HYBRIDIZATION BETWEEN THE PALLID AND SHOVELNOSE STURGEONS

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ABSTRACT

Additional shovelnose (*Scaphirhynchus platorynchus*) and pallid (*S. albus)* sturgeon hybrids are reported from the Missouri River, the middle Mississippi River, and the headwaters of the Atchafalaya River. Studies conducted throughout the range of the endangered pallid sturgeon in 1991 and 1992 found a high incidence of hybridization in the Mississippi (86.4%) and Atchafalaya rivers (43.8%). One possible hybrid was also found in the impounded section of the Missouri River in South Dakota where hybrids had not been previously reported. Few hybrids showed intermediacy in all characterictics as would be expected in a first generation cross. Data is provided to show the variability in individuals judged to be hybrids in relation to accepted morphometric proportions for parent stock. Male hybrid sturgeon are also reported where previous studies had found only female hybrids. Natural hybridization occurs over half of the range of the pallid sturgeon.

INTRODUCTION

The shovelnose sturgeon *Scaphirhynchus platorynchus* and pallid sturgeon *S. albus* are endemic to large rivers and are sympatric throughout the Missouri River and middle and lower Mississippi River, which represents the range of the pallid sturgeon (Bailey and Cross, 1954; Carlson et. al., 1985). The first report of hybridization between the two species was made by Carlson et. al. (1985) from sturgeon specimens collected from the lower Missouri River and Mississippi River in Missouri in 1978 and 1979. Warren et. al. (1986)

reported finding a possible hybrid between these species from a specimen collected from the Mississippi River in Kentucky in 1984. Carlson et. al. (1985) attributed hybridization between these species as a recent phenomenon due to man-made modification of the river environment and stated that hybridization may be a threat to the survival of the rare pallid sturgeon, a threat also identified as a factor in listing the pallid sturgeon as a federally endangered species in 1990 (*Federal Register*, September 6, 1990).

Reports of hybridization in fishes have been based on the finding of specimens that are intermediate in morphometric characters of presumed parent species (Campton, 1987). For pallid and shovelnose sturgeon, the mutually exclusive morphometric ratios and meristic counts found by Bailey and Cross (1954) have been used to identify interspecific hybrids. We report additional hybrid individuals from the channelized Mississippi River, the finding of hybrids in the Atchafalaya River where they were not previously reported, a hybrid from the impounded Missouri River where hybrids between these species had not been previously reported, the finding of male hybrids that had not been previously known to occur, and report on the variety in characteristics that suggests that hybridization may be occurring beyond first generation crosses.

METHODS AND MATERIALS

A total of 145 pallid sturgeon, including 47 presumed pallid sturgeon - shovelnose sturgeon hybrids were identified during 1991 and 1992. These collections were part of a cooperative effort between state and federal biologists from throughout the range of the pallid sturgeon to gather biological data for recovery planning for this rare species.

Six morphometric measurements that Bailey and Cross (1954) had found useful in distinguishing between the two species were obtained. Head length (HL), mouth width (MW), distance between the mouth to the inner barbel (MIB), inner barbel (IB) and outer barbel (OB) lengths, and distance from the tip of the rostrum to the outer barbel (interrostral length, I) were all recorded to the nearest millimeter. Morphometric ratios that Bailey and Cross (1954) had found to be mutually exclusive between these species were calculated by dividing the mouth width, interrostral length, and head length by the mouth to inner barbel distance and the outer barbel length, the interrostral length, and the head length by the inner barbel length.

Dorsal fin (DF) and anal fin (AF) ray counts were also obtained on most of the hybrids. Since the pallid sturgeon is an endangered species, and permit requirements were that these fish were not to be unnecessarily harmed when being studied, fin ray counts were not

normally collected on pallid sturgeon since they needed to be returned to the water. Bailey and Cross (1954) had found fin ray counts to also be a mutually exclusive characteristic between the species but noted the great difficulty in obtaining accurate fin ray counts without scraping tissues and without having enhanced lighting and visual aids capabilities not normally available in the field.

