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INSTITUTE FOR FISHERIES RESEARCH
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TROUT FOOD SUPPLY IN THE PINE RIVER, LAKE COUNTY

A recent decision of the Conservation Commission to develop extensively the recreational potentialities of the Pine River in Lake County made it desirable to investigate, from various angles, the suitability of this stream for heavy trout production. One of the questions immediately arising was that concerning the available food supply. During the first week of June, 1936, the writer examined rather thoroughly that section of stream lying between the Walker Bridge (just below the holdings of the Ne-Bo-Shone Club) and the abandoned Lincoln Bridge.

The stream was first cruised with a view to ascertaining its general character. Quantitative bottom samples were then taken in each of the dominant bottom types to determine their comparative productivity of trout food organisms.

It was observed at once that the extent of sand bottom greatly exceeded that of all other types combined. Very little coarse gravel was found, and moderate to fine gravel occurred rather sparingly, usually restricted to riffle areas. Bars of silt and muck, supporting growths of emergent aquatic vegetation (especially White Water Buttercup), existed wherever quiet water areas near shore permitted their development.

One of the most striking bottom features presented by the Pine River is the hard-pan clay ledges, which are of frequent occurrence throughout the region examined. These ledges are very sharply defined, often appearing at first glance to be old concrete structures. A deep pool is usually formed along them, and since they are often undercut, excellent "hides" for trout are created. The top of the ledge is usually rather near the surface of the water, almost flat, and covered with small slabs of clay loosened by the current. It is commonly thickly dotted with small, thimble-like depressions. These holes, and the loosened clay debris, offer the only suitable harborage for food organisms on the ledges.

Four quantitative bottom samples were taken, as follows: (1) Gravel 0.25 to 1.5 inches in diameter mixed with sand to the extent of 30% (estimated), water 6 to 8 inches deep, moderate current; (2) permanent bar of muck and sand, estimated proportion 40% muck to 60% sand, bar bearing a sparse growth of White Water Buttercup, water 8 inches deep, slight current, no shade; (3) permanent bar of muck and sand, estimated proportion 80% muck to 20% sand, bar very deep and stable, dense growth of White Water Buttercup, water 10 inches deep, slight current, shaded in forenoon; (4) ledge of hard-pan clay, top covered with clay debris in form of small, thin slabs, and densely perforated with small depressions 0.25 to 1.5 inches in depth, water 4 to 6 inches deep, moderate to swift current, shaded in early morning and late afternoon.

Tabulations of the amount and varieties of food organisms present in each of these bottom types are appended at the conclusion of this report. It will be noted that the gravel bottom (Table 1) proved to be the most productive of any of the types sampled. This is in accordance with findings derived from other streams sampled in similar fashion. The large amounts of mayfly nymphs and caddisfly larvae produced by the gravel indicate the desirability of increasing the total area of this bottom type wherever practicable.

It is of interest to compare Tables 2 and 3. While the total volume of invertebrates obtained from the densely-vegetated bar of deep muck greatly exceeds that produced by the sparsely-grown bar of shallower muck, in which sand was plentiful, 3 of the 3.175 cc. of organisms recorded in Table 3 are Tubificid worms. Although the direct value of these worms to trout is not yet fully understood, there are grounds for belief that trout feed upon them very seldom, and that their chief importance lies in their position in the food cycle of other invertebrates in the stream, thus making them only indirectly useful to trout. If the Tubificids are subtracted, the sparsely-grown bed of muck and sand becomes the more productive of the two. Studies on other streams have offerred increasing amounts of evidence that thinly distributed growths of vegetation, even when occurring on bars almost purely sandy in composition, may be more productive of such preferred items of trout food as mayflies, caddisflies, and midges, than dense weed beds growing on thick bars of muck and organic debris.

The clay ledge sample (Table 4) revealed a fair production of mayfly nymphs, but only a small amount of caddisfly larvae. Practically all of the invertebrates found in this situation either clung to the under side of loose clay debris or sought shelter in the numerous small depressions.

Random samples taken in shifting sand at various points demonstrated the uniform sterility of this type of bottom. Only where debris of various sorts had accumulated were food organisms found in significant numbers. It is to be regretted that the supply of shifting sand in the Pine River is being constantly increased by erosion of high sand banks, and by the movements of free-ranging cattle along the edge of the stream.

A most productive feature of the stream is the submerged logs (many of which are "deadheads") and trees, which are of frequent occurrence in the section investigated. Although it was impossible to sample these

situations in such a manner as to give results directly comparable with those listed in the tables, it is believed that the invertebrate fauna of such objects may often be richer than that produced by gravel riffles. Aquatic insect larvae were found to be exceedingly numerous on submerged timbers, particularly so where bark remained on the logs, or where moss (Fissidens sp.) grew in quantity. Most abundant forms encountered were mayflies (species of Paraleptophlebia and Ephemerella) and caddisflies (hydropsychids and limnephilids). All of these species are food organisms much favored by trout.

