

Reproduction of the catfish *Iheringichthys labrosus* (Lütken) (Pisces, Siluriformes) in Furnas reservoir, Minas Gerais, Brazil

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ABSTRACT. The reproductive biology of *Iheringichthys labrosus* (Lütken, 1874) was studied in Furnas reservoir, Minas Gerais, Brazil. The fishes, 323 males and 817 females, were captured bimonthly from August 1993 to July 1994 by using gill nets with 3-10 cm mesh size. Gonadal maturation of the specimens was analyzed through macro and microscopical characteristics of the gonads. The secretory activity of the tubules of the caudal region of the testis was analyzed during the maturational testicular cycle. Females and males were in reproductive activity throughout the year in the reservoir. The peak of advanced maturation/mature stages occurred from October to January and of spawned/spent from February to May. The spawning of *I. labrosus* was identified as fractional or multiple type: occurring in the reservoir or in tributaries around it. The oocyte development of the species was asynchronous as different clusters of oocytes occurred simultaneously in the ovarian parenchyma. The epithelium of the tubules of the caudal region of the testis was in high secretory activity during advanced maturation/mature stage and this activity was absent in resting. The gonadosomatic index followed gonadal maturation, and the hepatosomatic index of females was lowest in advanced maturation/mature probably due to the contribution of the liver in the vitellogenesis. The variations of the stomach repletion index, coelomic fat and condition factor indicated that the feeding activity was reduced and that the energetic reserves were consumed during the reproductive period.

KEY WORDS. Gonadal maturation, Pimelodidae, spawning.

RESUMO. A biologia reprodutiva de *Iheringichthys labrosus* (Lütken, 1874) foi estudada no reservatório de Furnas, Minas Gerais, Brasil, utilizando-se técnicas biométricas, macroscópicas e microscópicas. Capturaram-se, bimestralmente, 323 machos e 817 fêmeas, utilizando-se redes de emalhar no período de agosto de 1993 a julho de 1994. A atividade secretora dos túbulos da região caudal dos testículos foi analisada durante o período reprodutivo. Machos e fêmeas encontravam-se em atividade reprodutiva durante todo ano com pico de maturação avançada/maduro de outubro a janeiro de desovado/espermiado de fevereiro a maio. O longo período de desova e a alta frequência de fêmeas parcialmente desovadas indicaram que a espécie tem desova do tipo parcelado, com desenvolvimento assíncrono dos ovócitos. A espécie desova no reservatório e/ou em tributários nas suas proximidades. O epitélio dos túbulos da região caudal dos testículos apresentou alta atividade secretora durante o estágio maturação avançada/maduro, estando essa atividade ausente no estágio de repouso. O índice gonadossomático acompanhou a maturação das gônadas e o índice hepatossomático apresentou-se mais baixo na maturação avançada/maduro, sugerindo transferências de substâncias hepáticas para os ovários. As variações dos índices de repleção do estômago, de gordura celômica e o fator de condição indicaram que os peixes alimentam-se menos e consomem reservas graxas no período reprodutivo.

PALAVRAS CHAVE. Desova, maturação gonadal, Pimelodidae.

Reproductive cycle and gametogenesis are important parameters in understanding the reproduction of native fish species, and to the establishment conservation programs (BAZZOLI & GODINHO 1991).

A fish's spawning type indicates the frequency of mature oocytes released within the same reproductive period (VAZZOLER 1996). In fractional or multiple spawning, oocyte

development is asynchronous, maturation occurs in many clusters and the spawning takes place for a long period; this is a common strategy of many species from lentic environments (BAZZOLI 2003). In total spawning, oocyte development is group-synchronous, maturation occurs in only two clusters and spawning occurs over a short period of time: being characteristic of species from lotic environments (SATO *et al.* 2003).

