# REPRODUCTIVE ASPECTS OF PIRANHAS *Serrasalmus spilopleura* AND *Serrasalmus marginatus* INTO THE UPPER PARANÁ RIVER, BRAZIL

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(With 4 figures)

## ABSTRACT

Construction of the Itaipu Dam, 150 km downstream from Sete Quedas Falls, resulted in the drowning of that natural geographic barrier, with consequent invasion of *Serrasalmus marginatus* in the upper stream. This event was followed by the reduction in the abundance of the native species, *S. spilopleura*. Analyzes of reproductive activity these species revealed that in lotic waters *S. marginatus* had a very intense reproductive activity while activity of *S. spilopleura* was nil. This, probably made it possible for the invading species to occupy new environments into the Upper Paraná River, using the river as an entry port. In the 1987-1988 period there was a marked decline in reproductive activity of *S. spilopleura* reflecting the negative effects of its interaction with the invading species, *S. marginatus*. The assertiveness of *S. marginatus* in caring for its offspring and aggressiveness in establishing its feeding territory may be the determining factor for its competitive superiority over *S. spilopleura*, and consequently its success in colonizing the Upper Paraná River. In addition to the negative interference of *S. marginatus*, a possible recruitment failure of *S. spilopleura* could have benefited the colonization of the floodplain by the invader species.

*Key words*: *Serrasalmus*, piranha, reproduction, invasion, colonization.

## RESUMO

### Aspectos reprodutivos das piranhas *Serrasalmus spilopleura* e *Serrasalmus marginatus* no alto rio Paraná, Brasil

A construção da barragem de Itaipu, 150 km a jusante do salto de Sete Quedas, resultou no afogamento da barreira geográfica natural com conseqüente invasão de *Serrasalmus marginatus* no trecho superior do rio. Este evento foi seguido pela redução na abundância da espécie nativa, *S. spilopleura*. A análise da atividade reprodutiva dessas espécies revelou que, nos ambientes lóticos, *S. marginatus* apresentou atividade reprodutiva muito intensa enquanto a atividade de *S. spilopleura* foi nula. Isto provavelmente possibilitou à espécie invasora ocupar novos ambientes do alto rio Paraná, usando o rio como porta de entrada. No período de 1987-1988 ocorreu forte redução na atividade reprodutiva de *S. spilopleura*, interpretada como reflexo do efeito negativo da interação com a espécie invasora. A agressividade de *S. marginatus* no cuidado da prole e na defesa do território de alimentação pode ter sido o fator determinante de sua superioridade competitiva e, conseqüentemente, de seu sucesso na colonização do Paraná superior. Além da interferência negativa de *S. marginatus*, uma possível falha no recrutamento de *S. spilopleura* pode ter beneficiado a colonização da planície de inundação pela espécie invasora.

*Palavras-chave*: *Serrasalmus*, piranha, reprodução, invasão, colonização.

## INTRODUCTION

Information on breeding behavior of piranhas comes either from second-hand accounts or from reports on a few species successfully bred in captivity by aquarists. Thus, there is uncertainty concerning species identification, which is not an easy task even for systematists (Leão, 1996). Parental care in piranhas is practiced by male alone, female alone, both parents, and even no form of parental care has been reported (Braker, 1963; Ledecky, 1966; Kemper & Schreiner, 1971; Bebronne, 1982; Azuma, 1990). Piranhas have a defined although prolonged spawning season, beginning at the onset of the floods (Bonetto *et al*., 1968; Leão, 1985; Nico & Taphorn, 1986; Machado-Allison, 1987; Agostinho, 1997).

Construction of the Itaipu Dam, impounded in November 1982, 150 km downstream from Sete Quedas Falls, resulted in the drowning of that natural geographic barrier, with consequent mixing of the fish faunas. *Serrasalmus marginatus*, a species that had been restrict to the river segment downstream from Sete Quedas, invaded the Upper Paraná River. The description of the invasion process and the reaction of the resident species is analyzed by Agostinho & Júlio-Jr. (subm.). In this study the reproductive activity of *S. spilopleura* and *S. marginatus* was analyzed so as to answer the following questions: i) Is the reproduction activity of these species similar into the floodplain system? ii) Did the invader species alter the pattern of reproductive activity of the native species?

