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[Communication]

Inheritance of Predorsal Black Stripe in Black Crappie

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Abstract.—This study presents data on inheritance of the predorsal black stripe in black crappie *Pomoxis nigromaculatus*. Four progeny groups, obtained by crossing fish with certain phenotypes and of known origin, were investigated. Presence of the black stripe in all fish in two progeny groups, produced by crossing fish with and without the black stripe, indicated dominance of this trait. In two F_2 progeny groups, segregations of fish with: without stripe did not differ significantly from the 3:1 Mendelian ratio. It was concluded from the data that the appearance of predorsal stripe in black crappie is under the control of a dominant mutation of one gene (*St/st*): fish with genotypes *StSt* and *Stst* have a stripe, while fish with genotype *stst* do not possess this trait. Presence or absence of the black stripe was not connected with sex of the fish. This indicates that gene *St/st* is located in an autosome but not in a sex chromosome. Distribution of fish with stripe in one F_2 progeny group with regard to relative width of stripe did not differ significantly from unimodal normal distribution. This indicates that allele *St* approaches complete dominance or is, in fact, completely dominant. Black stripe may be used as a genetic marker in experiments on induced gynogenesis and in stocking programs for distinguishing introduced fish from the native stocks.

The black crappie *Pomoxis nigromaculatus* is a popular sport fish in the United States and has potential in aquaculture. Occurrence of a specific color morph—fish having a distinctive black predorsal stripe—has been found in this species. Buchanan and Bryant (1973) described this trait in black crappie from Beaver Reservoir in northwest Arkansas. Based on the result of special inquiries, these authors reported that black crappie with predorsal stripe occurred in at least 13 states from Florida to Wisconsin. This morph is commonly called "black-stripe" or "blacknose" crappie.

Based on the ratio of fish in preserved samples from Beaver Reservoir, Buchanan and Bryant (1973) hypothesized that this color pattern is inherited as a simple Mendelian recessive trait; however, this hypothesis was not supported by the results of experimental crosses. Dunham et al. (1994) noted that their preliminary breeding experiments indicated that this color pattern in black crappie is controlled by a dominant allele, but no data were presented. Parsons and Meals (1997) reported that hybrids obtained by crossing black crappie males having a predorsal stripe with female white crappies *Pomoxis annularis* possessed a stripe. This also indicated the dominant character of this trait; however, the authors did not discuss this subject.

The information presented above shows that in spite of wide distribution and relatively long-term cultivation of the black-stripe morph of black crappie, the mode of inheritance of this trait has never been specifically investigated and available information on this subject is scarce and contradictory. This study reports more comprehensive data on inheritance of predorsal black stripe in black crappie.

Methods

The experiments were conducted at the Aquaculture Research Center, Kentucky State University, Frankfort, in 2001–2003. The investigation of inheritance of black stripe included individual (one female × one male) crossing of fish with certain phenotypes and of known origin, and analysis of fish segregation in progeny groups. A total of four progeny groups were produced and analyzed (Table 1).

In 2001 progeny groups 1 and 2 were produced (Table 1). Fish with black stripe used in these crosses were obtained from the William H. Donham State Fish Hatchery, Arkansas; black crappies without a stripe were collected by electrofishing in Barren River Lake, Kentucky. For induction of spawning, fish were injected intramuscularly with human chorionic gonadotropin (HCG) at a dosage level of 1,000 IU/kg. Injected breeders were paired (one male and one female) and placed into separate 115-L aquaria for natural spawning. After transition to active feeding (5–6 d after hatching), the larvae were stocked into separate 0.04-ha earthen ponds.

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TABLE 1.—Characteristics of progeny groups and segregation of fish with regard to presence of predorsal stripe.

Progeny group	Female phenotype	Male phenotype	Number of fish analyzed	Segregation (%) With stripe	Segregation (%) Without stripe	Proposed type of cross	Proposed theoretical segregation
1	No stripe	Stripe	363	100	0	*stst* × *StSt*	1:0
2	Stripe	No stripe	42	100	0	*StSt* × *stst*	1:0
3	Stripe	Stripe	96	79.2[a]	20.8[a]	*Stst* × *Stst*	3:1
4	Stripe	Stripe	14	78.6[a]	21.4[a]	*Stst* × *Stst*	3:1

[a] Not significantly different from 3:1 ($P > 0.05$).

