THE STATUS OF THE COMMON SHINER, Notropis cornutus chrysocephalus (RAFINESQUE), IN KENTUCKY [1]

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ABSTRACT

Fishes belonging to the *Notropis cornutus* complex are commonly encountered by hydrobiologists. Consequently, a reasonable taxonomic designation of these forms is important. Several attempts have been made to place these fishes in an acceptable classification. To clarify the status of their classification, specimens sampled from collections totaling more than 3400 fish from 40 counties in Kentucky were analyzed for dorsal stripe configuration, chin pigmentation, and anterior dorsolateral and circumferential scale counts.

Distribution and meristics of shiner populations presented in this and other studies suggest that the *cornutus–chrysocephalus* complex forms a cline extending from the Gulf coast northward to the Great Lakes region. There is a general pattern of increasing scale counts of circumferential and anterior dorsolateral scales from south to north. The variations in pigmentation patterns and scale counts appear to be the result of differing environmental conditions and may be considered as "neutral" phenotypes. Most specimens examined from Kentucky conform to the description of the form *chrysocephalus*. Alternative views of the complex by other workers are presented.

INTRODUCTION

The common shiner is one of the most widespread and abundant minnows in the United States. At the same time, its taxonomy is one of the most questioned of the North American freshwater fishes. Because of these two points and the frequent appearance of this fish in studies made by fisheries biologists, a statement concerning the taxonomic position of this fish in Kentucky was considered necessary.

The first description of any member of this particular group of minnows was made by Mitchill (1817) when he described *Cyprinus cornutus* in the Hudson River Drainage in New York. This description was followed closely in 1820 by Rafinesque's description of *Luxilus chrysocephalus* in Kentucky. At the same time, Rafinesque also described a new species in Kentucky as *Rutilus plargyrus*. Following the original description by Mitchill, it was recognized that the species *cornutus* was totally unrelated to the genus *Cyprinus* and was subsequently placed in the old world genus *Leuciscus* by DeKay in 1842. This too was soon observed to be a mistake since *cornutus* had no affinity with the *Leuciscus* group. *Cornutus* then passed through several genera before being placed in the genus *Hypsilepis* by Cope (1867). Jordan (1876) reviewed Rafinesque's "Ichthyologia Ohiensis" and concluded that both *Luxilus chrysocephalus* and *Rutilus plargyrus* were synonyms of *Hypsilepis*, with both having precedence over *Hypsilepis*. However, since *Rutilus* contains only old world species not closely related to this particular group, the genus *Luxilus* and species *cornutus* were selected as the valid name for the common shiner.

Gilbert (1884) proposed that the genus *Notropis* be accepted for the group, and subsequently Jordan (1885) published a subgeneric classification to distinguish the various subgroups, including *Luxilus*. Hubbs (1926) discussed the forms *Notropis cornutus cornutus*, *N. c. frontalis*, and *N. c. chrysocephalus*, and reported *N. c. cornutus* to be an intermediate form in appearance. Additional details of the early taxonomic

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problems of the common shiner and other members of the subgenus *Luxilus* are presented in Gilbert (1960).

The question of species distinction between the *cornutus* forms was raised by Gilbert (1960, 1961) and *chrysocephalus*, the central common shiner, was elevated to species status. The *cornutus* group in this proposed classification (Gilbert, 1960) consisted of *Notropis cornutus cornutus* (Mitchill), *N. c. albeolus* Jordan (previously *N. albeolus* Jordan, the white shiner), *N. chrysocephalus chrysocephalus* (Rafinesque) (previously *N. cornutus chrysocephalus* (Rafinesque)), and *Notropis chrysocephalus isolepis* (previously *N. cornutus isolepis*). *N. c. albeolus* Jordan was subsequently returned to species status in a later revision (Gilbert, 1964).

In elevating *chrysocephalus* to species status, Gilbert (1961) cited physiological differences, ecological separation and intergradation in sympatric areas along with morphological characters. These latter characters included relative size and arrangement of the predorsal and anterior dorsolateral scales, the number of circumferential scales, dorsal color patterns and chin pigmentation. The common shiner, *cornutus*, is characterized by small and unevenly situated predorsal and anterior dorsolateral scales, and a combined scale count range of 48-59 in 90% of all specimens (extremes 42-67). A pair of wide, light olive stripes extend down the dorsal surface of the back parallel to the median dorsal septum and there is an absence of pigment on the chin and anterior gular areas. *Chrysocephalus* has larger and more evenly arranged predorsal and anterior dorsolateral scales, a combined scale count of 40-44 (38-48) in 90% of the specimens, as many as 3 pairs of dorsal stripes parallel to the dorsal midline, and distinct chin and gular pigmentation.

