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COMMENTS ON THE ADEQUACY OF ACCEPTED STREAM BOTTOM SAMPLING TECHNIQUE[1]

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For many years fisheries workers have attempted to devise methods for assessing the relative contributions to stream economy made by various recognizable stream bottom types. It has long been realized that the invertebrate bottom fauna supplies a great majority of the food taken by the fish population of a stream, and that the composition and abundance of this fauna differs with variations in bottom type, rate of flow, depth, streamside cover, and other environmental factors. In consequence bottom sampling has gone with fish censuses in recent stream survey programs, and results obtained thereby have been considered in the formulation of stocking policies and the evaluation of the carrying capacity of a stream for game fish, especially trout.

Various bottom sampling apparatuses, most of which are based upon a unit area of one square foot, have been devised. The device designed for use in the drainage system surveys of the New York State Department of Conservation (Needham, 1928) has been used widely elsewhere. In brief, it consists of an elongate rectangular box of galvanized sheet metal which, when placed in a stream, encloses one square foot of bottom and prevents the escape of any

[1]Contribution from the Institute for Fisheries Research, Michigan Department of Conservation and University of Michigan.

animals while the imprisoned occupants are removed to a pail with a dipper or strainer. The chief liability of this device is its awkward bulk. An apparatus similar to it in design and principle of operation but constructed largely of wood, collapsible, and enclosing four square feet of bottom was employed in Michigan during the experimental installation of stream improvement devices. In 1934 it was abandoned in favor of the light, collapsible net devised by A. S. Hazzard, P. R. Needham, and E. W. Surber for use by stream survey parties of the United States Bureau of Fisheries. This net, described in detail by Surber (1937), is composed of two foot-square frames of brass strips hinged together. One of the frames supports a bag of silk grit cloth into which bottom materials dislodged by the operator are carried by the current. The contents of the bag may be sorted immediately or preserved for later separation in the laboratory. Because of its many advantages this net has been employed by the Institute for Fisheries Research ever since its adoption in 1934.

Intensive sampling of certain restricted stream areas at monthly intervals was begun by the writer in June 1935, and carried through June 1937. Disparities in yields of particular areas, from month to month, raised doubts as to the accuracy of the sampling method and led me to question whether or not one square-foot sample could be expected to yield a reliable result for a given station. As a test the period from July 6 to August 7, 1937, was devoted to intensive sampling of three restricted areas. Although the length of time required to sort the samples was so great as to allow only a small number to be taken, some of the results obtained seem sufficiently interesting to warrant their publication.

Between July 6 and 12, 1937, five samples were taken from a gravel bed in the North Branch of the Boardman River, Grand Traverse County, Michigan. The bed, approximately 110 square feet in area, was quite uniform in appearance and was composed of a mixture of gravel ranging from the size of a pea to that of a hen's egg. It was made up of smoothly rounded glacial drift material, with very scanty deposits of marl. The stream at this point was about twenty-one feet in width and from six to eight inches deep. The surface velocity was about two feet per second. The banks, from two to five feet in height, sustained a very open growth of scrubby aspens (Populus tremuloides) which cast no appreciable amount of shade on the stream at any time.

A list of the invertebrates found in these samples, together with their numbers and volume (measured by fluid displacement) is given in Table 1. It may be seen that aside from the ubiquitous chironomid larvae the organisms which through numbers or volume appear to determine the complexion of the situation are larvae of the cranefly Eriocera, of the snipe fly Atherix variegata, and of elmid beetles. Mayflies, represented by nine species, were not numerous, probably because the peak of the emergence season for most of them had passed. The surprising paucity of stoneflies may be explained in the same way.

Between July 20 and August 7, 1937, fifteen samples were taken from the Pine River, Lake County, Michigan. Ten of these were collected from a uniform gravel riffle whose elements, ranging from the size of a robin's egg to that of a man's fist, were heavily coated with marl deposits. At the locality sampled the stream was approximately thirty-seven feet in width and eight inches in depth. The water flowed smoothly with a surface velocity of about two and one-half feet per second. The area received shade in the late afternoon from a high bluff rising some distance away from the left bank.

