

## Relationships between spot type on male anal fin of Malawian mouth-brooding cichlid fishes and mating behavior

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**Abstract** Mating behavior was observed on 8 mouth-brooding Malawian cichlid species in aquarium, and was discussed from a viewpoint of the spot type on the male anal fin. The mating behavior for the pair was divided into seven steps; step 1, display; step 2, navigation; step 3, stimulation; step 4, oviposition; step 5, egg collection; step 6, fertilization; and step 7, mimic fertilization. Spots on the anal fin were categorized into four types; oval (*Labidochromis caeruleus*, *Melanochromis auratus* and *Pseudotropheus zebra*), narrow-oval (*Aulonocara hansbaenschi*), ellipsoidal (*Nimbochromis livingstoni*) and disappeared (*Aulonocara jacobfreibergi*, *Fossorochromis rostratus* and *Placidochromis electra*). Steps 1 and 3 was observed for all the species. Step 7 was observed for all the species except for *A. hansbaenschi* and *F. rostratus*. Steps 4 to 6 were observed only for *N. livingstoni* and *P. electra*. On the other hand, step 2 was observed only for *A. hansbaenschi*, *L. caeruleus* and *M. auratus*, belonging to oval to narrow-oval spot types, suggesting the role of oval-type spots in induction of mating behavior of females.

**Key words:** anal fin, cichlid, egg spot type, fertilization, mating behavior, mouth-brooding

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### INTRODUCTION

More than 250 species of cichlid fishes are distributed in the Lake Malawi, which occupy at least 80% in the total number of fish species of the lake (Axelrod, 1985). Most of Malawian cichlids are known to be mouthbrooders which rear their offsprings in the mouth from eggs to certain developmental stages (Sato and Mori, 1984). On mating, females fertilize her eggs, already collected in the mouth, by orienting the snout to male anal fin with egg-shaped spots (egg dummies), when males eject seminal fluid (Sato and Mori, 1984). Egg dummies are usually conspicuous in a group, called "Mbunas", mainly comprising the species of genera *Labidochromis*, *Melanochromis* and *Pseudotropheus* and dwelling in the rocky littorals, whereas those are less conspicuous to faint in the species of other genera (Axelrod, 1993). However, practically no studies have been conducted on the relationships between the shape or presence of the egg dummies and the mating behaviors.

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In this study, 8 species of Malawian cichlids were categorized into several groups on the basis of the type of male egg dummies. The steps in mating behavior of the pair were entirely described and was compared among the groups. Besides, it was discussed whether the egg dummies do have any functions in fertilization.

## MATERIALS AND METHODS

### Fishes

Eight species of Malawian mouth-brooding cichlids were used for experiments; *Aulonocara hansbaenschi*, *A. jacobfreibergi*, *Fossorochromis rostratus*, *Labidochromis caeruleus*, *Melanochromis auratus*, *Nimbochromis livingstoni*, *Placidochromis electra* and *Pseudotropheus zebra*. Fishes usually at immature stages were obtained from ornamental fish shops in Kyoto, Osaka and Hiroshima Prefectures and were reared in the community tank. After maturation, males were kept individually for prevention of major damages from territorial contests. Maturation was judged on the basis of dressing of reproductive coloration for males and protrusion of ovipositive duct for females.

### Experimental devices

Mating experiments were performed using an aquarium (W120cm×H45cm×D45cm) which was spread with coral sand at about 5cm in depth, filtered by an overhead type filter and set in the thermostatic room (25°C). At first, a male and a female of the identical species were put into the two-partitioned aquarium with a tank separator. Experiments were started by removing the separator after the fish were settled down and showed no aggressive fashion in each other.

### Observation and recording

Mating behaviors were recorded by a video camera (NV-S5, Matsushita Electric Co. Ltd., Japan) and the movie was analysed using a personal computer (Performa 630, Macintosh, USA).

## RESULTS

### Description of steps in mating behavior of the pair (Fig. 1)

Mating behavior of the pair was divided into seven steps.

#### Step 1. Display

Male proudly displays the body side to females, fully spreading the fins, particularly dorsal and ventral fins.

#### Step 2. Navigation

Male navigates female to his mating stage of shallow bowl-shape and female follows male.

#### Step 3. Stimulation

Male stands still with his body axis oblique to the bottom, closing all the fins and vibrating finely.

#### Step 4. Oviposition

Female oviposits several eggs on the bottom.

#### Step 5. Egg collection

Female collects her eggs into the mouth.

