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# INTRA-SPECIFIC VARIATION IN THE COMMON SHINER, *NOTROPIS CORNUTUS FRONTALIS* (AGASSIZ) FROM MINNESOTA AND SOUTH DAKOTA[1]

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INTRODUCTION. The voluminous literature relating to intra-specific variations in fishes has been reviewed by Hubbs (1934, 1940), Tånning (1952), Lindsay (1953) and others. A majority of the workers have supported the interpretation that the variation is influenced by various environmental factors, primarily the temperature during the pre-fry stages of development. Certain of the meristic characters which show such variability have been generally used in identifiying various races of minnows. If such characters as the number of anal fin rays or scales in the lateral line are easily influenced by the environment, their usefulness in defining races is certainly open to question. However, if they are little influenced by environmental conditions, then their usefulness is not subject to such criticism. Support for the latter view can be found in certain experimental studies (Gabriel 1944, Heuts 1949).

The present problem was undertaken to determine the amount and nature of the intra-specific variation in isolated populations of the common shiner, *Notropis cornutus*, from a limited geographic area.

METHODS. During the years 1952-1960, 1,351 specimens of the common shiner were collected and examined. The above specimens were taken by means of quarter-inch mesh seines from the following drainage basins in the state of Minnesota: Mississippi, Minnesota, Missouri, St. Croix and Red Rivers and Lake Superior. In addition specimens were obtained from the Missouri and Red River drainages in South Dakota.

The characters listed below were measured in the manner outlined by Hubbs and Lagler (1958): scales in the lateral line, scales above and below the lateral line, scales on the caudal peduncle, rays in the dorsal, anal, pectoral and pelvic fins. Statistical analyses followed those outlined by Simpson, Roe and Lewontin (1960).

Each sample was analyzed separately and in certain instances

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where there were no significant differences in samples from the same station the samples were pooled. There was no evidence of sexual dimorphism in the common shiner for any of the characters studied. A comparison of males and females from the Credit River (Table 1) revealed no significant differences between the sexes. Similar comparisons of males and females in other samples revealed no significant differences.

TABLE 1. Variation in eight meristic characters in males and females of *Notropis cornutus* from the Credit River.

| Character | N | Males | N | Females |
|---|---|---|---|---|
| | | Mean ± SE | | Mean ± SE |
| Scales in Lateral Line | 25 | 39.56 ± 0.22 | 29 | 39.65 ± 0.12 |
| Scales Above Lateral Line | 26 | 7.54 ± 0.05 | 30 | 7.23 ± 0.07 |
| Scales Below Lateral Line | 26 | 5.31 ± 0.14 | 31 | 5.31 ± 0.06 |
| Caudal Peduncle Scales | 26 | 15.88 ± 0.11 | 31 | 16.09 ± 0.11 |
| Dorsal Rays | 26 | 8.04 ± 0.01 | 32 | 8.06 ± 0.01 |
| Anal Rays | 26 | 8.92 ± 0.01 | 32 | 8.87 ± 0.02 |
| Pectoral Rays | 26 | 15.96 ± 0.12 | 32 | 15.50 ± 0.21 |
| Pelvic Rays | 26 | 8.00 ± 0.00 | 32 | 8.00 ± 0.00 |

SEASONAL AND ANNUAL VARIATION. To determine whether the time of year of sampling might influence the sample average, the averages of samples taken in May and October, 1954, from the same station on the Credit River were compared (Table 2). Only one character, the number of scales below the lateral line, showed evidenec of seasonal variation. The May average was significantly higher than that of the October sample ($p = 0.01$).

The possibility of annual variations in the characters studied was

TABLE 2. Averages for eight meristic characters of samples of *Notropis cornutus* taken in the spring and fall of 1954 from the same station on the Credit River.

| Character | May (44) Mean ± SE | V* | October (23) Mean ± SE | V |
|---|---|---|---|---|
| Scales in Lateral Line | 39.47 ± 0.12 | 2.0 | 39.22 ± 0.17 | 2.1 |
| Scales Above Lateral Line | 7.15 ± 0.06 | 5.9 | 7.17 ± 0.09 | 6.0 |
| Scales below† Lateral Line | 5.43 ± 0.07 | 9.0 | 5.13 ± 0.07 | 6.6 |
| Caudal Peduncle Scales | 15.87 ± 0.09 | 3.9 | 15.96 ± 0.11 | 3.4 |
| Dorsal Rays | 8.07 ± 0.13 | 3.1 | 8.00 ± 0.00 | 0.0 |
| Anal Rays | 8.89 ± 0.05 | 3.5 | 8.91 ± 0.06 | 3.1 |
| Pectoral Rays | 15.71 ± 0.13 | 5.5 | 15.22 ± 0.13 | 4.1 |
| Pelvic Rays | 7.98 ± 0.02 | 1.9 | 7.96 ± 0.04 | 2.5 |

* Coefficient of Variation.
† Significantly different.

also examined; averages for samples taken at the same station on the North Branch of the Zumbro River in 1952, 1953 and 1954 were not signficantly different, except for the count of scales above the lateral line (Table 3). The averages for the number of scales below the lateral line and numbers of dorsal, anal and pelvic fin rays were not significantly different and exhibited very low variation.

