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Influence of Riparian Canopy on Macroinvertebrate Composition and Food Habits of Juvenile Salmonids in Several Oregon Streams

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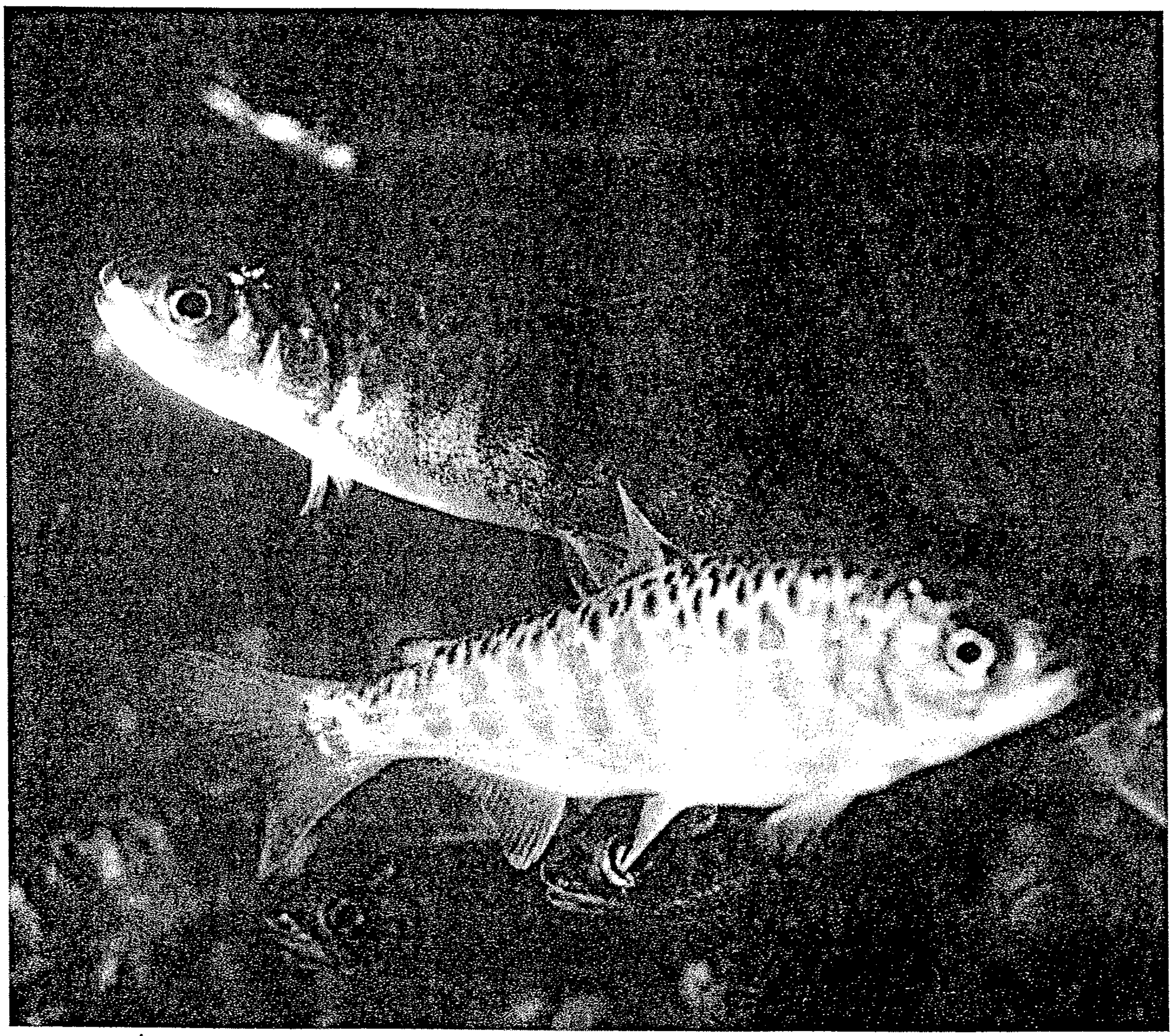

Abstract

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The community composition of macroinvertebrates and the feeding habits of juvenile salmonids were studied in eight Oregon streams. Benthic, drift, sticky trap, and water trap samples were taken over a 3-year period, along with stomach samples of the fish. Samples were taken in stream reaches with and without riparian canopy.

Both main effects—fish diet versus macroinvertebrate composition in the environment, and canopied versus noncanopied stream condition—were highly significant, but probably not of practical importance in terms of the amount of preferred food available to the fish.

