Reproductive biology and feeding of *Curimatella lepidura* (Eigenmann & Eigenmann) (Pisces, Curimatidae) in Juramento reservoir, Minas Gerais, Brazil

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ABSTRACT. Reproductive biology and feeding of *Curimatella lepidura* (Eigenmann & Eigenmann, 1889) were studied in Juramento reservoir, São Francisco River basin, Southeastern Brazil. Histological analyses and gonadosomatic indexes revealed females and males in reproductive activity from October to March and total spawning occurring from January to March coupled with the peak of spermiating males. In the dry season, the fishes accumulated energetic reserves for reproduction during a short rainy season. The species presented sexual dimorphism, being females larger than males and sexual maturation occurring close to 7.7 cm standard length for females and 7.1 cm for males. *C. lepidura* presented iliophagous feeding habit, ingesting mainly sediment/detritus and a small amount of acari, algae, Tricoptera insects and Ostracoda crustaceans, suggesting a probable role in nutrient recycling of the Juramento reservoir.
KEY WORDS. Diet; gonadal maturation; reproduction; São Francisco River; spawning.

RESUMO. **Biologia reprodutiva e alimentação de *Curimatella lepidura* (Eigenmann & Eigenmann) (Pisces, Curimatidae) no reservatório de Juramento, Minas Gerais, Brasil.** A biologia reprodutiva e alimentação de *Curimatella lepidura* (Eigenmann & Eigenmann, 1889) foram estudadas no reservatório de Juramento, Bacia do rio São Francisco, Sudeste do Brasil. Análises histológicas e índices gonadosomáticos mostraram fêmeas e machos em atividade reprodutiva de outubro a março e desova total ocorrendo de janeiro a março coincidindo com pico de espermiação. Na estação seca, os peixes acumularam reservas energéticas para a reprodução durante curta estação chuvosa. A espécie apresentou dimorfismo sexual, sendo as fêmeas maiores do que os machos e, a maturação gonadal ocorreu em torno de 7,7 cm de comprimento padrão para as fêmeas e 7,1 cm para os machos. *C. lepidura* apresentou hábito alimentar iliófago, ingerindo predominantemente sedimento/detrito e, em menor proporção, ácaros, algas, insetos Tricoptera e crustáceos Ostracodas sugerindo provável papel na reciclagem de nutrientes do reservatório de Juramento.
PALAVRAS-CHAVE. Desova; dieta; maturação gonadal; reprodução; Rio São Francisco.

Curimatidae family has geographic distribution restricted to South America and Southeastern Central America with representatives in different aquatic environments (NELSON 1994). *Curimatella lepidura,* known popularly as manjuba or saguiru, prefers lentic environments and is abundant in marginal lagoons of the São Francisco River basin (GOMES & VERANI 2003).

Damming imposes changes in the natural course of a river and may affect the biological functions of the fishes as reproduction, feeding, migration and growth, usually leading to extinction of some species and to abundance increasing of others (ALBRECHT & P-CARAMASCHI 2003). Basic biological information as feeding and reproduction are required in fish population studies with the purpose of conservation of native species and also for fish culture (GURGEL *et al.* 1995). Since species conservation and abundance depends on the reproductive success, knowledge of fish reproductive cycle in reservoirs is fundamental as it allows assessing if the populations remain viable (SUZUKI & AGOSTINHO 1997). Studies on diet are important to understand the dynamic of the fish communities, reflecting the role of each species in the ecosystem (SABINO & CASTRO 1990).

Although the dam of Juramento reservoir was concluded in 1981, studies on composition of its fish fauna (DABÉS *et al.* 2001) and reproductive biology (THOMÉ *et al.* 2005) are scarce. Studies on trophic ecology and reproduction of the main fish species have been carried out in Juramento reservoir since 2002. The present study is aimed at analysing the reproductive biology and diet of *C. lepidura* in this reservoir.

MATERIAL AND METHODS

The Juramento reservoir (16°45'-16°48'S; 43°41'-43°37'W) was built for supplying the Montes Claros city, Minas Gerais, Brazil. The reservoir has a flooded area of 7.6 Km^2, mean depth of 9.1 m and 45 x 10^6 m^3 of water, comprising the Canoas, Saracura and Juramento rivers from Verde Grande River, São Francisco River basin (Dabés *et al*. 2001).

The reproductive biology of *C. lepidura* was studied with 161 females and 49 males quarterly captured in Juramento reservoir from April 2002 to March 2003, using gillnets with mesh sizes from 3 to 10 cm between opposite knots and soaking during 15 hours.

To preserve stomach contents and determine food resources ingested by *C. lepidura*, 50 specimens were captured in May, June, September and November 2002, using gillnets which were exposed during three hours only (5 to 8 PM).