The parameters or biological indexes of reproduction show the way in which fish use environmental/energetic resources. The gonadosomatic index is a good indicator of reproductive activity, then being used in determining fish reproductive cycle stages (DE VLAMING *et al.* 1982). Variations in the hepatosomatic index of teleost are related to the liver capacity to store glycogen, physiological conditions, reproduction activity, feeding habit and food availability (TAVARES-DIAS *et al.* 2000). In tropical environments, feeding plays a fundamental role in determining reproductive rhythm (VAZZOLER & MENEZES 1992). Variations in fish coelomic fat level may be related to their reproductive cycle as well as the river or reservoir hydrologic cycle (LAMAS & GODINHO 1996). The Fulton condition factor may indicate the period of time in which gonadal maturation occurs and it is used as a measure of fish physiological state, allowing comparison between two or more populations that are found in different ecological conditions (NIKOLSKI 1963, BARBIERI *et al.* 1996).

The Siluriformes order shows wide geographic distribution, occurring principally in South America, Africa and Southeast Asia, with approximately 34 families, 412 genera and over 2400 species (NELSON 1994, DE PINNA 1998). The mandi-beiçudo, *Iheringichthys labrosus* (Lütken, 1874), belongs to the family Pimelodidae and occurs along the entire Prata river basin being abundant in several reservoirs (BURGES 1989). A recent study on the reproductive system of *I. labrosus* showed fringed testis and a peculiar morphofunctional organization with three regions: a spermatogenic cranial, a secretory caudal and a transitional medial with spermatogenic and secretory activities (SANTOS *et al.* 2001).

Despite of its wide geographic distribution, only a few studies on *I. labrosus* have been conducted, mainly concerning in its reproductive dynamics. At the Itaipú reservoir, Paraná state, Brazil, studies on *I. labrosus* showed that this species does not migrate nor exhibit parental care of its offspring and it spawns in the reservoir (AGOSTINHO & JÚLIO JR. 1999). In Furnas reservoir, *I. labrosus* is the second most captured species, representing 18% of the total fish biomass (SANTOS & FORMAGIO 2000).

Taking in account the importance of *I. labrosus* in ecology of the Furnas reservoir, the objective of this presents study was carried is to evaluate the reproductive dynamics through macro and microscopical analysis and the relationship of the biological indexes with the reproductive cycle.

MATERIALS AND METHODS

Animals

Adult specimens of *I. labrosus*, comprising 323 males and 817 females were captured bimonthly from August 1993 to July 1994, by using gill nets with 3-10 cm mesh size, in the Furnas reservoir (20°40'S, 46°19'W), state of Minas Gerais, Southeastern Brazil. The specimens were fixed in 10% formaldehyde for macroscopical analyses.

Gonads analyses

Fragments of gonads were fixed in Bouin's fluid for 8-12 hours, embedded in paraffin and glycol-methacrylate plastic resin, sectioned at 3-5µm and stained with hematoxylin-eosin for histological analyses, under light microscopy (JUNQUEIRA & JUNQUEIRA 1983).

Morphological characteristics of the spermatogenic lineage cells were determined according to SANTOS *et al.* (2001) and the oogenesis cells were classified based on features observed by BAZZOLI (2003).

Reproductive cycle and spawning

The reproductive cycle and spawning type were determined through macro and microscopic characteristics of the gonads as well as the frequency distribution of the reproductive cycle stages.

Biological indexes

From each specimen we measured standard length (SL); and the weights of the body (BW), of the gonads (GW), of the liver (LW), of the stomach (SW) and of the coelomic fat (CFW). The following biological parameters were determined for each stage of the reproductive cycle: gonadosomatic index ($GSI = GW/BW \times 100$), hepatosomatic index ($HSI = LW/BW \times 100$), stomach repletion index ($SRI = SW/BW \times 100$), coelomic fat index ($CFI = CFW/BW \times 100$) and Fulton condition factor ($K = (BW-GW)/SL^3 \times 100$) (LE CREN 1951, NIKOLSKI 1963, VAZZOLER 1996).

Statistical analysis

A one-way analysis of variance (ANOVA) followed by Duncan's test ($p < 0.05$) was performed to compare the means of the biological indexes for stages of the reproductive cycle.

RESULTS

Gonadal maturation

The gonads of *I. labrosus* were paired organs, related to the swimbladder cranially and to the kidneys caudally. They presented macro and microscopical variations during the different reproductive cycle stages:

Stage 1 (resting). The testes showed fringes with a reduced size. In the cranial region, the seminiferous tubules contained only spermatogonia in its wall, and an occluded lumen (Fig. 1). In the caudal region, the tubules were open and there was no secretion (Fig. 6). The ovaries were translucent, without evident vascularization and contained initial and advanced perinucleolar oocytes (Fig. 8).

