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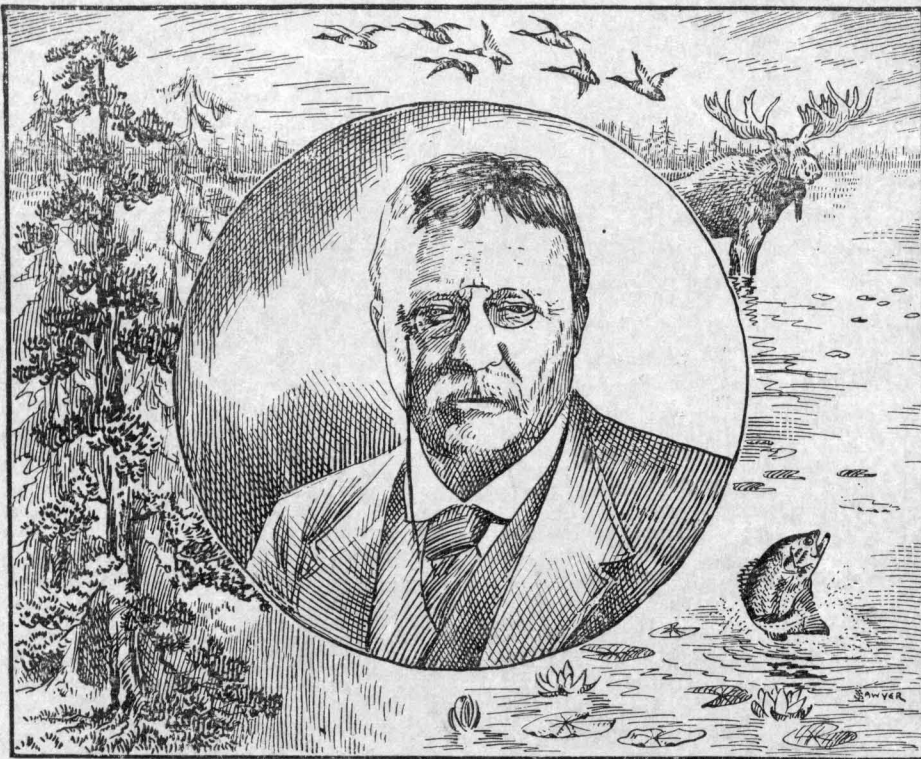
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THE ECOLOGY OF TROUT STREAMS  
THE FOOD OF TROUT STREAM INSECTS

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## THE FOOD OF TROUT STREAM INSECTS IN YELLOWSTONE NATIONAL PARK

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## INTRODUCTION

The present collaboration is based on certain joint investigations of the authors in Yellowstone National Park during the summer of 1921, under the direction of the Roosevelt Wild Life Forest Experiment Station, of the New York State College of Forestry at Syracuse. During that summer the senior author was engaged in the study of the broader problem of the ecology of trout stream organisms. In considering the trout stream as an ecological unit, it was necessary to study the biota not merely as related to trout, hence as a potential food supply, but also as related to each other. In other words, what is the food supply of the various animals inhabiting the trout streams?

For the study of this phase it was necessary to make a survey of the plant life of the streams and the part it plays in the food of the animals. For obviously, in the last analysis, all life in trout streams, quite as much as elsewhere, is dependent on the plant life. This phase was taken up more intensively after the arrival of the junior author in Yellowstone Park in early August, when collections were made of the plants of different streams together with associated animals. Collections were made from different parts of the streams in order to obtain as varied a series of selections as possible in these highly specialized habitats. For instance, from Lost Creek samples of plant life were obtained from the swiftest rapids, from the pools formed by the rapids, from relatively quiet waters, from exposed and shaded spots, and also from the lateral pools.

Specimens were collected jointly from four streams typifying the various kinds of trout streams found in Yellowstone Park,—indeed, found throughout the Northwest. These are: 1. Yellowstone River, typical of the larger and permanent rapid streams; 2. Lamar River, a good type of "variable" or fluctuating stream, carrying enormous masses of water for short periods, followed by equally short periods of rapid recession—on the whole, a stream with a relatively low, equable flow; 3. Lost Creek and Tower Creek, both precipitous mountain streams of rather short length, with many falls and rapids. Their type is very numerous and form the tributaries of the larger streams. Tower Creek is the best representative of this type; but Lost Creek, a smaller stream, comprises similar conditions and biota, and was selected because of its convenient location at Camp Roosevelt, our field base.

In each case two comprehensive survey collections were made covering as many different habitats as the stream seemed to offer. Besides these, a number of isolated collections made previously by the senior author were available for comparison. The collected material was studied while still fresh. This applied also to the stomach contents of the various insects.

In the following pages, the notes on animals are by the senior author, those on plants mainly by the junior author.

## DESCRIPTION OF LOCALITIES

Yellowstone River, within Yellowstone National Park, has a continuous fall, thereby increasing the force of its current enormously. Generally the current attains a speed of eight to ten miles per hour, in places up to twenty miles. The many rapids, short and long falls and the tortuous bed, make the stream un-navigable within the Park. In width it varies from fifty to three hundred feet, especially in the "eddies" where the waters are dammed somewhat by the inflow of some tributary. The depth may be considerable, some of the "holes" attaining thirty and even forty feet, and rarely less than six feet, except for a few fords. The bed of the stream contains many huge boulders, granite rocks, and smaller stones. Hardly anywhere along the Yellowstone does one find sand or gravel except in the interstices between the huge boulders and lesser stones along parts of shores that are less directly exposed to the current.

The shores of the Yellowstone are greatly varied, from volcanic rock to alluvial and glacial soil, the latter with the "sulphur slides" so characteristic of the canyons of the Yellowstone. In the spring the melting snow carries great quantities of this soil into the stream which then silts out as the period of high water passes. Such slides may, however, occur at any time in the summer and the river will then be turbid for a few hours or days, until the loose soil has settled or is washed away.

The Lamar River varies from fifty to one hundred and fifty feet in width, and at the ordinary stage is about two feet in depth. Its rapids are of a much milder type than those of the Yellowstone, although during the flood period they rage with tremendous force and appear formidable. In spring the melting snows bring enormous masses of mud and sand with them, which silt out among the shore rocks and boulders as the waters recede,—in fact, nearly covering the rocks and thus giving little idea of the ferocity of the spring torrents. Yet each year, with the spring floods, all these deposits are washed out, to be replaced by others coming down from the mountains.

The bed of the stream is generally clear, composed of granite boulders, and rocks usually not smaller than a cubic foot, but of smaller size at the fords. The Lamar is essentially a shallow stream and fordable in numerous places. Yet it is an excellent stream for trout and supports a rather luxuriant plant and animal life.

The precipitous streams, such as Lost Creek and Tower Creek, because of their great vertical fall, have few cobble stones or gravel or sand in their beds, except at the margin of the pools. Tower Creek is of practically constant width, about twenty to twenty-five feet, for at least seven miles above the falls, the junction point with the Yellowstone. The depth varies from eighteen inches to two feet. The bed is nearly uniformly composed of rounded cobbles varying from pebble size to a cubic foot, with some huge boulders scattered along the bed and shores of the stream.

Lost Creek is ideal for the study of the recession of waters. In flood periods (late June) it is an energetic and precipitous torrent which impresses one by the

amount and force of the descending waters. A few weeks later, in middle August, the creek is a thin trickle carrying a flow of hardly more than a gallon per second. Even this disappears entirely into the ground about five hundred yards below the pretty Lost Creek Falls in a bed of mixed gravel and cobbles, a short distance above Tower Fall Junction Ranger Station. Half a mile down the stream reappears as a sump along the Cooke City road, leading down to the Cooke City bridge across the Yellowstone River.

### THE PLANTS AND ANIMALS

**General Factors.** In such a highly specialized habitat as mountain trout streams both physiographical and physiological conditions act restrictively on the biota. The constant fall of the water and the resulting tremendous force of the current constitute the major factors in limiting the aquatic population. Secure places for temporary attachment are few: shelters against the current are none too many; there is little opportunity for swimming. Hence only plants and animals with holdfasts,—either natural or artificial, such as webs, claws, suckers—or powerful swimmers can establish and maintain themselves. In addition, the force of the water makes their resting places rather uncertain, since offal, sticks, and stones are constantly being whirled along and strike against the rocks. Even larger rocks may be moved by the current; indeed, well into the summer, weeks after the spring floods are over, one can hear the slow rubbing and grinding of the rocks in the stream beds.

On the other hand, the speed of the water, and the frequent rapids and falls make for high oxygen content. Most of the fauna seem to require this. If for any reason the oxygen is diminished, or the constant flow ceases, the animals die.

Due to these influences, the fauna is surprisingly sparse in all of the streams—that is, in number of species, but not in number of individuals of each species. The specialized conditions limit the number of species; but they also tend to increase the numbers of individuals of a species vastly. Hence one finds the endemic forms present in astonishing numbers.

The major portion of the fauna is composed of insects, to exceed 99%,—that is, if fish be excluded. One is surprised at the almost complete absence of Annelids, leeches, Crustacea, and Mollusca, and at the rarity of Protozoa and Rotifera, all of which are so abundant under less violent aquatic conditions.

The plants are restricted to algae; all higher plants are absent. Smaller algae, diatoms and desmids find shelter in tiny crevices, in the films of emergent shore rocks, or behind rocks where the current is not too strong.

Certain faunistic peculiarities of the streams may be noted. Thus, both Tower Creek and Lost Creek are characterized by the abundance of planarians and of the caddisworm *Hydropsyche*, and by the nearly total absence of *Simulium*. On the other hand, *Simulium* is present in quantities in the Yellowstone and the Lamar rivers, while planarians are exceedingly rare. The larger *Perloidea* are also very characteristic for these two streams. In smaller and precipitous streams they seem to be somewhat infrequent.

## List of Biota.

*Algae and Diatoms.*

<i>Cladophora</i> sp.	<i>Oscillatoria</i> sp.
<i>Closterium</i> sp.	<i>Prasiola</i> sp.
<i>Cocconeis</i> sp.	<i>Rhoicosphenium</i> sp.
<i>Epithemia</i> sp.	<i>Rhizoclonium</i> sp.
<i>Gomphonema</i> sp.	<i>Spirogyra</i> sp.
<i>Melosira</i> sp.	<i>Synedra</i> sp.
<i>Nostoc</i> sp.	(Moss—undetermined)

*Animals.*

## Protozoa

*Ameba* sp.*Colpoda* sp.*Gregarina* sp.—as parasites in Trichoptera, Perloidea, and Ephemeroidea.

## Rotifera

Several spp.

## Nematoda

*Mermis* (?) sp.—as parasites in mayfly nymphs and in *Simulium*.

## Arthropoda

## Perloidea.

*Pteronarcys californica**Pteronarcella badia**Acroneuria pacifica**Alloperla coloradensis**Alloperla fidelis**Alloperla lineosa**Alloperla* sp.*Doroneuria theodora**Isoperla 5-punctata**Perla verticalis**Perlodes signata**Pteronarcella badia**Pteronarcys californica*

## Ephemeroidea

*Ameletus* sp.*Baetis* sp.*Callibaetis* sp.*Drunella grandis**Ephemerella coloradensis**Ephemerella* sp.*Heptagenia* sp.*Iron longimanus*

## Trichoptera

*Brachycentrus* sp.*Glossosoma* sp.*Goera* sp.*Hydropsyche* sp.*Limnophilus* sp.*Neophylax concinnus**Philopotamus* sp.*Platyphylax* sp.*Rhyacophila torva**Thremma* sp.*Triaenodes* sp.

