POPULATION STRUCTURE AND REPRODUCTIVE BIOLOGY OF *Loricariichthys platymetopon* (SILURIFORMES, PISCES) IN THE UPPER RIVER PARANÁ

ESTRUTURA POPULACIONAL E BIOLOGIA REPRODUTIVA DE *Loricariichthys platymetopon* (SILURIFORMES, PISCES) NO ALTO RIO PARANÁ

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ABSTRACT

Distribution, length, and reproductive biology of *Loricariichthys platymetopon* were analyzed in different environment of the upper Paraná River. Samples were taken monthly from October 1986 to September 1988 using gillnets with different mesh size, being caught 7691 individuals. This species was more constant and showed higher densities in lentic environment than in other ones. Reproductive activity was more intensive in lentic environment, and under condition of low transparency and low concentration of dissolved oxygen. Spawning was observed from September 1986 to January 1987 when flood was absent and from September 1987 to April 1988 under normal flood conditions. Transportation of the eggs (340 on average) under the lips by males is a strategy appropriate for varying water levels and the limnological factors of floodplain lagoons, the main spawning environment.

Key words: Distribuição, Reprodução, *Loricariichthys platymetopon*; rio Paraná; Distribution; Reproduction; *Loricariichthys platymetopon*; Paraná River.

INTRODUCTION

Loricariichthys platymetopon is the most abundant loricarid in the remaining floodplains of the upper Paraná River and ranks as one of the most abundant species of the region (AGOSTINHO *et al*, 1997). It is a detritivorous species (FUGI *et al*, 1996). Although it has no importance in commercial fishing, this is important forage for predators such as dorado *Salminus maxillosus* (ALMEIDA *et al*, 1997).

Contrary to the majority of species with which it coexists, recruitment success of this loricarid seems to be independent of flooding regimes, as data on abundance from the last five years collected by the Research Nucleus in Limnology, Ichthyology and Aquaculture of the State University of Maringá show (AGOSTINHO *et al*, 1997). The species may live in low concentrations of dissolved oxygen and, unlike other species, remains in lagoons during periods of oxygen depletion even though it has the chance of escaping (AGOSTINHO *et al*, 1995). In this study the population distribution and abundance of *L. platymetopon* in the floodplain of the

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Paraná River, as well as its sex, size, and reproductive strategies (sexual maturity, period and place of reproduction, and care of young) are analyzed. These factors may be related to its success in the occupation of the region.

STUDY AREA

Thirteen sampling stations were established in a 380-km stretch of the Paraná River. Included in this reach were the Itaipu reservoir (150 km) and the upstream floodplain(230 km) (Fig. 1).