Fishes caught were fixed in 10% formalin and later stocked in 70% alcohol. Standard length (SL) and body weight (BW) were obtained from each specimen. Fishes were dissected to obtaining the weights of the gonad (GW), stomach (SW), liver (LW) and coelomic fat (CFW). The following biological indexes were calculated for each specimen: gonadosomatic index (GSI = GW x 100/BW), hepatosomatic index (HSI = LW x 100/BW), stomach repletion index (SRI = SW x 100/BW), coelomic fat index (CFI = CFW x 100/BW) and Fulton condition factor (K = BW – GW x 100/SL^3).

The specimens were grouped for classes of standard length and body weight and the relative frequencies were determined for each class. The length of the smallest male and female reproductively active was used to estimate the approximate size at first gonadal maturation (Bazzoli 2003). Sexual ratio was determined for total sampling.

For histological analyses, gonad fragments were fixed in Bouin's fluid, embedded in paraffin, sectioned with 4-6 mm thick and stained with Hematoxylin-Eosin. Reproductive cycle stages were determined based on macro- and microscopic characteristics of the gonads and GSI values.

After specimens dissection, the degree of the stomach fullness was recorded as follows: empty (0); almost empty (1), half-full (2) and completely full (3). Uncoiled intestine length (IL) was obtained from 15 specimens to calculate the intestinal quotient (IQ = IL/SL) (Barbieri *et al*. 1994).

In order to investigate the food resources consumed by *C. lepidura*, the gastric content from each specimen was analysed according to occurrence and volumetric methods under a stereomicroscope (Hyslop 1980). Food items were identified up to the lowest possible taxonomic level and algae was identified under a light microscope. Food importance index (FI) was determined during rainy season (November) and dry season (May, June and September): FI = 100 OV. $(\Sigma\ OV)^{-1}$, where O = % occurrence and V = % volume (Delariva & Agostinho 2001).

Temperature, pH, conductivity, water transparency and dissolved oxygen at water surface during the fish collections were supplied by COPASA (Companhia de Saneamento de Minas Gerais).

After performing the Kolmogorov-Smirnoff normality test, data were submitted to one-way ANOVA followed by a Tukey post-hoc test to compare means of biological indexes. Student's t test was used to analyse length and weight of males and females and sexual proportion was submitted to Chi-square test (χ^2). All tests were performed at significance level of 0.05.

RESULTS

Females of *C. lepidura* (6.9 to 13.2 cm SL and 12.2 to 77 g BW) were significantly larger than males (6.7 to 12.8 cm SL and 10 to 64 g BW). Most females had 11-12 cm SL and 50-60 g BW and most males had 10-11 cm SL and 30-40 g BW (Fig. 1). Sexual ratio of three females for each male was highly significant (χ^2 test, with $p < 0.001$). The smallest female in advanced maturation had 7.7 cm SL and 17.6 g BW and the smallest male had 7.1 cm SL and 13.8 g BW.

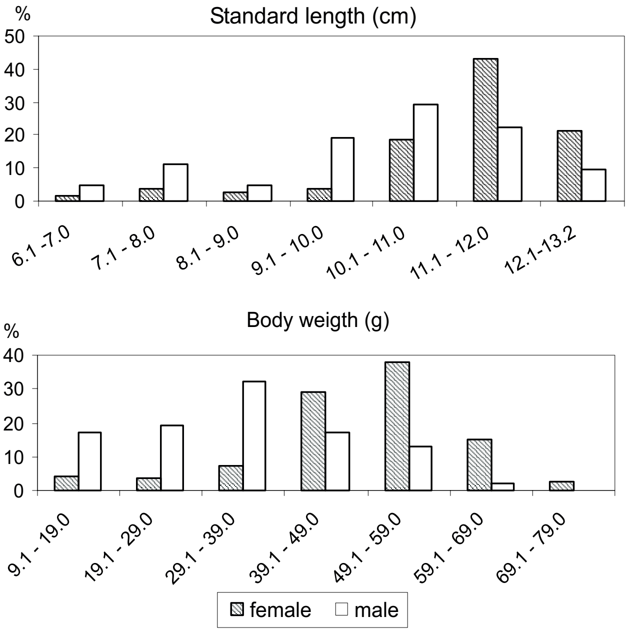


Figure 1. Distribution of *Curimatella lepidura* specimens for classes of body weight and standard length in Juramento Reservoir, São Francisco River basin, from April 2002 to March 2003.

In females, mean GSI was significantly higher while SRI and HSI were lower in October/November/December trimester (Tab. I). The same tendency was observed in GSI of males, although no significant difference had been detected between

Table I. Biological parameters of females and males of *Curimatella lepidura* in the Juramento Reservoir, São Francisco river basin, from April 2002 to March 2003.

