

## Morphology of Gonads, Maturity and Spawning Season of *Loricariichthys spixii* (Siluriformes, Loricariidae) in a Subtropical Reservoir

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### ABSTRACT

The gonad morphology and spawning season of *Loricariichthys spixii* in Lajes reservoir were described based on 175 males and 613 females. Cells from the spermatogenic lineage were divided in four phases: spermatogonia (primary and secondary), spermatocytes (primary and secondary), spermatids and spermatozoa, and the cells from the oocytarian lineage were divided in four phases: primary oocytes (O1), previtellogenic oocytes (O2), cortical vesicle oocytes (O3) and yolk globules or vitellogenic (O4). Five gonadal stages were described for the males/females according to oocytes and spermatogenic lineage cells distribution: resting (1); initial maturation (2a); advanced maturation (2b); partially spent/spawned (4a); totally spent/spawned (4b). Spawning was iteroparous, occurring throughout the year. Resting/recover occurred in July/August for the females coinciding with lower temperature and rainfall and decreasing water level. The wide spawning period was the part of the strategy developed to withstand environmental pressure and to get success in this oligotrophic and poorly structured environment.

**Key words:** Loricariidae, reservoir, fish reproduction, gonad morphology, Brazil

### INTRODUCTION

The armored catfish *Loricariichthys spixii* is one of the most abundant members of the Loricariidae family in the freshwater environment of Southeastern Brazil. It has successfully adapted to manmade lakes formed from impounded rivers, where fish composition has shift in response to changes in hydrological system (Duarte and Araújo, 2001). Few studies on its reproduction at Lajes reservoir, the largest man-made lake in Rio de Janeiro State, are available. Spawning season,

as indicated by the gonadosomatic index occur mainly from August to November, and the resting from April to June. The gonadal cycle also has been estimated based on macroscopic observation and five stages have been described (Araújo et al., 1998; Duarte and Araújo, 2000).

Studies on the reproductive biology that incorporate histological examination of gonads usually are suitable to determine the precise duration of the spawning period and whether spawning occurs more than once in a breeding season. Many freshwater fish species in the

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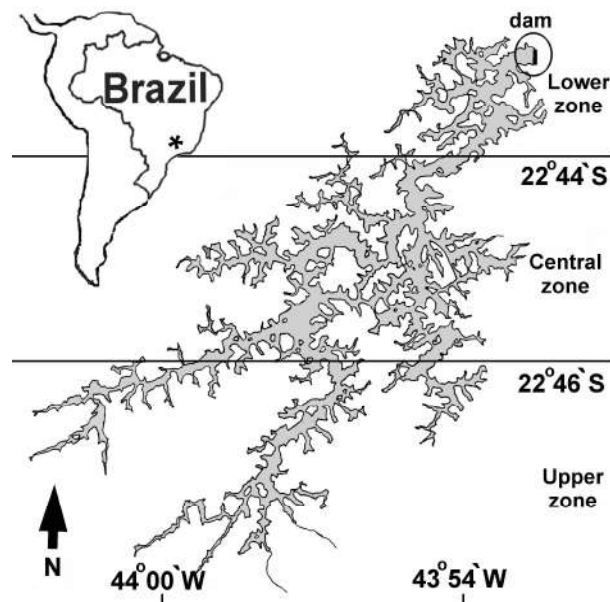
subtropical or tropical waters have long spawning seasons, whereas those species that inhabit temperate waters, where conditions in winter are more severe, typically have shorter and more clearly defined breeding periods (Conover, 1992). The emphasis here has been placed on describing the temporal trends exhibited by reproductive variables, such as the gonadosomatic index, maturation stages, based on gonadal development of the germinative cells. Bazzoli (1992) studied aspects of morphology and histochemical of the oogenes of 10 species of Loricariidae, among them, one species of *Loricariichthys*. To date, information on detailed aspects of gonad morphology of *L. spixii* in a manmade environment in Southeastern Brazil are lacking. The present work assessed the reproductive biology of *L. spixii* based on the description of the gonadal development and determination of the

spawning season on Lajes reservoir; also eventual influences of environmental variables on the reproductive cycle were evaluated.

## MATERIALS AND METHODS

### Study area

The Lajes reservoir (22°42'-22°50'S; 43°53'-44°05'W) is the largest dammed water collection in Rio de Janeiro State, Brazil (Fig. 1). The dam was built in the beginning of the last century for hydroelectric purposes, and is one of the oldest impounded environments in Brazil. The surface area is approximately 30 km<sup>2</sup>, at ca. 415 m above sea level. The water has excellent quality, with no significant influences of human activities (Barroso, 1989).



**Figure 1** - Study area, Lajes reservoir, Rio de Janeiro, Brazil

### Sampling

A total of 170 males and 613 females were collected by bimonthly sampling programme, from January 1996 to December 1997. Fishes were collected with 2.5-4.5cm (stretched mesh) gillnets. Individuals were selected ranging from 28 to 42 cm only to calculate parameters of the reproductive cycle. Identification followed the original description of Steindachner (1881).

