Reproductive and nutritional dynamics of *Salminus maxillosus* Valenciennes, 1849 (Pisces, Characidae) at Mogi Guaçu river, state of São Paulo, Brazil

Geraldo Barbieri[1]*, Fernando André Salles[2], e Marcos Antônio Cestarolli[2]

*[1]Centro de Estudos de Bacias Hidrográficas, Instituto de Pesca, Avenida Francisco Matarazzo, 455, 05001-900, São Paulo, São Paulo, Brasil. [2] Centro de Reprodução e Larvicultura, Instituto de Pesca. *Author for correspondence. e-mail: barbierig@uol.com.br*

ABSTRACT. The reproductive and nutritional dynamics of *Salminus maxillosus* Val. were studied in 327 specimens (195 females and 132 males) collected in the Mogi Guaçu river, São Paulo, Brazil from August, 1996 to July, 1997. Reproductive dynamics were assessed through analysis of monthly variation in gonadosomatic index, hepatosomatic index, relative frequencies of gonadal maturity stages and first sexual maturation size. Reproduction occurred from November to January (the highest values recorded in December),when the highest water temperatures and pluviometric index were observed. The size of *S. maxillosus* at first sexual maturation (Lpm) was calculated to be 346.7 mm (males) and 447.4 mm (females), the age being two years for both males and females. The L_{100} values calculated were 525.0 mm for males and 625.0 mm for females, respectively. The nutritional dynamics were estimated through analysis of the monthly variation and the relative frequency of the repletion stages. *S. maxillosus* from Mogi Guaçu River is in its optimum feeding condition before and during the reproductive season.

Key words: reproduction, nutrition, *Salminus*, river.

RESUMO. Dinâmica da reprodução e da nutrição de *Salminus maxillosus* Valenciennes, 1849 (Pisces, Characidae) do rio Mogi Guaçu, Estado de São Paulo, Brasil. A dinâmica da reprodução e a dinâmica da alimentação de *Salminus maxillosus* Val. foram estudadas em 327 exemplares (195 fêmeas e 132 machos) capturados no rio Mogi-Guaçu, estado de São Paulo, Brasil, no período de agosto de 1996 a julho de 1997. A dinâmica da reprodução foi analisada pela análise das variações médias mensais do índice gonadossomático, índice hepatossomático, freqüência relativa dos estádios de maturação gonadal e tamanho de primeira maturação gonadal. A reprodução ocorreu no período de novembro a janeiro (a maior atividade reprodutiva foi registrada no mês de dezembro), época em que foram registradas as maiores temperaturas da água e os maiores índices pluviométricos na região. O tamanho de primeira maturação gonadal foi estimado em 346,7 mm (machos) e 447,4 (fêmeas), quando os exemplares atingiram 2 anos de idade. O valor de L_{100} foi estimado em 525,0 mm para machos e 625,0 mm para fêmeas. A análise da dinâmica da alimentação, estudada pela variação mensal do índice de repleção e das freqüências relativas dos estádios de repleção, permitiu concluir que os exemplares encontram-se em melhores condições alimentares durante a reprodução.

Palavras-chave: reprodução, nutrição, *Salminus*, rio.

Reproductive and nutritional dynamics studies are very important as subsidy for fishery stock researches. *Salminus maxillosus* Val., commonly known as "dourado", is widely distributed in the major hydrographic basins of South America, Amazon and Paraná rivers, including the Pantanal/Mato Grosso and Mogi Guaçu river basins. This carnivorous fish migrates to a very extensive distance to prepare for spawning. It is commercially important, but few studies on *S. maxillosus* are found in the literature. The objective of the present study was to determine the spawning period, the first sexual maturation size and the period of highest feeding activity of the "dourado", *S. maxillosus* of the Mogi Guaçu river.

Material and methods

The Mogi Guaçu River flows through an important agriculture-industrial region of the state

of São Paulo, Brazil. It is 473 km long and 90 m wide. The river is an affluent of the Pardo river, which flows into the Paraná river, forming the La Plata basin and comprising an area of 3.200.000 km^2 (Godoy, 1975).

A total of 327 specimens (195 females and 132 males) were collected monthly from August 1966 to July 1997, using casting-net and long line. Total length (L), total weight (W), gonad weight (wg), liver weight (wf), stomach weight (we), viscera weight (wv), gonad maturation and repletion stage were recorded for each specimen. Gonad maturation stages were determined by macroscopically based on size, color, presence and egg size. The following stages were established: stage I (immature or virgin), II (maturing), III (mature), IV (spent) and V (resting). The repletion stages were defined as: I (empty stomach), II (partially full stomach) and III (full stomach).

Spawning period was established through analysis of the monthly frequency distributions of maturity stages, variations of average gonadosomatic (GSI) and hepatosomatic index (HSI) (Santos,1978). The GSI and HSI were calculated as the percentage of gonad and liver weight, respectively, as a relation to total weight. Size at maturity estimation was based on the relative frequency distribution of adults (stages II, III, IV and V) in each total length class (50 mm intervals), and corresponds to the class where 50% of specimens are adults (L_{50}). Line fitted to data corresponds to the function (Santos, 1978; Barbieri and Barbieri, 1983):

$$\text{frequency} = 1 - (e^{\varnothing L^{\theta}})$$

Feeding dynamics were evaluated by the repletion index (RI), calculated as we/W (Barbieri and Barbieri, 1984); and the viscera-somatic index, calculated as Wviscera/W.

