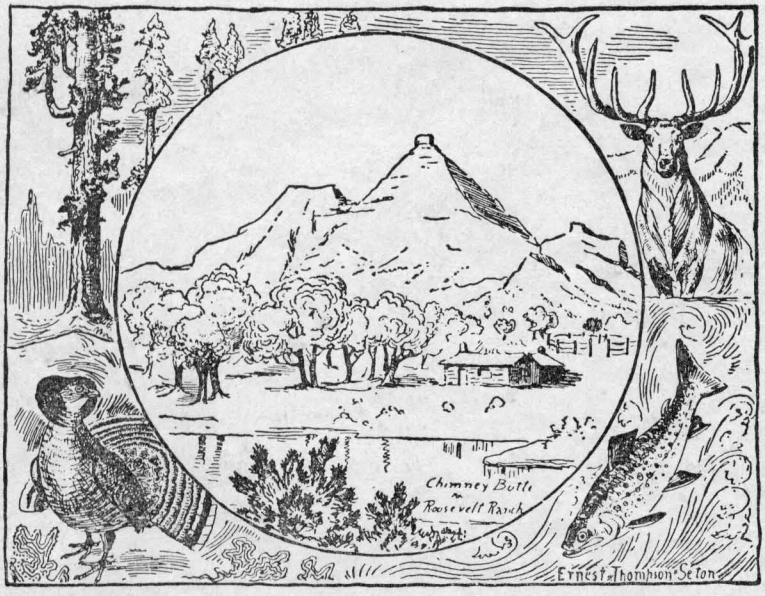
L. Berner

THE FOOD OF TROUT IN YELLOWSTONE NATIONAL PARK

By
DR. RICHARD A. MUTTKOWSKI



Reprinted from the ROOSEVELT WILD LIFE BULLETIN
Vol. 2, No. 4, pp. 470-497, Feb., 1925

Roosevelt Wild Life Forest Experiment Station
Dr. Charles C. Adams, Director
The New York State College of Forestry, at Syracuse

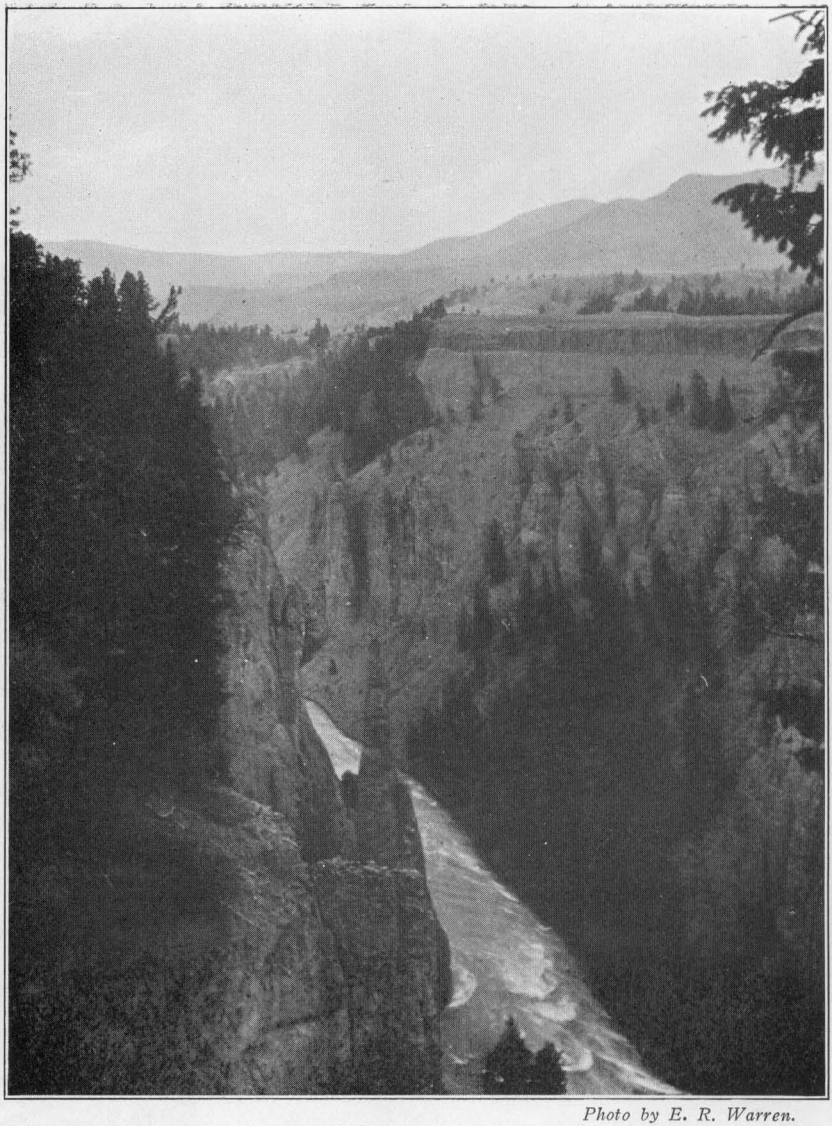


Photo by E. R. Warren.

Fig. 113. View down the rapids of the Yellowstone River at the entrance to the lower part of the Grand Canyon, below Tower Fall, showing the "palisades" and the rock columns known as "the needles."

THE FOOD OF TROUT IN YELLOWSTONE NATIONAL PARK*

By Dr. Richard A. Muttkowski

Collaborator, Roosevelt Field Naturalist, Roosevelt Wild Life Forest Experiment Station, Syracuse, New York

CONTENTS

1. Introduction.
2. Fishes and Their Environment.
3. The Food of the Native Redthroat Trout.
   The Water Food.
      Stone-flies.
      May-flies.
      Caddis-flies.
   The Surface Food.
4. Feeding Habits of the Trout.
5. Hints to Anglers in Yellowstone Park.
   Your Attitude.
   How to Fish.
   Bait and Flies.
   Your Catch.

INTRODUCTION

Through the courtesy and cooperation of the Park authorities, the Yellowstone Park Camps Company, and the Roosevelt Wild Life Station, the writer during the summer of 1921 was enabled to make certain studies of the trout streams of Yellowstone Park, particularly those of the northeastern section. The study extended through four months—from June 20 to September 10,—covering the critical period of the year, since the conditions during these months largely determine the propagation of trout and also of their natural food supply.

---

* Contribution from the Roosevelt Wild Life Forest Experiment Station, and from the Zoological Laboratory, University of Idaho, Moscow, Idaho.

This is the third of a series of papers on the wild life of Yellowstone National Park which has been made possible by gifts to this Memorial Station from the joint friends of Theodore Roosevelt and of wild life conservation. The initial aid for this plan came from Mr. Howard H. Hays, President of the Yellowstone Park Camps Company. I gladly avail myself of this opportunity to thank Mr. Hays and Dr. Muttkowski on behalf of the Roosevelt Wild Life Station for their contribution and cooperation in this investigation. (Cf. also *Roosevelt Wild Life Bull.*, Vol. 1, No. 1, pp. 96-99.)—The Director.

While dealing specifically with the trout streams of Yellowstone Park, the facts here presented have a much wider application. It is an axiom that like causes beget like results. In a broad sense the mountain trout streams of the Park and their fish are typical of the trout streams throughout the Rockies. The writer has had the opportunity to make comparisons of physical conditions, and to some extent of the biological conditions, in several of these states. In the region studied, the conditions affected but a single species of trout—the native redthroat, cutthroat, or blackspotted trout (*Salmo clarkii*)—the only one found in the northeastern part of the Park.

The present account is not in any sense complete, as it deals with only a few phases of the work, certain summaries presented in a form believed to be of most interest and value to the general reader. The technical, detailed report is to follow at a later date.

The illustrations accompanying this paper, with the exception of figure 113, are reproduced from photographs taken in 1921 by the author.

FISHES AND THEIR ENVIRONMENT

There are at least two points of view in dealing with fish,—that of the fish and that of the fisherman. A fish wants something to eat, and the fisherman, aside from a secondary "sporting" interest, wants to eat the fish. What the fisherman thinks we know pretty well. But no one has as yet succeeded in interviewing a fish directly to find out what he "thinks" about the matter. Indirectly, scientists have frequently forced fish to give us information by placing them under special, controlled conditions. This method is called experiment. To this is added observation. By combining the results gained by the two methods a good deal of information has been accumulated regarding a fish's habits, his likes and dislikes, and something of the world in terms of a fish's life.

