# GONADAL DEVELOPMENT OF THE PEACOCK BASS *Cichla monoculus* (PERCIFORMES: CICHLIDAE) IN THE MIDDLE SOLIMÕES

# DESENVOLVIMENTO GONADAL DO TUCUNARÉ *Cichla monoculus* (PERCIFORMES: CICHLIDAE) NO MÉDIO SOLIMÕES

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KEYWORDS

Peacock bass;

Gonadal development;

Fertility;

Reproduction;

Amazon fish.

## ABSTRACT

The common peacock bass, *Cichla monoculus* Spix; Agassiz, 1831, is a Neotropical cichlid native to the Amazon basin. Although it is highly valued for the quality of its flesh and intensely exploited by commercial fishing, representing the fourth most sold fish along the middle Solimões River in terms of landing statistics, little is known of the reproductive characteristics of this species in its natural habitat. The objective of this work was to reveal some morphological and histological aspects of gonadal development for this species. We also wanted to verify the gonadosomatic relation and allometric condition factor, and assess their use as reproductive indicators. Finally, we intended to reveal the fecundity and spawning type for some individuals of this species living in natural environments. In this study 73 females and 72 males of *C. monoculus* were utilized, from whom data were collected on total weight and total individual length. The gonads were later removed, weighed and macroscopically analyzed. To confirm this analysis tissue slices were taken from tissue cuts from 41 of the gonads. Based on the results of macroscopic and histological analyses five stages of development for females and four for males were identified. The ovaries were classified as immature, maturing, mature, spawned and at rest. The testicles were classified as immature, maturing, mature and spermiated. The females were found to be larger than the males, but the males were heavier. The gonadosomatic relation and the allometric condition factor were not considered good indicators of the reproductive status for this species. The spawning observed was of the total type, presenting an absolute average fecundity of 8,624 mature oocytes. Diameters of the vitellogenic oocytes varied from 1,210 $\mu$m to 3,000 $\mu$m. The total spawn, which is accompanied by oocytes with large diameters that have a large reserve of vitellus, is a factor that may favor the reproductive success of *C. monoculus* on the middle Solimões.

PALAVRAS-CHAVES:

Tucunaré;

Desenvolvimento gonadal;

Fertilidade;

Reprodução;

Peixe amazônico.

## RESUMO

O tucunaré comum, *Cichla monoculus* Spix; Agassiz, 1831, é um ciclídeo neotropical originário da bacia Amazônica. Embora seja muito apreciado pela qualidade de sua carne, e intensamente explorado na pesca comercial, representando a quarta espécie mais comercializada no médio Solimões nas estatísticas de desembarque, pouco se sabe das características reprodutivas desta espécie em seu habitat natural. O objetivo deste trabalho foi revelar alguns aspectos morfológicos e histológicos do desenvolvimento gonadal desta espécie. Também objetivamos verificar a relação gonadossomática e fator de condição alométrico, e avaliar o seu uso como indicadores reprodutivos. Finalmente, também objetivamos revelar a fecundidade e o tipo de desova de alguns indivíduos desta espécie vivendo em ambientes naturais. Neste estudo foram utilizadas 73 fêmeas e 72 machos de *C. monoculus* dos quais foram coletados dados de peso total e comprimento total individual. As gônadas foram posteriormente removidas, pesadas e analisadas macroscopicamente. Para confirmar esta análise foram efetuados cortes histológicos de 41 das gônadas. A partir dos resultados das análises macroscópica e histológica foram identificados cinco estádios de desenvolvimento para as fêmeas e quatro para os machos. Os ovários foram classificados em imaturo, em maturação, maduro, desovado e em repouso. Os testículos foram classificados em imaturo, em maturação, maduro e espermiado. As fêmeas mostram-se maiores do que os machos, mas os machos foram mais pesados. A relação gonadossomática e o fator de condição alométrico não foram considerados bons indicadores do estado reprodutivo desta espécie. A desova observada foi do tipo total, apresentando uma fecundidade absoluta média de 8.624 ovócitos maduros. Os diâmetros dos ovócitos vitelogênicos variaram de 1.210 $\mu$m a 3.000 $\mu$m. A desova total, acompanhada por ovócitos com diâmetros elevados, que possuem uma grande reserva de vitelo são aspectos que podem favorecer o sucesso reprodutivo de *C. monoculus* no médio Solimões.