Results

Reproduction of *S. maxillosus* in the Mogi Guassu River occurred from November to January (the highest values recorded in December) (Figure 1). A greater number of mature fish were caught during the period (Figures 2 and 3). Maturation of *S. maxillosus* starts in July (Figures 2 and 3) and henceforth increasing HSI and VSI values are observed until spawning (Figures 1 and 5). This suggests that indexes are related to vittelogenesis, migration and spawning. Spawning period was short.

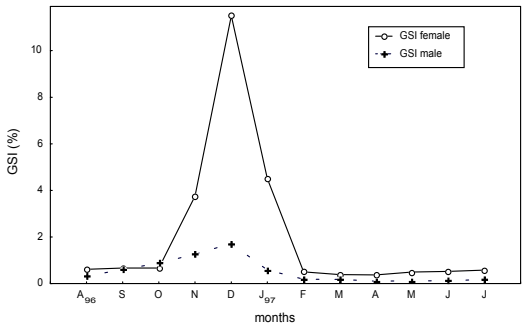

Figure 1. Monthly variation of average gonadosomatic index (GSI) of *Salminus maxillosus*

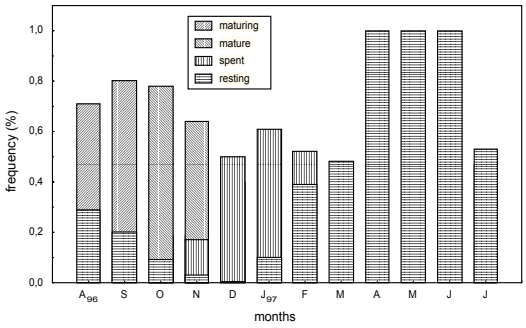

Figure 2. Monthly frequency distributions relative of maturity stages of females of *Salminus maxillosus*

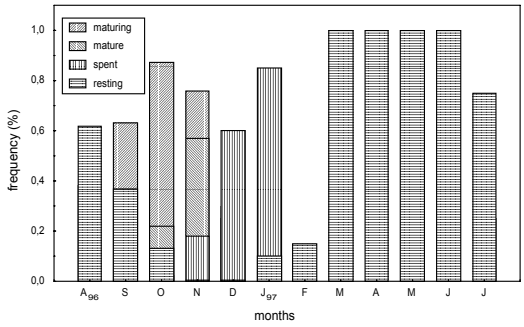

Figure 3. Monthly frequency distributions relative of maturity stages of males of *Salminus masillosus*

Figure 4 shows relative frequencies (fr) of adults by total length classes. The mathematical expressions obtained were:

$\text{fr} = 1 - e^{-3.894.10^{-11}.L^{4.022}}$ (for males)

$\text{fr} = 1 - e^{-3.009.10^{-21}.L^{7.688}}$ (for females),

corroborated by linearity of the logarithmic form of the variables:

$Y = -23.96 + 4.022\,X$ (males) $R^2 = 0.8915$

$Y = -47.25 + 7.688\,X$ (females) $R^2 = 0.8764$

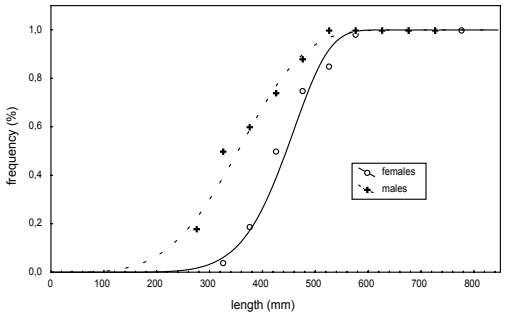

Figura 4. Relative frequencies distribution of adults in each total lenght class for males and females of *Salminus naxillosus*

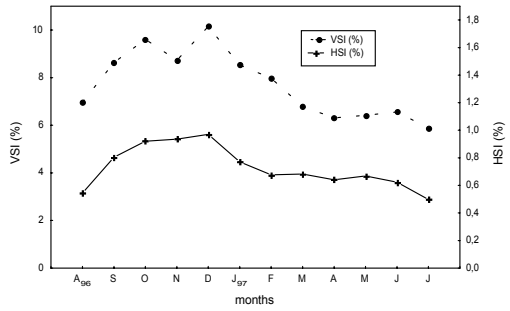

Figure 5. Monthly variation of hepatosomatic index (HSI) and viscerous-somatic index (VSI) of *Salminus maxillosus*

The size of *S. maxillosus* at first sexual maturation (L_{50}) was 346.7 mm for males and 447.4 mm for females. L_{100} values were 525.0 mm (two years old) for males and 625.0 mm (two years old) for females.

The maximum values of the repletion index occur before and during the reproductive season (Figure 6). The greatest relative frequencies of full stomachs (stage III) were also observed during the spawning period.