Sex	Trimester	N	SL (cm)	BW(g)	GSI	SRI	HSI	CFI	K
Females	Apr-Jun	22	11.3 ± 0.48 a	49.05 ± 7.05 a	0.25 ±0.16 a	1.82 ± 0.45 a	0.45 ± 0.17 a	0.86 ±0.6ac	3.38 ± 0.30 ab
	Jul-Sep	38	11.71 ± 0.78 a	50.74 ± 8.60 a	0.29 ±0.18 a	1.87 ± 0.43 a	0.44 ± 0.22 a	0.90 ±0.6a	3.14 ± 0.38a
	Oct-Dec	86	11.05 ± 1.46 a	49.45± 15.03 a	5.67 ±4.05 b	1.34 ± 0.37 b	0.22 ± 0.30 b	0.37 ±0.70bc	3.32 ± 0.27b
	Jan-Mar	15	11.05 ± 0.80 a	43.42 ± 8.74 a	2.25 ±2.74 a	1.97± 0.38 a	0.44 ± 0.20 a	0.01 ±0.03b	3.15 ± 0.25 ab
Males	Apr-Jun	12	10.48 ± 0.86 a	39.16 ± 8.8 a	0.22 ±0.18 a	1.80 ± 0.36 ab	0.55 ± 0.27 a	1.07 ±0.80a	3.36 ± 0.25a
	Jul-Sep	6	10.45 ± 2.80 a	39.16 ± 23.7 a	0.15 ±0.06 a	2.02 ± 0.85 a	0.61 ± 0.29 a	0.9 ±1.49ab	2.97 ± 0.30a
	Oct-Dec	24	9.50 ± 1.68 a	29.9 ± 13.28 a	0.51 ±0.40 a	1.37 ± 0.40 b	0.22 ± 0.14 b	0.09 ±0.22b	3.30 ± 0.37a
	Jan-Mar	7	10.24 ± 0.84 a	36.43 ± 9.01 a	0.36 ±0.28 a	1.53 ± 0.41 ab	0.37 ± 0.08 ab	< 0.01 b	3.33 ± 0.23a

* For each sex, values in the same column followed by identical letters are not significantly different, p > 0,05. standard length (SL), body weight (BW), gonadosomatic index (GSI), stomach repletion index (SRI), hepatosomatic index (HSI), coelomic fat index (CFI) and Fulton condition factor (K).

the trimesters. Females' CFI was higher from April to September decreasing to minimum at January/February/March trimester similar to males. Condition factor (K) presented some significant differences throughout the trimesters only for females.