Seining operations conducted by members of the Institute staff indicate that the Pine River supports a rather large crayfish population, these being most numerous in the gravel sections, but of general occurrence throughout the stream. Only one species, Cambarus virilis, was encountered. At a point just below the Lincoln Bridge a short sweep in to shore with the seine took five crayfish, while near the Carpenter Bridge a similar haul captured fifteen.

Comparison of figures obtained from analysis of the Pine River samples with those secured on other streams studied by the Institute indicates that food production of the various bottom types sampled is satisfactory. It should be borne in mind that these counts were made at a time when many aquatic insects had transformed into the adult stage. It is therefore probable that analysis of samples collected in March or April would reveal a much larger volume of food organisms. Examination of the stomach contents of a few trout (rainbow and brown) taken by angling near the collecting stations showed that they had been feeding almost exclusively on the surface, the most numerous organisms being adult caddisflies and mayflies, and miscellaneous terrestrial insects.

During the summers of 1928 and 1929 Dr. Jan Metzelaar examined the stomachs of a number of brook and rainbow trout from the Pine. The results

of his examinations are listed in Table 5. It will be seen that in the case of both species, land insects, aquatic insects, and forage fish made up the bulk of their diet, with crayfish and snails making up only a small percentage of the total.

Table 6 lists, in somewhat greater detail than the above, the stomach contents of 3 rainbow trout taken by an angler when fly-fishing in the Pine on May 28, 1937. Table 7 presents results of examination of stomachs of 3 small brook trout taken when seining for crayfish during the first week of June, 1936.

Although food production of the various bottom types sampled appears to be adequate for the support of a sizable population of trout, the total area of these types is much less than that occupied by relatively barren sand. It is probable that the installation of almost any kind of stream improvement devices, whether of timbers or stone, would result in a marked increase in the total supply of trout food organisms in the area studied. Whether such an increase is necessary and worthwhile cannot be stated because of the inadequate state of our knowledge concerning trout food requirements.

Summary

1. Such trout food organisms as mayflies, caddisflies, true flies, crayfish, and snails are present in adequate quantities in the Pine River where gravel riffles, weed beds, clay ledges, or submerged logs and driftwood occur.

2. The dominant bottom type is sand, which is very unproductive, unless bound in place by vegetation or partly mixed with muck or organic debris.

3. Erosion of the stream side, both from high sand banks and through trampling of banks by free-ranging cattle, is contributing to further

impoverishment of the trout food supply.

4. Installation of stream improvement devices, constructed of either timbers or gravel, should result in an increase and more uniform distribution of trout food organisms.

INSTITUTE FOR FISHERIES RESEARCH

By: J. W. Leonard
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TABLE 1

Moderate to fine gravel, 0.25 to 1.5 inches in diameter, mixed with sand to extent of 30% (estimated), water 6 to 8 inches deep, moderate current.

Organism	No. of Species	No. of Individuals	Volume in cc.
PLATYHELMINTHES			
Turbellaria (Free-living Flatworms)			
Planariidae	1	11	0.050
ANNELIDA			
Chaetopoda			
Lumbricidae (Aquatic Earthworms)	1	1	0.025
MOLLUSCA			
Gastropoda (Snails)			
Pleuroceratidae			
Goniobasis livescens	1	22	4.800
ARTHROPODA			
Hydracarina (Water Mites)	1	2	tr.
Insecta			
Ephemeroptera (Mayflies)			
Heptageniidae	1	1	tr.
Baetidae			
Ephemerella fuscata	1	8)	
Ephemerella needhami	1	11)	
Ephemerella septentrionalis	1	48)	0.300
Ephemerella cornuta	1	31)	
Paraleptophlebia sp.	1	25	0.100
Coleoptera (Beetles)			
Dryopidae	1	16 adults, 3 larvae)	tr.
Trichoptera (Caddisflies)			
Hydroptilidae	1	51 pupae	0.050
Philopotamidae	1	4 pupae	0.025
Hydropsychidae			
Hydropsyche spp.	2	21	0.200
Sericostomatidae			
Brachycentrus sp.	1	14	0.150
Genus ?	2	15	0.050
Genus ?	1	36 pupae	0.300
Diptera (True Flies)			
Tipulidae (Craneflies)	3	13 larvae, 2 pupae)	0.050
Chironomidae (Midges)	1	10	tr.
Simuliidae (Black Flies)	1	1	tr.
Rhagionidae (Snipe Flies)	1	25	0.600
		Total volume, 1 sq. ft.,	6.700 cc.

