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A N I N T E R N A T I O N A L J O U R N A L

Reproductive Strategies of *Plagioscion squamosissimus* Heckel, 1840 (Osteichthyes Sciaenidae) in the Itaipu Reservoir, Brazil

Regina Cintia Carnelós and Evanilde Benedito-Cecilio*
Universidade Estadual de Maringá; Department of Biology/NUPELIA; Av. Colombo, 5790; 87020-900; Maringá - PR - Brazil

ABSTRACT

Plagioscion squamosissimus *is a dominant species in the Itaipu reservoir and has a significant role in the regional economy. The aim of the present research was the investigation of the curvina's reproductive strategies during the first years of the Itaipu reservoir (November 1983 to October 1989). Collections were undertaken from eleven sampling sites in the reservoir area, left bank tributaries, Paraná River and its tributaries. Species begin the reproduction in the area of influence of the Itaipu reservoir only in 1986. Size of early maturation, local and period of spawning showed gradual variations, with a broadening trend of this activity in the area, and thus guaranteeing success of the species. Mean size of early sexual maturation for the* Plagioscion squamosissimus *reached 16.2 cm for males and 17.8 cm for females.*

Key words: Reproduction, Itaipu reservoir, *Plagioscion squamosissimus*, impact

INTRODUCTION

Reproductive strategies are a set of characteristics of a specie so that success in reproduction occurs through its descendents that guarantee the maintenance of the population. Reproduction strategies comprise age or size of early sexual maturation, fecundity, size and type of gametes, period and local of spawning, reproductive behavior, type of oocyte development and sexual proportion. Reproductive tactics are variable characteristics of standard type and a response to fluctuations in the environment. Variability of strategy-shaping tactic adopted by species or population is essential for the success of generation or cohort as a result of spawning. This is the reason why their structure and abundance may not be maintained by means of the recruitment of new individuals (Vazzoler, 1996). Potts and Wootton (1989), however, stated that one of the challenges for the ecologist is to show how strategy and reproductive tactics are adaptable in certain environmental circumstances.
Interception of watercourses by damming changes drastically the dynamics of the natural system, so new ecological conditions are established. Fish species will respond to such pressure by the evolution of compromising adaptations to the new environment. If this fails to happen, they will disappear or their population will decrease significantly. The establishment of reproduction strategies, adequate to the new environment, will determine the success of the species (Agostinho et al., 1999).

* Author for correspondence

Plagioscion squamosissimus, commonly known as *curvina*, was introduced in reservoirs of the northeastern Brazil in the 40s and in the Pardo River (state of São Paulo, Brazil) in the 60s (Nomura, 1984). Currently species is widely distributed in South America and it's one of the dominant species in the Itaipu reservoir which maintains a high contribution in fisheries (Agostinho, 1994; Benedito-Cecilio, 1994).

The present research work investigated the reproductive strategies of the *Plagioscion squamosissimus* in the early years of the Itaipu reservoir. These informations are indispensable data to the understanding of the auto-ecology of the species and fundamental for the management this fishery resource.

MATERIALS AND METHODS

Between November 1983 and October 1989, eleven sampling sites were established: three stations in the Itaipu reservoir (municipalities of Guaíra - GUAI; Santa Helena - SHEL; Foz do Iguaçu - FOZ); four in the left bank tributaries (Ocoí River - OCOI; São Francisco Falso River - SFFA; São Francisco Verdadeiro River - SFVE; Arroio Guaçu River - GUAC); two in the Paraná River (one upstream - MONT; one downstream - JUSA, the Itaipu reservoir); and two in tributaries of the Paraná River (Iguatemi River - IGUA; Piquiri River - PIQUI).

Fishing gear consisted of stationary nets with mesh sizes 3 to 16-cm mesh nets between nonadjacent knots, set out for 24 hours at each sampling station. Standard length (Ls), total weight (Wt) and weight of gonads (Wg) were taken for each specimen. Gonads, sex and stages of gonadal maturity were identified for each and every individual by macroscopic inspection (Vazzoler, 1996).