Stage 2 (initial maturation). The testes increased in volume and the fringes were a milky white colour. In the wall of the seminiferous tubules we identified cysts of spermatogenic cells in different developmental phases (Fig. 2). In the cranial region, few spermatozoa were in the lumen, and little secretion occurred on the caudal region. The ovaries were yellowish, and also increased in volume, contained initial and advanced perinucleolar oocytes and some previtellogenic oocytes (Fig. 9).

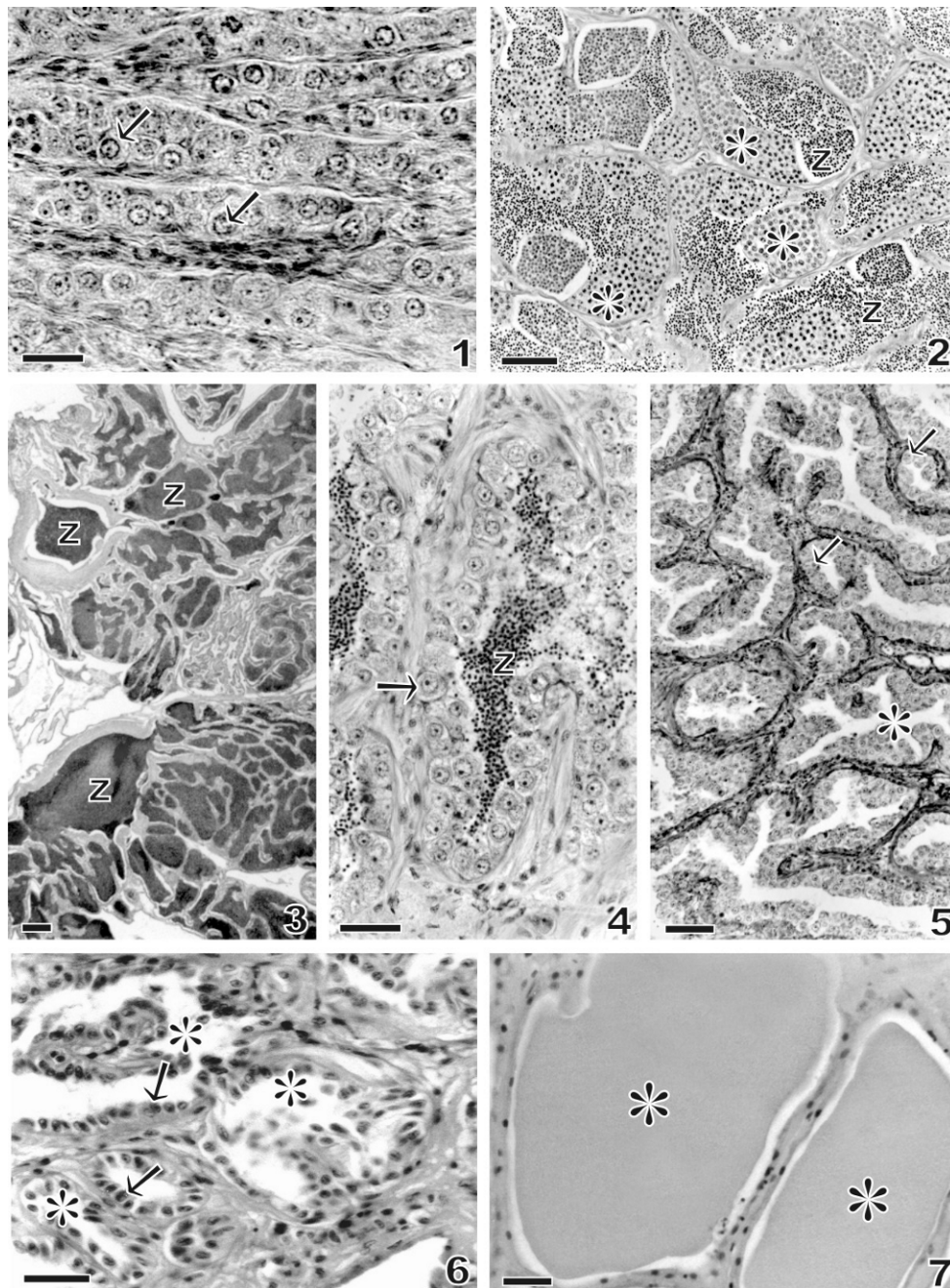


Figure 1-7. Histological sections of testis of *I. labrosus* stained with hematoxilin-eosin, in different reproductive cycle stages: (1) resting stage showing seminiferous tubules with an occluded lumen and spermatogonia surrounded by connective tissue (arrow); (2) initial maturation stage containing spermatogenic lineage cell in different development phases (*) and few spermatozoa (Z) inside the lumen of the seminiferous tubules; (3) advanced maturation/mature stage with the lumen of the seminiferous tubules and spermatic ducts filled with spermatozoa (Z); (4) partially spent stage showing seminiferous tubules with spermatogonia (arrow) and an opened lumen with few spermatozoa (Z); (5) totally spent stage showing seminiferous tubules with an open lumen (*) and epithelium containing only spermatogonia (arrow); (6) caudal region of resting testis: tubule walls consisting of secretory cells only (arrow); open lumen with no secretion (*); (7) caudal region of advanced maturation/mature testis: accumulation of secretion in lumen (*). Scale: 200 μ m.

