

A Preliminary Survey of the Food of Oregon Trout



Agricultural Experiment Station
Oregon State Agricultural College
and
Oregon State Game Commission
Cooperating
CORVALLIS

SUMMARY

1. Insects are the dominant food organisms in the diet of cutthroat and rainbow trout in Oregon streams and lakes.
2. The insects of aquatic origin form the bulk of the food of Oregon trout during all seasons of the year.
3. Insects of terrestrial origin are prominent in the diet of Oregon trout during the spring, summer, and fall months.
4. The aquatic insects of importance in the diet of Oregon trout are mayflies, stoneflies, caddis flies, midges, and blackflies.
5. Crayfish, small fish, and pieces of dead salmon are important items in the diet of the larger trout.
6. The immature stages of blackflies and midges are important items in the diet of small trout in streams.
7. In lakes, the diet of small trout is mainly composed of immature midges and water-fleas.
8. Fresh-water shrimps are important items in the diet of Oregon trout in lakes, especially in lakes in which the eastern brook trout thrives.

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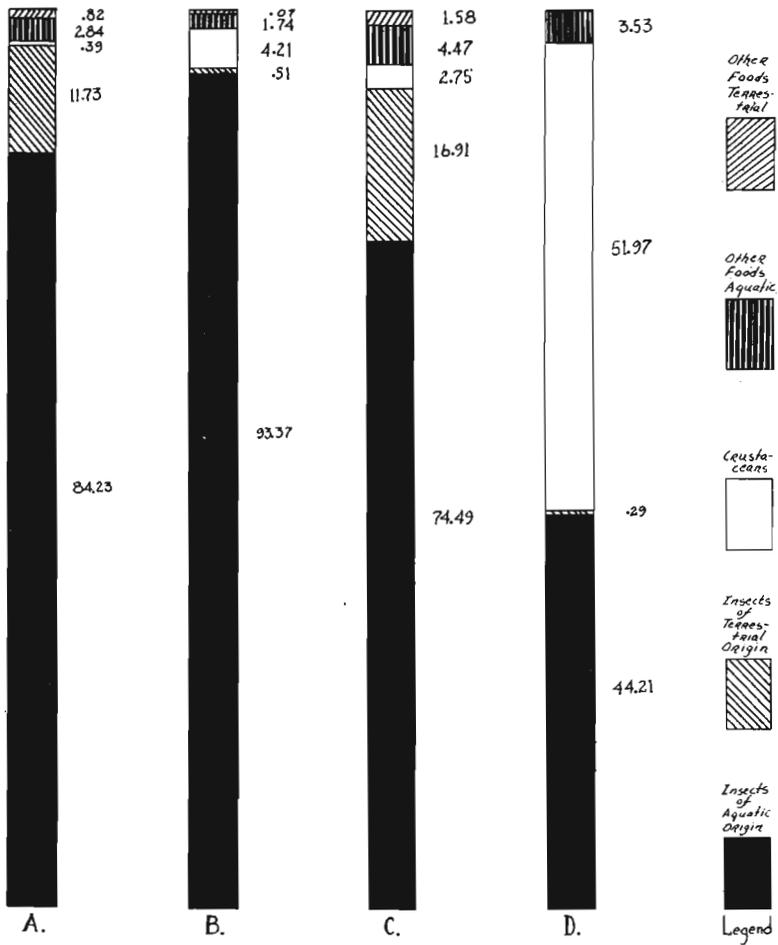


Figure 1. A GRAPHIC COMPARISON OF THE FOOD ORGANISMS OF OREGON TROUT.

Percentage distribution of the food organisms found in the stomachs of trout: (A) 103 rainbow trout from streams, (B) 19 rainbow trout from lakes, (C) 326 cutthroat trout from lakes and streams, and (D) 25 eastern brook trout from lakes.

A Preliminary Survey of the Food of Oregon Trout*

By

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INTRODUCTION

THE fish food studies reported herein represent a record of progress in the cooperative investigations undertaken by the Oregon Agricultural Experiment Station at the request of the Oregon State Game Commission.

Oregon is fast becoming known the country over as a game fishermen's mecca. To perpetuate and increase the game fishing activities, a study of the problems of fish conservation through adequate feeding and disease control becomes essential. In order to cope more adequately with these problems, these investigations were conducted. Although this bulletin represents only a progress report and is not designed to be a complete treatise of the foods of Oregon game fishes, it presents basic knowledge valuable to sportsmen and to the Oregon State Game Commission alike, leading to an ultimate study of the productivity of Oregon streams and lakes.

One of the first considerations in game fish husbandry is a definite knowledge of the natural foods constituting the diet of the game fish to be managed. This information can be obtained only by making a study of the stomach contents of fish specimens obtained in their natural habitats. Such information is basic when coupled with quantitative and qualitative food surveys of lakes and streams in determining which bodies of water are suitable for supporting game fish.

To determine what the diet of the more common Oregon species of trout consists of, examinations of the stomach contents were made of 326 cutthroat trout (*Salmo clarkii clarkii* R.), Table II; 122 rainbow trout (*Salmo gairdneri irideus* G.), Tables I and III; 23 steelhead or sea-run rainbow trout (*Salmo gairdneri irideus* G.), Table V; and 25 eastern brook trout (*Salvelinus fontinalis* M.), an introduced fish, Table IV. The stomachs were from fish caught either by nets, baited spinners, baited hooks, or artificial flies, in lakes and streams in various parts of the state. No differences in the amounts or kinds of food organisms could be found in stomachs of fish netted or caught on a hook.

In determining what constituted the normal diet of Oregon trout, an attempt was also made to find whether the naturally selected food varied with the size of the fish, for if various sizes of trout feed upon certain definite types of organisms, it then becomes obvious that hatchery-reared

*In these investigations much assistance was rendered by individuals of the Oregon State College faculty and sportsmen throughout the state who collected fish, preserved the fish stomachs, and recorded the data regarding the conditions under which each fish was collected.

The drawings of the fish food organisms and the diagram contained in this bulletin were made by Robert W. Prentiss.

fish of different sizes should be liberated in places along streams and in the parts of lakes where their natural food is present.

ANIMAL AND PLANT FOODS

The food found in the stomach contents of cutthroat, rainbow, and eastern brook trout consisted, in the main, of animal organisms. Occasionally plant material was found in the form of algae, conifer needles, pieces of leaves, seeds, sticks, and bark, but not in sufficient quantities or of sufficient frequency to consider plant material as a preferred or staple food. The one exception was a single eighteen-inch rainbow trout taken in Crater Lake, in the stomach of which were 109 caddis-fly larvae and algae equaling these in bulk. The infrequency with which plant items are found in the diet of trout leads to the supposition that these foods are taken accidentally or form what have been termed "pastime foods."