### Step 6. Fertilization

Female chases the males' anal fin and brings her snout near to the fin when male ejects the seminal fluid. Thereafter, the fertilization was carried out.

### Step 7. Mimic fertilization

To take the other's role in each other was observed quite conversely to the fertilizing behavior. This step was termed 'mimic fertilization'.

Steps 3 to 7 were repeated at least 10 times.

### Types of egg spots (Fig. 2)

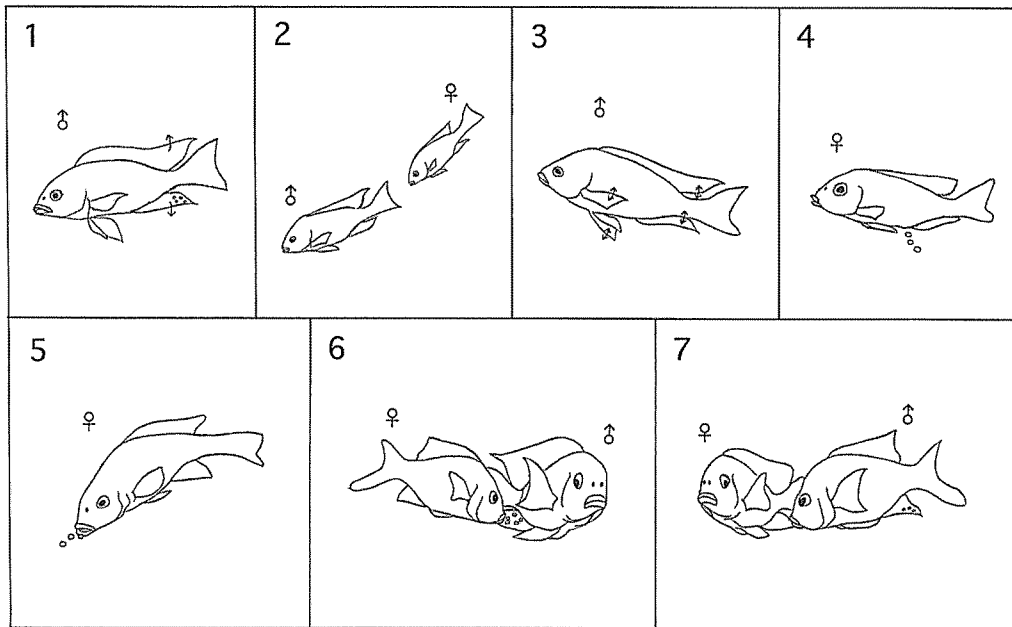


Fig. 1. Seven steps in mating behavior.

Step 1, Display; Step 2, Navigation; Step 3, Stimulation; Step 4, Oviposition; Step 5, Egg collection; Step 6, Fertilization; Step 7, Mimic fertilization.

Egg spots of male anal fin were categorized into four types; A, oval (*L. caeruleus*, *M. auratus* and *P. zebra*); B, narrow-oval (*A. hansbaenschi*); C, ellipsoidal (*N. livingstoni*); and D, disappeared (*A. jacobfreibergi*, *F. rostratus* and *P. electra*).

### Records of steps in mating behavior for 8 species (Table 1)

Steps 1 and 3 was observed for all the species. Step 7 was observed for all the species except for *A. hansbaenschi* and *F. rostratus*. Step 2 was observed only for *A. hansbaenschi*, *L. caeruleus* and *M. auratus*, all belonging to spot types A and B. Steps 4 to 6 were observed only for *N. livingstoni* and *P. electra*.

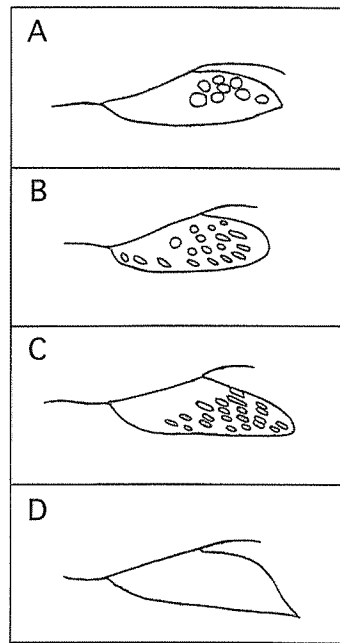


Fig. 2. Four types of egg spots on male anal fin.

A, oval; B, narrow-oval; C, ellipsoidal; D, disappeared.

Table 1. Differences in steps observed in the mating behavior among 8 Malawian mouth-brooding cichlid species.