In all aquatic sample types, including fish stomachs, Diptera and Ephemeroptera were the predominant invertebrates collected. In sticky trap and water trap samples, Diptera and Collembola were the predominant orders, reflecting the input of terrestrial invertebrates.

Keywords: Macroinvertebrates, community composition, salmonids, feeding habits, riparian canopy, Oregon.

Contents

Summary

Eight streams in Oregon were selected to study the community composition of macroinvertebrates and the feeding habits of juvenile salmonids. The streams were in coastal Oregon, along the west side of the Cascade Range, in central Oregon, and in eastern Oregon; thus they generally transected the State from west to east. The streams were second- to third-order streams and representative of the many small streams that provide rearing habitat for young salmon and trout. In each of the four geographical areas studied, two streams were sampled, and each had a reach with a canopy of vegetation over the stream and a reach without riparian canopy.

Benthic, drift, sticky trap, and water trap samples, along with stomach samples of the fish, were taken throughout the year over a 3-year period. The data used in this analysis resulted from compositing the samples of invertebrates into four distinct categories: diets of fish in canopied and noncanopied stream sections, and the populations of macroinvertebrates present in the stream environment in canopied and noncanopied sections.

Two simple main effects were considered—one associated with canopied versus noncanopied stream conditions, and the other with fish diet versus presence of the invertebrates in the environment. The interaction of these two effects also was evaluated.

In all aquatic sample types, including fish stomachs, Diptera and Ephemeroptera were the predominant invertebrates collected. In sticky trap and water trap samples, Diptera and Collembola were the predominant orders, reflecting the input of terrestrial invertebrates.

Both main effects—fish diet versus invertebrates in the environment, and canopied versus noncanopied stream condition—were highly significant ($P \leq 0.01$), but in terms of the amount of preferred fish food organisms available, the presence or absence of riparian canopy did not seem to be a major concern.

Introduction

Many studies have compared the prey of juvenile salmonids to food items available in the environment; although some trends can be identified, the results have not shown consistent relations. For example, Irvine and Northcote (1982) found that rainbow trout (*Oncorhynchus mykiss*) in the Lardeau River system in British Columbia feed almost exclusively on drift; small fry feed primarily on surface drift, and larger fry feed on drift lower in the water column. McNicol and others (1985) likewise found that brook trout (*Salvelinus fontinalis*) in the South Duck River, Manitoba, feed to a large extent on subsurface drift. Some studies have shown diel differences in feeding behavior. Bisson (1978) reported that during daylight hours, small rainbow trout in a spring-fed experimental stream in southwestern Washington feed on midwater drift, while large trout use surface drift; both sizes of fish feed on benthos at night.

The main objectives of this study were to (1) compare the food taken by juvenile salmonids to the food in the environment, and (2) determine how riparian canopy affects the composition of fish-food organisms and their subsequent use by young salmonids.

Lists of the seasonal distribution of invertebrates collected during this study have been published (Porter and Meehan 1987). In this report, I have presented the invertebrate taxonomic data at the order level.

Study Area

Eight streams in Oregon were selected for study (fig. 1)—two in each of four geographical regions: coastal Oregon, the west side of the Cascade Range, central Oregon, and eastern Oregon. Thus, a general transect of the State from west to