The purpose of this study was to analyze these characteristics on common shiners in Kentucky and present an opinion on the taxonomic status of that form.

MATERIAL AND METHODS

Specimens used in this study were taken from the collections of the Biology Departments of the University of Louisville, Western Kentucky University and Eastern Kentucky University, and the Water Resources Laboratory of the University of Louisville. These specimens represented intensive stream studies on the Salt River, Drake's Creek and the Red River, as well as samples from the Ohio River and streams throughout the state. The counties from which collections of common shiners were examined are shown in Fig. 1. The collections included more than 3400 fish, of which 1900 were examined for dorsal stripe configuration and chin pigmentation, and 411 for the above characters and anterior dorsolateral and circumferential scale counts. Scale counts were made as outlined by Gilbert (1961).

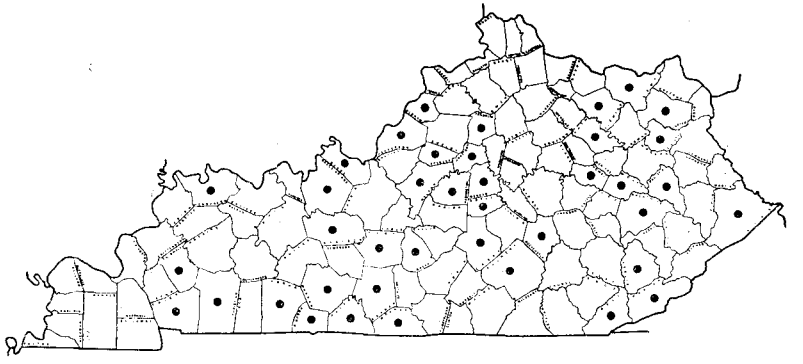

FIGURE 1. Map of Kentucky showing counties where collections of common shiners were analyzed for circumferential and anterior dorsolateral scales and/or dorsal stripe configuration and chin pigmentation.

Stream	County	Catalog No.	Combined Scale Counts												
			37	38	39	40	41	42	43	44	45	46	47	48
Barren River	Allen	U.L. 6446				2	1		1	1				
Long Creek	Allen	U.L. 6870 U.L. 11798			1	1	4	1						
	Allen-Barren	U.L. 11946					1	2						
Salt River	Anderson				2	4	7	5	11	4	5	1	1	
Hammond's Creek	Anderson	W.K.U. 00019			1	2					2	1		
Trammel Ck.	Barren	W.K.U. 00105						1	1					
Slate Creek	Bath	U.L. 6166				2			1					
Yellow Ck.	Bell	U.L. 7767						1		1	3			
Bear Branch Creek	Breathitt	E.K.U. 128				1		1	1	1			1	
Lamb's Ck.	Caldwell	UL 5109		1		3		1						
Tygarts Ck.	Carter	U.L. 12980						3				1	1	
Little Sandy River	Carter	U.L. 12451 12417 12409 12261		2	1	4	7	3	2	1				
Green River	Casey	U.L. 6163 6171				1	3	5	1					
Trace Creek	Casey	U.L. 6169		1			1	1	2					
	Christian	U.L. 6851					2	1		2				
Sinking Ck.	Christian	U.L. 10779	1			2			1					
Little Sandy River	Elliot	U.L. 12385			1	2		1	1					
North Fork River	Fleming-Lewis	U.L. 5130						2	2					
Elkhorn Ck.	Franklin	U.L. 10473 U.L. 12621			2	2		2	1					
Green River	Green	U.L. 11911				1	1	2			1			
Bacon Ck.	Hart	U.L. 1441					1							
Ohio River	Henderson	U.L. 8825	1		1	4	3		1					
Pope Lick Creek	Jefferson	U.L. 1093					1	1	2	1				
Ohio River	Jefferson	U.L. 8205						1						
Beargrass Creek	Jefferson	U.L. 6851			1				3		1			
Goose Ck.	Jefferson	U.L. 7071				1	3		1					
Little Goose Creek	Jefferson	U.L. 7056			1	1	2	1						
Greasy Ck.	Leslie	U.L. 11832 U.L. 11558				1	2	1	1					
Bethel Ck.	Lewis	U.L. 6969			1	2	2							
Kinniconic Creek	Lewis	U.L. 7000				2		2	1					
Whiporwill Ck.	Logan	U.L. 5433				1	1		1	2				
Licking River	Magoffin	U.L. 12518				1	1	1			1			
Doe Run	Meade								1					

TABLE 1. Combined circumferential and anterior dorsolateral scale counts of populations of common shiners in Kentucky