## Diptera

*Atherix variegata**Bibiocephala comstocki**Bibiocephala grandis**Chamaedipsis* sp.*Chironomus* sp.*Cricotopus varipes**Metriocnemus* sp.*Orthocladius* sp.*Philolutra simplex**Procladius* sp.*Psychoda* sp.*Rhamphomyia* sp.*Simulium* sp.*Tanytarsus exiguus*

## THE FOOD OF THE INSECTS IN TROUT STREAMS

In the following tables the first numbers are the collection numbers. The succeeding number refers to the individual insect whose stomach contents are listed. The estimates are given in percentages. "Detritus" signifies unidentifiable refuse. The figures in parenthesis are the numbers of individual items of food.

**The Food of Perloidea or Stoneflies.** The table below gives in detail the food percentage of the stoneflies as determined from the specimens examined.

TABLE NO. I.—SHOWING THE FOOD OF THE PERLOIDEA OR STONEFLIES.

Collection Number	Number and Name of Individual Specimens	Date 1921	Locality	Habitat	Food Items in Percentages
5517	1. Pteronarcys californica..	July 5	Yellowstone R.	Rapids near shore.	Intestines with wood fibers, 100.
5517	2. Pteronarcys californica..	July 5	Yellowstone R.	Rapids near shore.	Intestines with wood fibers, 100.
5517	3. Pteronarcys californica..	July 5	Yellowstone R.	Rapids near shore.	Plant matter, 100.
5506J	3. Acroneuria pacifica.....	Aug. 10	Lost Creek...	Rapids of fair violence.	Heptagenia (2), 75; diatoms, 25.
5507a	1. Acroneuria pacifica.....	Aug. 11	Yellowstone R.	Strong rapids....	Drunella, 25; Heptagenia, 25; Rhyacophila, 45; wood fragments, 5.
5507a	2. Acroneuria pacifica.....	Aug. 11	Yellowstone R.	Strong rapids....	Tanytarsus pupa, 100. Gregarina.
5507a	3. Acroneuria pacifica.....	Aug. 11	Yellowstone R.	Strong rapids....	Tanytarsus larvae, 99; wood fragment, .5; pollen grain of pine, .5.
5507a	4. Acroneuria pacifica.....	Aug. 11	Yellowstone R.	Strong rapids....	Tanytarsus (5), 50; Heptagenia, 20; Rhyacophila, 28; detritus, 2.
5507a	5. Acroneuria pacifica.....	Aug. 11	Yellowstone R.	Strong rapids....	Tanytarsus (3), 50; Ephemerella, 49; Cladophora, 1.
5507a	6. Acroneuria pacifica.....	Aug. 11	Yellowstone R.	Strong rapids....	Chironomus in tube, 100.
5507a	7. Acroneuria pacifica.....	Aug. 11	Yellowstone R.	Strong rapids....	Empty.
5507a	8. Acroneuria pacifica.....	Aug. 11	Yellowstone R.	Strong rapids....	Detritus, 100.
5507a	9. Acroneuria pacifica.....	Aug. 11	Yellowstone R.	Strong rapids....	Tanytarsus, 100.
5507a	10. Pteronarcys californica..	Aug. 11	Yellowstone R.	Strong rapids....	Tanytarsus (3), 5; Cladophora, 75; shore diatoms, 15; wood and bark fragments, 5.
5507a	11. Pteronarcys californica..	Aug. 11	Yellowstone R.	Strong rapids....	Small moth, 100.
5507a	12. Pteronarcys californica..	Aug. 11	Yellowstone R.	Strong rapids....	Detritus, 100.
5572a	1. Perla verticalis ? .....	Aug. 12	Lost Creek...	Strong rapids....	Ephemerella, 40; Heptagenia, 50; Chironomus, 9; diatoms, 1.
5574d	1. Acroneuria pacifica.....	Aug. 13	Lamar River..	Feeding among rocks in quiet current.	Chironomus larvae, 100. Gregarina.
5574d	2. Acroneuria pacifica.....	Aug. 13	Lamar River..	Feeding among rocks in quiet current.	Mayfly fragments, 100. Gregarina.
5574d	3. Acroneuria pacifica.....	Aug. 13	Lamar River..	Feeding among rocks in quiet current.	Tanytarsus (5), 20; mayfly nymph, 50; insect fragments, 20; detritus, 10. Gregarina.
5574d	4. Acroneuria pacifica.....	Aug. 13	Lamar River..	Feeding among rocks in quiet current.	Tanytarsus pupae (2), 100.
5574d	5. Acroneuria pacifica.....	Aug. 13	Lamar River..	Feeding among rocks in quiet current.	Tanytarsus pupae (2), 90; wood fragments, 10. Gregarina.
5574d	6. Acroneuria pacifica.....	Aug. 13	Lamar River..	Feeding among rocks in quiet current.	Bachycentrus (2), 100.
5575a	1. Acroneuria pacifica.....	Aug. 14	Tower Creek..	Mild rapids.....	Heptagenia, 60; Ephemerella, 20; Perla, 15; detritus, 5.
5575a	2. Acroneuria pacifica.....	Aug. 14	Tower Creek..	Mild rapids.....	Ameletus (4), 100.
5575a	3. Acroneuria pacifica.....	Aug. 14	Tower Creek..	Mild rapids.....	Heptagenia, 60; Rhyacophila (2), 40.
5575a	4. Acroneuria pacifica.....	Aug. 14	Tower Creek..	Mild rapids.....	Chironomus pupa, 60; caddisworm, 40.
5575a	5. Acroneuria pacifica.....	Aug. 14	Tower Creek..	Mild rapids.....	Chironomus (2), 40; Protenthes, 50; wood fragment, 10.
5585a	20. Acroneuria pacifica.....	Aug. 26	Lost Creek...	In shade. No vegetation.	Perla nymphs (5), 35; Chironomus pupa, 15; Melosira, 48; wood fragments, 2.
5585a	21. Acroneuria pacifica.....	Aug. 26	Lost Creek...	In shade. No vegetation.	Insect fragments, 15; Melosira, 85.

TABLE NO. 1.—SHOWING THE FOOD OF THE PERLOIDEA OR STONEFLIES.—  
(Continued).

Collection Number	Number and Name of Individual Specimens	Date 1921	Locality	Habitat	Food Items in Percentages
5585a	22. <i>Acroneuria pacifica</i> . . . . .	Aug. 26	Lost Creek . . .	In shade. No vegetation.	Chironomus, 5; Chironomus pupa, 20; perla nymphs (12), 65; Melosira, 5; detritus, 5.
5585a	23. <i>Acroneuria pacifica</i> . . . . .	Aug. 26	Lost Creek . . .	In shade. No vegetation.	Insect fragments, 100.
5585a	24. <i>Acroneuria pacifica</i> . . . . .	Aug. 26	Lost Creek . . .	In shade. No vegetation.	Cocconeis, 10; Melosira, 5; diatoms, 5; detritus, 80.
5585a	25. <i>Acroneuria pacifica</i> . . . . .	Aug. 26	Lost Creek . . .	In shade. No vegetation.	Mayfly fragments, 30; Melosira, 5; detritus, 65.
5585b	20. <i>Perla (verticalis)</i> . . . . .	Aug. 25	Lost Creek . . .	Sunlit parts of stream.	Empty.
5585b	21. <i>Perla (verticalis)</i> . . . . .	Aug. 25	Lost Creek . . .	Sunlit parts of stream.	Heptagenia, 60; Chironomus pupa, 25; perla nymphs, 14; melosira, 1.
5585b	22. <i>Perla (verticalis)</i> . . . . .	Aug. 25	Lost Creek . . .	Sunlit parts of stream.	Perla nymphs (7), 99; Melosira, 1.
5585b	23. <i>Perla (verticalis)</i> . . . . .	Aug. 25	Lost Creek . . .	Sunlit parts of stream.	Perla nymphs (13), 100.
5585b	24. <i>Perla (verticalis)</i> . . . . .	Aug. 25	Lost Creek . . .	Sunlit parts of stream.	Chironomus pupa, 30; Melosira, 50; sand, 10; wood fragments, 10; all in clearly marked zones in stomach.
5580a	12. <i>Pteronarcys californi</i> a . . . . .	Aug. 26	Lamar River . . .	Strong rapids among moss and Cladophora.	Moss, 60; bark, 35; diatoms, 5.
5580a	13. <i>Pteronarcys californi</i> a . . . . .	Aug. 26	Lamar River . . .	Strong rapids among moss and Cladophora.	Moss, 80; Epithemia, 20.
5580a	14. <i>Pteronarcys californi</i> a . . . . .	Aug. 26	Lamar River . . .	Strong rapids among moss and Cladophora.	Moss, 50; diatoms, 10; Epithemia, 40.
5580a	15. <i>Pteronarcys californica</i> . . . . .	Aug. 26	Lamar River . . .	Strong rapids among moss and Cladophora.	Moss, 85; diatoms, 1; Epithemia, 14.
5580a	16. <i>Pteronarcys californica</i> . . . . .	Aug. 26	Lamar River . . .	Strong rapids among moss and Cladophora.	Moss, 50; diatoms, 10; Epithemia, 40.
5580a	17. <i>Pteronarcys californica</i> . . . . .	Aug. 26	Lamar River . . .	Strong rapids among moss and Cladophora.	Epithemia, 100. Small amount.
5580a	18. <i>Acroneuria pacifica</i> . . . . .	Aug. 26	Lamar River . . .	Strong rapids among moss and Cladophora.	Ephemereella nymph, 99; moss, 1.
5580a	19. <i>Acroneuria pacifica</i> . . . . .	Aug. 26	Lamar River . . .	Strong rapids among moss and Cladophora.	Insect fragments, 100.
5580b	8. <i>Acroneuria pacifica</i> . . . . .	Aug. 26	Lamar River . . .	Minor rapids, among decaying Cladophora.	Chironomus larvae (16), 40; Perla, 40; sand, 20.
5580b	9. <i>Acroneuria pacifica</i> . . . . .	Aug. 26	Lamar River . . .	Minor rapids, among decaying Cladophora.	Chironomus larvae (19), 95; sand, 5.
5580b	10. <i>Acroneuria pacifica</i> . . . . .	Aug. 26	Lamar River . . .	Minor rapids, among decaying Cladophora.	Chironomus larvae (16), 90; Epithemia, 5; diatoms, 5.
5580b	11. <i>Acroneuria pacifica</i> . . . . .	Aug. 26	Lamar River . . .	Minor rapids, among decaying Cladophora.	Chironomus larvae (6), 40; Perla nymphs, 50; insect fragments, 10.
5580b	12. <i>Acroneuria pacifica</i> . . . . .	Aug. 26	Lamar River . . .	Minor rapids, among decaying Cladophora.	Perla nymphs, 45; mayfly nymph fragments, 50; sand, 5.
5580b	13. <i>Acroneuria pacifica</i> . . . . .	Aug. 26	Lamar River . . .	Minor rapids, among decaying Cladophora.	Chironomus larvae (2), 100.
5590a	1. <i>Acroneuria pacifica</i> . . . . .	Aug. 26	Yellowstone R.	Moderate rapids.	Chironomus larvae (4), 40; Rhyacophila, 50; sand, 10. Gregarina.
5590a	2. <i>Acroneuria pacifica</i> . . . . .	Aug. 26	Yellowstone R.	Moderate rapids..	Insect fragments, 100. Gregarina.
5590a	3. <i>Acroneuria pacifica</i> . . . . .	Aug. 26	Yellowstone R.	Moderate rapids..	Rhyacophila, 100.
5590a	4. <i>Pteronarcys californica</i> . . . . .	Aug. 26	Yellowstone R.	Moderate rapids..	Detritus, 100.
5590a	5. <i>Pteronarcys californica</i> . . . . .	Aug. 26	Yellowstone R.	Moderate rapids..	Detritus, 100.
5590a	6. <i>Pteronarcys californica</i> . . . . .	Aug. 26	Yellowstone R.	Moderate rapids..	Detritus, 100.
5590a	7. <i>Pteronarcys californica</i> . . . . .	Aug. 26	Yellowstone R.	Moderate rapids..	Detritus, 100.
5590a	8. <i>Pteronarcys californica</i> . . . . .	Aug. 26	Yellowstone R.	Moderate rapids..	Trebionema, 5; moss fragments, 10; detritus, 85.
5590a	9. <i>Pteronarcys californica</i> . . . . .	Aug. 26	Yellowstone R.	Moderate rapids..	Trebionema, 15; moss fragments, 5; diatoms, 10; detritus, 70.