### Biometry and gonadosomatic index

Measurements of total length (TL, cm), total weight (W, g), gonad weight (GW, g) and cellomic cavity length (cm) were taken for each specimen by the sex and by the stage of the gonadal maturity. Gonadosomatic index ( $GSI = GW / (W - GW) \times 100$ ) was calculated.

### Light microscopy

Slices were taken from the posterior portion of the gonads. Fragments were fixed in Bouin during 4-8 h and submitted to ordinary histological techniques. Preserved ovaries were embedded in the paraffin, sectioned at 5-7 mm thickness and stained with Harris haematoxylin and eosin (HE).

### Stages of cycle reproductive

Stages of reproductive cycle were determined for the males and females based on both the macro and microscopic characteristics of the gonads and on the gametogenic cell distribution. Testes were classified according to form and size of the cysts, which were patches of germinative cells in different spermatogenesis stages (Bazzoli and Godinho, 1991; Santos et al. 2001), while oocytes were classified according to the changes in the nucleus, cytoplasm and in the peripherics follicles: zona pellucida, follicles cells and theca. (Bazzoli and Rizzo, 1990). Stages of the reproductive cycle were classified according to Bazzoli (1992). Spawning type was defined according to the stage of the reproductive cycle frequencies and histological analyses for spent ovarian

### Environmental variables

Water temperature, transparency and pH were taken by a digital multisensor Horiba mod. U-10, at each sampling occasion. Level of water of the reservoir and the rainfall were supplied by LIGHT (Meteorological Station), the power station concessionaire of the reservoir.

### Statistical analyses

Two-way analysis of variance (ANOVA) was used to compare environmental variables and GSI means among years and months. When there were significant differences, a `a posteriori` SNK test was used to identify which values were significantly different at  $\alpha=0.05$  level (Zar, 1984). Raw data were previously Log<sub>10</sub> (x+1) transformed to address the normality and homocedasticity assumptions of ANOVA. The Chi-square test was used to compare sex rate for each class interval of total length and for the whole examined sample. Linear regression procedures were used to assess the slope and the y-intercept for the relationship between gonad weight (dependent variable) and total weight (independent variable) for each maturation stage.

## RESULTS

### Morphology of the gonads

Macroscopic examination confirmed that gonads were paired, longitudinally flattened, located in dorso-posterior region, attached to coelomic wall cover by the mesorc and mesovarium. Testes were filliform and ovaries fairly cylindrical. The gonads joined each other at the caudal region, forming a common duct, opening at the uro-genital papillae. Males were observed in all the stages of the reproductive cycle. Testes were with transversal folds in the median region. The anterior border was streamlined or slightly curved in the early maturation stages and truncated in the others stages of the reproductive cycle (Fig. 2).

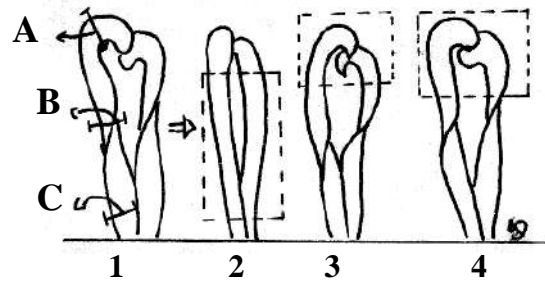
The testes and ovaries were covered by the albuginea tunic of conjunctive origin, by hundreds of smooth muscular cells and blood vessels. They emitted septa to the inner part of the organ, forming lobes that were filled by the seminiferous tubules in the testis (Fig. 3), and in ovarian lamellae in which oocytes in different development phases were found in the ovaries (Fig. 4).

In the testis, the seminiferous tubules were formed by cysts, defined by the cytoplasmic projections of Sertoli cells. In each cyst, the spermatogenic lineage cells were found in the similar development phase of the ovarian lineage cell, changing according to reproductive cycle stage. The main morphological characteristics of the testis and ovaries in the different stages of the reproductive cycle are shown in Table 1.

### Spermatogenesis

#### *Spermatogonia*

These were of two types - primary and secondary. Primary spermatogonia were the largest cells of the spermatogenic lineage, presenting clear cytoplasm, large and prominent nucleus. They occurred isolated and presented no cysts. The secondary spermatogonia were formed from the primary ones, showing smaller size and formed cysts of 2 to 4 cells.