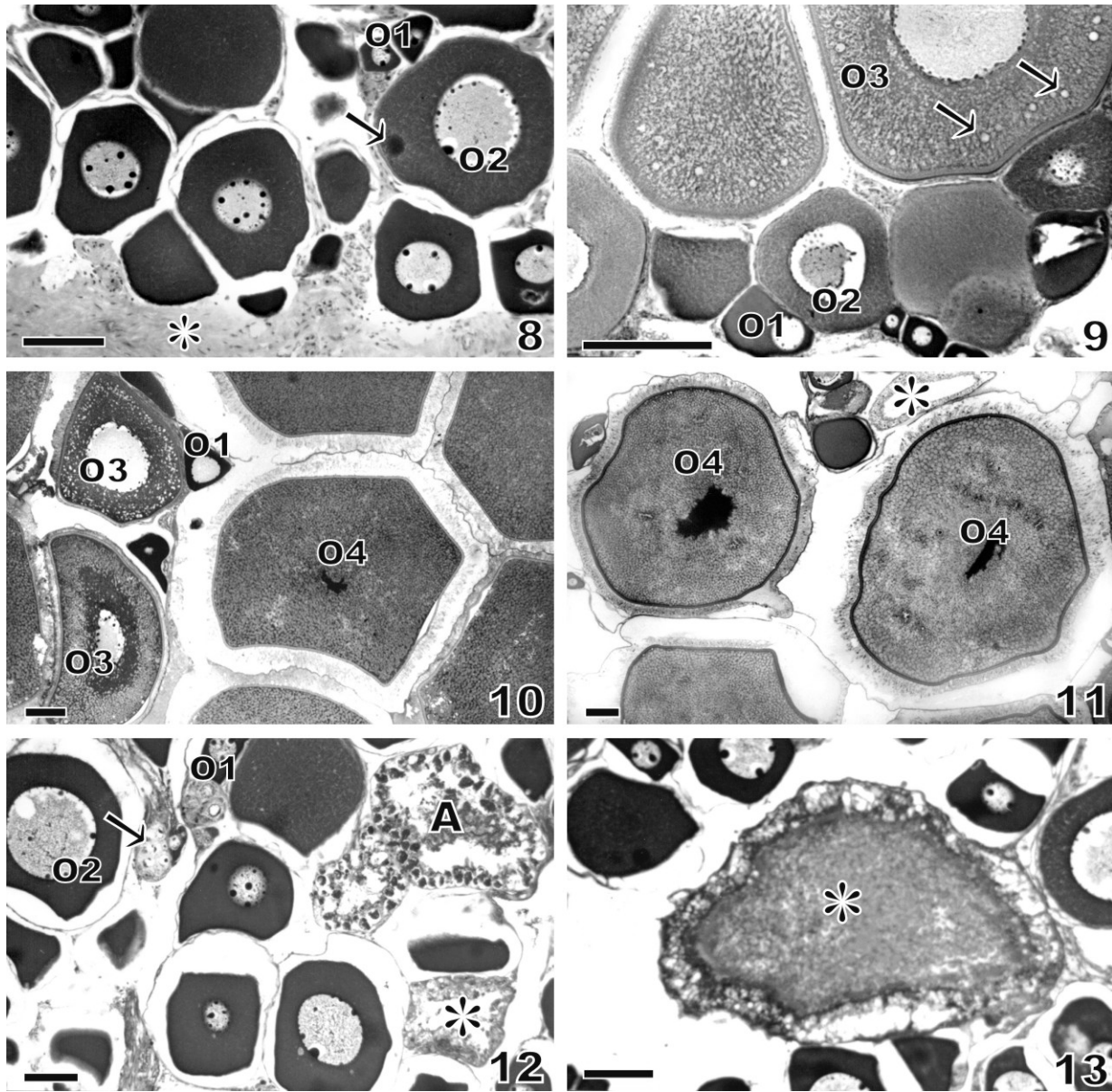


Figure 8-13. Histological sections of ovaries of *I. labrosus* stained with hematoxylin-eosin, in different reproductive cycle stages: (8) resting stage presenting initial perinucleolar oocytes (O1), advanced perinucleolar oocytes (O2) with yolk nucleus (arrow) and tunica albuginea (*); (9) initial maturation stage containing O1, O2 and previtellogenic oocytes (O3) with cortical vesicles (arrow); (10) advanced maturation/mature stage presenting O1, O2, O3 and vitellogenic oocytes (O4); (11) partially spawned stage presenting postovulatory follicle (*) and O4; (12) totally spawned stage showing atretic follicle (A), postovulatory follicle (*), O1, O2 and oogonia (arrow); (13) detail of atretic follicle showing hypertrophied follicular layer and yolk liquefaction (*). Scale: 100 μ m.

Stage 3 (advanced maturation/mature). Voluminous testes showed prominent milky white fringes. In the cranial region, the lumen of the seminiferous tubules and spermatic ducts were filled with spermatozoa (Fig. 3), and there was abun-

dant secretion accumulated into the lumen of the tubules of the caudal region (Fig. 7). Yellowish and voluminous ovaries presented oocytes visible to the naked eye. Histological analyses showed predominance of vitellogenic oocytes (Fig. 10).

Stage 4A (partially spent/spawned). Milky white color testes showed flaccid fringes with reduced volume. In the cranial region, the lumen of the seminiferous tubules was open and contained few spermatozoa (Fig. 4), and secretion was still observed in the caudal region. Flaccid ovaries with hemorrhagic areas contained oocytes in all development phases and post-ovulatory follicles (Fig. 11).

Stage 4B (totally spent/spawned). Flaccid testes showed considerable reduction in volume and small fringes. The lumen of the seminiferous tubules of the cranial region and spermatic duct were open and empty or with residual spermatozoa (Fig. 5). Little acidophilic secretion was observed in the caudal region. Flaccid hemorrhagic ovaries contained initial and advanced perinucleolar oocytes as well as atretic vitellogenic follicles (Figs 12 and 13).

Reproductive cycle and biological parameters. Fish in reproductive activity (stages 2, 3 and 4) occurred all year around. Peaks of advanced maturation/mature were observed from October to January (Tabs I and II). Spent and spawned fish (stages 4A and 4B) were captured throughout the year with peaks from February to May. Fish in the resting stage were predominant from April to July.

The GSI of males and females reached the highest values in stage 3, while K showed its highest values in stages 1 and 2, gradually decreasing in the following stages. The HSI of females reached the lowest values in stage 3, however, in males it did not show any difference between stages. The CFI of males and females showed the lowest values in stage 3 (Tabs III and IV).

Spawning. The presence of spawned females during the whole reproductive cycle indicated that *I. labrosus* exhibits fractioned or multiple spawning with asynchronous oocyte development.

