Agonistic and reproductive behaviors in males of red hybrid tilapia, *Oreochromis niloticus* (Linnaeus, 1758) × *O. mossambicus* (Peters, 1852) (Osteichthyes: Cichlidae)

Medeiros, APT.*, Chellappa, S.* and Yamamoto, ME.*

*Postgraduate Programme in Psychobiology, Department of Physiology, Centre of Bioscience, Universidade Federal do Rio Grande do Norte, Av. Salgado Filho, 3000, Lagoa Nova, CEP 59072-970, Natal, RN, Brazil

*Postgraduate Programme in Aquatic Bioecology, Centre of Bioscience, Universidade Federal do Rio Grande do Norte – UFRN, Praia de Mãe Luiza, s/n, CEP 59014-100, Natal, RN, Brazil

*e-mail: anapatriciatargino@yahoo.com.br, bama@dol.ufrn.br, emilia.yamamoto@uol.com.br

Received May 11, 2005 – Accepted May 31, 2006 – Distributed November 30, 2007

(With 2 figures)

Abstract

The red hybrid tilapia, *Oreochromis niloticus* (Linnaeus, 1758) × *O. mossambicus* (Peters, 1852) is a fertile hybrid used in the semi-intensive level of fish culture in the Northeast of Brazil. It is a territorial cichlid and highly aggressive towards conspecifics during the breeding season. The purpose of this study was to investigate and describe the aggressive behaviour displayed by the males of this hybrid in non-reproductive and reproductive contexts. Behavioural observations revealed that aggression displayed by the reproductive males of red hybrid tilapia included threatening, undulation, parallel, lateral and frontal attacks, chasing, escape and submission. Possession of a territory influenced male aggressiveness, which was more intense in their own territory than that observed in a neutral situation. The males built nests, irrespective of female presence. All the behavioural patterns were in accordance with those previously described for one parental species, the Nile tilapia, *O. niloticus*.

Keywords: freshwater fish, *Oreochromis niloticus* × *Oreochromis mossambicus*, reproductive aggression, red hybrid tilapia.

1. Introduction

Aggressiveness is greater in fish during the breeding phase when males of many species establish and defend a territory for reproductive purposes (Turner and Huntingford, 1987). In cichlids, the territory is also considered a limited reproductive resource, whose occupation is aggressively defended by the males. During conflicts, territorial males exhibit agonistic behavior towards their opponents, which includes threatening, spreading...
their fins and gill covers, thus resulting in increased body size (Yabuta, 2002; Telerph, 2004) and aggressive fights (Alvarenga and Volpato, 1995)

Body size affects the results of agonistic encounters between the males of many fish species (Enquist et al., 1990; Gonçalves-de-Freitas, 1999). Body size is considered as an attribute of crucial importance to the males of fish that are involved in conflict resolutions, since larger males become dominant (Turner, 1994). The male characteristics, such as relative body size and aggression, coupled with the possession of a good quality territory, could cause differences in mating success (Chellappa et al., 1999a,b). Aggression in fish is affected by other factors, such as familiarity (Giaquinto and Volpato, 1997), previous territory occupancy and reproductive period (Gonçalves-de-Freitas, 1999). Despite these effects on aggression, social interactions affect several processes of aquaculture interest, such as growth (Volpato and Fernandes, 1994), stress (Fernandes and Volpato, 1993; Alvarenga and Volpato, 1995) and reproduction (Chellappa et al., 1999a,b).