Alga apparently finds its way into the stomachs of trout because it frequently harbors aquatic animal organisms. Particles of bark and leaves and the like are probably mistaken by trout for floating or alighting insects.

The animal food of trout examined consisted of insects, crustaceans, spiders, water-mites, molluscs, fish, fish eggs, and occasionally earthworms, free-living nematodes, leeches, millipeds, centipedes, scorpions, frogs, snakes, birds, and small mammals.

A few stomachs were found to contain refuse or other accidental foods. Such materials are not included in the tables because they do not constitute natural foods. Such items were beef liver, found in a cutthroat trout taken below a slaughter yard, and milk curds found in quantity in the stomach of a cutthroat trout taken just below a creamery.

Insects. Numerically, insects form the principal food item in the diet of trout in fresh water fishing areas of Oregon (Figure 1, page 4). Three eastern brook trout taken from East Lake, Deschutes county, were found to contain many more fresh-water shrimps than insects, but in the remaining 22 stomachs examined from the same species of trout taken in five other lakes insects predominated.

The insect food was of two general types—that of aquatic origin and that of terrestrial origin. Aquatic insects are those which live at least for the major part of their lives in fresh water. Very few aquatic insects inhabit salt-water locations. The vast majority of the aquatic insects pass their immature stages in the water and their shorter mature lives above the water's surface. Terrestrial insects are those normally living and developing on land. They become fish food by accidentally falling or being blown upon the surface of the water.

Insects formed 91.4 per cent of the food contained in the stomachs of all 326 cutthroat trout examined (Figure 1, page 4). These fish were taken from lakes and streams during each month of the year and ranged from 1 to 19 inches in length. The importance of insects of aquatic origin in the diet of cutthroat trout is evident since they constituted 74.4 per cent of the foods found.

Rainbow trout from both lakes and streams likewise chose insects more frequently than other foods (Figure 1). These fish were taken from February to September inclusive and varied in size from 4 to 19 inches. In the 103 specimens from streams, insects formed 95.9 per cent of the diet.

Rainbow trout taken from lakes, nineteen in number, were found to contain 93.8 per cent insects.

Mayflies (Order Ephemera). These insects form the first choice of all cutthroat and rainbow trout in Oregon, judged by the frequency and quantity of their occurrence in the fish stomachs analyzed. Mayflies, of which there are many kinds in the state, spend their immature life in the water of streams, ponds, and lakes. During this stage they furnish much of the food of trout. These immature mayflies known as nymphs (Figure 2) are herbivorous feeders. When they have obtained their growth, they swim to the top of the water or crawl on to rocks or banks, shed their nymphal skins, and emerge as winged insects which fly to some resting place near by. After a short time—a few hours, a day, or a few days at the most—they again cast off their outer skins, thus becoming known as adult mayflies (Figure 3). Then the adults return over the water to mate and the females to deposit eggs. The males often die and drop to the water surface, becoming items of fish food. The female mayflies are frequently taken by fish as they dip to the surface of the water to deposit their eggs. The mayfly does not eat during the adult stage, which is very brief. In the nymphal stage these insects in some of the Oregon species may live as long as two years.



Figure 2. A mayfly nymph (*Baetis* sp.). (Enlarged 3 times.)

Mayflies, both aquatic and aerial stages, formed 26.5 per cent of all food found in the stomachs of cutthroat trout examined. They were the most frequent and numerous item in the diet of all sizes of cutthroats except in the trout under two inches in length and in some of the larger fishes. Also, they were present in stomachs throughout each month of the year.

In the rainbow trout, ranging from 4 to 19 inches in length, taken from streams from February to September inclusive, mayflies were the predominant food organisms except in fish more than 15 inches in length. They formed 47.1 per cent of all food consumed. On the other hand, the 19 stomachs examined from rainbow trout caught in Oregon lakes indicated that mayflies probably ranked second numerically of the aquatic insect groups in the diet of these trout inhabiting lakes, for mayflies constituted only 5.8 per cent of the animal food found.

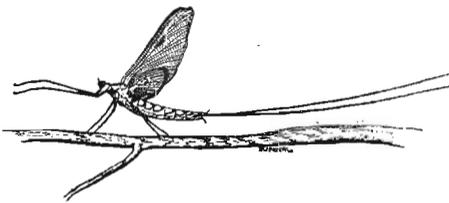


Figure 3. Adult mayfly (*Hexagenia limbata*). (3/4 natural size.)

In the case of eastern brook trout, mayflies appear frequently but not as often as they do in cutthroat and rainbow trout.

Stoneflies (Order Plecoptera). The nymphal and adult stoneflies are important items in the diet of rainbow and cutthroat trout living in Oregon streams. The stoneflies, like the mayflies, pass their mature stages in water. They are almost always found in running streams or brooks. Some

have been reported in other sections in lakes having wave action along the shoreline, but as yet no lake forms have been found in Oregon. The nymphs are of two general feeding kinds—(1) those that feed on vegetable materials, and (2) those that feed on animal organisms, particularly mayfly nymphs, and the larvae of blackflies and midges. Most of the Oregon stoneflies spend one year and a few spend two years in the nymphal stage. When the nymph has completed its growth, it crawls out of the water, splits its nymphal skin down the back, and emerges as a four-winged adult. The adults are somewhat longer-lived than the adults of mayflies and a few are known to feed on vegetation. The adults mate and the females return to the streams to deposit eggs. The majority of adults found in trout stomachs were egg-depositing females.

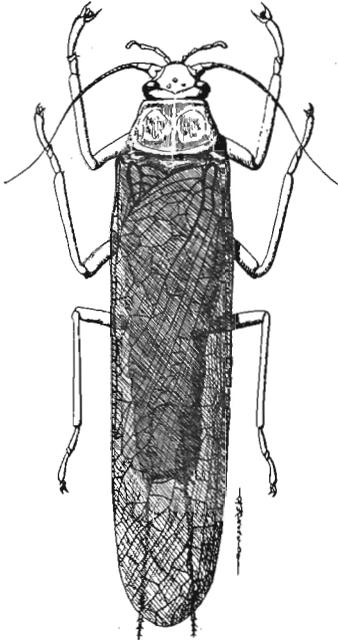


Figure 4. An adult stonefly (*Pteronarcys californica*). (Enlarged $1\frac{1}{2}$ times.)

Stoneflies, both adults and nymphs, ranked second in the diet of rainbow trout examined from Oregon streams. From February to September, inclusive, the adults far outnumbered the nymphs in the stomachs of these fish. Adult stoneflies composed 15.03 per cent and nymphs composed 1.04 per cent of the total foods found in rainbow trout from streams.