## INTRODUCTION

Perciforms are the largest known order of fishes (KULLANDER, 2003). Their representatives can inhabit marine environments, or be catadromous, whereas others, such as cichlids, occur only in fresh or brackish water (KULLANDER, 2003). The family Cichlidae has around 1,400 species that are characterized by having spiny rays in their dorsal, anal and pelvic fins and an interrupted lateral line (SANTOS et al., 2006). They present a broad geographic distribution, occurring in the Americas, Africa, Madagascar, southern coast of India, Sri Lanka and Middle East (KULLANDER, 2003).

The common peacock bass, *Cichla monoculus* Spix; Agassiz, 1831, is a Neotropical cichlid that occurs along floodplains in the Amazon basin in Colombia, Peru, and Brazil, where its presence has been recorded in Amazon rivers, and in the border region between Brazil and French Guyana (KULLANDER ; FERREIRA, 2006).

*C. monoculus* presents diurnal habits, is piscivorous and sedentary, and may live in small groups. It prefers to live in environments with clear water and also shows a preference for lentic environments in which to feed and reproduce (GOMIERO; BRAGA, 2004). It utilizes trunks and branches of fallen or submerged trees for food and shelter. During the reproductive period the fish in pairs build nests near substrates or beaches and demonstrate pronounced parental care in protecting the eggs and larvae (SANTOS et al., 2006). Spawning generally occurs at the beginning of the flood season, which in the Amazon usually occurs from November to March (SANTOS et al., 1991; 2006). After the eggs are fertilized, they attach to hard substrates (SANTOS et al., 2006; SOUZA et al., 2008).

Due to their natural abundance, wide geographic distribution, tasty flesh and aggressive nature, many species of the genus *Cichla* have been introduced into various regions of the country. There are known to have been introductions of *C. monoculus* to Rio Grande do Norte (CÂMARA et al., 2002; CHELLAPPA et al., 2003), of *C. kelberi,* in the Lobo reservoir, in Albufeira (SOUZA et al., 2008), and *C. piquiti* in the Paraíba river (VIEIRA et al., 2009). Those species are highly appreciated by sport-fishing enthusiasts (GOMIERO et al., 2008), which is the main reason for these introductions. However, these fish can cause changes ranging from small to catastrophic in the receiving environment (SÚAREZ et al., 2001). *C. monoculus* is highly valued for the quality of its flesh, and his highly sought after in commercial fishing (SANTOS et al., 2006). It accounts for 9 to 19% of the fish sold in Manaus (SANTOS et al., 2006) and is the fourth most important species in commercial fishing along the Middle Solimões (LIMA; AMARAL, 2008).

Despite its great economic importance for both commercial and sport fishing, there are no published works describing the reproductive phases for *C. monoculus* in its natural environment. The few papers published about reproduction for the species were developed with peacock bass introduced into the southern, southeastern and northeastern regions in Brazil (CÂMARA et al., 2002; CHELLAPPA et al., 2003;

GOMIERO; BRAGA, 2004). The systematics and taxonomy of the genus *Cichla* are still highly controversial and there are recognized doubts about the determination of the introduced species mentioned here. In a review of the genus done in 2006 it was noted that peacock bass cited in some of those papers as *C. monoculus* might actually belong to other species in the genus, *Cichla kelberi, Cichla piquiti* and *Cichla pinima* (KULLANDER; FERREIRA, 2006).

