SPAWNING AND PARENTAL CARE IN *Hoplias malabaricus* (TELEOSTEI, CHARACIFORMES, ERYTHRINIDAE) IN THE SOUTHERN PANTANAL, BRAZIL

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(With 1 figure)

ABSTRACT

Herein we describe spawning and egg guarding in the erythrinid fish *Hoplias malabaricus* observed in the southern Pantanal (19° 34' S and 57° 00' W), state of Mato Grosso do Sul, Brazil. Nests were depressions built on sandy soil in flooded areas, and contained a mean of 8,197 ± 2,204 eggs (N = 4); the mean diameter of eggs was 1.44 ± 0.09 mm (N = 400). Among 11 nests observed, eight were guarded by males and three by the pair. One male remained in the nest for six days, and two pairs remained guarding the eggs for at least three days before being captured. Females (N = 2) captured in the nest contained oocytes in their ovaries. Our observations suggest that male parental care is the normal form of parental care in *H. malabaricus*, but biparental care also seems to occur.

Keywords: reproduction, parental care, *Hoplias malabaricus*, Erythrinidae, Pantanal.

RESUMO

Desova e cuidado parental em *Hoplias malabaricus* (Teleostei, Characiformes, Erythrinidae) no Pantanal Sul, Brasil

No presente estudo, descrevemos os comportamentos de desova e cuidado parental para um membro da referida família, *Hoplias malabaricus*, os quais foram observados no Pantanal sul (19° 34' S e 57° 00' W), Estado de Mato Grosso do Sul, Brasil. As desovas foram observadas no início da cheia, depositadas em ninhos construídos em substrato arenoso em áreas alagadas. As desovas continham, em média, 8.197 ± 2.204 ovos (N = 4); o diâmetro médio dos ovos foi de 1,44 ± 0,09 mm (N = 400). Entre 11 ninhos observados, oito foram guardados por machos e em três observamos o casal. Um macho permaneceu no ninho por seis dias, e dois casais foram observados por três dias no ninho até serem capturados. As fêmeas (N = 2) capturadas nos ninhos continham óvulos nos ovários. O cuidado parental em *Hoplias malabaricus* é normalmente exercido pelos machos, mas nossas observações sugerem que o cuidado biparental pode ocorrer de forma facultativa.

Palavras-chave: reprodução, cuidado parental, *Hoplias malabaricus*, Erythrinidae, Pantanal.

INTRODUCTION

Egg guarding is the most common form of parental care in fish (Clutton-Brock, 1991), and in the majority of species that show parental care, only one parent is involved. Among teleost families, male care is much more common than female care, with 61% against 39%, respectively, and biparental care occurs in less than 25% of the families with care (Gross & Shine, 1981). Reduced egg predation and/or increased hatchability are proposed as the main benefits of egg guarding (Baylis, 1981).

The Erythrinidae family consists of predatory and carnivorous fish, grouped into three genera: *Hoplias*, *Hoplerythrinus*, and *Erythrinus* (Quagio-Grassiotto *et al*., 2001). Some are air-breathers, being able to move from one lake to another on land (Nelson, 1994; Britski *et al*., 1999). Concerning reproduction, erythrinid species are characterized by external fertilization, nest building, and egg guarding; generally performed by males (Blumer, 1982).

Hoplias malabaricus (Bloch, 1794) is a member of the Erythrinidae family and is widely distributed in the Neotropical region (Matkovic & Pisanó, 1989a). The species is well adapted to lentic environments, although it can also occur in small or large rivers. Individuals are generally found in pools (amidst the marginal vegetation), are cryptically colored, and capture prey by ambush (Uieda, 1984; Casatti *et al*., 2001). Furthermore, *H. malabaricus* shows multiple spawning and parental care (Caramaschi & Godinho 1982; Araújo-Lima & Bittencourt, 2001). However, previous studies do not report which sex is responsible for the care in *H. malabaricus*.

Herein we describe the spawning and parental care behaviors of *H. malabaricus*, known as "traíra" at the study site, in the floodplain of the south Pantanal, state of Mato Grosso do Sul, western Brazil.