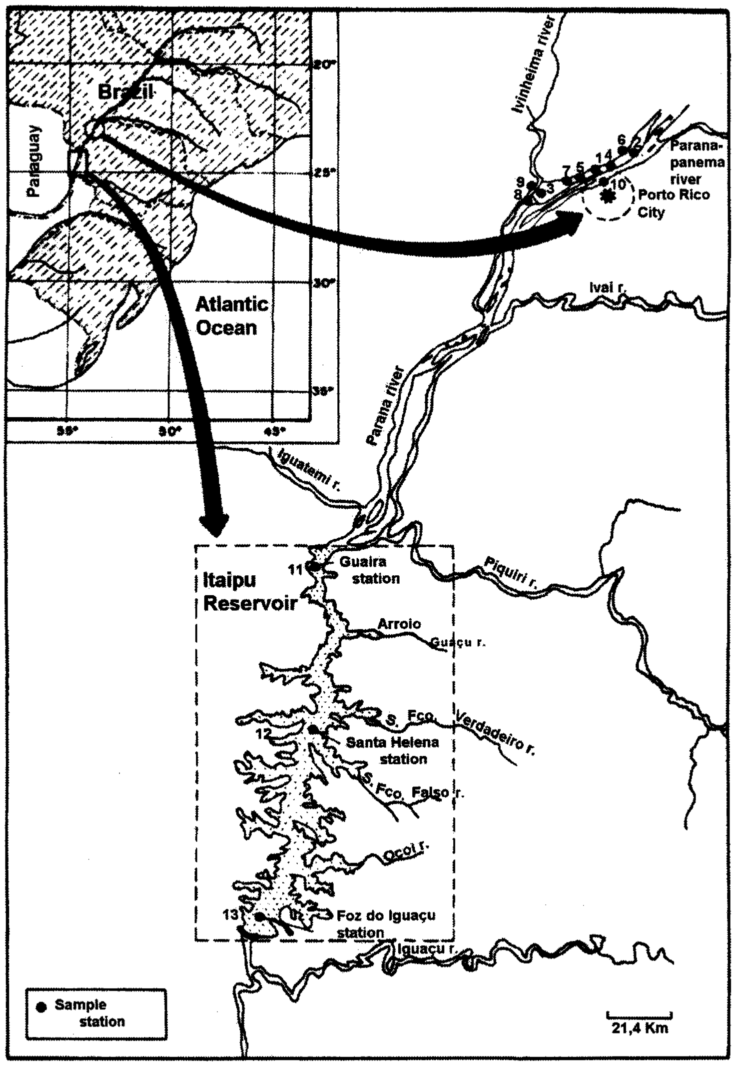

Figure 1. Study area and sampling stations (•) 1- Guaraná, 2- Pousada das Garças, 3- Patos, 4- Fechada, 5- Baía 1, 6- Baía 2, 7-Corutuba, 8- Ipoitã, 9- Ivinheima, 10- Paraná, 11- Guaíra, 12- Santa Helena e 13- Foz do Iguaçu.

The Itaipu Reservoir (RES) was dammed in 1982 and has an approximate surface area of 1,360 Km^2. It is monomictic and mesotrophic, but has branches which are eutrophic (AGOSTINHO *et al,* 1992). Three sampling stations were utilized located in the reservoirs' riverine (Guaíra), transition (Santa Helena), and lacustrine (Foz do Iguaçu) zones.

The Paraná River and its floodplain (predominantly lying on its east margin state of Mato Grosso do Sul) are formed by a complex system of braided channels, numerous temporary and permanent lagoons. These form a floodplain that extends itself laterally for 20 km with a complex dranage system (AGOSTINHO & ZALEWSKI, 1996). Ten sampling stations were placed in this region: four in lentic environments (Lake Guaraná - GUA; Lake Pousada das Garças - PGA; Lake Patos - PAT and Lake Fechada - FEC), three in semilotic environments (Baía 1 - BA1; Baía 2 - BA2 and Corutuba - COR) and three in lotic environments (Ipoitã - IPO; Ivinheima - IVI and Paraná - PR). Some environmental characteristics of the region during the period are shown in Fig. 2. Fluviometric levels are considered the main function force on the region's communities (AGOSTINHO *et al,* 1995).