Mean size at first sexual maturation (Lpm) in males and females was considered the size at which 50% of individuals began the reproductive process (Vazzoler, 1981). Evaluation of changes in size of species's entrance in reproduction activity was analyzed by standard average length for the three smallest individuals (males or females) captured in the gonadal maturation stage during the period in which investigation occurred (Sato and Godinho, 1988).

Relative contribution of gonadal weight (Wg) in total weight (Wt), or Gonadal Somatic Relationship (GSR) of each individual was calculated by GSR = Wg/Wt x 100, in which chief events of reproduction cycle were evaluated by graphs of seasonal variation of average GSR (Vazzoler, 1996). Applied to data in each sampling station, procedure was used to identify reproduction activity in distinct environments under analysis, while seasonal analysis determined the period of species reproduction.

RESULTS

During the period from November 1983 and October 1989 were caught 3,629 males and 3,258 females totaling 6,887 individuals. Analysis of mean size of the three smallest individuals, males and females with maturating gonads, show increase of standard mean length during the study period. However, in the last period lengths were higher than those recorded at the start of the research (Tab. 1).

Table 1 - Mean standard length (cm) of the smallest three individuals, males and females of *P. squamosissimus*, per period (maximum standard length between parentheses).

	Sex	
Periods	Males	Females
1983-84	15,1 (43,0)	- (36,5)
1984-85	15,8 (36,5)	18,5 (41,0)
1985-86	14,6 (37,3)	23,3 (44,1)
1986-87	16,9 (37,7)	18,7 (43,6)
1987-88	15,1 (38,0)	21,7 (46,9)
1988-89	17,7 (36,4)	22,8 (47,9)

The size of 50% of individuals of *P. squamosissimus* capable of reproduction was 16.2 cm for males and 17.8 cm for females. Whole population participated effectively in the reproductive process to 22.5 cm (Fig.1).

Mean values for males and females of Gonadal Somatic Relationship for each sampling station and for each period analyzed are shown in Figures 2 and 3, respectively. During the first three years following the Itaipu reservoir formation no reproductive activity of species was recorded. It was only after 1986-87 that recorded the higher GSR values for both sexes, specially in OCOI and SFVE. In the period 1987-88, station SFFA presented high GSR values too. Within the principal body of the reservoir only FOZ showed increase of mean values of GSR.

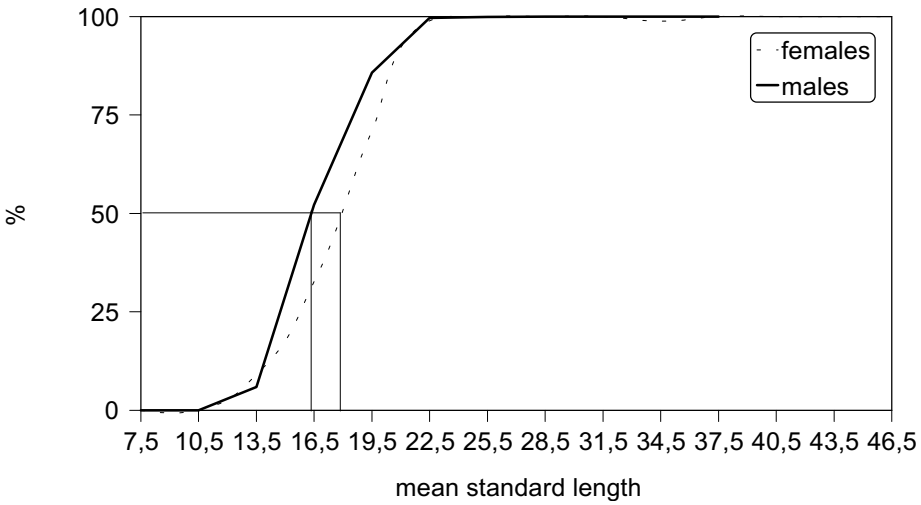

Figure 1 - Distribution of frequency of males and females of *P. squamosissimus* according to class of standard length.

These values doubled during 1988-89, the last period under analysis. Further, during the latter period reproduction area extended to the tributary GUAC.

Reproduction period of species extended itself from spring to autumn, with peaks in spring and summer (Tab. 1). It should be emphasized that GSR variations were perceived as from spring 1986. Mean values became gradually higher during the last periods under analysis.

