Distributional and Populational Isolation of the Spring Cavefish, Chologaster agassizi (Pisces: Amblyopsidae)[1]

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The spring cavefish, *Chologaster agassizi* Putnam, is a member of the family Amblyopsidae, the small group of North American freshwater cavefishes. The amblyopsids are confined to the central and southeastern portions of the United States and restricted to specific subterranean-spring habitats.

MATERIALS AND METHODS

Extensive collections were made in both hypogean and epigean environments throughout Kentucky, Tennessee, and southern Illinois. Localities in which the spring cavefish was found were recorded on a regional map.

A population located centrally in the fish's range, Warren County, Kentucky, was utilized for meristic analyses. Characters analyzed were the numbers of rays of the dorsal, anal, and pectoral fins including the two or three rudimentary rays anterior to the principal rays. Sample means of the meristic characters were compared statistically by analysis of variance for each age group represented in the population.

RESULTS

Distribution—The distributional range of the spring cavefish is within the zone bounded by the approximate lines of Pleistocene glaciation and Mississippian embayment in Kentucky, Tennessee, and southern Illinois (Figure 1). The present distribution and pattern of variation of *C. agassizi* have suggested to Woods and Inger (1957) and Poulson (1961) that dispersal was from the eastern Dripping Springs Escarpment through the Cumberland Saddle, into the Nashville Basin, along the Cumberland River Basin to the Ohio River, and across southern Illinois through caves in the escarpments. This would suggest epigean dispersal, which appears feasible since *C. agassizi* frequently inhabits epigean portions of its environment. There are, however, no known records of the spring cavefish in the epigean portions of the Green and Cumberland rivers, probably as a result of inadequate collecting rather than actual absence of the fish.

Meristics—Thriving populations of *C. agassizi* usually exist in cave-spring environments. These areas appear to be isolated, although subterranean connections undoubtedly exist. Inferences on the degree of populational isolation may be suggested from analyses of meristic characters.

Results of the analyses of the meristic characters for the cavefish are presented in Tables I-IV. Of the four meristic characters analyzed, no statistical differences existed at the 5% level of probability. Thus it is assumed that the causative factors for meristic variations, whether genetic or environmental, are reduced from an extremely local population of cavefish under the influence of relatively stable environmental conditions. Woods and Inger (1957) found rather consistent occurrences of interspecific differences of meristic characters as compared to the sporadic occurrences of intraspecific differences among samples of amblyopsid fishes collected from Kentucky, Tennessee, and Illinois. It was suggested that, instead of having two or three major subdivisions of *Chologaster* that are approximately distinct from one another, there exist extremely

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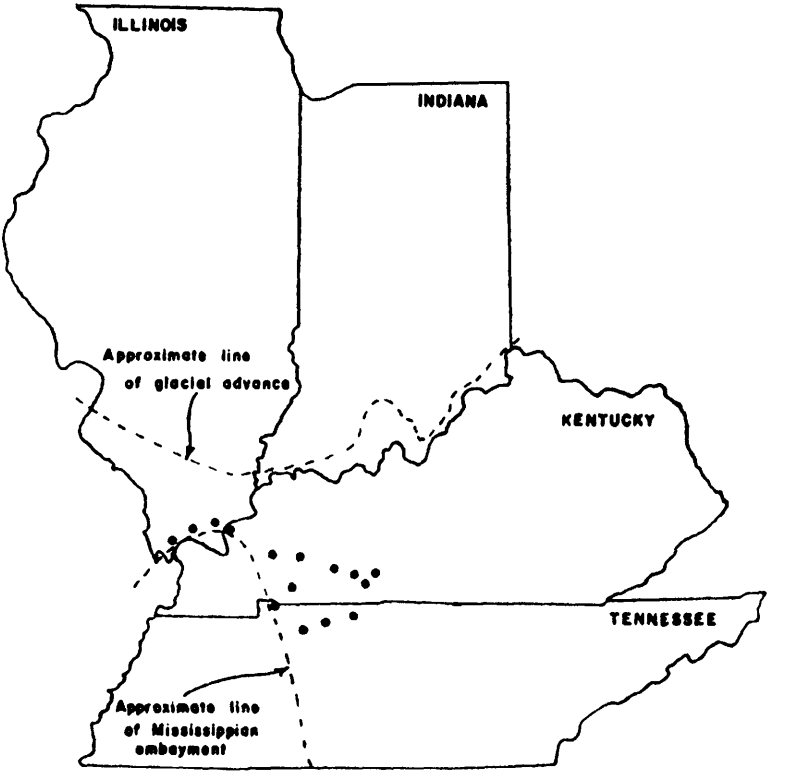

Figure 1. Present distribution pattern of the spring cavefish, *Chologaster agassizi* Putnam.

local populations that are differentiated to varying degrees and in different characters. From these data it appears that one would not be able to justify the recognition of subspecies of *agassizi*, but rather could propose the existence of geographical races.