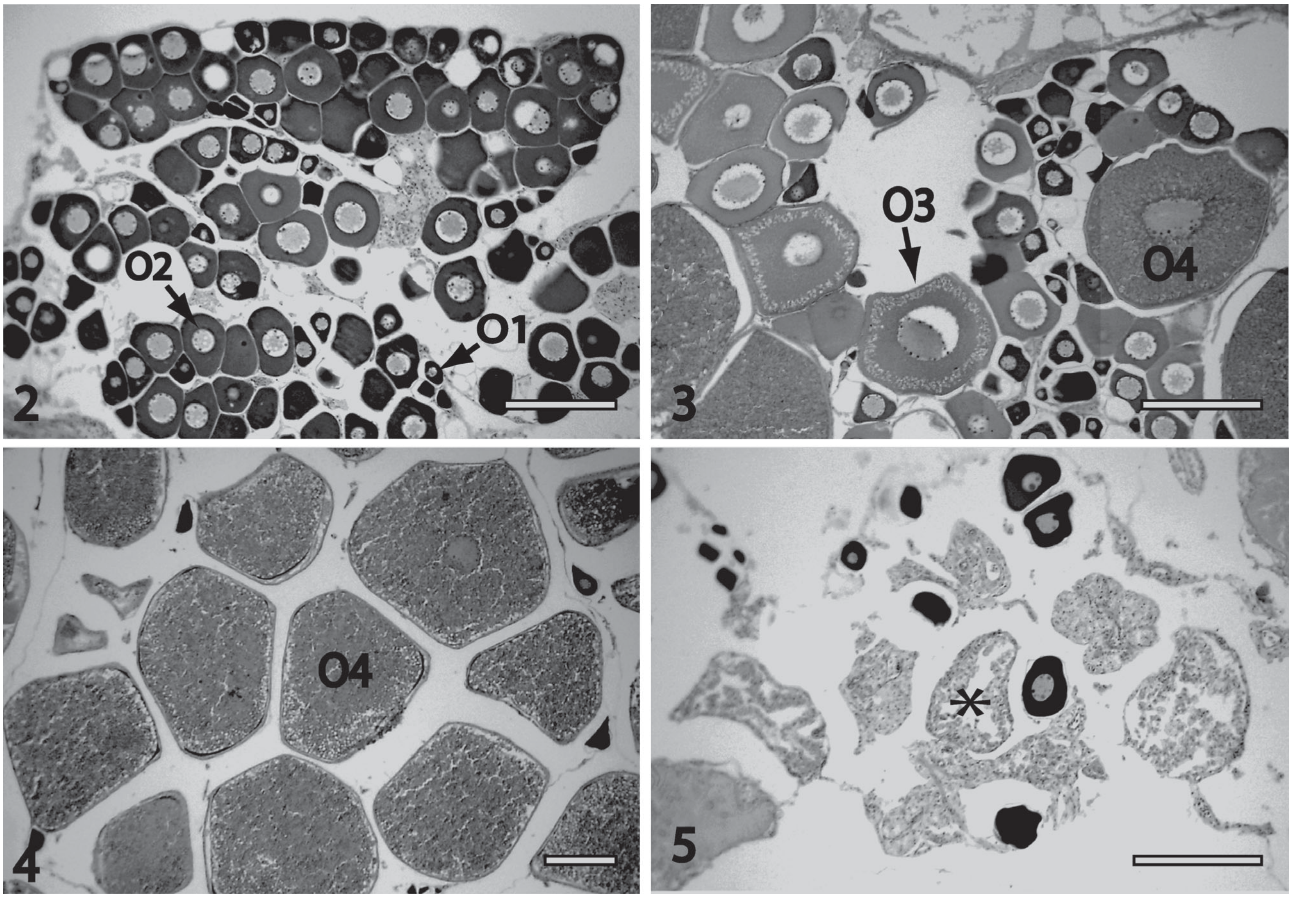
Gonadal maturation was classified in four stages (Tab. II and Figs 2 to 9). Regarding the frequencies of reproductive cycle stages, resting stage was predominant from April to September (Fig. 10). Initial and advanced maturing stages were more frequent in October/November/December but also occurred in January/February/March trimester. Spawned females occurred in January/February/March only coupled with the peak of spermiated males. Brown-yellowish bodies constituted of cell aggregates storing pigments involved by a highly vascularised connective tissue were numerous during the ovarian recovery postspawning.

Higher dissolved oxygen and pH occurred at advanced maturation from October to December (Fig. 11). During spawning from January to March, water temperature and conductivity were higher and transparency was lower. The lowest pH, oxygen, temperature and conductivity were found at resting from April to June.

All sampled stomachs had some food, however the stomach repletion was higher in the dry season and, most stomachs were almost empty during the rainy season (Tab. III). Stomach contents included mainly sediment/detritus whereas Ostracoda (Crustacean), Tricoptera larvae (insect), algae *Pleurotaenium ovatum* (Nageli, 1849) (Desmidiaceae) and acari (Arachnida) were less found. Sediment/detritus was the most important food item (FI = 0.96 in the dry season and 0.99 in the rainy season), followed by Ostracoda (FI = 0.04 in the dry season and 0.01 in

Table II. Gonadosomatic indexes (GSI), macro- and microscopical features of gonadal maturation stages of *Curimatella lepidura* in Juramento Reservoir, São Francisco River basin.

Stages	Female	Male
1	GSI < 2	GSI < 0.2
Resting	Translucent and thin ovaries containing only initial and advanced perinucleolar oocytes (O1 and O2). (Fig. 2)	Fusiform and transparent testes; Seminiferous tubules with spermatogonia only and closed lumens. (Fig. 6)
2	GSI = 0.5 to 5	GSI = 0.1 to 0.5
Initial maturation	Thick ovaries containing O1, O2, some previtellogenic and vitellogenic oocytes (O3 and O4). (Fig. 3)	Increased testes containing cysts of spermatogenic lineage cell in different development phases and few spermatozoa inside the lumens of seminiferous tubules. (Fig. 7)
3	GSI > 5	GSI = 0.2 to 1.5
Advanced maturation/mature	Voluminous ovaries with visible oocytes; Numerous O4. (Fig. 4)	Voluminous testes; Seminiferous tubules with lumen full of spermatozoa and few cysts of spermatocytes. (Fig. 8)
4	GSI = 0.5 to 2.5	GSI < 0.7
Spawned/ Spermiated	Flaccid and hemorrhagic ovaries; Presence of O1, O2, postovulatory follicles and atretic follicles. (Fig. 5)	Flaccid testes with reduced volume. Emptied seminiferous tubules with opened lumen, presenting some residual spermatozoa. (Fig. 9)



Figures 2-5. Histological sections of ovaries of *Curimatella lepidura* in different reproductive cycle stages: resting (2), initial maturation (3), advanced maturation/mature (4), spawned (5). (O1 and O2) Initial and advanced perinucleolar oocytes, (O3 and O4) previtellogenic and vitellogenic oocytes, (*) postovulatory follicle. Bar = 200 µm.

