PONTIFÍCIA UNIVERSIDADE CATÓLICA DE MINAS GERAIS
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INFLUÊNCIA DO RIO PARDO NO SUCESSO REPRODUTIVO DO MANDI-AMARELO *Pimelodus maculatus* La Cepède, 1803 (PISCES: SILURIFORMES) A JUSANTE DA BARRAGEM DE PORTO COLÔMBIA, RIO GRANDE, SUDESTE DO BRASIL.

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Dissertação apresentada ao Programa de Pós-graduação em Zoologia de Vertebrados, como requisito parcial para obtenção do título de Mestre em Zoologia de Vertebrados

Orientador: Nilo Bazzoli (PUC Minas)
Colaboradores: Dirceu Marzulo Ribeiro (FURNAS)
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RESUMO

A jusante das barragens hidrelétricas ocorrem alterações no regime hidrológico que podem causar impactos sobre o processo reprodutivo dos peixes. O objetivo do presente estudo foi analisar a influência de parâmetros físico-químicos da água do rio Grande e rio Pardo sobre a maturação gonadal, diâmetro ovocitário, atresia folicular e índices biológicos de *Pimelodus maculatus* coletados em três trechos: a jusante do reservatório de Porto Colômbia (P1), a jusante da confluência do rio Grande com rio Pardo (P2) e na calha do rio Pardo, a aproximadamente 100 km de P2 (P3). Machos e fêmeas capturados no ponto 1 apresentaram valores médios de comprimento total e peso corporal significativamente maiores do que aqueles capturados nos pontos 2 e 3. Os valores de IGS foram significativamente maiores nos peixes coletados no ponto 3 e o fator de condição de Fulton não apresentou diferenças significativas entre os peixes coletados nos três pontos. O diâmetro ovocitário, a altura das células foliculares e a espessura da zona pelúcida dos ovócitos vitelogênicos não mostraram diferenças estatísticas entre os pontos. A condutividade apresentou diferença significativa entre os pontos 1 e 3 e a transparência da água durante o período reprodutivo apresentou valores próximos nos dois pontos amostrais do rio Grande (P1= 2,45 ± 0,05m, P2= 2,35 ± 0,05m), e valor bem menor no ponto amostral do rio Pardo (P3= 0,22 ± 0,02m). Em P1 registrou-se baixa frequência de peixes em atividade reprodutiva (19,70%), e em P2 (56,25%) e P3 (55,55%) maiores freqüências de peixes reproduzindo. Os resultados encontrados enfatizam a necessidade de conservação de tributários para o sucesso reprodutivo de *P. maculatus*, do rio Grande no sudeste do Brasil.

Palavras-Chave: Impacto ambiental. Reprodução. Fatores abióticos. Índice gonadossomático.

ABSTRACT

The alterations to the hydrologic regime downstream from hydroelectric dams may cause an impact on the reproductive success of fishes. This study aimed to analyse the influence of the water physical and chemical parameters of the Grande and Pardo Rivers on gonadal maturation, oocyte diameter, follicular atresia and biological indexes of *Pimelodus maculatus* collected in three river sections: Grande river, downstream from the Porto Colômbia reservoir (S1), Grande river, downstream from the confluence with the Pardo River (S2) and in the Pardo River channel (S3). Males and females captured in S1 presented significantly higher average values for total length and body weight than those captured in S2 and S3. The gonadosomatic index values were significantly higher in fish collected in S3 and the Fulton condition factor did not show significant differences in fish collected from the three sections. The oocyte diameter, the follicular cells height and the zona pellucida thickness did not show any statistical differences between the sections. Conductivity presented a significant difference between S1 and S3 and during the reproductive period, water transparency presented similar values in the two sampling sections of the Grande River (S1= 2.45 ± 0.05m, S2= 2.35 ± 0.05m), but a much smaller value in the Pardo River (S3= 0.22 ± 0.02m). A low frequency of fish with reproductive activity (19.70%) was registered in S1, whereas in S2 (56.25%) and S3 (55.55%) higher frequencies were recorded, emphasizing the need to preserve the tributaries for the reproductive success of *P. maculatus* of the Grande River in Southeastern Brazil.

Key words: Environmental impacts. Reproduction. Abiotic factors. Gonadosomatic index.

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1 APRESENTAÇÃO

Ecossistemas de água doce fornecem recursos vitais para os seres humanos e são habitats de uma biota extraordinariamente rica, diversa e sensível à mudanças ou oscilações ambientais. A demanda dos humanos em relação as águas continentais vêm crescendo rapidamente desde o século passado, causando diversos impactos nesses ambientes (Dudgeon *et al.,* 2006). Deste modo, a humanidade está utilizando a água doce para diversos fins como irrigação, consumo, produção energética, despejo de lixos industriais e domésticos, transporte, recreação, mineração, dentre outros. Como conseqüência disso, o valor econômico direto gerado através do uso desse ecossistema gira em torno de US$ 6,5 trilhões/ ano, correspondendo a cerca de 20% de toda a riqueza gerada por todos os ecossistemas no mundo (Costanza *et al*. 1997).

Na região Neotropical, o interesse em estudos relacionados à ecologia, bem como a influência de variáveis ambientais na comunidade de peixes é relativamente recente (Oliveira & Bennemann, 2005; Fialho *et al.*, 2008), porém diversos autores vêm relatando nas ultimas décadas o impacto causado pelas mudanças em fatores abióticos da água, em virtude de interferência antrópica ou não, na biota aquática (Penczak *et al*., 1994; Abes & Agostinho, 2001; Braga & Andrade, 2005; Fialho *et al*., 2008; Arantes *et al*., 2010; Thomé *et al*., 2012).