Six hybrid sturgeon collected from the Atchafalaya River in Louisiana near the control structure connecting the Atchafalaya with the Mississippi River; nine hybrids taken from the Mississippi River near Chester, Illinois; and fifteen hybrids obtained from the Mississippi River near Caruthersville, Missouri, are being held by the U. S. Fish and Wildlife Service in Bismarck, North Dakota, and by the Missouri Department of Conservation at Columbia, Missouri, as voucher specimens. The hybrid sturgeon found in South Dakota remains in the wild and was one of the specimens used to obtain telemetry information on habitat use of pallid sturgeon in Lake Sharpe, a Missouri River impoundment (Erickson, 1992). Measurements were collected on the remaining hybrids before they were released; however fin ray counts were not obtained because of the difficulty of obtaining accurate counts on live fish.

RESULTS

Nearly one in three (32.4 percent) of the *Scaphirhynchus* specimens examined in 1991 and 1992, and not identified as shovelnose sturgeon, were considered as showing hybrid characteristics. One hybrid was found in the Missouri River from 76 specimens examined (1.3 percent), whereas 32 of 37 (86.4 percent) of the Mississippi River fish collected, and 14 of 32 (43.8 percent) sturgeons collected from the Atchafalaya River were found to possess hybrid characteristics. This compares to 12 hybrids and 11 pallid sturgeon (52.2 percent) collected in 1978 and 1979 by Carlson et. al. (1985) from the lower Missouri River near Kansas City (2) and St. Louis (2) and the Mississippi River above St. Louis (7) and near Cairo, Illinois, close to the mouth of the Ohio River (1). Warren et. al. (1986) report one hybrid in 7 sturgeon (14.3 percent) collected from the Mississippi River in 1985 near Columbus, Kentucky, (between Chester and Caruthersville in our studies).

Table 1 contains information on 31 of 47 fish we examined that did not fit the mutual exclusivity characteristics between the species as described by Bailey and Cross (1954). Bailey and Cross (1954) found that shovelnose sturgeon had between 30 and 36 dorsal fin rays while the pallid sturgeon possessed from 37 to 43 rays. Shovelnose sturgeon had 18 to 23 anal fin rays while pallid sturgeon had 24 to 28. These authors found the MW/MIB ratio was 1.07 to 1.42 for shovelnose

sturgeon and 1.63 to 2.00 for pallid sturgeon, the I/MIB ratio 1.27 to 2.19 and 2.29 to 3.26 respectively, and the HL/MIB 4.00 to 5.04 and 5.54 to 7.00 respectively. They found the OB/IB ratio to be 1.17 to 1.48 for the shovelnose and 1.72 to 2.41 for the pallid sturgeon the I/IB ratio 1.26 to 2.50 and 2.63 to 3.73 respectively, and the HL/IB ratios 3.65 to 5.76 and 6.35 to 8.00 respectively. To simplify our table, we note only whether the specimen fits under pallid (P) or shovelnose (S) criteria for fin rays, since no intermediacy value exists for these characteristics, but also show an intermediate (I) value for morphometric ratios if the specimen fits between the given ranges of values identified for the parent species.

While Carlson et. al. (1985) found their hybrids to be intermediate in characteristics, in accordance with the Bailey and Cross (1954) data, our fish showed a wide variety of mixtures of intermediacy along with characteristics that would fit under one or both of the parent species. Carlson et. al. (1985) presumed that their specimens were first generation crosses because of the intermediacy between parent stocks and, since all their specimens were female, presumed that the offspring may be infertile.

None of our fish were intermediate in every ratio, and no particular pattern seems to emerge as to which characteristic remains intermediate. Of the two divisors for developing ratios, the mouth to barbel distance identified more intermediacy (as also shown in Table 1). We conclude that increased distance of barbel placement in relation to distance from the mouth is more characteristic of hybrids than the length of the inner barbels.