Let us summarize briefly the conditions under which a fish lives. Water is supposedly transparent. But have you ever looked at the under side of the surface film of water in an aquarium? Seen from an acute angle, this surface film is not at all transparent, but acts as a mirror, reflecting the objects beneath. The more closely the angle of vision approximates a right angle the less the mirroring, and the greater the transparency. There is a further difference whether one gazes toward the sunny or shaded side of the water. A fish can see objects outside of the water, provided these are fairly above him, at an angle of view not exceeding 45 degrees, or within

an arc of approximately 90 degrees. Beyond that point the surface film becomes a mirror to the fish. These points can be easily tested by any person with sufficient courage to keep his eyes open under water for a few seconds. There is a slight difference in a stream where the surface is mobile, as in rapids. Here the effect is primarily that of a " freak " mirror, constantly moving like a dish of agitated mercury or molten silver or lead, with bright streaks and dark bands, the bands being transparent places.

To the fish, then, the water surface is in good part a mirror, through which he cannot see; but he does see objects beneath him reflected plainly in the surface mirror — upside down, of course. This is an advantage, for it aids him to find the food in the water, to come upon his prey suddenly, unobserved, and from an unexpected angle. It is also to his disadvantage, for while it aids him in finding his prey, it exposes him to his enemies in the water, putting him in the position of prey. It places him at the further disadvantage of not being able to see external enemies, such as man, birds, and fishing mammals, except through the circumscribed area directly above him. And finally, the mirror tricks him into accepting bait that is poked through the surface mirror while preventing him from seeing the fisherman on the shore who is offering the bait.

Another point is that fish are more or less near-sighted and do not recognize objects unless they move. Further, a good deal of scientific evidence indicates that fish are color-blind, that they do not see colors as we do. To fish, all colors apparently must be more or less shades of gray, much as to a color-blind person. If this is true, in just what way are colored flies so useful when used as bait for fish, since fish are not supposed to recognize colors as we do? Again, since a fish generally strikes from below and sees the colors of bait *against light,* of what use are colors under such conditions? To test this, let the reader try to recognize colors of an opaque object held against light. Whether a fish recognizes colors as such, or merely as shades of gray, is as yet an unsettled question which offers splendid opportunity for experimental study.

For the observer who wishes further information on this interesting subject, the following references are suggested:

The Senses and Learning in Fishes, by Jacob Reighard. In *Transactions Amer. Fisheries Soc.,* Vol. 46, No. 3, 1917, pp. 133–170.

Marvels of Fish Life, as Revealed by the Camera, by Francis Ward. 2nd ed., pp. 1–196. London, 1912.

Animal Life Under Water, by Francis Ward. Pp. 1–178. New York, 1920.

THE FOOD OF THE NATIVE REDTHROAT TROUT

The habits of fishes are as varied as those of terrestrial animals. Fish are carnivores, first of all. But the different kinds of fish have their preferences in the way of food. A silver bass is primarily a surface feeder, that is, he prefers to pick his food from the water's surface or from plants near the surface. Both the large-mouthed and small-mouthed black bass are chiefly plant feeders, se'ecting their food from plants, while the crappie is more or less an indiscriminate feeder, although he really prefers the muddy bottoms. The trout, in general, are clean feeders; that is to say, they do not like to skim the bottoms, but prefer to catch their prey when the latter moves through the water.

In mountain trout streams the rapidity of the current limits the make-up of the fauna to such animals as are adapted to withstand strong currents. In rapids one finds no leeches, no worms (except flat-worms), no air-breathing insects, nor crustaceans (crayfish, water-fleas, etc.). This limitation means that the food supply is confined to such plants and animals as can withstand the strong current either by strong clinging or propelling devices. It also means that the fauna consists of relatively few species, which generally are present in enormous numbers. It means further that the diet of the fish inhabiting such streams is limited to these items primarily and that, humanly speaking, the diet must become monotonous.

The food of trout can be conveniently classed into two types: *water bait,* which is the normal supply found in the water, and *surface bait,* consisting of insects and other animals that have fallen into the water and become "water trapped." This latter condition applies when an insect's wings become water-logged or so adhere to the surface that the insect cannot rise from it. This surface bait may be of various types, such as ants, grasshoppers, beetles, moths, butterflies,— in fact, anything that a sudden gust of wind may carry onto the surface. It may even include frogs, mice, worms, and other stray land animals.

The Water Food.— The normal food of trout streams, comprising the water bait, is represented in the main by three groups. Named in the order of their importance, for trout streams only, these are the Perloidea or stone-flies, the Ephemerida or May-flies, and the Trichoptera or caddis-flies.

Stone-flies.— The Perloidea or stone-flies are the most conspicuous fish food item in the Yellowstone streams. In this respect, these

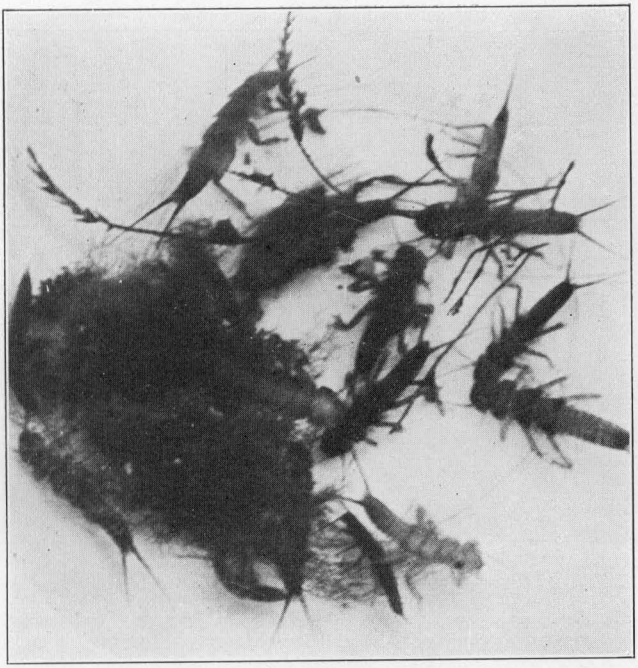


Fig. 114. Stone-fly nymphs from the Yellowstone River near Yellowstone River Bridge.

Fig. 115. A stone-fly nymph (*Pteronarcys californica*) which has just come out of the water and is crawling up a rock to a sheltered spot for transformation to the adult insect. Photo July 25.

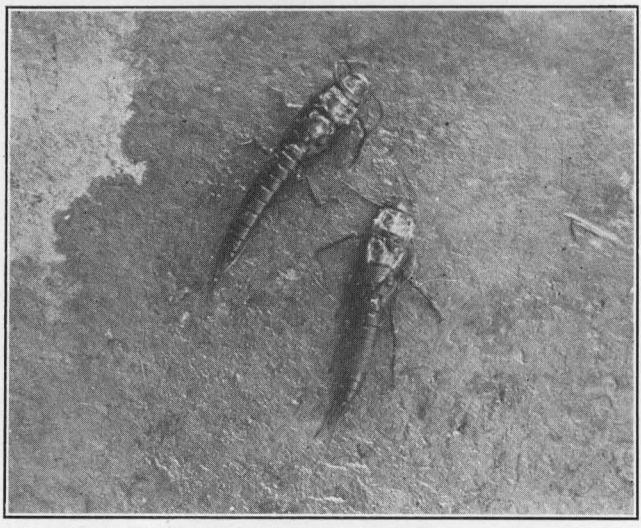


Fig. 116. Salmon colored stone-flies (*Pteronarcys californica*) "emerging" from the larval skins. In the upper specimen the larval skin has just split; in the lower one the head and legs are free. Photo July 25.