Os peixes migradores são importantes componentes da ictiofauna Neotropical de água doce (Carolsfeld & Harvey, 2003) e nas últimas décadas essas espécies vêm sofrendo com o crescente número de usinas hidroelétricas (UHE) que alteram o regime hidrológico natural e formam barreiras para a realização de suas migrações reprodutivas (Agostinho *et al*., 2003; Mérona *et al*., 2005). O rio Grande, maior tributário do rio Paraná, é um exemplo da crescente demanda energética no Brasil nas últimas décadas, abrigando 13 UHEs em seus 1300 Km transformando o rio que antes era um ambiente lótico, com diversas corredeiras em uma cascata de lagos artificiais (Santos & Formagio, 2000).

O mandi-amarelo, *Pimelodus maculatus*, pertencente a ordem dos Siluriformes e da família Pimelodidae, é uma espécie de médio porte podendo atingir aproximadamente 36 cm de comprimento total. Essa espécie é amplamente distribuída em águas continentais da região sudeste do Brasil, e possui importância tanto para a pesca comercial quanto esportiva. Como espécie migradora, o mandí utiliza trechos menores de rio para realizar sua reprodução, diferentemente de outros peixes migradores Neotropicais (Agostinho *et al*., 2003; Lundberg & Littmann, 2003). Pelo fato de ainda não existirem estudos pormenorizados sobre a reprodução de peixes a jusante de usinas hidroelétricas do rio Grande, o presente estudo analisa comparativamente a reprodução de *P. maculatus* em 3 trechos da bacia do rio Grande a jusante da UHE de Porto Colômbia.

2 OBJETIVOS

2.1 Objetivo geral

Avaliar a influência do rio Pardo no sucesso reprodutivo do mandi-amarelo em três pontos da bacia do rio Grande, a jusante da barragem de Porto Colômbia.

2.2 Objetivos específicos

a) Calcular o número de ovócitos vitelogênicos (fecundidade) por grama de ovário dos peixes capturados nos três pontos de amostragem;
b) Estimar, nos três pontos de amostragem, a fecundidade relativa por unidade de peso corporal, comprimento total e peso gonadal;
c) Avaliar parâmetros físico-químicos da água (Oxigênio dissolvido, temperatura, condutividade elétrica e pH) nos três trechos de amostragem;
d) Determinar o diâmetro dos ovócitos vitelogênicos, índice gônado-somático (IGS), índice hepato-somático (IHS), fator de condição de Fulton (K) nos três pontos;
e) Relacionar a fecundidade com as variáveis: diâmetro dos ovócitos vitelogênicos, IGS, tipo de ovo, tipo de desova;
f) Comparar estatisticamente os parâmetros reprodutivos analisados (comprimento total, peso corporal, freqüência dos estádios de maturação gonadal e fecundidade) com os parâmetros físico-químicos da água nos três pontos de amostragens.

3 ARTIGO SUBMETIDO

INTRODUCTION

Several physical and chemical factors affect the behaviour and the reproduction of freshwater fishes, such as: water temperature, rainfall, turbidity, water level, photoperiod and population density (Janz *et al*., 2001; Weber *et al*., 2002; Arantes *et al.*, 2010; Thomé *et al.*, 2012). Water temperature and rainfall are critical factors which trigger spawning migration, therefore, the reproductive success of a species may be related to water volume increase and temperature (Parkinson *et al*., 1999; Rizzo *et al*., 2003).

Alterations to the hydrologic regime downstream from hydroelectric power plants, such as a decrease in the flood peaks, may result in unstable thermal and hydrologic conditions (Baxter, 1977; Agostinho *et al*., 1992). Such impacts seem to especially affect the reproductive process of fish since, in tropical regions, the flood regime is considered to be critical for trigging reproduction and spawning migration (Sato *et al*., 2003). Thus, several impacts in the fish communities downstream from dams has been reported reflecting change in the ichthyofauna composition up and downstream the dam, interruption of the migration process, reproduction inhibition, facility to introduce exotic species, changes in behaviour, disorientation and imbalance, immobilisation and death, an increase in vulnerability to predation, interference in feeding areas and juvenile recruitment (Welcomme, 1979; Ruane *et al*., 1986; Agostinho *et al*., 1993; Sato *et al*., 2003). In the Paraná River, Brazil, the reproductive behaviour of migratory fish was altered in the first kilometres downstream the Itaipu dam, where fish could not spawn, and thus presented an intensive process of follicular atresia (Agostinho *et al*., 1993). Likewise, the colder water released by the dams of the Colorado River, in the USA, resulted in a decline of the local ichthyofauna (Paukert & Rogers, 2004).

In the São Francisco River, downstream from the Três Marias dam, the reproduction cycle of *Prochilodus argenteus* in the first 34 km of this river, where the water is colder (below 24° C) and from the hypolimnium, most fish were found to be in reproductive resting. On the other hand, after the confluence with the Abaeté River, where the water temperature reaches 26° C, fish exhibit intense reproductive activity (Sato *et al.* 2003 and 2005, Arantes *et al*., 2010; Thomé *et al*., 2012).

The *Pimelodus maculatus* (La Cepède, 1803), called mandi-amarelo, is considered by some authors to be a migratory species, requiring shorter sections of rivers in which to reproduce, differing from other Neotropical migratory fishes which migrate for long distances (Agostinho *et al*., 2003). Considering that the mandi-amarelo represents an important species, both for commercial and recreational fishing (Lundberg & Littmann, 2003) and that there are no detailed studies analysing the importance of tributaries to this species' reproduction, this study comparatively analyses the reproduction of *P. maculatus* in the Grande River, downstream from the Porto Colômbia hydroelectric power plant, and its tributary, the Pardo River, in Southeastern Brazil.