Thus, this study is the first to report some of the parameters for *Cichla monoculus* reproduction in natural environments. Those aspects may be very relevant in development appropriate means for managing the species and for its conservation. The reproductive aspects and gonadal development phases of this species in its natural habitat may enable an enhanced estimate of its biological recruitment, which is crucial for the sustainable use of this natural resource. This article reports characteristics of the morphology and histology of gonadal development in the common peacock bass, *C. monoculus*. It also assesses its fecundity and spawning type, its gonadosomatic relation, allometric condition factor and their potential use as indicators of the functional status of adult animals of this species.

## MATERIAL AND METHODS

A total of 145 individuals (73 females and 72 males) of *C. monoculus* were analyzed. The specimens were obtained at the Municipal Market in Tefé, and analyzed in the Fish Laboratory at the Mamirauá Institute for Sustainable Development - IDSM. Biometric data were collected for total weight (g), total length (cm) and weight of gonads (g). The fish were dissected through an incision in the abdomen for sex identification and removal of the gonads, which were fixed in 10% formaldehyde. They were later transferred to 70% to preserve the material.

The stages of gonadal maturation were classified through a macroscopic evaluation, which considered the number of gonads, color, transparency, form, and vascularization, the estimated volume of occupation in the abdominal cavity, and, in the case of the ovaries, the degree of visualization, size, color and form of the oocytes present. These evaluations were made according to criteria listed in Vazzoler (1996).

To corroborate the macroscopic classification, fragments of 41 female gonads were submitted to routine tissue analysis techniques: inclusion in paraffin cuts with a thickness of 5$\mu$m and staining with hematoxilin-eosin (VAZZOLER, 1996). The slides were analyzed with the aid of an optical microscope.

The gonadosomatic relation (GSR) individual calculated through the formula:

$$GSR = (Pg/Pt)*100$$

where Pg is the weight of the gonad and PT is the total weight of the individual (Vazzoler, 1996).

The allometric condition factor (K) was estimated for each fish through the formula:

$$K = Pt/Ct^b$$

a ratio between the total weight (Pt) and o total length (Ct) raised to the allometry coefficient (b), was obtained by adjusting the equation that describes the weight-length relation (VAZZOLER, 1996).

To assess if the gonadosomatic relation and the condition factor are good quantitative indicators of maturity, their average values at the different stages of development were estimated. To verify possible differences between the averages, simple analysis of variance was employed (ANOVA), followed by the Tukey-Kramer significance test (AYRES et al., 2007).

To calculate fecundity and spawning type only five already mature gonads were utilized. The sampling of oocytes was done through the gravimetric method (VAZZOLER, 1996), and 10% of the weight of the ovary was sampled. After this procedure counts and measurements were made for each oocyte from the sampling of each individual analyzed. The determination of spawning type was done through verifying the frequency distribution of oocytes by size class (VAZZOLER, 1996), represented graphically and by the assessment of the results of tissue slices from the dos ovaries.

## RESULTS

The total length of the fish analyzed varied from 250 to 490 mm, with an average of 335.7 mm, and standard deviation (s.d.) of 49.1 mm for the females, and 245 to 475 mm, with an average of 336.2 mm and s.d. of 54.0 mm for the males. The males presented the largest values for weight, 235 to 1500 g with an average of 559.9 g (s.d. = 326,6 g) when compared to the females, 223 to 1260 g with an average of 540 g (s.d. = 279 g).

### Macroscopic and Microscopic Description of the Gonads

The macroscopic observation revealed that *C. monoculus* has a homogeneous pair of gonads, with a main blood vessel that is very evident in the internal part, with secondary ramifications following to the sides of the gonad (Figures 1 and 3). The ovaries had a length inferior to that of the testicles, which actually can extend until the back part of the swim bladder. However, the presented a smaller volume. In the ovaries oocytes of distinct sizes were visible to the naked. Based on the macroscopic and histological analysis of the ovaries, the organs were classified into five stages of development: immature, maturing, mature, spawned and at rest. The testicles were classified into four stages: immature, maturing, mature and spermiated. Each one of those states of development was described, as presented below.

i. **Immature ovaries**: in this phase, the ovaries of juvenile females are small, occupy around 10% of the celomatic cavity, are in a tubal form, narrow, translucent, whitish, with little apparent blood irrigation, presenting very small oocytes that are barely visible to the naked eye (Figure 1a). Histologically they are well organized, presenting cells in the nucleolar chromatin phase (phase I) and in the perinucleolar phase (phase II) (Figure 2a).

ii. **Maturing ovaries**: these occupy between 15% and 20% of the celomatic cavity, and have a sack-shaped form, are opaque, with color varying from yellow to orange and blood irrigation is regular. Many small and average-sized oocytes were observed, which were opaque and yellow (Figure 1b).

