 m. The contents of the net were then emptied into a white enamel pan. Larger stones and debris were examined for attached larvae then discarded. Water was

Table 1. Water temperature and flow at each station during collection of benthic samples.

Station	July		October	
	Temperature °C	Flow m^2/s	Temperature °C	Flow m^2/s
A	17.0	1.02	4.5	1.01
B	17.5	2.75	8.5	1.01
C	18.5	2.24	5.5	1.01
D	16.5	2.24	5.5	1.01
E	11.0	2.24	3.5	1.01
F	17.5	2.02	5.0	1.01

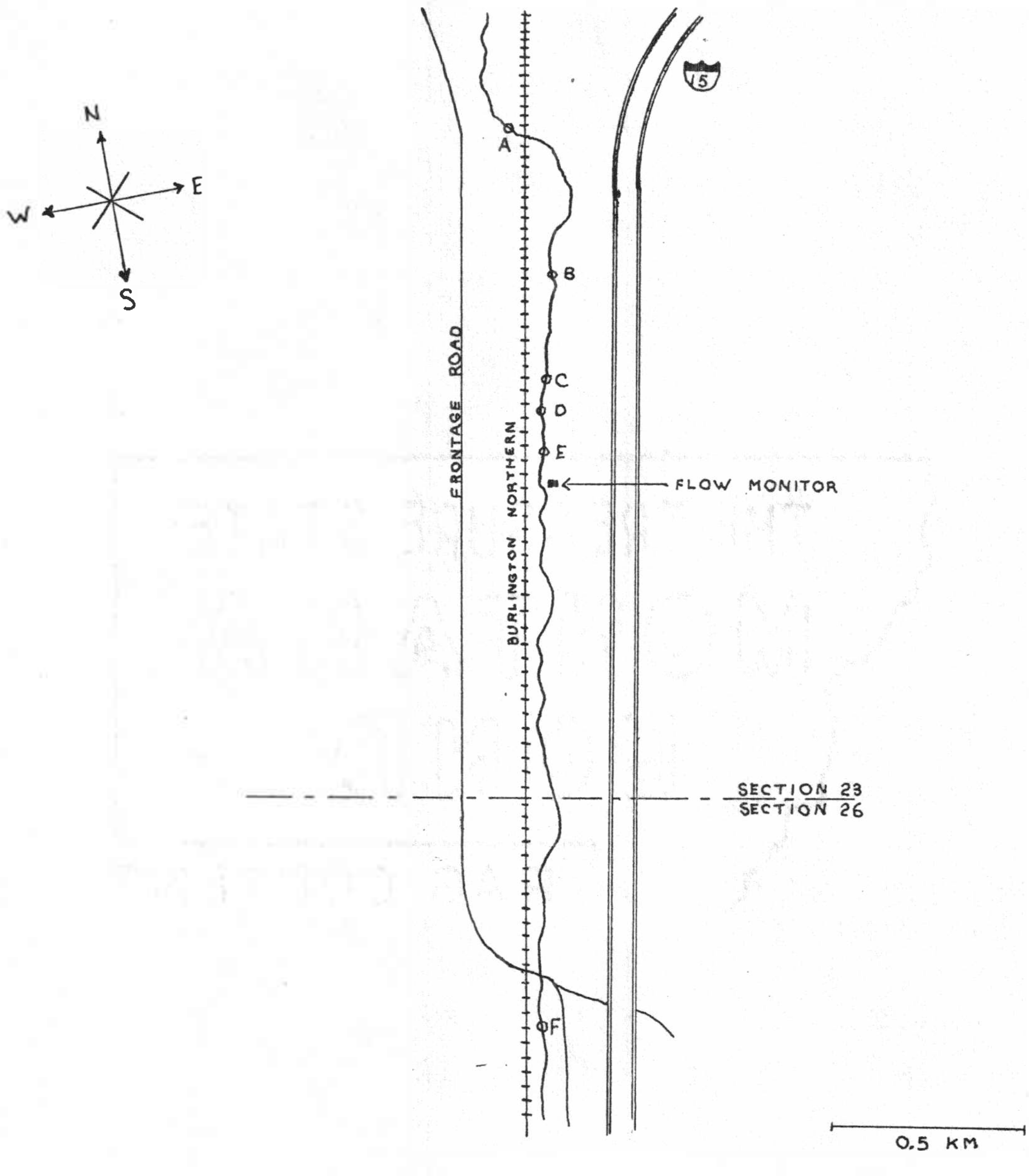

Fig. 2. Location of sampling stations A through F. Six 0.093 m^2 Surber samples were taken at each sampling site. (Map drawn by Virgil Frei).

