HYBRIDS BETWEEN THE CYPRINODONTID FISHES, *FUNDULUS NOTATUS* AND *FUNDULUS OLIVACEUS* IN SOUTHERN ILLINOIS

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ABSTRACT. — Three *Fundulus notatus* X *Fundulus olivaceus* from the Little Saline River were generally intermediate between the parent species but had unusually broad heads. These were the only hybrids found out of 805 specimens examined. *Fundulus notatus* outnumbered *F. olivaceus* by 10 to 1 at the hybrid locality. Rare local hybridization thus may have an effect on *F. olivaceus*.

Reports of natural hybrids of cyprinodontid fishes are few. Hubbs, Walker and Johnson (1943) reported one *Fundulus diaphanus* X *Fundulus heteroclitus*, one *Fundulus sciadicus* X *Fundulus* (as *Plancterus*) *kansae*, and four *Lucania* (as *Chriopeops*) *goodei* X *Lucania parva* specimens. Two *Fundulus notatus* X *Fundulus olivaceus* hybrids have been previously reported (Thomerson, 1966), one from Louisiana, the other from Mississippi. These seeem to be the only reliable reports of North American cyprinodontid hybrids.

Even though natural cyprinodontid hybrids are rare, several workers have had considerable success in making experimental crosses between various species of *Fundulus* (see Hubbs and Drewry, 1959, for a review). Particular success has been realized in obtaining *F. notatus* X *F. olivaceus* hybrids by placing a ripe male of one species with a ripe female of the other in an aquarium and allowing them to spawn "naturally" (Thomerson, 1966). The resulting hybrids were vigorous, fertile, sexually active and were spawned successfully with other hybrids and backcrossed with both parent species.

This paper reports an additional three specimens of *F. notatus* X *F. olivaceus* taken in southern Illinois and compares them with their parent species and the laboratory hybrids described by Thomerson (1966).

HYBRID ANALYSIS

The three hybrids were collected 30 Sept. 1966 from the Little Saline River at U. S. Hwy. 45 in Saline Co., Ill. An effort had been made to collect as many *Fundulus* as possible for another study and 128 *F. notatus* and 12 *F. olivaceus* were taken in addition to the hybrids. The three hybrids were males, as were the two previously reported natural hybrids (Thomerson, 1966), and about the same size (40.7, 39.2, 37.2 mm Standard Length, respectively) as the young of the year *F. olivaceus* taken with them.

A comparison of parental populations and laboratory-reared hybrids was given by Thomerson (1966, Table 10., p. 42), who found male hybrids were intermediate in dorsolateral spotting and general appearance but tended to have

broader heads and more anal fin spots than males of either parent species. The laboratory hybrids resembled *F. notatus* in number of anal rays and lateral scales but resembled *F. olivaceus* in number of lateral stripe extentions. Both Braasch and Smith (1965) and Thomerson (1966) agreed there were significant differences in average number of dorsal rays between Upper Mississippi Valley populations of *F. notatus* and *F. olivaceus*. However, there was no significant difference in this character between the populations where Thomerson obtained the parents of his experimental hybrids.

These characters were studied for the three Little Saline River hybrids and for samples of the *F. olivaceus* and *F. notatus* collected with them. Counts and measurements were made as described by Thomerson (1966) except as noted below.

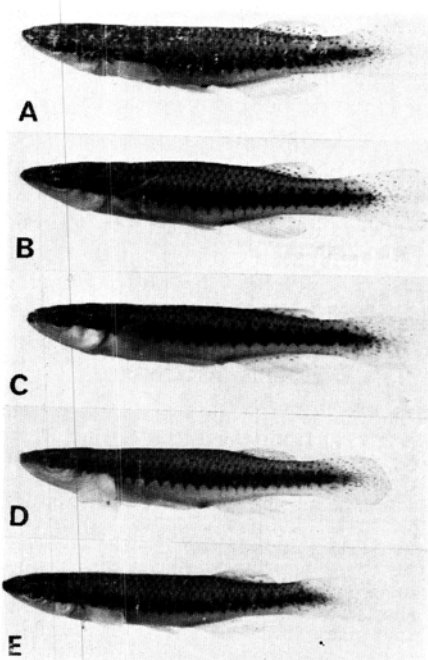

FIGURE 1. — Little Saline River hybrids and males of the parent species from the same collection. A—*Fundulus olivaceus* male, 40.7 mm SL. B, C, D—*Fundulus notatus* X *Fundulus olivaceus* males; 39.2, 37.2, and 40.7 mm SL respectively. E—*Fundulus notatus* male, 35.0 mm SL.