DISCUSSION

Reproduction is one of the main events in the life history of the species (King, 1995). It is a more conservative item than all the other vital activities. Thus, it imposes limits to the colonization of reservoirs (Agostinho et al., 1999). In the case of *P. squamosissimus* the above supposition was confirmed since it was only in the spring of 1986 that the species had favorable conditions for spawning and development of young specimens and, consequently, a more thorough occupation of the flooded impounding. Nevertheless, the process involved displacements between areas in search of specific sites favorable to spawning and to the development of the juveniles ("cradle areas").

In the reservoir the size of first gonadal maturation of the *P. squamosissimus* was bigger in females. The fact has been recorded for various teleosts (Geevarchese and John, 1983; Benedito, 1989; Vazzoler, 1991). However, the size was approximately the same for both sexes when 100% of the population was capable of reproduction. When minimum sizes of *P. squamosissimus* specimens in the maturation stage were analyzed, size fluctuations were recorded. In the last year of the period under analysis, it was higher than was the first. It has also been found that maximum standard length reached by the population in the last years of the period studied was greater than that recorded immediately after impounding. This fact suggested an increase in species fecundity throughout the years, since there was a linear relationship in teleosts between body size and fecundity (Eenennaam and Doroshov, 1998).

Since effect of environmental changes on age and size of maturity depends on variations in growth and mortality rates (Wooton, 1990), limnological modifications by Itaipu impounding caused alterations in growth and mortality of species. This has consequently determined modification in size of early maturation of *P. squamosissimus*. After the first three years a adaptation of the fish community occurred, carrying to successful of the specie (Agostinho et al., 1994; Benedito-Cecilio, 1994). In his study on *Gymnotus carapo* during two consecutive years, Barbieri (1981) recorded that the species reached first maturation with a greater size in the second year of study. The same author believes that this fact may have occurred owing to a significant increase in the reservoir's water level.