DISCUSSION

The morphofunctional organization of the male reproductive system of Siluriformes is variable between species. Some species may present testis with digitiform fringes with or without secretory caudal region; accessory organ like a seminal vesicle was also seen in some Siluriformes (LOIR *et al.* 1989). In *I. labrosus* testes are fringed in all their extension, with cranial spermatogenic region and caudal secretory region (SANTOS *et al.* 2001). Conversely, ovaries of this species presented morphological characteristics similar to the majority of teleosts.

In the present study we established five reproductive cycle stages in *I. labrosus*, based on morphological characteristics and distribution of gametogenic cells. The variations of the secretory activity of the cells in tubules of the caudal region of the testis were also observed during the maturational cycle. Seasonal alterations in secretory activity of the seminal vesicles in relation to testis cycle have already been described in few spe-

cies: *Mystus tengara* (Hamilton, 1822) (RASTOGI 1969), *Heteropneustes fossilis* (Bloch, 1794) (NAYYAR & SUNDARARAJ 1970) and *Clarias batrachus* (Linnaeus, 1748) (SINGH & JOY 1999).

For both females and males, peak GSI values were recorded in the advanced maturation/mature stage, with GSI decreasing in the spawned/spent stage. In fact, increasing GSI values are associated with maturation, whereas decreasing values are related to gamete extrusion and/or reabsorption (AGOSTINHO *et al.* 1992). In females, the highest values for IHS during stages 2 and 3 may be related to the synthesis of vitellogenin in the liver (SELMAN & WALLACE 1989). However, no significant differences were found among the values for IHS (ANOVA) in the various reproductive cycle stages of the males, demonstrating that the liver does not influence testes maturation (SCOTT & PANKHURST 1992). The highest mean values for SRI in females were observed during the spawned stage, indicating that the species found better feeding conditions after the reproductive cycle, probably to compensate for spawning losses (LE CREN 1951). During the advanced maturation/mature stage, the feeding activity had been reduced due to the compression of the digestive organs by the gonads, especially in females, and after the spawning feeding activity began again (SLOTTE 1999). Males and females of *I. labrosus* presented the lowest values for CFI in the advanced maturation/mature stage, suggesting that the fish consume their lipid reserve during this period, which has also been reported by BAZZOLI *et al.* (1998). Contrarily, GODINHO *et al.* (1997) observed the presence of colomic fat in advanced maturing and spawned females of *Plagioscion squamosissimus* (Heckel, 1840), indicating that vitellogenesis proceeds without depleting the lipid reserve. The lowest values for K in *I. labrosus* were registered in the advanced maturation/mature and spent/spawning stages, due to reduction of feeding activity and the consumption of lipid reserve during the reproductive period (ORTAZ 1997).

In conclusion, *I. labrosus* spawned almost throughout the year in the Furnas Reservoir or in small tributaries around it. The epithelium of the tubules of the caudal region of the testis was in high secretory activity during advanced maturation/mature stage and this activity was absence in the resting stage. The species showed fractional or multiple spawning with peaks of advanced maturation/mature from October to January and it spawned from February to May, similar to *Pimelodus maculatus* Lacépède, 1803 in the same reservoir (BAZZOLI *et al.* 1997).

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Table I. Frequency distribution of the reproductive cycle stages for males of *I. labrosus*, in the Furnas reservoir from August 1993 to July 1994.

Bimester/Year	1		2		3		4A		4B		Total
	Fa	Fr (%)	Fa	Fr (%)	Fa	Fr (%)	Fa	Fr (%)	Fa	Fr (%)	
Aug-Sep/93	5	6.25	29	36.25	35	43.75	4	5.00	7	8.75	80
Oct-Nov/93	–	–	5	4.95	88	87.12	6	5.94	2	1.98	101
Dez/93-Jan/94	–	–	1	2.00	45	90.00	1	2.00	3	6.00	50
Feb-Mar/94	1	2.70	–	–	14	37.84	8	21.62	14	37.84	37
Apr-May/94	8	29.62	–	–	–	–	1	3.70	18	66.66	27
Jun-Jul/94	9	32.14	6	21.42	–	–	1	3.57	12	42.85	28
Total	23	7.12	41	12.69	182	56.36	21	6.50	56	17.33	323

(1) Resting, (2) initial maturation, (3) advanced maturation/mature, (4A) partially spawned, (4B) totally spawned, (–) not captured.