The hybrids were first recognized on the basis of their distinctive intermediate color pattern (FIG. 1.). Specimens of *Fundulus olivaceus* have a variable number of distinct, regular dark dorsolateral spots; specimens of *F. notatus*, on the other hand, are often immaculate, but may have scattered, dusky irregular dorsolateral spots or blotches. The hybrids had regular dusky dorsolateral spots. The four *F. olivaceus* males collected with the hybrids had 48, 46, 32, and 32 dorsolateral spots respectively (all spots counted on left side). The three hybrids had 43, 38, and 21 spots respectively. Though larger *F. olivaceus* males, and possibly hybird males as well, tend to have more dorsolateral spots than small males, these males were of similar size, and thus size was probably not responsible for the differences in number of dorsolateral spots. One of the Little Saline River hybrids had fewer spots than any of the *F. olivaceus* males in the same collection. The other two hybrids had more spots than two of the four *F. olivaceus* males. Laboratory male hybrids tended to have an intermediate number of dorsolateral spots (Thomerson, 1966), and a larger sample of natural hybrids might show a stronger trend toward intermediacy.

Little Saline River *F. notatus* had the dorsal scales sharply outlined with melanophores and the dorsum thus had a crosshatched appearance. *Fundulus olivaceus* from this collection had poorly defined scale outlines and their dorsums had a fairly uniform dusky cast. The dorsum of the hybrids was intermediate in pattern. Neither the hybrids nor the *F. olivaceus* in this collection had the line of predorsal spots or dashes seen in spotted or blotched *F. notatus*.

Fundulus olivaceus males from this collection had a reduced number of ex tentions to the rear one third of the lateral stripe. The *F. notatus* males and the three hybrids had strongly developed extentions to this portion of the lateral band.

Although average head width of the laboratory hybrids was significantly greater than that of samples from either parent population, there was considerable overlap (Thomerson, 1966). Relationship of head width of the three Little Saline River hybrids to those of samples of *F. notatus* and *F. olivaceus* collected with them is shown in FIGURE 2. There is no sexual dimorphism in

TABLE 1.—Comparison of Meristic Characters of the Little Saline River Hybrids and the Parent Species.

		Dorsal Rays		Anal Rays			Lateral Scales				
	Number	9	10	11	12	13	32	33	34	35	36
Hybrids	3	1	2	1	1	1	....	1	2	....	....
F. olivaceus	11	1	10	2	7	2	1	1	5	3	1
F. notatus	11	8	3	....	9	2	4	5	....	2	....

this character and seven females are included in the *F. olivaceus* sample. The hybrid sample is small for statistical treatment but it seems clear that they have the same relationship to their parent populations as did the laboratory hybrids.

There were no appreciable consistent differences in anal fin spotting between the Little Saline River *Fundulus* males.

Dorsal ray, anal ray, and lateral-scale counts are given in TABLE 1. Two of the hybrids had 10 dorsal rays, the usual number for Upper Mississippi Valley *F. olivaceus;* the other had 9 dorsal rays, the usual number for *F. notatus* in this region. The three hybrids had different anal ray numbers. The range of variation in this character (11-13) was the same as seen in 167 Mississippi River sissippi River *F. olivaceus* (see Tables *F. notatus* and in 269 out of 270 Mis-2 and 6, Thomerson, 1966). Two of the hybrids had 34 lateral scales, the usual number for Mississippi River *F. olivaceus*, and the other had 33 lateral scales, the usual number for Mississippi River *F. notatus* (see also Tables 4 and 8, Thomerson, 1966).

Relationships between the parental stocks and the Little Saline River and laboratory hybrids are summarized in TABLE 2.

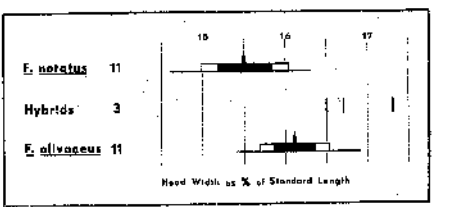

FIGURE 2.—Comparison of head widths for the Little Saline River hybrids and samples of the parent species from the same collection. Drawn following Hubbs and Hubbs (1953).

TABLE 2.—Relationship of the Little Saline River and Laboratory Hybrids to Parental Stocks of *Fundulus notatus* and *Fundulus olivaceus.*

Character	Experimental Hybrids (Thomerson, 1966)	Little Saline River Hybrids Three Males
Dorsolateral spots	Intermediate	Intermediate (?)
Head width	Very broad	Very broad
Anal fin spots	More than either	Same as both
Lateral scales	*F. notatus*	*F. olivaceus* (?)
Lateral stripe extentions	*F. olivaceus*	*F. notatus*
Dorsum pattern	Intermediate	Intermediate
Dorsal rays	Both	*F. olivaceus* (?)
Anal rays	*F. notatus*	Both (?)