Fig. 3. Surber bottom sampler. The 0.093 m^2 area outlined by the frame defines the working area.

drained from the pan, and the insects and remaining gravel and debris were placed in a jar with 95% ethanol.

Within 2 days following collection the alcohol contaminated with the body fluids of the specimens was drained from the jars and replaced with 70% ethanol.

Specimens were later sorted by emptying the contents of each jar into a white 3.78 liter bucket then adding approximately 1.5 liters of water. The water was then whirled causing the insects and lighter debris to float. The supernatant was then quickly poured through a 1.0 mm mesh net. Care was taken to avoid decanting the sand and gravel. This process was repeated until the separation was complete. The insect larvae and nymphs were removed from the netting and placed in vials containing 70% ethanol. Gravel remaining in the bucket was also examined for organisms, especially for members of the genus *Glossosoma* whose sand cases inhibit them from floating.

Classification

Taxonomic keys were utilized in the identification of the benthic invertebrates. Especially helpful were *Aquatic Insects of California* (Usinger 1956) and *Fresh-Water Invertebrates of the United States* (Pennak 1953). Other texts and journals also referred to for detailed descriptions and illustrations of aquatic invertebrates were Borror et al. (1976), Needham and Needham (1962), and Ross (1944). A 40X binocular dissection scope was used extensively for identification supplemented by a compound microscope magnifying 100X. Ken Knudson, a pollution control biologist for the Montana Department of Fish and Game, verified the identification of some forms.

RESULTS

The benthic invertebrates collected during both July and October represented five major insect orders: Trichoptera, Ephemeroptera, Diptera, Coleoptera, and Plecoptera. The numbers of invertebrates in each order varied with the location of the sample and season in which they were collected (Table 2).

Table 2 shows that in July a total of 403 benthic invertebrates was collected. Insects of the order Trichoptera were most numerous comprising 52.4% of the total number followed by Ephemeroptera comprising 31.5%, Coleoptera 8.9%, Diptera 6.5%, and Plecoptera 0.7%. In four stations (A, B, E, and F) Trichoptera were highest in both number and relative percentage while Ephemeroptera were highest in one station (C) and both orders were equal in number and relative percentage at station D (Fig. 4 and Fig. 5). The genus Brachycentus was the most numerous comprising 46.7% of the total number followed by the subfamily Leptophlebiidae comprising 23.6% of the total number (Table 3).

During October a total of 1138 invertebrates was collected (Table 2). Again Trichoptera were the most abundant, comprising 81.6% of the total number followed by Diptera with 9.8%, Plecoptera with 5.1%, Ephemeroptera with 1.9%, and Coleoptera with 1.6% of the total number. Trichoptera were highest in both number and relative percentage at all stations (Fig. 6 and Fig. 7). As in the summer the members of the genus Brachycentus were the most numerous comprising 37.79% of the total number (Table 3). The prominance of Trichoptera cannot solely be attributed to the genus Brachycentus as it was in the summer; the genera

Table 2. The numbers of benthic animals collected during 13 July to 20 July 1976 and 14 October to 22 October 1976. Six samples were taken at each station.

Taxon	Organisms/Station													
	July							October						
	A	B	C	D	E	F	Total	A	B	C	D	E	F	Total
Diptera	3	9	7	0	2	5	26	3	30	32	25	11	10	111
Plecoptera	0	2	0	0	0	1	3	5	29	12	2	9	1	58
Ephemeroptera	20	21	36	19	17	14	127	4	6	7	3	1	1	22
Trichoptera	48	28	13	19	19	84	211	90	433	97	81	138	90	929
Coleoptera	7	5	10	6	3	5	36	0	15	2	1	0	0	18
Total	78	65	66	44	41	109	403	102	513	150	112	159	102	1138