**Figure 2** - Schematic drawing showing macroscopic morphology of the testis (1) of *Loricariichthys spixii*: cranial (A), median (B) and caudal (C) regions for adults. Anatomic aspects during the reproductive cycle: retile (2), curvilinear (3) and truncated (4) indicate the immature (2) and mature (3 and 4) condition

### Spermatocytes

They were divided in the primary and secondary spermatocytes. The primary spermatocytes were formed after repeated mitotic divisions of the secondary spermatogonia. They were shown in several phases of the meiotic prophase, commonly zygoten and pachyten. The nucleus was prominent with filamentous chromatin. The secondary spermatocytes were smaller than the primary ones and presented the nucleus with slightly condensed chromatin in one of the poles.

### Spermatids

They originated from the secondary spermatocytes being smaller than those. Cytoplasm scarce. Nucleus was spherical and dense. These cells suffered modifications until they became spermatozoa.

### Spermatozoa

They were the smallest cells of the spermatogenic lineage. The nucleus was round and very dense. They were concentrated in the lumen of the tubules after breaking the cyst wall.

### Oogenesis

#### Primary oocyte (O1)

Oocytes diameter was small; vitreous cytoplasm, basophilic, large nucleus, prominent, centralized and with peripheric nucleolus.

#### Previtellogenic oocyte (O2)

Cytoplasm was finely granulated, with nucleolus attached to nuclear wrapping. The vitellinic nucleus was shown in the cytoplasm, as a conspicuous structure, basophilic, located close to the nucleus. The zona pellucida was thin and the follicle cells are pavementous.

#### Oocytes with cortical vesicles (O3)

It was characterized by the presence of the vesicles in the whitish cytoplasm. Nucleus was central, badly delineated and the nucleolus were randomly distributed. Cytoplasm lost gradually the basophilic characteristics. The pellucida zone was thin and the follicles cells were cubic.

#### Vitellogenic oocytes (O4)

Yolk globules in the cytoplasm could be seen. The pellucida zone remained thin and the follicles cells became prismatic.

The composition and distribution of the cells of spermatogenic and ovarian lineage changed according to the stages of the reproductive cycle. The main morphologic characteristics of the testes and ovaries and stages of the reproductive cycle are shown in Table 1.

**Table 1** – Comparison of macroscopic and histological appearance of males and females for *Loricariichthys spixii* in the Lajes reservoir, RJ, 1996-1997.

Maturity Stage	Testis	Ovary
1	No fish caught in this stage.	Whitish-yellow color. Ovary takes up 40% of coelomic cavity; weight averaging 7.4 g. Presence of O1 and O2 oocytes.
2 a	Aspect filiform and whitish color. The testis are thin, taking up 38% of coelomic cavity. Weight up to 0.2 g The testis presents few spermatozoas and large number of other spermatogenic lineage cells (Fig.3.1)	Yellowish, turgid, with oocytes visible to naked eyes. Blood vessels no evident. The ovary occupies in average 72% of coelomic cavity and weights around 11.6 g Presence of O1 and O2; few O3 oocytes
2b	Aspect of ribbon. White color. Turgid and voluminous. The testis taking up to 81.6 % of coelomic cavity and weights up to 0.5g. Predominance of spermatozoas in relation to the other spermatogenic lineage cells (Fig. 3.2)	Strong yellow coloration, voluminous, very turgid and with many vitellogenic oocytes, visible to naked eye. Blood vessels evident. Ovary taking in mean 86.7 % of coelomic cavity and weights approximately 22.5g (Fig. 4.1) Presence of O1, O2 and O3. Large numbers of O4.
4 a	Testis white to reddish and with flaccid parts. It takes in average 76.7% of coelomic cavity, and weights until 0.4 g. Numerous spermatozoa when compared to the other spermatogenic lineage cells. Lumen partially empty (Fig.3.3).	Reddish, flaccid, with vitellogenic oocytes. Ovary occupies in average 78.0% of the coelomic cavity, weights c.a. 19.0g Presence of O1, O2, O3, O4, and post-ovulatory follicles and atresy.
4 b	Testis reddish, very hemorrhagic and flaccid, taking up to 75.0 % of coelomic cavity, with weight averaging 0.4 g. Only spermatozoa are found and the lumen of seminiferous tubules is open.	Ovary dark-red and hemorrhagic, flaccid, with numerous opaque oocytes (atresic), visible to naked eye. Ovary occupying in mean 68.8% of coelomic cavity, weighting approximately 14.1 g (Figs. 4.2; 4.3 and 4.4) Presence of O1, O2, and many post-ovulatory follicles. Oocytes O3 and O4 when present, in atresic stage.