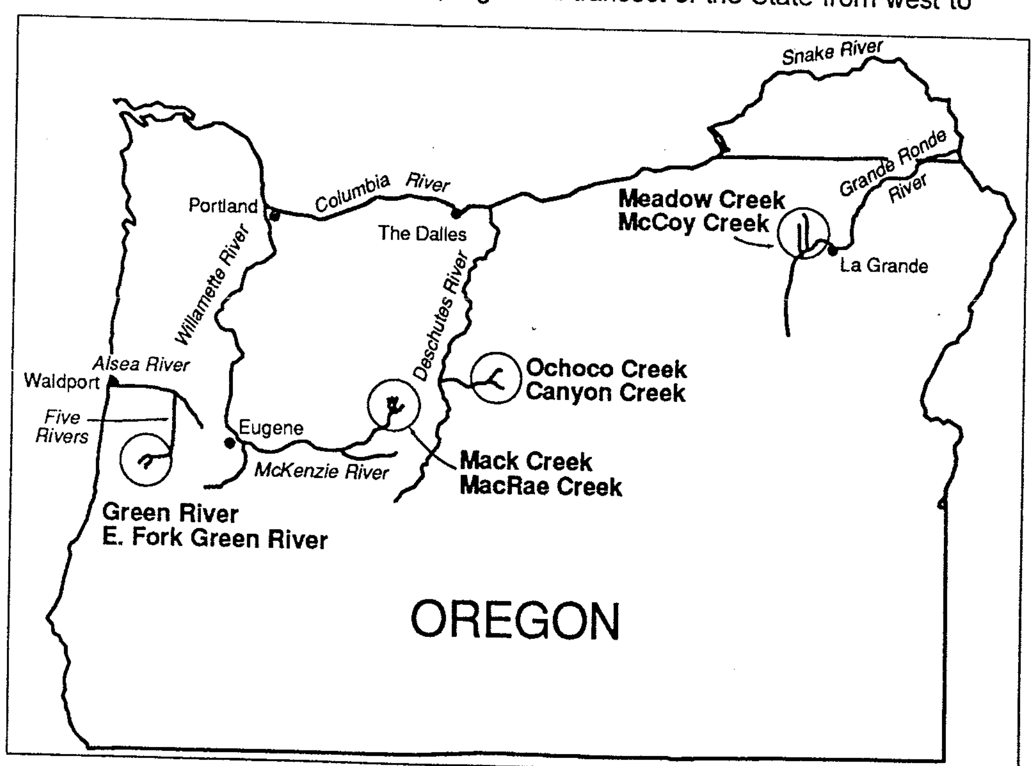

Figure 1—Locations of study streams.

east was sampled. All the study streams were second- or third-order streams, comparable in size, and representative of the small streams that furnish a large amount of rearing habitat for young salmon and trout. The study streams, by area, were:

Coast—Tributaries of Five Rivers in the Alsea River drainage:
- Green River
- East Fork Green River

Cascades—Tributaries of the Lookout Creek system, which drains into the McKenzie River:
- Mack Creek
- MacRae Creek

Central—Tributaries of the Deschutes River drainage:
- Ochoco Creek
- Canyon Creek

Eastern—Tributaries of the Grande Ronde River:
- Meadow Creek
- McCoy Creek

In each of the eight streams, samples were collected from a reach with a canopy of vegetation over the stream, and a reach that was open. Canopy type ranged from mixed coniferous and hardwood forest in the coastal and Cascades areas to shrubs and grasses in the central and eastern areas. Stream substrates were generally similar and ranged from cobble to coarse sand.

Material and Methods

Aquatic Sample Types

Benthic—Benthic samples were collected by using a modified Hess sampler covering a surface area of 0.09 m^2. Two samples were collected from each study reach at the beginning and again at the end of a 16-day sampling period; the samples were preserved in formal alcohol (half 70-percent ethanol and half 10-percent Formalin). In the laboratory, invertebrates were sorted from the benthos, counted, and identified to the lowest taxonomic level possible (generally to family and, where feasible, to genus or species). After the invertebrates were sorted, the entire sample was freeze-dried and weighed on an analytical balance to the nearest 0.1 mg.

Drift—Macroinvertebrate drift was sampled in each study section with a 280-μ mesh Nitex drift net.[1] Nets were 46 cm wide, 31 cm high, and 76 cm long. One net was set in place at the lower end of each study reach for 24 hours at the beginning and end of each 16-day sampling period. Nets were placed in riffles or runs with the bottom of the net on the streambed and the top above the stream surface such that the entire water column was sampled. Samples were processed in the field and laboratory as described for benthic samples.

[1] The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the U.S. Department of Agriculture of any product or service to the exclusion of others that may be suitable.

Fish stomach contents—Fish were collected with a Smith-Root 12-v D.C. backpack electroshocker in each study reach at the beginning and again at the end of a 16-day sampling period. During each sampling period, 10 fish, or as many as could be collected, of each salmonid species were captured. Fish from 50- to 150-mm fork length were used when possible, because complete flushing of stomachs of larger fish was difficult and error was more likely. Captured fish were anesthetized with Tricaine Methanesulfonate (MS-222), measured (fork length in mm), and weighed to the nearest 0.1 g on an analytical balance. Stomachs were then flushed (Meehan and Miller 1978) and the contents were preserved in formal alcohol. After reviving in fresh water, the fish were released back into the stream at the same location where they were captured.

Aerial Sample Types

Terrestrial insects and adult aquatic insects that dropped onto the stream surface were sampled during each sampling period by using sticky traps and water traps. A pair (one of each type) was located at each of two sites within each study reach.

