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BOTTOM-PREFERENCES OF FISHES OF NORTHEASTERN KENTUCKY STREAMS*

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During some three summers the junior author was engaged in stream-survey work for the Kentucky Division of Game and Fish. The principal areas covered were the basins of the Big Sandy and Little Sandy Rivers, Tygart's Creek, Kinniconnick Creek, and the Licking River, all in the northeastern section of the state. In connection with other features of the project, he, together with the senior author, gave considerable attention to the matter of local distribution of fishes. This emphasis was fruitful of a rather voluminous accumulation of data with respect to the types of stream-bottom upon which fishes were collected.

We have 945 records of the occurrence of particular species upon specific types of bottom in given localities. From these it seems reasonable that some conclusions may be drawn as to whether the fishes in question do exercise choice of bottom, and if so, where their preferences lie.

We recognize seven distinct types of stream-bed, which, with their respective intergradations and combinations, give us a total of twenty-five discernible varieties of bottom. Each of our records means the occurrence of *one species* on a *certain type of sub-stratum* in *one locality*. That is our unit for calculation. If five species or ten species were taken together, they are entered five or ten times correspondingly in the record. Each species is entered into the record once for each occurrence in a different type of bottom or different locality, in the same stream or different streams. No account is taken of the numbers of individuals collected.

The seven principal bottom-types were: (1) Bedrock, (2) Boulder, (3) Rubble, (4) Gravel, (5) Sand, (6) Mud, and (7) Detritus. It will readily be seen that this series is arranged in accordance with the coarseness or fineness of the material; also that they represent a gradation of materials correlated with the velocity of the current, the bedrock having been transported not at all, the boulders but little with the assistance of steep gradients, the rest grading out to a point at which detritus occurs in the sluggish pools and backwaters, far downstream.

Due to considerable declination of the terrain within the east-

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west axis of the state, something on the order of 4000 to 400 feet in 400 miles, our streams possess considerable gradient, much moderated, however, by the fact that they are deeply entrenched toward their headwaters, and much of the fall assumed by their numerous and declivitous tributaries. Thus they present problems in the distribution of aquatic life which would seem to set off the region from the Gulf and Mississippi lowlands on the one hand, and from an aggraded glacial terrain on the other. The present paper looks toward a more complete future appraisal of the problems of distribution.

A chart, Table I, shows the types of correlation existing between current velocity and bottom structure, measured in terms of the numbers of species collected from each. From this you will note that at one extreme we have eight records from bedrock bottom, all showing swift water. At the other extreme no fishes were recorded upon a bottom of pure detritus, and only five records where detritus even existed in combination with sand and gravel. Only 18 occurrences are attributed to mud bottom, all in sluggish water, and eight in situations even partly muddy, in water mostly sluggish. Boulder-bottoms

TABLE I. Correlation of Bottom with Velocity of Current

Relative fineness of bottom materials	Type of bottom	Current						Total
		Moderate		Sluggish		Swift		
		Records	Per cent	Records	Per cent	Records	Per cent	
1	Bedrock	.....	.....	.....	.....	8	100.0	8
1, 3, 4	Bedrock, Rubble, Gravel	1	16.6	3	50.0	2	33.3	6
1, 3, 5	Bedrock, Rubble, Sand	1	33.3	2	66.6	.....	.....	3
1, 3, 6	Bedrock, Rubble, Mud	1	100.0	.....	.....	.....	.....	1
1, 4	Bedrock, Gravel	.....	.....	3	21.4	11	78.6	14
1, 4, 5	Bedrock, Gravel, Sand	.....	.....	4	80.0	*1	20.0	5
1, 5	Bedrock, Sand	1	20.0	2	40.0	2	40.0	5
1, 6	Bedrock, Mud	1	100.0	.....	.....	.....	.....	1
2	Boulder	.....	.....	.....	.....	1	100.0	1
2, 3, 4	Boulder, Rubble, Gravel	.....	.....	.....	.....	1	100.0	1
3	Rubble	1	14.2	.....	.....	6	85.8	7
3, 4	Rubble, Gravel	2	2.8	9	12.7	60	84.5	71
3, 4, 5	Rubble, Gravel, Sand	2	2.3	43	48.3	44	49.4	89
3, 5	Rubble, Sand	.....	.....	5	71.4	2	28.6	7
3, 5, 6	Rubble, Sand, Mud	.....	.....	1	100.0	.....	.....	1
4	Gravel	39	32.8	44	36.9	36	30.3	119
4, 5	Gravel, Sand	27	7.5	249	69.2	84	23.3	360
4, 5, 6	Gravel, Sand, Mud	3	100.0	.....	.....	.....	.....	3
4, 5, 7	Gravel, Sand, Detritus	2	66.6	1	33.3	.....	.....	3
4, 6	Gravel, Mud	2	100.0	.....	.....	.....	.....	2
5	Sand	42	24.7	124	73.8	3	1.5	169
5, 6	Sand, Mud	45	91.8	4	8.2	.....	.....	49
5, 7	Sand, Detritus	2	.....	.....	.....	.....	.....	2
6	Mud	18	100.0	.....	.....	.....	.....	18
7	Detritus	.....	.....	.....	.....	.....	.....	.....
	Totals	190	20.1	494	52.3	261	27.6	945