Species	Egg spot type	Mating steps						
		1: Display	2: Navigation	3: Stimulation	4: Oviposition	5: Egg collection	6: Fertilization	7: Mimic fertilization
<i>Aulonocara hansbaenschi</i>	B	◇	◇	◇				
<i>A. jacobfreibergi</i>	D	◇		◇				◇
<i>Fossorochromis rostratus</i>	D	◇		◇				
<i>Labidochromis caeruleus</i>	A	◇	◇	◇				◇
<i>Melanochromis auratus</i>	A	◇	◇	◇				◇
<i>Nimbochromis livingstoni</i>	C	◇		◇	◇	◇	◇	◇
<i>Placidochromis electra</i>	D	◇		◇	◇	◇	◇	◇
<i>Pseudotropheus zebra</i>	A	◇		◇				◇

## DISCUSSION

A continuous variety of egg spot patterns are observed on the anal fin of male Malawian mouth-brooding cichlids (Axelrod, 1993). In this study, the steps in mating behavior were compared among the different groups in anal fin spot type. Step 2, i.e., male's navigation and female's follow, was observed only for *A. hansbaenschi*, *L. caeruleus* and *M. auratus*, all belonging to spot types A and B. This suggests that mating behavior of females be apt to be induced by such oval-type spots of male. However, further detailed observation and skilful experiments should be performed on mating behavior of much more species before conclusion.

On the other hand, even in *N. livingstoni* and *P. electra*, whose spots were categorized into C and D types, females clearly chased males' anal fins on step 6, fertilization. However, for a certain specialized species whose male anal fin spots are not in oval shape, a female can fertilize her eggs in the mouth without chasing males' anal fins (Sato and Mori, 1984). This difference may be partly attributable to the difference in the species examined between these studies. Further detailed analyses of the chasing behavior of female to male's anal fin should be carried out. Besides, the genera of *Melanochromis* and *Pseudotropheus* were reported to belong to phylogenetically different group (group B) from the genus *Placidochromis* (group A) (Kocher et al., 1993). Therefore, interspecific differences in the female's chase to male's anal fin should be compared among each phylogenetic group.

'Mimic fertilization' was observed irrespectively of egg spot type. What is a meaning of mimic fertilization? Do the step have any critical functions in mating? Otherwise, is it only a ritual? It might be an essential step to end a cycle of oviposition process.

Unfortunately, oviposition was observed only for 2 species, *N. livingstoni* and *P. electra*, in the experimental system used in this study. This is partly because of the lacking of open and calm space enough for completion of mating process in other species. Another important cause may be a failure in obtaining compatible pairs, i.e., those in which a male has considerably larger size than females. Improvements in the experimental system and in procuring methods of adequate pairs are necessary for more comparable results.

Only 7 of about 40 genera, distributed in the Lake Malawi (Eccles and Trewavas, 1989), were examined for mating behavior in this study, due to unavailability of samples. Different species in evolutionary stage of mating behavior should be obtained and examined in order to clarify the relationships between egg spot type and mating behavior.

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## マラウイ湖産シクリッド魚類の臀鰭斑紋型と繁殖行動との関係について

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**要 旨** 8種の口内保育型マラウイ湖産シクリッドについて、繁殖行動を観察し、雄臀鰭の斑紋タイプと繁殖行動との関係を調べた。繁殖行動は7つの段階、すなわち、体側誇示（段階1）、誘導（段階2）、刺激（段階3）、産卵（段階4）、卵回収（段階5）、受精（段階6）、擬似受精（段階7）、に区分された。臀鰭の斑紋は4タイプ、すなわち、卵型（*Labidochromis caeruleus*, *Melanochromis auratus* および *Pseudotropheus zebra*）、長卵型（*Aulonocara hansbaenschi*）、楕円型（*Nimbochromis livingstoni*）および消失型（*Aulonocara jacobfreibergi*, *Fossorochromis rostratus* および *Placidochromis electra*）に分けられた。段階1と3は全種で観察され、段階7は *A. hansbaenschi* と *F. rostratus* 以外で観察された。段階4から6は *P. electra* と *N. livingstoni* でのみ観察された。一方、段階2は卵型あるいは長卵型斑紋を有する *A. hansbaenschi*, *L. caeruleus* および *M. auratus* でのみ観察され、雌の繁殖行動誘発における卵型の斑紋の役割が示唆された。

キーワード：口内保育，シクリッド，受精，臀鰭，繁殖行動，斑紋型

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