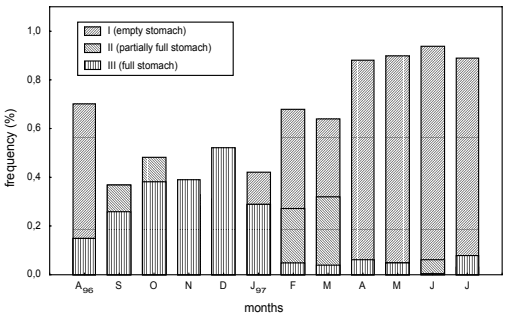

Figure 6. Monthly frequency distribution relative of stages of *Salminus maxillosus* (males and females)

Discussion

Salminus maxillosus, known as "dourado", is one of the most appreciated species in the professional and sporting fisheries. *S. maxillosus* reproduces in the spring and summer, a period of very high water temperatures and rainy season in the Mogi Guaçu river (Godoy, 1975; Barbieri *et al*., 1999). Temperature is one of the most important ecological feature in determining the spawning season in high latitudes (Wootton, 1991). In the southeast region of Brazil, most Characiformes species spawn in spring and summer, which are the rainiest and warmest seasons of the year (Vazzoler and Menezes, 1992). The water level is also an important factor related to the spawning of *S. maxillosus*. Spawning period begins before the warmest months to guarantee food for juveniles. The spawning season of this species is short and occurs only once a year, which is a characteristic feature of migratory and total spawning. It has great fecundity, perhaps the highest among Characiformes (Morais Filho and Schubart, 1955; Godoy, 1975) in the Parana river basin. While the process of gonadal maturation was relatively fast for *S. maxillosus*, males and females reached the size of first maturation in the second year of life, although their total asyntotic lengths (L_{∞}) are different, or rather, 874 mm for females and 713 mm for males (Barbieri *et al*., 1999). *Salminus maxilosus* may migrate hundreds of kilometers to spawn (Godoy, 1975). The greatest values for both HSI and VSI indexes were obtained in the pre-spawning period. Results suggest that the hepatic depletion is related to vitellogenesis, whereas the lipidic depletion is related to migration and spawning. The smallest values of above index were recorded during the spawning period. The same behavior was described for *Rhinelepis aspera* (Agassiz, 1829) from the Paranapanema river (Agostinho *et al*., 1986).

The better feeding condition of *S. maxillosus* occurs before the reproductive season, a fact reported for all carnivorous Characiforms species from the Lobo Reservoir (Barbieri *et al*., 1981).

References

AGOSTINHO *et al*. Ciclo reprodutivo e primeira maturação de *Rhinelepis aspera* (Agassiz, 1829) (Teleostei, Loricariidae) no rio Paranapanema. *Revista Unimar,* Maringá, v.*8*, no. 1, p. 17-27, 1986.

BARBIERI, G. *et al*. Dinâmica quantitativa da nutrição de *Hoplias malabaricus* (Bloch, 1794) da represa do Lobo, São Paulo, Brasil. *Rev. Bras. Biol.,* Rio de Janeiro, v. *42*, p. 295-302, 1981.

BARBIERI, G.; BARBIERI, M. C. Growth and first sexual maturation size of *Gymnotus carapo* (Linnaeus, 1758) in the Lobo Reservoir (São Paulo, Brazil) (Pisces, Gymnotidae). *Rev. Hydrobiol. Trop*., Ostrom, v.*16,* p. 195-201, 1983.

BARBIERI, G.; BARBIERI, M. C. Note on Nutritional Dynamics of *Gymnotus carapo* (L.) from the Lobo Reservoir, São Paulo State, Brazil. *J. Fish. Biol.,* London*,* v. *24*, p. 351-355, 1984.

BARBIERI, G. *et al*. Aspectos da biologia populacional do dourado, *Salminus maxillosus*, Valenciennes, 1849 do rio Mogi Guassu, São Paulo, Brasil. In: ENCONTRO BRASILEIRO DE ICTIOLOGIA, 13, 1999, São Carlos. Anais... São Carlos: UFSCar, 1999. p. 461.

GODOY, M. P. *Peixes do Brasil, Subordem Characoidei*. Ed. Franciscana: Piracicaba, 1975.

MORAIS FILHO, M. B.; SCHUBART, O. *Contribuição ao estudo do dourado (Salminus maxillosus Val.) do rio Mogi Guassu (Pisces, Characidae)*. São Paulo: Ministério da Agricultura, 1955.

SANTOS, E. P. *Dinâmica de populações aplicada à pesca e piscicultura*. São Paulo: Editora Universidade de São Paulo, 1978.

VAZZOLER, A. E. A. M. DE; MENEZES, N. A. Síntese de conhecimento sobre o comportamento reprodutivo dos Characiformes da América do Sul (Teleostei, Ostariophysi). *Rev. Bras. Biol.,* Rio de Janeiro, v.*52*, p. 627-640, 1992.

WOOTTON, R. J. *Ecology of teleost fishes*. (Fish and Fisheries Series; 1), London: Chapman & Hall,. 1991

Received on June 30, 2000.
Accepted on March 08, 2001.