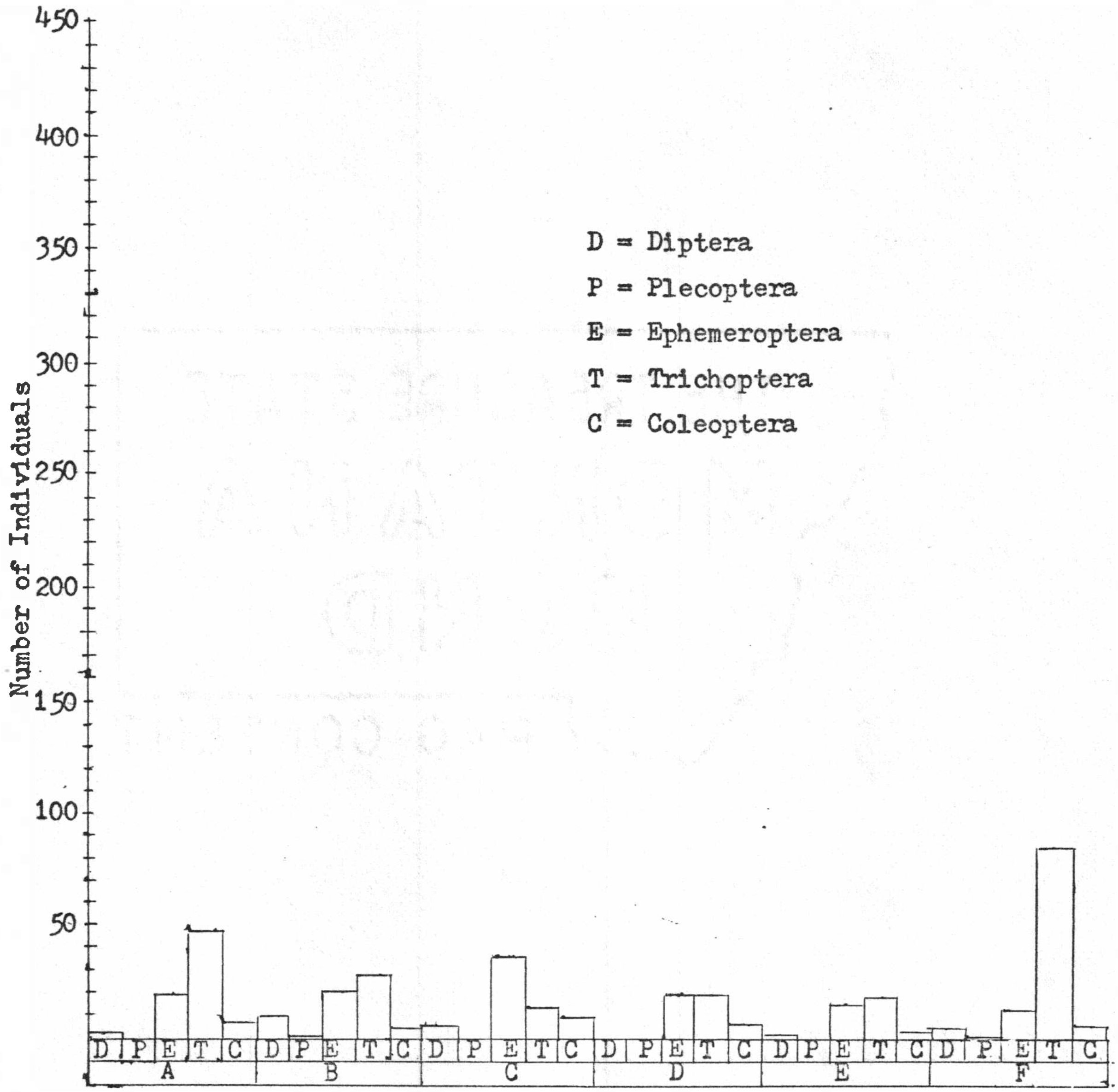

Fig. 4. Total numbers of Diptera, Plecoptera, Ephemeroptera, Trichoptera, and Coleoptera per station. Each station consists of six Surber samples. Samples were taken from 13 July to 20 July 1976.