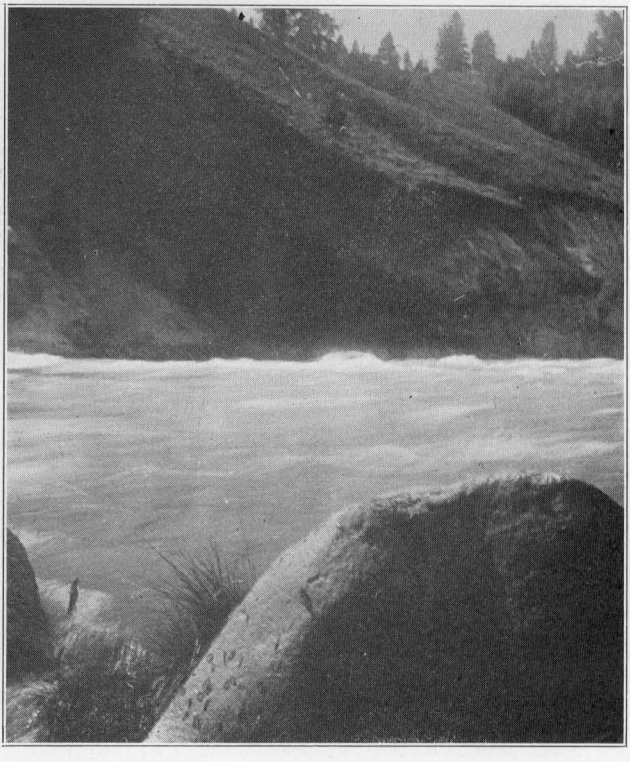


Fig. 117. Stone-flies "emerging" on a rock near Yellowstone River Bridge. Some of the dried cast larval skins are sticking to the rock. Photo July 6.

streams, especially where there are trout, are like other mountain streams. Indeed one may say that the life of trout streams as far as the fish are concerned is absolutely dependent on stone-flies. They are indispensible in the natural propagation of trout. While in the water, they are more or less flattened, six-legged creatures (fig. 114), varied in color and size, and generally may be found under stones or clinging to them, busily searching for food. Hence they are known to zoologists as "stone-flies." Most of them are carnivores in the aquatic stage; they eat other insects, flatworms and other aquatic animals, and even turn cannibal, eating their own kind or their young. Curious to say, the largest and most conspicuous species of the stone-flies (*Pteronarcys californica*) found in the rivers of Yellowstone Park is almost entirely herbivorous, eating the various algae and diatoms off the rocks, and also bits of wood and bark that come down the stream.

Beginning with July, the stone-flies "emerge," that is, they crawl out of the water onto the shore or on exposed rocks, split the larval skin, draw out the thorax, head, legs, and finally the abdomen, and expand their two pairs of wings (see figs. 115–116). They generally come out in enormous numbers from early morning till early afternoon. After the wings are dried, which takes from ten to fifteen minutes, they fly toward some upright object. Naturally, any person standing or moving along the stream will be taken for a convenient resting place by the stone-flies, much to the delight of the trout fishermen who encounter flights of these beautiful creatures.

According to local habit, these stone-flies are known by various names in different sections of the country. Thus, they are called willow flies, trout flies, mountain flies, salmon flies, yellow flies, river flies, red flies, black flies and so on, according to color, place of occurrence and the fish found in the particular neighborhood.

Stone-flies are almost wholly confined to rapid streams (figs. 117–119), as their distribution is controlled by the degree of aeration of the water. Since wave action along the shores of lakes provides fair aeration, stone-flies are found also along lake margins, although not in such profuse numbers as in the mountain streams. They are but seldom found in quiet streams or ponds and then only in relatively small numbers.

After becoming winged they generally spend the day in short flights and in copulation (figs. 120, 121). In the dusk of the evening they fly upstream for considerable distances and then oviposit. This is not a nuptial flight, for mating appears to precede the flight,

but an instinct to go upstream for better distribution, which is more readily understood in view of the fact that the eggs are formed into a loose clump of 200 to 300 by the females and these clumps are washed off in the current to scatter as they may. The adults do not live more than three or four days. More, however, are eaten by the birds, both dusk-flying and day-flying species, than die naturally; and also by snakes, frogs, spiders, and even by ground squirrels. At the flight period one finds thousands of wings torn from the stone-flies and scattered along the shores of the streams,— evidence of destruction by their enemies. The hot sulphur springs along the Yellowstone River (see fig. 122) account for the death of other thousands. Whatever the attraction the springs exert upon the stone-flies,—whether heat, odor, or color,—this much is certain: hundreds of the insects fly to the springs and are literally boiled.

The transformation period lasts about ten days for a single species. After that, only isolated stragglers come from the water to transform into winged adults. However, as there are some eight to ten species of stone-flies in Yellowstone Park alone, and the total period of transformation covers some six weeks with slight overlapping, one may find stone-flies for a good part of the summer. Of these the large salmon-colored stone-fly (*Pteronarcys californica*), growing to a length of two and one-half to three inches, with a wing expanse of four inches, is the most numerous and conspicuous. After that, the sizes dwindle down through the black stone-fly (*Acroneuria theodora,* two by three inches, the yellow stone-fly (*Acroneuria pacifica*), one and one-half by three and one-half inches, the dusky stone-fly (*Perla verticalis*), one by two inches, to the green stone-fly (*Alloperla lineosa*), which is barely half an inch long and has a wing expanse slightly exceeding an inch. Only the first three can be called abundant. The transformation periods of the salmon-colored and yellow stone-flies coincide, and occur early in July, that of the black stone-fly not till early August. As regards these dates, one important fact should be noted; namely, transformation appears to be largely dependent on the temperature of the water. Where a stream is open the water will heat more rapidly from the sun than where a stream flows through steep-walled canyons. Thus, in the Yellowstone and Lamar rivers the stone-flies in 1921 transformed much earlier in sunlit open places than in the canyons. In the open stretches of the Yellowstone River between the Grand Canyon and the Lower Canyon (the "Needles,"—see fig. 113), transformation occurred nearly a week earlier than in the canyons proper. This was true also for the black stone-fly. This species transformed a week earlier in the

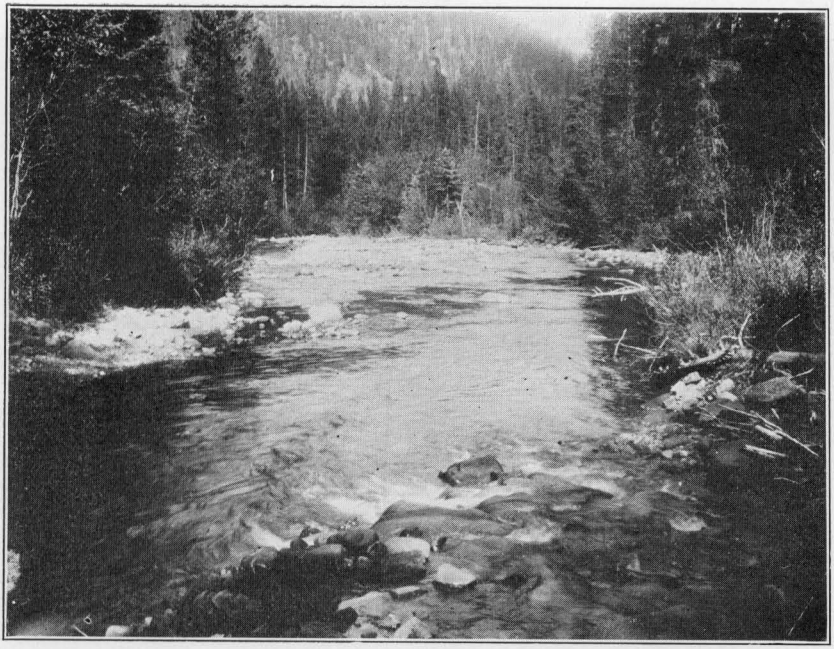


Fig. 118. Tower Creek, looking down the gorge; from junction of Carnelian Creek (right) and Tower Creek (left). Photo Sept. 6.