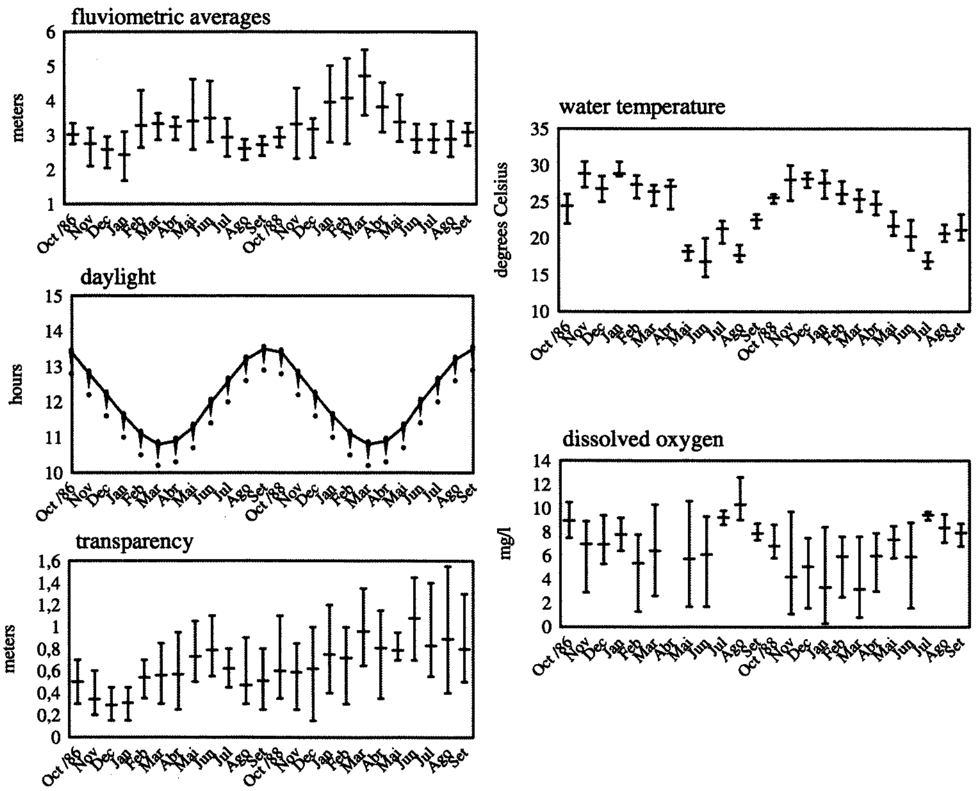

Figure 2. Monthly average values of fluviometric levels, length of day, water temperature, transparency of water column and dissolved oxygen (Sources: National Department of Waters and Electric Energy and Thomaz, 1991)

MATERIALS AND METHOD

From October 1986 to September 1988 samples were taken, with simple nets with meshes of 3 cm, 4 cm, 6 cm, 8 cm, 10 cm, 12 cm, 14 cm and 16 cm, and gillnets, with meshes of 6 cm and 8 cm, sampling was conducted monthly during 24 hours, with fish removal at dawn (from 0700 - 0800 hours), dusk (from 1600 - 1800 hours) and in the evening (from 2100 - 2200 hours). Abundance of sampled specimens was expressed by capture per unit of effort (CPUE) in number of individuals per 1,000m^2 of net/24 hours. Measurements of standard length (SL, cm), total weight (W, g) and gonad weight (GW, g) of fish were taken, in besides data on sex and stage of gonadal maturity. The latter were obtained according to macroscopic characteristics such as transparency, irrigation, color and, in females, the presence of intraovarian oocytes visible to the naked eye; according to microscopic characteristics based on the presence and abundance of ovarian follicles in different phases of development. With regard to the mass of loaded eggs for the male during the reproduction period, the width data and length were taken and, after the treatment with Gilson's solution, its eggs were measured and counted. The analysis of variance (ANOVA) was employed with repeated measurements (MACEINA *et al*, 1997; VON ENDE, 1993) to verify whether CPUE in length class was differed significantly by sex, year, environments and bimonthly. Considering the assumptions of ANOVA, data were previously transformed $\left(\sqrt{y+1}\right)$. Analyses were undertaken by statistics package SYSTAT (WILKINSON, 1990).

Size of first sexual (when 50% of individuals were adults) was estimated for males and females based on the frequency of adults for each size class (VAZZOLER, 1996). Thus, adults were considered individuals with gonads in maturation or in more advanced stages. Relation between standard length (SL) and total weight (W) was established by the equation $W = a\,SL^{b}$, in which **a** and **b** are regression constants. Local and period of reproduction were established according to Index of the Reproductive Activity (IRA), applied to females, suggested by AGOSTINHO *et al* (1991a) and set by the equation:

$$IRA = \frac{LnN_i\left(\frac{n_i}{\sum n_i} + \frac{n_i}{N_i}\right) * \left(\frac{RGS_i}{RGS_e}\right)}{LnN_m * \left(\frac{n_m}{\sum ni}\right) + 1} * 100$$

where

N_i = number of individuals in sampling unit i.

n_i = number of individuals in reproduction phase in sampling unit i.
N_m = number of individuals in the biggest sampling unit.
n_m = number of individuals in reproduction phase in sampling unit with biggest n.
RGS_i = average Gonad Somatic Relationship of individuals in reproduction phase in sampling unit i.
RGS_e = greatest individual value of RGS.
RGS = weight of gonads / total weight* 100.

Reproductive activity was classified as incipient ($0<IRA \leq 5$), moderate ($5 < IRA \leq 10$), intense ($10< IRA \leq 20$), very intense ($IRA > 20$), as suggested by AGOSTINHO *et al* (1991a).

RESULTS

The sampling resulted in 7,691 individuals of *L. platymetopon*: 3,419 for the first year (Oct 1986 - Sept 1987) and 4,272 for the second year (Oct 1987 - Sept 1988). The species was more abundant in lentic environments of the floodplain followed by semilotic environments. Abundance in lotic environments and in Itaipu Reservoir was low (Fig. 3).

