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Exceptions to color being a sexually dimorphic character in *Melanochromis auratus* (Teleostei: Cichlidae)

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Prominent sexual dimorphism, such as distinct color differences, is a character on which researchers rely when making in situ observations. Distinguishing characters between the sexes are often used in laboratory experiments in order to minimize the handling of fishes. Male and female *Melanochromis auratus*, a maternal mouth brooding cichlid from Lake Malawi, are colored differently. Male fish are mostly black with a light blue midlateral band, whereas female fish are mostly yellow with a dark midlateral band. Although a random sample of 119 *M. auratus* from Lake Malawi are consistent with this description, two female *M. auratus* in the laboratory are black fish with midlateral bands.

Introduction

Melanochromis auratus (Boulenger), is a maternal mouth brooder endemic to Lake Malawi, Africa. It is found in abundance among medium-sized rocks to a depth of 10 m (Ribbink et al., 1983). Within this habitat, females and non-territorial adult males occur singly or in small groups of 8-10 individuals. *Melanochromis auratus* feed primarily on aufwuchs that is frequently within the boundaries of territories defended by highly aggressive species (Ribbink et al., 1983); they also feed on fish, sponge spicules, and cyclopoid copepods (Reinthal, 1990).

Female *M. auratus* have been described as being mostly yellow with a black mid-lateral band (see Konings, 1995: 99, fig 4), whereas the males (see Konings, 1995: 99, fig. 1) are mostly black with a light blue mid-lateral band (Boulenger, 1899; Burgess, 1976; Burgess & Axelrod, 1976; Ribbink et al., 1983; Lewis et al., 1986). Several authors, however, have noted that sexual dimorphism in *M. auratus* may not be as distinct as generally described in the literature (Fryer & Iles, 1972; Axelrod & Burgess, 1988; Konings, 1995; Trewavas, 1991). In this paper we describe observations of females with male coloration.

Methods

Wild-caught *M. auratus* were housed in aquaria with a gravel and rock substrate. Dechlorinated,

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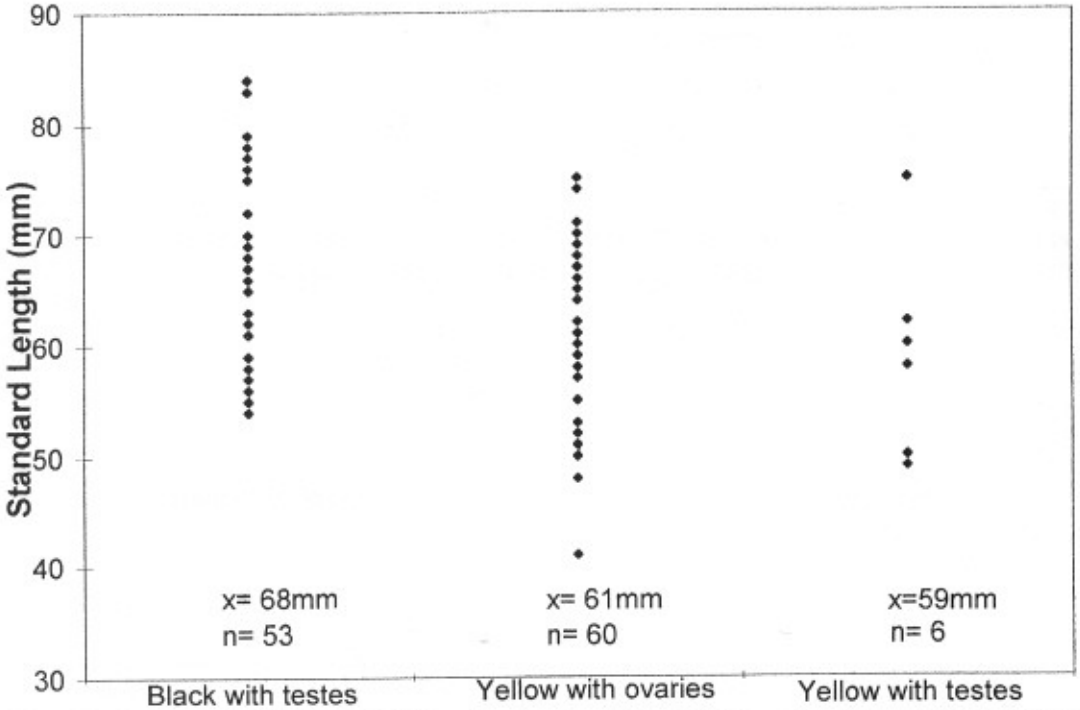

Fig. 1. Size frequency distribution of 119 *Melanochromis auratus*: black with testes, yellow with ovaries, and yellow with testes.

aerated, filtered water was maintained at approximately 26 °C by a submersible heater. Fish were fed Tetra Cichlid Food Large Flakes and Tetra Doro Min Floating Food Sticks.