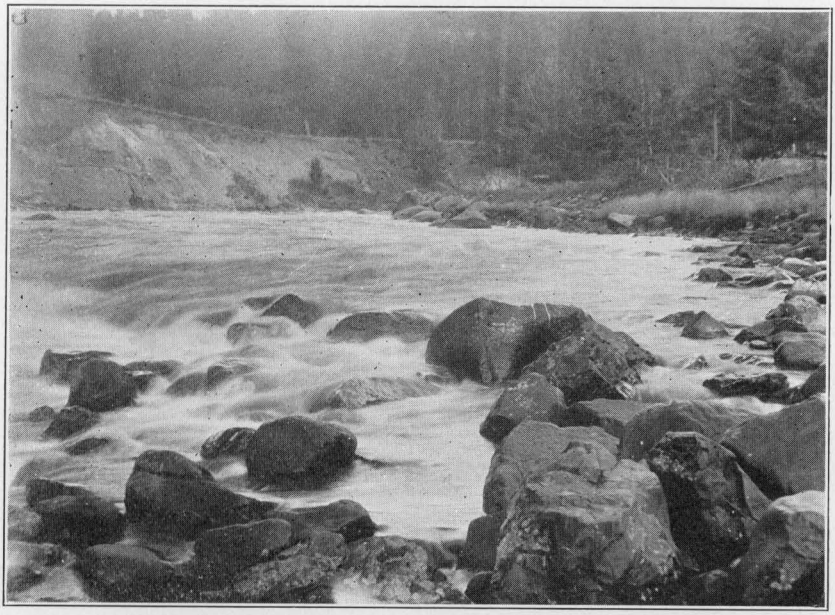


Fig. 119. Rapids just above Yellowstone River Bridge, on Cooke City road. Detail of foreground shows lesser rapids and pockets which form the feeding grounds of young fish. Photo Aug. 15.

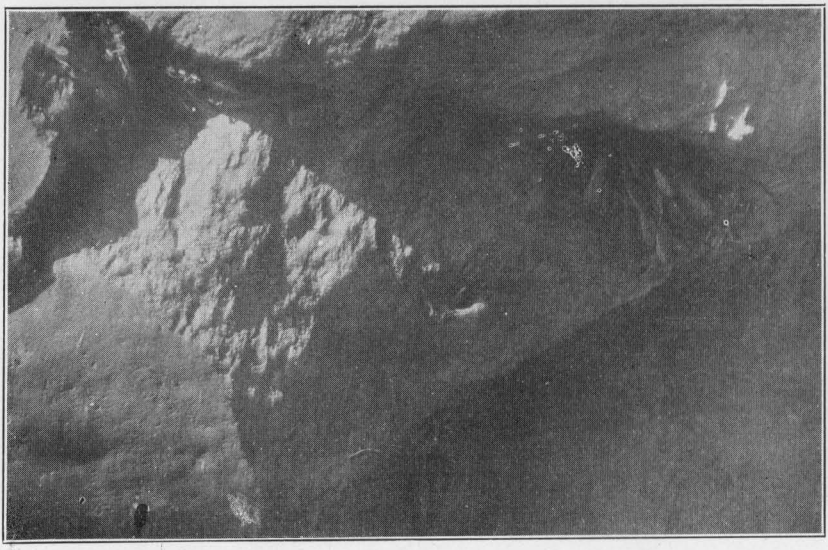


Fig. 120. Stone-flies in characteristic clusters, often as many as twenty individuals, in crevices of rocks along the lower Lamar River. (See also figure 131 for general habitat.) Photo July 6.

Fig. 121. Stone-flies mating on shore grass along the Yellowstone River. Photo July 6.

open Lamar River, Gardiner River, and the meadows of Slough Creek, than in the gorges of the Lamar, Slough Creek, and the much-shaded Lava Creek.

Another factor possibly is the light which may stimulate the species to transform in early July. By this is meant both the light of the shores and the light that penetrates the water. It has been noted that in open, sunlit places transformation occurs earlier than in the gloomy canyons. The amount of light to penetrate the water is variable. The spring floods carry great quantities of sediment which hinders the penetration of light. This makes the situation equally difficult for fish and for the fisherman. For where the one cannot see much in the line of prey in the water, the other cannot see the fish, nor pick the likely places to cast. Perhaps this turbidity accounts for the fact that when the floods recede and the water grows clearer the trout are hungry and "rise" more readily to bait; for it is obvious that the gloom resulting from the turbidity makes hunting difficult for the fish, and at a time when he needs an excess of food for the propagation of his kind.

On the other hand, it has already been remarked that certain species of stone-flies, such as the black and green stone-flies, do not emerge until August, hence long after the floods have receded and the water has clarified. Whichever the factor may be that chiefly stimulates transformation, whether light or temperature, prolonged study and experimentation are needed for its definite determination.

From the examination of hundreds of stomachs of trout, especially the cutthroat trout (*Salmo clarkii*), it is evident that stone-flies, both in their larval stage in the water and after transformation, form about 90 per cent of the food of the trout. The foregoing merely confirms what others have found as regards the dependence of fish life in rapid streams on stone-flies for food. It is a curious fact that some of the mountain streams which have a very low representation of stone-flies will not support fish life, or at least trout life.

May-flies.—The second and third groups, namely the may-flies and the caddis-flies, are variable in their representation and appear to change their position of importance according to the stream. In the Lamar River, for instance, the caddis-flies outnumber by far the may-flies, while in the Yellowstone River, Lava Creek, and other streams the may-flies are more conspicuous numerically. Whatever the cause of this variability, they appear to be equally abundant in the fish stomachs.

May-flies are otherwise known as day-flies or shad-flies. They have their names from the fact that they live but one day in the adult or

winged stage, live only to reproduce and die, or to fall a prey to birds, mice and other animals. In the streams of the Middle West they are important as scavengers. They generally emerge in enormous numbers, but for one day only, and then they are gone. In some streams in Europe it has been noted that certain species emerge on definite dates; in fact, within stated hours on a given day, year after year. Much speculation, but little evidence, exists as to the factors which control this remarkable synchronism.

In their aquatic stage the may-flies are of varied form, some of them very flat and found under rocks (fig. 123), some swimming about with quick, minnow-like darts, and some with elaborate gills by means of which they propel themselves. All have gills for breathing air from the water, some of the gills being thread-like, others flat, and still others attached to slender stalks like leaves to a branch. Some have elaborate processes on their heads for burrowing. These, however, are found primarily in muddy streams, and in lakes and ponds. In the mountain streams none of the burrowers occur.

After transformation, the adults have two pairs of wings, the fore wings large and triangular, the hind wings very small and inconspicuous, indeed, sometimes entirely absent. Also, they generally have from two to three fine tail filaments.

In the mountain streams, their transformation is spread over a considerable period, so that they are but little noticed. In the more temperate and quiet streams they transform in one mass and fill the air for a brief period for one or two days, and then disappear.

Caddis-flies.—The third group, the caddis-flies, derive their name from the fact that nearly all of them, in their aquatic stage, build cases from bits of stone, wood, or fibres, or weave a net which they attach to stones. These cases are infinitely varied in form, and from the standpoint of craftsmanship are intensely interesting. In the mountains one finds three types especially abundant. The first is that of the "barnacle" caddis-worms (*Rhyacophila* sp.), which build their cases in large clusters from tiny stones (see fig. 127). The second is that of the "picket" caddis-worms (*Limnephilus* sp.), which build square cases of neatly paralleled series of plant fibers. Since the cases are fastened to the support by their bases and stand out at right angles, the name "picket" is quite appropriate (figs. 126, 127). The third type is made up of extremely minute particles of sand and secretion gummed together to form a conical, gently-curved cornucopia about half an inch in length. Just before transformation, caddis-flies, like moths and butterflies, go through a resting period, called the "pupal" period, in which the change from grub to winged

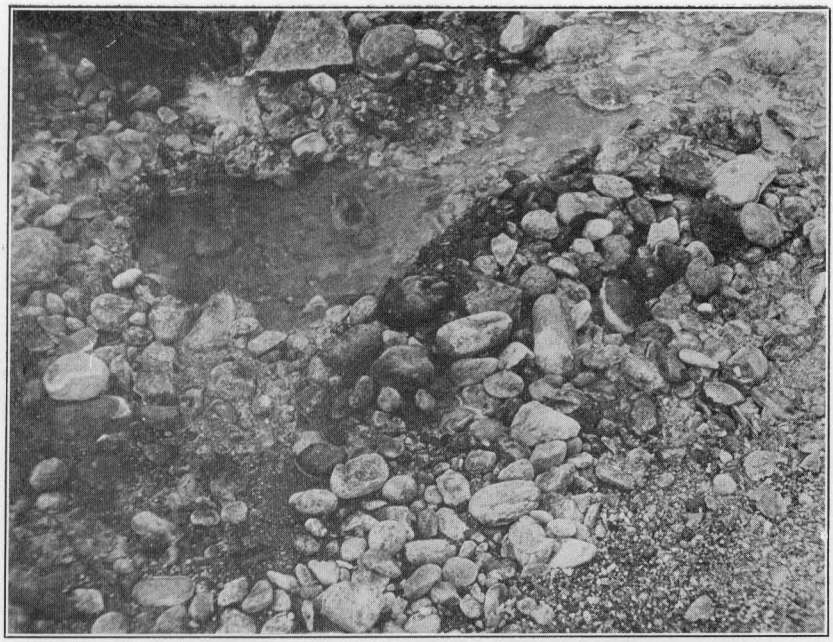


Fig. 122. One of the hot sulphur springs along the Yellowstone River. This particular spring lies at the base of a hollowed rock shown in upper middle of figure 119.