Sticky trap—Sticky traps were 31-cm squares of white-painted 6.35-mm plywood; each was covered with a piece of 6-mil clear polyethylene film. This square surface was sprayed with "Tree Tanglefoot," a sticky substance used as a barrier to crawling insects on trees. Each coated board was taped to a Styrofoam float 36 cm square and 5.1 cm thick. Two sticky traps were placed in each study reach for the full 16 days of each sampling period. When the trap was removed at the end of the sampling period, the plastic film was cut off at the edges of the board so that a 31-cm-square collection surface was retained, butcher paper was placed over the sticky side to prevent crushing or mold damage to the specimens, and this film and butcher paper "sandwich" was transported to the laboratory. In the laboratory, the butcher paper was removed and the film cut into 2.54-cm strips for viewing under a microscope. Insects were counted and identified, usually to the family level.

Water trap—Water traps were made from 33- by 28-cm plastic dishpans, 13 cm deep, surrounded by a 61-cm rectangle of 5.1-cm-thick Styrofoam for support and floatation. Each pan was filled to about half its depth with water, and 28.4 g of formalin and 28.4 g of a surfactant (Ortho R X-77 Spreader) were added. The surfactant reduced surface tension and allowed insects to settle to the bottom. A small hole was bored into a lower corner of the pan and was fitted with a rubber stopper for easy removal of the contents. Two water traps were set out in each study reach for the full 16 days. When a trap was removed at the end of a sampling period, the corner plug was removed and the contents of the pan were strained through a 0.5-mm mesh screen. The material remaining on the screen was washed into a jar with formal alcohol and processed as described for benthic and drift samples.

Sampling Schedule

Each stream was sampled during summer and fall 1974 and during all four seasons in 1975 and 1976. Samples were taken at the following times: winter—mid January to early February; spring—early to late April; summer—early to late July; and fall—early October to early November.

A sampling period was organized as follows:

On day 1, sticky traps, water traps, and drift nets were set out. On day 2 (24 hours later), drift nets were pulled. During these 2 days, benthic and fish stomach content samples were taken.

Two weeks later, macroinvertebrates and fish were again sampled . On day 15, drift nets were set out, and 24 hours later (day 16), they were pulled. Sticky traps and water traps that had been in place during the 16-day period were removed. During these 2 days, benthic macroinvertebrates and fish stomach contents were again sampled.

Because of ice and other weather-related problems, the winter sampling period at the central and eastern sites in both years, and at the Cascade site in 1976, was only one trip of 2 days rather than two trips over 16 days. During these shortened sampling periods, samples from sticky traps and water traps were not obtained, and only half as many of the other samples were collected.

Identification of Organisms

Invertebrates other than insects were identified through descriptions in Pennak (1978), Ward and Whipple (1959), and Burch (1982). Aquatic insects were identified from taxonomic keys in Hatch (1953, 1957, 1961, 1965, 1971), Usinger (1956), Jensen (1966), Cole (1969), Anderson (1976), Edmunds and others (1976), Baumann and others (1977), and Merritt and Cummins (1978). Terrestrial insects were identified primarily from Borror and others (1976). Amphibians and fish were identified from Stebbins (1954) and Bond (1973), respectively.

Statistical Analysis

To simplify the various analyses and comparisons, invertebrates were studied at the order level. Seven orders comprised the majority of the invertebrates collected, so these seven orders were listed individually, and the remaining organisms were lumped into the category "other."

Initial data analysis showed that in the four geographical areas, fish preyed on the available food items comparably; that is, in all four geographical areas, a particular order of invertebrates was fed on in about the same proportion relative to its percentage of occurrence in the environment. Therefore, areas (and years) were combined in the analyses. Likewise, no obvious differences in the feeding habits of the fish were seen between the two streams in each area, and so streams within areas also were combined.

The data used in this analysis resulted from compositing the samples of invertebrates for four distinct categories: diets of fish in canopied and noncanopied stream sections, and the populations of macroinvertebrates present in the stream environment in canopied and noncanopied sections. The response variable was the number of macroinvertebrates in each taxon (order) that occurred in the composite sample within each of the four categories.

The response variable can be viewed as a categorical variable with eight nominal categories; that is, a multinomial variable with eight categories, one for each invertebrate order. The purpose of the analysis was to compare the profiles of this response variable among the four populations described above. The profile was best presented as the set of percentages (or proportions) of invertebrates in each order group. These percentages were computed separately within each population. The profiles for the four populations were compared to determine whether the profiles were similar for canopied and noncanopied stream sections, and more importantly, whether the profile of fish diet was similar to the profile of invertebrates available in the environment. In fact, two simple main effects were considered, one associated with canopied versus noncanopied stream conditions, and the other with fish diet versus presence of the invertebrates in the environment. The interaction of these two effects also was evaluated.