MATERIALS AND METHODS

Fish

Specimens of *P. maculatus*, 302 females and 254 males, were captured bimonthly, in three sections of the Grande River basin, between January/2010 and February/2011. The first section was located in the Grande River, immediately downstream from the Porto Colômbia dam (S1) (20º 7' 44"S, 48º 34' 34"W), the second section, downstream from the confluence of the Grande River and the Pardo River (S2) (20º 10' 04"S, 48º 38' 44"W), and the third, in the channel of the Pardo River (S3) (20º 81' 48"S, 48º 23' 41"W) (Figure 1). The fish were captured by fishermen from FURNAS Centrais Elétricas S/A, using gillnets and casting nets and the animals were sacrificed by cross-section of the cervical medulla in accordance with the Animal Experimentation Guidelines, established by the Brazilian College of Animal Experimentation (COBEA). For all specimens, we registered the following biometric data: total length (TL), standard length (SL), body weight (BW) and gonad weight (GW). From the biometric data obtained, we calculated the gonadosomatic index (GSI = GW.100/BW) and the condition factor (K = BW.100/SL^3).

Physical and chemical parameters of the water

A multiparameter surface sonde (YSI brand) was used for measuring the following physical and chemical parameters of the water: temperature, dissolved oxygen concentration, pH and electrical conductivity. The water transparency was measured with a Secchi disc.

Histology, gonadal maturation stages and follicular diameter

Gonad fragments were fixed in Bouin's fluid for 8 to 12 hours, kept in alcohol 70% and were submitted to the routine histological techniques: paraffin embedding, 3-5 µm thick microtomy sections, and hematoxylin and eosin stain (HE). The gonadal maturation stages were established based on the oocyte distribution, spermatogenic lineage cells, and variations of the GSI (Santos *et al.*, 2004; Arantes *et al.*, 2010). The diameter of the vitellogenic follicles was determined from histological slides of the mature ovaries using a micrometric ocular attached to the light microscopy.

Fecundity

In order to estimate fecundity, samples from the middle region of the ovaries were fixed in a modified Gilson's solution (100 ml of alcohol 60%, 880 ml of distilled water, 15 ml of nitric acid 80%, 18 ml of glacial acetic acid and 20 g of mercury chloride) until complete dissociation of the oocytes had occurred. The vitellogenic oocytes were separated from the others by the use of sieves whose meshes presented a diameter smaller than the minimum diameter of the vitellogenic oocytes. Absolute fecundity (Af) was determined from the following expression: Af = NFG.GW; where NFG = number of follicles per ovary gram and GW = gonad weight. The relative fecundity (RF) was calculated in order to eliminate the interference of body weight (BW) on the fecundity estimates, using the expression: RF = $Af.BW^{-1}$.

Statistical Analysis

All results were expressed as means ± standard deviation and were considered significant with $p<0.05$. The comparison of follicular diameters, morphometric measurements, abiotic factors and biological indexes of the three river sections were done through the Kruskal-Wallis non-parametric test followed by Dunn post-test. For all tests, a degree of freedom of H= 2 was obtained.

RESULTS

Macroscopically, the ovaries of the *P. maculatus* are sacciform in shape, yellow in colour and the testes are elongated organs with filiform projections. Microscopically, ovaries showed oogonias nests and follicles in different phases of maturation, and the testes showed anastomosed seminiferous tubules. In the caudal region of the testes in advanced maturation/mature and spent stages, the lumen of the seminiferous tubules presented globular acidophilic secretions (Figure 2).

Males and females captured from S1 presented average values of total length and body weight higher than those captured in S2 and S3. The GSI values were significantly higher in fish collected in S3 and the Fulton condition factor did not show significant differences in fish collected in the three sections (Tables 1 and 2).

Through macro and microscopic analyses of gonads and GSI variations, four gonadal maturation stages were determined: 1 = resting, 2 = initial maturation, 3 = advanced maturation/mature and 4 = spawned for females and spent for males (Figures 2 and 3). During the whole sampling period, there was predominance of resting females in the three sections and of resting males in S1. Males and females in mature stages were recorded in the three sampling sections, although females in that stage were rare. Spawned females (F4) were only registered in S3, whereas spent males (M4) were found in the three sections (Figure 4). The highest values for absolute fecundity and GSI were recorded in S2 and S3 (Tables 1 and 2). The oocyte diameter, the follicular cells height and the zona pellucida thickness did not show any statistical differences between the sampling sections (Table 3). Despite the low number of spawned females, we observed a high frequency of atretic follicles in the ovaries of fish in this stage captured in S3. This process was characterized by the fragmentation of the zona pellucida, liquefaction of the yolk, hypertrophy of the follicular cells and yellow body formation. Three phases of follicular atresia were determined in *P. maculatus*: 1= initial, 2 = intermediate, 3 = final (Figure 3).

Among the chemical and physical parameters of the water, there were no statistical differences between the three sections regarding the pH, dissolved oxygen concentration and temperature. In all three sections, the temperature was higher from October to March. The conductivity presented the highest values in S3 and the lowest ones in S1, with statistically significant differences between them. The conductivity peak in S2 and S3 occurred in October, followed by a sharp decrease until February, during the reproductive period. Water transparency in the reproductive period, from November to January, presented similar values from the two sampling sections of the Grande River (S1= 2.45 ± 0.05m, S2= 2.35 ± 0.05m), and a much smaller value in the Pardo River site (S3= 0.22 ± 0.02m).

Tabela 1: Biological variables of *P. maculatus* males, collected between January/2010 and February 2011, from three different sections of the Grande River basin, downstream from the Porto Colômbia power plant.

	Section 1		Section 2		Section 3	
	Mean ± SE	**Range**	**Mean ± SE**	**Range**	**Mean ± SE**	**Range**
TL (cm)	27.51 ± 2.25a	23 - 33.6	25.42 ± 2.53b	20 - 33	26.31 ± 2.60c	16.5 - 33.5
BW (g)	254.59 ± 78.8a	140 - 527	217.51 ± 60.22b	115 - 415	238.48 ± 72.63a	52 - 533
GSI (%)	0.17 ± 0.13a	0.004 - 0.54	0.29 ± 0.10b	0.10 - 0.58	0.33 ± 0.26b	0.003 - 1.01
K	2.12 ± 0.42a	1.18 - 4.33	2.40 ± 0.40a	1.69 - 4.39	2.28 ± 0.40a	1.15 - 3.25

Section 1: Grande River, downstream from the Porto Colômbia power plant; Section 2: confluence of the Grande and Pardo rivers; Section 3: the Pardo River channel; GSI: Gonadosomatic index; K: Fulton condition factor. Data expressed as mean ± standard deviation (SD); different letters indicate statistical differences between the sampling sections ($p < 0.05$).