Tilapia belongs to the Cichlidae family, is territorial and aggressive towards their conspecifics. The behaviour of Nile tilapia, Oreochromis niloticus (Linnaeus, 1758), has been extensively investigated. Studies on this fish behaviour patterns considered several aspects, such as communication (Giaquinto and Volpato, 1997), social stress (Fernandes and Volpato, 1993; Alvarenga and Volpato, 1995; Correa et al., 2003; Volpato et al., 2003; Barreto and Volpato, 2004), social hierarchy (Barki and Volpato, 1998), aggression (Alvarenga and Volpato, 1995; Giaquinto and Volpato, 1997; Correa et al., 2003); reproduction (Gonçalves-de-Freitas and Nishida, 1998), learning (Barki and Volpato, 1998; Moreira and Volpato, 2004), and others. However, most of the studies on the Nile tilapia are related to fish production or fish management due to the importance of this species in tropical systems (Vijayan et al., 1997; Barcellos et al., 1999a,b; Gontijo et al., 2003).

Despite these studies, few studies on the behaviour of the hybrid red Nile tilapia, O. niloticus × Oreochromis mossambicus (Peters, 1852), using this hybrid, have been carried out. The red hybrid tilapia is increasingly being used in semi-intensive level of fish culture in Northeast Brazil (Câmara and Chellappa, 1996, 2000). Therefore, an understanding of their aggressive behaviour, which is strongly associated with the reproductive cycle, can contribute information of interest, resulting in a more efficient and profitable cultivation of red hybrid tilapia.

The purpose of this study was to investigate the behaviour of the red Nile tilapia, markedly describing social interactions in agonistic and reproductive disputes, which included competition for breeding territory, effects of territory occupation, and behaviour patterns associated with the construction of nests during the initial phase of reproduction.

2. Material and Methods

2.1. Acquisition, maintenance and sex identification of the fish

Ninety individuals of both sexes of the red hybrid tilapia, Oreochromis niloticus × O. mossambicus were obtained from the Fish Culture Station of the Agriculture College of the Federal University of Rio Grande do Norte (UFRN), Macaíba, RN, Brazil. The body length of red hybrid males was 163.6 mm ± 67.1 mm, with maximum and minimum lengths of 225 and 130 mm, respectively. The body length for the females was 122.2 mm ± 28.2 mm, with maximum and minimum values of 140 and 100 mm, respectively.

The fish were acclimatized in rectangular asbestos cement tanks (1.50 x 0.65 x 0.97 m). The temperature was maintained in the range of 26 and 28 °C, pH was maintained between 7.0 and 7.5, and dissolved oxygen between 7.0 and 8.0 mg L⁻¹. Food was offered on a twice-daily basis, consisting of pelleted ration for cichlids (tetra cichlids), corresponding to 3% of body weight. To assess sexual maturity, the genital pore region of the fish was coloured with methylene blue, which evidenced hyperemia (Gonçalves-de-Freitas and Nishida, 1998). The following secondary sexual characteristics were considered for sex identification of the fish: the males had two orifices situated near the anal fin, the anus and the urogenital opening located on a small papilla. The females had three orifices, the anus, a transversal genital opening and a urinary opening.

This study consisted of three tests, which is specified below. All these tests were conducted in glass aquariums, each measuring 60 x 40 x 40 cm, with a total water volume of 100 L.

2.2. Specific procedures

2.2.1. Aggressive behaviour (Test 1)

To describe the agonistic behaviour between the males of red hybrid tilapia during the initial breeding phase, eight males of equal size (166 mm) were placed in pairs in each aquarium in a neutral situation, where there was no territory established. All glass aquariums used in this study measured 60 x 40 x 40 cm with a total water volume of 100 L. The fish were observed in two sessions a day of 30 minutes each in the morning and in the afternoon (with an interval of four hours between the observations), during a period of one month, with a total of 60 observations. Continuous focal sampling method was adopted for the observations, using a digital chronometer. The behaviours displayed by the males during the conflicts were recorded and described according to studies of this species (Gonçalves-de-Freitas and Nishida, 1994) and of other cichlids (Chellappa, 1988; Neat, 1996; Chellappa et al., 1999a).

2.2.2. Agonistic behavior while establishing territory (Test 2)

Eight equally sized males were used (180 mm) to evaluate agonistic behaviour between males. Each aquar-
The fish bites the lateral region of the body of the opponent. The fish keeps its head elevated with its fins retracted and remains motionless. The fish swims towards the other following its trajectory. The fish swim side by side, undulating their bodies, without physical contact.