The two black *M. auratus* that have female gonads were wild caught and had been housed with 15 other *M. auratus* in 185 liter tanks. As part of a protocol for another study, one of the black fish was placed in a 75.7 liter tank with four smaller second generation yellow fish (eleven months old). Two days after the fish were placed in the tank, the large black individual was observed to be mouth brooding. The four yellow fish of unknown sex were removed from the tank to reduce stress on the black individual. The isolated fish died of an unknown cause within four days, none of the eggs survived.

The second black female *M. auratus* had not been isolated. It died of unknown causes while in the 185 liter tank, we discovered that it had female gonads when we dissected it. All dead individuals were preserved in 10 % formalin, and then stored in 70 % ethanol.

To determine whether black female *M. auratus* are present in the field the following data were collected from 119 preserved *M. auratus* individuals: site, color, shape of genitalia, type of gonads, standard length, and total length. The individuals were collected from seven sites in Lake Malawi: Domwe Island (PSU 3110, Thumbi East Island (PSU 3112), Mazinzi Reef (PSU 3111), Monkey Bay (PSU 3109), Mitande Rocks (PSU 3106), Mpandi Island (PSU 3107), and Nkudzi Point (PSU 3108).

Results

External and internal examinations of *M. auratus* revealed two black *M. auratus* with female external genitalia, and female gametes. One of these individuals had been observed holding eggs.

All black *M. auratus* (n = 53) that were wild caught and preserved had male gonads, whereas six of the 66 yellow *M. auratus* had testes and 60 had ovaries. Size class (standard length) frequency distributions of black *M. auratus*, yellow

M. auratus with ovaries and yellow *M. auratus* with testes show overlap; however, there is a significant difference of mean standard length between black *M. auratus* and yellow *M. auratus* with testes (Fig. 1; T-test, $p<0.05$, black mean = 68 mm, yellow with testes mean = 59 mm). The mean standard length of yellow fish with testes (59 mm) was significantly smaller than the standard length of yellow *M. auratus* with ovaries (61 mm; T-test, $p<0.05$).

Discussion

Although external genitalia can be used to positively sex fish in the laboratory, distinct colors between the sexes are used to minimize handling the fish. Contrary to the descriptions in the literature, however, a black *M. auratus* with a light blue band was found holding eggs. Internal examination of the fish revealed female gonads. Female fishes that adopt male coloration have been observed in other cichlids. Naish & Ribbink (1990) observed *Metriaclima lombardoi* with male coloration holding eggs in Lake Malawi. Furthermore, Turner & Falter (1989) observed that female mouthbrooding *Oreochromis* species sometimes adopt color patterns of territorial males. In Lake Malawi there are several species of egg predators, which ram brooding females to dislodge the eggs and/or larvae. If these predators key on female coloration, then a change of the dominant color from yellow to black may make a female who is holding eggs less vulnerable to egg predators.

On the other hand, the male coloration in brooding females may be an artifact of being held in aquaria. Changes in color may be caused by hormonal imbalances following spawning, or may be related to the female establishing a territory for defense of her brood.

A fish holding eggs typically implies mating success. We have, however, observed isolated yellow females holding eggs in their mouth, thus suggesting that the black female may not have been holding fertilized eggs. Black *M. auratus* have been observed holding eggs in their mouth while in situ (Konings, 1995; Eccles & Trewavas, 1989). Dissections of 119 wild caught *M. auratus* that were preserved immediately after capture, however, revealed no evidence of black *M. auratus* with ovaries.

Of the 119 individuals dissected, we found six yellow individuals with testes. Although there are black fish with standard lengths similar to the yellow fish with testes, the six fish with testes were significantly smaller than the black males ($p<0.05$). The small male yellow fishes may be males that have not matured fully and have yet to change color. Perhaps they are 'sneaky males', mature males posing as females to reduce the threat to other males as they sneak fertilizations. The field component of this study supports the literature's identification of black *M. auratus*. Although, all the black *M. auratus* collected in situ were male, not all yellow *M. auratus* were females.

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