The degrees of fineness or coarseness of the bottom materials are expressed as numerals from one to seven, ranging through bedrock, boulder, rubble, gravel, sand, and mud to detritus. (First column.)

The numbers in the columns headed "Records" indicate the frequency with which distinct species were taken on each type of bottom, in as many distinct localities.

are exceedingly uncommon, and have yielded only one record, with one record also in combination; both were in swift water. The rubble bottoms, nearly all in swift water, produced seven species-records; when in combination with other materials, we have 179 occurrences of fishes on mixed-rubble bottoms, of which 109 were from swift water, 63 in moderate, only 7 in sluggish. Upon gravel, we have 119 records, almost equally divided among sluggish, moderate, and swift water. Upon sand bottom we have 42 records in sluggish water (fewer than in gravel), 124 in moderate current (three times the record on gravel); only three in swift current on sand. The total for sand, 169, as against 119 for gravel, may be accounted for in part by the greater predominance of sand from the weathering sandstone of the region. The chart indicates clearly that a much higher frequency was obtained upon mixed gravel-and-sand bottom than any other, the total of 360 records being 38 per cent of the grand total of all records. This may be compared with the occurrence of 52 per cent (494) in moderate current, as against 20 per cent (190) in sluggish water, and 27 per cent (261) in swift current.

In the region in question we have some 98 species of record. Welter has reported 70 from the Licking River drainage, Clark 52 from the Levisa Fork of the Big Sandy River. Of the 98 known species, our record applies to 74. With some allowance for taxonomic revision, we find 21 species and subspecies taken on bedrock bottom, 39 on rubble, 66 on gravel, 67 on sand, 36 on mud, and 5 on detritus. Thus not only are the *records* for sand and gravel much greater in number than for other substrata, but a much larger number of *species* are found frequenting those types of bottom. Of the total number of combinations of different species with each of the types of bottom on which it had sometimes been found, and casting out duplicates, we have 236 distinct from one another, and 133 of this total, or 56 per cent, occur where sand or gravel is present.

In Table II we have an analysis by species of certain representative distribution records, about one-third of the total, and enough to explain how the totals were arrived at. This table also shows, of course, the great predominance in the columns headed sand and gravel.

However, Table III, a summary by families, may present the total picture more graphically:

With no significant exceptions, the preferred habitat of this fish population is upon bottoms in which sand and gravel predominate. This may be due either to the actual choice of a preferred substratum, or to the selection of waters having a preferred velocity, which happens to correspond with the resting-state of sand and gravel. The