In the stomachs of cutthroat trout examined, stoneflies ranked fifth in importance of the insects of aquatic origin, forming 4.2 per cent of the foods found. Seventy-four of these fish were from lakes, which undoubtedly accounts for a lower number of stoneflies than would have been the case had all the cutthroat specimens been from streams.

A good many kinds of stoneflies are found throughout Oregon, and winged forms were found in stomachs of cutthroat trout during every month of the year except December. Three kinds were especially frequent in cutthroat and rainbow trout. The adults of *Pteronarcys californica* N., known as the "Big Curler" (Figure 4)

were frequently found in the stomachs of stream-caught trout from the last of March in the lower altitudes until June in the higher altitudes. The nymphs (Figure 5), were frequently found in the stomachs of rainbow trout. These nymphs were of two sizes, which indicates that two years are spent in the immature stage. This stonefly is present throughout Oregon and is an herbivorous feeder in the nymphal stage.

Acroncuria californica B., the "Western Stonefly" (Figure 6), is found in Eastern and Western Oregon trout streams, and the adults were the most numerous stonefly found in rainbow trout stomachs from fish caught in streams flowing on the west side of the Cascade Mountains. The adults were found in trout stomachs from May in the lower altitudes until the middle of September in the higher elevations. At times in late June and

in July, they occur on the wing in countless numbers along many of the Cascade Mountain streams, and are particularly noticeable at dusk, when many of the females are depositing eggs. Rainbow trout at these times fairly gorge themselves upon Western stoneflies. It is not uncommon to find from forty to fifty adults in a single stomach of medium sized trout. The nymphs (Figure 7), which are carnivorous feeders, are occasionally found in cutthroat and rainbow trout throughout most of the year.

Acroneuria pacifica B., which has been called the "Western Drummer", is on the wing in Oregon from late March in Western Oregon until late September along the streams which flow on the eastern slope of the Cascade Mountains. It was the most numerous stonefly encountered in the stomachs of rainbow trout from the Deschutes River and its tributaries. The nymphs of this stonefly are carnivorous, feeding upon aquatic organisms.

Caddis flies (Order Trichoptera).
Caddis flies are important organisms in the diet of cutthroat, rainbow, and east-

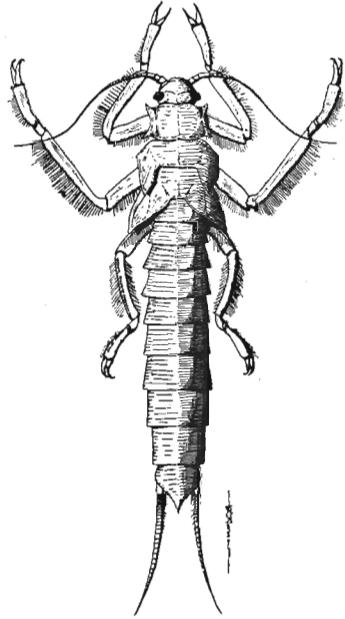


Figure 5. A stonefly nymph (*Pteronarcys californica*). (Enlarged 1½ times.)

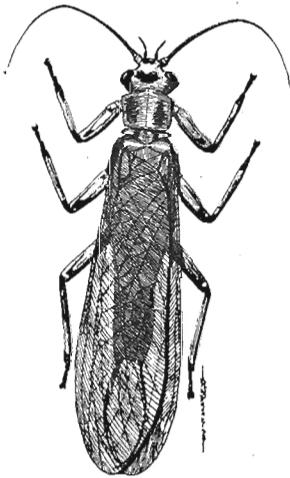


Figure 6. Adult of stonefly (*Acroneuria californica*). (Enlarged 2 times.)

ern brook trout in Oregon streams and lakes throughout all seasons of the year, particularly in the larger trout. They were found frequently in the stomachs of all species of trout of various sizes examined, except those of cutthroat trout under three inches in length. In the diet of cutthroat, rainbow, and eastern brook trout, the adults, larvae, and pupae of caddis flies ranked third numerically of the aquatic insects. They formed 11.6 per cent of the organisms found in cutthroat trout stomachs, 9.9 per cent of the total diet in rainbow trout caught in streams, 5.2 per cent of the food of rainbow trout from lakes, and 2.8 per cent of the items in the eastern brook trout.

The immature stages, known as caddis larvae (Figure 8) live in streams, ponds, and lakes. These larvae, generally, construct portable cases of sticks, grass, leaves, bark, grains of sand, small pebbles, and other

materials, according to the species and building material available. Silk secretion is given off by the larva which cements the materials used in the construction of the cases. Certain species of caddis larvae build cases entirely of silk in the form of a parchment-like shelter. Still others build no cases at all, but instead construct silken tubes upon rocks or other submerged objects from which they construct webs for the capture of food. Others spin no webs or do not make cases during at least portions of their development. Most caddis larvae probably are herbivorous feeders, although some are mainly carnivorous, and others appear to be largely scavengers. When the larva has completed its growth, it transforms to the transitional stage called the pupa. Following the pupal stage, the adults (Figure 9) emerge from the water's surface to mate and deposit eggs.

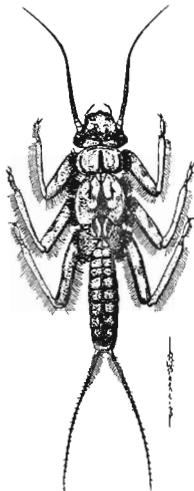


Figure 7. Stone fly nymph (*Acroeuria californica*). (Enlarged $\frac{1}{2}$ times.)

In the majority of trout stomachs examined, larvae were far more numerous than were pupae and adults. Frequently, trout swallowed larvae and pupae enclosed in cases. When the pupae leave their cases and swim to the surface of the water to emerge as adults, they fall prey in large numbers to the feeding trout. Then again, as the females are depositing eggs on the water, they are often fed upon by the fish.

Little is known regarding the habits and the kinds of caddis flies in Oregon. Limited collections

indicate that there are many different kinds in most of the lakes and streams.

Midges (Order Diptera, Family Chironomidae). The immature stages of midges, which include the larvae and pupae, are exceedingly important items in the diet of the various trout found in Oregon. Although found in the stomachs of all sizes of trout examined, except the largest rainbow trout from streams,



Figure 8. A caddis fly larva in its case. (Enlarged $\frac{1}{2}$ times.)