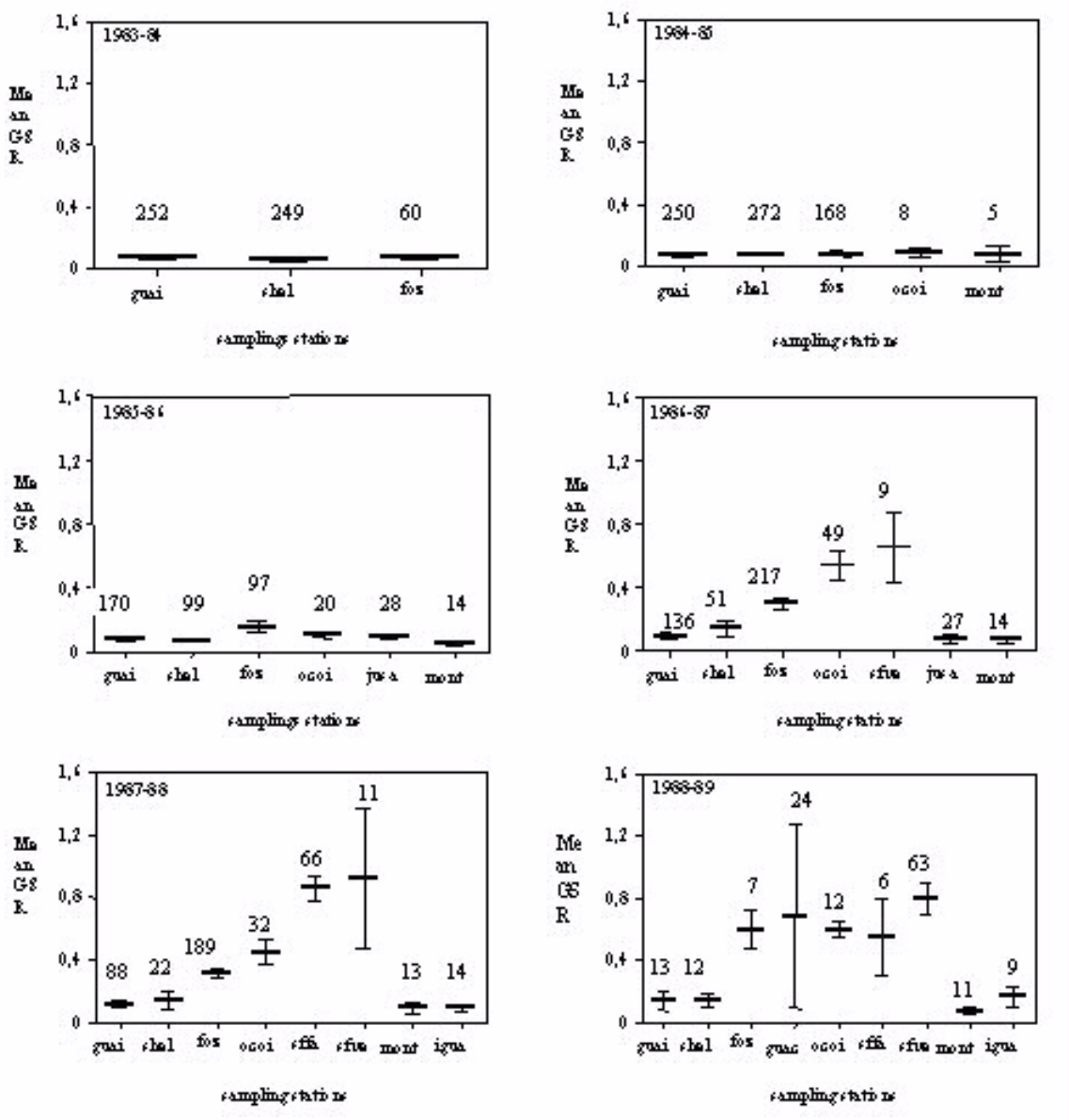

Figure 2 - Average values of Gonadal Somatic relationship (GSR) of *P. squamosissimus* males for each sampling station and period (internal horizontal line = mean GSR; vertical bar = confidence interval at 95%; the number means individuals sampled).