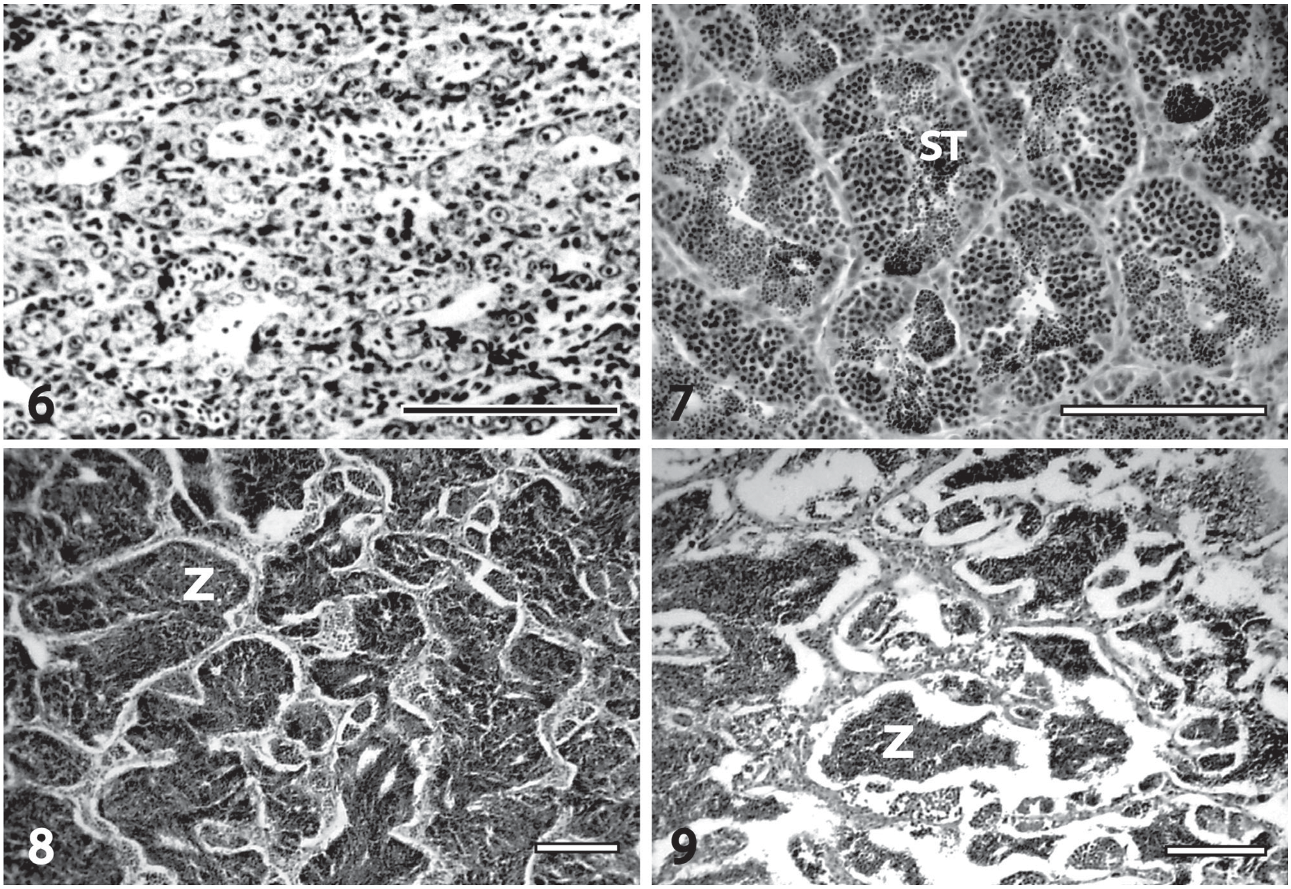
Table III. Frequency (%) of stomach repletion degree and frequency (%) of stomach containing the different food items ingested by *Curimatella lepidura* during dry and rainy seasons in Juramento reservoir, São Francisco River basin. (Dry) May, June and September; (Rain) November.