Histologically they were characterized by the presence of oocytes at different phases of development, perinucleolar from the reserve stock (phase II), lipid vitellogenesis (phase III), as well as lipid and proteic vitellogenesis (phase IV) (Figure 2b).

iii. **Mature ovaries**: are larger and more voluminous, occupying around 50% of the celomatic cavity, opaque, sack shaped, with coloring ranging from yellow to greenish, presenting intense vascularization. Numerous large opaque and ellipsoid oocytes were observed, as well as small oocytes that were small, opaque, whitish and ellipsoid (Figure 1c). Histologically there was a predominance of oocytes with complete vitellogenesis (phase V), as well as a few oocytes of the reserve stock (phase II) (Figure 2c).

iv. **Spawned ovaries**: occupy 40% of the abdominal cavity, are yellow, opaque, sack-shaped, hemorrhagic and presenting cellular disorganization. Many small, yellow opaque and elliptic oocytes were observed (Figure 1d). Histologically this stage is characterized by the presence of follicular artresia and post-ovulatory follicles (Figure 2d).

v. **Ovaries at rest:** are flaccid, small, occupying around 10% of the celomatic cavity. They present a reddish coloring, are opaque, with a tubular form and apparently regular blood irrigation (Figure 1e). Histologically they present oocytes with chromatin nucleolus, perinucleolar and in lipidic vitellogenesis, as well as post-ovulatory follicles (Figure 2e).

The sequential order of oocyte development identified in analysis of the tissue slices was the following:

Phase I: the nucleus of the oocytes has little affinity for dyes in comparison to the cytoplasm, which showed itself to be intensely basophilous. A thin layer of tissue surrounds the oocytes.

Phase II: the oocytes are seen to be slightly more developed than in the previous phase. The cytoplasm is more basophilous at the periphery that at the nucleus.

Phase III: characterized by large, voluminous oocytes, with evident nuclei, granular cytoplasm with the appearance of cortical alveoli at the periphery and lipidic droplets.

Phase IV: the nucleus was still at the center, with an irregular surface. Besides the lipidic droplets, there were protein deposits along their length.

Phase V: the oocytes increase rapidly in size, due to the rapid increase in the number of granules with acidophilic vitelli. The nucleus has become imperceptible. Those oocytes were ready for elimination from the follicle.

Atresia of the oocytes: this was recognized by its irregular shape, disintegration of the nucleus and liquefaction of yolk granules.

i. **Immature testicles:** these are narrow, occupy around 5% of the abdominal cavity, are string like in shape, long, translucent, whitish and apparently poorly irrigated (Figure 3a). Histologically they present small seminiferous tubules with the presence of spermatogonies (Figure 4a).

ii. **Maturing testicles:** are larger and longer than in the previous phase, occupying around 15% of the celomatic cavity, beige coloring, phytaceous, narrow and poorly irrigated and extending until the end of the swim bladder (Figure 3b). Histologically the seminiferous tubules contain mainly spermatocytes, as well as spermatides (Figure 4b).

**iii.** **Mature testicles**: are more turgid, with a more elliptical typhaceous form, occupying around 30% of the abdominal cavity, wide and long. They present a whitish coloring, opaque and highly irrigated. It was possible to observe semen when the testicle was pressed (Figure 3c). Histologically the seminiferous tubules are full of spermatozoids (Figure 4c).