Tabela 2: Biological variables of *P. maculatus* females, collected between January/2010 and February 2011, from three different sections of the Grande River basin, downstream from the Porto Colômbia power plant.

	Section 1		Section 2		Section 3	
	Mean ± SE	**Range**	**Mean ± SE**	**Range**	**Mean ± SE**	**Range**
TL (cm)	30.34 ± 3.10a	23.0 - 39.0	27.98 ± 3.72bc	14.5 - 39.0	29.65 ± 2.49ac	24.0 - 36.0
BW (g)	364.57 ± 125.04a	168 - 935	296.69 ± 125.6bc	38 - 873	350.73 ± 88.8ac	178 - 587
GSI (%)	0.74 ± 0.36a	0.22 - 2.25	1.18 ± 1.13ac	0.31 - 4.62	1.30 ± 1.42bc	0.36 - 7.55
K	2.16 ± 0.34a	1.49 - 3.85	2.31 ± 0.33a	1.49 - 2.89	2.29 ± 0.31a	1.55 - 3.2
AF	25136 ± 1259.7a	9038 - 26812	45763 ± 1377.6b	7274 - 47289	27095 ± 6731.9a	17165 - 62857
RF	47.40 ± 7.56a	40.9 - 55.7	93.66 ± 58.78a	27.98 - 167.1	75.38 ± 35.04a	31.55 - 125.72

Section 1: Grande River, downstream from the Porto Colômbia power plant; Section 2: confluence of the Grande and Pardo rivers; Section 3: the Pardo River channel; GSI: Gonadosomatic index; K: Fulton condition factor; Af: Absolute fecundity; RF: Relative fecundity. Data expressed as mean ± standard deviation (SD); different letters indicate statistical differences between the sampling sections ($p < 0.05$).

Tabela 3. Measurements of *P. maculatus* vitellogenic follicles from the three sampling sections.

	Section 1		**Section 2**		**Section 3**	
	Mean ± SE	**Range**	**Mean ± SE**	**Range**	**Mean ± SE**	**Range**
Oocyte diameter (µm)	429.7 ± 53.7a	337.8 - 518.1	446.3 ± 70.7a	263 - 563.3	457.5 ± 62.5a	351.2 - 547.8
Follicular cells (µm)	15.01 ± 3.40a	9.60 - 21.50	26.18 ± 12.47a	11.90 - 40.30	18.13 ± 7.41a	7.20 - 35.00
Zona pellucida (µm)	2.63 ± 0.46a	1.80 - 3.50	2.54 ± 0.73a	1.60 - 4.00	2.81 ± 0.62a	1.70 - 4.10

Section 1: Grande River, downstream from the Porto Colômbia power plant; Section 2: confluence of the Grande and Pardo rivers; Section 3: the Pardo River channel. Data expressed as mean ± standard deviation (SD); different letters indicate statistical differences between the sampling sections ($p < 0.05$).

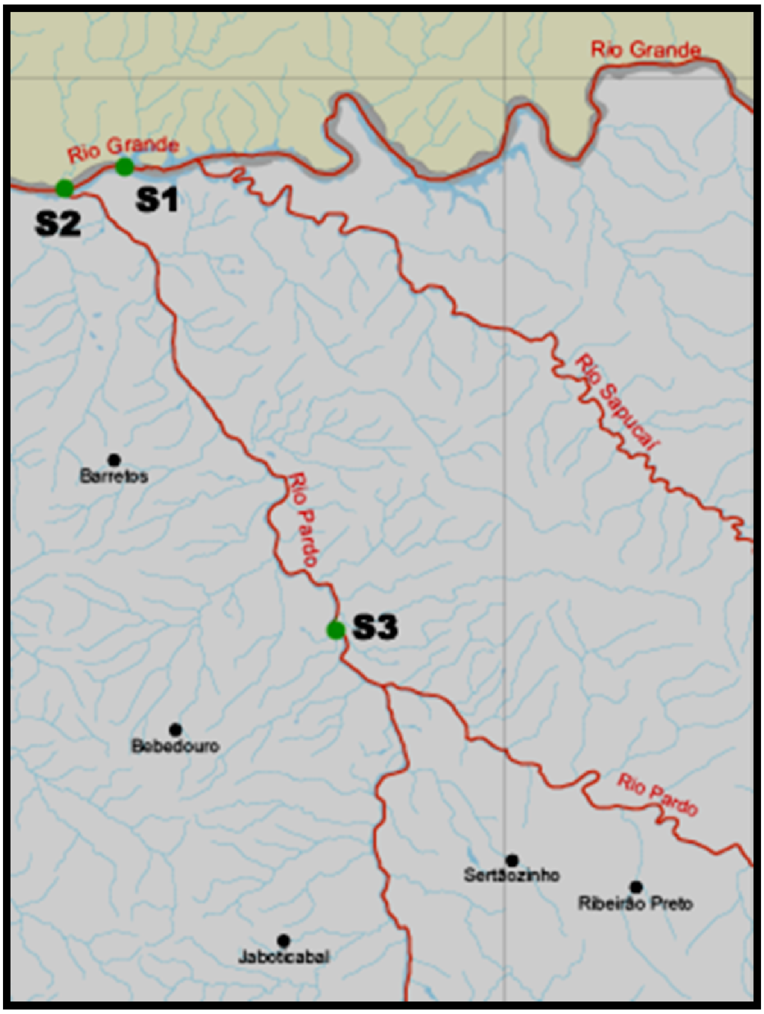

Figura 1 - Study area with samples sections.
(Fonte: ANA)