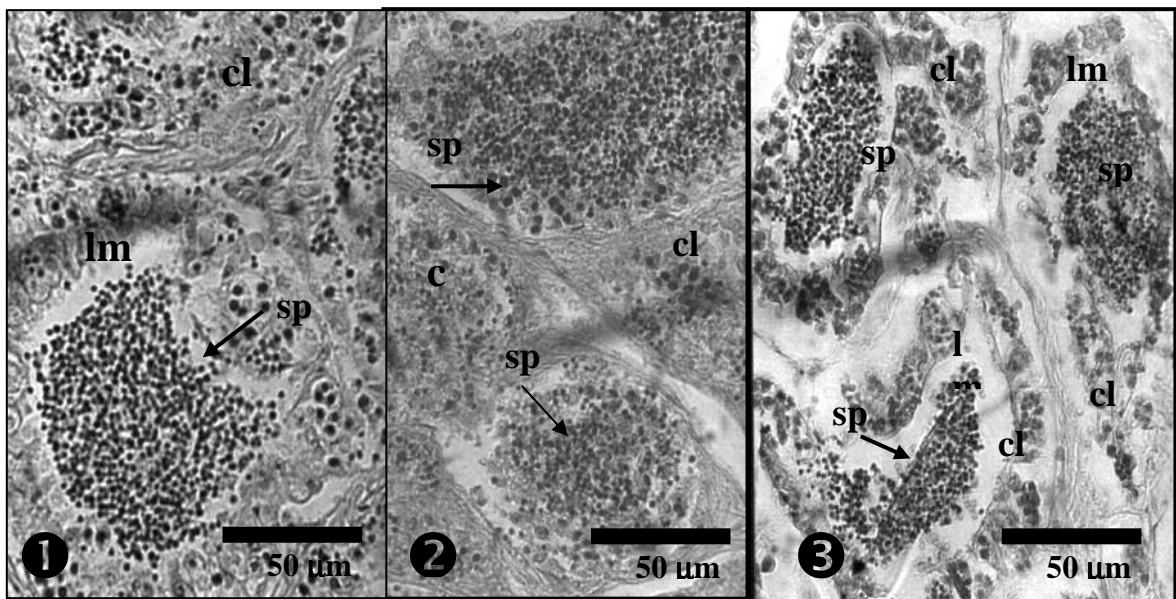
1 = rest, 2 a = initial maturation; 2b = advanced maturation; 4 a = partially spawn/spent; 4 b = totally spawn/spent

### Morphological characteristics of the stages of the reproductive cycle

#### Sex rate

Significant differences were found according to Chi-square test ( $\chi^2 = 328.9$ ;  $P < 0.01$ ), with the overall number of females (78.7%) being higher than the number of males (21.3%) (Table 2). Secondary sexual dimorphism was a well-

evidenced character by the form and size of the labial papillae. Males presented an elongated and flatted papilla, while in females this papillae was of smaller size and relatively rougher. The more elongated papillae in males were associated with the broodcare, which occurred after fecundation, with males carrying the eggs in the antero-ventral part until eggs eclosion (Fig. 5).



**Figure 3** - Cross section of the testes of *Loricariichthys spixii* (1, 2, 3) showing different phases of development, stained by Hematoxylin-Eosin. 1 = Testis in initial maturation (stage 2a) with abundant spermatozoa (sp) in the lumen (lm) of the seminiferous tubes, large amount of spermatogenic lineage cells (cl) – 370 x; 2 = Testis in advanced maturation (stage 2b) with abundant amount of spermatozoa (sp) in the lumen (lm) in the seminiferous tubules, small amount of spermatogenic lineage cells (cl) – 370 x; 3 = Testis partially spent (stage 4A) showing seminiferous tubules open with large amount of spermatozoa and other spermatogenic lineage cells (cl) and lumen partially empty (lm) – 370 x

#### Gonadosomatic index of males

The gonadosomatic index for each maturation stage, as well as the values of the parameters (a) and (b) and of the linear relationship between the weight of the testis and the total fish weight are presented in Table 3.

#### Gonadosomatic index of females

The gonadosomatic index for each maturation stage, as well as the values of the parameters (a) and (b) of the linear relationship between the weight of the ovary and the total fish weight are presented in Table 4. Higher mean values for females were recorded in September/December 1996, March/April-1997, and September / October-1997. The lowest mean values were found consistently in July/August in 1996 and 1997 (Table 4; Fig. 6).