Figure 1 contains photos of the barbel placement of a pallid sturgeon, a shovelnose sturgeon, and a specimen that showed hybrid characteristics. Both Bailey and Cross (1954) and Pfleiger (1975) noted that the shovelnose sturgeon has its barbels placed in a straight line approximately halfway between the mouth and the tip of the rostrum while the pallid sturgeon has barbels in an arched form about a third of the distance between the mouth and the tip of the rostrum. Both authors also noted the distinct differences in lengths between the inner and outer barbels of the pallid sturgeon and the nearly equal length of inner and outer barbels for the shovelnose sturgeon. In the particular hybrid we show, barbel placement is more like that of the shovelnose in that the barbels are more forward on the rostrum; but the slight forward placement of the inner barbels also is obvious, which is characteristic of the pallid sturgeon. The differences in lengths between the inner and outer barbels show the intermediacy on the hybrid. The difference in the relative distance between the placement of the barbels between the mouth and the inner barbel is quite apparent between this hybrid and the barbel location for the pallid sturgeon.

Table 1. Variability of meristic and morphometric characters of 31 hybrid sturgeon collected from three river systems in 1991 and 1992. Variable abbreviations are provided in text. P is pallid, S is shovelnose, and I is an intermediate characteristic according to Bailey and Cross (1954). An asterisk indicates a male specimen.

Meristic counts		Morphometric ratios					
DF	AF	MW/MIB	I/MIB	HL/MIB	OB/IB	I/IB	HL/IB
		Missouri River					
P	P	I	S	I	I	P	P
		Mississippi River -- Chester					
S	S	P	P	I	I	S	S
S	P	I	P	I	I	S	S
S	P	S	S	S	I	S	S
P	P	I	I	S	P	S	S
P	P	I	I	I	P	S	I
P	P	I	P	P	I	S	S
P	P	P	P	P	P	P	S
P*	S	P	P	I	P	P	P
		Mississippi River -- Caruthersville					
S	S	I	S	S	S	S	S
S	S	S	S	S	S	I	S
P	P	P	P	P	P	P	I
P	S	P	I	P	I	S	S
S	S	I	S	S	I	S	S
P	S	S	S	S	S	S	S
S	P	S	S	S	S	S	S
S	S	S	S	I	S	S	S
P	P	I	I	I	I	S	S
S	S	I	S	S	S	S	S
P	P	I	I	I	P	S	S
S	S	S	I	I	S	S	S
S	S	P	P	I	P	S	S
S*	S	S	S	S	P	S	I
S*	S	I	P	I	P	S	S
P	P	P	P	S	P	P	I
		Atchafalaya River					
S*	S	S	I	S	P	P	P
S	S	S	I	I	P	P	P
P	S	I	P	P	S	S	S
P	P	P	S	I	P	S	S
P*	S	S	S	S	P	I	I
S	S	P	P	P	S	S	S

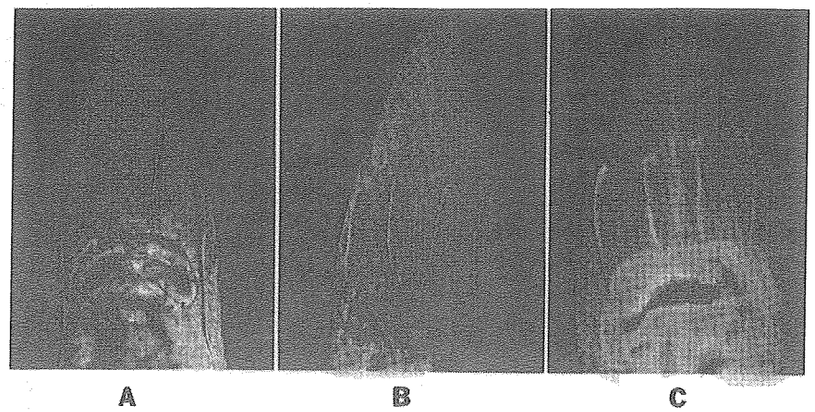

Figure 1. Photograph of rostrum of pallid (A), shovelnose (C), and hybrid (B) sturgeon showing relative barbel size and placement.