Segregations with regard to the presence of black stripe were recorded by analyzing 5-month-old fish.

Fish from progeny group 1 were pond raised to sexual maturity in 2 years. In 2003 fish from progeny group 1 were used in crosses for production of progeny groups 3 and 4 (Table 1). Spawning technique and rearing procedure were the same as described above for crosses performed in 2001. Segregations with regard to the presence of a black stripe were recorded by checking fish at age 6.5 months. Total length (TL) of each fish in the progeny groups and the width of the black stripe (in fish having that trait) were also recorded. An index "relative width of stripe" (%) was determined as 100 × stripe width/TL. Part of the fish from progeny group 3 were sacrificed for sex determination.

Deviations of the observed fish segregations with regard to both presence or absence of stripe and sex of fish from theoretical ratios were assessed by an exact binomial test (Zar 1999). Distribution of fish with regard to the relative width of the black stripe was compared with the normal distribution by means of the Kolmogorov–Smirnov goodness-of-fit test (Zar 1999).

FIGURE 1.—Dorsal view of adult black crappies without (left) and with (right) predorsal stripe; bar = 1 cm.

Results

The appearance of adult black crappies with and without a black stripe is shown in Figure 1. Fish segregations (with: without stripe) in progeny groups are given in Table 1. In progeny groups 1 and 2, all fish had predorsal stripe. In progeny groups 3 and 4, segregations of fish with: without stripe did not differ significantly ($P > 0.05$) from Mendelian ratio 3:1 (Table 1).

In progeny group 3, mean total length of fish, mean width of predorsal stripe, and mean relative width of stripe (±SD) were 10.64 ± 0.59 cm, 0.25 ± 0.03 cm, and 2.37 ± 0.28%, respectively. Distribution of fish from progeny group 3 with regard to relative width of stripe is presented in Figure 2. The distribution did not differ significantly ($P > 0.05$) from normal. In progeny group 4, mean

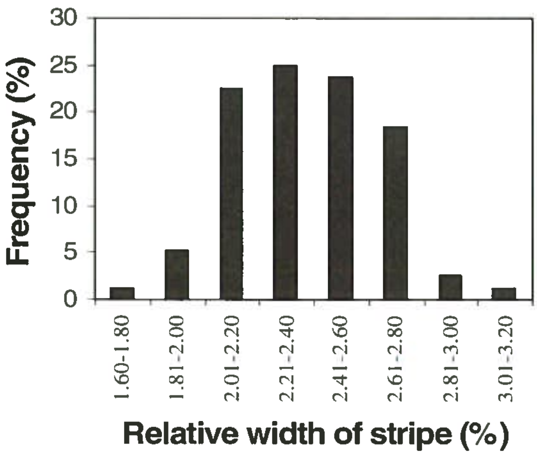

FIGURE 2.—Distribution of fish in progeny group 3 with regard to relative width of stripe.

total length of fish, mean width of predorsal stripe, and mean relative width of stripe (±SD) were 13.68 ± 0.64 cm, 0.35 ± 0.03 cm, and 2.56 ± 0.22%, respectively. Progeny group 4 was not large enough to analyze distribution of fish with regard to relative width of predorsal stripe.

In progeny group 3, the segregation of analyzed fish with regard to sex did not differ significantly ($P > 0.05$) from 1:1 both in fish without stripe (9 males : 8 females) and with stripe (19 males : 16 females).

Discussion

The presence of a black stripe in all fish in progeny groups 1 and 2, produced by crossing fish with and without stripe, indicated the dominance of this trait. Segregations with: without stripe in progeny groups 3 and 4 did not differ significantly from the 3:1 classical Mendelian ratio. Therefore, it may be concluded that the appearance of the predorsal black stripe in black crappie is under the control of a dominant mutation of one gene (*St/st*). Fish with genotypes *StSt* and *Stst* have the predorsal stripe, while fish with genotype *stst* do not develop this trait. Proposed genotypes of fish parents used in crosses are shown in Table 1.