**iv.** **Spermiated testicles**: occupy 5% of the celomatic cavity, are filiform and long, narrow thickness, they are hemorrhagic and flaccid and demonstrate a reddish coloring (Figure 3d). Histologically they are characterized by the presence of empty and non-uniform seminiferous tubules, but still have some seminiferous tubules with a small quantity of spermatozoids (Figure 4d).

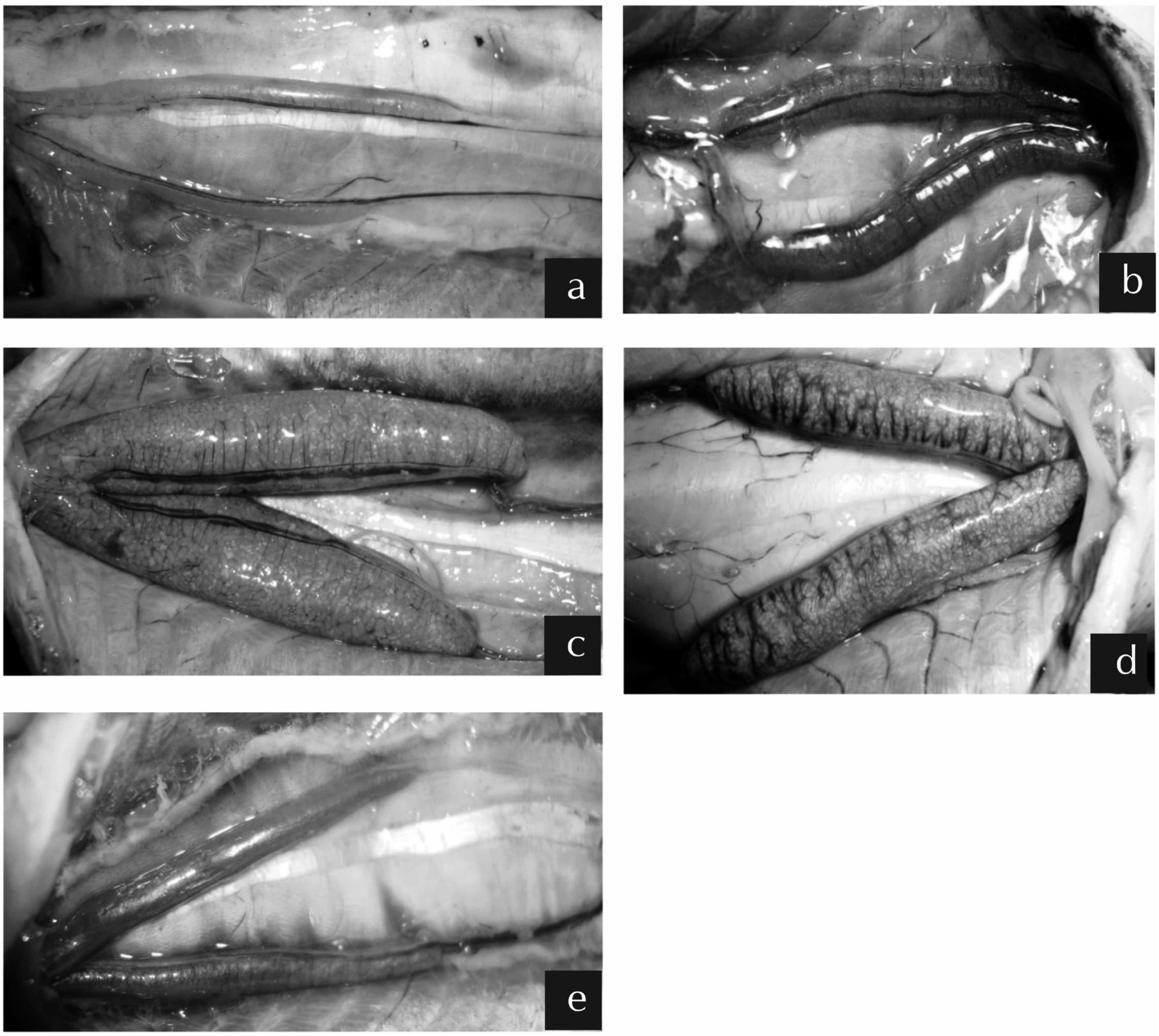


Figure 1 - Photos of ovaries of *C. monoculus* in different phases of development. a) Immature. b) Maturing. c) Mature. d) Spawned. e) At rest.