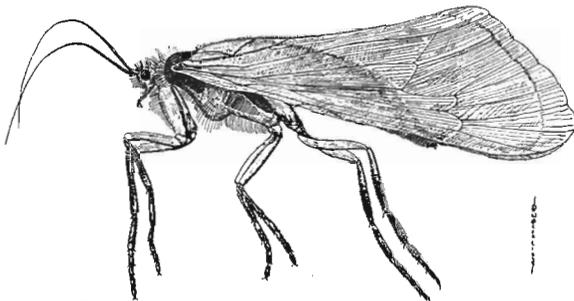


Figure 9. An adult caddis fly. (Enlarged 2 times.)

midges were particularly noticeable in the diet of the smallest fish. They were the most numerous item found in stomachs of cutthroat trout under two inches in length. The adult midges (Figure 10) which were taken by the fish

on the surface of the water were not as frequently found as were the larvae and pupae. The larvae (Figure 11) appeared more numerous in the

stomachs of trout from streams. The pupae, on the other hand, were more numerous in the trout taken from lakes.

The midges ranked first numerically in the diet of rainbow trout examined from lakes, comprising 82.1 per cent of all foods; second in the eastern brook trout, comprising 37.7 per cent of their food. In cutthroat trout from streams and lakes, midges formed 8.6 per cent of all foods taken; in rainbow trout from streams they constituted 4.8 per cent of the diet.



Figure 10. Adult of midge (*Chironomus utahensis*). (Enlarged 5½ times.)

The larvae abound in streams, lakes, and ponds, and many construct cases composed of sedimentary material held together by silk secretions. Midge larvae are chiefly herbivorous feeders living largely upon algae, diatoms, and other vegetable material. After the larva has completed its growth, it transforms to the pupal stage. When the pupal period is almost completed, the pupa generally leaves the larval case and swims to the surface of the water. The adult then emerges from the pupal skin. The adult midges are generally noticed dancing in swarms during late afternoons and evenings and occasionally in the early mornings. Paring of the sexes takes place in the swarm. The mated female returns to the water to deposit her eggs.

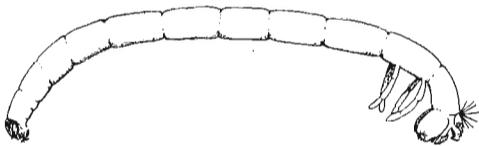


Figure 11. Midge larva (*Chironomus utahensis*). (Enlarged 4 times.)

From the limited observations made in Oregon, midge larvae vary greatly in numbers along the courses of the different waterways. In some places they are numerous and in other places scarce. This fact has considerable bearing on the

proper places to plant young trout. Since midge larvae are the main items in the diet of such fish, it is important to know where these food organisms exist in numbers as places for fish liberation.

Twenty-five kinds of midges are known to occur in Oregon and undoubtedly many more will be found in the state in the future.

Blackflies (Order Diptera, Family Simuliidae). In streams, the blackflies form one of the major foods of Oregon trout. They were frequently found in the diet of all sizes of trout, except in the larger fish; and they were particularly prominent in the diet of the smallest cutthroat trout examined. The larvae (Figure 12) of blackflies appeared more frequently and in larger numbers in stomachs of cutthroat and rainbow trout than did the pupae and adults (Figure 13). Blackflies formed 21.4 per cent of all food found in stomachs of cutthroat trout examined; in the rainbow trout from streams, they comprised 2.4 per cent of the total food.

The larvae of blackflies live in running streams and are usually found

attached to stones by a sucker located at the rear end of the body. They feed chiefly on vegetable materials brought to them by the water current. When the larva has completed its growth, it spins a parchment-like case composed of a silk secretion, and transforms into the pupal stage, which develops later into the adult. Then the adult leaves the pupal case and emerges through the water into the air. The mated females return to the water to deposit their eggs.

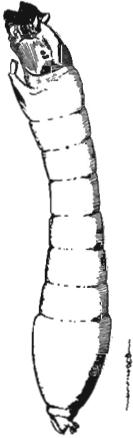


Figure 12. A blackfly larva. (Enlarged 7 times.)

Miscellaneous aquatic insects. Numerous other groups of insects of aquatic origin were represented in the trout stomachs examined, but not in sufficient numbers or frequency to be considered of primary importance in the diet of Oregon trout. These groups appeared to be of secondary importance when compared with various kinds and quantities of mayflies, stoneflies, caddis flies, midges, and blackflies found in the stomachs analyzed.

The nymphs of dragon and damsel flies (Odonata) were occasionally found in the stomachs of cutthroat, rainbow, and eastern brook trout taken from lakes. Although infrequently present, they are, nevertheless, important because they feed mainly upon organisms that are of primary importance as fish food.

The adult dance-flies (Empididae) were frequently found in cutthroat and rainbow trout, particularly from streams. They were present in fish stomachs during the summer and early fall months. Although 20 kinds of dance-flies are known to occur in Oregon, little is known of their life histories. Some species found in other sections are known to be aquatic or semi-aquatic in habits.

Other insects of aquatic origin found in the stomachs of rainbow and cutthroat trout which appeared to be of secondary importance were adults and larvae of crane flies, *Tipulidae*; larvae of dixa midges, *Dixidae*; larvae of mosquitoes, *Culicidae*; larvae of horse-flies, *Tabanidae*; larvae of net-winged midges, *Blepharoceridae*; larvae of alder-flies, *Sialidae*; water-boatmen, *Corixidae*; water-striders, *Gerridae*; larvae and adults of predacious diving-beetles, *Dytiscidae*; adults of whirligig-beetles, *Gyrinidae*; the larvae and adults of water-scavenger beetles, *Hydrophilidae*; and water spring-tails, *Collembola*.

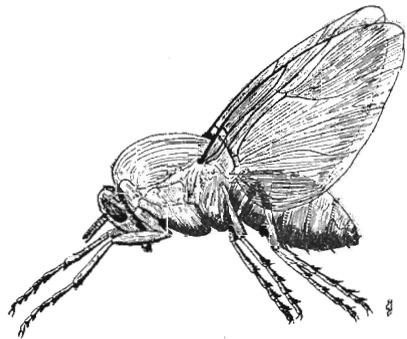


Figure 13. A blackfly (*Prosimulium* sp.). (Enlarged 10 times.)

Insects of terrestrial origin.

During the spring, summer, and fall months, insects of terrestrial origin were prominent items in the diet of trout examined. These land insects were found in the stomachs of fish

specimens during each month of the year. Their presence was indicative of the period of abundance and activity. They were least numerous during the winter months, frequent during spring months, and more numerous during summer and fall months.

The groups of terrestrial insects frequently found in trout stomachs were aphids, *Aphididae*, spittle-bugs, *Cercopidae*, and leaf hoppers, *Cicadellidae*, belonging to the order Homoptera; ground beetles, *Carabididae*, click beetles, *Elateridae*, long horned beetles, *Cerambycidae*, and leaf beetles, *Chrysomelidae*, belonging to the order Coleoptera; various kinds of true flies belonging to the order Diptera; ants, *Formicidae*, and wasps, *Vespidae*, belonging to the order Hymenoptera; and the larvae and adults of moths and butterflies belonging to the order Lepidoptera.