Methods described by Agresti (1990) were used to compare these profiles. The generalized baseline-category logit transformation was applied to the profile percentages in each population. Diptera were consistently the most abundant invertebrates collected; hence, this order was used as the baseline category. The resulting transformed profiles were then compared by testing main effects associated with (1) fish diet compared to invertebrate populations available in the environment, (2) canopied versus noncanopied stream conditions, and (3) the interaction. All tests were based on maximum-likelihood methods for model fitting.

Results and Discussion

Statistical Analysis

In comparing the profiles of the four categories (fish diet and invertebrate presence in canopied and noncanopied stream sections), these categories represent a two-by-two arrangement of treatment factors. One factor is riparian condition—canopy or no canopy; the other factor is fish diet versus invertebrates in the environment (tables 1 and 2). Fitting a model with both main effects and the interaction would describe the observed profiles exactly. Thus, a first consideration was the need for the interaction term in the model describing the transformed profiles. The interaction term was statistically significant, but the chi-square value associated with the interaction term (χ^2=198, df=7) was relatively small compared to other sources of variation (table 3). Further, examination of differences in observed and predicted profiles, using only the main-effects model, indicated that the main-effects model fitted the data well, thereby confirming that the interaction effect was small from a practical perspective.

Both main effects—fish diet versus invertebrates available in the environment, and canopied versus noncanopied stream condition—were highly significant ($p \leq 0.01$). This indicates that the profile of fish diet differed from the profile of invertebrates in the environment. And the profile for canopied sections differed from the profile for noncanopied sections. These profiles are contrasted in figures 2 and 3. Because climate and geographical factors differed greatly among the areas, the same analysis was run separately on each stream; the results were similar to those from the analysis using combined areas.

Table 1—Number of invertebrates, by order, collected from fish stomachs (cutthroat trout, rainbow trout, coho salmon)

Order	Cutthroat trout	Rainbow trout	Coho salmon	Total fish
Collembola	165	70	471	706
Ephemeroptera	4,010	6,238	989	11,237
Plecoptera	1,412	1,602	345	3,359
Homoptera	158	3,570	282	4,010
Coleoptera	361	1,245	323	1,929
Trichoptera	1,715	2,560	492	4,767
Diptera	5,557	9,166	4,051	18,774
Other	1,497	2,511	746	4,754
Total	14,875	26,962	7,699	49,536

Table 2—Number of invertebrates, by order, collected from the environment (benthic, drift, sticky traps, water traps)

Order	Benthic	Drift	Sticky trap	Water trap	Total environment
Collembola	49	307	20,213	13,579	34,148
Ephemeroptera	34,905	20,554	911	464	56,834
Plecoptera	16,593	9,343	977	773	27,686
Homoptera	213	5,740	2,845	1,788	10,586
Coleoptera	10,724	3,172	1,015	1,527	16,438
Trichoptera	8,866	3,084	1,980	1,174	15,104
Diptera	25,612	13,572	37,072	22,903	99,159
Other	5,492	3,109	1,125	3,029	12,755
Total	102,454	58,881	66,138	45,237	272,710

Table 3—Interaction-effect analysis of variance

Source	DF	Chi-square	Probability
Intercept	7	99,560.16	<0.01
Environment vs fish	7	7,861.90	<0.01
Canopy vs noncanopy	7	3,496.50	<0.01
Likelihood ratio	7	198.42	<0.01

Although the differences in profiles were statistically significant, the differences did not appear to be of practical importance. Notice, for example, the percentages of Diptera and Ephemeroptera—the two dominant orders of macroinvertebrates collected—in figures 2 and 3. For these two orders, the difference between treatment effects was small. The greater differences in other orders that are not as important as fish food organisms, such as Collembola and Homoptera, would account for most of the statistical differences found in the profiles (figs. 2 and 3).

Benthic

Mayflies (Ephemeroptera) were the most abundant invertebrates in benthic samples in both canopied and noncanopied stream sections, followed closely by true flies (Diptera) and stoneflies (Plecoptera) (table 4).