Table II. Frequency distribution of the reproductive cycle stages of *I. labrosus* females in the Furnas reservoir from August 1993 to July 1994.

Bimester/Year	1		2		3		4A		4B		Total
	Fa	Fr (%)	Fa	Fr (%)	Fa	Fr (%)	Fa	Fr (%)	Fa	Fr (%)	
Aug-Sep/93	27	13.37	68	33.66	74	36.63	18	8.91	15	7.43	202
Oct-Nov/93	1	0.41	15	6.15	207	84.84	15	6.15	6	2.45	244
Dez/93-Jan/94	10	9.35	2	1.87	84	78.50	9	8.41	2	1.87	107
Feb-Mar/94	7	5.88	–	–	2	1.68	29	24.38	81	68.06	119
Apr-May/94	16	24.61	–	–	–	–	6	9.23	43	66.16	65
Jun-Jul/94	64	80.00	2	2.50	–	–	–	–	14	17.50	80
Total	125	15.24	87	10.60	367	44.92	77	9.39	161	19.71	817

(1) Resting, (2) initial maturation, (3) advanced maturation/mature, (4A) partially spawned, (4B) totally spawned, (–) not captured.

Table III. Mean values of gonadosomatic (GSI), hepatosomatic (HSI), stomach repletion (SRI), and coelomic fat (CFI) indices and condition factor (K) for each stage of the reproductive cycle (SRC) of *I. labrosus* males in the Furnas reservoir, from August 1993 to July 1994.

SRC	N	GSI	HSI	SRI	CFI	K
1	23	0.22 ± 0.17 d	0.57 ± 0.14 a	0.69 ± 0.26 a	0.65 ± 0.47 a	1.43 ± 0.20 ab
2	41	1.47 ± 0.80 b	0.62 ± 0.17 a	0.73 ± 0.36 a	0.57 ± 0.48 a	1.46 ± 0.15 a
3	182	2.04 ± 0.82 a	0.59 ± 0.22 a	0.68 ± 0.60 a	0.24 ± 0.37 b	1.34 ± 0.10 c
4A	21	1.04 ± 0.54 c	0.58 ± 0.18 a	0.79 ± 0.37 a	0.58 ± 1.06 a	1.36 ± 0.10 abc
4B	56	0.46 ± 0.32 d	0.56 ± 0.23 a	0.75 ± 0.30 a	0.46 ± 0.59 ab	1.38 ± 0.16 bc

(N) number of specimens. Values followed by same letter within the same column are not significantly different. (1) resting; (2) initial ripening; (3) advanced ripening/mature; (4A) partially spent; (4B) totally spent.

Table IV. Mean values of gonadosomatic (GSI), hepatosomatic (HSI), stomach repletion (SRI), and coelomic fat (CFI) indices and condition factor (K) for each stage of the reproductive cycle (SRC) of *I. labrosus* females in the Furnas reservoir, from August 1993 to July 1994.

SRC	N	GSI	HSI	SRI	CFI	K
1	125	0.62 ± 0.44 d	0.63 ± 0.20 d	0.67 ± 0.24 b	0.53 ± 0.51 a	1.48 ± 0.14 a
2	87	1.49 ± 0.91 c	0.81 ± 0.22 a	0.56 ± 0.23 c	0.57 ± 0.46 a	1.47 ± 0.15 a
3	367	4.55 ± 2.22 a	0.76 ± 0.24 ab	0.46 ± 0.21 d	0.14 ± 0.27 c	1.37 ± 0.10 b
4A	77	1.92 ± 1.51 b	0.72 ± 0.21 bc	0.68 ± 0.30 b	0.24 ± 0.33 bc	1.39 ± 0.11 b
4B	161	0.71 ± 0.27 d	0.67 ± 0.22 dc	0.77 ± 0.49 a	0.31 ± 0.40 b	1.38 ± 0.12 b

(N) number of specimens. Values followed by same letter within the same column are not significantly different. (1) resting; (2) initial ripening; (3) advanced ripening/mature; (4A) partially spawned; (4B) totally spawned.

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