Results obtained from an examination of this series of samples are recorded in Table 2. The greatest bulk of each sample is made up by larvae and pupae of one species of the trichopteran subfamily Glossosomatinae. The species could not be reared, but probably pertains to the genus *Agapetus*. By far the greater part of the total number of this species was made up of very young larvae from 2.0 to 3.5 mm. in length. Discovery of very young larvae and advanced pupae of the same species side by side causes one to speculate on whether there may be an overlapping of generations with two distinct adult emergence peaks. The position of *Eriocera* as a dominant cranefly in the North Branch of the Boardman appears to be taken in the Pine by *Pedicia*. It is of interest to note that larvae and adultsof elmid marl beetles were very numerous in the North Branch of the Boardman where marl was scanty and very scarce in the Pine where marl was most abundant.

A considerable number of very large specimens of the snail *Goniobasis livescens* were taken in this series of samples. They could be ~~seen~~ detected very readily when examining the bottom, and because it could be seen that their distribution was most irregular they are not considered with the other invertebrates taken, but are listed separately in Table 3. This table also shows results of a test made on shrinkage of invertebrates in preservative. All specimens were measured in the field immediately after being killed. They were measured again after fifteen months of preservation in 73 per cent alcohol. The large amount of shrinkage displayed demonstrates the necessity of applying a correction factor when comparing preserved samples with those measured while fresh.

Brief allusion may be made at this time to five samples taken from a dense bed of *Potamogeton filiformis* in the Pine River a few hundred yards above the gravel bed just described. It is planned to discuss these more fully in connection with another study, so no complete tabulation of species or numbers is given now. The total volumes obtained, however, are pertinent here, and are as follows: 4.5; 4.3; 4.3; 4.3; and 4.1 cc. The very luxuriant plants grew densely in water averaging twenty-four inches in depth. The bottom was smooth and composed uniformly of sand with a slight admixture of clay and organic debris. In collecting the sample all of the plants enclosed by the net were pulled up by the roots and swept into the bag together with the upper two inches of the bottom. The bottom was almost wholly devoid of macroscopic animal life. The fauna harbored on the vegetation itself, while of considerable bulk and numbers, was composed almost entirely of simuliid larvae and pupae, and the larvae of tanypodine midges. The simuliids were by far the more abundant. Unless other forms encroach later, these plant beds must have been nearly free of animal life from the end of the blackfly and midge emergence period until they died or the next generation of larvae made its appearance.

It is granted that the number of samples reported upon here is very small, and that positive conclusions can hardly be drawn from them. The results obtained and recorded in the tables are in such good agreement, however, as to suggest strongly that the figures obtained for variation in volume and fauna are quite close to their true values, and that considerable reliance can be placed on the results derived from a single carefully handled sample.

Examination of the totals expressed in Tables 1 and 2 shows rather strikingly that, although repeated sampling of a uniform bottom type within a restricted area yields very similar volumetric values, the faunistic elements making up these values vary greatly in species composition. In Table 1, for example, it may be seen that Sample No. 4, which contained two Ophiogomphus nymphs measuring 0.20 cc. only slightly exceeds in total volume Sample No. 3, which lacked Odonata but contained 0.40 cc. more Atherix larvae than did No. 4. Many similar examples may be found in the tables.

These figures lead to the suggestion that a given area of stream bottom is capable of sustaining a definite amount of insect life and that this can be composed of any combination of a variety of species suited to the habitat, the actual composition being determined either by chance or by the operation of factors as yet undetected. In brief, the findings lead the writer to the belief that one sample of the sort described may be depended upon to yield a reasonably accurate index to the amount of food organisms produced per unit area of uniform bottom type, but cannot be expected to provide a comprehensive picture of the relative numbers of individual species throughout the larger areas from which the sample is collected.

If this be true, added weight is given to the questions of availability of food organisms, and the true position occupied by each species present in the food cycle of game fishes. Fisheries workers are greatly handicapped by the fact that complete life histories are known for only a handful of aquatic insects. Only a few, relatively, are specifically recognizable in their immature aquatic stages. Stomach analysis studies do not yet permit the formulation of positive conclusions as to whether many species enter directly or indirectly into the food cycle of a game fish, or whether they occupy a position in some cycle in which the fish plays no part. Much remains to be learned of the effect of predacious insects, such as Odonata nymphs, Atherix and tabanid larvae and others upon the herbivorous and detritus-feeding forms which make up the bulk of the invertebrate bottom fauna. It is obvious that all of these subjects must receive much attention if stream fish food production is to be managed efficiently through environmental control.

Although the bottom sampling method just discussed appears to be the most satisfactory yet developed, it possesses many limitations and drawbacks. A few of those which have impressed the writer during his experience may be mentioned.