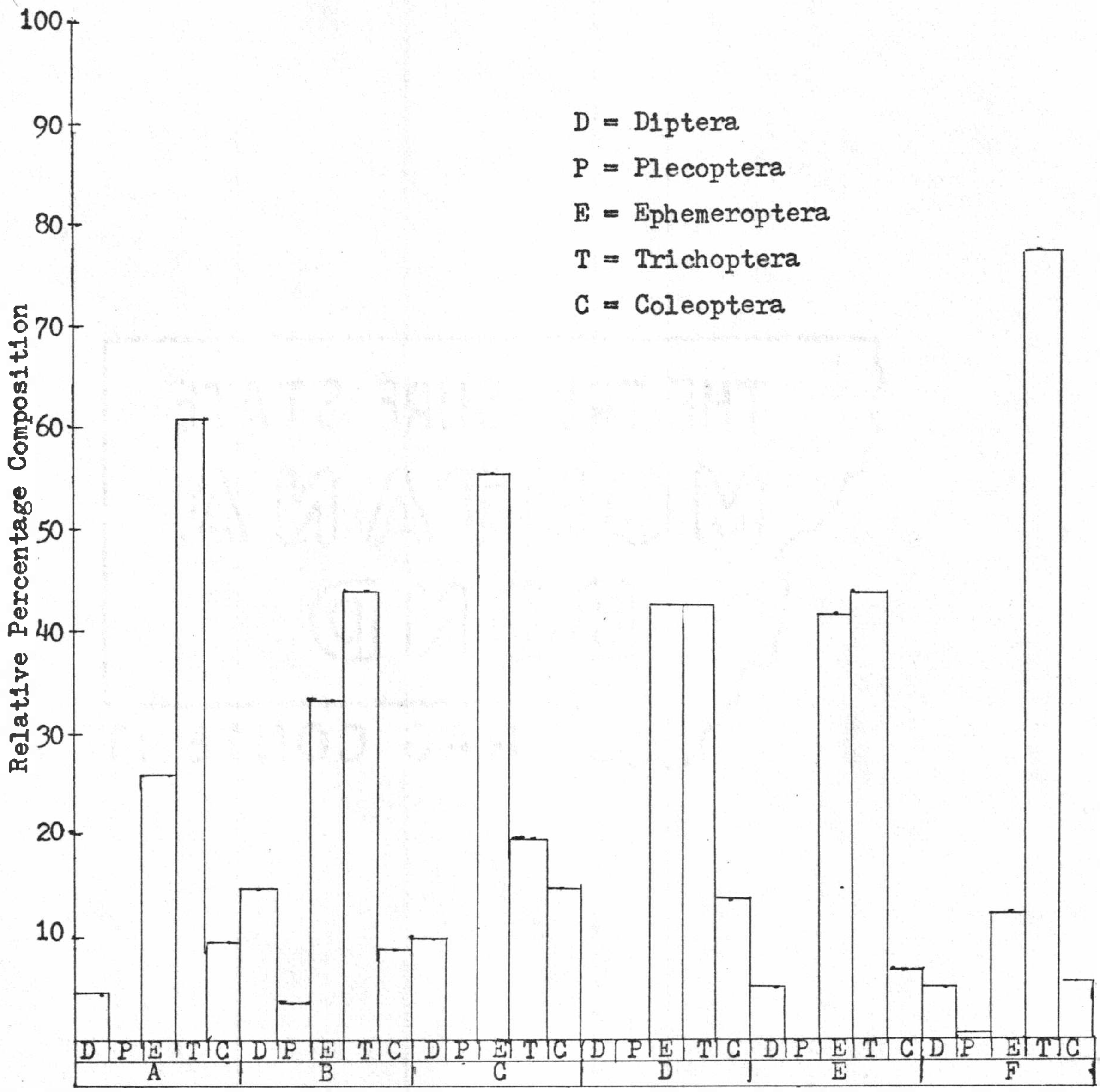

Fig. 5. Relative percent composition of benthic invertebrates. Samples were taken from 13 July to 20 July 1976.

Table 3. Components of the benthic fauna of Prickly Pear Creek collected during 13 July to 20 July 1976 and 14 October to 22 October 1976.

Taxon	Total number of individuals collected	
	July	October
Order Diptera		
Family Simuliidae[a]	10	2
Family Rhagionidae		
Genus *Antherix*	16	109
Order Plecoptera		
Family Pteronarcidae		
Genus *Pteronarcella*	3	45
Family Perlodidae		
Genus *Isogenus*	0	10
Family Perlidae		
Genus *Acroneuria*	0	1
Family Nemouridae		
Genus *Taeniopteryginae*	1	1
Order Ephemeroptera		
Family Baetidae		
Subfamily Leptophlebiinae	95	22
Family Heptageniidae		
Genus *Ironodes*	21	0
Genus *Cinygmula* (?)	10	0
Genus[b] (?)	1	0
Order Trichoptera		
Family Brachycentridae		
Genus *Brachycentrus*	188	430
Family Rhyacophilidae		
Genus *Glossosoma*	17	226
Family Hydropsychidae		
Genus *Hydropsyche*	4	51
Genus *Arctopsyche*	0	26
Family Phryganeidae		
Genus *Ptilostomis*	1	190
Family Psychomyiidae		
Genus *Phylocentropus*	1	6
Order Coleoptera		
Family Elmidae		
Genus *Narpus* (?)	6	8
Family Hydrophilidae		
Genus[c] (?)	29	1

[a]No taxonomical keys available for further classification.
[b]Further classification incomplete due to loss of several anatomical parts during the collection process.
[c]Author was unable to further classification.