TABLE 2

Permanent bar, estimated composition 60% sand, 40% muck, bearing sparse growth of White Water Buttercup; water 8 inches deep, no shade.

Organism	No. of Species	No. of Individuals	Volume in cc.
ANNELIDA			
Chaetopoda			
Tubificidae (Tube-forming aquatic earthworms)	1	157	0.150
MOLLUSCA			
Gastropoda (Snails)			
Pleuroceratidae			
Goniobasis livescens	1	14	0.700
ARTHROPODA			
Hydracarina (Water Mites)	1	8	tr.
Ephemeroptera (Mayflies)			
Ephemeridae			
Hexagenia spp.	2	3	0.700
Baetidae			
Ephemerella needhami	1	12)	
Ephemerella invaria	1	3)	0.100
Ephemerella cornuta	1	1)	
Odonata (Dragonflies)			
Calopteryigidae			
Calopteryx maculata	1	2	0.050
Hemiptera			
Corixidae (Water Boatmen)	1	1	0.025
Coleoptera (Beetles)			
Dryopidae	1	1 adult	tr.
Diptera			
Tipulidae (Craneflies)	2	2	0.025
Chironomidae (Midges)	3	47	0.050
		Total volume, 1 sq. ft.	1.800 cc.

TABLE 3

Permanent bar, estimated composition 80% muck, 20% sand, densely grown with White Water Buttercup; water 10 inches deep, slight current, shaded in forenoon.

Organism	No. of Species	No. of Individuals	Volume in cc.
ANNELIDA			
Chaetopoda			
Tubificidae (Tube-forming aquatic earthworms)	1	4500[1]	3.000
ARTHROPODA			
Insecta			
Ephemeroptera (Mayflies)			
Ephemeridae			
Hexagenia sp.	1	1	
Baetidae			
Baetis sp.	1	1	0.025
Ephemerella sp.	1	1	
Plecoptera (Stoneflies)			
Chloroperlidae			
Isoperla signata	1	1	tr.
Hemiptera			
Corixidae (Water Boatmen)	1	3	0.025
Coleoptera (Beetles)			
Dryopidae	1	1	
Haliplidae	1	1	tr.
Dytiscidae	1	1	
Diptera			
Tipulidae (Craneflies)	2	8	
Chironomidae (Midges)		28 larvae	
Chironominae	2	3 pupae	0.125
Ceratopogoninae (Sand Flies)	2	23	
		Total volume, 1 sq. ft.	3.175 cc.

[1] Impossible to determine actual number, due to fragmentation of specimens.

TABLE 4

Ledge of hardpan clay, top covered with clay debris in form of small, thin slabs, densely perforated with small depressions 0.25 to 1.5 inches in depth; water 4 to 6 inches deep, moderate to swift current, shaded in early morning and late afternoon.

Organism	No. of Species	No. of Individuals	Volume in cc.
ANNELIDA			
Chaetopoda			
Tubificidae (Tube-forming aquatic earthworms)	1	8	tr.
MOLLUSCA			
Gastropoda (Snails)			
Pleuroceratidae			
Goniobasis livescens	1	1	0.600
ARTHROPODA			
Hydracarina (Water Mites)	2	14	tr.
Insecta			
Ephemeroptera (Mayflies)			
Baetidae			
Ephemerella fuscata	1	7)	
Ephemerella needhami	1	5)	
Ephemerella septentrionalis	1	64)	0.350
Ephemerella cornuta	1	29)	
Ephemerella invaria	1	9)	
Paraleptophlebia spp.	2	7	tr.
Baetis sp.	1	7	0.025
Trichoptera (Caddisflies)			
Hydropsychidae			
Hydropsyche spp.	2	9	0.050
Sericostomatidae			
Brachycentrus sp.	1	2	tr.
Diptera			
Tipulidae (Craneflies)	1	2 larvae, 2 pupae)	tr.
Chironomidae (Midges)	3	46	0.050
		Total volume, 1 sq. ft., -	1.075 cc.

TABLE 5

Stomach analyses made by Dr. Metzelaar, 1927 and 1928, May to August

Rainbow Trout (43 in number)
(Average length 8.6 inches)

Aquatic Insects	39%
Land Insects	32
Fish (chiefly Cottus)	22
Algae	5
Snails	1
Trash	1
	100%

Brook Trout (76 in number)
(Average length 9.3 inches)

Fish (chiefly Cottus and Rhinichthys)	34.5%
Land Insects	32.0
Aquatic Insects	22.5
Worms	4.5
Crayfish	4.0
Trash	2.0
Mollusca	0.4
Vegetation	0.1
	100%

TABLE 6

Stomach Contents of Three Rainbow Trout Taken by Angling from Pine River
May 28, 1937