The folding square-foot sampler is difficult to operate at very low temperatures. When the air temperature drops to about -25° F., anchor ice forms readily on the stream bottom and on any immersed objects. In consequence, attempts to collect samples during severe cold spells may be thwarted by the net freezing solid and so causing dislodged bottom materials to wash out around the edges.

It is very difficult to seat the net in rough gravel or rubble in such a way as to enclose accurately one square foot without possible loss of material under the net frame. On uneven bedrock covered with loose shale the same difficulty appears, although it may be overcome partially by padding the frame with burlap or other coarse cloth sufficiently compressible to pack into uneven places.

The net is practically useless in quiet water sections of stream, where there is not sufficient current to wash dislodged materials into the bag. The writer improvised a folding screen which would transform the sampler into a cube, and has used it with some success; but it is, of course, valueless if the water is a foot or more in depth.

In winter organisms cannot be sorted alive unless shelter is very near at hand. It is customary to preserve entire samples for subsequent analysis in the laboratory, a procedure which undoubtedly results in many organisms being overlooked.

Probably the greatest drawback of this or any other common bottom sampling technique based upon sorting out of all organisms is the great amount of time involved. Most of the samples tabulated here required the combined efforts of two people through the daylight hours of at least one, and sometimes one and one-half, days. Furthermore, all the samples were sorted while the organisms were alive and capable of attracting attention through their movements. Samples taken in barren, shifting sand or in smooth, polished gravel destitute of marl or settled organic debris may be handled much more rapidly. In Michigan, however, a great many of the most productive gravel riffles are heavily coated with marl in whose recesses burrow many organisms, such as Antocha larvae, larvae and adults of elmid beetles, and various chironomid and ceratopogonid midge larvae. The saturated salt solution method of flotation, devised by a British worker and now being tested in America, is of no assistance in recovering such burrowing forms.

SUMMARY

The collapsible brass-frame bottom sampler is considered the most satisfactory device for studying supplies of fish food organisms in streams.

Its accuracy was tested by repeated sampling of three restricted, uniform areas. Tabulated results indicate satisfactory accuracy as regards total volume of food organisms present, but show that complete composition of the total fauna present is not likely to be obtained from one sample in a given area.

It is suggested, on the basis of data collected, that while a given area of stream bottom is capable of supporting a definite volume of food organisms, these may vary as to species within a restricted uniform area for reasons not clearly apparent.

Shrinkage of food organisms after fifteen months of preservation is shown.

Some problems in need of attention are indicated.

Objections to the described sampling method are mentioned.

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TABLE 1. BOTTOM SAMPLES, NORTH BRANCH BOARDMAN RIVER

JULY 6-12, 1937

SAMPLE NUMBER	I		II		III		IV		V	
ORGANISM	No.	Vol.	No.	Vol.	No.	Vol.	No.	Vol.	No.	Vol.
ANNELIDA										
Tubificidae	...	...	...	...	...	...	1	tr.	...	...
CRUSTACEA										
Hyalella	...	...	...	...	3	tr.	...	...	1	tr.
INSECTA										
Odonata										
Ophiogomphus	1	tr.	1	tr.	...	...	2	0.200	...	...
Ephemeroptera										
Stenonema terminatum	...	...	...	...	...	...	...	...	2	0.025
Iron humeralis	...	...	...	...	1	0.025	...	...	...	...
Siphlonurus sp.	...	...	...	...	...	...	...	...	17	0.025
Ephemerella lata	1	0.025	...	...	4	0.050	5	0.075	1	tr.
Ephemerella bicolor	...	...	...	...	...	...	2	0.025	...	...
Ephemerella fuscata	...	...	2	0.025	1	0.025	...	...	1	0.025
Ephemerella invaria	...	...	3	...	1	0.025	...	...	1	tr.
Tricorythodes allectus	1	tr.	2	tr.	1	...	...	...	...	...
Baetis sp.	...	...	1	tr.	...	...	2	tr.	...	...
Megaloptera										
Chauliodes sp.	...	...	...	...	...	...	...	...	3	0.075
Plecoptera										
Togoperla media	...	...	...	...	...	...	...	...	2	tr.
Coleoptera										
Elmidae - larvae	112	0.100	249	0.200	222	0.250	156	0.150	163	0.150
Elmidae - adults	4	tr.	2	tr.	7	0.025	9	...	12	...
Hydrophilidae	...	...	...	...	2	tr.	...	...	...	...
Trichoptera										
Hydroptilidae	7	tr.	...	...	3	tr.	5	...	12	tr.
Rhyacophilidae	...	...	...	...	1	tr.	6	0.025	6	0.050
Hydropsychidae	1	tr.	7	0.025	8	tr.	9	...	69	0.050
Philopotamidae	...	...	...	...	...	...	...	...	1	tr.
Seridostomatidae	3	tr.	6	0.075	5	tr.	...	...	7	0.050
Diptera										
Eriocera sp.	16	0.500	15	0.350	19	0.400	17	0.600	15	0.275
Antocha sp.	4	tr.	12	tr.	13	tr.	4	tr.	23	0.025
Empididae	1	tr.	6	tr.	2	tr.	...	...	...	...
Chironomidae	850	0.350	404	0.100	631	0.150	830	0.325	159	0.150
Ceratopagonidae	3	tr.	...	...	...	...	...	...	3	tr.
Simuliidae	...	...	2	tr.	...	...	...	...	30	tr.
Atherix variegata	7	0.200	24	0.800	27	0.650	10	0.250	17	0.400
Ephydridae	...	...	...	...	...	...	1	tr.	2	tr.
ARACHNIDA										
Hydracarina	7	tr.	1	tr.	10	tr.	16	tr.	27	tr.
TOTALS	1,118	1.175	731	1.575	964	1.600	1,075	1.650	574	1.300