The absence this species at the Foz do Iguaçu sampling station and low captures in Guaíra (69 individuals) and Santa Helena (20 individuals) resulted in the exclusion of the Itaipu Reservoir from further analysis.

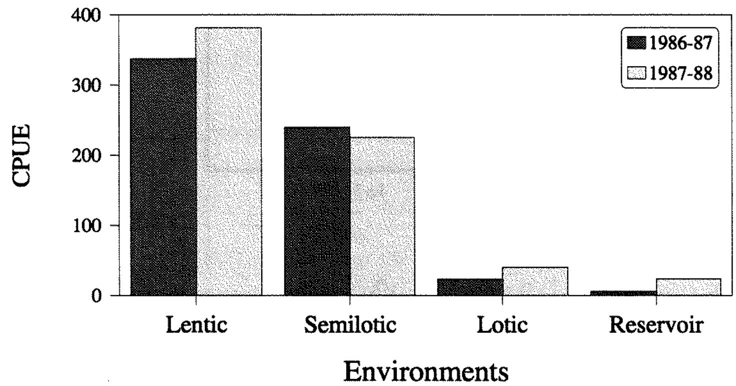

Fig. 3. Capture per unit of effort (CPUE) of *L. platymetopon*, for lentic, semilotic, lotic and Itaipu Reservoir environments in different periods under analysis.

ANOVA results with repeated measurements showed that differences in CPUE among the environments were significant for all length class. Between the years, captures were significantly different in lengths over 14 cm and environment + year in all classes (Table I). In the first year captures were higher in the 14 - 18 cm size class, it was more evident in lentic and semilotic environments (Fig. 4). While in the second year the higher captures were observed in measure 18 cm and over. Significant differences in abundance were also observed between sexes; in lengths over 18 cm females were predominant.

Table I. Values for F and probability of Type I error from ANOVA with repeated measurements applied to CPUE for each length class (ls,cm). The values in boldface were significant (P<0.05). DF = degrees of freedom

Source of Variation	F (Ls < 14)	F (Ls 14-18)	F (Ls 18-21)	F (Ls > 22)
Sex (DF=1)	1.49	0.001	**35.67**	**355.85**
Year (DF=1)	0.02	**23.16**	**81.73**	**332.47**
Environment (DF=2)	**260.40**	**260.40**	**1377.42**	**167.34**
Sex x Year (DF=1)	5.09	7.57	0.18	0.16
Sex x Environment (DF=2)	7.31	3.21	11.95	6.68
Year x Environment (DF=2)	**49.06**	**15.70**	**29.84**	**26.30**
Residue (DF=2)	0.040	0.077	0.033	0.162
Bimester (DF=5)	**5.27**	**15.47**	**13.84**	1.21
Bimester x Sex (DF=5)	**4.52**	0.38	1.07	0.39
Bimester x Year (DF=5)	**8.71**	**22.91**	**17.53**	3.21
Bimester x Environment (DF=10)	**4.12**	**7.80**	**7.74**	2.36
Bimester x Year x Environment (DF=10)	**4.45**	**8.19**	2.08	2.05
Bimester x Year x Sex (DF=5)	1.50	1.42	0.91	0.68
Bimester x Environment x Sex (DF=10)	1.14	0.32	0.44	1.02
Residue (DF=10)	0.142	0.130	0.098	0.286
ε Greenhouse-Geisser	0.2830	0.2273	0.2226	0.2674
ε Huynh-Feldt	1.0000	1.0000	1.0000	1.0000