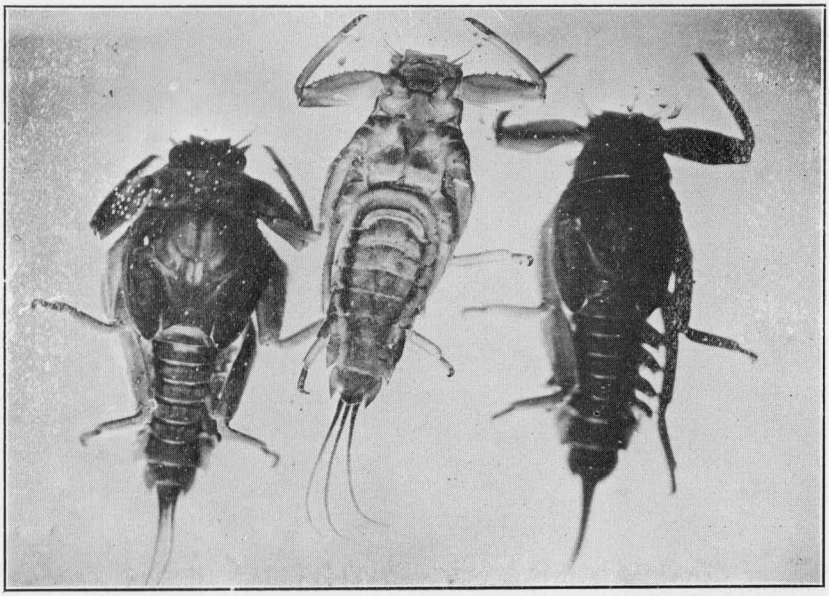


Fig. 123. May-fly nymphs from the Lamar River; four times actual size. Middle specimen turned over to show the "sucker" on under side, by means of which this particular species clings to rocks.

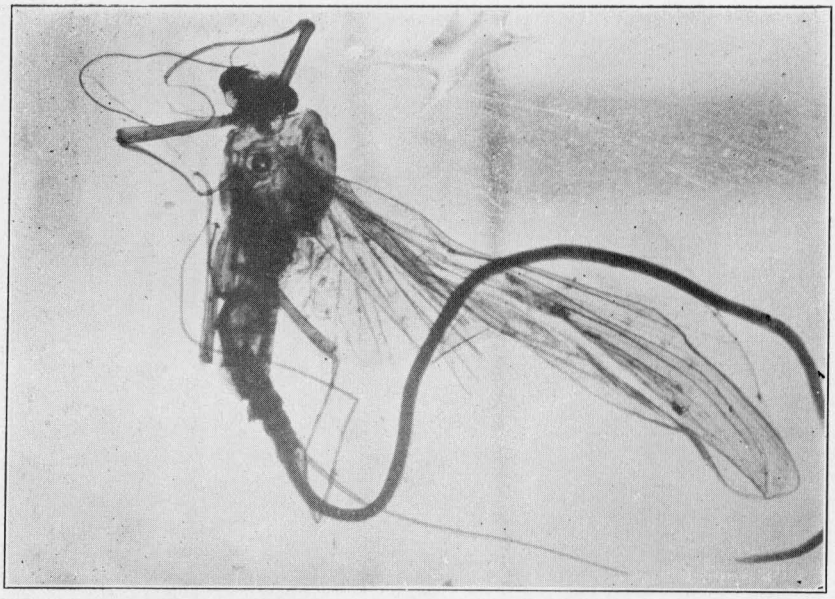


Fig. 124. An adult may-fly with a parasitic worm emerging from the caudal end. Enlarged eight times. Note the loop formed by the parasite within the abdomen of the host.

Fig. 125. An association of caddis-worms in their cases, attached to a wet rock. Four types of cases are shown on this overturned rock on the margin of Lost Creek. Photo July 27.

adult takes place. During this pupal period the "cornucopia" caddis-worm (*Leptocerus* sp.) seeks the under side of rocks; there the individuals cluster together, forming prickly patches which resemble a cluster of dead spruce needles or the spines of a porcupine (figs. 128, 129).

Still another species of the mountain waters builds itself a net-work which it anchors with stones (*Hydropsyche* sp.). The net is in the shape of a funnel, with a sieve across the wide end, and the smaller end directed downstream.

In the grub or larval stage the caddis-flies are particularly interesting because of their manifold structures. They resemble caterpillars; in fact, they are the nearest relatives of the moths and butterflies. They have tufts of filaments on their bodies, a head and six legs resembling those of caterpillars, and two posterior legs provided with hooklets which serve as grapples or claws to anchor the worms in their cases.

In the mountain streams none of the caddis-fly species are free swimmers; that is, their cases are all fixed. What migrating they do, is done slowly and laboriously. In the lakes, ponds and quiet streams one may find species with square or spiral cases swimming about freely.

After transformation the adult caddis-flies resemble tiny moths. Indeed, they are often mistaken for moths, even by scientists, and have been thus described. They like to gather on the rocks along the shores of streams, where they run back and forth briskly, or fly about the rapids, alighting on the water's surface and flying up into the spray. They may even dive into the water, for the water does not wet their wings and body. Only prolonged submergence will water-log them.

The Surface Food.—Besides these main items of the normal trout diet in the mountain streams, the so-called "water bait," there is the surface drift or surface bait of water-trapped animals, chiefly insects. This comprises especially the weak fliers such as moths, ants and grasshoppers, while spiders, centipeds, mice, and other animals may occur. But the life of a trout stream is dependent on its normal inhabitants, not on the odds and ends which a kind wind or accident may provide. It is only during the brief summer period that surface bait becomes important; and for a period of four to six weeks the fish are largely dependent on this type of food for their existence. That the emergence of their natural water bait, with the resulting depletion of this primary food supply, should be synchronous with the summer flights of ants, moths, grasshoppers and other poor

fliers that are easily water-trapped, is one of many instances of the admirable provisions of nature.

Indeed, this is carried still further at this period. At this time the minute life of the shore waters, especially the shore diatoms, flat-worms, chironomids, and the young stages of may-flies, stone-flies and caddis-flies, receives a tremendous impulse and becomes quite prominent. At this period also the young of trout, suckers and other fish in the mountain streams can be found in the shore pools and shallow rapids feeding on the minute organisms in these places. Here lies the remarkable coincidence: the simultaneous appearance and growth of fish fry and of a protected food supp'y for its use. For the older trout are unable to get into these shallows, which therefore offer both protection and food to the young fish (figs. 119, 130).

From the foregoing it is evident that there exist only two well-marked periods in the annual cycle of mountain trout streams, namely, a "water food" period covering nearly eleven months of the year, and a "surface food" period, occurring during the summer, and lasting from four to six weeks. This is the period when trout, as anglers put it, "rise to bait." These same periods might a'so be called flood and ebb periods, or flood and drought periods, from the fact that high water lasts from October to July, while the ebb or low water stage of the summer is really very brief.

With the fall rains the brief low water stage ceases and the conditions revert to those existing during winter and spring, and continue to the time of emergence described, that is, about the first week of July.