TABLE NO. I.—SHOWING THE FOOD OF THE PERLOIDEA OR STONEFLIES.—  
(Concluded).

Collection Number	Number and Name of Individual Specimens	Date 1921	Locality	Habitat	Food Items in Percentages
5590a	10. Pteronarcys californica..	Aug. 26	Yellowstone R.	Moderate rapids..	Bark fragments, 85; detritus, 15.
5590a	11. Pteronarcys californica..	Aug. 26	Yellowstone R.	Moderate rapids..	Trebionema, 3; detritus, 97.
5590b	1. Pteronarcys californica..	Aug. 26	Yellowstone R.	Moderate rapids..	Wood fragments, 85; detritus, 15.
5590b	2. Pteronarcys californica..	Aug. 26	Yellowstone R.	Moderate rapids..	Detritus, 100.
5590b	3. Pteronarcys californica..	Aug. 26	Yellowstone R.	Moderate rapids..	Sand, 5; diatoms, 5; detritus, 90.
5590b	4. Pteronarcys californica..	Aug. 26	Yellowstone R.	Moderate rapids..	Wood fragments, 40; diatoms, 10; Trebonema, 5; detritus, 45.
5590b	5. Pteronarcys californica..	Aug. 26	Yellowstone R.	Moderate rapids..	Wood fragments, 3; diatoms, 5; Trebonema, 2; detritus, 90.
5590b	6. Acroneuria pacifica . . . .	Aug. 26	Yellowstone R.	Moderate rapids..	Insect fragments, 95; diatoms, 5.
5590b	7. Acroneuria pacifica . . . .	Aug. 26	Yellowstone R.	Moderate rapids..	Rhyacophila pupa (2), 100.
5590b	8. Acroneuria pacifica . . . .	Aug. 26	Yellowstone R.	Moderate rapids..	Chironomus (2), 90; sand, 10.
5590b	9. Acroneuria pacifica . . . .	Aug. 26	Yellowstone R.	Moderate rapids..	Empty.
5590c	1. Pteronarcys californica..	Aug. 26	Yellowstone R.	Strong, violent rapids.	Bark, 95; detritus, 5.
5590c	2. Pteronarcys californica..	Aug. 26	Yellowstone R.	Strong, violent rapids.	Bark, 25; detritus, 75.
5590c	3. Pteronarcys californica..	Aug. 26	Yellowstone R.	Strong, violent rapids.	Bark, 50; detritus, 50.
5590c	4. Pteronarcys californica..	Aug. 26	Yellowstone R.	Strong, violent rapids.	Empty.
5591a	7. Acroneuria pacifica . . . .	Aug. 27	Tower Creek..	Minor rapids.....	Mayfly fragments, 100.
5591a	8. Acroneuria pacifica . . . .	Aug. 27	Tower Creek..	Minor rapids.....	Detritus, 100.
5591a	9. Acroneuria pacifica . . . .	Aug. 27	Tower Creek..	Minor rapids.....	Empty.
5591a	10. Acroneuria pacifica . . . .	Aug. 27	Tower Creek..	Minor rapids.....	Detritus, 100.
5591a	11. Acroneuria pacifica . . . .	Aug. 27	Tower Creek..	Minor rapids.....	Mayfly fragments, 95; detritus, 5.
5591a	12. Acroneuria pacifica . . . .	Aug. 27	Tower Creek..	Minor rapids.....	Moth scales, 50; detritus, 50.
5591a	13. Acroneuria pacifica . . . .	Aug. 27	Tower Creek..	Minor rapids.....	Chironomus larvae, 90; detritus, 10.
5591b	6. Acroneuria pacifica.....	Aug. 27	Tower Creek..	Strong rapids. . . .	Digested matter, 100.
5591b	7. Acroneuria pacifica . . . .	Aug. 27	Tower Creek..	Strong rapids. . . .	Detritus, 100.
5591b	8. Alloperla sp.....	Aug. 27	Tower Creek..	Strong rapids. . . .	Digested matter (plants?), 100.

TABLE NO. 2.—SHOWING SUMMARY OF FOOD OF PERLOIDEA. (EMPTY STOMACHS ARE NOT INCLUDED IN COMPUTING THE AVERAGES).

Name	Locality	Number of Specimens	Animal Food	Plant Food	Detritus
Pteronarcys . . . . .	Yellowstone River . . . . .	20	5	43	52
Pteronarcys . . . . .	Lamar River . . . . .	6	.....	90	10
Average for . . . . .		26	3.85	53.85	42.3
Acroneuria . . . . .	Yellowstone River . . . . .	14	90	1	9
Acroneuria . . . . .	Lamar River . . . . .	14	95.5	1.5	3
Acroneuria . . . . .	Lost Creek . . . . .	7	50	30	20
Acroneuria . . . . .	Tower Creek . . . . .	14	60	5	35
Average for . . . . .		49	77.4	6.3	16.3
Perla verticalis (?) . . . . .		8	85	15	.....

Undoubtedly, the stoneflies are the dominant insect forms of the mountain trout streams, particularly in Yellowstone and Lamar rivers. Previous to their final ecdysis, about the time the spring floods abate, the nymphs are extremely abundant and appear to constitute the bulk of the insect fauna. The stomachs of trout taken from the stream at this period are largely filled with stonefly nymphs.

But where are all these nymphs to obtain their food? They are carnivores, one generally reads. But if their numbers are so great that their bulk exceeds the available animal food supply, how can they subsist? This was one of the puzzles the senior author met early in the work,—one which was not solved until the present data were obtained.

From the examination of the stomach contents of Perlid nymphs several surprising results were obtained: (1) That Perloidea are not exclusively carnivores, but that their diet contains an admixture of plant matter and detritus, i. e., predigested and decomposed matter. (2) That the largest species, *Pteronarcys californica*, is largely a vegetarian. (3) That about 12% of those Perloidea whose main diet was animal matter, were parasitized by gregarines.

The diet of *Pteronarcys* was perhaps the most surprising result. Its first notice was so unexpected that thereafter special efforts were made to secure a considerable number of specimens from different localities for examination. Whether this species is really a vegetarian, or whether it is so only on occasion, cannot be stated positively. Only this much seems clear: The specimens examined, about thirty in number, had fed chiefly on a plant diet, averaging less than 4% animal diet.

The other prominent perlid species, *Acroneuria pacifica*, is quite evidently a carnivore. The admixture of plant food and detritus may be accounted for on the basis that they were taken in with the insect food. It is also possible, that the gregarines found in six of the *Acroneuria* were not "resident" parasites, but were taken in with some insect hosts, such as mayfly nymphs or caddisworms.

In a very interesting study of *Nemoura*, C. F. Wu ('23, p. 39) remarks as follows: "Besides some fine sediment and the half digested fragments of decaying leaves, there were found great varieties of unicellular algae, chiefly diatoms and desmids. No remains of animal tissue have ever been detected, so that naiads are herbivorous in their food habits." Relative to the food of the adult Wu (l. c.) states, "Of the various kinds of living plant leaves found around the water and fed to the adults, the young leaves of Touch-me-not are eaten." Newcomer ('18) reports the adults of *Taeniopteryx pacifica* as feeding on the buds and leaves of plants and causing considerable injury.

**Food of Ephemeroidea or Mayfly Nymphs.** The following table shows in detail the food percentages of the mayfly nymphs examined.

TABLE NO. 3.—SHOWING FOOD OF MAYFLY NYMPHS.