METHODS

The study was conducted in the southern Pantanal, southwestern Brazil. The Pantanal is a great floodplain, with an area of *ca.* 140,000 km^2, delimited mostly by the Paraguay river in the west and Brazilian uplands in the east (see Por, 1995). Observations and data collection were carried out in the municipality of Corumbá, state of Mato Grosso do Sul (19° 34' S and 57° 00' W) along the Miranda river, an important tributary of the Paraguay river. The region is characterized by a seasonal climate ("Aw" type in Köppen's classification), with a rainy summer from October to April and a dry winter from May to September. Annual floods are common along the Miranda system (Por, 1995), and generally occur at the study site from January to April. Savanna-like vegetation ("cerrado") predominates in the area and has patches of semi deciduous forests, gallery forests, and grassland fields.

The observations were made between 11 and 18 January, 2002. Subsequent to flooding, individuals of *H. malabaricus* were observed reproducing around the Base de Estudos do Pantanal/UFMS, a research station that offered us logistical support. The water depth was measured close to the nests to the nearest 0.1 cm with a measuring tape. Nests containing individuals were checked at least twice a day. Individuals were collected with fishhooks and meat as bait. Afterwards, they were preserved in 10% formalin, and dissected for sex identification. The total body length (TL) was measured to the nearest 1 mm with a plastic ruler. Some clutches were collected and immediately preserved in 5% formalin; the number of eggs per clutch was determined and the egg diameter was measured with an ocular micrometer under a stereomicroscope (± 0.1 mm). We have used all occurrences sampling method (Altmann, 1974) to describe spawning and nest guarding behaviors.

RESULTS

Nests and clutches

Nests of *H. malabaricus* were observed in flooded areas along the Miranda river. Reproduction began approximately 30 days after the flood had arrived at the study site. A total of 11 nests containing eggs were found where the mean water depth was 17.9 ± 6.0 cm (range = 10 - 29; N = 11), and the water was clean and transparent. The nests were depressions similar to basins built on sandy soil, with a clean bottom, containing no vegetation or debris. The format of the depressions was approximately circular with a diameter of about 10 cm and 3 cm deep. Clutches examined contained a mean of 8,197 ± 2,204 eggs (range = 5,380 - 10,768; N = 4; Table 1); the mean diameter of eggs was 1.44 ± 0.09 mm (N = 400 eggs from four clutches). All the eggs in each nest observed (N = 11) were in the same developmental stage. Eggs were yellowish colored; the clutches formed a compact mass of eggs, but were not adhered to the nest bottom. The first nest was observed on 11 January, but half of the nests were found four days later (Table 1). By 18 January 2002, our field

TABLE 1
Summary of data on nests of *Hoplias malabaricus* in the southern Pantanal during January 2002. M, male; F, female; a, sex identified by dissection; b, sex suggested by observations; and c, sex identified by spawning observation.

Date	Nest	Sex Guarding	Total length (mm)	N Eggs per clutch	Mean (± SD) egg diameter (mm)
11 Jan	01	M_a	230.0	10,768	1.42 ± 0.10 (N = 100)
12 Jan	02	M_c	-	-	-
12 Jan	03	M_b F_a	- 265.0	-	-
12 Jan	04	M_a F_b	320.0 -	-	-
14 Jan	05	M_a	215.0	5,380	1.44 ± 0.07 (N = 100)
14 Jan	06	M_c	-	-	-
15 Jan	07	M_a	210.0	8,288	1.49 ± 0.07 (N = 100)
15 Jan	08	M_b	-	-	-
15 Jan	09	M_a	220.0	-	-
15 Jan	10	M_b	-	-	-
16 Jan	11	M_a F_a	255.0 215.0	8,352	1.40 ± 0.09 (N = 100)

work had finished, and when we returned to the study site, about 20 days later, the reproduction had already finished.