FEEDING HABITS OF THE TROUT

From the examination of fish stomachs it is possible to deduce much about the food habits of fish. First, fish wi'l take food that is easily captured; secondly, that which is accessible with difficulty; and lastly, strange and unusual food. Of the food available in mountain streams, stone-flies and may-flies are most easily obtained and constitute the major portion of the food eaten. Here, too, the eggs, fry and fingerlings should be listed, as fish are cannibals when opportunity offers; and trout are no exception, but will eat other fish just as greedily as will bass. Caddis-flies, well protected by virtue of their tough attached cases, and moreover, even more inaccessible on account of the appressed structure of many cases, rank in the second category, and for that reason constitute a much smaller item of fish food than the other two groups of insects. However, they

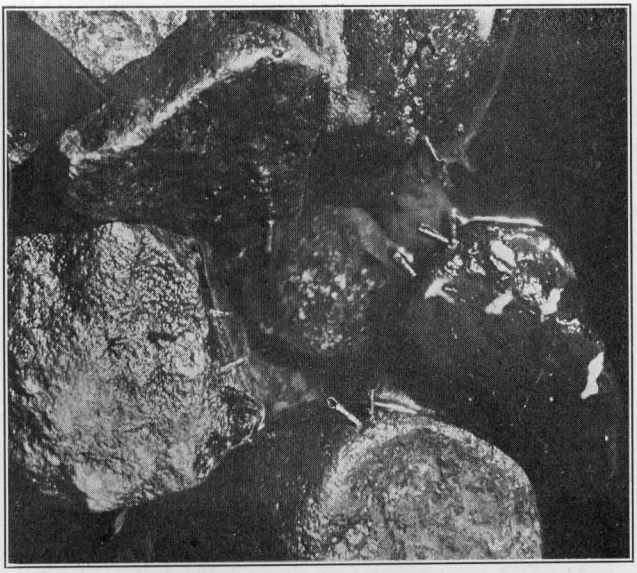


Fig. 126. "Picket" caddis-worms in their square cases, showing characteristic position and attachment. On wet boulders along the Lamar River. Photo July 25.

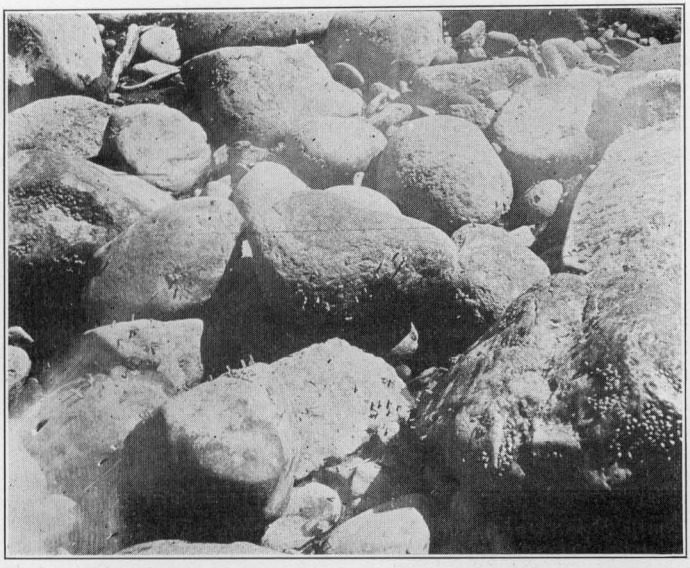


Fig. 127. Caddis-worms along the Lamar River, left stranded by recession of the stream. Two types are here shown,—"picket" caddis-worms (*Limnephilus*) and "barnacle" caddis-worms. Photo Aug. 8.

Fig. 128. "Cornucopia" caddis-worms in a cluster on a rock during pupation period. Lost Creek, July 19.

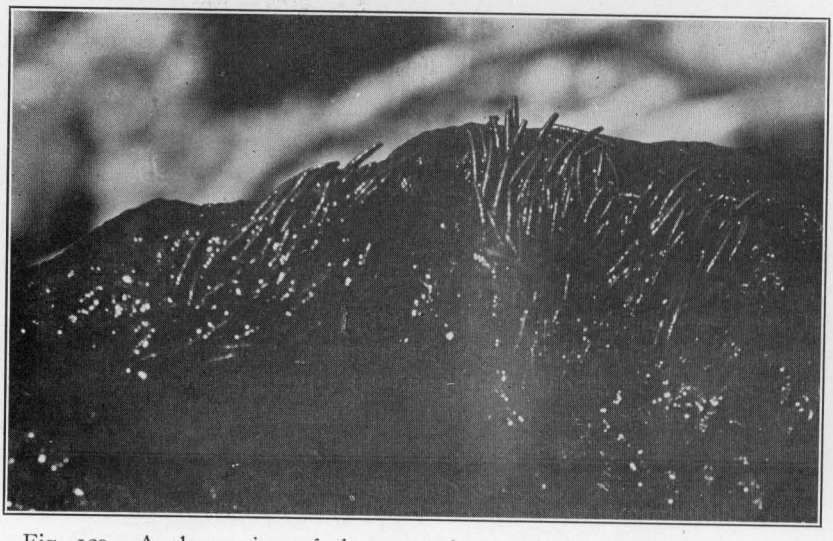


Fig. 129. A closer view of the same cluster of cornucopia caddis-worms shown in figure 128. Note the resemblance to pine needles.

are used extensively as food by the stone-flies and may-flies, and in this respect become as important, though indirectly so, as their enemies. Among strange and unusual foods can be listed the surface bait.

In general, fish are opportunists as far as their food is concerned. They eat what animal food is available, regardless of the origin. As a result, if one knows the animal life of a particular region, one can tell from the stomach contents where a fish has fed. In a lake, for instance, the plant and animal life is distributed in regular "zones," most animals limiting themselves to particular depths. Some are found only on the shores, others on the vegetation in the shallows, still others only in the muck at considerable depths. With a knowledge of the animals found in these various zones it is possible to learn a good deal about the food habits of a fish, his migrations, and his food preferences.

On the whole, fish are indiscriminate in their choice of food as far as quality is concerned. They like to feed in a particular region, and stay there until satiated. Thus, when feeding from plants, they eat whatever they can find there; and once they begin to feed from plants they continue feeding there until their hunger is satisfied. At periods of plentiful food, fish do not migrate while feeding.

Curious to say, it often happens that a fish may find a certain type of food so much to his liking that he will seek only that type. This may be worms, leeches, snails, back swimmers, caddis-worms, or other kinds. Thus, we may find stomachs filled with dozens of individuals of one type of animal, such as crayfish or snails. Even more striking, one may find stomachs filled with highly distinctive cases of some particular species of caddis-worm.

This predilection for some particular food is more often observed in the case of surface food than in water bait. I have found fish stomachs, including trout stomachs, gorged with hundreds of specimens of a single type, such as ants, grasshoppers, dragon flies, caddis-flies, orl flies, may-flies, midges, etc., indicating that the particular fish had taken a fancy to this special type of food, and had hunted assiduously for the delicacy. There is nothing abnormal in such a predilection, not more so than in the case of a boy who makes a meal off desserts, be it ice cream, or fruit, or cake. But right there, in the longing for the unusual, lies the weakness of the feeding habits of fish, the trait which lays them open to capture by the angler. Since the unusual attracts, anglers have made use of this phenomenon in the types of flies selected by them.

A fish is easily deceived, for he is not very observant. His eyesight is poor and he recognizes things chiefly through their movements. For instance, when an angler uses a fly, the fish is supposedly deceived by three factors,—form, pattern, and movement. In the matter of form and pattern the fish's vision is too weak and near-sighted to recognize the bait for what it is. He is used to certain distorted images which impress him more through motion than by any other factor, and he captures or tries to capture such a moving object. But it is also the unfamiliar, the unusual, which tempts fish, perhaps more than the customary objects. How else can one explain the presence of blocks of wood, of straws, twigs, leaves and the like, in fishes' stomachs? On more than a dozen occasions I have found blocks of wood in trout stomachs. In at least half the cases there was not the remotest resemblance in the shape of the block to any type of surface bait. An irregular cube has no resemblance to any insect, while an oblong bit might well have the approximate outline of a stone-fly or a grasshopper. But it was probably the strangeness, the unusualness of the block of wood which attracted and tempted the trout. The most interesting feature of these instances was that in only one case were the blocks of wood taken by a hungry fish; that is, only once were the blocks of wood the sole stomach content. In all other instances, blocks and sticks were gulped by fairly well-fed fish. One might say that they were taken as a sort of salad or dessert, indicating that their novelty tempted the fish.

The foregoing has its practical application. When fish are well fed they may rise to bait, but less to grasp it than to look it over. Every fisherman has seen some coveted fish rise thus, examine the bait, roll over lazily, and return to his retreat. However, if the bait be unusual, a fish may be led to bite if he is convinced that the lure offered is some particularly juicy morsel which should be a fitting wind-up to his meal. The more the bait offered resembles some moving surface bait, the more likely is the trout to strike at it.