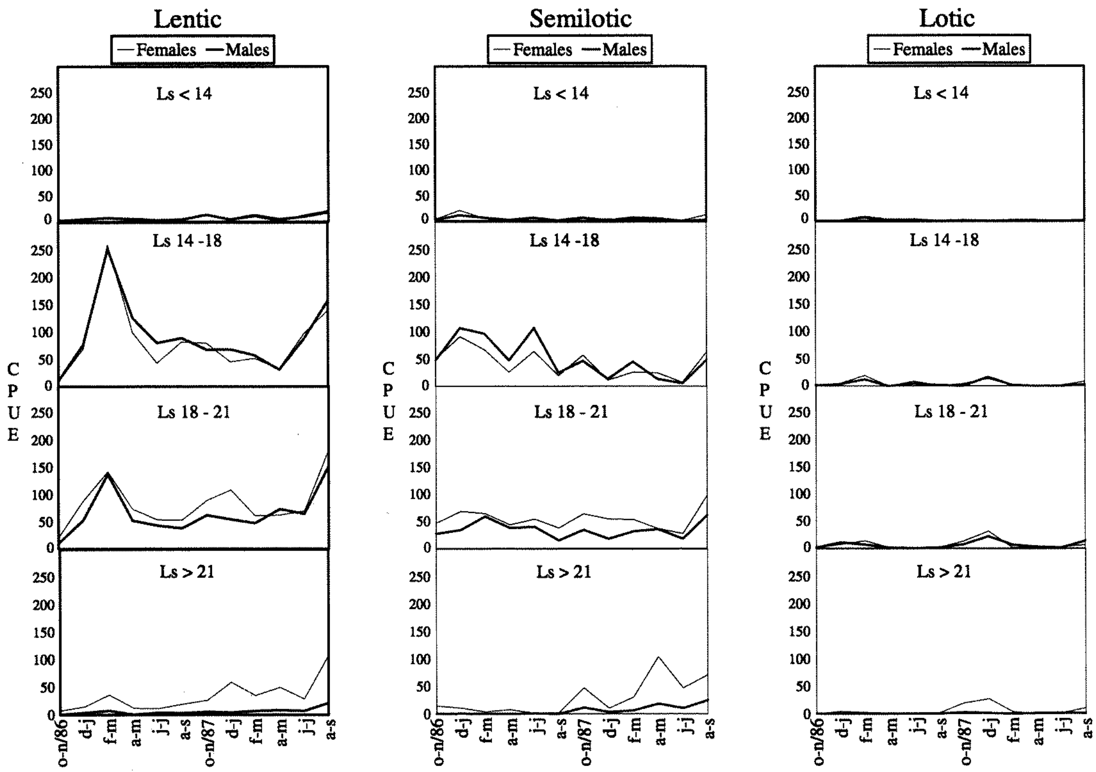

Fig. 4. Estimates of CPUE, by bimester, for each sex, by environments and standard length class (Ls).

Equations relating weight and length are:

$$W = 0.005 \cdot Sl^{3.15} \text{ for males} \qquad r = 0.96$$
$$W = 0.004 \cdot Sl^{3.19} \text{ for females} \qquad r = 0.98$$

Maturity was reached at different lengths in the two annual cycles analyzed (Fig. 5). In the first year the average length of first maturation was 13.6 cm and 14.6 cm for males and female, respectively. In the second year, the lengths were 15.1 cm and 16.6 cm. In all adult individuals size was 19.0 cm in both years. However, females reached greater maximum size than males, with standard length of 33.6 cm and 28.2 cm , respectively.

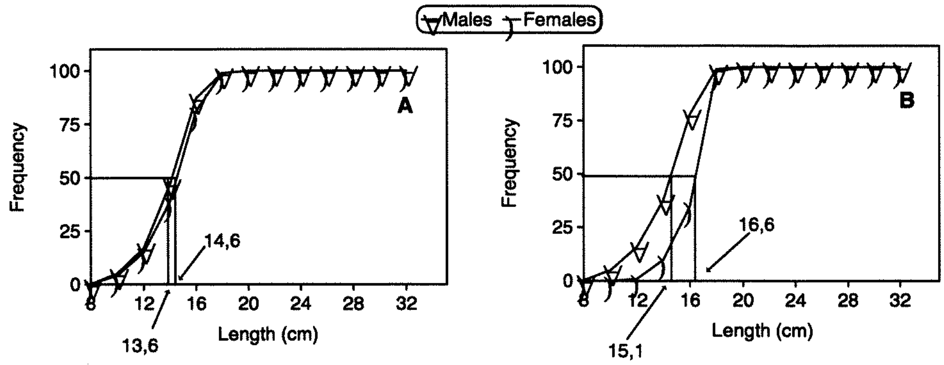

Fig. 5. Relative frequency of *L. platymetopon* adults per length class (A = Oct 1986 to Sept 1987, B = Oct 1987 to Sept 1988) in the floodplain of the upper Paraná River.