Spawning behavior and parental care

Three pairs of *H. malabaricus* were observed spawning during the morning. In the first case, observed on 12 January, 2002 between 9 h and 10 h 30 (Nest # 2 in Table 1), the spawning was in course, and when finished the male remained on the nest while the female went away. The male and female could be distinguished because of the female's position during oviposition. The nest was checked at least twice during the day and night, and the male remained on the nest for six days, up to 18 January, 2002. The male protected the eggs aggressively against other fish and observers that tried to approach. The second spawn occurred *ca.* 30 m from the first nest, on 14 January, 2002, between 8 h 40 and 9 h 10 (Nest # 6 in Table 1). The bodies of the pair were positioned side by side, heads toward the same side, and the male tried to approach its vent to the female's vent. By the end of oviposition, the male remained on the nest and the female went away. The male was observed close to the nest in the two subsequent days, protecting the eggs from other fish. The third spawning was observed on 16 January, 2002 (Nest # 11 in Table 1). The pair was first observed at 8 h 45, before spawning, trying to expulse the male that was guarding the eggs in the nest described above (Nest # 6). When the pair finally expulsed the male, at 9 h 30, they immediately initiated the spawn in a nest previously constructed *ca.* 70 cm from the nest # 6. Before oviposition, the male touched the female with its head and body, then the spawn occurred in a similar way described above, finishing at 10 h 10. Afterwards, the male and the female remained close to the nest. The expulsed male from the nest # 6 returned to its nest approximately 40 min later, but was aggressively pursued by both the male and female that had recently spawned in nest # 11. The guarding male from nest # 6 ended up abandoning the nest, which by that time had the eggs almost totally predated by other fish.

Of the 11 nests studied, in eight we observed one individual close to the nest (Fig. 1) and in three we observed two individuals close to the nest. The eight solitary individuals were males and behaved aggressively against observers and fish that tried to approach the nests (Table 1). Four individuals were collected and dissected for gonad observation and sex identification, two were identified as males by spawning observation, and doubts remained about the other two individuals. In two nests where two individuals were observed, the nests were regularly checked, and they actively guarded the eggs for at least three days before the capture of one of the

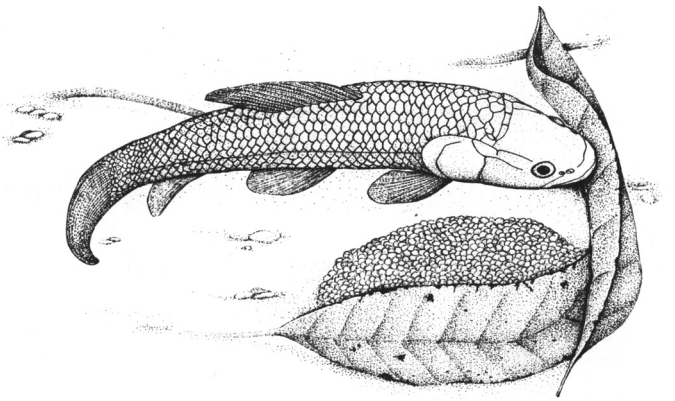

Fig. 1 — Male *Hoplias malabaricus* guarding eggs deposited in a basin in the southern Pantanal, Brazil. Drawn after slides.

individuals (Nests # 3 and 4 in Table 1). In nest # 3, the individual captured was a female, so we suggest that the other was the male. In nest # 4, the individual captured was the male, so the other could be the female. The third nest where two individuals were observed was that where the pair's spawning and pursuit behaviors were described above (Nest # 11). Both individuals were captured 24 h after spawning, dissected as the others, and one was a female and the other a male. In these three cases, one individual was always on the nest and the other around 1.0 m from the nest; individuals captured on the nests were always males and those close to them were females. When dissected, females performing parental care contained oocytes in different developmental stages. The mean total length of captured males was 241.7 ± 41.5 mm (range = 210 – 320, N = 6) and the two captured females attained a total length of 215 and 265 mm (Table 1).

DISCUSSION

In the present study, *H. malabaricus* was observed reproducing in the Pantanal at the beginning of the flooding season, constructing nests, spawning, and guarding eggs in flooded areas. This species is known to show multiple spawning in the Venezuelan rivers (Machado-Allison, 1990), which are generally synchronized with periods of floods, and also builds nests and guards eggs in flooded areas, but which sex is responsible for egg attendance is not mentioned. Other studies, conducted in different regions throughout South America, showed that the period of reproduction is variable for the species. Reproduction may occur during months of high rainfall in some sites (*e.g.*, state of São Paulo, Brazil, Caramaschi & Godinho, 1982; Barbieri, 1989; Argentina, Matkovic & Pisanó, 1989b; Domanico *et al*. 1993; central Amazonia, Brazil, Araújo-Lima & Bittencourt, 2001; State of Paraíba, Brazil, Marques *et al*., 2001), such as the data registered in this study for the south Pantanal, but also during periods of drought and lower temperatures in other regions (upper Paraná river floodplain, States of Paraná and Mato Grosso do Sul, Brazil, Bialetzki *et al*., 2002).