Length* - - 15.5 inches

Sole contents 1 Cottus (Muddler), 3.0 inches in length

Length* - - 9.5 inches

Terrestrial Insects - - 50%

Hymenoptera
Formicidae
Camponotus pennsylvanicus, winged females - - - - - - - - - - 50%

Aquatic Insects - - 50%

Ephemeroptera (Mayflies)
Baetidae
Ephemerella septentrionalis (nymphs) - - - - - - - - 10%

Coleoptera (Beetles)
Hydrophilidae (larva) - - - - - - - - - - - - - - - - 15%

Trichoptera (Caddisflies)
Hydropsychidae (larvae) - - - - - - - - - - - - - - - 2.5%
Limnephilidae (larvae) - - - - - - - - - - - - - - - - 15%

Diptera
Tipulidae (Cranefly larvae) - - -
Antocha sp. - 5%
Chironomidae (Midge larvae) - - - - - - - - - - - - - trace

Vegetation (Algae) - - - - - - - - - - - - - - - - - - 2.5%

Length* - - 8.5 inches

Crustacea
Astacidae
Cambarus virilis (Crayfish) - - - - - - - - - - - - - - - - - 60%

Aquatic Insects - 44.5%

Ephemeroptera (Mayflies)
Baetidae
Ephemerella sp. (nymphs) - - - - - - - - - - - - - - 5.0%

Plecoptera (Stoneflies)
Chloroperlidae
Isoperla annecta (adults) - - - - - - - - - - - - - - 20.0%

Trichoptera (Caddisflies)
Hydropsychidae (larvae) - - - - - - - - - - - - - - - - 2.5%
Sericostomatidae (larvae) - - - - - - - - - - - - - - - 2.5%
" (pupae) - - - - - - - - - - - - - - - - 2.5%

Diptera
Tipulidae (Craneflies)
Limnophila sp. (adult)) - - - - - - - - - - - - - - - - 2.0%
" " (pupae))
Antocha sp. (larva))
Chironomidae (midge larvae) - - - - - - - - - - - - - trace

(continued)

* All lengths total

Table 6 - - continued

Terrestrial Insects -		5.5%
Homoptera		
Aphididae (plant lice) - - - - - - - - - - - -	trace	
Lepidoptera (moths		
Geometridae (larva) - - - - - - - - - - - - -	2.5%	
Hymenoptera		
Formicidae (ants) - - - - - - - - - - - - - -	2.5%	
Diptera (true flies) - - - - - - - - - - - - -	0.5%	

TABLE 7

Stomach Contents of Three Brook Trout Seined from Pine River

June 1936

Length* - - 2.875 inches		
Aquatic Insects (nymphs and larvae) - - - - - - - - - - - - - - - - - -		100%
Ephemeroptera (Mayflies)		
Heptageniidae		
Stenonema sp. -	10.0%	
Baetidae		
Baetis sp. -	5.0	
Ephemerella needhami - - - - - - - - - - - - - - - - - -	40.0	
Ephemerella cornuta - - - - - - - - - - - - - - - - - - -	20.0	
Diptera		
Tipulidae (Craneflies)		
Antocha sp. -	5.0	
Chironomidae (midges) - - - - - - - - - - - - - - - - - - -	20.0	
	100.0%	
Length* - - 3.250 inches		
Aquatic Insects (nymphs and larvae) - - - - - - - - - - - - - - - - - -		65%
Ephemeroptera (Mayflies)		
Baetidae		
Baetis sp. -	15.0%	
Trichoptera (Caddisflies)		
Sericostomatidae -	25.0	
Diptera		
Chironomidae (Midges)		
larvae -	10.0	
pupae -	15.0	
Terrestrial Insects -		45%
Homoptera		
Cercopidae (Froghoppers) - - - - - - - - - - - - - - - - -	5.0%	
Aphididae (Plant lice) - - - - - - - - - - - - - - - - - -	5.0	
Coleoptera (Beetles)		
Coccinellidae		
Epilachna sp. (larva) - - - - - - - - - - - - - - - - - -	10.0	
Lepidoptera (Moths)		
Pyralidae (larva) -	15.0	
	100.0%	
Length* - - 3.375 inches		
Aquatic Insects -		95%
Ephemeroptera (Mayflies)		
Baetidae		
Ephemerella needhami - - - - - - - - - - - - - - - - - -	70.0%	
Ephemerella cornuta - - - - - - - - - - - - - - - - - - -	10.0	
Trichoptera (pupae, just emerging) - - - - - - - - - - - -	10.0	

* Total lengths (continued)

Table 7, continued

Diptera		
Chironomidae (Midges, pupae)	5%	
Terrestrial Insects		5%
Homoptera		
Aphididae (Plant lice)	trace	
Hymenoptera		
Ichneumonidae (Parasitic Wasps)	5%	
	100%	