Collection Number	Number and Name of Individual Specimens	Date, 1921	Locality	Habitat	Food Items in Percentages
5566b	3. Ameletus . . . . .	Aug. 10	Lost Creek . . . .	From rocks with clusters of vegetation, chiefly Melosira and some Gomphonema and Closterium.	Melosira, 90; Gomphonema, 10.
5566b	1. Drunella sp. . . . .	Aug. 10	Lost Creek . . . .	Pure Melosira . . . . .	Melosira, 99; Gomphonema, 5; protozoan, 5.
5566b	2. Drunella sp. . . . .	Aug. 10	Lost Creek . . . .	.....	Melosira, 99; Gomphonema, 1.
5566d	1. Drunella sp. . . . .	Aug. 10	Lost Creek . . . .	From Prasiola and Oscillatoria.	Melosira, 80; Closterium, 1; Oscillatoria, 19.
5566d	2. Drunella sp. . . . .	Aug. 10	Lost Creek . . . .	From Prasiola and Oscillatoria.	Prasiola, 99; Oscillatoria, 1.
5566d	5. Ephemerella sp. . . .	Aug. 10	Lost Creek . . . .	From Prasiola and Oscillatoria.	Melosira, 50; empty diatom shells, 50.
5566d	6. Ephemerella sp. . . .	Aug. 10	Lost Creek . . . .	From Prasiola and Oscillatoria.	Prasiola, 100.
5566j	1. Heptagenia sp. . . . .	Aug. 10	Lost Creek . . . .	From Prasiola . . . . .	Melosira, 60; Oscillatoria, 40.
5566h	4. Ephemerella sp. . . . .	Aug. 10	Lost Creek . . . .	From barren region . . . . .	Empty.
5566i	1. Ephemerella sp. . . . .	Aug. 10	Lost Creek . . . .	Barren region with few diatom shells.	Melosira, 75; mixed diatoms, 25.
5566i	2. Ephemerella sp. . . . .	Aug. 10	Lost Creek . . . .	Barren region with few diatom shells.	Melosira, 95; mixed diatoms, 5.
5566j	2. Heptagenia sp. . . . .	Aug. 10	Lost Creek . . . .	Barren, with few diatoms.	Melosira, 50; Oscillatoria, 45; diatoms, 5.
5566j	7. Ephemerella sp. . . . .	Aug. 10	Lost Creek . . . .	Barren, with few diatoms.	Prasiola, 99; Oscillatoria, 1.
5566j	8. Ephemerella sp. . . . .	Aug. 10	Lost Creek . . . .	Barren, with few diatoms.	Gomphonema, 85; diatoms, 15.
5566k	1. Heptagenia sp. . . . .	Aug. 10	Lost Creek . . . .	Barren with few diatoms, some Closterium.	Melosira, 85; diatoms and Closterium, 15.
5566k	2. Ameletus sp. . . . .	Aug. 10	Lost Creek . . . .	Barren with few diatoms, some Closterium.	Melosira, 100.
5566l	1. Ephemerella sp. . . . .	Aug. 10	Lost Creek . . . .	Mostly Oscillatoria. Traces of Melosira.	Oscillatoria, 99; diatoms, 1.
5566l	2. Ephemerella sp. . . . .	Aug. 10	Lost Creek . . . .	Mostly Oscillatoria. Traces of Melosira.	Oscillatoria, 99; diatoms, 1.
5567a	15. Ameletus sp. . . . .	Aug. 11	Yellowstone R.	Strong rapids . . . . .	Sand, 95; diatoms, 5.
5567a	16-19. Ameletus sp. . . . .	Aug. 11	Yellowstone R.	Strong rapids . . . . .	Detritus, 100.
5567a	20. Ameletus sp. . . . .	Aug. 11	Yellowstone R.	Strong rapids . . . . .	Fresh diatoms, 15; sand, 85.
5567a	21, 22. Ameletus sp. . . . .	Aug. 11	Yellowstone R.	Strong rapids . . . . .	Both with detritus, 100.
5567a	23. Heptagenia sp. . . . .	Aug. 11	Yellowstone R.	Strong rapids . . . . .	Detritus, 100.
5567a	24. Heptagenia sp. . . . .	Aug. 11	Yellowstone R.	Strong rapids . . . . .	Sand, 50; diatoms, 5; detritus, 45.
5567a	25. Heptagenia sp. . . . .	Aug. 11	Yellowstone R.	Strong rapids . . . . .	Detritus, 100.
5567a	26. Heptagenia sp. . . . .	Aug. 11	Yellowstone R.	Strong rapids . . . . .	Sand, 15; diatoms, 5; detritus, 80.
5567a	27. Heptagenia sp. . . . .	Aug. 11	Yellowstone R.	Strong rapids . . . . .	Sand, 5; diatoms, 5; detritus, 90.
5567a	28. Heptagenia sp. . . . .	Aug. 11	Yellowstone R.	Strong rapids . . . . .	Diatoms, 5; detritus, 95.
5567a	29. Ephemerella sp. . . . .	Aug. 11	Yellowstone R.	Strong rapids . . . . .	Cladophora, 5; sand, 10; detritus, 85.
5567a	30, 31. Ephemerella sp. . . . .	Aug. 11	Yellowstone R.	Strong rapids . . . . .	Both with detritus, 100.
5567a	32. Ephemerella sp. . . . .	Aug. 11	Yellowstone R.	Strong rapids . . . . .	Detritus, 75; adult dipteran, 25.
5567a	33, 34. Ephemerella sp. . . . .	Aug. 11	Yellowstone R.	Strong rapids . . . . .	Both with detritus, 100.
5572a	4. Ameletus sp. . . . .	Aug. 12	Lost Creek . . . .	Rapids. Vegetation: Melosira, Prasiola, Oscillatoria, Calpoda and Rotifera among plants.	Melosira, 50; detritus, 50.
5572a	5, 6. Ameletus sp. . . . .	Aug. 12	Lost Creek . . . .	Rapids. Vegetation: Melosira, Prasiola, Oscillatoria, Calpoda and Rotifera among plants.	Both with detritus, 100.
5572a	7. Heptagenia sp. . . . .	Aug. 12	Lost Creek . . . .	Rapids. Vegetation: Melosira, Prasiola, Oscillatoria, Calpoda and Rotifera among plants.	Rock diatoms, 15; sand, 5; detritus, 80.
5572b	5. Ameletus sp. . . . .	Aug. 12	Lost Creek . . . .	Among rocks in rapids. Much detritus and Melosira.	Melosira, 50; detritus, 50.
5572b	6. Ameletus sp. . . . .	Aug. 12	Lost Creek . . . .	Among rocks in rapids. Much detritus and Melosira.	Detritus, 50; sand, 25; rock diatoms, 25.
5572b	7. Ameletus sp. . . . .	Aug. 12	Lost Creek . . . .	Among rocks in rapids. Much detritus and Melosira.	Rock diatoms, 75; detritus, 20; sand, 5.
5572b	8. Ephemerella sp. . . . .	Aug. 12	Lost Creek . . . .	Among rocks in rapids. Much detritus and Melosira.	Rock diatoms, 85; detritus, 5; diatoms, 10.
5572b	9. Ephemerella sp. . . . .	Aug. 12	Lost Creek . . . .	Among rocks in rapids. Much detritus and Melosira.	Rock diatoms, 75; detritus, 23; sand, 2.

TABLE NO. 3.—SHOWING FOOD OF MAYFLY NYMPHS.—(Continued).

Collection Number	Number and Name of Individual Specimens	Date, 1921	Locality	Habitat	Food Items in Percentages
5572b	10. <i>Drunella</i> sp. . . . .	Aug. 12	Lost Creek . . .	Among rocks in rapids. Much detritus and <i>Melosira</i> .	Wood fibers, 35; detritus, 65.
5572e	1. <i>Heptagenia</i> sp. . . . .	Aug. 12	Lost Creek . . .	From rocks in rapids. Moss and <i>Prasiola</i> .	Detritus, 95; wood fragments, 2; mixed diatoms, 3.
5572e	2, 3, 4. <i>Heptagenia</i> sp. . . . .	Aug. 12	Lost Creek . . .	<i>Melosira</i> caught in moss. From rocks in rapids. Moss and <i>Prasiola</i> .	All with detritus, 100.
5572e	5. <i>Heptagenia</i> sp. . . . .	Aug. 12	Lost Creek . . .	<i>Melosira</i> caught in moss. From rocks in rapids. Moss and <i>Prasiola</i> .	Detritus, 95; mixed diatoms, 5.
5575b	1. <i>Baetis</i> sp. . . . .	Aug. 14	Tower Creek . . .	Mild rapids . . . . .	Sand, 20; detritus, 80.
5575b	2. <i>Baetis</i> sp. . . . .	Aug. 14	Tower Creek . . .	Mild rapids . . . . .	Detritus, 100.
5575c	1. <i>Ephemerella</i> sp. . . . .	Aug. 14	Tower Creek . . .	From lateral rapids . . . . .	Sand, 20; detritus, 80.
5575c	2. <i>Ephemerella</i> sp. . . . .	Aug. 14	Tower Creek . . .	From lateral rapids . . . . .	Sand, 10; detritus, 50; wood fragments, 15; insect fragments, 25.
5575c	3, 4. <i>Ephemerella</i> sp. . . . .	Aug. 14	Tower Creek . . .	From lateral rapids . . . . .	Detritus, 100.
5575d	1. <i>Ameletus</i> sp. . . . .	Aug. 14	Tower Creek . . .	Mild rapids . . . . .	Diatoms, 1; wood fragments, 4; detritus, 75; sand, 20.
5575e	1. <i>Ephemerella</i> sp. . . . .	Aug. 14	Tower Creek . . .	From lesser rapids . . . . .	<i>Heptagenia</i> , 50; detritus, 49; wood, 1.
5584a	15. <i>Heptagenia</i> sp. . . . .	Aug. 25	Lost Creek . . .	Shaded area. No vegetation.	Detritus, 30; <i>Cocconeis</i> , 65; wood fragments, 2; mixed fragments, 3.
5584a	16. <i>Heptagenia</i> sp. . . . .	Aug. 25	Lost Creek . . .	Shaded area. No vegetation.	<i>Cocconeis</i> , 25; <i>Rhoicosphenia</i> , 25; mixed diatoms, 5; detritus, 40; sand, 5.
5584a	17. <i>Drunella</i> sp. . . . .	Aug. 25	Lost Creek . . .	Shaded areas. No vegetation.	<i>Cocconeis</i> , 40; <i>Rhoicosphenia</i> , 5; mixed diatoms, 5; detritus, 50.
5584a	18. <i>Drunella</i> sp. . . . .	Aug. 25	Lost Creek . . .	Shaded areas. No vegetation.	<i>Cocconeis</i> , 35; <i>Melosira</i> , 15; <i>Synedra</i> , 3; mixed diatoms, 7; sand, 5; detritus, 35.
5584a	19. <i>Drunella</i> sp. . . . .	Aug. 25	Lost Creek . . .	Shaded areas. No vegetation.	Sand, 25; <i>Cocconeis</i> , 25; <i>Melosira</i> , 5; mixed diatoms, 5; detritus, 40.
5589a	20. <i>Drunella</i> sp. . . . .	Aug. 26	Lamar River . . .	Strong rapids. Feeding on moss and <i>Cladophora</i> .	<i>Epithemia</i> , 80; <i>Cocconeis</i> , 10; mixed diatoms, 10.
5589a	21. <i>Drunella</i> sp. . . . .	Aug. 26	Lamar River . . .	Strong rapids. Feeding on moss and <i>Cladophora</i> .	<i>Epithemia</i> , 50; detritus, 50.
5589b	14. <i>Ephemerella</i> sp. . . . .	Aug. 26	Lamar River . . .	Minor rapids. Feeding among decaying <i>Cladophora</i> .	<i>Chironomus</i> (2), 5; <i>Epithemia</i> , 50; mixed diatoms, 10; detritus, 35.
5589b	15. <i>Ephemerella</i> sp. . . . .	Aug. 26	Lamar River . . .	Minor rapids. Feeding among decaying <i>Cladophora</i> .	Sand, 5; <i>Epithemia</i> , 50; mixed diatoms, 10; detritus, 35.
5589b	16. <i>Ephemerella</i> sp. . . . .	Aug. 26	Lamar River . . .	Minor rapids. Feeding among decaying <i>Cladophora</i> .	Sand, 5; <i>Epithemia</i> , 15; diatoms, 10; detritus, 70.
5589b	17. <i>Ephemerella</i> sp. . . . .	Aug. 26	Lamar River . . .	Minor rapids. Feeding among decaying <i>Cladophora</i> .	Mixed diatoms, 5; detritus, 95.
5589b	18. <i>Ameletus</i> sp. . . . .	Aug. 26	Lamar River . . .	Minor rapids. Feeding among decaying <i>Cladophora</i> .	<i>Epithemia</i> , 75; diatoms, 10; detritus, 15.
5589b	19, 20. <i>Ameletus</i> sp. . . . .	Aug. 26	Lamar River . . .	Minor rapids. Feeding among decaying <i>Cladophora</i> .	Both with <i>Epithemia</i> , 10; diatoms, 15; detritus, 75.
5590a	13. <i>Heptagenia</i> sp. . . . .	Aug. 26	Yellowstone R. . . . .	Moderate rapids . . . . .	<i>Cladophora</i> , 90; sand, 10.
5590a	14. <i>Heptagenia</i> sp. . . . .	Aug. 26	Yellowstone R. . . . .	Moderate rapids . . . . .	Detritus, 100.
5590b	9. <i>Ephemerella</i> sp. . . . .	Aug. 26	Yellowstone R. . . . .	Minor rapids . . . . .	Detritus, 100.
5590b	10. <i>Ephemerella</i> sp. . . . .	Aug. 26	Yellowstone R. . . . .	Minor rapids . . . . .	Detritus, 85; diatoms, 5; <i>Trebionema</i> , 10.
5590b	11. <i>Ephemerella</i> sp. . . . .	Aug. 26	Yellowstone R. . . . .	Minor rapids . . . . .	Detritus, 90; diatoms, 5; <i>Trebionema</i> , 5.
5591a	14. <i>Heptagenia</i> sp. . . . .	Aug. 27	Tower Creek . . .	Minor rapids . . . . .	Detritus, 100.
5591a	15. <i>Heptagenia</i> sp. . . . .	Aug. 27	Tower Creek . . .	Minor rapids . . . . .	Detritus, 99; diatoms, 1.
5591a	16, 17, 18. <i>Heptagenia</i> sp. . . . .	Aug. 27	Tower Creek . . .	Minor rapids . . . . .	All with detritus, 100.
5591a	19. <i>Ameletus</i> sp. . . . .	Aug. 27	Tower Creek . . .	Minor rapids . . . . .	Sand, 15; detritus, 85.
5591a	20. <i>Ameletus</i> sp. . . . .	Aug. 27	Tower Creek . . .	Minor rapids . . . . .	Sand, 18; detritus, 80; diatoms, 2.
5591a	21. <i>Ephemerella</i> sp. . . . .	Aug. 27	Tower Creek . . .	Minor rapids . . . . .	Sand, 1; detritus, 97; diatoms, 2.
5591a	22. <i>Ephemerella</i> sp. . . . .	Aug. 27	Tower Creek . . .	Minor rapids . . . . .	Sand, 1; detritus, 97; diatoms, 2.
5591a	23. <i>Drunella</i> sp. . . . .	Aug. 27	Tower Creek . . .	Minor rapids . . . . .	Insect fragments, 50; wood fragments, 45; detritus, 5. <i>Gregarina</i> as parasites.