As emphasized before, a fish is near-sighted, and even close up his vision is poor; he sees objects more or less distorted. On top of all this he is not particularly intelligent, but rather stupid. It takes him a long while to learn a simple fact, and hence he is easily deceived. If the fly because of its resemblance to a regular food item does not attract, try the unusual. This should be particularly effective when the fish has fed, or is partly satiated.

HINTS TO ANGLERS IN YELLOWSTONE PARK

Your Attitude.— In older days man hunted because he required food. Modern conditions have supplanted hunting by the domestic breeding of animals, so that a sufficient food supply is at hand. Moreover, agriculture has encroached on nature's fastnesses to an extent that these cannot possibly propagate a sufficient food supply in the natural state. The hunting instinct, engendered because of necessity for so many generations, must naturally be slow to die out. So man still loves to hunt, be it big game, fish — for fishing is but hunting in the water,— flowers, or little game, such as insects and still smaller things. For years hunters have realized that game is getting scarce, that it is more difficult to stalk, and that the cost of hunting is fast increasing. But because there is no longer any real necessity for hunting, it follows that our inherited attitude should be modified to conform to the new conditions. This change is already evidenced in the attitude of the conservationists, of the nature lovers, and of sportsmen.

What is a sportsman? The popular and correct idea of such a man is that he hunts for the pleasure of the hunt, for the thrills he receives in pitting his ingenuity against that of the quarry he seeks. He possesses discrimination; he does not kill wantonly, he does not slaughter, he is moderate in the amount of game he hunts. He is not cruel, but kills his catch at once and does not let it suffer needlessly. His bag is made up of choice specimens rather than of many; he seeks quality, not quantity. He will not countenance "mass killing," as in the case of dynamiting streams or even catching the legal limit when that is obviously too high. He is eminently a man who believes in the "square deal," for himself, for others, for the things he hunts. A splendid ideal, this synthetic conception of the sportsman! And he is not a phantasm, but a reality; he is made up of you and me, of the best that is in all of us.

Fishing is the one type of hunting that is still available to all of us, and the only kind that can possibly be allowed in our National Parks. Big game and wild life of all kinds are becoming more and more restricted to natural strongholds, some of them difficult to reach. But fish! They travel in the waters that pass our very doorsteps. Thus a source of both food and pleasure is easily avaliable. Fish as a reserve food supply are unfortunately too little esteemed. Few people, even well informed citizens, realize and appreciate the food resources of the waters in the United States. Generally, people

fish with little thought of where the fish came from and whether more are to follow.

Yet even with all the tremendous resources of inland waters, game fishing, that is, for fish that battle fiercely with the angler, has gradually become restricted to the less accessible places. Trout fishing has always largely been confined to turbulent streams and mountain lakes. But how often does one hear the regretful exclamation: "Fished out!" The angler himself is to blame; not he individually, but his kind. There have been many fishermen, but too few sportsmen. In the wonderful trout streams all through the Rockies we see the same discouraging results. In the populated areas the streams are now fished out, while in distant but readily accessible regions the numbers and size of the fish have decidedly decreased. Throughout Idaho, for instance, the mountain streams in their lower reaches have been fished so thoroughly that a two-pounder trout has become a rarity. The old settlers tell of four- and five-pounders, even of eight-pounders, but the present generation does not know them. True, the streams are still plentifully restocked, chiefly through the efforts of the fish hatcheries; but what are the chances of a trout against thousands of anglers when each wants to catch his legal limit every day, regardless of whether he can use them all? No propagation, natural or artificial, be it ever so thorough, can keep pace when anglers catch at the rate of sixty to a hundred fish a day.

Just consider for a moment what it means to raise a trout under natural conditions! The eggs are laid in great numbers in shallow rapids, to be carried passively by the current. They become trapped in the interstices between the rocks and there go through their development. But before this the eggs may become the prey of larger fish; they may be crushed between rocks, or silted over; they may be carried by the flood water to some lateral pool, to dry up later with the pool or perish from lack of aeration; or they may become a prey to parasites or to a fungus (*Saprolegnia*) that attacks the eggs of almost any freshwater animal.

If the eggs survive, they hatch into fry that carry their food with them in a small yolk sac. When this stored food, received from the parent, is used up by the fry they hunt the shallows in quest of small insects, diatoms and other minute food. But here they are exposed to predacious insects and larger fish, to the action of molar agents, such as winds, waves and currents, all of which combine to render their life precarious. Parasites, too, lurk in the shallows. Everything considered, it is surprising that so many do survive. But it takes

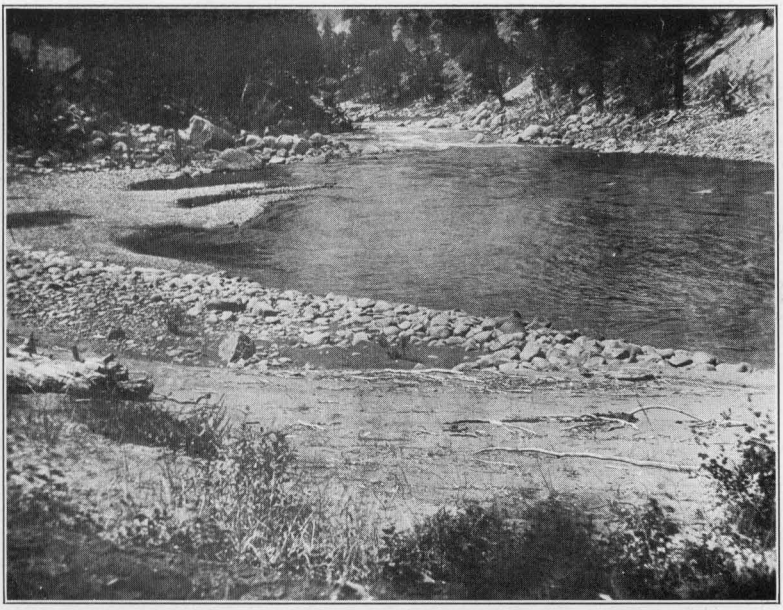


Fig. 130. An eddy of the Lamar River about 500 yards above its mouth. The shallow, pebbly pools at left are favorite feeding places for the young of trout, minnows and suckers. Photo July 16.

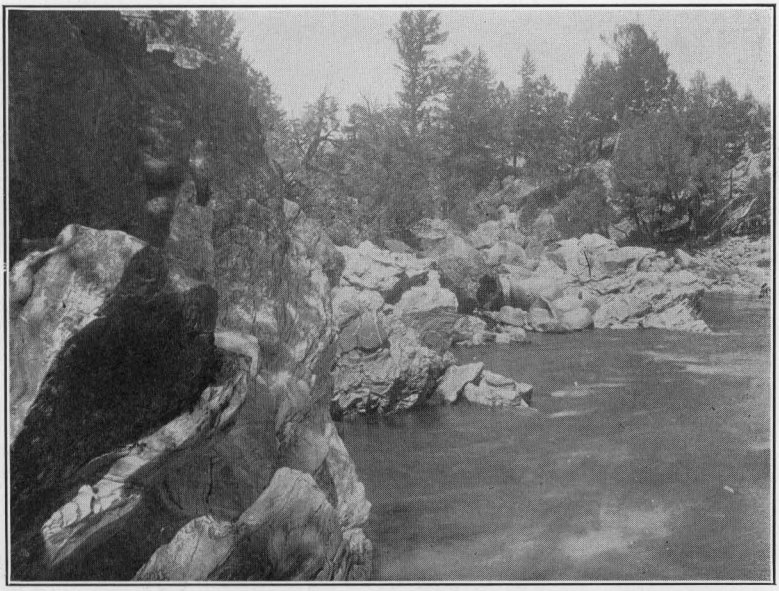


Fig. 131. Shore of the Lamar River about 150 yards above its mouth. The "holes" formed by the eroded rocks are favorite spots for adult trout. Photo July 22.