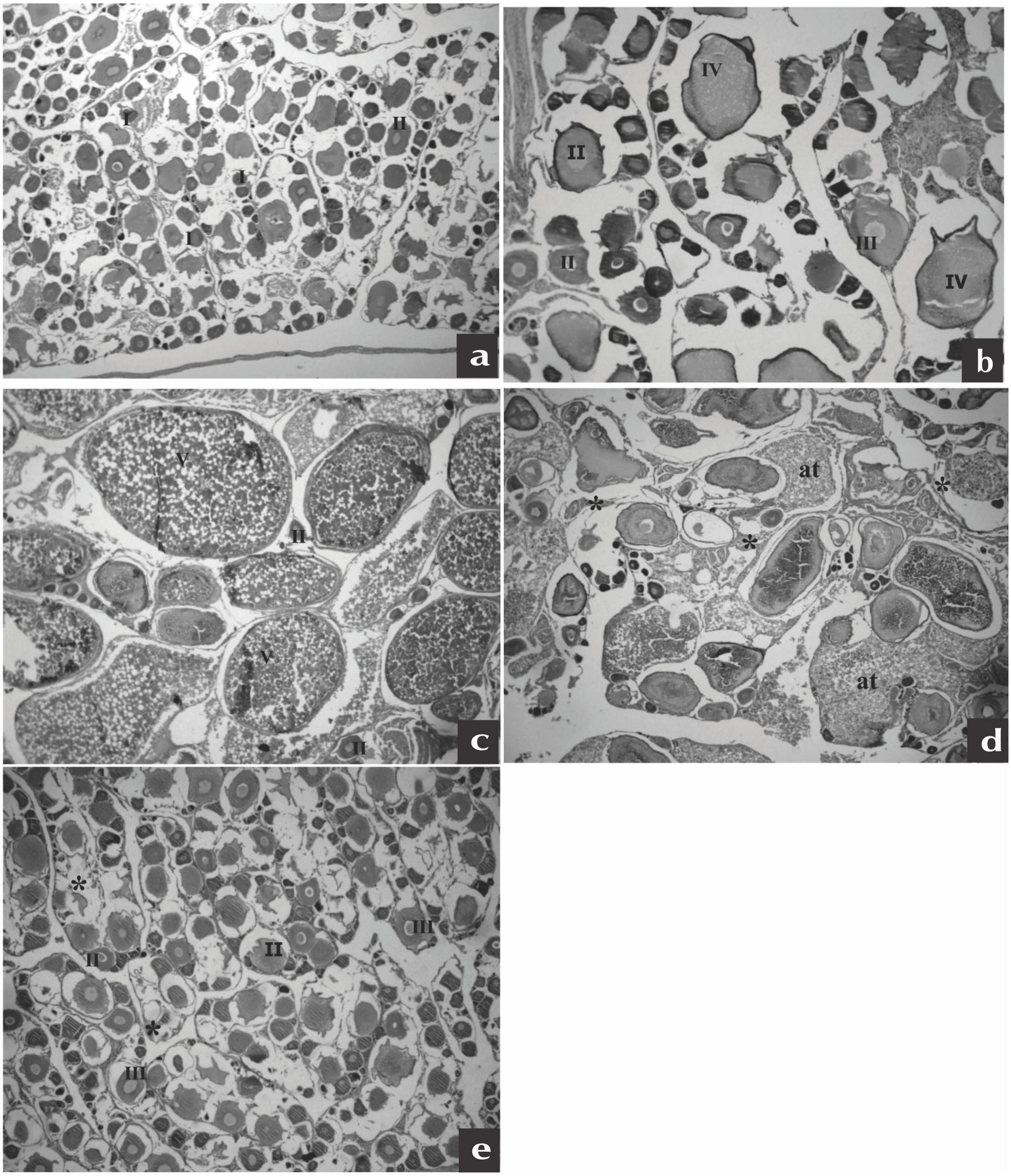


Figure 2 - Photomicrography of the ovary of *C. monoculus* during the gonadal cycle. a) Immature, 50X. b) Maturing, 100X. c) Mature, 50X. d) Spawned, 50X. e) At rest, 50X. Coloring HE. I. Nucleolar chromatin phase (Phase I); II. Perinucleolar phase (Phase II); III. Lipidic vitellogenesis (Phase