TABLE NO. 3.—SHOWING FOOD OF MAYFLY NYMPHS.—(Concluded).

Collection Number	Number and Name of Individual Specimens	Date, 1921	Locality	Habitat	Food Items in Percentages
5591a	24. <i>Drunella</i> sp. ....	Aug. 27	Tower Creek...	Minor rapids. ....	Wood fragments, 10; detritus, 90. Gregarina.
5591a	25. <i>Drunella</i> sp. ....	Aug. 27	Tower Creek...	Minor rapids. ....	Insect fragments, 80; diatoms, 2; detritus, 18. Gregarina.
5591a	26. <i>Drunella</i> sp. ....	Aug. 27	Tower Creek...	Minor rapids. ....	Detritus, 100. Gregarina.
5591a	27. <i>Drunella</i> sp. ....	Aug. 27	Tower Creek...	Minor rapids. ....	Insect fragments, 5; wood fragments, 10; sand, 4; diatoms, 1; detritus, 80.
5591a	28. <i>Heptagenia</i> sp. ....	Aug. 27	Tower Creek...	Minor rapids. ....	Diatoms, 20; detritus, 70; sand, 10. With nematode ( <i>Mermis</i> sp.?) as parasite.
5591a	29. <i>Heptagenia</i> sp. ....	Aug. 27	Tower Creek...	Minor rapids. ....	Diatoms, 20; detritus, 70; sand, 10. With two nematode parasites ( <i>Mermis</i> sp.?).
5591b	9. <i>Ameletus</i> sp. ....	Aug. 27	Tower Creek...	Strong rapids. ....	Detritus, 100.
5591b	10. <i>Ameletus</i> sp. ....	Aug. 27	Tower Creek...	Strong rapids. ....	Detritus, 95; diatoms, 5.
5591b	11. <i>Ameletus</i> sp. ....	Aug. 27	Tower Creek...	Strong rapids. ....	Detritus, 94; sand, 5; diatoms, 1.
5591b	12. <i>Drunella</i> sp. ....	Aug. 27	Tower Creek...	Strong rapids. ....	Insect fragments, 75; sand, 5; detritus, 20. With Gregarina.
5591b	13. <i>Drunella</i> sp. ....	Aug. 27	Tower Creek...	Strong rapids. ....	Insect fragments, 10; sand, 5; detritus, 85. Gregarina.
5591b	14. <i>Drunella</i> sp. ....	Aug. 27	Tower Creek...	Strong rapids. ....	Bark fragments, 20; sand, 5; detritus, 75. Gregarina.
5591b	15. <i>Drunella</i> sp. ....	Aug. 27	Tower Creek...	Strong rapids. ....	Diatoms, 2; sand, 23; detritus, 75. Gregarina.
5591b	16. <i>Heptagenia</i> sp. ....	Aug. 27	Tower Creek...	Strong rapids. ....	Detritus, 100.
5591b	17. <i>Heptagenia</i> sp. ....	Aug. 27	Tower Creek...	Strong rapids. ....	Diatoms, 5; sand, 5; detritus, 90.
5591b	18. <i>Heptagenia</i> sp. ....	Aug. 27	Tower Creek...	Strong rapids. ....	Sand, 5; detritus, 95.
5591e	2. <i>Heptagenia</i> sp. ....	Aug. 27	Tower Creek...	Lateral pools. With moderate current.	Detritus, 100.
5591e	3. 4. <i>Heptagenia</i> sp. ....	Aug. 27	Tower Creek...	Lateral pools. With moderate current.	Both with detritus, 100.
5591e	5. <i>Drunella</i> sp. ....	Aug. 27	Tower Creek...	Lateral pools. With moderate current.	Insect fragments, 100. Gregarina.
5591e	6. <i>Drunella</i> sp. ....	Aug. 27	Tower Creek...	Lateral pools. With moderate current.	Insect fragments, 50; wood fragments, 20; detritus, 30. Gregarina.

TABLE NO. 4.—SHOWING SUMMARY OF FOOD OF MAYFLY NYMPHS.

Name	Locality	Number of Specimens	Animal Food	Plant Food	Detritus
Ameletus sp. ....	Yellowstone R. ....	8	.....	2	98
Ameletus sp. ....	Lamar River. ....	3	.....	45	55
Ameletus sp. ....	Lost Creek. ....	8	.....	50	50
Ameletus sp. ....	Tower Creek. ....	6	.....	3	97
Average for. ....		25	==	22.7	77.3
Drunella sp. ....	Lamar River. ....	2	.....	75	25
Drunella sp. ....	Lost Creek. ....	7	.....	68	32
Drunella sp. ....	Tower Creek. ....	11	33.6	10	56.4
Average for. ....		20	== 18.5	36.8	44.7
Baetis sp. ....	Tower Creek. ....	2	.....	50	50
Ephemerella sp. ....	Yellowstone R. ....	9	2.6	3.4	94
Ephemerella sp. ....	Lamar River. ....	4	1.25	37	61.75
Ephemerella sp. ....	Lost Creek. ....	8	.....	96.25	3.75
Ephemerella sp. ....	Tower Creek. ....	7	11	10	79
Average for. ....		28	== 3.7	36.3	60
Heptagenia sp. ....	Yellowstone R. ....	8	.....	14	86
Heptagenia sp. ....	Lost Creek. ....	13	.....	50	50
Heptagenia sp. ....	Tower Creek. ....	13	.....	4	96
Average for. ....		34	==	24	76

From the predominance of detritus in the food of mayfly nymphs, as indicated by the averages, it would seem that these nymphs are primarily scavengers. They appear to feed on the flotsam and jetsam that is caught between rocks, on diatoms, and the bits of filamentous algae that grow on rocks. The animal matter eaten may possibly be dead specimens caught with the flotsam.

Of *Drunella* ten specimens, and these all from Tower Creek, were parasitized by gregarines. Two *Heptagenia* are noted as parasitized by a nematode, perhaps a species of *Mermis*; these, too, were taken from Tower Creek. In another paper (Muttkowski, '25, Fig. 124, facing p. 485) is shown an adult mayfly with such a nematode emerging from the caudal end. This adult was taken from Gardiner River, at its junction with Lava Creek, a short distance from Mammoth Hot Springs.

Whether these records indicate that only *Drunella* is parasitized by *Gregarina*, and *Heptagenia* by a nematode parasite, is conjectural. The records are too few to permit any definite conclusions.

The proportions of plant and animal matter and of unidentifiable detritus accord well with the findings of Needham ('20) for midwestern lakes and streams.

**The Food of Trichoptera.** The following table shows in detail the food percentages of the specimens of caddisworms studied.

TABLE NO. 5.—SHOWING FOOD OF TRICHOPTERA.

Collection Number	Specimen Number and Name	Date, 1921	Locality	Habitat	Food in Percentages
5566a	1. Rhyacophila.....	Aug. 10	Lost Creek....	Rocks splashed with spray	Rotifera, 60; Oscillatoria, 40.
5566h	1. Thremma.....	Aug. 10	Lost Creek....	Vegetation consisting of Melosira, chiefly. Some Gomphonema and Closterium.	Melosira, 99; Colpoda, 1.
5566d	3. Thremma.....	Aug. 10	Lost Creek....	From Prasiola and Oscillatoria.	Melosira, 100.
5566d	4. Thremma.....	Aug. 10	Lost Creek....	.....	Empty.
5566d	1. Hydropsyche.....	Aug. 10	Lost Creek....	From shady area.....	Spirogyra, 50; empty diatom shells, 50.
5566d	2. Hydropsyche.....	Aug. 10	Lost Creek....	From shady area.....	Melosira, 80; diatom shells, 17; Closterium, 3.
5566d	3. Hydropsyche.....	Aug. 10	Lost Creek....	From shady area.....	Diatom shells, 100.
5566d	5. Thremma pupa.....	Aug. 10	Lost Creek....	From shady area.....	Empty.
5566i	3. Hydropsyche.....	Aug. 10	Lost Creek....	Prasiola and diatoms.....	Melosira, 95; mixed diatoms, 5.
5566i	4. Hydropsyche.....	Aug. 10	Lost Creek....	Prasiola and diatoms.....	Melosira, 65; mixed diatoms, 35.
5566i	5. Rhyacophila.....	Aug. 10	Lost Creek....	Prasiola and diatoms.....	Diatom shells, 100. Gregarine parasites.
5566j	1. Rhyacophila.....	Aug. 10	Lost Creek....	Barrens. Few diatom shells.	Rotifers, 1; chironomids, 4; Melosira, 40; diatoms, 10; Oscillatoria, 45.
5566j	2. Hydropsyche.....	Aug. 10	Lost Creek....	Barrens. Few diatom shells.	Mayfly, 1; ad. Chironomus, 90; Melosira, 5; diatoms, 4.
5566j	6. Rhyacophila.....	Aug. 10	Lost Creek....	Barrens. Few diatom shells.	Mayfly nymph, 30; Chironomus ad., 60; Melosira, 5; diatoms, 5; Gregarina.
5566l	3. Rhyacophila.....	Aug. 10	Lost Creek....	Oscillatoria with trace of Melosira.	Oscillatoria, 95; diatoms, 5.
5566l	4. Rhyacophila.....	Aug. 10	Lost Creek....	Oscillatoria with trace of Melosira.	Caddisworm, 30; Chironomus ad., 30; diatoms, 10; Oscillatoria, 30.
5566l	5. Hydropsyche.....	Aug. 10	Lost Creek....	Oscillatoria with trace of Melosira.	Mayfly nymphs (5), 30; Chironomus larvae (10), 50; Melosira, 15; Oscillatoria, 5.
5587a	35. Hydropsyche.....	Aug. 11	Yellowstone R.	Rapids.....	Chironomus, 10; stem parenchyma, 15; diatoms (Melosira chiefly), 15; detritus, 60.
5587a	36. Hydropsyche.....	Aug. 11	Yellowstone R.	Rapids.....	Mayfly nymph, 95; sand, 5.
5587a	40. Brachycentrus....	Aug. 11	Yellowstone R.	Rapids.....	Wood fragments, 50; diatoms, 15; detritus, 35.
5587a	48. Hydropsyche.....	Aug. 11	Yellowstone R.	Rapids.....	Tanypus pupa, 40; shore diatoms, 20; lake plankton, 5; Rhizoclonium, 5; detritus, 30.
5587a	49. Philopotamus?...	Aug. 11	Yellowstone R.	Rapids.....	Empty.
5587a	50. Thremma.....	Aug. 11	Yellowstone R.	Rapids.....	Shore diatoms, 50; Tritonema, 5; detritus, 45.
5572a	2. Hydropsyche.....	Aug. 12	Lost Creek....	Rapids. Oscillatoria, Prasiola, and Melosira. Colpoda and rotifers feeding among plants.	Ameletus, 25; Ephemerella, 35; Melosira, 40.
5572a	3. Hydropsyche.....	Aug. 12	Lost Creek....	.....	Glossosoma (?) pupae (3), 40; Glossosoma (?) larvae, 10; Ephemerella, 15; Chironomus adult, 25; Melosira, 20.
5572b	1. Hydropsyche.....	Aug. 12	Lost Creek....	Rocks in rapids. Accumulations of detritus and Melosira. Ameba and Colpoda feeding.	Ephemerella (5), 50; Glossosoma (?), pupa, 35; Melosira, 10; detritus, 5. Gregarina.
5572b	2. Hydropsyche.....	Aug. 12	Lost Creek....	Rocks in rapids. Accumulations of detritus and Melosira. Ameba and Colpoda feeding.	Chironomus (2), 20; caddisflies (6), 65; Melosira, 14; sand and detritus, 1.
5572b	3. Hydropsyche.....	Aug. 12	Lost Creek....	Rocks in rapids. Accumulations of detritus and Melosira. Ameba and Colpoda feeding.	Chironomus (2), 50; Chironomus adult, 45; Melosira, 3; detritus, 2. Gregarina.
5572b	4. Hydropsyche.....	Aug. 12	Lost Creek....	Rocks in rapids. Accumulations of detritus and Melosira. Ameba and Colpoda feeding.	Caddisflies (7), 75; Acro-neuria sp. leg, 7; wood fragment, 10; trichopterous pupa, 5; Melosira, 3. Gregarina.
5574a	1. Brachycentrus....	Aug. 13	Lamar River...	Rapids.....	Trebionema, 20; Cymbella, 40; Cocconeis, 20; Syndra, 10; diatoms, 10; Gregarina.