The following tests were used in the statistical analysis: Descriptive analysis (mean and standard deviation) of the measured variables and Students t-test for paired samples. Results were considered statistically significant at p < 0.05. Analyses were performed using the Statistica software program, version 6.0.

3. Results

The agonistic behavior exhibited by the males of red hybrid tilapia in a neutral area included threatening, undulation, parallel, lateral, and frontal attacks, chasing, escape, and subordination, which are described in Table 1.

The red hybrid males manifested social interactions during the initial phase of breeding, and the resident males emitted these interactions at a higher frequency than the non-residents (t = 3.84, p < 0.05) (Figure 1).

In relation to the aggressiveness displayed by the males in a neutral situation, it was verified that the mean frequency of aggressiveness in their own territory was greater than that in a neutral setting (t = 4.22 p < 0.05) (Figure 2).

The nest-building activities began with the excavation of the substrate, when the fish removed the sand with their mouth and deposited it approximately 20 cm from the excavation site. The total number of nests excavated in this study was 476 and the time of excavation was 30 ± 21.3 minutes. The frequency of excavation in the absence of females was 198 ± 7.1 times, and in the presence of females it was 278 ± 28.2 times. The excavated nest had a concave shape, resembling an inverted cone. The diameter of the nest was 167 ± 26 mm, with a depth of 49 ± 12 mm. The males initiated nest-building activities regardless of the presence of females. The time spent by the males at the nest was 24.6 ± 1.67 min, and the time away was 20.6 ± 0.82 min. The time spent by the females near and away from the nest was 2.15 ± 1.14 min and 22.6 ± 1.21 min, respectively. The time spent by the pair near and away from the nest was 4.6 ± 0.53 min and 11.14 ± 1.03 min, respectively.

### Table 1. Description of behaviour displayed during conflicts between males of red hybrid tilapia, *Oreochromis niloticus* × *O. mossambicus*.

<table>
<thead>
<tr>
<th>Behaviour</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Threatening</td>
<td>The fish spreads its fins fully and opens its gill covers as it approaches the opponent.</td>
</tr>
<tr>
<td>Undulation</td>
<td>The fish moves its body in a wave-like motion in an antero-posterior direction.</td>
</tr>
<tr>
<td>Parallel confrontation</td>
<td>The fish swim side by side, undulating their bodies, without physical contact.</td>
</tr>
<tr>
<td>Lateral attack</td>
<td>The fish bites the lateral region of the body of the opponent.</td>
</tr>
<tr>
<td>Frontal attack</td>
<td>Juxtaposition of the jaws and undulation of the tail region.</td>
</tr>
<tr>
<td>Chasing</td>
<td>The fish swims towards the other following its trajectory.</td>
</tr>
<tr>
<td>Escape</td>
<td>The pursued fish leaves the area of confrontation.</td>
</tr>
<tr>
<td>Subordination</td>
<td>The fish keeps its head elevated with its fins retracted and remains motionless.</td>
</tr>
</tbody>
</table>
Aggressive behavior is relatively common in territorial fish and many species of fish have a diversified repertory of responses during agonistic encounters (Turner, 1994). Many of these responses involve the spreading of fins and extending the gill covers, resulting in an apparent increase in body size, in addition to fin movement and biting, during which the opponents can demonstrate their fighting skills. In the Nile tilapia, Oreochromis niloticus, the aggressive males present agonistic behavior patterns, such as threatening, undulation, parallel, lateral and frontal attacks, chasing and escape (Gonçalves-de-Freitas and Nishida, 1994; Gonçalves-de-Freitas, 1999).