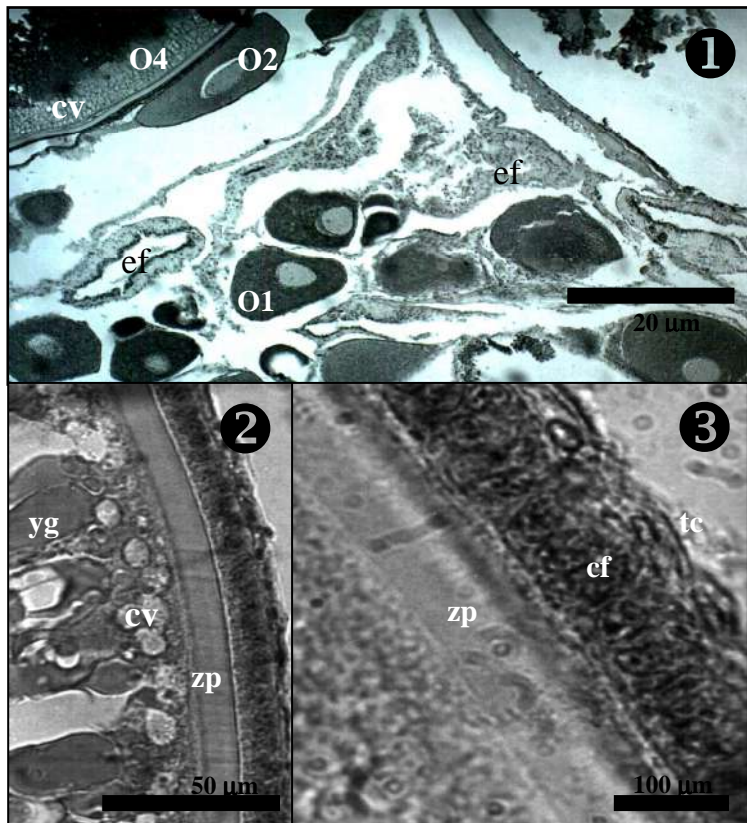
#### Spawning season

The GSI values differed significantly among sex according to ANOVA, being higher for the females and lower for the males, but no clear temporal (bimonthly or yearly) pattern of variation was shown during the studied period. Males

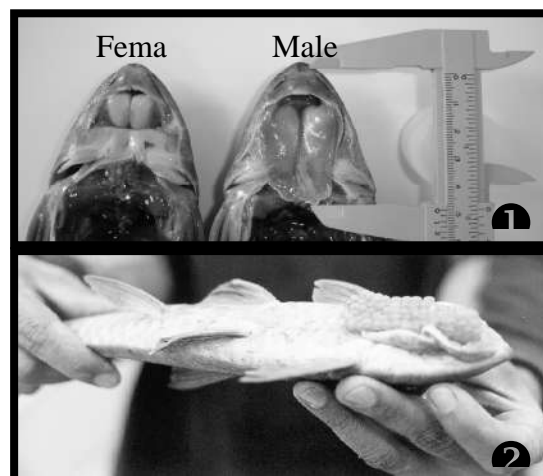
showed higher GSI in September/October 1996, when compared with March/June-1996 and Nov-1996 to June-1997 (Table 5).

#### Environmental variables

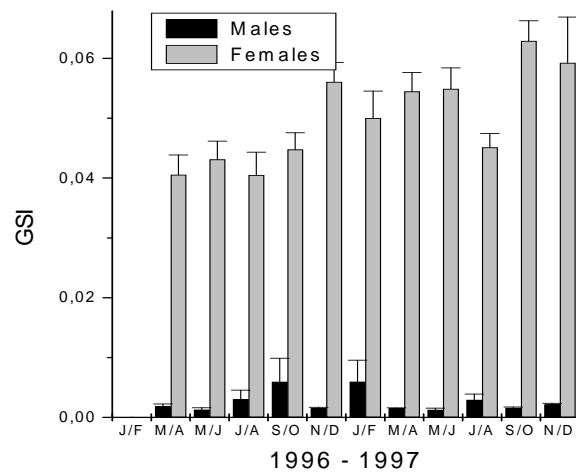
Significant differences were found for mean temperatures among bimonth and years, with significant interactions bimonthly vs. yearly (Table 6; Fig. 7). Peaks of temperature were recorded in January/February and the lowest records in July/August. Water transparency also presented significant differences between the years and bimonthly, and significant interaction between these two factors occurred. Highest values occurred in July/August and lowest values in November/December in 1996; no significant changes were recorded in 1997.



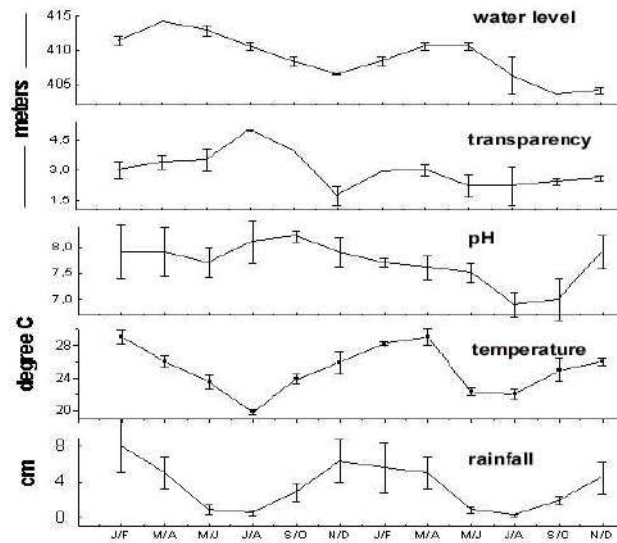
**Figure 4** - Cross section of the ovarians of *Loricariichthys spixii* (1, 2, 3) showing different phases of oocyte development, stained by Hematoxylin-Eosin. 1 = partial spawning (sub-stage 4 a) with young oocytes (O1) and previtellogenic oocytes (O2), vitellogenic oocytes (O4) e empty follicles (ef) 120x ; 2 = Section of vitellogenic oocyte (O4) with large cortical vesicles (cv), yolk globules (yg), follicles and thin zona pellucida (zp) 370x; 3 = follicle membrane of yolk oocyte formed by zona pellucida (zp), follicles cells (fc) and teca (tc) 870 x