## METHODS

Collections were made monthly during the periods of 1986-1988 and 1992-1994, on the floodplain of the Upper Paraná River (22°40'-22°50'S; 53°10'-53°40'W), situated 230 km upstream the Itaipu dam. Sampling floodplain includes numerous temporary and permanent lakes. Collections were carried out in ten stations, grouped in three types of environments: lagoons (Fechada, Guaraná, Patos, and Pousada das Garças), channels and arms of the rivers (Curutuba Channel, Baía I and Baía II), and rivers (Paraná, Ipoitã and Ivinheima) (Fig. 1).

Nylon gill nets were 1.7 m tall x 20.0 m long, with meshes of 3, 4, 5, 6, 7, 8, 10, 12, 14, and 16 cm (stretched measure). Nets were fished at the surface for 24 h periods at each site, once per month: the fish were removed every 8 hours. In 1992-93 the catch was removed every 4 hour. Abundance of sampled specimens was expressed by capture per unit effort (number of individuals in 1000 $m^2$ of gillnet per 24 h).

Following capture, fishes were transported to a field laboratory where they were identified and labeled according to capture place and date. The following information was recorded for each specimen: total ($L_T$) and standard length ($L_S$) to the nearest 1 mm, and total weight ($W_t$) to the nearest 0.01 g. A ventral incision was made to expose gonads for macroscopic determination of sex and gonadal development stage. The latter was determined according to macroscopic characteristics such as transparency, irrigation, color, and in females, the presence of intraovarian oocytes visible to the naked eye. The following stages were established: stage I (immature or virgin), II (maturing), III (mature), IV (spent) and V (resting). Fish in immature gonadal stages were considered as immature, and fish with gonads in all other stage as adult. Gonads were removed and weighed wet ($W_g$) to the nearest 0.01 g. Gonad weight was recorded only in 1986-88. Reproductive activity was analyzed using the Index of the Reproductive Activity (IRA) (Agostinho *et al*., 1991), given by the formula:

$$IRA = \frac{\ln Ni\left(\frac{ni}{\sum ni} + \frac{ni}{Ni}\right)\frac{RGSi}{RGSe}}{\ln Nm\left(\frac{nm}{\sum ni} + 1\right)} * 100$$

where:

Ni = number of individuals in unit i;

Nm = number of individuals in largest sample unit;

ni = number of individuals in reproduction in sample unit i;

nm = number of individuals in reproduction in sample unit with greatest n;

RGSi = ratio of gonadosomatic mean of individuals in reproduction in sample unit i;

RGSe = highest individual value of gonadosomatic ratio.

Reproductive activity was classified as incipient ($0 < IRA \leq 5$), moderate ($5 < IRA \leq 10$), intense ($10 < IRA \leq 20$), or very intense ($IRA \leq 20$), as proposed by Agostinho *et al*. (1991).