Stream	County	Catalog No.	Combined Scale Counts											
			37	38	39	40	41	42	43	44	45	46	47	48
Salt Lick Ck.	Monroe	U.L. 5583			1	1			2		1			
Shake River	Nelson	U.L. 12246			1		1	1						
Harrods Ck.	Oldham	U.L. 76, 143 U.L. 11667 U.L. 1522 U.L. 1284				6	5	7	1					
Big Sandy River	Pike	E.K.U. 60				3			1			1		
Red River	Powell-Wolf	E.K.U. 19,126 99, 17, 119, 101 50, 43, 93, 120, 25 U.L. 63			3	6	9	11	8	5	2		2	
Buck Creek	Pulasky	E.K.U. 27							1					
Clear Ck.	Rockcastle	E.K.U. 214, 216 217		2	2	1	3	2	4	1				
Rockcastle River	Rockcastle	U.L. 5167					1		1	1				
Spring	Simpson	U.L. 5470				1	2		1	1				
Drake's Ck.	Simpson, Warren	W.K.U. 00489, 00455, 00741, 00425 00067, 00506, 00522, 00119, 00210, 00051, 00134, 00153				2	7	14	9	14	3	1	1	
Plum Ck.	Spencer	W.K.U 00186							2					
Belcher Ck.	Warren	W.K.U. 00241 00235, 00227			1	2	1	5			1			
Litle Difficult Creek	Warren	00246						3	1	1				
Ivy Ck.	Warren	W.K.U. 00306 00314, 00270					3	2	3					
Indian Ck.	Warren	W.K.U. 00377, 00392, 00411			2		1	3	3	2	1		1	1
Salt Lick Creek	Warren	W.K.U. 00177						1	1	2		1		
Brush Ck.	Warren	W.K.U. 00219					1	1	1	1			1	
Chism Ck.	Warren	W.K.U. 00345						2	3					
Lick Ck.	Warren	W.K.U. 00200			1		2							
Jenning's	Warren	W.K.U. 00356				1		1		1				

TABLE 1. (cont.). Combined circumferential and anterior dorsolateral scale counts of populations of common shiners in Kentucky.

RESULTS

Most of the specimens examined exhibited multiple dorsal stripes that merged toward the median dorsal septum posterior to the dorsal fin, and prominent chin pigmentation as described by Gilbert (1961) for *chrysocephalus*. However, many specimens had faintly developed dorsal lines or none at all. Likewise, a great degree of variation in the pattern of chin pigmentation was observed, ranging from only slightly pigmented on the chin to heavily pigmented as far posterior as the gular region. Variation in the size of individual chromatophores was also observed.

The combined number of anterior dorsolateral and circumferential scales ranged from 37 to 48 with a mode of 42 (Table 1). Eighty-four percent of the fish counted had scale totals ranging from 40 to 44. Of

the 16% outside this range, 9% had totals between 45 and 48. Fish lengths ranged from 36 to 205 mm total length.

No noticeable pattern of variation was noted between fish from the Ohio River and Kentucky streams, between collections taken within the state, and between headwater and midstream areas of the Salt River and Drake's Creek.

DISCUSSION

The results of this study, with the exception of dorsal stripe disappearance and the higher percentage of combined scale counts outside the 40-44 range, generally agree with Gilbert's (1961, 1964) description of *chrysocephalus*. These findings are similar to the results of Gilbert's earlier study (1960) of populations of shiners in the *cornutus* complex in Kentucky. However, the degree and distributional pattern of variation exhibited by the various forms of this shiner complex throughout the central United States (Gilbert, 1960, 1964) and the findings of other investigators (Miller, 1968; Menzel, 1970) makes the elevation of *chrysocephalus* to species status questionable.

Based on the distribution and meristic complements of shiner populations presented by Gilbert (1964), it is the opinion of the authors that the common shiner populations form a broad cline extending from the Gulf Coast northward to the Great Lakes region, with the *chrysocephalus* form inhabiting the southern portion of this region and blending into the *cornutus* form extending northward. Interpopulation variations in pigmentation patterns and scale counts throughout the range, seem to result from differing environmental conditions. Similar traits described by Mayr (1963) are considered to be nonadaptive, "neutral" phenotypes that are established and supported by natural selection.

The general pattern of increasing scale counts in fish populations from south to north as seen in the *cornutus–chrysocephalus* complex (Gilbert, 1960, 1964) is consistent with the ecogeographical rule (Lagler et al., 1963) which states that fishes at the southern extent of broad ranges tend to have fewer meristic elements than their northern counterparts due to shortened developmental times. These patterns in certain cases, may be correlated with temperature as shown by abrupt meristic changes produced experimentally in the smallmouth bass in one generation through temperature manipulation (Castro, 1963; Wallace, 1965). Consequently, the biological, significance of these rapidly changing characters as indicators of species distinction becomes highly suspect.