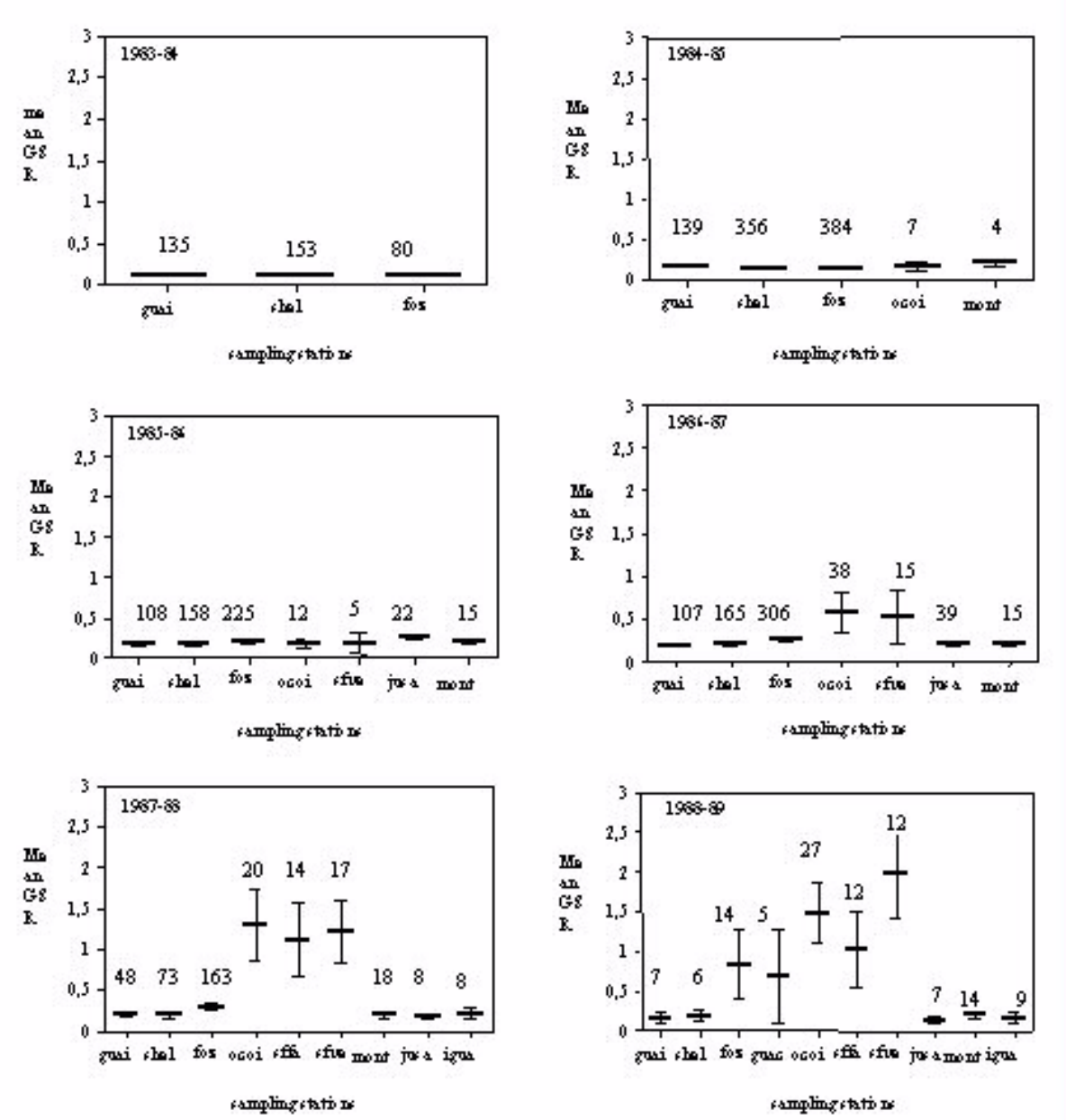

Figure 3 - Mean values of Gonadal Somatic Relationship (GSR) of *P. squamosissimus* females for each sampling station and period (internal horizontal line = mean GSR; vertical bar = confidence interval at 95%; the number means individuals sampled).

Table 2 - Mean values of Gonadal Somatic Relationship (GSR) and confidence interval at 95% (t* s0) for the period 1983 – 89 of *P. squamosissimus* males and females.

	Males		females	
Seasons	**n**	**RGS ± t* s0**	**n**	**RGS ± t* s0**
Spring 83	50	0,0916 ± 0,0617	12	0,1206 ± 0,0774
Summer 83-84	306	0,0596 ± 0,0651	175	0,1131 ± 0,0608
Autumn 84	149	0,0577 ± 0,0354	118	0,1206 ± 0,0535
Winter 84	20	0,0606 ± 0,0465	16	0,1451 ± 0,0614
Spring 84	62	0,0948 ± 0,0609	76	0,1426 ± 0,0689
Summer 84-85	274	0,0828 ± 0,0744	388	0,1397 ± 0,0590
Autumn 85	221	0,0609 ± 0,0413	303	0,1535 ± 0,0557
Winter 85	28	0,0621 ± 0,0294	44	0,1818 ± 0,0691
Spring 85	190	0,0644 ± 0,0316	66	0,1898 ± 0,0316
Summer 85-86	168	0,0866 ± 0,0619	214	0,0866 ± 0,0652
Autumn 86	32	0,0699 ± 0,0333	65	0,1804 ± 0,0643
Winter 86	79	0,9509 ± 0,1844	115	0,1746 ± 0,0701
Spring 86	194	0,1618 ± 0,2320	185	0,1699 ± 0,0837
Summer 86-87	314	0,2610 ± 0,2539	444	0,2311 ± 0,2421
Autumn 87	41	0,1804 ± 0,2513	78	0,2690 ± 0,3468
Spring 87	9	0,1049 ± 0,1451	5	0,1504 ± 0,0410
Winter 87	60	0,1913 ± 0,2174	91	0,2531 ± 0,2391
Summer 87-88	323	0,4233 ± 0,3584	279	0,4086 ± 0,5174
Autumn 88	29	0,0966 ± 0,0967	35	0,2557 ± 0,3602
Spring 88	79	0,4414 ± 0,3714	32	1,0173 ± 0,9815
Summer 88-89	189	0,5475 ± 0,3768	82	0,7342 ± 0,7160
Autumn 89	3	0,8978 ± 0,2915	4	0,1351 ± 0,0293
Winter 89	-	-	44	0,1818 ± 0,0691
Spring 89	-	-	13	1,3563 ± 1,1903

In the Itaipu reservoir the characteristics of the new environment reflected the complex interaction between the biotic and the abiotic components as a result of changes within the set of limnological variables which characterized impact on fish populations.