Macroscopic and microscopic characteristics of ovaries of *L. platymetopon* at different stages of gonadal maturation and average values of gonadosomatic relationship are shown in Table IIa and IIb.

Table IIa. Macroscopic characteristics of ovaries of *L. platymetopon* at different stages of maturation.

Macroscopic characteristics	IMMATURE	REST	MATURATION	REPRODUCTION	FINISHED
Transparency	Hyaline	Opaque	Opaque	Opaque	Opaque
Irrigation	Very thin	Thin	Moderate	Intense	Intense
Colour	Colourless	Yellowish	Yellowish	Yellowish (middlesize ocytes) Greenish (big oocytes)	Yellowish
Presence of intra-ovary oocytes seen by the naked eye	No	No	Yes	Yes	Yes
Proportion of abdominal cavity	1/5	2/5	3/5	All	2/5
Gonadosomatic relationship ± C.I. (Confidence Interval)	0.40 (± 0.02)	0.47 (± 0.02)	1.13 (± 0.02)	4.72 (± 0.09)	0.90 (± 0.02)

Table IIa. Microscopic characteristics of ovaries of *L. platymetopon* at different stages of maturation.

Microscopic characteristics (development phases oocytary)	IMATURE	REST	MATURATION	REPRODUCTION	FINISH
Nucleolar chromatine	+++	++	+	+	++
Initial perinucleolar	++	+++	+++	++	+
Final perinucleolar	+	+++	+++	++	
Cortical vesicle			+++	++	+
Vitelogenesis			++	+++	+
Mature				+++	+
Postovulatory				+	+++

+ = Rare; ++ Moderate; +++ Abundant.

Estimates of Index of Reproductive Activity (Fig. 6) classify spawning as intense at stations Patos (PAT), Baía 1 (BA1), Pousada das Garças (PGA) and Guaraná (GUA) in the first year. In the second year spawning was very intense in Patos (PAT) and moderate in Ivinheima (IVI) and Pousada das Garças (PGA). In the Paraná River (PAR) and Baía 2 (BA2) reproductive activity was nil or incipient during both years.

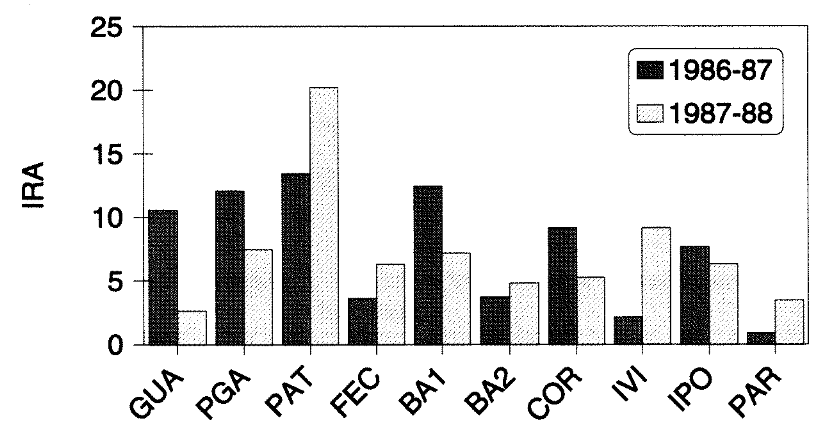

Fig. 6 Index of Reproductive Activity of *L. platymetopon* per sampling station.

IRA estimates (Fig. 7) show that when sampling began in October of the first year reproductive activity was already very intense; intense in November and December; moderate in January and incipient in February. In the following year reproduction was moderate in October; intense between November and February and in April; incipient or nil in the other months, or rather, reproduction was belated. Intense activity in September of 1988 suggests that reproduction began earlier in the third cycle.