**Figure 5** - Sexual secondary dimorphism in *Loricariichthys spixii* associated to parental care. Males showing larger elongated lips than females (1). Males carrying eggs in the lips (2)



**Figure 6** - Bi-monthly means and standard error (vertical lines) for gonadosomatic index for *Loricariichthys spixii* by sex in Lajes reservoir, RJ, 1996–1997



**Figure 7**- Bi-monthly variation in environmental variables means and standard errors (vertical lines) for Lajes reservoir, 1996-1997



**Table 2** - Distribution of number (n), percentage (%) e expected frequency (ef) from Chi-square test for comparison by size class of *Loricariichthys spixii* in Lajes reservoir, 1996-1997. \*\* P < 0.01.

Size class TL (mm)	Males		Females		Total (n)	Fe	$\chi^2$
	n	%	n	%			
175-225	1.0	50.0	1.0	50.0	2.0	1.0	0.0
225-275	1.0	33.0	2.0	66.7	3.0	1.5	0.3
275-325	37.0	53.6	32.0	46.37	69.0	34.5	0.36
325-375	112.0	29.5	268.0	70.5	380.0	190.0	64.0**
375-425	15.0	4.9	294.0	95.1	308.0	154.0	250.9**
425-475	1.0	7.7	12.0	92.3	13.0	6.5	9.3**
475-525	0.0	0.0	4.0	100.0	4.0	2.0	4.0**
<b>Total</b>	<b>167.0</b>	<b>21.3</b>	<b>613.0</b>	<b>78.7</b>	<b>783.0</b>	<b>391.5</b>	<b>328.86**</b>

**Table 3** - Means and dispersion parameters for gonadosomatic index (GSI) for males of *Loricariichthys spixii*, in different maturation stages and parameters of the linear regression of testis weight on body weight.

Stage	GSI Average	Standard deviation	Confidence Interval	a	b	n
1			0.146 – 0.0005			
2a	2.48	3.57	0.0697 – 0.0097	0.0036	0.00241	52
2b	8.51	6.46	0.0522 – 0.0005	2.3359	-0.0113	10
4a	3.33	0.91	0.0071 – 0.0005	0.1540	0.00167	61
4b	1.67	0.92		-0.0549	0.00198	47

n= number of individuals; a = regression constant; b = regression coefficient.

**Table 4** - Means and dispersion parameters for gonadosomatic index (GSI) for females of *Loricariichthys spixii*, in different maturation stages and parameters of the linear regression of testis weight on body weight.

Stage	GSI average	Standard deviation	Confidence Interval	a	b	n
1	1.29	0.196	0.175 – 0.00053	-0.9851	0.02096	5
2a	4.18	0.84	0.095 – 0.0017	1.6706	0.03375	122
2b	6.33	0.235	0.139 – 0.002	3.4762	0.0375	422
4a	4.93	0.108	0.211 – 0.011	3.8050	0.0331	332
4b	3.97	0.122	0.035 – 0.0039	7.0786	-0.0004	64

n= number of individuals; a = regression constant; b = regression coefficient;

**Table 5** - F-values and significance of ANOVA on gonadosomatic index (GSI) for males and females of *Loricariichthys spixii* for comparisons between bi-months and years, in Lajes reservoir, 1996-1997

GSI	F	p	SNK - Test	
			Year	Bimonth
Males	2.82	0.0040	1996 > 1997	Sep-Oct 1996 > Mar-Jun 1996 and Nov 1996-Jun1997
Females	4.28	0.0001	1996 > 1997	Sep-Dec 1996; Mar-Apr 1997; Sep-Oct 1997 > Jul-Aug 1996 and 1997

**Table 6** - F-values and significance of ANOVA on environmental variables for comparisons between bi-months and years, in Lajes reservoir, 1996-1997 \*\* P < 0.01

Variables	Year	Month	Year x Bimonth	SNK - Test	
				Year	Month
Temperature	14.7**	144.8**	7.7**	-	j/f > m/a; n/d > m/j > s/o > j/a
Transparency	252.0**	55.4**	17.2**	1996 > 1997	j/a > m/a; m/j; s/o > j/f; n/d
pH	94.4**	19.7**	13.2**	1996 > 1997	m/a; n/d > j/f; s/o > m/j; j/a
Water level	92.5**	63.7**	10.8**	1996 > 1997	m/j; m/a > j/f; j/a > s/o; n/d
Rainfall	0.5	26.9**	3.0	-	j/f; m/a; n/d > m/j > j/a; s/o