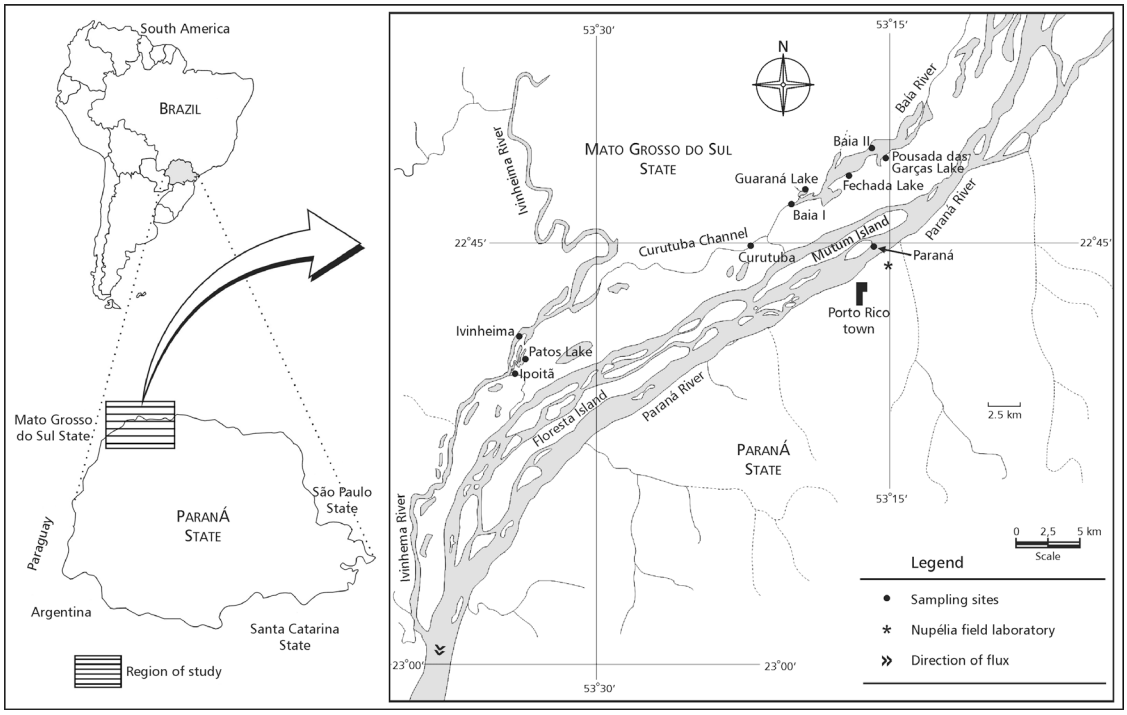


**Fig. 1 —** Locations of the sampling stations on the floodplain of the Upper Paraná River.

## RESULTS

Reproductive activity of both species varied from intense to very intense in lagoons and water channels. In rivers waters, reproductive activity of *S. marginatus* was very intense, and activity of *S. spilopleura* was nil (Fig. 2).

There was a decline in abundance of individuals in reproduction and adults of *S. spilopleura*, to near zero in 1992-1993 and 1993-1994. The number of individuals in reproduction of *S. marginatus* remained approximately constant. However, there was a marked increase in the abundance of juveniles and adults of this species during the periods analyzed (Fig. 3).

The reproductive season of both species extended from September through January. In 1987-1988 there was a marked decline in reproductive activity of *S. spilopleura* (Fig. 4).

## DISCUSSION

Observations of fish in aquarium revealed that *S. spilopleura* deposits its eggs on plant roots, and the males care for the offspring (Ledecky, 1966; Schultz, 1972). There are, however, no published observations of the behavior of this species toward possible predators while it is caring for its young. Resistance to abandonment of the offspring by the guarding individual is a species-specific character. At the approach of a human, *S. nattereri* passively abandons the nest and its eggs are immediately eaten by small characiforms (Uetanabaro *et al*., 1993), while *S. marginatus* attacks the potential predator. The parental care and aggressiveness of *S. marginatus* were observed in the Itaipu Reservoir (at the Santa Helena artificial beach), when individuals of this species, sheltering with their young in the banks of submersed macrophytes (*Nytella*), began to attack human swimmers (Agostinho *et al*., 2000). The aggressiveness of *S. marginatus* is also shown in the defense of its feeding territory. Individuals of *S. spilopleura* cause *S. marginatus* to flee from their feeding territory only if they were 30% to 50% larger than the latter (Sazima & Machado, 1990). The assertiveness of *S. marginatus* in caring for its offspring and aggressiveness in establishing its feeding territory may be the determining factor for its competitive superiority over *S. spilopleura*, and consequently its success in colonizing the Upper Paraná.

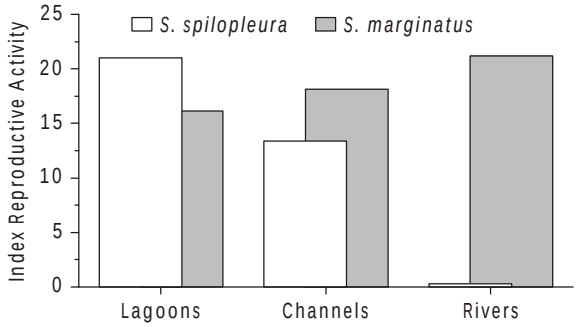


**Fig. 2 —** Values of the Index of the Reproductive Activity of females *of Serrasalmus spilopleura* and *S. marginatus* by environment.