TABLE 3. Averages for meristic characters in *Notropis cornutus* from the same station on the Zumbro River in the years 1952 to 1954.

| Character | 1952 (18) Mean ± SE | 1953 (60) Mean ± SE | 1954 (30) Mean ± SE | 1952-1954 Mean ± SE |
|---|---|---|---|---|
| Scales in Lateral Line | 39.17 ± 0.18 | 39.40 ± 0.09 | 39.04 ± 0.16 | 39.34 ± 0.08 |
| Scales Above Lateral Line | 6.17 ± 0.12 | 6.81 ± 0.06 | 7.39 ± 0.10 | 6.86 ± 0.06 |
| Scales Below Lateral Line | 5.39 ± 0.10 | 5.42 ± 0.08 | 5.50 ± 0.11 | 5.44 ± 0.06 |
| Caudal Peduncle Scales | 15.89 ± 0.10 | 16.18 ± 0.10 | 15.93 ± 0.11 | 15.96 ± 0.07 |
| Dorsal Rays | 8.05 ± 0.06 | 8.07 ± 0.05 | 8.00 ± 0.00 | 8.05 ± 0.03 |
| Anal Rays | 8.89 ± 0.09 | 8.80 ± 0.06 | 8.86 ± 0.06 | 8.82 ± 0.04 |
| Pectoral Rays | 15.17 ± 0.20 | 15.13 ± 0.13 | 15.59 ± 0.12 | 15.26 ± 0.09 |
| Pelvic Rays | 7.94 ± 0.06 | 7.88 ± 0.04 | 8.00 ± 0.00 | 7.93 ± 0.02 |

Another group of characters, scales in the lateral line, pectoral fin rays and caudal peduncle scales displayed an intermediate level of variation. For example, the 1952 average for pectoral fin rays does not differ significantly from either the 1953 or 1954 average, but the difference between the means of the 1953 and 1954 samples is significant.

INTRA-BASIN VARIATION. Comparisons of averages for samples from the same stream but different stations revealed no significant differences for characters other than the number of scales above and below the lateral line. Three samples from Rock Creek, a tributary of the St. Croix River, and three samples from the Zumbro River revealed no significant differences between the sample averages. No trend was evident, that is no sample was high, low or intermediate for all or a majority of the characters. The distances between the stations on Rock Creek were 2, 4 and 6 miles, and on the Zumbro River 30, 60, and 70 miles. The similarity in averages for samples obtained from the same stream but different stations indicated that the populations of individual streams were homogeneous.

When similar comparisons of averages for samples from different streams in the same drainage basin were made, considerable variation was found in the number of lateral line scales, rays in the pectoral fin and scales on the caudal peduncle (Table 4). No significant differences were evident for the following characters: numbers of rays in the dorsal, anal and pelvic fins.

The variation exhibited by the pectoral fin is representative of the

TABLE 4. Variation in the number of scales in the lateral line, caudal peduncle scales and the number of rays in the pectoral fin of *Notropis cornutus* from various tributaries of the Minnesota River. (Streams listed in order from headwaters to mouth.)

| Stream | N | Scales in Lateral Line | Caudal Peduncle Scales | Pectoral Fin Rays |
|---|---|---|---|---|
| | | Mean ± SE | Mean ± SE | Mean ± SE |
| Little Minnesota | 48 | 39.08 ± 0.12 | 15.92 ± 0.10 | 15.81 ± 0.11 |
| Yellow Bank | 78 | 38.99 ± 0.11 | 16.03 ± 0.06 | 16.08 ± 0.10 |
| Pomme de Terre | 48 | 38.54 ± 0.11 | 15.92 ± 0.11 | 16.57 ± 0.12 |
| Lac Qui Parle | 21 | 38.42 ± 0.21 | 15.75 ± 0.14 | 16.33 ± 0.15 |
| Rush | 36 | 39.28 ± 0.13 | 16.26 ± 0.12 | 16.25 ± 0.12 |
| Credit | 134 | 39.46 ± 0.09 | 15.94 ± 0.06 | 15.65 ± 0.08 |