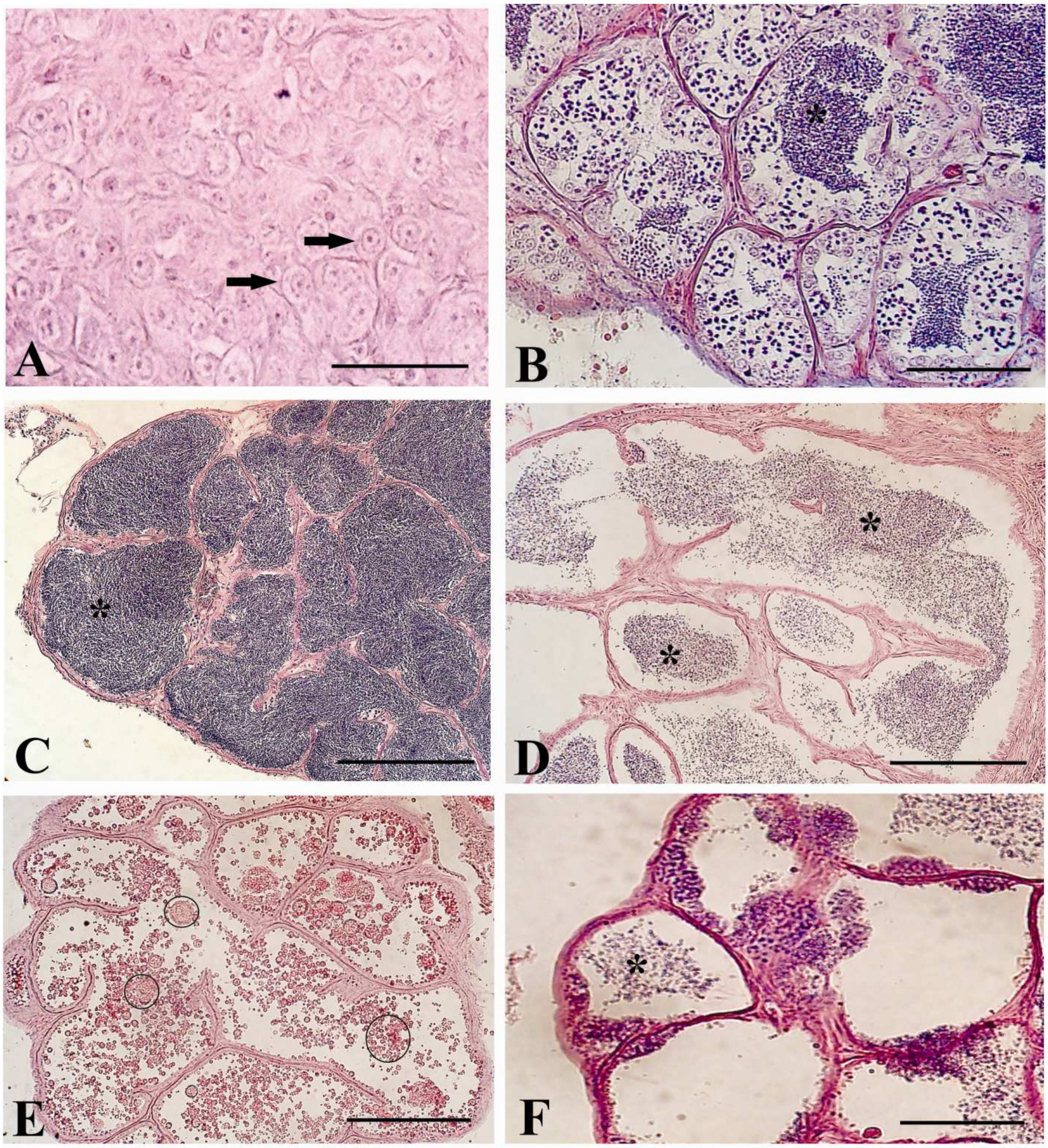

Figura 2 - Histological sections of *P. maculatus* testes, in different stages of gonadal maturation, stained with HE. A: Resting with seminiferous tubules closed containing only spermatogonia; B: Initial maturation, with seminiferous tubules containing all spermatogenic lineage cells and a small amount of sperm; C: Advanced maturation/mature, with seminiferous tubules filled with sperm; D: Partially spent, with open seminiferous tubules containing a considerable amount of sperm; E: Caudal region of a partially spent testis with globular acidophilic secretion (circle); F: fully spent, with open seminiferous tubules containing residual sperm in the lumen. * = Sperm; Arrow = Spermatogonia. Scale bars= 20 μm (A), 50 μm (B and F), 100 μm (C-E).