The groups of insects of terrestrial origin which were infrequently encountered in trout stomachs examined were grasshoppers belonging to the order Orthoptera; termites belonging to the order Isoptera; psocids of the order Corrodentia; bristle-tails belonging to the order Thysanura; various families of true bugs of the order Hemiptera; and snake-flies, *Raphidiidae*, and lacewing-flies, *Chrysopidae*, belonging to the order Neuroptera.

Crustaceans. Next to the insects, the fresh-water crustaceans rank second in numerical importance in the diet of Oregon trout, judging from the numbers found in the various fish stomachs examined (Figure 1). They formed 51.9 per cent of the food found in the stomachs of eastern brook trout examined, 4.2 per cent in rainbow trout from lakes, .38 per cent in rainbow trout from streams, and 2.7 per cent in the cutthroat trout from streams and lakes.

The aquatic crustaceans found in the stomachs of Oregon trout were two or three species of crayfish belonging to the genus *Potamobius* (Figure 14), four species of fresh-water shrimps belonging to the order Amphipoda, fresh-water sow-bugs belonging to the family Asellidae, an opossum-shrimp *Mysis relicta* L., water fleas or *Cladocera*, and fairy shrimps or *Phyllozoa*.

The frequency with which crayfish were found in the stomachs of the larger cutthroat and rainbow trout taken from streams indicates that they are important sources of food for the large trout of streams. Crayfish were present in fish stomachs during the spring, summer, and fall months. Although they were most often encountered in cutthroat trout from the slower moving streams of the Coast region, they were also found in the rainbow trout taken from Cascade Mountain streams having steep gradients.

Fresh-water shrimps (Figure 15) are important sources of trout foods, particularly in some of the Central Oregon lakes in which the eastern brook trout thrives. These fish food organisms were occasionally found

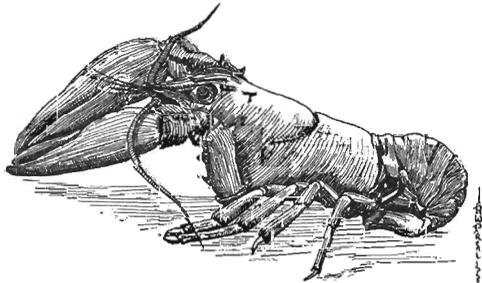


Figure 14. Crayfish (*Potamobius trobridgei*). (Reduced $\frac{1}{2}$ size.)

in cutthroat trout taken from the coast lakes and from the slow moving stretches of coast streams. They were found to be a staple food of rainbow trout in lakes, but were not found in this species in streams.

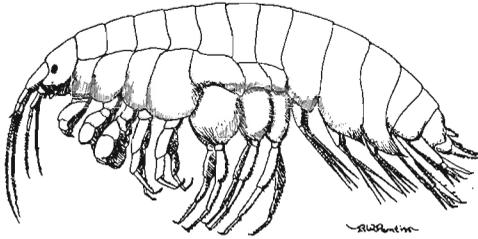


Figure 15. Fresh-water shrimp (*Eucrangonyx* sp.). (Enlarged 5 times.)

Four kinds of fresh-water shrimps are known to occur in Oregon. *Eucrangonyx gracilis* (Smith) was found in several lakes in Central Oregon and in an overflow pond of the Willamette River, near Corvallis. This shrimp attains a large growth size in Oregon

and from fish stomach examination appears to be an excellent trout food organism. The Caledonia shrimp, *Gammarus limnaeus* (Smith), was found in East Lake, and in the Deschutes River, near Bend. *Gammarus ramellus* W. was found in many coast lakes and streams. *Hyaella azteca* (Saussure) was found in several lakes located in the Cascade Mountains, coast counties, Eastern and Central Oregon. Although this shrimp attains small growth size, it was the most frequent fresh-water shrimp encountered in the trout stomachs examined.

The opossum-shrimp, *Mysis relicta* L., was frequently found in stomachs of cutthroat trout taken from several of the coast lakes. This crustacean is known from lakes in Europe and from a few lakes in North America.

Mollusca. Various species of fresh-water snails belonging to the class Gastropoda were occasionally found in the stomachs of all species of trout examined. They appear to be of secondary importance as food, for they constituted less than 1 per cent of the diet of each group of trout examined.

Small fresh-water clams belonging to the family Sphaeriidae were found now and then in the stomachs of eastern brook and rainbow trout from lakes.

Spiders and water-mites. Spiders of terrestrial origin were present in the stomachs of trout examined during each month of the year except December, January, and February. They formed 1.2 per cent of the diet of the cutthroat trout examined, .03 per cent of the food of eastern brook trout, and .7 per cent of the stomach contents of rainbow trout from streams.

Water-mites belonging to the family Hydrachnidae which prey upon or are parasites of aquatic animal organisms were occasionally found in the trout stomachs examined. They occurred frequently in the diet of the small cutthroat trout examined. When water-mites appeared in the stomachs of the large fish, they were generally quite numerous.

Fish eggs. Of the 252 fish eggs found in the stomachs of cutthroat trout, 210 were eggs of the silver salmon, *Oncorhynchus kisutch* (Walbaum). The remaining 42 fish eggs were unidentified. The majority of salmon eggs found in the fish stomachs were from cutthroat trout taken from the

spawning beds of silver salmon in small creeks. There was no evidence found in the stomachs examined that cutthroat trout normally feed upon their own eggs.

Fish. Small-sized fish were conspicuous in the diet of larger trout examined. The fish found in cutthroat trout stomachs included young silver salmon, *Oncorhynchus kisutch* W.; sticklebacks, *Gasterosteus aculeatus aculeatus* L.; bullheads, *Cottus* sp.; a small lamprey; and several fishes in which digestion had advanced too far to make identification possible. In the coast streams, pieces of salmon were frequently found in the stomachs of large cutthroat trout. These pieces were from salmon which had died following spawning and are recorded in the tables as "refuse fish."

The fish found in rainbow trout consisted of bullheads, *Cottus* sp.; and roaches, *Siphateles bicolor* (Girard).

No definite case of cannibalism was found in any of the fish examined.

Miscellaneous animal foods. Animal organisms which appeared infrequently in the trout examined were considered as miscellaneous animal foods. This group included centipedes, millipeds, scorpions, earthworms, free-living nematodes, leeches, snakes, a frog, a mouse, and a bird

FOOD OF STEELHEAD TROUT

The stomach contents of 23 steelhead or sea-run rainbow trout, *Salmo gairdneri irideus* Gibbons, caught in fresh water, were analyzed (Table V). Nineteen of these trout were "incoming" fish migrating to spawning areas, and four were "outgoing" fish which had spawned. Most of these fish had been caught in the Alsea and Siletz rivers and one in the Rogue River.