However, other agonistic profiles or denominations have been considered in the studies of the Nile tilapia (Alvarenga and Volpato, 1995; Giaquinto and Volpato, 1997; Volpato and Trajano, 2005). In the present study the males of the red hybrid displayed aggressive behaviour similar to that of O. niloticus. The agonistic behaviour of other cichlid fishes, such as angelfish, Pterophyllum scalare and the common tucurané, Cichla ocellaris includes movements of approximation, frontal attack, threatening, change of eye colour, biting, chasing, escape and submission (Chellappa et al., 1999a).

Aggressive fish displays, such as the erection of the dorsal fin and lateral display are common in the Nile tilapia (Barki and Volpato, 1998; Gonçalves-de-Freitas, 2002). Besides these, the eye color is also used as an indicator of social rank in the Nile tilapia, O. niloticus (Volpato et al., 2003), and in other fish species (Beaching, 1995; O’Connor et al., 1999, 2000; Sutter and Huntingford, 2002). However, in the Nile tilapia, social and rank signals do not rely exclusively on visual cues. It has been demonstrated that chemical signals affect rank recognition in this species (Giaquinto and Volpato, 1997).

In the current study, it was observed that there was a gradual increase in the intensity of fighting as an encounter proceeded among male fishes. The fights often started with energy-saving movements, such as threatening displays, which were performed at a distance without physical contact. These movements were followed up by more energy-intensive behaviour that involved physical contact, such as lateral and frontal attacks and mouth locking. Alvarenga and Volpato (1995) showed that ventral nipping and lateral fights are the two main agonistic behaviors associated with high energy consumption in the Nile tilapia. In interactions where physical contact did not occur, such situation allowed the opponents to assess their relative strength, and to become subordinate at this point (Chellappa, 1988; Chellappa and Huntingford, 1989).

Territory is a fixed area from which other males are expelled by means of agonistic behaviour. Territoriality occurs when males adjust their fighting behaviour to their position in space. In the present study it was observed that breeding males restrict their activity to specific areas and chase any intruding males to the edge of the territory, using a combination of displays and attacks. In territorial species, the claiming of territory confers an arbitrary advantage on the resident, providing it with greater chances of winning, regardless of the size of the opponent (Maynard Smith, 1984). This has been reported as “previous territory effect” and is frequently encountered in fish (Gonçalves-de-Freitas and Nishida, 1994; Chellappa et al., 1999b). In the present study, though the males were of equal size, the residents were more aggressive and victorious in the conflicts. Furthermore, residency is considered to be one of the important factors that influences male aggressiveness and consequently the results of the conflicts (Chellappa et al., 1999b).

Occasionally males in a group can be arranged in terms of a linear ranking system or dominance hierarchy that reflects the pattern of agonistic relationships within them. Dominant males often get priority of access to limiting resources, such as territories, food and mates. This social status established by overt confrontations is maintained by less aggressive encounters, usually characterized by displays, which avoid serious damage between conspecifics (Turner and Huntingford, 1986; Volpato and Fernandes, 1994; Haller and Wittenberger, 1988). In the present study, during encounters between two male fishes, the subordinate (having lost in the previous encounters) often withdrew in response to an approach by the dominant male. In the Nile tilapia, O. niloticus, the dominant α males have priority in access to reproductive territories and in the courting of females in comparison.
to the small subordinate males (Gonçalves-de-Freitas and Nishida, 1998). In this study, dominant males had access to the nest and to court females, which indicates that this ability is also encountered in the red hybrid.

The size of the nests built by male fish corresponds approximately to the total length of their body size. This result was similarly observed in a study performed with the species Symphodus melops, in which the nest size was positively correlated with male body size (Uglen and Rosenqvist, 2002). In the current study it was demonstrated that the red hybrid presents the same patterns of social relationship previously described for one parental species, the Nile tilapia, O. niloticus. Further studies on agonistic and reproductive behaviour of the red hybrid should be conducted in order to provide broader comparisons.

Acknowledgments — All the authors wish to thank CNPq-MCT (The National Council for Scientific Research and Technological development of the Ministry of Science and Technology, Brazil) for the grants provided during the study period.

References