intra-basin variation. Fish from the Little Minnesota and Yellow Bank Rivers had significantly fewer fin rays than did those from the Pomme de Terre River (p. $<0.001$). Samples from Rush Creek and the Credit River had means which were significantly different (p. $<0.001$), but the Credit River average did not differ significantly from the averages for either the Little Minnesota or Yellow Bank rivers (p $>0.20$). Less variation was exhibited by the number of scales in the lateral line, although samples from the Pomme de Terre and Lac Qui Parle Rivers had significantly fewer scales than all the other samples.

When the samples from the various streams were ranked for all eight characters, with the highest average equal to 1 and the lowest averages equal to 6, the Pomme de Terre River and Rush Creek samples had the lowest ranking (22 and 20) while the remaining four streams had higher but nearly equal rankings (27, 31, 31, 32). The significance of these differences is not apparent at present, the streams are similar although not identical, distances are in many instances less than those between samples from the Zumbro River, all lie in the same climatic zone, and there is no evidence of a cline. While these differences are too small to warrant taxonomic recognition, it is of importance to point out that the Minnesota River population of *Notropis cornutus* is not homogeneous for the three characters discussed. On the other hand, the sample averages for pelvic, anal and dorsal fin rays are nearly identical from stream to stream.

INTER-BASIN VARIATION. The variation between samples drawn from different drainage basins was no greater than that exhibited by the samples from the tributaries of the Minnesota River. In Table 5 the means and standard errors of samples taken from the Little Minnesota River and Jim Creek are presented. Jim Creek is at the headwaters of the Red River and the Little Minnesota River lies at the north end of Big Stone Lake and is the source of the Minnesota River. At one point in Roberts County, So. Dakota, the two streams are only two miles apart. The means for the samples from these streams did not differ significantly even though the populations are geographically isolated from one another, yet samples from adjacent streams in the Minnesota River drainage did differ significantly from one another. The populations of the Red River and Minnesota River are related, as for a time during the retreat of the ice sheet melt waters drained south through the Red River Valley into the River Warren, the late glacial precursor of the Minnesota River.

TABLE 5. Variation of eight meristic characters in *Notropis cornutus* from Jim Creek and the Little Minnesota River, South Dakota.

| Character: | Jim Creek (38) | Little Minnesota River (48) |
|---|---|---|
| | Mean ± SE | Mean ± SE |
| Scales in Lateral Line | 38.76 ± 0.18 | 39.08 ± 0.12 |
| Scales above Lateral Line | 6.79 ± 0.08 | 6.94 ± 0.03 |
| Scales below Lateral Line | 5.00 ± 0.08 | 5.26 ± 0.08 |
| Caudal Peduncle Scales | 15.92 ± 0.12 | 15.92 ± 0.10 |
| Dorsal Rays | 8.00 ± 0.04 | 8.04 ± 0.03 |
| Anal Rays | 9.00 ± 0.08 | 8.83 ± 0.06 |
| Pectoral Rays | 16.03 ± 0.13 | 15.81 ± 0.11 |
| Pelvic Rays | 7.88 ± 0.07 | 8.08 ± 0.04 |

When samples from the major drainage basins were pooled, the basin averages were in several instances significantly different from all the other averages (Table 6). Common shiners from the Lake Superior drainage had a significantly higher average number of scales in the lateral line than did all other samples. The latter finding might be taken to support Jordan's Rule that northern forms tend to have larger numbers of parts than their southern relatives, but for the fact that this same population had significantly fewer pectoral fin rays than all other populations and an average number of scales on the caudal peduncle that did not differ significantly from the other sample averages. The significance of the inter-basin differences is certainly questionable when it is recalled that the average represents a pooling of samples which had means that were in certain cases significantly different from one another, i.e. pooling of non-homogeneous samples. The inter-basin variation is merely a reflection of the high intra-basin variation, pooling of sub-samples simply ignores this component of the variation. Furthermore, sub-sampling from sub-

TABLE 6. Variation in *Notropis cornutus* from the major drainage basins of Minnesota and South Dakota.

| Drainage | Scales in Lateral Line | Pectoral Fin Rays | Caudal Peduncle Scales |
|---|---|---|---|
| | Mean ± SE | Mean ± SE | Mean ± SE |
| Lake Superior | 40.49 ± 0.14 | 15.08 ± 0.09 | 16.08 ± 0.10 |
| Red River | 39.24 ± 0.08 | 16.17 ± 0.06 | 16.25 ± 0.07 |
| Mississippi River | 39.25 ± 0.03 | 15.93 ± 0.03 | 15.99 ± 0.02 |
| Missouri River | 39.43 ± 0.06 | 16.45 ± 0.05 | 16.09 ± 0.05 |
| Total | 39.32 ± 0.03 | 16.04 ± 0.02 | 16.05 ± 0.02 |

samples, a procedure mentioned in papers relating to fish systematics, may perhaps create a totally erroneous impression of the variation exhibited by a species throughout its range.