Very little food except salmon or steelhead eggs which had been used as bait was found in the stomachs of incoming steelheads. In the cases of the four outgoing trout, all stomachs contained natural foods, but not in large amounts. The food consisted of immature mayflies, stoneflies, and caddis flies.

From these observations it appears that incoming steelhead trout feed very sparingly on natural foods of the streams probably because they have sufficient stored food materials in their tissues to last until spawning has been completed. On the other hand, these fish are often caught with bait, particularly fish eggs, and such materials as leaves and sticks are present in their stomachs, which might indicate that some time is necessary for them to adjust their food hunting activities upon returning to fresh water from the ocean.

FISH FOOD SURVEYS OF OREGON STREAMS AND LAKES

Although the major portion of the fish food investigations were restricted to the laboratory analyses of fish-stomach contents, partial stream and lake surveys of fish foods in several sections of the state were made. These surveys were incomplete but nevertheless indicated that the amounts and kinds of fish food organisms vary greatly between different water-

ways. Some streams and lakes are so sparsely populated with fish food organisms that the planting of additional fish would be an unwise procedure. The majority of waterways investigated, however, appear to have ample food organisms present.

These partial fish food surveys also indicate that the fish food organisms vary in the amounts and kinds along the courses of the waterways. This has important bearing upon determining the places along streams and in lakes where fish should be planted. Fish should be liberated where their natural foods abound.

SUGGESTIONS FOR FISH LIBERATIONS

Without definite knowledge gained from thorough fish food surveys of the main fishing waters, recommendations regarding fish liberations may be liable to gross error, for food conditions and predatory conditions may vary greatly throughout the different portions of any one stream and between different waterways. The following suggestions for the liberation of young trout in Oregon are based entirely upon food contents found in fish stomachs examined and upon limited observations in several Oregon streams and lakes.

1. Trout under two inches in length should be liberated in locations having an abundance of immature midges, or immature blackflies, or waterfleas, or combinations of these organisms.

2. Trout from two to five inches in length should be liberated in locations having an abundance of the following food organisms: immature midges, or immature blackflies, or mayfly nymphs, or combinations of these organisms.

3. Large numbers of fish should not be liberated in one area but should be distributed in several locations along the course of a waterway. The available food may be exhausted if too large a number are turned loose in one place.

4. In the light of present knowledge, liberations of young trout should not be made in tidewater or in fresh water close to tidewater. Very few aquatic insects are found in salt water. Observations made of young silver salmon liberated in large numbers near tidewater showed that these fish drifted down stream into salt water and examinations of their stomachs showed no food present. Also, many of these young salmon were found in the stomachs of large cutthroat trout. This would indicate that small fish should be liberated in the smaller creeks which possess plenty of fish food organisms and which are tributaries to the main fishing streams. In such situations the small fish may have a better chance of escaping from being preyed upon by the larger fishes, which are generally more numerous in the main body of the stream.

5. Liberate young trout in situations where, in the past, other liberations have been known definitely to have been successful or in locations in which trout of corresponding size and kind are known to exist under natural conditions.

TABLE I. FOOD OF NINETEEN RAINBOW TROUT CAUGHT IN FIVE DIFFERENT LAKES

	Length of fish in inches*						Total (19)
	7- 7.99 (1)	8- 8.99 (4)	9- 9.99 (2)	10- 11.99 (2)	12- 14.99 (5)	15- 19.00 (5)	
<i>Insects of aquatic origin</i>							
Mayfly nymphs .....	.....	151	.....	10	2	.....	163
Mayfly subimagos .....	.....	.....	.....	7	.....	.....	7
Caddis fly larvae .....	.....	24	.....	3	.....	109	136
Caddis fly pupae .....	.....	1	.....	1	.....	.....	2
Caddis fly adults .....	.....	.....	.....	2	13	.....	15
Midge larvae	2	1	.....	2	84	.....	89
Midge pupae .....	.....	5	552	34	1,192	318	2,101
Midge adults	210	.....	.....	.....	2	.....	212
Dragon and Damsel fly nymphs.....	1	2	.....	1	.....	.....	4
Dance-fly adults .....	.....	.....	1	.....	.....	.....	1
<i>Insects of terrestrial origin</i>							
Aphids	3	.....	.....	.....	.....	.....	3
True bugs	2	.....	.....	.....	.....	.....	2
Beetles .....	.....	1	.....	.....	2	.....	3
True flies	2	.....	.....	.....	.....	.....	2
Unidentified insects .....	.....	.....	.....	5	.....	.....	5
<i>Crustaceans</i>							
Fresh-water shrimps .....	.....	54	1	.....	15	.....	70
Water-fleas .....	.....	.....	.....	.....	48	5	53
<i>Mollusca</i>							
Fresh-water snails .....	.....	.....	.....	5	24	.....	29
Fresh-water clams <i>Spacriidae</i>	1	2	.....	.....	.....	.....	3
<i>Fish</i>							
Roaches .....	.....	.....	.....	.....	4	11	15
<i>Miscellaneous</i>							
Snakes .....	.....	.....	.....	2	.....	.....	2
Leeches .....	.....	1	.....	.....	6	.....	7
Algae .....	.....	+	.....	+	.....	+	.....

*Figures in parentheses indicate number of stomachs examined.

TABLE II. FOOD OF CUTTHROAT TROUT IN OREGON STREAMS AND LAKES.