The results show that presence or absence of a black stripe is not connected with sex of the fish. This indicates that the gene *St/st* is located in an autosome but not in a sex chromosome. Female homogamety in black crappie was determined by Gomelsky et al. (2002).

Since phenotypic ratios with: without stripe in progenies 3 and 4 were close to 3:1, the groups of fish with stripe should consist of heterozygotes *Stst* and homozygotes *StSt* with ratio 2:1. Distribution of fish with stripe in progeny 3 with regard to relative width of stripe did not differ significantly from a unimodal normal distribution. This indicates that allele *St* approaches complete dominance, or is in fact completely dominant. If profound incomplete dominance for this allele occurred, the large difference between fish with genotypes *Stst* and *StSt* would have resulted in a bimodal distribution.

The occurrence of color morphs in fish inhabiting natural waters or among aquaculture species is a fairly rare phenomenon. As a rule, color morphs in fish arise from mutations of genes controlling the synthesis of black pigment (melanin). Absence of melanin both in the skin and in the eyes results in the appearance of albino fish, while absence or reduced production of melanin only in the skin (not in eyes) results in the appearance of so called "golden" ("yellow," "pink") color morphs. Albino morphs have been described for several aquaculture species, including rainbow trout *Oncorhynchus mykiss* (Bridges and von Limbach 1972; Thorgaard et al. 1995), channel catfish *Ictalurus punctatus* (Bondari 1984), and grass carp *Ctenopharyngodon idella* (Rothbard and Wohlfarth 1993). In all of these cases, the albinism was controlled by recessive mutation. The mode of inheritance of other color morphs is more variable. Dunham and Childers (1980) described a golden morph in green sunfish *Lepomis cyanellus* as a recessive trait. Wright (1972) showed that a mutant allele, which induces the appearance of golden or palomino color morphs in rainbow trout, has incomplete dominance relative to the allele for wild color. In the same species, Chourrout (1982) described a yellow (golden) color morph which was dominant over wild color. This shows that similar color modifications may be caused by mutations of different genes with different modes of inheritance. A similar situation was described for tilapia *Oreochromis* spp. where red color was described either as a dominant (McAndrew et al. 1988; Reich et al. 1990) or recessive (Wohlfarth et al. 1990) trait.

In all cases described above, mutation of a gene controlling pigment synthesis impacts the color of the whole fish body. However, the mutation causing development of a black stripe in black crappie has a very different effect. In this case, mutation induces production of melanin in a specific area of the fish body. As far as we know, no similar color morphs have been described in fish inhabiting natural waters or in any aquaculture species. This makes the occurrence of a black stripe in crappie a unique phenomenon. Color morphs, including the appearance of black markings or spots, have been described before only in some ornamental aquarium fishes (Schroder 1976; Kirpichnikov 1981).

Black crappie has some potential for aquaculture. One of the main obstacles to successful management of their populations in ponds or small impoundments is their high rate of reproduction, which leads to overcrowding and subsequent stunting (USDA 1983; Martin 1988; Hooe 1991). One possible solution is the production of monosex progenies. This objective stimulated studies on induced gynogenesis (Gomelsky et al. 2000) and hormonal sex reversal (Al-ablani and Phelps 1997; Gomelsky et al. 2002; Arslan and Phelps 2004) in this species. Data on the inheritance of a black stripe permits the use of this trait as a genetic marker in further experiments on induced gynogenesis. For this purpose, eggs taken from females without a black stripe should be inseminated with irradiated sperm taken from males with a black stripe for the production of gynogynetic progenies. Because of the dominance of this trait, the absence of fish with stripe in experimental groups would indicate successful genetic inactivation of the paternal genome.

Black stripe may be used also as a genetic marker in stocking programs for distinguishing introduced fish from native stocks. In this case, the results of the present study should be taken into account. Since this trait is dominant, it would be relatively difficult to develop a true bred "black-stripe" line (giving only fish with stripe in consecutive generations) since the crossing of two heterozygotes (*Stst*) gives the mixed progeny. Development of a true bred "black-stripe" line could be achieved only by identifying heterozygotes *Stst* by means of test crosses and removing them from the stock.

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