Gilbert (1961) justified the elevation of *chrysocephalus* to species status on the basis of the following points: intergrading populations of subspecies should show a normal blending of morphological characters and although this is approached in certain instances in this complex, in others the populations remain distinct; temperature tolerances differ from north to south and are greater than one would expect from subspecies; in some areas *cornutus* populations have been completely replaced by *chrysocephalus;* relict populations of *cornutus* exist in *chrysocephalus* territory; distribution patterns of both forms suggest a long separation, possibly of sufficient duration to allow separation to the species level.

Miller (1968) reported that the elevation of *chrysocephalus* to species status was unwarranted and that the various forms of this complex may best be considered as subspecies that have diverged to a level below that of full species. In Miller's opinion, Gilbert's critical weakness in his argument for elevating these forms to species level is based not on how these forms fulfill the criteria for being recognized as species but on how poorly they fulfill the criteria for being recognized as subspecies. Gilbert's above points for justification of species status are interpreted in an alternate manner by Miller (1968) on the basis of the following points: that some character blending and complete population separation may occur in the same area where secondary intergradation has occurred and complete speciation has not been reached; temperature tolerance differences are not sufficient to support species recognition; geographic replacement of *cornutus* populations by *chrysocephalus* is due to the

physiological differences in temperature tolerance between the two forms and the recent amelioration of the climate and corresponding northward expansion of southern forms. According to Miller, Gilbert fails to show that subspecies cannot compete, explaining the mutual exclusion of one form while also neglecting to show that good species reduce competition by reducing niche overlap and consequently would not replace each other. Lastly, imperfect amalgamation of both forms in sympatric areas suggest that reproductive isolation has not occurred long enough for complete speciation.

Recent evidence by Menzel (1970) also sheds doubt on the species status of *chrysocephalus*. In studies involving both meristics and electrophoretic analyses of blood proteins and enzymes, *cornutus* and *chrysocephalus* appeared to be related at the infraspecific level.

In interpreting the variations in members of the *cornutus–chrysocephalus* complex in terms of environmental influences and nonadaptive changes, many of the points of dispute of Gilbert (1961) and Miller (1968) are explainable. Miller (1968) stressed the importance of a cautious approach to the *cornutus–chrysocephalus* complex on the basis that these shiners are among the most widespread and abundant minnows, and that many conclusions, some unjustified, have been drawn as to whether two interbreeding forms can best be considered as species or subspecies. From an examination of the available information on this subject, the most reasonable approach to the members of the *cornutus–chrysocephalus* complex is to treat them as geographical variants of one species rather than as distinct species. If future research on these forms proves conclusively that throughout the range the variation is entirely of an environmental and not a genetic basis then the populations should not even be accorded subspecific status. However, at this time, it is our belief that the correct nomenclature for the common shiner in Kentucky should be *Notropis cornutus chrysocephalus*.

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THE SPAWNING BEHAVIOR, FECUNDITY RATES, AND FOOD HABITS OF THE REDBREAST SUNFISH IN SOUTHEASTERN NORTH CAROLINA [1]

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ABSTRACT

Redbreast sunfish *Lepomis auritus* (Linnaeus) were found to spawn during June at water temperatures of 71° to 78°F. Redbreast sunfish redds were almost identical in design and size in the Lumber, Waccamaw, and the South Rivers. Each redd was located in or near a sheltered area such as a log, fallen tree, or stump. The preferred bottom substrate for spawning was sand and small gravel. No redds were observed in silt or detritus.

Age II, III, IV, V, and VI year redbreast sunfish had mean egg counts of 963, 1,000, 3,563, 5,620, and 8,250, respectively, with corresponding standard deviations of 88.4, 435.9, 763.1, 851.9, and 278.4.

The most important food items found in the redbreast sunfish stomachs were aquatic insects, represented by Coleoptera, Odonata, and Ephemeroptera. It appeared that redbreast sunfish were selective and preferred the larger mayfly, dragonfly, and beetle larvae found in the streams. When confined to aquaria, redbreast sunfish preferred live food items such as worms, crickets, grubs, and grasshoppers over artificial foods.

INTRODUCTION

The redbreast sunfish *Lepomis auritus* (Linnaeus) is a highly prized game fish in the inland waters of North Carolina and is a significant game fish in North Carolina's Coastal Plain streams. The redbreast sunfish is found inland along the east coast of North America from New Brunswick to Florida, and inland along the Gulf States to Texas.

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