	Length of fish in inches*														Total (326)
	1- 1.99 (12)	2- 2.99 (5)	3- 3.99 (5)	4- 4.99 (10)	5- 5.99 (15)	6- 6.99 (36)	7- 7.99 (48)	8- 8.99 (60)	9- 9.99 (32)	10- 10.99 (45)	11- 12.99 (36)	13- 14.99 (14)	15- 16.99 (5)	17- 19.00 (3)	
<i>Insects of aquatic origin</i>															
Mayfly nymphs	2	20	18	60	140	280	342	417	185	235	171	56	76	.....	2,002
Mayfly subimagoes .....	.....	3	.....	5	3	22	18	315	16	175	6	18	1	.....	582
Mayfly adults .....	.....	.....	.....	1	52	99	17	79	5	4	4	1	2	.....	264
Stonefly nymphs .....	.....	1	15	8	7	25	59	62	33	34	33	36	12	.....	325
Stonefly adults .....	.....	.....	.....	3	2	25	7	81	3	9	.....	.....	.....	.....	130
Caddis fly larvae .....	.....	.....	2	6	36	149	122	131	192	144	26	68	235	.....	1,111
Caddis fly pupae .....	.....	.....	2	1	5	4	5	26	7	16	.....	12	1	.....	79
Caddis fly adults .....	.....	.....	.....	.....	.....	11	1	22	9	2	2	3	5	.....	55
Midge larvae	24	11	2	39	22	59	184	22	32	6	7	1	20	.....	429
Midge pupae	21	.....	2	2	.....	21	93	59	9	144	2	13	1	5	372
Midge adults	18	.....	1	.....	.....	2	18	83	1	11	.....	1	.....	.....	135
Blackfly larvae	15	.....	1	75	7	393	957	71	25	11	117	1	.....	.....	1,673
Blackfly pupae .....	.....	.....	.....	1	1	52	35	73	4	89	9	.....	.....	.....	264
Blackfly adults	1	.....	.....	2	2	248	87	16	10	1	.....	1	.....	.....	368
Dance-fly adults .....	.....	.....	.....	.....	8	15	9	14	2	.....	2	.....	.....	.....	50
Crane fly larvae .....	.....	.....	.....	.....	4	17	3	6	6	4	1	1	.....	.....	42
Net-winged midge larvae .....	.....	1	.....	.....	3	6	.....	2	5	.....	.....	.....	.....	.....	21
Other true flies—larvae and adults .....	.....	1	1	1	1	1	3	2	3	.....	1	.....	1	.....	15
Water-striders .....	.....	.....	.....	.....	1	2	1	8	1	3	.....	3	.....	.....	19
Alder-fly larvae .....	.....	.....	.....	.....	1	3	.....	2	.....	2	1	4	.....	.....	13
Dragon and Damsel fly nymphs .....	.....	.....	.....	.....	.....	1	2	1	.....	4	1	3	.....	.....	12
Spring-tails .....	.....	.....	2	10	.....	.....	3	1	1	.....	.....	.....	.....	.....	17
Beetle larvae and adults .....	.....	.....	1	.....	3	6	.....	5	.....	.....	1	.....	.....	.....	16
<i>Insects of terrestrial origin</i>															
Grasshoppers, etc. ....	.....	.....	.....	.....	.....	1	.....	3	.....	.....	.....	.....	.....	.....	4
Termites .....	.....	.....	.....	.....	.....	6	3	.....	14	.....	.....	.....	.....	.....	23
Snake-flies and lace-wing flies .....	.....	.....	.....	1	.....	1	4	2	.....	.....	.....	.....	.....	.....	8
Psocids (Corrodentia) .....	.....	.....	.....	3	4	3	2	1	6	.....	.....	1	.....	.....	20
Aphids, Spittle bugs, etc. ....	.....	.....	9	5	71	64	151	101	29	13	.....	.....	.....	.....	443
True bugs (Hemiptera) .....	.....	.....	.....	1	2	5	6	17	5	2	1	.....	2	.....	41
Beetles, larvae and adults	3	5	3	2	7	19	7	89	35	19	21	2	1	.....	213
True flies, larvae, and adults	7	21	.....	3	15	21	4	95	13	5	6	.....	.....	.....	191
Moths, butterflies—larvae and adults	2	.....	1	.....	3	2	9	18	3	4	.....	.....	1	.....	41
Ants, bees, etc.	2	.....	.....	2	11	41	26	66	26	641	8	.....	.....	.....	823
Bristle tails (Thysanura)	3	.....	1	.....	.....	.....	.....	2	.....	.....	.....	.....	.....	.....	6
Unidentified insects .....	.....	.....	.....	1	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	2

*Figures in parentheses indicate number of stomachs examined.

TABLE II (Continued)

	Length of fish in inches															Total (326)
	1- 1.99 (12)	2- 2.99 (5)	3- 3.99 (5)	4- 4.99 (10)	5- 5.99 (15)	6- 6.99 (36)	7- 7.99 (48)	8- 8.99 (60)	9- 9.99 (32)	10- 10.99 (45)	11- 12.99 (36)	13- 14.99 (14)	15- 16.99 (5)	17- 19.00 (3)		
<i>Crustaceans</i>																
Fresh-water shrimps	2		1			20	3	32		2		42			102	
Fresh-water sowbugs	1			1		1			1	1					6	
Opossum-shrimps	2						37	29	28	27	2				127	
Crayfish				1	1	1	1	8	4	5	5	2	2		30	
Fairy shrimps						2	10	2	3						17	
Water-fleas	13					2									13	
<i>Mollusca</i>																
Fresh-water snails						15	9	17	4	12	7	1	3		68	
<i>Arachnida</i>																
Spiders	1			3	4	6	6	17	13	10		2			62	
Water-mites	13	7	4	4	1	32	21								82	
Scorpion								1							1	
<i>Diplopoda</i>																
Millipeds							1				5				6	
<i>Chilopoda</i>																
Centipedes				1		1			3						5	
<i>Nemathelminthes</i>																
Free-living nematodes				1			4	1		1					7	
<i>Annelida</i>																
Earthworms			1						2	4	3				10	
<i>Fish</i>																
Sticklebacks								3		4	1			5	13	
Bullheads (<i>Cottus</i> sp.)								1	2	1	2				6	
Undetermined fish					1		3	1	4	2	4				15	
Young silver salmon								2		56	12	10		1	81	
Catfish											1				1	
Lamprey											1				1	
Fish refuse								6	1	1	4	2			14	
Fish eggs, unidentified							2	24	14			2			42	
Fish eggs, silver salmon								15		31	66	97	1		210	
Frog											1				1	
Mouse												1			1	
Unidentified animal organism						1									1	

TABLE III. FOOD OF RAINBOW TROUT IN OREGON STREAMS.