[redacted]

TABLE 2

BOTTOM SAMPLES FROM PINE RIVER, JULY 20 - AUGUST 7, 1937 SHOWING NUMBER OF SPECIMENS AND VOLUME IN CUBIC CENTIMETERS

SAMPLE NUMBER	I		II		III		IV		V		VI		VII		VIII		IX		X	
ORGANISM																				
TURBELLARIA																				
Planariidae	5	0.050	...	.....	...	.....	...	.....	3	0.050	8	0.025	6	trace	4	0.050	4	trace	9	0.050
ANNELIDA																				
Glossiphonidae	...	.....	1	0.100	...	.....	...	.....	...	.....	...	.....	...	.....	...	.....	...	.....	...	.....
Lumbriculidae	...	.....	...	.....	...	.....	...	.....	1	0.025	...	.....	...	.....	...	.....	...	.....	...	.....
Tubificidae	45	0.050	89	0.100	48	0.050	59	0.025	82	0.100	44	0.050	19	trace	48	0.025	147	0.100	170	0.125
MOLLUSCA																				
Physidae	...	.....	...	.....	...	.....	...	.....	1	0.025	...	.....	...	.....	...	.....	...	.....	...	.....
Ancylidae	...	.....	5	trace	3	trace	4	trace	1	trace	3	trace	...	.....	1	trace	...	.....	2	trace
INSECTA																				
Ephemeroptera																				
Heptagenia sp.	1	trace	...	.....	...	.....	...	.....	...	.....	...	.....	...	.....	...	.....	...	.....	...	.....
Stenonema sp.	...	.....	3	trace	1		...	.....	1	0.025	...	.....	2	trace	...	.....	4	trace	1	trace
Rhithrogena sp.	...	.....	...	.....	1		...	.....	...	.....	...	.....	...	.....	...	.....	...	.....	...	.....
Paraleptophlebia sp.	...	.....	...	.....	...	0.100	...	.....	...	.....	1	trace	...	.....	...	.....	...	.....	...	.....
Baetis sp.	2	trace	2	trace	2		4	trace	1	trace	...	.....	9	trace	1	trace	2	trace	3	trace
Tricorythodes allectus	18	0.075	19	0.050	22		30	0.125	27	0.200	16	0.075	29	0.100	24	0.100	31	0.150	27	0.100
Ephemerella lata	...	.....	...	.....	1		...	.....	...	.....	1	trace	7	0.100	...	.....	...	.....	...	.....
Odonata																				
Ophiogomphus sp.	...	.....	...	.....	...	.....	...	.....	...	.....	...	.....	...	.....	...	.....	1	trace	...	.....
Megaloptera																				
Sialis sp.	...	.....	...	.....	...	.....	1	trace	1	trace			1	trace	...	.....	...	.....	1	trace
Coleoptera																				
Elmidae - larvae	11	trace	27	0.025	14	trace	46	0.050	33	0.025	17	trace	17	0.025	41	0.075	34	0.025	13	0.025
adults	7	0.025	...	.....	18	0.050	1	trace	4	trace	8	trace	4		...	.....	4	trace	2	trace
Trichoptera																				
Glossosomatinae - larvae	310	0.650	441	0.625	142	0.300	278	0.350	417	0.600	385	0.550	72	0.075	304	0.300	237	0.350	385	0.475
pupae	20	0.250	14	0.175	33	0.300	24	0.300	4	0.075	12	0.150	44	0.475	16	0.300	27	0.300	16	0.200
Hydroptilidae - larvae	14	0.025	26	0.025	12	trace	14	0.025	5	0.025	12	0.025	8	trace	10	0.025	...	.....	3	trace