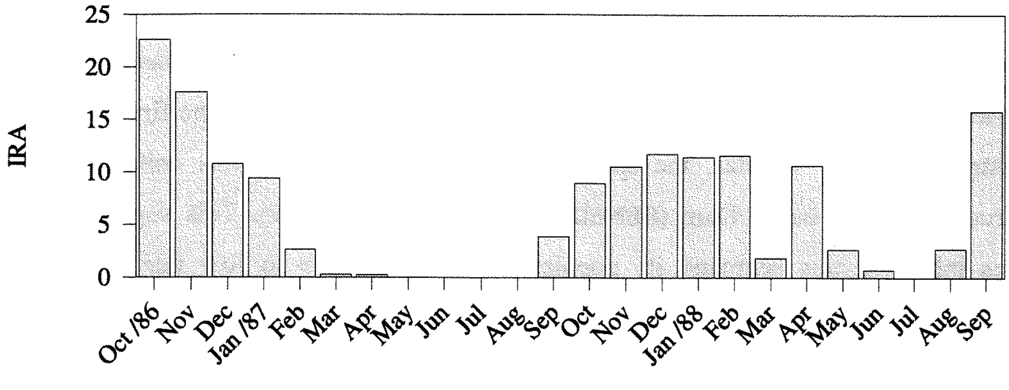

Fig. 7 Monthly Index of Reproductive Activity of *L. platymetopon*.

Field observations confirmed the behavior of the species's parental care as quoted in literature. Males carry a mass of eggs in the shape of a wedge, rounded at one of its extremities and placed under the lower lip which becomes markedly enlarged. Adherence to the bearer's tegument is very slender and the mass of eggs may be easily removed. Eggs masses were collected by nets or freed spontaneously from the samples after capture. Observations in confinements showed that when the male is disturbed it abandons the eggs masses without any defense behavior. However, after the harassment is stopped the male returns to the mass of eggs and takes it with great agility. The dimension of these eggs masses may vary as shown in Table III.

Table III. Mean length and width of *L. platymetopon*'s eggs masses.

Measurements	N	average (x)	standard (Ss)	range
Length (mm)	5	49.2	3.53	53.8 - 45.5
Width (mm)	6	18.7	1.08	20.0 - 17.0

The average number of eggs per mass was 341, varying from 220 to 480. Maximum egg diameter was 3,670 μm.

DISCUSSION AND CONCLUSIONS

The distribution area of *Loricariichthys platymetopon* (ISBRÜCKER & NIJSSEN, 1979) comprises Solimões River, Lake Janauaca in the Amazon, the Paraguay River, and the lower stretch of the Paraná River. In the floodplain of the upper Paraná River this species had not been recorded in the literature before studies began in October 1986. This study showed that *L. platymetopon* is one of the most abundant in the region (AGOSTINHO *et al*, 1995). According to inhabitants of the region, the species has always been present in the area, this information indicates that *L. platymetopon* has a natural distribution in the study area and is not limited to the lower segments to the former Sete Quedas. On the other hand, in the first 170 kilometers downstream of Sete Quedas, the species was absent in the samples collected before the construction of the Itaipu Dam (BENEDITO CECILIO *et al,* 1997). This suggests that if the species inhabited this segment, its population densities were so low that its capture was unlikely. Even though found in low numbers in lotic environments, the fact that it preferred lentic environments supports this assumption, since areas downstream of the dam are characterized by swift waters, rare backwaters and, therefore, inadequate habitat for such a species.

The species was sporadic in the capture during first year after the Itaipu dam's construction (BENEDITO CECILIO *et al,* 1997). Nevertheless, results of present study show its occurrence in the upper dammed stretches (Guaíra, Santa Helena), even though it is still absent in the inner most parts (Foz do Iguaçu). This suggests that colonization of the reservoir is being made from the upstream floodplain. The species distribution was recorded by (AGOSTINHO *et al,* 1995) as sporadic in the Paraná River segment immediately downstream from Itaipu Dam.

Species that show some parental care, in which males are responsible for the protection of the young, reach larger sizes. This has also been shown for loricarids (GOULART, 1981; ANTONIUTTI, 1991; MAZZONI, 1993) and other genera. However, results of the present study suggest that *L. platymetopon* males are smaller despite high parental care. Even if such facts are apparently paradoxal, they are related to differences in the strategies employed to assure a greater survival of eggs. While loricarids males of the genus *Hypostomus* defend their nest which is usually placed in holes in the bank or stones (AGOSTINHO *et al,* 1991b), loricarids of the genus *Loricariichthys* carry their eggs in the belly, passively protected by labial expansions (TAYLOR, 1983; BRUSCHI, 1992). It is expected that for first strategy body size is greatly advantageous since they have to struggle against predators in the manner of territorial species. With regard to the second strategy protection consists of passively transporting the eggs, resulting in possible feeding restrictions, taking, but without the necessity of any struggle.