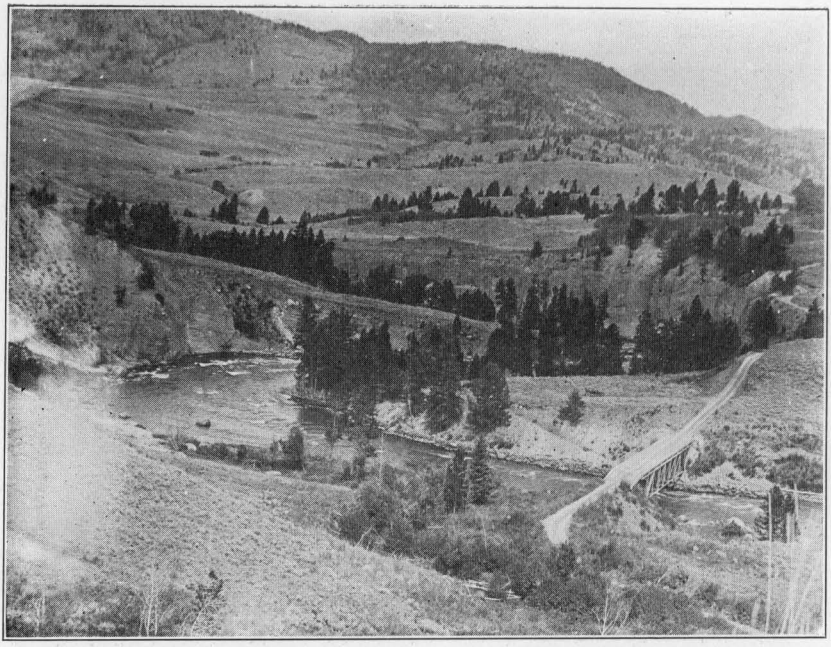


Fig. 132. Panoramic view above confluence of Yellowstone and Lamar Rivers. Cooke City Road and bridge across the Yellowstone, at right; Lamar River valley in middle distance. Photo Aug. 8.

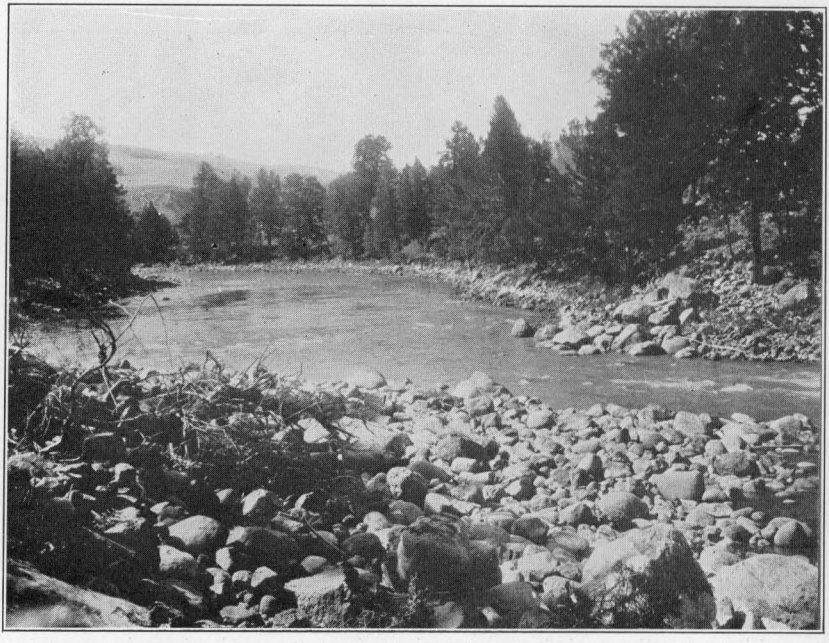


Fig. 133. Junction of the Yellowstone and Lamar Rivers at low water stage. View downstream; Yellowstone River at left, Lamar entering at right. In the spring the boulders in the foreground are under water. Photo Sept. 5.

several years for trout to attain a good size and weight, and the angler should appreciate that it is the excessive toll he exacts that prevents fish from reaching a real "fighting" size.

Trout of large size are happily still available in Yellowstone Park. One- or two-pounders are quite abundant in the streams, while larger fish, of four and even five pounds, hide in the more inaccessible "holes" of the Yellowstone, Lamar and other rivers. But these last are only for the truly elect — the sportsmen who will take risks and pains for the opportunity to match their skill and wits against those of the wary trout. Figures 131 to 133 show some of the favorite trouting haunts in the delightful Camp Roosevelt region where this particular study was made.

Fishing in the Park is a pleasure that appeals to many of us. But if that pleasure is to continue in this "nation's playground," it must be limited for each of us so as to be shared by the many. Unrestricted fishing — "butchery" would be the more applicable word — is destructive no matter where it occurs. To preserve the opportunities of the Park — indeed, of every natural resource, there and elsewhere — there is needed the support of every public spirited citizen. Fishing is a splendid sport, one that should remain to us in the future as well as now. Truly, then, what fishing we do should be in the spirit of fair play, of moderation, of consideration for others,—this is the attitude of the true sportsman.

How to Fish.— The following points may be of use to amateur fishermen. They are based on the conditions noted in the first part of this discussion:

1. Stand low on the shore and cast your line far out, holding the rod low.

2. Keep moving. If the fish do not rise after a few casts, move to another spot. As a rule you cannot sit still and fish successfully for trout, as one does for perch or herring. Trout are not quite so stupid as most other fish; they cannot afford to be.

3. Let your fly strike the water sharply and quickly; do not dangle your bait. Trout cannot be treated like perch. They do not "nibble"; they make up their minds and strike quickly, or not at all.

4. When the fish is hooked, play him with a steady line. Take up the slack; but above all, do not jerk. The steady pull does the trick.

5. Pull the fish well up to the shore before you ease the line, Otherwise, he may manage to slip the hook and get away.

6. Should you enter the stream, see that your shadow does not lie with the current.

Bait and Flies.— Many interesting things may be learned about the habits of fishes by a little careful study of natural and artificial lures.

1. Note whether insects are being carried by the stream. Try to see what insects are abundant on the shore and use some of these for bait.

2. When hooking an insect, hook it in the axis of the body through the *top* of the thorax. The hook should enter behind the thorax and come out in front behind the head. In this way the destruction of the insect's brain and nervous system is avoided and the bait will struggle when striking the water,— hence an additional element to deceive the fish. Do not pierce the head, or hook through the under side; for the brain of an insect lies near the top of the head and two connections go to the nerve cord, which lies in the thorax and abdomen, on the " belly " or ventral side. If you hook the brain or cord, death or paralysis will result and the bait will not be so attractive. Hooking through the thorax is best, because that part of an insect is firmest, since its strong plates are needed for the attachment of the leg and wing muscles.

3. When you have caught your first fish, kill it by striking it sharply on the front of the head, or by thrusting a knife blade through the neck to sever the spinal cord. Examine the stomach contents and note whether it comprises a general mixture or if some particular insect is more abundant. Then select that type for bait. Or if you prefer an artificial fly, try one which seems to bear some resemblance to the bait eaten.

4. A hungry fish will accept almost anything in the line of bait. After mid-forenoon, however, greater care must be used in choosing baits or flies.

5. A satiated fish will refuse the regular diet, but, like human beings, he does not despise something choice in the way of dessert. Some lure that seems strange and looks palatable may often entice a surfeited fish to bite.

6. When you have caught sufficient fish for a meal, and are still keen for the sport, try for some situation that requires special skill. Try for some old Methuselah and see if you can outwit him. Since he is too wise to be lured by ordinary methods, you may have to resort to unusual tactics. All animals, like men, have their trait of curiosity, and an old and wary trout is not exempt. In such cases, do not make your approach too obvious. Bait or flies that appear easy to capture will not tempt him. Try an unusual bait, and make it require some effort on the part of Methuselah to get it.

Your Catch.— The following suggestions are important for beginners in the gentle art of angling:

1. It is not necessary to catch the legal limit to prove yourself a good fisherman. The true sportsman looks for quality, not quantity. Quantity does not necessarily indicate skill,— only some luck, and greed.

2. Kill your fish as soon as you have caught him, and before cleaning. There is no need of causing useless suffering. The habit of cruelty to animals engenders the habit of cruelty to men.

3. If your trout is below legal size, carefully disengage it under water, taking care not to rub off the slime which is the protective covering of the fish.

4. Do not allow your catch to lie in the heat of the sun, or decomposition will set in. Clean and pack the fish before returning to camp, burying the offal so as to leave no disagreeable traces for those who follow you.

5. When packing trout to take back to camp, wrap each one separately in coarse grass and see that they lie compactly so that they will not jolt. If loose, even slight movements of your body will jar and bruise them, and they will speedily become soft and unappetizing.

6. Weigh and photograph your trout; and possibly you may also wish to write a permanent record of your fishing adventure. In retrospect, this frequently proves to be the most satisfying part of one's catch.