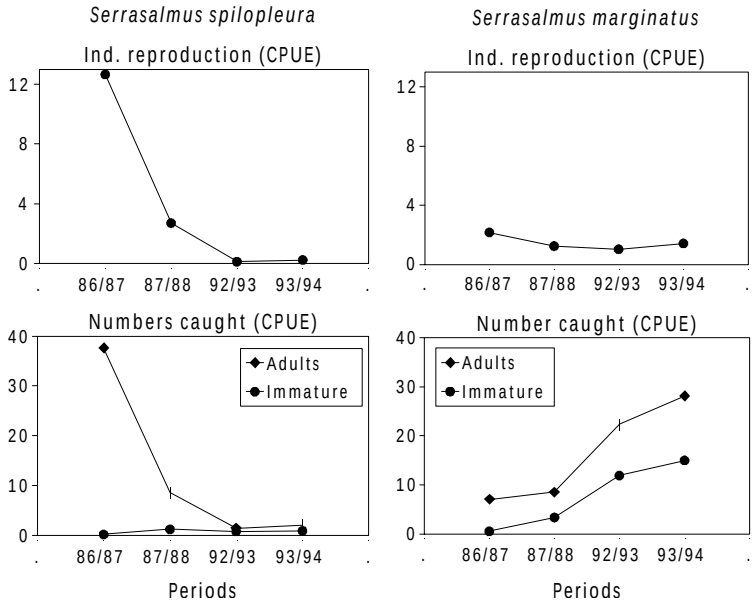


**Fig. 3 —** Capture per unit effort of individuals in reproduction, and individuals adults and immature of *Serrasalmus spilopleura* and *S. marginatus* by collection period.

Aggressiveness was the determining factor for the success of introductions of the brown trout in North America (Taylor *et al*., 1984).

The high reproductive intensity of *S. marginatus* in all environments, especially lotic waters, of the Porto Rico floodplain confers on this species an additional competitive advantage over *S. spilopleura*, which, besides being present in low abundance, does not reproduce in these environments. The adaptation of *S. marginatus* to lotic waters made it possible for this species to occupy new environments, using the rivers as an entry port. The higher index of reproductive activity value of *S. marginatus* in lotic waters was probably because of the virtual absence of *S. spilopleura*, which would result in greater availability of locations and make possible greater reproductive investment.

How can we explain the abundance increase of *S. marginatus* adults not accompanied by an increase in the number of individuals in reproduction?

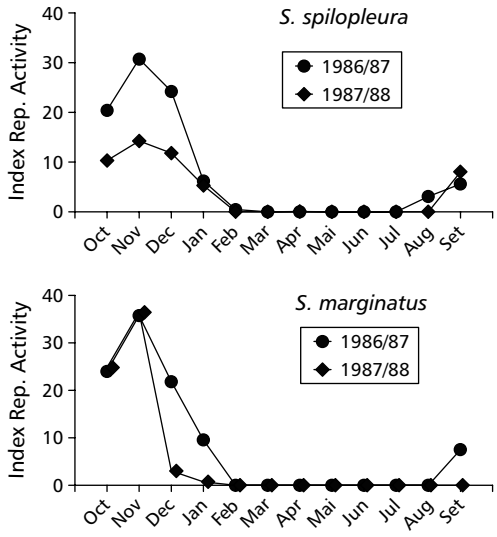


**Fig. 4 —** Monthly water level and monthly variation of the Index of the Reproductive Activity of *Serrasalmus spilopleura* and *S. marginatus*.

The fact that *S. marginatus* is a solitary species, with parental care, and which establishes feeding territories from 3 to 4 $m^2$ (Sazima & Machado, 1990; Agostinho *et al*., 2000) makes the space available for reproduction and feeding the most relevant ecological factor for the execution of these activities. The population increase of *S. marginatus* probably resulted in decreased available space, and limited the gonadal maturation process of this species. The low reproductive activity of *S. spilopleura* in the 1987-1988 period probably reflects the negative effects of its interaction with the invading *S. marginatus*. Interspecies competition between adult males for locations suitable for nests is an important factor determining the reproductive success of *Gasterosteus wheatlandi* and *G. aculeatus* (Cleveland, 1994).

Floods determine to a variable extent the availability of shelter and food, reproduction, growth and mortality rate, and the relationships in competition, predation and parasitism in the fish community (Agostinho *et al*., 2001). The absence of floods in the period of 1986-1987 probably decreased the availability of places to reproduce and increased the density of predators into the lagoons. *S. spilopleura* reproduces mainly into lagoons and its low captures of immature in 1987-1988 period is probably a recruitment failure on former period due to predation in these lagoons. Gomes & Agostinho (1996) described a similar fact on *Prochilodus scrofa* an abundant detrivore fish in the Paraná floodplain. Therefore, in addition to the negative interference of *S. marginatus*, a possible recruitment failure could have benefited the colonization of the floodplain by the invader species.

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