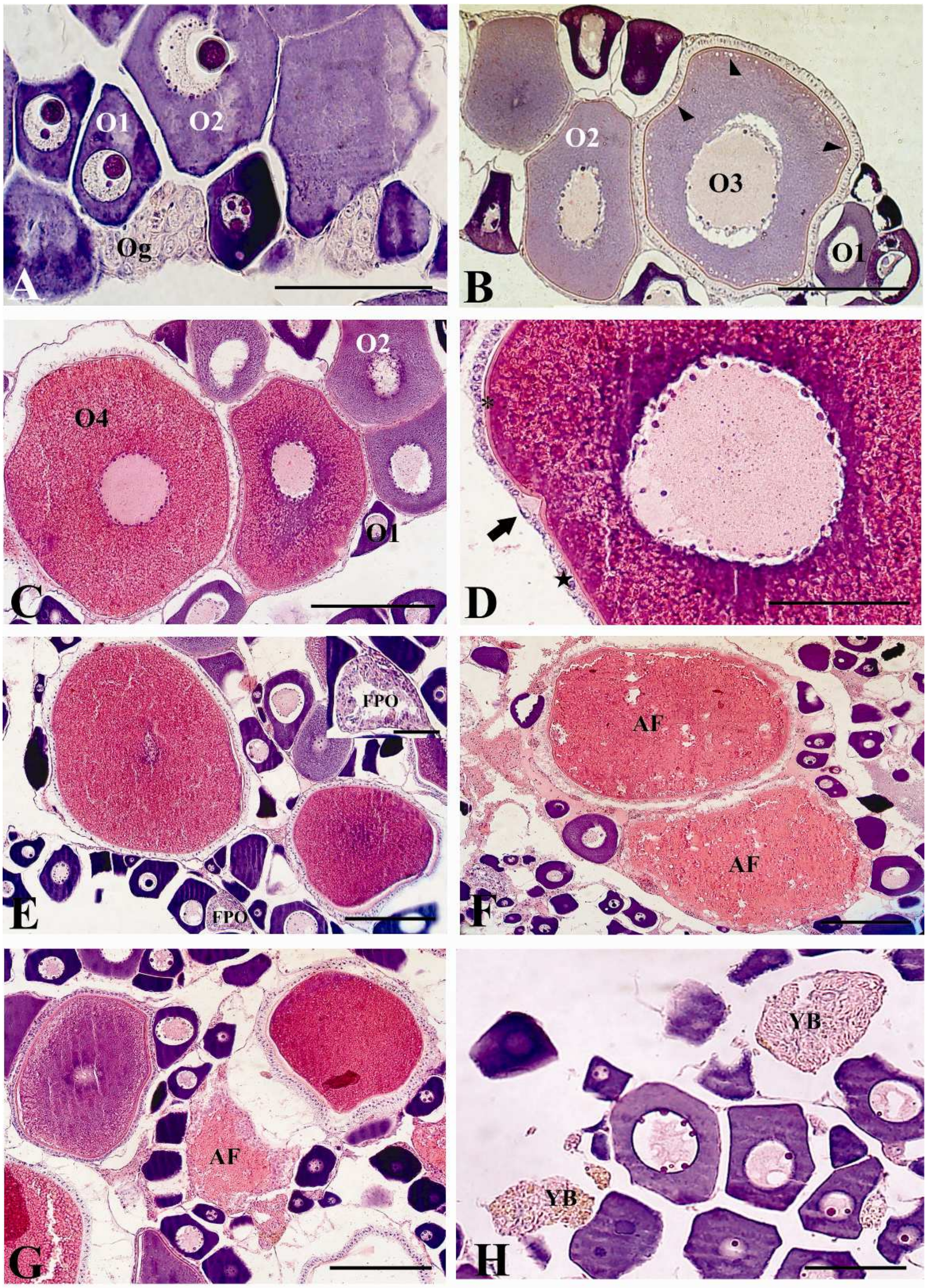

Figura 3 - Histological sections of *P. maculatus* ovaries, in different stages of gonadal maturation, stained with HE. A: Resting, with oogonias nests (Og), initial perinucleolar oocyte (O1) with basophilic cytoplasm and advanced perinucleolar follicles (O2) with granular cytoplasm; B: Initial maturation, with O1, O2 and pre-vitellogenic oocyte (O3) presenting cortical alveoli (arrow head) in the peripheral ooplasm; C: Advanced maturation/mature with O1, O2 and O3 and vitellogenic oocytes (O4) with ooplasm filled with acidophilic yolk globules; D: Detail of vitellogenic oocyte with cubic follicular cells (star), thin zona pellucida (*) and funnel-shaped micropile (arrow); E: Partially spawned, with O1, O2, O3, O4 and post-ovulatory follicles (POF); insert of post-ovulatory follicle with wide lumen and wall of follicular cells and theca; F: Atretic follicles (AF) in the initial phase with yolk liquefaction and fragmentation of the zona pellucida; G: Partially spawned ovary with atretic follicle (AF) in the intermediate phase with hypertrophy of the follicular cells and an almost fully reabsorbed yolk; H: Fully spawned ovary with O1, O2 and atretic follicle in the final stage, forming yellow bodies (YB). Scale bars= 50 µm (A, D, insert of POF and H), 100 µm (B, C), 200 µm (E-G).