## DISCUSSION

The population of *L. spixii* in the Lajes reservoir was comprised mainly by the females, which also reached relatively larger size than the males, and this pattern was consistent over the two studied years. Araújo et al. (1998) also found significant higher number of the females than the males. Sex rate is one of the most important parameters of population's structure. Nikolsky (1969) reported that sex rate varied according to age, depending on the species, reflecting the interaction with the environment, and suggested that areas with plenty of food presented higher proportions of females. Among the members of Loricariidae, the number of males was higher than the number of the females (Nomura and Mueller, 1980; Bruschi-Jr. et al., 1997), but there were some exceptions (Barbieri and Santos, 1987). Non-significant differences in sex rate for Loricariidae were found by Antoniutti et al., (1985) and Mazzoni and Caramaschi (1995). Several factors can influence sex rate: growth rates influence *Plecostomus albopunctatus* (Antoniutti et al., 1985); mortality rates influence *H. affinis* and *Hypostomus luetkeni* (Mazzoni and Caramaschi, 1997); differences on behavior between males and females or selective capture influence *Pseudocurimata gilberti* (Honda, 1979 apud Antoniutti et al., 1985); and partial segregation by sex influences *Oligosarcus jenynsii* (Hartz et al., 1997). Secondary sexual dimorphism allows easy distinction of males from females at all sizes in *L. spixii* in Lajes reservoir, although nothing has been cited for this aspect before. The most elongated labial papilla in the males, located in the antero-ventral area of the head, in opposite to a relatively shorter structure in females, was associated with the broodcare practiced by the former. According to Py-Daniel (1981), species of the gender *Furcodontichthys* share with *Loricariichthys* the same characteristic, with the males broodcaring and presenting elongated labial

papilla. This sexual dimorphism was first observed for *L. spixii* by Steindachner (1881) and confirmed for *Loricariichthys acuta* by Eigenmann and Eigenmann (1890) apud Regan (1904) and Menezes (1949). Taylor (1983) observed that males of *Loricariichthys simillia*, *Loricariichthys labialis*, *Loricariichthys platymetopon* and *Loricariichthys anus* presented a great labial papilla development during the reproductive period, covering the whole ventral surface of the head, behind the mouth, where agglutinated eggs were attached. According to Bazzoli and Rizzo (1990), follicle cells from the vitellogenic oocytes of neotropical freshwater teleosts played an important role in the vitellogenesis and in the oocyte final maturation phase. All the Loricariidae species presented in the composition of the follicles cells neutral glycoproteins and glyconjugate carboxylates acids. The variations of the glycoproteins of these cells could be related with the adhesiveness of the eggs of some species. According to macro and microscopic observations, the reproductive cycle was classified in five phases of gonadal development gonadal. This classification followed Bazzoli and Godinho (1991) as described for *Acestrorhynchus lacustris*. This methodology has been used thoroughly for other freshwater fish species such as *Serrasalmus brandtii* (Teles and Godinho, 1997), *Shizodon knerii* (Soares et al., 1996) *Leporinus amblyhyrnychus* and *Leporinus striatulus* (Ricardo et al., 1991), *Astyanax bimaculatus* (Cangussu-Mariani et al., 1991). According to this classification, the stage is considered mature only when it reaches the climax of the gonadal maturation, that is, the exact moment of the ovulation or spermatation. As this event is of short duration (Selman and Wallace, 1986), it is hardly observed. The distinction between the immature and resting stages, which are histologically differentiated due to the presence of ovuliger lamella in the later stage, being absent in immature

females, is other phase that need careful observation to be determined. Testis in resting stage presents numerous spermatozoa and scarce interstitial strome, unlike immature stage, where there is abundant interstitial strome and spermatozoa randomly distributed, as reported by Soares et al. (1996). Although advanced maturation (2b) and partially empty (4a) stages appear rather similar in terms of number of spermatozoa/number of cells probably due to long reproductive season. Araújo et al. (1998) classified maturation stages based on macroscopic description of *L. spixii* following Vazzoler (1996). Stages ripe/spent corresponds to partially spawned in Araújo et al's classification.

Gonad morphology presented remarkable differences between the sexes, with different asymmetry types. Testis for *L. spixii* presented morphological characteristics differing from most of those described for other teleosteans (Vazzoler, 1982; 1996). It was flat and presented traverse folds, and the extremities with different formats that varied according to the reproductive cycle. Non-filiform or tubular testis were not common, as the case of *R. aspera*, which presented flat testis and folds in the outer margins, which became accentuated with the maturation, besides transversal folds in the mature fishes which gave lobuled aspect (Agostinho et al., 1986; 1990). Testis in *P. striatulus* (Araújo et al. 2000) presented folds during the whole reproductive cycle, varying in turgidity, coloration and size. Barbieri and Barbieri (1984) reported that testes of *Gymnotus carapo* were oval, sometimes taking a pyramidal form. The flat form was also reported for *L. anus* (Bruschi-Jr. et al., 1997). Barbieri and Barbieri (op cit) reported that testis coloration did not change much as compared with ovary, and that both the testes showed the same size, although in some cases this might not occur.