III); IV. Lipidic and proteic vitellogenesis (Phase IV); V. Complete vitellogenesis (Phase V); Follicular atresia (at); Post-ovulatory follicle (*)

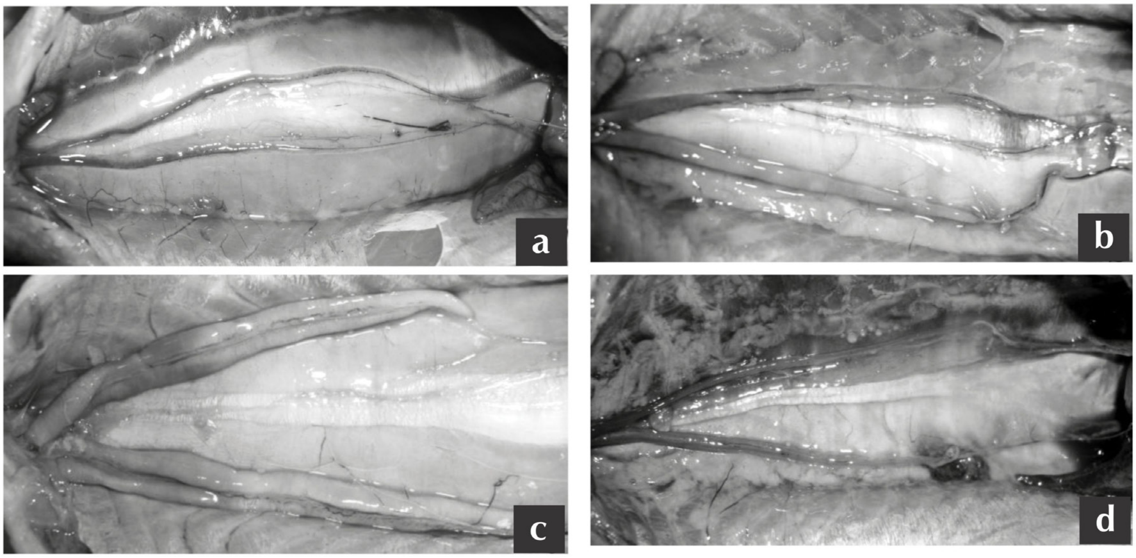


Figure 3 - Photos of the testicles of *C. monoculus* in different phases of development. a) Immature. b) Maturing. c) Mature. d) Spermiated.