TABLE II. Distribution of a Selected List of Species

Our No.	Check list No.	Species	Types of bottom: Bedrock	Boulder	Rubble	Gravel	Sand	Mud	Detritus
10	736	Catostomus commersonii	....	....	3	11	11	2	....
11	758	Hypentelium nigricans	....	....	6	25	38	1	1
15	781	Moxostoma erythrurum	....	....	....	7	10	2	....
18	800	Chrosomus erythrogaster	....	....	1	4	6	2	1
19	833	Semotilus a. atromaculatus	3	1	19	49	53	3	....
23	880	Notropis photogenis	....	....	1	11	8	....	....
24	895	Notropis rubellus	2	....	6	15	19	....	....
26	904	Notropis u. umbratilis	....	....	....	8	5	....	....
27	905	Notropis ardens lythrurus	1	....	1	3	3	....	....
29	934	Notropis cornutus chrysocephalus	3	....	8	36	40	2	....
30	940	Notropis spilopterus	2	....	3	10	9	1	....
31	(940)	Notropis whipplii	....	....	6	18	18	....	....
32	976	Hybopsis amblops amblops	1	....	....	12	14	1	....
35	993	Notropis deliciosus stramineus	....	....	3	20	23	1	....
37	1022	Nocomis micropogon	1	....	3	11	10	....	....
42	1063	Ericymba buccata	....	....	1	12	22	4	....
45	1091	Hyborhynchus notatus	1	....	23	46	43	1	....
47	1098	Campostoma a. anomalum	4	1	19	41	49	2	....
52	1164	Ameiurus nebulosus nebulosus	....	....	1	3	2	4	....
58	1182	Schilbeodes miurus	....	....	....	10	11	2	....
62	1974	Labidesthes sicculus	2	....	4	8	7	3	....
64	2185	Percina caprodes caprodes	....	....	....	13	9	1	....
65	2190	Hadropterus maculatus	3	....	11	38	43	4	....
71	2217	Etheostoma b. blennioides	4	....	8	16	10	....	....
73	2225	Boleosoma nigrum nigrum	1	....	3	15	27	3	....
80	2276	Catonotus f. flabellaris	3	....	1	17	16	1	....
86	2324	Lepomis auritus	....	....	1	8	9	2	....
89	2329	Lepomis megalotis megalotis	....	....	6	24	29	3	....
93	2351	Pomoxis annularis	1	....	2	4	2	2	....
		Total individual species (duplicates not included)	21	2	39	66	67	36	5
		Total records (including duplicates)	40	2	178	667	673	74	5

For purposes of analysis bottoms of mixed character are counted under all the heads, as, for example, a sand-gravel area would be included under both sand and gravel. Hence the totals in this table do not tally with those in Table I, and we have a grand total of 1639 as against 945, Table I.

Check-list numbers based on Jordan, Evermann and Clark, 1930.

TABLE III. Distribution by Families

Families	Type of bottom: Coarser	Gravel	Sand	Finer
Catostomidae	9	49	63	7
Cyprinidae	126	344	367	36
Ameiuridae	7	26	22	10
Esocidae	....	3	3	....
Cyprinodontidae	.....	.....	3	3
Percopsidae	2	4	3	....
Atherinidae	6	8	7	3
Etheostomidae	59	182	173	10
Centrarchidae	10	45	49	10

latter choice would be in the middle range of swiftness. No matter which motive actuates the fishes, we do find a definite correlation at any rate.

Our present analysis is out of balance from the fact that few of the data were obtained from deeper water, such as the Ohio River and lower courses of its tributaries. Depth may be a factor which would largely cancel out any bottom selection, except for those species frequenting the bottom. This unbalance of our record is reflected in the small numbers of certain families such as catfishes or the Esocidae in the record. The record is, then, chiefly that of the more settled time of year; we offer no data as to what happens during freshets or the occasional excessively dry season.

In further interpretation of the data, we can well understand certain reasons for the paucity of records in the extreme situations. Our collections came mostly from shallow streams, and from the more shallow portions of those streams. Therefore the bed of the stream would have the maximum effect upon the life of the fishes. The effect of detritus and mud upon the gills should be found at their greatest, and that type of bottom should be avoided to a greater extent than in deep water. Our lack of specimens from boulder strewn waters is the common experience of those who do collecting in all kinds of streams. Furthermore, we should expect in sandy or gravelly situations the greatest amount of plant growth, such as *Potamogeton,* and in rocky or boulder-riffles only the minimum. This should affect the amount of food and shelter in favor of the sand-gravel complex. Bedrock is found more often well upstream, in sections most exposed to the flash-freshets of our climate. This fact, together with a probable sweeping out of food-supplies, renders the well-swept floors less acceptable. Rock-bottom pools further downstream have a decided attraction for some species.

The question might be raised whether the use of a current-meter to determine velocities and screens for bottom-materials would eliminate the personal factor. However, for purely qualitative purposes, we believe we have been more than reasonably consistent. Our total records of 667 for gravelly situations, 673 for sand, added together give 1340, or 82 per cent of all records. This should be significant, with ample allowance for error.