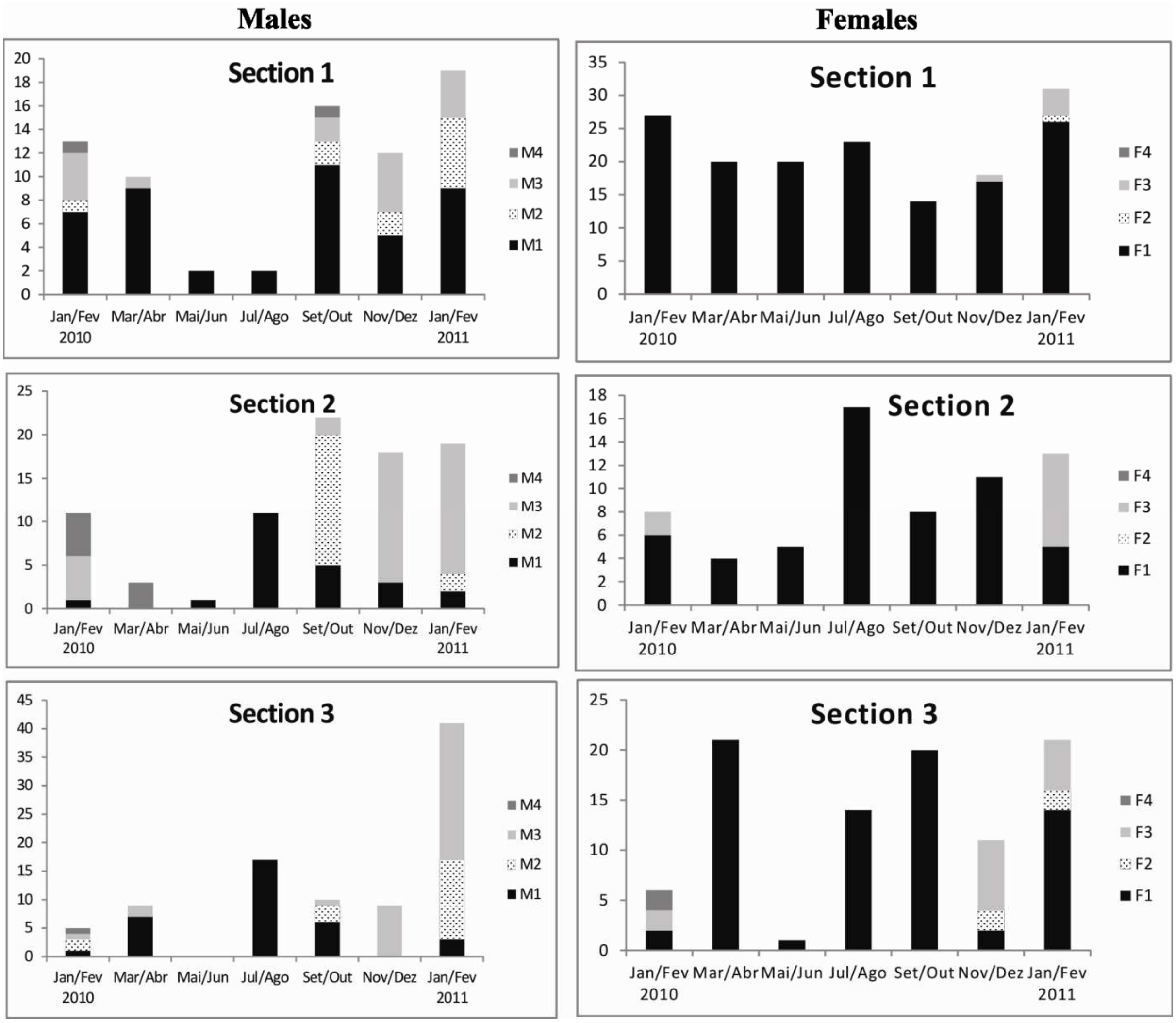

Figura 4 - Bimonthly frequency of the gonadal maturation stages of *P. maculatus* males and females from three sampling sections of the Grande River basin, downstream from the Porto Colômbia power plant. Section 1: Grande River, downstream from the Porto Colômbia power plant; Section 2: confluence of the Grande and Pardo rivers; Section 3: the Pardo River channel.

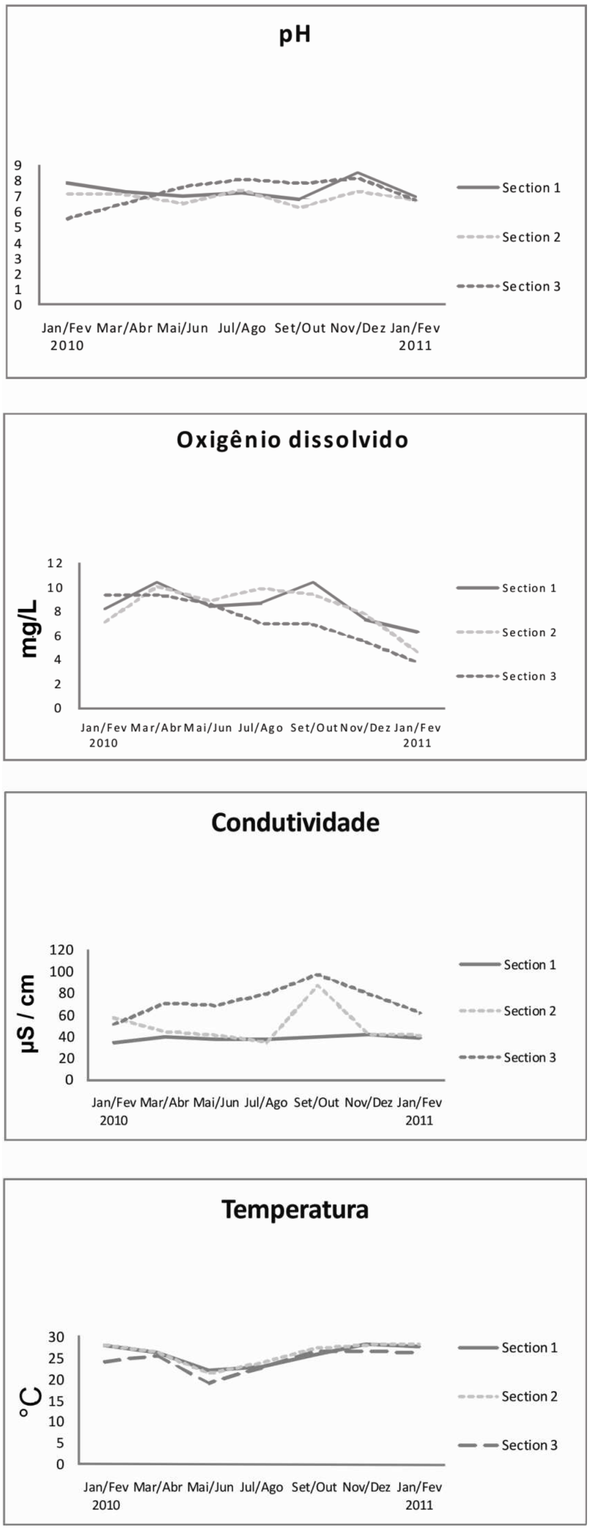

Figura 5 - pH, dissolved oxygen, electrical conductivity and temperature in three sections of the Grande River basin, downstream from the Porto Colômbia power plant. Section 1: Grande River, downstream from the Porto Colômbia power plant; Section 2: confluence of the Grande and Pardo rivers; Section 3: the Pardo River channel.