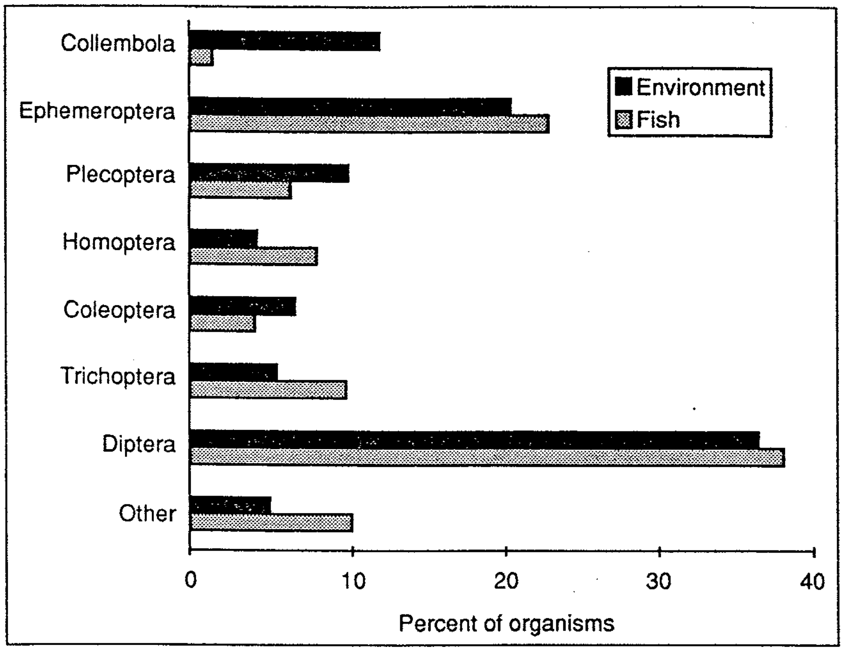

Figure 2—Percentage of invertebrates, by order, collected from the environment (combined benthic, drift, sticky trap, and water trap samples) and from fish stomachs (cutthroat trout, rainbow trout, and coho salmon combined).

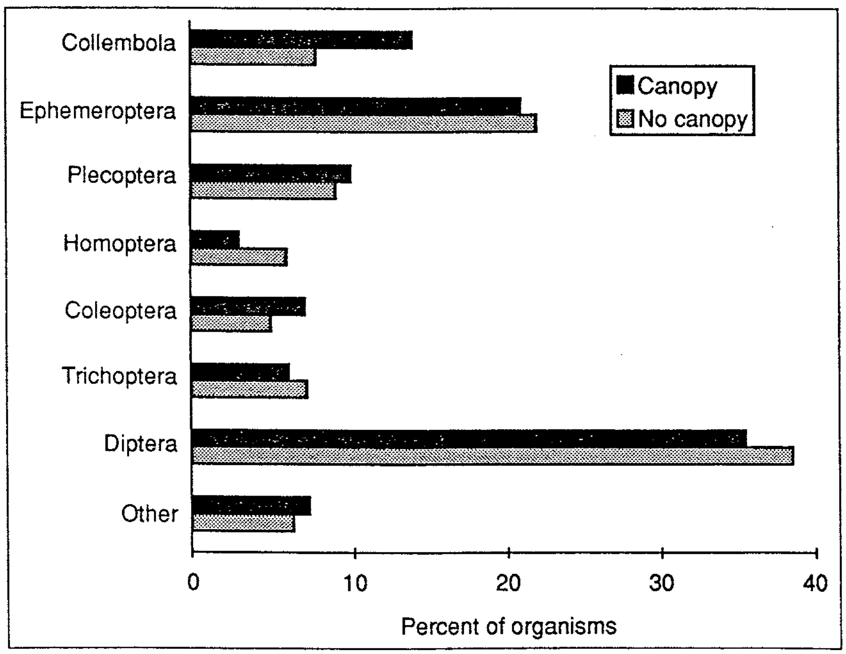

Figure 3—Percentage of invertebrates, by order, collected by combined sampling methods (benthic, drift, sticky trap, water trap, cutthroat trout stomachs, rainbow trout stomachs, coho salmon stomachs) in canopied and noncanopied stream sections.

Table 4—Number and percentage of invertebrates, by order, collected in benthic samples in canopied and noncanopied stream sections

Order	Canopy		No canopy		Total	
	Number	Percent	Number	Percent	Number	Percent
Collembola	15	0.0	34	0.1	49	0.0
Ephemeroptera	16,591	34.6	18,314	33.6	34,905	34.1
Plecoptera	8,295	17.3	8,298	15.2	16,593	16.2
Homoptera	162	.3	51	.1	213	.2
Coleoptera	5,873	12.3	4,851	8.9	10,724	10.5
Trichoptera	3,692	7.7	5,174	9.5	8,866	8.7
Diptera	10,674	22.3	14,938	27.4	25,612	25.0
Other	2,637	5.5	2,855	5.2	5,492	5.3
Total	47,939	100.0	54,515	100.0	102,454	100.0

Drift

As in the benthic samples, ephemeropterans were the most abundant invertebrates found in the drift samples in both canopied and noncanopied stream sections, followed by dipterans (table 5). In canopied sections, plecopterans were the next most abundant; in noncanopied sections, however, homopterans were slightly more numerous than plecopterans. This abundance of homopterans in the drift in noncanopied sections was the result of a very high percentage of this order collected in the fall sampling in streams in eastern Oregon, particularly Meadow Creek (Porter and Meehan 1987: 36).