	Length of fish in inches*									
	4- 4.99 (3)	5- 5.99 (16)	6- 6.99 (29)	7- 7.99 (20)	8- 8.99 (11)	9- 9.99 (6)	10- 11.99 (6)	12- 14.99 (5)	15- 19.00 (7)	Total (103)
<i>Insects of aquatic origin</i>										
Mayfly nymphs	56	206	249	152	49	55	7	12	1	787
Mayfly subimagoes .....	.....	23	86	83	3	39	.....	6	.....	240
Mayfly adults	1	365	305	310	115	40	142	35	16	1,329
Stonefly nymphs	3	7	2	7	5	13	3	8	4	52
Stonefly adults .....	.....	12	149	145	121	144	39	20	122	752
Caddis fly larvae	10	25	66	43	154	10	10	17	33	368
Caddis fly pupae .....	.....	7	23	22	4	3	1	2	1	63
Caddis fly adults .....	.....	14	13	7	4	10	12	5	3	68
Midge larvae	1	20	147	7	8	1	3	.....	.....	187
Midge pupae .....	.....	.....	31	2	7	.....	.....	2	.....	42
Midge adults .....	.....	1	7	.....	2	.....	.....	1	.....	11
Blackfly larvae .....	.....	61	5	7	2	2	1	.....	.....	78
Blackfly pupae .....	.....	6	2	1	.....	.....	.....	.....	.....	9
Blackfly adults .....	.....	6	18	7	5	.....	.....	.....	.....	36
Dance-fly adults .....	.....	7	44	20	1	17	4	.....	6	99
Crane fly larvae .....	.....	4	5	7	3	.....	38	.....	.....	57
Net-wing midge larvae .....	.....	.....	1	1	.....	.....	.....	.....	.....	2
Other true flies—larvae and adults .....	.....	1	6	1	.....	.....	.....	.....	.....	8
Water-striders .....	.....	.....	1	3	.....	3	1	.....	.....	9
Beetle larvae and adults .....	.....	.....	13	2	.....	.....	.....	.....	1	16
<i>Insects of terrestrial origin</i>										
Termites .....	.....	.....	.....	.....	.....	.....	2	.....	.....	2
Psocids .....	.....	.....	1	1	.....	.....	.....	.....	.....	2
Aphids, spittlebugs, etc. ....	.....	48	29	40	3	9	7	.....	1	137
True bugs .....	.....	2	8	3	3	2	.....	.....	.....	18
Beetles, larvae and adults	1	7	29	22	8	8	1	3	.....	86
Moths and butterflies, larvae and adults .....	.....	1	11	19	3	2	2	.....	13	51
True flies, larvae and adults	4	13	14	2	4	.....	4	.....	6	47
Ants, bees, etc.	1	14	65	44	49	16	9	11	28	237
Unidentified insects .....	.....	.....	5	.....	.....	.....	1	.....	1	7

* Figures in parentheses indicate number of stomachs examined.

TABLE III (Continued)

	Length of fish in inches*									Total (103)
	4- 4.99 (3)	5- 5.99 (16)	6- 6.99 (29)	7- 7.99 (20)	8- 8.99 (11)	9- 9.99 (6)	10- 11.99 (6)	12- 14.99 (5)	15- 19.00 (7)	
<i>Crustaceans</i>										
Crayfish .....	.....	.....	1	.....	.....	.....	.....	15	3	19
<i>Arachnida</i>										
Spiders .....	.....	5	17	10	.....	1	1	.....	2	36
Water-mites .....	.....	21	45	3	1	8	.....	.....	.....	78
<i>Mollusca</i>										
Fresh-water snails .....	.....	.....	35	7	6	.....	.....	.....	1	49
<i>Fish</i>										
Bullheads (<i>Cottus</i> sp.) .....	.....	.....	.....	.....	.....	.....	1	2	2	5
Unidentified fish .....	.....	.....	.....	.....	1	.....	.....	.....	.....	1
Fish eggs, salmon .....	.....	.....	.....	.....	3	.....	.....	.....	.....	3
<i>Miscellaneous groups</i>										
Earthworms .....	.....	.....	1	1	.....	.....	.....	.....	1	3
Free-living nematodes	1	.....	.....	.....	.....	.....	1	.....	.....	2
Millipeds .....	.....	.....	.....	.....	.....	.....	.....	1	2	3
Unidentified animal organisms .....	.....	1	.....	.....	.....	.....	.....	.....	2	3

TABLE IV. FOOD OF TWENTY-FIVE EASTERN BROOK TROUT CAUGHT IN SIX DIFFERENT LAKES

Number of stomachs examined	Length of fish in inches				
	6- 8.99 (11)	9- 11.99 (8)	12- 14.99 (4)	15- 17.99 (2)	Total (25)
<i>Insects of aquatic origin</i>					
Mayfly nymphs	37	17	25	.....	79
Mayfly adults	1	.....	.....	.....	1
Caddis fly larvae	55	86	9	1	151
Caddis fly pupae	3	.....	19	.....	22
Caddis fly adults	4	.....	.....	.....	4
Midge larvae	59	12	13	1	85
Midge pupae	39	411	.....	1,834	2,284
Midge adults	1	1	.....	.....	2
Dragon and Damsel fly nymphs .....	.....	4	4	.....	8
Water-boatmen	10	34	.....	.....	44
Alder-fly larvae (Sialidae)	7	.....	.....	.....	7
Whirligig beetle .....	.....	.....	1	.....	1
Crane-fly larvae (Tipulidae)	1	86	2	.....	89
Horsefly larvae (Tabanidae)	1	.....	.....	.....	1
<i>Insects of terrestrial origin</i>					
Grasshoppers	1	1	.....	.....	2
Beetle, larvae and adults	4	4	.....	.....	8
Moth larva .....	.....	1	.....	.....	1
True flies	2	2	.....	.....	4
Ants	2	.....	.....	.....	2
<i>Crustaceans</i>					
Fresh-water shrimps	21	.....	467	1,950	2,438
Water-fleas	129	.....	698	.....	827
<i>Arachnida</i>					
Spiders	1	1	.....	.....	2
Water-mites	83	52	.....	.....	135
<i>Mollusca</i>					
Fresh-water snails .....	.....	.....	1	10	11
Fresh-water clams <i>Spaeridae</i>	72	.....	.....	.....	72
<i>Fish</i>					
Unidentified .....	.....	1	.....	.....	1
Eggs, unidentified	1	.....	.....	.....	1

TABLE V. MATERIALS FOUND IN THE STOMACHS OF 19 "INCOMING" AND "OUTGOING" STEELHEAD TROUT CAUGHT IN OREGON STREAMS

	Length of fish in inches*			
	16- 19.99 (7)	20- 24.99 (9)	25- 29.99 (3)	Total (19)
<i>19 "Incoming" Trout</i>				
Salmon eggs	4	6	1	11
Steelhead eggs .....	.....	39	.....	39
Fresh-water snails	1	.....	.....	1
Fish refuse	1	.....	.....	1
Bird, unidentified .....	.....	.....	1	1
Bird feather .....	.....	.....	1	1
Plant leaf	2	.....	.....	2
Wood, pieces .....	.....	7	1	8
Pebbles .....	.....	6	.....	6
	(1)	(2)	(1)	(4)
<i>4 "Outgoing" Trout</i>				
Mayfly nymphs .....	.....	28	4	32
Stonely nymphs	1	16	8	25
Caddis fly larvae	8	8	.....	16
Fresh-water snails	4	2	.....	6
Algae	1	.....	.....	1
Wood, pieces .....	.....	2	1	3
Pebbles	4	6	10

*Figures in parentheses indicate number of stomachs examined.

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