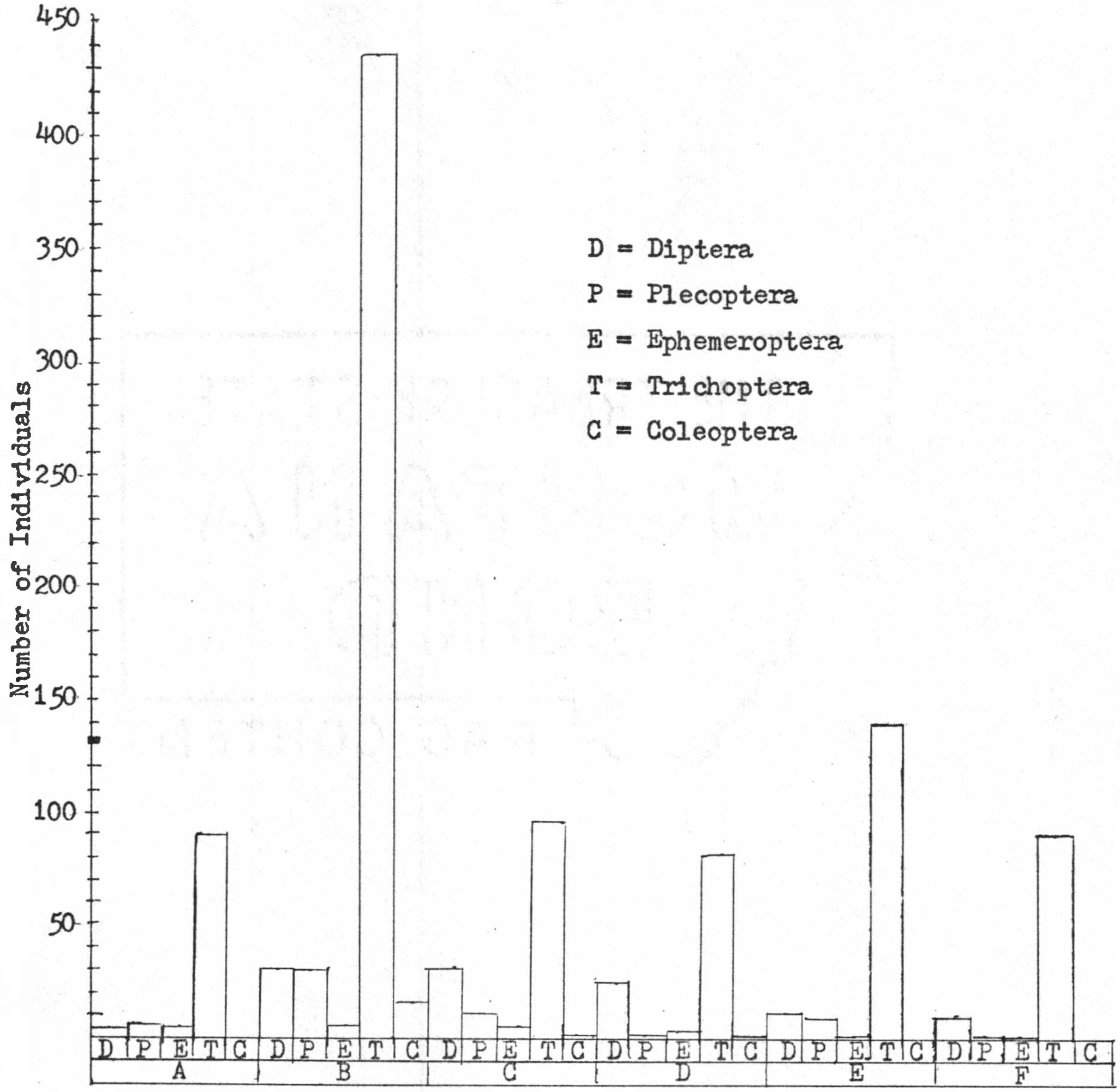

Fig. 6 . Total numbers of Diptera, Ephemeroptera, Trichoptera, Plecoptera, and Coleoptera per station. Each station consists of six Surber samples. Samples were taken from 15 October to 22 October 1976.