Sticky Trap

Dipterans were the most abundant invertebrates collected on sticky traps in both canopied and noncanopied stream reaches, followed by collembolans (table 6); ephemeropterans and plecopterans were the least numerous in both canopied and noncanopied sections.

Water Trap

Water trap samples were similar to sticky trap samples: in both canopied and noncanopied stream reaches, dipterans were the most abundant invertebrates, followed by collembolans (table 7).

Fish Stomach Contents

Cutthroat trout—In both canopied and noncanopied stream reaches, Diptera and Ephemeroptera were the most abundant taxa found in cutthroat trout stomachs, and Homoptera and Collembola were the least numerous (table 8).

Rainbow trout—Rainbow trout stomach samples were similar to those of cutthroat trout: dipterans and ephemeropterans were the most abundant invertebrates found in both canopied and noncanopied sections (table 9) and collembolans were the least abundant. In both canopied and noncanopied sections, however, homopterans were quite abundant in rainbow trout stomachs.

Table 5—Number and percentage of invertebrates, by order, collected in drift samples in canopied and noncanopied stream sections

Order	Canopy		No canopy		Total	
	Number	Percent	Number	Percent	Number	Percent
Collembola	195	0.7	112	0.4	307	0.5
Ephemeroptera	10,171	36.8	10,383	33.2	20,554	34.9
Plecoptera	4,818	17.4	4,525	14.5	9,343	15.9
Homoptera	806	2.9	4,934	15.8	5,740	9.7
Coleoptera	1,799	6.5	1,372	4.4	3,172	5.4
Trichoptera	1,781	6.4	1,303	4.2	3,084	5.2
Diptera	6,316	22.8	7,256	23.2	13,572	23.1
Other	1,766	6.5	1,343	4.3	3,109	5.3
Total	27,652	100.0	31,229	100.0	58,881	100.0

Table 6—Number and percentage of invertebrates, by order, collected on sticky traps in canopied and noncanopied stream sections

Order	Canopy		No canopy		Total	
	Number	Percent	Number	Percent	Number	Percent
Collembola	12,388	33.6	7,825	26.7	20,213	30.5
Ephemeroptera	442	1.2	469	1.6	911	1.4
Plecoptera	640	1.7	337	1.1	977	1.5
Homoptera	1,603	4.4	1,242	4.2	2,845	4.3
Coleoptera	487	1.3	528	1.8	1,015	1.5
Trichoptera	1,202	3.3	778	2.7	1,980	3.0
Diptera	19,558	53.1	17,514	59.8	37,072	56.1
Other	510	1.4	615	2.1	1,125	1.7
Total	36,830	100.0	29,308	100.0	66,138	100.0

Table 7—Number and percentage of invertebrates, by order, collected on water traps in canopied and noncanopied stream sections

	Canopy		No canopy		Total	
Order	Number	Percent	Number	Percent	Number	Percent
Collembola	8,527	33.9	5,052	25.2	13,579	30.0
Ephemeroptera	260	1.0	204	1.0	464	1.0
Plecoptera	505	2.0	268	1.3	773	1.7
Homoptera	1,161	4.6	627	3.1	1,788	4.0
Coleoptera	1,066	4.2	461	2.3	1,527	3.4
Trichoptera	523	2.1	651	3.2	1,174	2.6
Diptera	11,539	45.8	11,364	56.7	22,903	50.6
Other	1,609	6.4	1,420	7.2	3,029	6.7
Total	25,190	100.0	20,047	100.0	45,237	100.0

Table 8—Number and percentage of invertebrates, by order, collected from cutthroat trout stomachs in canopied and noncanopied stream sections

	Canopy		No canopy		Total	
Order	Number	Percent	Number	Percent	Number	Percent
Collembola	65	1.1	100	1.1	165	1.1
Ephemeroptera	1,743	28.5	2,267	25.9	4,010	26.9
Plecoptera	639	10.5	773	8.8	1,412	9.5
Homoptera	52	.9	106	1.2	158	1.1
Coleoptera	167	2.7	194	2.2	361	2.4
Trichoptera	814	13.3	901	10.3	1,715	11.5
Diptera	1,919	31.4	3,638	41.5	5,557	37.4
Other	711	11.6	786	9.0	1,497	10.1
Total	6,110	100.0	8,765	100.0	14,875	100.0