	Dry	Rain
Stomach repletion		
Almost empty	18.2	57.1
Half-full	65.9	42.9
Completely full	15.9	0
Food items		
Arachnida: acari	2.3	0
Algae: Pleurotaenium ovatum	51.2	0
Insect: Trichoptera larvae	11.6	0
Crustacean: Ostracoda	100	14.3
Sediment/detritus	100	100

the rainy season). The other items presented volume less than 0.5 mm^3 and then they were not used to calculate the FI. The IQ value for *C. lepidura* was 13.52 ± 4.24.

DISCUSSION

Size distribution indicated sexual dimorphism for *C. lepidura*, being females larger than males as also reported for other curimatids such as *Steindachnerina elegans* (Steindachner, 1875) in Tiête river (RODRIGUES *et al*. 1989) and *Cyphocharax voga* (Hensel, 1869) in Emboaba lagoon (HARTZ & BARBIERI 1994). Prevalence of females in sampling as also reported for *S. elegans* and *C. voga* (RODRIGUES *et al*. 1989, HARTZ & BARBIERI 1994) may be due to great probability of females being captured by the mesh size of the gillnets used during the fish collections. In the present study, immature fishes were not captured and, then the size of first gonadal maturation was not determined by L_{50} method. However, the smallest specimen in advanced matura-



Figures 6-9. Histological sections of testis of *Curimatella lepidura* in different reproductive cycle stages: resting (6), initial maturation (7), advanced maturation/mature (8), spermiated (9). (ST) Seminiferous tubule, (Z) spermatozoa. Bar = 100 µm.

tion (7.7 cm SL for females and 7.1 cm SL for males) may be an indicator of first gonadal maturation (BAZZOLI 2003). This parameter of the reproduction biology may avoid captures of the juveniles in order to conservation of the fish populations.

In the present work, GSI and reproductive cycle stages frequencies indicated gonadal maturation occurring mainly in October/November/December and spawning in January/February/March. Absence of partially spawned females and a short-term reproduction pattern indicated total spawning for *C. lepidura*. This non-migratory species with no parental care reproduces at Três Marias reservoir, exhibiting an extended reproductive period (SATO *et al.*2003). Other authors also reported that species of Curimatidae family are generally characterised by a long reproductive period (RODRIGUES *et al.* 1989, HARTZ & BARBIERI 1994, SCHIFINO *et al.* 1998). Probably due to the short rainy season, spawned females were captured at the Juramento reservoir during January/February/March only and, all females were found in resting in the following trimester.

Unlike the females, testicular maturation and spermiation were prolonged in *C. lepidura*, as also occur in other species of total spawning such as *Leporinus reinhardti* Lütken, 1874 (RIZZO *et al.* 1996) and *Pseudoplatystoma corruscans* (Spix & Agassiz, 1829) (BRITO & BAZZOLI 2003). Despite the males to be apt to reproduction for a longer period than the females, the spermiation peak is coupled with spawning.

In the present study, GSI peak associated to decreasing of HSI at advanced maturation suggest liver participation in the vitellogenin synthesis and mobilisation of energetic reserves for reproduction since the feeding activity is reduced or interrupted during reproduction in accordance with other authors (HTUN-HAN 1978, AGOSTINHO *et al.* 1990, BAZZOLI & GODINHO 1991, TAVARES & GODINHO 1994, BENNEMANN *et al.* 1996). Higher CFI in resting period decreasing during the advanced maturation indicated energetic consume for concluding the reproductive activity, which was compensated by a greater feeding activity at resting similar to other Characiformes (NOGUEIRA *et al.* 1997, BARRETO *et al.* 1998, BRITO *et al.* 1999, HOJO *et al.* 2004). According to BARBIERI & VERANI (1987) high K values happen simultaneously to GSI peak in advanced maturation and low K coincided with low GSI and high frequency of females in resting