Meristic characters, those serially repeated characters such as fin rays, spines, scales in the lateral line, vertebrae, etc. have been used intensively as taxonomic criteria in ichthyology.

Hubbs (1962) found that the nature of morphological variation in fishes responded inversely to the developmental rate, longer developmental periods usually producing higher counts of meristic structures. Other causative agents which have effects parallel to those of low temperatures are light intensity (McHugh, 1954) light duration (Lindsey, 1954), oxygen tension (Hubbs, 1926), salinity (Heuts, 1947a), and carbon dioxide (Strawn, 1961).

Genetic determinations of meristic characters have been demonstrated both for inter- and intraspecific populations or races. Gabriel (1944) found that the progeny of the killifish, *Fundulus heteroclitus* (Linnaeus), with high vertebral numbers also have high counts, and that progeny from killifish with low counts had low counts. Similar results have been

TABLE I. ANALYSIS OF VARIANCE TEST COMPARING MEANS OF DORSAL FIN RAYS AMONG AGE GROUPS OF *C. agassizi*, WARREN COUNTY, KENTUCKY.

Source of Variation	D. F.	Sum of Squares	Mean Squares
Total	910	1178.260	1.294
Classes	2	0.561	0.280
Individuals	908	1177.699	1.297
F			0.215

TABLE II. ANALYSIS OF VARIANCE TEST COMPARING MEANS OF ANAL FIN RAYS AMONG AGE GROUPS OF *C. agassizi*, WARREN COUNTY, KENTUCKY.

Source of Variation	D. F.	Sum of Squares	Mean Squares
Total	910	222.479	0.243
Classes	2	0.911	0.455
Individuals	908	221.568	0.244
F			1.864

TABLE III. ANALYSIS OF VARIANCE TEST COMPARING MEANS OF PECTORAL FIN RAYS (RIGHT) AMONG AGE GROUPS OF *C. agassizi*, WARREN COUNTY, KENTUCKY.

Source of Variation	D. F.	Sum of Squares	Mean Squares
Total	910	10369.204	11.394
Classes	2	12.404	6.202
Individuals	908	10356.800	11.406
F			0.543

TABLE IV. ANALYSIS OF VARIANCE TEST COMPARING MEANS OF PECTORAL FIN RAYS (LEFT) AMONG AGE GROUPS OF *C. agassizi*, WARREN COUNTY, KENTUCKY.

Source of Variation	D. F.	Sum of Squares	Mean Squares
Total	910	82.314	0.090
Classes	2	0.255	0.127
Individuals	908	82.059	0.090
F			1.41

observed for the guppy, *Lebistes reticulatus* (Peters), (Schmidt, 1919 and Svardson, 1945). It has also been demonstrated that different races of species reared under similar environmental conditions give dissimilar meristic counts (Mottley, 1947; Heuts, 1947b, 1949; Seymour, 1956).

The significance of the rather uniform meristic counts found for the cavefish exemplifies an interaction between environmental and genetic factors. Siblings of *Chologaster* develop under cave conditions. That caves support near stable environmental conditions has been proclaimed by Eigenmann (1899, 1903, 1905, 1909; Heuts, 1953; and Poulson, 1961). Miller (1948) found that species of *Cyprinodon* inhabiting relatively stable spring conditions were also characterized by uniform meristic counts among successive year classes.

Population size and genetic homeostasis also affect the expression of meristic traits. Gabriel (1944) noted that even though he could experimentally produce high or low vertebral numbers in *Fundulus heteroclitus*, the count in the wild population was usually less variable than the count for laboratory-reared fish. These data support the thesis that the extremes had been present in the natural population but were eliminated, as would be predicted if the populations were genetically homeostatic (Lerner, 1954). From studies of specimens collected from wild populations, Bailey and Gosline (1955) concluded that natural selection reduces the variability of vertebral numbers in a percid fishes. In small populations, new characters, whether adaptive or not, possess a greater probability of survival than in very large populations (Miller, 1948). In the large population of *Chologaster*, the probability of the expression of meristic variations may also be decreased by population size and natural selection.

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