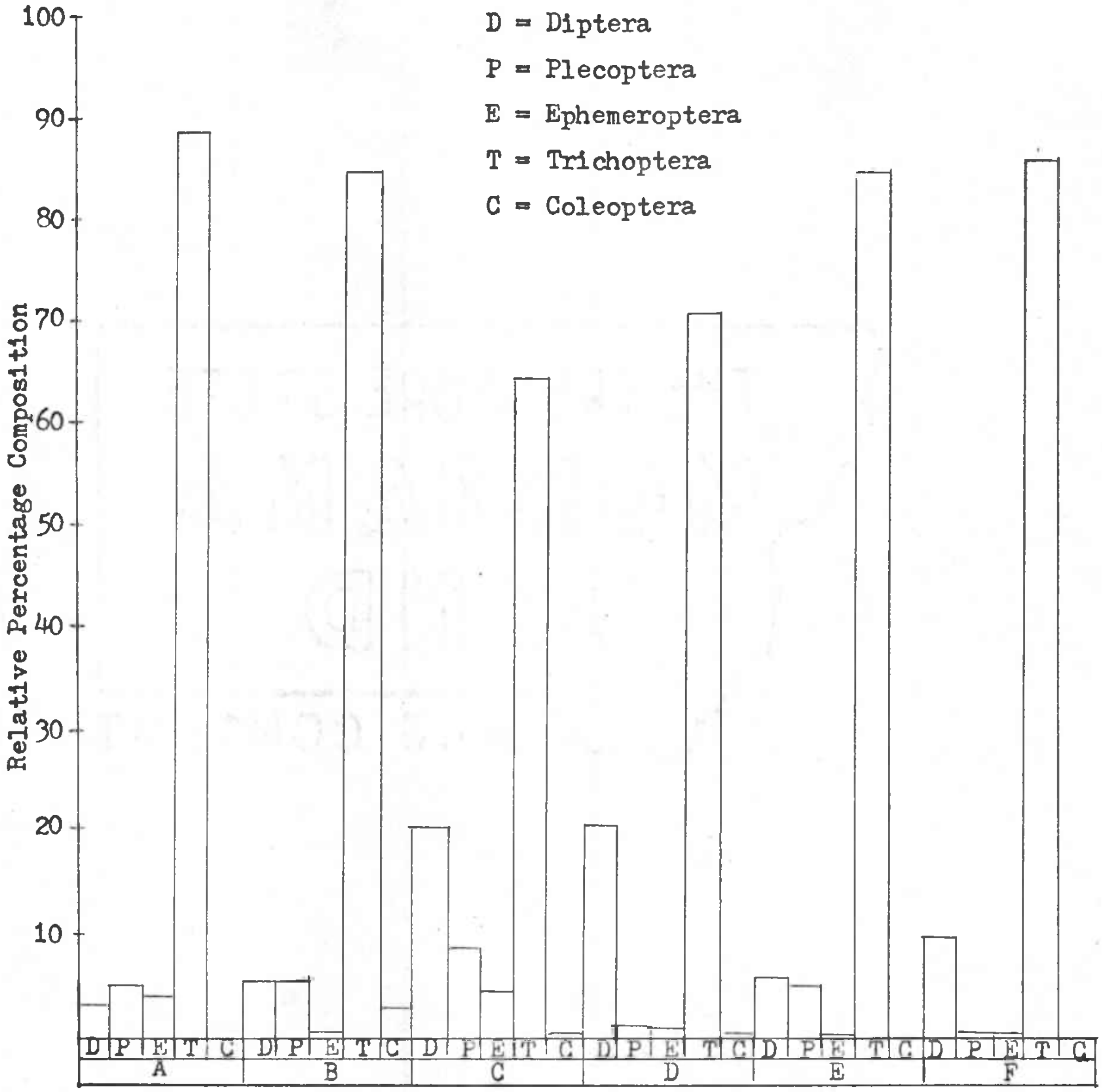

Fig. 7. Relative percent compostion of benthic invertebrates. Samples were taken from 15 October to 22 October 1976.

Glossosoma and Ptilostomis comprised 19.88% and 16.70% of the total number, respectively, with the remaining three Trichoptera genera comprising 7.29% of the total number.

Table 3 illustrates that the autumn increase in density was accompanied by the addition of two Plecoptera genera and a reduction of Ephemeroptera genera from four to one. The number of Diptera, Trichoptera, and Coleoptera genera remained relatively constant for both seasons, but the number of individuals within each genus varied greatly with each season. Fig. 8 summarizes the seasonal differences in the relative percentage composition of the major benthic orders.