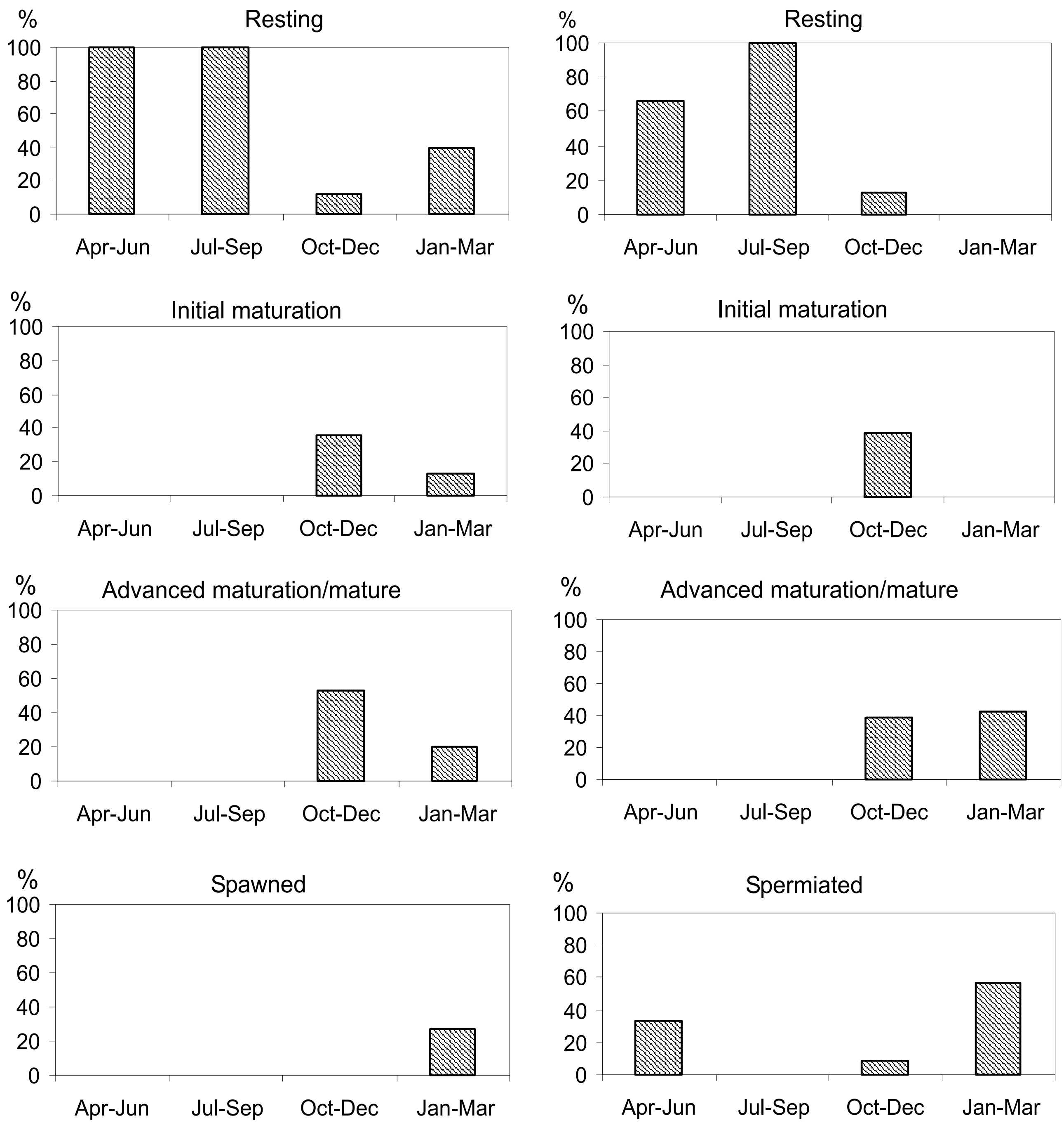


Figure 10. Frequency (%) of the reproductive cycle stages of *Curimatella lepidura* females (left graphics) and males (right graphics) in Juramento Reservoir, São Francisco River basin, from April 2002 to March 2003.

stage. However, K values were few significant in *C. lepidura* due probably to its feeding habit.

In the present work, reproduction of *C. lepidura* occurred during the period of highest temperature as also reported for other Characiformes (Hartz & Barbieri 1994, Bazzoli *et al*. 1998, Nogueira *et al.* 1997, Ricardo *et al.* 1997). Temperature regulates the reproductive process acting in specific thermoreceptors or through effects on the metabolism and growth. Higher