The prevalence of parental care by the male in fish may be a consequence of the strong relationship between body size and female fecundity (SARGENT & GROSS, 1993). Since parental behavior expends energy and causes reduction in somatic growth, it may be logically expected that if it were done by the females, it would cause a decrease of future production of young than when undertaken by males, since fecundity is a function of size.

For the species under analysis, b values of the weight / length relationship were 3.15 and 3.19 for males and females, respectively. These values show that growth is alometric. Sexual dimorphism in this species may be witnessed during the time of reproduction by the shape and dimension of the lower lip and not by differences in weight increase, even though females reach larger sizes than males.

L. platymetopon males reach sexual maturity at smaller lengths than females. In this study, differences in size at sexual maturity estimated for each sample year were observed. Sizes were larger in the second year. It has also been demonstrated that the capture of larger individuals was greater for the second year. It is supposed that adverse environmental conditions during the first year in which floods didn't occur, should be related to the lesser size reached by juveniles in this period. In the second year when floods were more intense and longer, large land areas were flooded, reduced density and increased food availability (the species is detritivorous) influenced growth. Favourably *L. platymetopon* spawns in all environments but reproductive activity was greater in lentic and semilotic environments where the species is more abundant. This fact shows that species has sedentary habits, preferring environments with slow water. Such environments likely offer more food availability (accumulation of organic material) and shelter, as well as lesser restrictions in the transport of egg masses.

Reproduction of *L. platymetopon* is a long process, with individuals spawning more than once a year. Oocyte development is classified as synchronic in groups and spawning is of the parcel type (SUZUKI, 1992). Reproduction period of species differed significantly between in the two years being more extensive in the second year. This seems to be associated to actual environmental conditions in each period since the flood regimen which regulates the principal processes in the floodplain of the Paraná River (THOMAZ, 1991) was distinct for each year.

Reproduction of *L. platymetopon* occurred in low transparency water conditions and reduced concentrations of dissolved oxygen. Although high concentrations of fine particles and low oxygen concentrations in the water restrict development of fish eggs and larvae, this condition reduces the mortality rate since it inhibits visual predators (AGOSTINHO *et al*, 1992). Also, the fact that the species carries its eggs masses means a decrease in the negative impact of turbidity and unfavourable oxygen conditions since the surrounding water is always being renewed.

Results show that increasing temperature and length of day and the associated environmental variations have a relevant role in the gonadal maturation of *L. platymetopon.* Reproduction occurs during long hot days. On the other hand, floods influence the length of the reproductive period and probably the number of spawning. Its absence, however, does not hinder reproduction, as against what has been recorded on migratory species and those without parental care.

Parental care has been associated with larger of eggs and low fecundity. This relation was shown by (SUZUKI, 1992) for teleosts of the upper Paraná River basin which records the largest eggs in members of the Loricariidae family. The number of eggs carried by the male was shown to be low, averaging 341 eggs with maximum diameter of 3,670 µm. TAYLOR (1993) studied *L. platymetopon* in Lake Ypacarai, a large, shallow lake in the central region of Paraguay, and reported an average of 508 eggs per egg mass (192 to 1,005) and average diameter of 2.13 mm (1.95 mm - 2.50 mm). These observations suggest that the *L. platymetopon* population in the Paraná River floodplain produces larger eggs, but in smaller quantities than the population in Lake Ypacarai. This suggests that the mortality rate in the initial phases in the former is less than that in the latter.

The water bodies of the Paraná River floodplain where *L. platymetopon* is more abundant and constant, are influenced by large variations in water level and limnological conditions as a consequence of floods in the region. Among the most relevant stress factors one may number the fluctuations of the water level and variations caused by absolute densities of predators, low concentrations of oxygen and high temperatures. In this context respiratory adaptations and tolerance to broad limnological variations presented by the species may explain its permanence in these environments. However, abundance may be related to efficiency with which parental care is exercised and to the parceling of spawning. The carrying of eggs, for instance, seems to be an advantageous strategy in aquatic environments whose littoral zone are inconstant or in cases where conditions with low oxygen concentrations exist. Although *L. platymetopon* reproduced in the absence of floods (1986-1987), growth was greater in the year flooding were normal. This fact manifested in larger sizes at first maturation and increased CPUE for larger size classes.

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