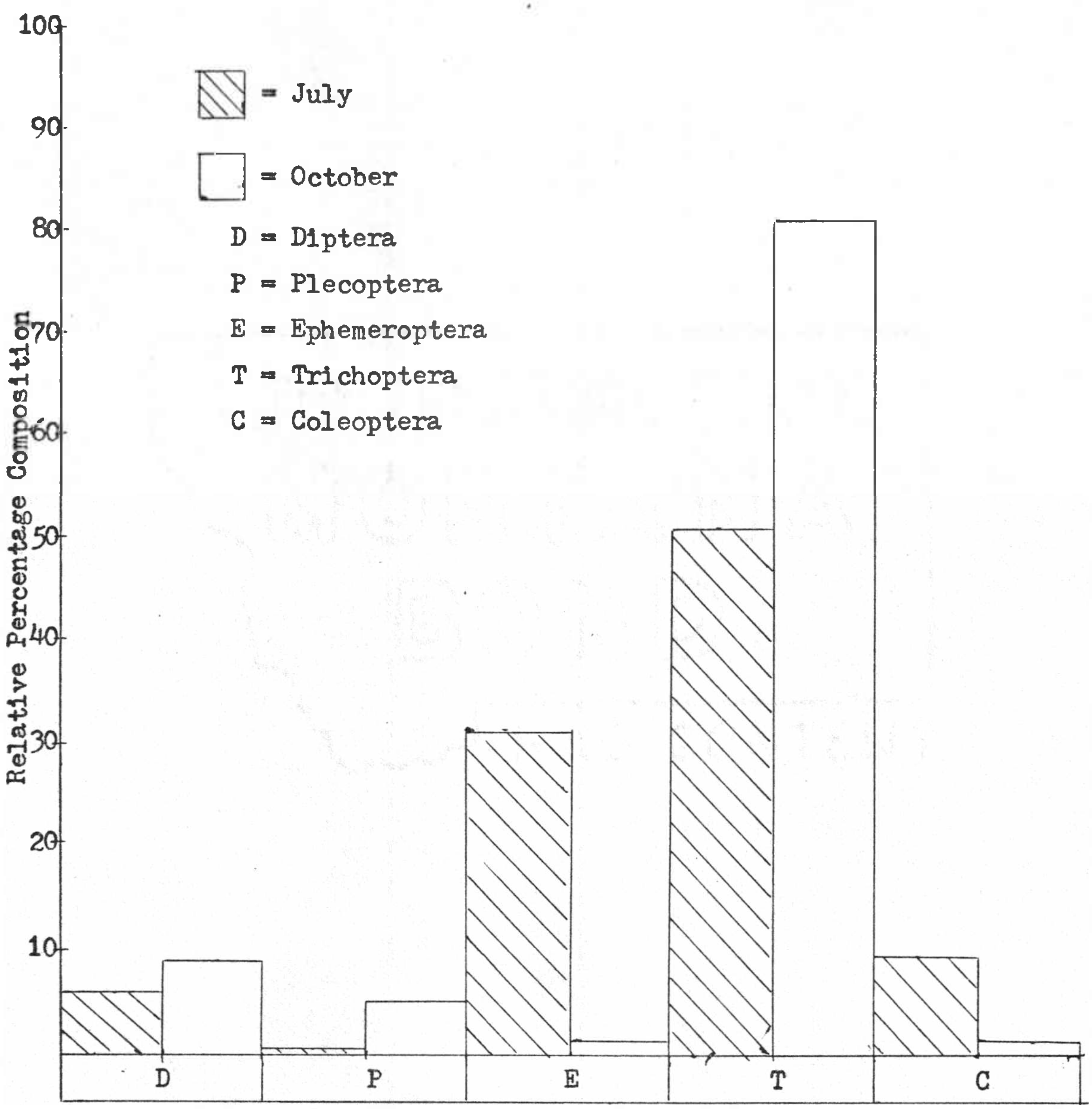

Fig. 8. Relative percentage composition of benthic invertebrates for all samples.

DISCUSSION AND CONCLUSIONS

The results clearly illustrate a difference in both the numbers and composition of the stream populations during July and October. This difference can be attributed to individual life cycles of various species, effects of temperature, length of day, availability of nutrients, and complexity of the substratum.

Variations in the metamorphosis of the benthic invertebrates offer a possible explanation for the results obtained during this study. Ephemeroptera and Plecoptera undergo incomplete metamorphosis in which there are three main stages: egg, naiad, and adult. The egg and the naiad stages are aquatic. During these first two stages growth and development make up all but a few days of the life cycle, whereas, the adult stage is aerial, reproductive, and lasts only a few days. Nymphal development is characterized by the occurrence of successive molts in which the nymph will shed its exoskeleton which prevents the expansion of its body. At each instar (growing stage) following molting the nymph will continue to develop. After the last molt it becomes a winged adult.

Trichoptera, Diptera, and Coleoptera undergo complete metamorphosis which consists of four stages: egg, larva, pupa, and adult. Trichoptera and Diptera egg, larval, and pupal stages are aquatic, whereas, the Coleoptera egg and larval stages are also aquatic, but the mature larvae of nearly all beetles leave the water and burrow into the damp soil to make their pupal cells. During these first three stages growth and development compose all but a few days of the life cycle. The adult stage is winged and primarily reproductive. The young emerge as larvae and go through several instars, then pass into the pupa stage from which they will emerge as adults.