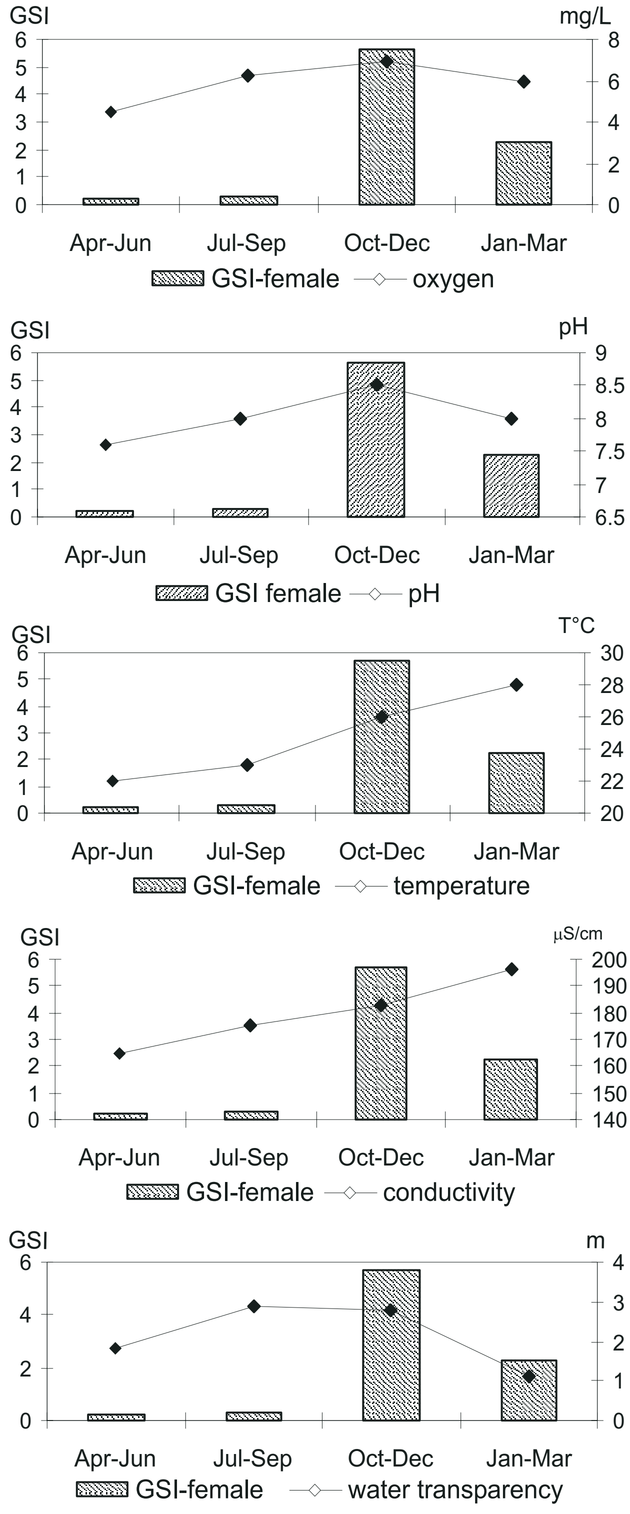


Figure 11. Relationship between GSI of *Curimatella lepidura* and environmental variables in Juramento Reservoir, São Francisco River basin, from April 2002 to March 2003.

temperatures cause an increase in the pituitary response to the hypothalamic factor increasing gonadotrophin release, which, in its turn, induces gonadal recrudescence (QUINTANA *et al*. 2004). Rain may alter water parameters causing an increase in oxygen, pH and conductivity levels and a decrease in the transparency due to the allochthonous materials (PINTO *et al*. 2003). In accordance with BAZZOLI (2003), rainfall is the best stimulus to spawning, usually acting in fish reproduction due to a higher oxygenation at the water surface, where most of the eggs and newly-hatched larvae are found in suspension.

Regarding the feeding habit, *C. lepidura* was previously considered an iliophagous or detritivorous species (GOMES & VERANI 2003). However, according to HAHN *et al*. (1997), sediment and detritus are considered distinct categories and detritivorous fish present feeding composed usually of large particles along with dead arthropod and invertebrate exuviae. In the present study, *C. lepidura* presented an iliophagous feeding habit ingesting mainly sediment associated with a small amount of detritus. Species from this trophic category explore the bottom or the periphyton, ingesting a great quantity of sediment associated with unicellular algae and micro organisms and organic matter in fine particles (AGOSTINHO *et al*. 1997). Mechanisms employed by fish for its diet, represent adaptations, which make them able to use a specific kind of prey (LUNARDON-BRANCO & BRANCO 2003). As an adaptation to the iliophagous habit, the digestive tract of *C. lepidura* presents a mechanic stomach similar to gizzard and long-coiled intestine for a better utilisation of food and does not present teeth in the maxillary (AGOSTINHO *et al*. 1997, GOMES & VERANI 2003). Moreover, the long coiled intestine found in *C. lepidura* is characteristic of the detritivorous fish, being intestine length related directly to food digestibility and quantity of detritus (DELARIVA & AGOSTINHO 2001).

In present study, *C. lepidura,* has ingested Ostracoda during the dry season, but sediment/detritus was predominant along all year. Analysis of stomach repletion index has shown greater feeding activity in the dry season, coinciding with resting period, when fish accumulate energetic reserves for the reproductive activity. Differences in the abundance of food between dry and rainy seasons affect directly the tropical fish communities. As a response to these variations, opportunistic species change their diet according to the food availability (POMPEU 1999). However, the morphological adaptations of the digestive tract of some trophic categories like the iliophagous fishes including *C. lepidura*, make these species highly specialised and impose limits on diet changing (AGOSTINHO *et al*. 1997).

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