Discussion

Even though *F. notatus* and *F. olivaceus* have overlapping ranges (Thomerson, 1966, Figure 1, p. 30) and have similar behavior and appearance, they are seldom syntopic. There is, however, an area in the southern parts of Illinois and Missouri where the two species occur together. Braasch and Smith (1965) reported that about 10% of some 235 collections of the two species from this general area included both species. These sympatric (and presumably syntopic) collections included 333 *F. notatus* and 108 *F. olivaceus* (data from Braasch and Smith, 1965, Table 1), and most came from the Saline River and Big Muddy River drainages in Southern Illinois. Braasch and Smith did not consider any of their material to be of hybrid origin. I have re-examined most of this material and found no hybrids.

I have examined an additional 290 *F. notatus* and 71 *F. olivaceus* from other Upper Mississippi Valley sympatric collections. The three hybrids reported here were the only ones found. This is in accordance with my earlier data (Thomerson, 1966) on this hybrid combination in nature and indicates that even when *F. notatus* and *F. olivaceus* occur together, mismating and production of hybrids are rare.

In many respects these hybrids support the ideas on hybridization in freshwater fishes detailed by Hubbs (1955). They are of intermediate appearance between the two parent species but have one character, head width, which tends to extend beyond the limits of the parental species — perhaps a reflection of hybrid vigor. They come from a locality that is marginal for *F. olivaceus* and where it is outnumbered by 10 to 1 by *F. notatus*. The locality has been somewhat modified by the building of the Hw. 45 bridge, and by farming in the drainage basin.

The five *F. notatus* X *F. olivaceus* that have been reported were all small males. This fact suggests that in nature this hybrid combination may tend to have an unbalanced sex ratio, though this was not seen in the laboratory-reared hybrids (Thomerson, 1966). All five hybrids were probably young of the year; the largest was 40.7 mm Standard Length. Male *F. notatus* may be mature at this size but male *F. olivaceus* seldom are. This observation suggests that hybrids may not survive to reproduce in nature.

Sympatric collections known from the Upper Mississippi Valley include a total of 805 *Fundulus;* 623 *F. notatus,* 179 *F. olivaceus* and the three hybrids. This very low hybrid percentage shows that isolating mechanisms exist which are quite effective even when the two species occur together, even though they readily hybridize in the aquarium.

Hybridization does not seem to be important except as a local phenomenon. However, the effects may be quite large in a given area. *Fundulus olivaceus* is usually the least abundant of the two species in sympatric collections, particularly in the Saline and Big Muddy Rivers.

If my number of fish collected is representative of the number of *Fundulus* present, and there is no reason

to think otherwise, then some conclusions may be drawn on the effect of hybridization on either parent species. Of the 12 *F. olivaceus* collected at the Little Saline River locality, 11 were young of the year. To the three hybrids are added, total *F. olivaceus* reproduction represented is 14. Moreover, 127 of the 128 *F. notatus* were young of the year. Matings involving *F. notatus* thus produced 130 young, including the three hybrids. The hybrids represented 21% of the *F. olivaceus* reproductive potential but only 2% of the *F. notatus* potential If the hybrids in fact do not survive to reproduce, then at this rate hybridization alone would soon eliminate the local *F. olivaceus* population. If the hybrids have only reduced survival of reproductive potential, the effects are still 10 times as great on the *F. olivaceus* as on the *F. notatus*. Preliminary experiments indicate that the isolating mechanisms involve species recognition ability coupled with mate selection. It will be interesting to find out if these mechanisms are more highly refined in *F. olivaceus* from the sympatric area than in *F. notatus*.

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Literature Cited

Braasch, M. E., and P. W., Smith. 1965. Relationships of the topminnows *Fundulus notatus* and *Fundulus olivaceus* in the Upper Mississippi River Valley. Copeia 1965 (1): 46-53.

Hubbs, C. L. 1955. Hybridization between fish species in nature. Syst. Zool. 4: 1-20.

———, and Clark Hubbs. 1953. An improved graphical analysis and comparison of series of samples. Syst. Zool. 2: 49-56, 92.

———, R. W. Walker, and R. E. Johnson. 1943. Hybridization in nature between species of American cyprinodont fishes.
Cont. Lab. Vert. Biol., Univ. Michigan (23): 1-21, Pl. I-VI.

Hubbs, C., and G. E. Drewry. 1959. Survival of F hybrids between cyprinodont fishes, with a discussion of the correlation between hybridization and phylogenetic relationship. Bull. Inst. Mar. Sci. U. Texas 6: 81-91.

Thomerson, J. E. 1966. A comparative biosystematic study of *Fundulus notatus* and *Fundulus olivaceus* (Pisces: Cyprinodontidae). Tulane Stud. Zool. 13(1): 29-47.

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