DISCUSSION

This studied showed that the construction of the Porto Colômbia power plant on the Grande River resulted in alterations to the reproduction process of *P. maculatus*, in the section downstream from the dam, and that the Pardo River is an important tributary for reproductive success of this species.

In this study, fish in S1 presented higher body weight and total length averages than the ones in S2 and S3. This may be explained by the fact that the area immediately downstream from the Porto Colômbia dam, a length of approximately 500 meters, is a protection area, where fishing is completely prohibited, therefore, favouring somatic growth. In the other areas of the Grande River and in the Pardo River, there is intensive commercial and recreational fishing, and *P. maculatus* is one of the most captured species, thus preventing somatic growth as in S1, similar to what Godinho & Kynard (2009) has found in the São Francisco River, downstream from the Três Marias dam.

The morphological features of the fish ovaries and testes captured in the three sampling sections were similar. The yellowish colour of the ovaries and the histological features of the follicular cells and zona pellucida of the vitellogenic oocytes are similar to what has been reported by Melo *et al.* (2011). The funnel-shaped micropyle observed in *P. maculatus* in this study seems to be a common pattern for fish of the Pimelodidae family (Rizzo *et al.,* 2002). In this study, anastomosis of the seminiferous tubules, characteristic of testes of the anastomotic tubular type, was observed (Parenti & Grier, 2004). In the caudal portion of the spent testes of *P. maculatus,* globular acidophilic secretion was observed, as has also been observed by Melo *et al.,* (2011). Some studies showed that this secretion may be related to sperm maturation and nutrition, and may play a crucial role in fertilization (Mazzoldi *et al*., 2005; Chowdhury & Joy, 2007).

In this study, we observed that the mandi-amarelo reproduces between October and February, which coincides with the rainy season, confirming the observations of Braga (2000). The low variation of the Fulton condition factor in the three sampling sections suggests that the fish's health is not affected by the reproductive period. A similar result was found for this same species in the Piracicaba River, state of Sao Paulo, by Lima-Junior & Goitein (2006). Analyzing only the reproductive period, from October to February, it was observed that *P. maculatus* presented a low frequency of fish in reproductive activity (19.70%) from S1, whereas in S2 and S3, higher frequencies, 56.25% and 55.55% respectively, were registered. A similar situation was observed with fish captured in the reproductive period, in the São Francisco River, downstream from the Três Marias dam (Sato *et al.,* 2005).

Impacts on the ichthyofauna downstream from dams have been reported by several authors (Agostinho *et al*., 1993; Clarkson *et al*., 2000; Paukert & Rogers, 2004; Todd *et al.*, 2005; Olden & Naiman, 2010). A recent study showed that, in the São Francisco River immediately downstream from the Três Marias dam, the species *P. argenteus* presented high rates of vitellogenic oocytes atresia and alterations to the endocrine system due to the physical and chemical changes of the water, especially the colder water temperature of this river section (Arantes *et al*., 2010). Contrarily, in the present study, the mean water temperature in the three sections was not statistically different, thus this is probably not the cause of the low frequency of fish in reproductive activity immediately downstream from the Porto Colômbia dam.

In this study, it was verified that in S3, during the reproductive period, there is a sharp decrease in conductivity and water transparency values, indicating that this decrease may act as a reproduction trigger for *P. maculatus.* This assumption is borne out by Godoy (1972) reports, who also observed in the Grande/Pardo/Mogiguaçu Rivers system a decrease in conductivity and transparency during the reproductive period and considered them to be critical factors for triggering fish reproduction. Even though spent/spawned fish were captured from the Pardo River, the small number of fish in these stages, in relation to the total number of collected fish, leads us to believe that S3 is not a reproduction site, and may only be a migratory route for fish which spawn in the Mogiguaçu River, as described by Godoy (1967 and 1972).

In S1, a low frequency of mature and spawned/spent fish was observed, significantly lower GSI and significantly higher body weight, when compared to S2 and S3. These findings confirm the idea that *P. maculatus* uses S1 in the Grande River for somatic growth. On the other hand, the higher number of mature and spawned/spent fish captured in S2 and S3 reinforces the idea that *P. maculatus*, in its reproductive migration, makes this potamodromous movement between the Rivers Grande, Pardo and Mogiguaçu up to Cachoeira de Emas (21º 92' 54"S, 48º 23' 41"W), where it probably finishes its reproductive migration. After intensive work of fish marking and recapture in the Grande/Pardo/Mogiguaçu Rivers system, Godoy (1967 and 1972) observed that there is a reproductive site located at Cachoeira das Emas in the Mogiguaçu River and a “feeding site” located in the Grande River, between the Marimbondo power plant and the Jaguara power plant, which is now the location of Porto Colômbia power plant.

It is known that the construction of dams harms the aquatic biota (Agostinho *et al*., 1993; Sato *et al.*, 2003; Sato *et al.*, 2005; Arantes *et al*., 2010), thus emphasizing the importance of tributaries on the reproductive process, since these water bodies may present a natural hydrological system and abiotic factors still unaltered by anthropic action, or within a tolerable threshold for the maintenance of the local biota (Antonio *et a*l., 2007). Therefore, our results emphasize the need to preserve the Pardo River for the reproductive success of *P. maculatus*.

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4 CONCLUSÕES

a) Logo a jusante da barragem de Porto Colômbia, rio Grande, *Pimelodus maculatus* não encontrou condições propícias para desova, caracterizando-se apenas por um local de alimentação e crescimento somático da espécie;

b) Na confluência do rio Grande com o rio Pardo e na calha do rio Pardo, *P. maculatus* encontrou condições ambientais favoráveis para a desova, caracterizando-se uma área de migração reprodutiva e reprodução.

c) O tributário rio Pardo serve como uma rota alternativa ao barramento, desempenhando um papel fundamental para o sucesso reprodutivo de *P. maculatus,* na bacia do rio Grande, a jusante da UHE de Porto Colômbia.

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