The *L. spixii* presented a morphological asymmetric pattern for the ovaries, but only in partially spawning / totally spawning stages due to probable elimination of eggs when the fish was caught, since that part of the oocytes were usually eliminated by the females. In other stages, such oocytes were not eliminated since they were not enough developed and the gonads did not present such asymmetry. This could be a mechanism to increase species survival. The pellucida zone was considered thin. Differently from the mammals, the pellucida zone in fish was complex, constituted by layers and presented radiate strays at light

microscopy, being also called for this reason, radiate zone (Rizzo and Bazzoli, 1991).

The yolk is a nutritional reserve of accumulated material in the oocytes during its development and differs among species, especially in the proportion and amount of proteins, lipids and carbohydrates. In the teleosteans, there was large ranges in the chemical nature of the cortical vesicles and globules of yolk. Yolk globules in *L. spixii* were spherical, and in high amount. Yolk globules were formed in the cells of oocytarian lineage O4, the largest oocytes in the cell.

The long reproductive period seemed to be a rule for the gender *Loricariichthys* as stated by Vazzoler (1996), who reported *Loricariichthys platymetopon* and *Loricariichthys* sp as parcel spawning, with a wide reproductive period from October to March, coinciding with rainfall period. The *Loricaria* spp were also classified as iteroparous spawning but with a more restricted reproductive period, between November and January. The wide reproductive period was shown in this work for *L. spixii*, with resting in July/August for the females. Seasonal variations in the males GSI were less evident, with a trend of higher values in September-October 1996 and January-February 1997, coinciding with peaks in rainfall and temperatures, conditions usually favorable for neotropical fish reproduction. Water levels did not match rainfall season due to the highest hydroelectric power demands during the summer. This disturbance could contribute to the wide reproductive period, a mechanism to increase eggs and juvenile survival by the species. Duarte and Araújo (2001) found a close relationship between the water level and *L. spixii* abundance and attributed this pattern to the increased feeding resources availability and shelter during the high water level season. Overall *L. spixii* probably found in Lajes reservoir favorable environmental conditions to its development, as indicated by its remarkable high abundance in this relatively closed environment.

## CONCLUSIONS

1. The structure of *L. spixii* population in the Lajes reservoir showed an asymmetric sexual pattern, with females being more abundant than males, and also reaching larger sizes.

2. Four gonadal development phases were detected for both the sexes: males -spermatogonia (primary and secondary), spermatocytes (primary and secondary), spermatids and spermatozoa; females - primary oocytes (O1), previtellogenic oocytes (O2), cortical vesicle oocytes (O3) yolk globules or vitellogenic (O4)

3. Five gonadal stages were described for the males/females: resting (1); initial maturation (2a); advanced maturation (2b); partially spent/spawned (4a); totally spent/spawned (4b).

4. This species was iteroparous spawning with resting/recover occurring in July/August for the females, coinciding with lower temperature and rainfall and decreasing water level. The wide spawning period seemed to be the part of the strategy developed by this species to withstand environmental pressure (biotic and abiotic).

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## RESUMO

A morfologia das gônadas e a época de desova de *Loricariichthys spixii*, no reservatório de Lajes foi descrita baseada em 175 machos e 613 fêmeas, coletados de Janeiro-1996 a Dezembro-1997.

Células de linhagem espermatogênica foram divididas em 4 fases: espermatogônias (primárias e secundárias), espermatócitos (primários e secundários), espermatídes e spermatozoides, enquanto as células de linhagem ovocitária também foram divididas em 4 fases, baseadas em características do núcleo, ooplasma e folículos dos ovócitos: ovócitos primários (O1), ovócitos previtelogênicos (O2), ovócitos de vesícula cortical (O3) e glóbulos de vitelo ou vitelogênicos (O4). Cinco estádios gonadais foram descritos para machos/fêmeas de acordo com a distribuição das células de linhagem ovocitária / espermatogênicas: repouso (1); maturação inicial (2a); maturação avançada (2b); parcialmente esvaziado/desovado (4a); totalmente esvaziado/desovado (4b). Desova é parcelada, ocorrendo através do ano. O repouso/recuperação ocorreu em Julho/Agosto para fêmeas coincidindo com menores temperaturas e pluviosidades, e diminuições do níveis da água. O amplo período reprodutivo é parte da estratégia desenvolvida por esta espécie para suportar as pressões ambientais (bióticas e abióticas) e obter sucesso neste reservatório oligotrófico e pobremente estruturado.

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