As observed in the present study, in central Amazonia the yellowish eggs are also deposited in shallow water (~ 15 cm deep), close to aquatic vegetation, in saucer-format nests, forming an adherent mass of eggs (Araújo-Lima & Bittencourt, 2001); eggs are adhered to each other due to the presence of a specific glicoprotein (Matkovic & Pisanó, 1989c). Previous studies showed that the total length of females of *H. malabaricus* at first reproduction could vary from 141.0 mm (Oliveira & Nogueira, 2000) to 230.0 mm (Barbieri, 1989), the mean diameter of mature oocytes was 1.75 mm, and the number of mature oocytes could vary from 6,446 to 14,131 (Araújo-Lima & Bittencourt, 2001). These values differ from those recorded for the species in the present study. An explanation could be related to population differences, or alternatively due to taxonomic problems; these studies may involve more than one species currently identified as *H. malabaricus* (J. C. Garavello, pers. comm.).

Male parental care was more frequently observed in *H. malabaricus* in the Pantanal in the present study. The Erythrinidae family is distinguished by showing male parental care of eggs (Blumer, 1982), but the author did not cite the species presenting male parental care. Moreover, in prior studies on *H. malabaricus* it is not clear which parent provides parental care (Caramaschi & Godinho, 1982; Machado-Allison, 1990; Araújo-Lima & Bittencourt, 2001). Thus, this study is the first to describe parental care in detail for *H. malabaricus*. Male parental care is much more frequent among bony fish (Clutton-Brock, 1991); among external fertilizers with parental care, about 76% of cases involve males, which commonly defend territories used by several females in succession (*e. g.*, Williams, 1975; Ridley, 1978; Gross & Sargent, 1985). Three different hypotheses have been proposed to explain which parent is selected to care: 1) "gamete-order" (Dawkins & Carlisle, 1976; Ridley, 1978); 2) "reliability of paternity" (Trivers, 1972; Ridley, 1978); and 3) "parent-offspring association" (Williams, 1975). Gross & Shine (1981) tested the three hypotheses and showed that the association hypothesis was the most consistent with the available data. The authors also suggested that the prevalence of paternal care in external fertilizers resulted from male territoriality. Taking this into account, along with territoriality, the presence of multiple spawning was important in the evolution of male parental care because males that defend sites of spawning against other males indicate higher chances of reproducing again (Blumer, 1979). *Hoplias malabaricus* is known to show male territoriality and multiple spawning (Barbieri, 1989), which are consistent to the presence of male parental care.

In the present study, along with paternal care, we suggest the occurrence of biparental care of eggs in three of the 11 nests of *H. malabaricus* which were observed. Biparental care is rare among teleost fishes, occurring in approximately 13% of the external fertilizer families (Gross & Shine, 1985), and is unusual where care-taking is limited to eggs (Blumer, 1979). However, multiple patterns of parental care (no care, male care, biparental care, or female care) are known to occur within a single population during a single breeding season in many groups of animals, including fish (Webb *et al.*, 1999). Benefits associated with biparental care generally are the increase of offspring protection against predators and the possibility of one partner to assume care if the other dies or deserts (Annett *et al.*, 1999). For example, females of the ictalurid fish *Ictalurus nebulosus* commonly remain in the vicinity of their brood, though males are primarily responsible for care (Blumer, 1986). However, if the male disappears, the female takes over the male's role. In the case of *H. malabaricus* herein described, although we did not notice a partner in the vicinity of eight of the 11 nests, we can not exclude this possibility. As females of this species show multiple spawns, and females captured contained oocytes, alternative explanations for the presence of the female close to the nest could be that females were waiting for those partners to spawn later or for favorable sites for oviposition. Our observations suggest that male parental care is the normal form of parental care in *H. malabaricus*, but biparental care could also occur. Further observations in spawning and parental care behaviors of *H. malabaricus* in the Pantanal and other regions are needed.

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