Plecoptera usually produce one generation per year, but there is great variation within this order concerning the time of hatching of their eggs. The majority hatch within 2 to 3 months, but there exists an irregular incubation period in which the eggs will continue to hatch for an extended period of time instead of simutaneously (Hynes 1970). Hynes also states that the eggs of several Pteronarcella species remain dormant for 10 to 11 months before hatching. This irregularity is compenstated for by the nymphal growth period lasting 3 to 4 years. This offers a possible explaination for the increase in Pteronarcella numbers during the autumn. The overall increase in the Plecoptera population during the autumn is primarily due to their low temperature threshhold which is 0 C. This means they can continue growing at temperatures above 0 C.

As with the Plecoptera, the Ephemeroptera are univoltine, which means they have one generation per year. They also possess an irregular incubation period. But, unlike the Plecoptera, the Ephemeroptera population and generic diversity decreased considerably during the October samples. This difference can be attributed to the high Ephemeroptera temperature threshhold which causes them to remain as small instars during the cold months (Hynes 1970). The temperature decreased from an average of 16.3 C during the summer sampling period to 5.5 C during the fall sampling period (Table 1).

Trichoptera illustrate the greatest increase in number as a result of the seasonal change. Trichoptera usually maintain a univoltine life cycle, but young larvae in this order tend to appear while the older larvae or pupae are still present (Hynes 1970). It was noticeable during the collection that a variety of sizes was present, especially during the October collection. Therefore, the increase in the autumn population can be attributed to the appearance of the young larvae before the metamorphosis of the previous generation is completed.

The increase in the Diptera population is due to the genus Antherix. This increase can be attributed to the prompt hatching of Antherix eggs and their low temperature threshhold. Members of the family Simuliidae have great variation within their life cycles. Most species are univoltine, but there are also many with multivoltine life cycles, having more than one generation per year. Another variation in this family is in the hatching of their eggs. Depending upon the species, hatching can follow three patterns: hatching soon after deposition into the water, hatching after a long dormant period lasting several months, and hatching after the low temperatures of the fall and winter rise (Hynes 1970). Due to this great amount of variation no conclusions can be drawn concerning the effect of seasonal change on the family Simuliidae.

The Coleoptera population consisted of two families: Hydrophilidae and Elmidae. Hydrophilidae are primarily univoltine. They lay their eggs usually in the spring, therefore the majority of the larvae are found in the summer (Usinger 1956). The Elmidae life cycle takes 2 years to complete, therefore the larval stage can be found year round.

The water temperature and photoperiod play a role in determining the time of emergence for most species. The time of emergence is peculiar to each species and primarily occurs during the spring, but there are some aquatic forms that emerge during the fall and winter. The spring emergence accounts for the limited benthos within the stream during the summer. It is generally accepted that when a form is absent from the stream during collection it is present in the egg or early instar stage (Hynes 1970).

Mackay and Kalff (1969) determined that the more stable the substrate is, the greater the number of species inhabiting that area. For this reason all efforts were made to keep the substrate constant for each sample. Substrates with leaves as a major component offer the greatest species diversity and, therefore, a greater population of inhabitants. This is due to an increase in the habitat complexity and and increase in the amount of food available. During autumn fallen leaves are numerous in the stream; therefore, this is an important factor in the seasonal change between July and October.

Although many precautions were taken to assure the accuracy of the results, several variables were introduced into the study. The Surber sampler used had a net with nine meshes per cm. The size of the mesh determines the minimum size of organisms captured. It has been shown that 70% of the animals can be lost from nets having less than 16 meshes per cm (Mackay and Kalff 1969). Therefore, mesh size must be taken into consideration when comparing these data with other studies. Classification was completed only to genus. The reason for this was that no detailed keys were available for the insects of this area. Each species has a unique life cycle and is affected by the environment individually, therefore, it is hard to make generalizations concerning the benthic invertebrates.

The disruption of the natural stream environment can have drastic effects on the benthic invertebrates. Stream straightening and shortening increase the water flow and volume within the stream resulting in a reduction in the stability of the substratum and also a reduction in the amount of food available, i. e., leaves during the fall. It also results in the removal of bank vegetation which causes increased erosion and runoff and a decrease in the amount of leaves. Placer mining causes a total disruption of the substrate which is vital to the benthos. It may also result in the massacre of the benthos as they are passed through the dredging apparatus. Water drawdown, especially in the fall, should be avoided since this a critical time for the benthic forms. If the stream went dry in the fall the benthos, an important component of the stream ecosystem, could be exterminated. If measures are not taken to protect Prickly Pear Creek from future disruptions it will become a dead stream.

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