Table 9—Number and percentage of invertebrates, by order, collected from rainbow trout stomachs in canopied and noncanopied stream sections

Order	Canopy		No canopy		Total	
	Number	Percent	Number	Percent	Number	Percent
Collembola	27	0.2	43	0.3	70	0.3
Ephemeroptera	2,845	25.2	3,393	21.7	6,238	23.2
Plecoptera	915	8.1	687	4.4	1,602	5.9
Homoptera	1,089	9.6	2,481	15.8	3,570	13.2
Coleoptera	668	5.9	577	3.7	1,245	4.6
Trichoptera	769	6.8	1,791	11.4	2,560	9.5
Diptera	3,782	33.5	5,384	34.4	9,166	34.0
Other	1,195	10.7	1,316	8.3	2,511	9.3
Total	11,290	100.0	15,672	100.0	26,962	100.0

Coho salmon—As with the cutthroat trout and rainbow trout stomach samples, true flies and mayflies were the most abundant invertebrates found in coho salmon stomachs in both canopied and noncanopied stream reaches (table 10). Percentages of the remaining taxa were fairly similar.

Variation Among Sample Types

In all sample types except sticky and water traps, dipterans and ephemeropterans were the predominant invertebrates collected; dipterans were somewhat more abundant than ephemeropterans, except in benthic and drift samples, where ephemeropterans were slightly more numerous. In the sticky and water trap samples, Diptera was again the most abundant taxon, but the second most abundant group was the collembolans. Collembolans were the least abundant invertebrates in all sample types, except sticky and water traps and coho salmon stomachs.

Fish Diet

Dipterans and ephemeropterans were the dominant invertebrates consumed by all fish species sampled, and in most cases, collembolans were the least used group. Because of the abundance of collembolans in the sticky and water trap samples, even though they were not found in abundance in the drift, it appears that the fish were probably negatively selective toward this taxon.

Use of Traps

The proportions of taxa found in sticky trap and water trap samples were relatively similar. Based on the results of this study, it appears unnecessary to collect both of these sample types if a general description of food items available in the environment and items eaten by fish is the final objective. Water traps are easier to work with than sticky traps, and the invertebrates are also in better condition. As a result, if the least amount of sampling possible is a prerequisite, sticky traps at the water surface could probably be eliminated from the sampling scenario. If differences in invertebrate abundance and composition above the air-water interface are sought, however, then sticky traps would be an important consideration.

Table 10—Number and percentage of invertebrates, by order, collected from coho salmon stomachs in canopied and noncanopied stream sections

	Canopy		No canopy		Total	
Order	Number	Percent	Number	Percent	Number	Percent
Collembola	166	4.4	305	7.8	471	6.1
Ephemeroptera	412	10.9	577	14.7	989	12.8
Plecoptera	163	4.3	182	4.6	345	4.5
Homoptera	147	3.9	135	3.4	282	3.7
Coleoptera	180	4.8	143	3.7	323	4.2
Trichoptera	264	7.0	228	5.8	492	6.4
Diptera	2,094	55.3	1,957	50.0	4,051	52.6
Other	359	9.4	387	10.0	746	9.7
Total	3,785	100.0	3,914	100.0	7,699	100.0

In all sample types except sticky and water traps, total numbers of invertebrates were somewhat greater in noncanopied stream sections than in canopied sections. In sticky and water traps, the greater abundance of Collembola in canopied sections probably accounted for this difference from the other sample types.

Conclusions

The results of this study showed a significant difference between the profile of macroinvertebrates sampled in the environment and those taken as food items by fish, and between those stream sections sampled that had riparian canopy and those that did not. "Profile" in this case can be likened to invertebrate community structure. However, the two dominant macroinvertebrate taxa—Diptera and Ephemeroptera—did not appear to be much different from a practical standpoint; that is, in terms of the amount of preferred fish food organisms available, the presence or absence of riparian canopy did not appear to be a major concern. There were a few more dipterans and ephemeropterans in the noncanopied sections than in the canopied sections (fig. 3), but probably not enough to warrant a management prescription that would open up the riparian canopy for the sole purpose of providing more preferred food items for fish.

English Equivalents

1 meter (m) = 3.28 feet

1 square meter (m^2) = 10.76 square feet

1 centimeter (cm) = 0.39 inch

1 millimeter (mm) = 0.039 inch

1 micrometer (μ) = 0.000039 inch

1 gram (g) = 0.035 ounce

1 milligram (mg) = 0.000035 ounce

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