TABLE NO. 5.—SHOWING FOOD OF TRICHOPTERA.—(Continued).

Collection Number	Specimen Number and Name	Date, 1921	Locality	Habitat	Food in Percentages
5574a	2. Brachycentrus...	Aug. 13	Lamar River...	Rapids.....	Tanytarsus, 2; Nauplii (?), 30; wood fibre 1; 50. Gregarina.
5574a	3. Brachycentrus...	Aug. 13	Lamar River...	Rapids.....	Chironomus, 5; mayfly nymph, 20; Cocconeis, 50; Synedra, 20; minor diatoms, 5. Gregarina.
5574a	4. Brachycentrus....	Aug. 13	Lamar River...	Rapids.....	Tanytarsus pupa, 30; Cocconeis, 30; Synedra, 30; minor diatoms, 10. Gregarina.
5574a	5. Brachycentrus....	Aug. 13	Lamar River...	Rapids.....	Mayfly fragments, 20; Trebonema, 5; Cocconeis, 65; Melosira, 5; minor diatoms, 5. Gregarina.
5574a	6. Brachycentrus....	Aug. 13	Lamar River...	Rapids.....	Synedra, 50; mixed diatoms, 10; detritus, 40. Gregarina.
5574a	7. Brachycentrus....	Aug. 13	Lamar River...	Rapids.....	Tanytarsus, 25; Cladophora, 20; diatoms, 10; detritus, 55. Gregarina.
5574a	8. Brachycentrus....	Aug. 13	Lamar River...	Rapids.....	Mayfly fragments, 30; Melosira, 20; Cladophora, 20; diatoms, 10; detritus, 20. Gregarina.
5574a	9. Brachycentrus....	Aug. 13	Lamar River...	Rapids.....	Mayfly fragments, 10; Cocconeis, 5; Melosira, 65; diatoms, 10; detritus, 10. Gregarina.
5574b	1. Brachycentrus sp.	Aug. 13	Lamar River...	Violent rapids.....	Tanytarsus pupae, 80; plant tissues, 15; diatoms, 5. Gregarina.
5574b	2. Brachycentrus sp.	Aug. 13	Lamar River...	Violent rapids.....	Synedra, 5; detritus, 95. Gregarina.
5574b	3. Brachycentrus sp.	Aug. 13	Lamar River...	Violent rapids.....	Mayfly fragments, 10; diatoms, 1; detritus, 89. Gregarina.
5574b	4. Brachycentrus sp.	Aug. 13	Lamar River...	Violent rapids.....	Mayfly fragments, 20; Synedra, 60; Cocconeis, 10; detritus, 10. Gregarina.
5574b	5. Brachycentrus sp.	Aug. 13	Lamar River...	Violent rapids.....	Tanytarsus larvae, 5; Tanytarsus pupae, 15; Synedra, 10; Cocconeis, 10; detritus, 60. Gregarina.
5574c	1. Brachycentrus sp.	Aug. 13	Lamar River...	From Cladophora.....	Tanytarsus pupae, 30; Cladophora, 40; Cocconeis, 25; diatoms, 5. Gregarina.
5574c	2. Brachycentrus sp.	Aug. 13	Lamar River...	From Cladophora.....	Detritus, 5; Cladophora, 70; Cocconeis, 20; diatoms, 5. Gregarina.
5574c	3. Brachycentrus sp.	Aug. 13	Lamar River...	From Cladophora.....	Cladophora, 85; Cocconeis, 14; diatoms, 1. Gregarina.
5574c	4. Brachycentrus sp.	Aug. 13	Lamar River...	From Cladophora.....	Synedra, 5; Cladophora, 30; Cocconeis, 60; diatoms, 5. Gregarina.
5574c	5. Brachycentrus sp.	Aug. 13	Lamar River...	From Cladophora.....	Cladophora, 85; Cocconeis, 14; diatoms, 1. Gregarina.
5574c	6. Brachycentrus sp.	Aug. 13	Lamar River...	From Cladophora.....	Synedra, 4; Cladophora, 20; Cocconeis, 75; diatoms, 1. Gregarina.
5575f	1. Thremma.....	Aug. 14	Tower Creek...	Rapids.....	Cocconeis, 5; detritus, 95.
5575f	2. Thremma.....	Aug. 14	Tower Creek...	Rapids.....	Detritus, 100.
5575g	1. Rhyacophila.....	Aug. 14	Tower Creek...	Lateral pools.....	Rhyacophila (3), 80; detritus, 20. Gregarina.
5575g	2. Rhyacophila.....	Aug. 14	Tower Creek...	Lateral pools.....	Glossosoma (?) pupa, 90; detritus, 10. Gregarina.
5575g	3. Rhyacophila.....	Aug. 14	Tower Creek...	Lateral pools.....	Chironomus, 20; mayfly caudal setae, 80.
5585a	1. Hydropsyche.....	Aug. 25	Lost Creek...	Shaded area. No vegetation.	Chironomus (3), 10; mayfly nymph, 10; Melosira, 75; diatoms, 5. Gregarina.
5585a	2. Hydropsyche.....	Aug. 25	Lost Creek...	Shaded area. No vegetation.	Mayfly fragments, 10; Melosira, 85; diatoms, 5. Gregarina.
5585a	3. Hydropsyche.....	Aug. 25	Lost Creek...	Shaded area. No vegetation.	Chironomus, 2; mayfly fragments, 18; Melosira, 75; diatoms, 5. Gregarina.

TABLE NO. 5.—SHOWING FOOD OF TRICHOPTERA.—(Continued).

Collection Number	Specimen Number and Name	Date, 1921	Locality	Habitat	Food in Percentages
5585a	4. Hydropsyche.....	Aug. 25	Lost Creek....	Shaded area. No vegetation.	Chironomus, 5; mayfly fragments, 10; Glossosoma (?) pupae, 20; Hydrachnid, 3; Melosira, 60; diatoms, 2. Gregarina.
5585a	5. Hydropsyche.....	Aug. 25	Lost Creek....	Shaded area. No vegetation.	Melosira, 18; diatoms, 2; Glossosoma (?) pupa, 40; mayfly fragments, 40. Gregarina.
5585a	6. Rhyacophila.....	Aug. 25	Lost Creek....	Shaded area. No vegetation.	Emptv. Gregarina.
5585a	7. Rhyacophila.....	Aug. 25	Lost Creek....	Shaded area. No vegetation.	Mayfly fragments, 50; Melosira, 25; wood fragments, 20; diatoms, 5. Gregarina.
5585a	8. Rhyacophila.....	Aug. 25	Lost Creek....	Shaded area. No vegetation.	Insect fragments, 100. Gregarina.
5585a	9. Rhyacophila.....	Aug. 25	Lost Creek....	Shaded area. No vegetation.	Glossosoma (?) pupa, 50; wood fragments, 40; Melosira, 1. Gregarina.
5585a	10. Glossosoma (?)...	Aug. 25	Lost Creek....	Shaded area. No vegetation.	Rhoicosphenia, 96; Cocconeis, 3; diatoms, 1. Gregarina.
5585a	11. Glossosoma (?)...	Aug. 25	Lost Creek....	Shaded area. No vegetation.	Rhoicosphenia, 92; Cocconeis, 8. Gregarina.
5585a	12. Glossosoma (?)...	Aug. 25	Lost Creek....	Shaded area. No vegetation.	Empty.
5585a	13. Glossosoma (?)...	Aug. 25	Lost Creek....	Shaded area. No vegetation.	Rhoicosphenia, 90; Cocconeis, 4; wood fragments, 4; mixed diatoms, 2. Gregarina.
5585a	14. Glossosoma (?)...	Aug. 25	Lost Creek....	Shaded area. No vegetation.	Melosira, 95; Cocconeis, 2; Synedra, 2; other diatoms, 1. Gregarina.
5585b	1. Hydropsyche.....	Aug. 25	Lost Creek....	Sunlit areas. Melosira predominant. Some Oscillatoria and Prasiola.	Mayfly fragments, 25; Glossosoma (?) pupa, 25; Melosira, 50. Gregarina.
5585b	2. Hydropsyche.....	Aug. 25	Lost Creek....	Sunlit areas. Melosira predominant. Some Oscillatoria and Prasiola.	Mayfly fragments, 5; Synedra, 5; Melosira, 90. Gregarina.
5585b	3. Hydropsyche.....	Aug. 25	Lost Creek....	Sunlit areas. Melosira predominant. Some Oscillatoria and Prasiola.	Mayfly fragments, 15; diatoms, 2; Melosira, 83. Gregarina.
5585b	4. Hydropsyche.....	Aug. 25	Lost Creek....	Sunlit areas. Melosira predominant. Some Oscillatoria and Prasiola.	Mayfly fragments, 15; Glossosoma (?) pupa, 15; Melosira, 68; diatoms, 2. Gregarina.
5585b	5. Hydropsyche.....	Aug. 25	Lost Creek....	Sunlit areas. Melosira predominant. Some Oscillatoria and Prasiola.	Mayfly fragments, 40; Chironomus pupa, 5; Perlid young (2), 15; Melosira, 38; mixed diatoms, 2; Gregarina.
5585b	6. Rhyacophila sp...	Aug. 25	Lost Creek....	Sunlit areas. Melosira predominant. Some Oscillatoria and Prasiola.	Rhyacophila, 50; perlid young, 10; mayfly fragments, 25; Melosira, 15.
5585b	7. Rhyacophila sp...	Aug. 25	Lost Creek....	Sunlit areas. Melosira predominant. Some Oscillatoria and Prasiola.	Mayfly fragments, 100. Gregarina.
5585b	8. Rhyacophila sp...	Aug. 25	Lost Creek....	Sunlit areas. Melosira predominant. Some Oscillatoria and Prasiola.	Perlid young (3), 60; insect fragments, 40. Gregarina.
5585b	9. Rhyacophila sp...	Aug. 25	Lost Creek....	Sunlit areas. Melosira predominant. Some Oscillatoria and Prasiola.	Mayfly fragments, 99; Melosira, 1. Gregarina.
5585b	10. Rhyacophila sp...	Aug. 25	Lost Creek....	Sunlit areas. Melosira predominant. Some Oscillatoria and Prasiola.	Melosira (small amount), 100. Gregarina.
5585b	11. Thremma.....	Aug. 25	Lost Creek....	Sunlit areas. Melosira predominant. Some Oscillatoria and Prasiola.	Melosira, 50; Cocconeis, 5; diatoms, 5; detritus, 40.