Although *P. squamosissimus* is distributed in all the reservoir's environments, GSR results indicate that reproduction preferentially occurs in the tributaries of the reservoir. This is corroborated by ichthyoplanctonic studies by Nakatani (1994) in the same environment. The author states that larvae, spawned in the tributaries, are carried to the reservoir and their development is completed therewith. Tributaries of the reservoir are characterized by low transparency and water temperature rates (Benedito-Cecilio, 1994). Nonetheless, upstream the reservoir and in the tributaries of the Paraná River, values of the GSR are low. It is supposed that small-sized lotic water bodies, in comparison to those of the Paraná River, are more favorable to the development of *P. squamosissimus* eggs and larvae.

Mean GSR results indicated that the reproduction of the of *P. squamosissimus* occurred from spring to autumn, with peaks in summer for males and in the spring for females. This was especially true for the last years of the studied period. Nakatani (1994) also recorded this broad spawning period for larvae, since *P. squamosissimus* larvae were found between November and June, with peaks in March and April. Environmental changes in impounding probably impeded the reproduction success in the early years. In the following years, when stabilization of environmental conditions was ratified, the *curvina* expanded its reproduction areas to the tributaries.

Reproductive strategies are generally adaptable to environmental conditions and consist of a response of the species or of the population to minimize energetic costs. In this work the size of first maturation, environmental and spawning period

represented homeostatic responses of the species with regard to the environment towards a reduction of energy costs.

It is, thus, important to emphasize that the *curvina* had a wide feeding variability in the area of the Itaipu reservoir. During the same period, the species obtained a diet composed of approximately 30 species of fish, with *Hypophthalmus edentatus* and *Roeboides paranensis* as its main feeding items (Hahn, 1991; Hahn et al., 1998). In the first years following impounding *Hypophthalmus edentatus* had the highest captures per unit of effort (Benedito-Cecilio, 1994). This showed that easiness in food acquisition due to availability of prey decreased energy spending. Transference of recourses to reproduction consequently increased the species's fitness in the environment.

On the other hand, diversity of prey caught by the predator and the latter's ability in changing its diet when prey availability changes influenced the stability of present populations and of the assemblage (Pianka, 1982). When reproduction aspects of the of *P. squamosissimus* during the first six years of the Itaipu reservoir were taken into account, reproduction tactics of the species underwent gradual changes because of biotic and abiotic conditions in the new environment. This fact reflected in the species's population success in the Itaipu reservoir. However, since *P. squamosissimus* is an introduced species, a follow up of the degree of interference of its population on fish assemblage would be required. Further studies will help towards more efficient measures of correction and prevision of impact of this and other fish introductions in Brazilian rivers.

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RESUMO

Plagioscion squamosissimus, amplamente distribuída na América do Sul, constituiu-se no reservatório de Itaipu em uma das espécies dominantes e de expressiva participação nos desembarques comerciais. Com o intuito de investigar as estratégias reprodutivas utilizadas pela espécie nos primeiros anos de formação do reservatório de Itaipu foram realizadas coletas durante o período de novembro de 1983 a outubro de 1989 em onze estações de amostragens situadas na área do reservatório, tributários da margem esquerda, rio Paraná e seus tributários. Constatou-se que a espécie iniciou o processo reprodutivo na área de influência o reservatório de Itaipu somente apartir de 1986. Após este período a estratégia reprodutiva exibida pela espécie foi adaptativa, sendo que o tamanho da primeira maturação, local e período de desova, apresentaram variações gradativas no sentido de ampliação desta atividade na área, garantindo o sucesso da espécie. O tamanho médio da primeira maturação sexual para a população de *P. squamosissimus* é de 16,2 cm para machos e de 17,8 cm para fêmeas.

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