Carlson et. al. (1985) found only female hybrids in their studies. Most of our specimens were also females; however, several males also exhibited hybrid qualities (Table 1). This information, coupled with the observation that we are finding a broad mixture of morphometrically recombinant types in the hybrids suggests to us that crossing may be occurring between hybrids and hybrids or between hybrids and parent species (Campton, 1957).

DISCUSSION

Hubbs (1955) indicated that the frequency of natural hybridization in fish was a function of the environment, and the seriousness of consequences of hybridization were dependent on hybrid viability. Hybridization can occur in fish if spawning habitat is limited, if many individuals of one potential parent species live in proximity to a limited number of the other parent species, if spawning habitat is modified and rendered intermediate, if spawning seasons overlap, or where movement to reach suitable spawning habitat is limited (Hubbs, 1955). Pflieger and Grace (1987) describe alteration of the Missouri River by navigation and channel stabilization modifications which have affected fish by altering flow regimes, channel substrate, and water temperatures and chemistry, and by dams which block fish movement. Fremling et. al. (1989) describe similar physical alteration of the Mississippi River for navigation through channelization and impoundment by locks and dams. Any of the conditions indicated by Hubbs (1955) that contributes to hybridization, or a combination of them, could be causing the apparent breakdown in isolating mechanisms which prevented hybridization between these species of river sturgeon in the past. With our findings, in addition to the findings of Carlson et. al. (1955), interspecific hybrids between the shovelnose

and pallid sturgeon have been found in over half the range of the pallid sturgeon (Kallemeyn, 1983).

Both our studies and those of Carlson et. al. (1985) used the meristic and morphometric criteria established by Bailey and Cross (1954) for the two parent species to identify possible hybrids. However, Campton (1987) states that detecting hybrids through use of such characters has many shortcomings and can provide only circumstantial evidence, at best, that hybridization is occurring. He also states that distinguishing individuals of mixed ancestry is often impossible if hybridization has proceeded beyond the first generation and that the finding of many recombinant genetic types is an indicator that introgression has occurred. Campton (1987) states that electrophoretic techniques can often be successfully used on some species to test for hybridization.

Phelps and Allendorf (1983) performed electrophoretic analyses on the hybrid sturgeon collected by Carlson et. al. (1985) and found them indistinguishable at 37 loci from shovelnose and pallid sturgeon collected from the Missouri and Mississippi rivers. They concluded that, although morphometrically distinct, the close genetic similarity of the two species suggested recent or incomplete reproductive isolation and that, because morphological differences were likely controlled by many separate loci, many intermediate types could be produced. Campton (1987) states that many recombinant types suggest that reproduction beyond the first generation cross has occurred and that a wide range of recombinants is strong evidence of hybrid fertility. Our finding of a wide range of morphometric characteristics where Bailey and Cross (1954) found mutual exclusivity between the species 40 years ago, supports the conclusion of Phelps and Allendorf (1983) that the breakdown in reproductive isolation between the species is fairly recent. Our finding of many recombinant types, however, along with hybrid males, where Carlson et. al. (1985) found intermediacy and only female hybrids, suggests that some reproduction is resulting from the hybrids although we do not know whether this is with parent species or amongst themselves.

Campton (1987) states that, from a population genetics perspective, hybridization is a dynamic process which mixes and reorganizes genomes to the organismic level and, presumably, allows them to adapt to a modified or changing environment. Mitochondrial DNA techniques can be used to detect introgression provided that it is the female and her offspring that are fertile. Campton (1987) notes that hybridization is also a process that confounds our desire to manage fishes as discrete species and raises a question that is especially appropriate to the endangered pallid sturgeon as one of the species in our study. The question is: At what level of hybridization should biologists preserve introgressed admixtures as native forms?

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