DISCUSSION. The variability that exists in a population of fishes is determined by the interaction between the individual genotypes of the members of the population and the environments in which they exist. This is not the environment as represented by an average of conditions throughout a year, but for the meristic characters, scales and fin rays, it is the environment of the egg and early post-hatching stages. Over a wide geographic range environmental conditions during this short period in the life history of the fish are probably not similar, but within the confines of a single stream or perhaps within neighboring stream systems it is more probable that the conditions will be similar or at least more similar than for populations from different drainage basins.

Certain characters in the common shiner are more variable than others. The number of scales in the lateral line, caudal peduncle scales, and the number of pectoral fin rays show considerable variation, while another group, dorsal, anal and pelvic fin rays exhibit little variation. Both groups are exposed to the same environmental influence, yet the variation is strikingly different. For example, populations of the common shiner from the Lake Superior drainage have significantly more scales in the lateral line than do other populations, yet the number of rays in the dorsal, anal or pelvic fin do not differ in any of the populations. If one had only counted the number of scales in the lateral line or the number of rays in the pectoral fin quite different interpretations could be made, for the number of fin rays in the Lake Superior population is significantly lower than in all other populations. The number of scales on the caudal peduncle did not differ significantly between the populations. Since Tånning (1952) has shown that these characters are not determined during the same stage of development, the contradictions that appear might be explained by assuming that the environments were similar during certain stages in development but dissimilar during earlier or later stages. The probability of environmental conditions being identical for that period when the anlage of the anal or pelvic fin rays are determined but different during the pectoral fin ray stage is not great. The variation seems more easily explained by assuming that certain characters are more variable than others, hence subject to greater environmental influence. By the same reasoning characters exhibiting less variation are less subject to environmental influence.

Samples taken in May and October from the same station did not differ significantly, except for the number of scales below the lateral line. Similarly, samples taken from the same station in different years did not differ significantly from one another. Samples from three stations on the Zumbro River did not differ from one another in the characters studied. With the exception of the number of scales above and below the lateral line, the common shiner populations of a stream may be considered homogeneous. A comparison of sample means for various streams tributary to the Minnesota River revealed considerable intra-basin variation and a lack of homogeneity.

The lack of homogeneity for certain characters may perhaps be explained by the habitat preferences of the common shiner. Collections during the past decade have shown that the common shiner is characteristic of small streams, small rivers and lakes. This shiner is seldom taken in the large river habitat and when present is represented by only one or two individuals.

The inter-basin variation exhibited by the common shiner is a reflection of the intra-basin variation. The fact that neighboring streams in two basins were not significantly different, while populations within the same basin did differ supports the above view.

While the common shiner is quite variable, it is not as variable as the bigmouth shiner, *N. dorsalis*, studied by Underhill and Merrell (1959). Both species inhabit small streams and rivers, but the common shiner has a more continuous distribution within a stream than does the bigmouth shiner. The former species did not display the annual or intra-stream variation that was characteristic of the bigmouth shiner. Samples of the two species from the three main branches of the Zumbro River, were different in their variation. The samples of the common shiner did not differ significantly from one another, but the bigmouth shiner samples did show significant differences. These differences in the variation of the two species may be explained by the differences in the habitat preferences or specificities of the two species. The common shiner is represented from all habitat types sampled in small streams and rivers, while the bigmouth shiner appears to prefer the shifting sand and sand gravel habitats. Therefore, within a stream the common shiner has a more continuous distribution than does the bigmouth shiner. Further work on other species will be required before a relationship between variability and habitat specificity can be established.

SUMMARY. The annual, inter-stream, inter-basin and intra-basin variation in eight meristic characters in the common shiner from the Minnesota, Mississippi, Missouri, Red and St. Croix rivers and Lake Superior in Minnesota and the Missouri and Red Rivers in South Dakota was studied. Three characters, scales in the lateral line, caudal peduncle scales and pectoral fin rays, showed considerable variation. The variation exhibited by the common shiner was compared with that reported for the bigmouth shiner.

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