TABLE NO. 5.—SHOWING FOOD OF TRICHOPTERA.—(Continued).

Collection Number	Specimen Number and Name	Date, 1921	Locality	Habitat	Food in Percentages
5585b	12. Thremma .....	Aug. 25	Lost Creek . . .	Sunlit areas. Melosira predominant. Some Oscillatoria and Prasiola.	Rhoicosphenia, 10; Cocconeis, 35; Melosira, 10; diatoms, 5; detritus, 40.
5585b	13. Thremma .....	Aug. 25	Lost Creek . . .	Sunlit areas. Melosira predominant. Some Oscillatoria and Prasiola.	Cocconeis, 50; Melosira, 30; diatoms, 5; detritus, 15.
5585b	14. Thremma .....	Aug. 25	Lost Creek . . .	Sunlit areas. Melosira predominant. Some Oscillatoria and Prasiola.	Rhoicosphenia, 5; Cocconeis, 10; Melosira, 10; diatoms, 5; detritus, 70.
5585b	15. Thremma .....	Aug. 25	Lost Creek . . .	Sunlit areas. Melosira predominant. Some Oscillatoria and Prasiola.	Rhoicosphenia, 65; Cocconeis, 15; diatoms, 5; detritus, 15.
5585b	16. Thremma .....	Aug. 25	Lost Creek . . .	Sunlit areas. Melosira predominant. Some Oscillatoria and Prasiola.	Cocconeis, 5; diatoms, 5; detritus, 90.
5589a	1. Brachycentrus . . .	Aug. 26	Lamar River . . .	Strong rapids. From moss and Cladophora.	Moss, 90; Cymbella, 10. Gregarina.
5589a	2. Brachycentrus . . .	Aug. 26	Lamar River . . .	Strong rapids. From moss and Cladophora.	Chironomus pupae (4), 40; Chironomus larva, 5; mayfly nymph, 30; Cladophora, 10; Cocconeis, 10; Cymbella, 3; diatoms, 2. Gregarina.
5589a	3. Brachycentrus . . .	Aug. 26	Lamar River . . .	Strong rapids. From moss and Cladophora.	Trebonema, 50; Cladophora, 10; Cocconeis, 35; diatoms, 5. Gregarina.
5589a	4. Brachycentrus . . .	Aug. 26	Lamar River . . .	Strong rapids. From moss and Cladophora.	Chironomus, 15; Cladophora, 5; Cocconeis, 5; diatoms, 5; mayfly fragments, 30; moss fragments, 30; Epithemia, 10. Gregarina.
5589a	5. Brachycentrus . . .	Aug. 26	Lamar River . . .	Strong rapids. From moss and Cladophora.	Moss, 40; Trebonema, 30; Epithemia, 15; Cocconeis, 5; Cladophora, 5; diatoms, 5. Gregarina.
5589a	6. Brachycentrus . . .	Aug. 26	Lamar River . . .	Strong rapids. From moss and Cladophora.	Mayfly fragments, 10; Cocconeis, 30; Chironomus, 5; diatoms, 5; Epithemia, 50. Gregarina.
5589a	7. Brachycentrus . . .	Aug. 26	Lamar River . . .	Strong rapids. From moss and Cladophora.	Cocconeis, 14; diatoms, 1; Epithemia, 85. Gregarina.
5589a	8. Thremma .....	Aug. 26	Lamar River . . .	Strong rapids. From moss and Cladophora.	Moss, 70; Epithemia, 30.
5589a	9. Thremma .....	Aug. 26	Lamar River . . .	Strong rapids. From moss and Cladophora.	Moss, 70; Epithemia, 30.
5589a	10. Thremma .....	Aug. 26	Lamar River . . .	Strong rapids. From moss and Cladophora.	Moss, 70; Epithemia, 30.
5589a	11. Thremma .....	Aug. 26	Lamar River . . .	Strong rapids. From moss and Cladophora.	Moss, 70; Epithemia, 30.
5589b	1. Brachycentrus . . .	Aug. 26	Lamar River . . .	Minor rapids. Decaying Cladophora.	Mayfly fragments, 50; Melosira, 35; Cocconeis, 5; Epithemia, 5; diatoms, 5. Gregarina.
5589b	2. Brachycentrus . . .	Aug. 26	Lamar River . . .	Minor rapids. Decaying Cladophora.	Mayfly fragments, 30; Chironomus, 5; detritus, 15; Cocconeis, 25; Epithemia, 20; diatoms, 5. Gregarina.
5589b	3. Brachycentrus . . .	Aug. 26	Lamar River . . .	Minor rapids. Decaying Cladophora.	Melosira, 10; mayfly fragments, 20; Chironomus, 5; Trebonema, 20; Cocconeis, 30; Epithemia, 10; diatoms, 5; Gregarina.
5589b	4. Brachycentrus . . .	Aug. 26	Lamar River . . .	Minor rapids. Decaying Cladophora.	Melosira, 5; detritus, 20; Cocconeis, 30; Epithemia, 40; diatoms, 5. Gregarina.
5589b	5. Brachycentrus . . .	Aug. 26	Lamar River . . .	Minor rapids. Decaying Cladophora.	Melosira, 5; Cocconeis, 20; Epithemia, 65; diatoms, 10. Gregarina.
5589b	6. Brachycentrus . . .	Aug. 26	Lamar River . . .	Minor rapids. Decaying Cladophora.	Ameletus fragments, 40; Chironomus pupae, 5; Cocconeis, 10; Epithemia, 40; diatoms, 5. Gregarina.

TABLE NO. 5.—SHOWING FOOD OF TRICHOPTERA.—(Continued).

Collection Number	Specimen Number and Name	Date, 1921	Locality	Habitat	Food in Percentages
5589b	7. Thremma	Aug. 26	Lamar River	Minor rapids. Decaying Cladophora.	Epithemia, 100.
5590a	12. Rhyacophila	Aug. 26	Yellowstone R.	Moderate rapids	Cladophora, 5; detritus, 95.
5590b	5. Rhyacophila	Aug. 26	Yellowstone R.	Rapids along shore	Ephemera fragments, 40; Chironomus, 40; Trebonema, 5; detritus, 15.
5590b	6. Rhyacophila	Aug. 26	Yellowstone R.	Rapids along shore	Wood fragments, 50; Trebonema, 5; detritus, 45.
5590b	7. Rhyacophila	Aug. 26	Yellowstone R.	Rapids along shore	Insect fragments, 15; detritus, 85.
5590b	8. Rhyacophila	Aug. 26	Yellowstone R.	Rapids along shore	Trebonema, 10; detritus, 90.
5590b	9. Rhyacophila	Aug. 26	Yellowstone R.	Rapids along shore	Detritus, 50; Trebonema, 20; Cladophora, 5; moss leaves, 15; wood fragments, 10.
5590b	10. Rhyacophila	Aug. 26	Yellowstone R.	Rapids along shore	Chironomus, 20; detritus, 80.
5590b	11. Rhyacophila	Aug. 26	Yellowstone R.	Rapids along shore	Insect fragments, 90 Chironomus, 10.
5591a	1. Hydropsyche	Aug. 27	Tower Creek	Minor rapids	Insect fragments, 100.
5591a	2. Rhyacophila	Aug. 27	Tower Creek	Minor rapids	Unrecognizable matter (detritus?), 100. Gregarina.
5591a	3. Rhyacophila	Aug. 27	Tower Creek	Minor rapids	Insect fragments, 80; detritus, 20. Gregarina.
5591a	4. 5. Rhyacophila	Aug. 27	Tower Creek	Minor rapids	Detritus, 100. Gregarina.
5591a	6. Thremma	Aug. 27	Tower Creek	Minor rapids	Detritus, 100. Gregarina.
5591a	7. Thremma	Aug. 27	Tower Creek	Minor rapids	Detritus, 100. Gregarina.
5591a	30. Rhyacophila	Aug. 27	Tower Creek	Minor rapids	Insect fragments, 100.
5591b	1. Hydropsyche	Aug. 27	Tower Creek	Strong rapids	Mayfly fragments, 98; Chironomus, 2.
5591b	2. Rhyacophila	Aug. 27	Tower Creek	Strong rapids	Detritus, 100. Few Gregarina.
5591b	3. Rhyacophila	Aug. 27	Tower Creek	Strong rapids	Insect fragments, 100. Few Gregarina.
5591b	4. Thremma	Aug. 27	Tower Creek	Strong rapids	Diatoms, 1; detritus, 99.
5591b	5. Thremma	Aug. 27	Tower Creek	Strong rapids	Diatoms, 5; detritus, 95.
5591c	1. Rhyacophila	Aug. 27	Tower Creek	Lateral pool, with moderate current.	Detritus, 100.

TABLE NO. 6.—SHOWING SUMMARY OF FOOD OF TRICHOPTERA.

Name	Locality	Number of Specimens	Animal Food	Plant Food	Detritus
Rhyacophila	Yellowstone River	8	27	16	57
Rhyacophila	Lost Creek	14	57	43	.....
Rhyacophila	Tower Creek	10	55	.....	45
Average for		32	= 49	23	28
Hydropsyche	Yellowstone River	3	48	20	32
Hydropsyche	Lost Creek	22	35	64	.....
Hydropsyche	Tower Creek	2	100	.....	.....
Average for		27	= 42	54.3	3.7
Brachycentrus	Yellowstone River	1	.....	65	35
Brachycentrus	Lamar River	32	19	73	8
Average for		33	= 18.3	72.7	9
Thremma	Yellowstone River	1	.....	55	45
Thremma	Lamar River	5	.....	100	.....
Thremma	Lost Creek	11	.....	80	20
Thremma	Tower Creek	6	.....	2	98
Average for		23	=	64	36

Of the results obtained from the study of the stomach contents of insects, those from trichopterous stomachs are perhaps of most interest. Of these results the following might be said: (1) Each species must be judged by itself. Some species seem to have a large percentage of animal matter in their diet, others little or none at all. (2) Those feeding on animal matter are inclined to be cannibalistic. (3) Local conditions beget local results. A species may have a large animal diet in one locality, and a large plant diet in a different locality. (4) About sixty per cent of the caddisworms are parasitized by gregarines. It was thought possible to establish a correlation between the number parasitized and the amount of animal food taken. Thus, *Rhyacophila* with an animal diet of 49% was parasitized to about 45%, and *Hydropsyche* with an animal diet of 42%, to 60%. In contrast to this, *Brachycentrus* with the much smaller percentage of 18.3 animal matter was parasitized practically 100%. Hence no correlation can be said to exist.