pupae	...	.....	5	trace	2	trace	10	trace	8		10		...	.....	2		6	trace	6	trace
Hydropsychidae - larvae	4	0.025	6	trace	18	0.050	3	trace	7	0.050	4	trace	4	0.300	1	trace	10	0.200	2	trace
pupae	...	.....	1	0.025	3	0.300	7	0.300	...	.....	2	0.200	...	.....	2	0.200	...	.....	3	0.200
Philopotamidae	1	trace	...	.....	...	.....	...	.....	...	.....	...	.....	...	.....	...	.....	1	trace	4	trace
Molannidae	...	.....	...	.....	...	.....	...	.....	2	trace	...	.....	...	.....	...	.....	5	trace	...	.....
Leptoceridae	...	.....	4	trace	...	.....	...	.....	16	0.025	...	.....	10	0.075	1	0.025	1	trace	5	trace
Sericostomatidae	...	.....	...	.....	2	trace	...	.....	...	.....	...	.....	...	.....	...	.....	...	.....	...	.....
Diptera																				
Pedicia sp.	3	trace	5	0.100	1	trace	1	0.075	2	0.025	6	0.175	3	0.100	...	.....	2	0.025	...	.....
Antocha sp. - larvae	25	0.100	30	0.025	58	0.100	30	0.100	15	0.025	37	0.075	56	0.100	38	0.075	43	0.050	46	0.075
pupae	7	0.025	6	0.025	10	0.050	4	0.025	3	0.075	8	0.050	1	trace	7	0.025	9	0.025	8	0.025
Chironomidae - larvae	156	0.100	196	0.100	174	0.050	252	0.150	239	0.150	129	0.075	166	0.125	244	0.175	182	0.150	192	0.075
pupae	...	.....	13	trace	12	trace	9	trace	15	trace	17	trace	1	trace	14	0.025	12	trace	12	trace
Ceratopogonidae	...	.....	...	.....	1	trace	...	.....	...	.....	...	.....	...	.....	...	.....	...	.....	...	.....
Simuliidae - larvae	...	.....	2	trace	2	trace	...	.....	...	.....	1	trace	3	trace	...	.....	...	.....	...	.....
pupae	...	.....	...	.....	2	trace	...	.....	...	.....	...	.....	...	.....	...	.....	1	trace	...	.....
Atherix variegata	21	0.100	25	0.100	36	0.250	15	0.075	11	0.075	21	0.150	28	0.175	36	0.250	29	0.300	31	0.350
Chrysops sp.	...	.....	...	.....	2	trace	2	trace	1	trace	...	.....	1	trace	...	.....	...	.....	...	.....
ARACHNIDA																				
Hydracarina	28	0.025	43	0.035	31	trace	29	trace	19	0.025	41	trace	29	trace	27	0.025	50	0.025	42	0.025
TOTALS	678	1.500	973	1.500	651	1.600	823	1.600	919	1.600	786	1.700	520	1.650	821	1.675	842	1.700	983	1.725

TABLE 3

VOLUMES OF SNAILS AND INSECTS FROM PINE RIVER SHOWING SHRINKAGE

AFTER FIFTEEN MONTHS IN PRESERVATIVE

	Vol. of snails 1937	Vol. of snails 1939	Shrinkage	Vol. of insects 1937	Vol. of insects 1939	Shrinkage
	5.6	4.3	1.3	1.800	1.500	0.300
	8.0	6.4	1.6	1.900	1.500	0.400
	11.0	9.2	1.8	2.200	1.600	0.600
	3.3	3.0	0.3	2.100	1.600	0.500
	3.0	2.7	0.3	2.000	1.600	0.400
	4.6	4.0	0.6	1.950	1.600	0.350
	10.0	7.4	2.6	2.100	1.650	0.450
	10.8	8.4	2.4	2.000	1.675	0.325
	7.0	4.9	2.1	2.100	1.700	0.400
	7.7	5.7	2.0	2.300	1.725	0.575
Average	7.1 cc.	5.6 cc.	1.5 cc.	2.045 cc.	1.615 cc.	0.430 cc.