The findings of other writers seem to corroborate the foregoing conclusions, especially 1, 2, and 3. Thus Muttkowski ('18, p. 442) calls attention to the fact that caddisworms readily exchange a phytophagous for a sarcophagous diet. Felber ('08) remarks on the avidity of *Halesus* larvae. These are carnivores, and not only do they not content themselves with smaller animals as food, but may even attack larger animals. Thus on one occasion Felber noted that some fifteen larvae clung to a Triton in an aquarium. Next day the salamander was dead and the skeleton had been practically stripped.

Lloyd ('21) in a series of detailed studies of various caddisflies brings together considerable data as to the food of the larvae. In successive order the food is noted for the following species:

*Neuronia postica*, *stygipes*, and *pardalis*—leaves in all stages of preservation.

*Phryganea interrupta*, and *vestita*—green plant tissues in natural environment, in the laboratory any plant food.

*Limnophilus combinatus*—vegetable matter, some diatoms.

*L. indivisus*—vegetable matter, without discrimination, decaying tissues in greater abundance.

*D. submonilifer*—raspings from sticks and plants, diatoms and other microscopic organisms, as well as wood or plant fragments.

*Arctoecia consicia*—shallow raspings from sticks and vegetation.

*Astenophylax argus*—dead bark and wood.

*Pycnopsyche scabripennis*—raspings of decomposed wood.

*Platyphylax designata*—young larvae with diatoms; large larvae with diatoms, sand, and fragments of higher plants. Vorhies lists "watercress and watermilfoil."

*Halesus guttifer*—fine raspings of decomposed wood.

*Chilostigma difficilis*—fragments of wood and leaves.

*Brachycentrus nigrisoma*—diatoms at first, then green algae and seed plants; carnivorous at the end of six weeks.

*Mystacides sepulchralis*—masticated pulp of vegetable origin.

Hydropsychidae—young larvae on green and blue-green algae. Older larvae tend to be carnivores.

Polycentropus—plankton and small insects.

Rhyacophilidae—filamentous algae and small larvae.

The last three are the types noted for their animal food in Yellowstone Park. It would seem, therefore, that the animal diet of these species is not confined to inhabitants of trout streams of the West.

**The Food of Diptera.** The following table gives in detail the food percentages of the specimens studied.

TABLE NO. 7.—SHOWING THE FOOD OF DIPTERA.

Collection Number	Specimen Number and Name	Date, 1921	Locality	Habitat	Food Material Percentages
5566b	2. Chironomus sp...	Aug. 10	Lost Creek....	From Melosira.....	Melosira, 50; Cymbella, 50.
5566j	4. Chironomus sp...	Aug. 10	Lost Creek....	From barrens with a few diatom shells.	Sand, 80; diatoms, 20.
5566k	3. Chironomus sp...	Aug. 10	Lost Creek....	From barrens with a few diatom shells. Some Closterium.	Diatoms, 5; sand, 95.
5566l	6. Chironomus sp...	Aug. 10	Lost Creek....	Nearly pure Oscillatoria with a trace of Melosira.	Oscillatoria, 95; diatoms, 5.
5567a	13. Tipulid larva.....	Aug. 11	Yellowstone R.	Rapids.....	Juices of other animals?, 100.
5567a	14. Tipulid larva.....	Aug. 11	Yellowstone R.	Rapids.....	Juices of other animals?, 100.
5567a	37. Tanytarsus larva.	Aug. 11	Yellowstone R.	Rapids.....	Diatoms, 95; sand, 5.
5567a	38. Tanytarsus larva.	Aug. 11	Yellowstone R.	Rapids.....	Diatoms, 100.
5567a	41. Simulium sp.....	Aug. 11	Yellowstone R.	Rapids.....	Shore diatoms, 45; Rhizoclonium, 5; lake plankton, 50.
5567a	42, 43, 44, 45. Simulium sp.	Aug. 11	Yellowstone R.	Rapids.....	Shore diatoms, 45; Rhizoclonium, 5; lake plankton, 50.
5567a	46. Simulium sp.....	Aug. 11	Yellowstone R.	Rapids.....	Shore diatoms, 80; lake plankton, 20.
5567a	47. Simulium sp.....	Aug. 11	Yellowstone R.	Rapids.....	Shore diatoms, 80; lake plankton, 20.
5589a	22. Simulium sp.....	Aug. 26	Lamar River...	Strong rapids on moss and Cladophora.	Trebionema, 1; diatoms, 60; Cladophora, 1; detritus, 38.
5590c	12. Simulium sp.....	Aug. 26	Yellowstone R.	Strong rapids. Violent current.	Detritus, 50; diatoms, 45; green algae, 5.
5590c	13, 14, 15. Simulium sp.	Aug. 26	Yellowstone R.	Strong rapids. Violent current.	Detritus, 50; diatoms, 45; green algae, 5.
5590c	16. Simulium sp.....	Aug. 26	Yellowstone R.	Strong rapids. Violent current.	Detritus, 50; diatoms, 45; green algae, 5. Parasitized by Mermis (?).
5590c	17. Simulium sp.....	Aug. 26	Yellowstone R.	Strong rapids. Violent current.	Detritus, 50; diatoms, 45; green algae, 5. Parasitized by Mermis (?).

TABLE NO. 8.—SHOWING SUMMARY OF FOOD OF DIPTERA.

Name	Locality	Number of Specimens	Plant Food	Detritus
Chironomids.....	Lost Creek.....	4	58	42
Chironomids.....	Yellowstone River.....	2	97	3
Average for.....		6	= 71	29
Simulium.....	Lamar River.....	1	62	38
Simulium.....	Yellowstone River.....	14	80	20
Average for.....		15	= 79	21

Probably more than three times the number of specimens listed of both chironomids and *Simulium* were examined, but since the contents were very much alike, it was not considered worthwhile to record them separately. What is noted here for the food of chironomids agrees in the main with prior data recorded by the senior author (Muttkowski, '18, p. 411) for species from Lake Mendota. The diet comprises primarily the micro-food so abundant in the slimy deposits on rocks.

For *Simulium* taken from Yellowstone River the large percentage of lake plankton is of interest. The source of this is Yellowstone Lake, some forty miles above the point where the *Simulium* were taken. A check made with catches from a fine plankton net showed a somewhat similar proportion of lake plankton and river algae and diatoms.

A considerable number of the *Simulium* were parasitized by a nematode (*Mermis*?). In the field notes of the senior author, under date of Aug. 15, 1921, Yellowstone River, the following remarks are relevant: "*Simulium* taken with *Mermis* (?) emerging. Young *Pteronarcys* nymphs (black at this stage) found feeding among the larvae and pupae. Enemies feeding on *Simulium* are fish and Perlids, and perhaps mayflies. Parasites were found in about one third of the larvae." Another note, dated Aug. 11, is as follows: "All swollen individuals (of *Simulium*) were parasitized. It was not determined whether any pupae were parasitized or if parasitized individuals could pupate. It was evident that the *Mermis* were leaving the larvae for their adult free-living stage. Just at what point they left the *Simulium* larvae was not determined. It was noted, however, that the parasite was coiled chiefly at the posterior end of the larva, with a small coil near the head."

**Comparative Summary of the Food of Insects.** Even from so brief a study as the foregoing certain facts can be gleaned. The most notable point is that aquatic insects in rapid streams are opportunists as regards food and eat whatever becomes available. Secondary to this is the fact that the aquatic insects forage extensively, and migrate freely in search of food.

Both of these points become evident from the collections made in Lost Creek, where special efforts were made to select various spots in the creek for sample collections of food and of specimens in the vicinity or upon that food. Reference to the stomach contents of the individual specimens and comparison with the food items listed for the particular spot shows at once that the large majority of specimens contained food that did not occur within many feet of the particular locality. This indicates that these species must be rovers and foragers to a marked extent, and that they are opportunists on the whole and eat whatever is available.

Environmental conditions in mountain streams are strenuous; the strong current in particular makes life somewhat precarious and selective feeding difficult. Hence as a result the diet becomes diversified; the insects take whatever comes along, be it plant, detritus, or animal matter. Their diet thus becomes much more generalized than the diet of related species in more permissive habitats, such as ponds and slow streams. In the latter the less strenu-

ous conditions permit the insects to select their food, that is, to restrict their diet to favored food, and to search for that food.

In other words, specialization of habitat leads to diversification of diet, while generalization of habitat permits a restriction of diet.

The following table gives a comparative summary of the food of the insects studied.

TABLE NO. 9.—SHOWING COMPARATIVE SUMMARY OF FOOD OF INSECTS. (EMPTY STOMACHS NOT INCLUDED IN THE COMPUTATIONS).

	Name	Number of Specimens	Animal Food	Plant Food	Detritus
Perloidea.....	Pteronarcys.....	26	3.85	53.85	42.3
Perloidea.....	Acroneuria.....	49	77.4	6.3	16.3
Perloidea.....	Perla.....	5	85	15	.....
Average for.....		80	= 54	22.3	23.7
Ephemeroidea.....	Ameletus sp.....	25	.....	22.7	77.3
Ephemeroidea.....	Baetis sp.....	2	.....	50	50
Ephemeroidea.....	Drunella sp.....	20	18.5	36.8	44.7
Ephemeroidea.....	Ephemerella sp.....	28	3.7	36.3	60
Ephemeroidea.....	Heptagenia sp.....	34	.....	24	76
Average for.....		109	= 4.3	29.7	66
Trichoptera.....	Rhyacophila.....	32	49	23	28
Trichoptera.....	Hydropsyche.....	27	42	54.3	3.7
Trichoptera.....	Brachycentrus.....	33	18.3	72.7	9
Trichoptera.....	Thremma.....	23	.....	64	36
Average for.....		115	= 28	54	18
Diptera.....	Chironomidae.....	6	.....	71	29
Diptera.....	Simulium.....	14	.....	79	21
Average for.....		20		76.6	23.4

### LIST OF REFERENCES

References to food of aquatic insects are exceedingly scant. As a rule they consist of brief notations in papers devoted to the biology and metamorphosis of aquatic forms.

Felber, Jacques

1908. Die Trichopteren von Basel und Umgebung, mit Berücksichtigung der Trichopterenfauna der Schweiz. Arch. f. Naturgesch 74, pp. 80.

Lloyd, J. T.

1921. The Biology of North America Caddisfly larvae. Lloyd Library Bull. 21, p. 124.

Mutkowski, R. A.

1918. The Fauna of Lake Mendota: A Qualitative and Quantitative Survey with Special Reference to the Insects. Trans. Wis. Acad. Sci., Vol. 19, pt. i, pp. 374-482.

1925. The Food of Trout in Yellowstone National Park. Roosevelt Wild Life Bulletin, Vol. 2, No. 4, pp. 470-497.

- Needham, J. G. and Claassen, W. C.  
1925. Monograph of Plecoptera or Stoneflies of America north of Mexico.  
Pp. 397. (Am. Ent. Soc. Monographs, Lafayette, Ind.)
- Needham, J. G.  
1920. Burrowing Mayflies of our Larger Lakes and Streams. U. S. Bureau  
Fisheries Bull. 36, pp. 269-292.
- Newcomer, E. J.  
1918. Some Stoneflies Injurious to Vegetation. Jour. Agr. Research, No.  
13, pp. 37-41.
- Woodsdalek, J. E.  
1912. Natural History and General Behavior of the Ephemeridae Nymphs  
*Heptagenia interpunctata* (Say). Ann. Ent. Soc. Am., No. 5,  
pp. 31-40.
- Wu, C. F.  
1923. Anatomy and Ethology of *Nemoura*. Lloyd Library Bull. Ent. Ser.  
No. 3, pp. 81.