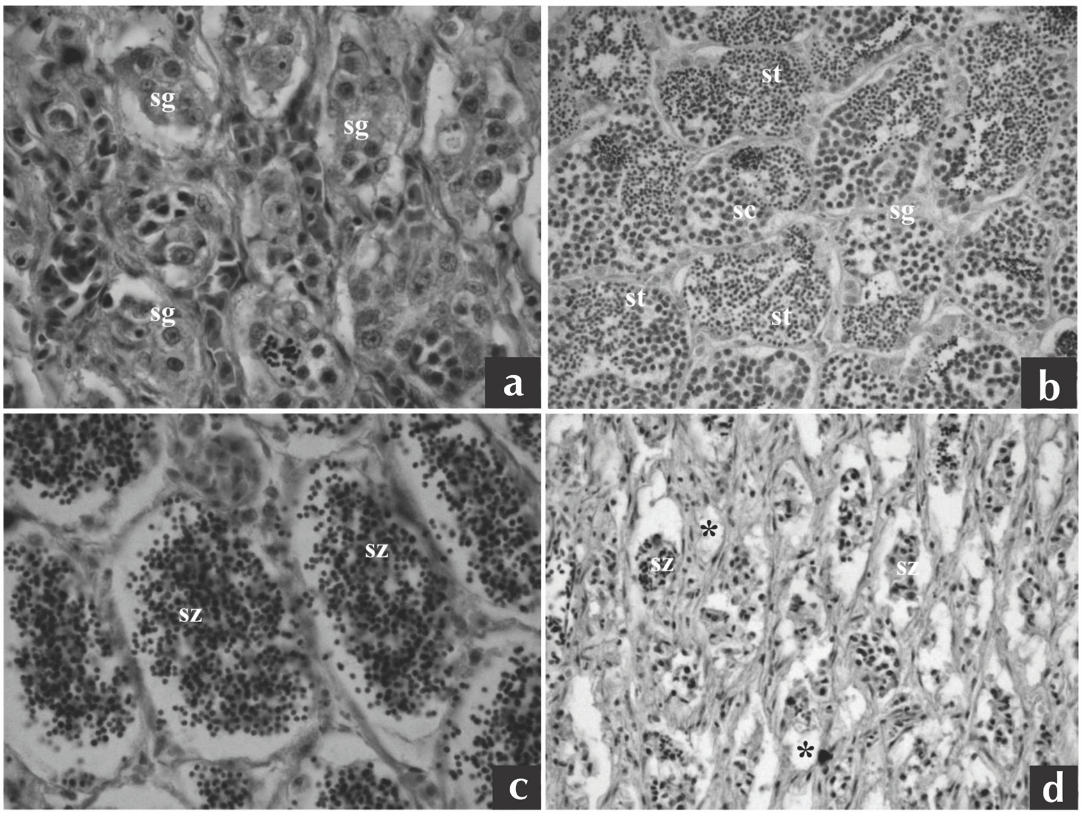


Figure 4 – Testicular micrography of *C. monoculus*. The) Immature, HE, 1000X; b) Maturation, HE, 400X; c) Mature, HE, 1000X. D) Spermiated, HE, 400X. Spermatogonies (sg), spermatocytes (sc), spermatides (st), tubules with spermatozoids (sz), Empty seminiferous tubules (*).

## Biological Indices

The average GSR values accompanied ontogenetic development of the gonads. The highest values were obtained at the mature stage for both sexes (Table 1). That increase was followed by a reduction in the value after spawning in both sexes (spawned and spermiated stages). The average GSR values were greater in females that in males throughout evolution of the stages of development. Through ANOVA, followed by the Tukey-Kramer test, a significant difference was verified for the females between the mature and immature stage ($p<0,001$; Tukey test = 10.34), maturing ($p<0.001$; Tukey test = 16.36), spawned ($p<0.001$; Tukey test = 14.17) and at rest ($p<0,001$; Tukey test = 14.06). In males significant differences were only found between the mature and immature stages ($p<0.001$; Tukey test = 11.93), maturing ($p<0.001$; Tukey test = 11.39) and spermiated ($p<0.001$; Tukey test = 8.12).

Table 1 - Average values of the Gonadosomatic relation (GSR) of the maturation stages of female and male specimens of *Cichla monoculus*. (N is the number of individuals and SE is the standard error).

| Fêmeas | | | | Machos | | | |
|---|---|---|---|---|---|---|---|
| | **N** | **RGS Média (%)** | **EP (%)** | | **N** | **RGS Média (%)** | **EP (%)** |
| Imaturo | 4 | 0,113 | 0,510 | Imaturo | 10 | 0,023 | 0,009 |
| Em Maturação | 21 | 0,359 | 0,238 | Em Maturação | 33 | 0,101 | 0,088 |
| Maduro | 25 | 2,001 | 0,740 | Maduro | 18 | 0,289 | 0,089 |
| Desovada | 14 | 0,397 | 0,231 | Espermiado | 11 | 0,114 | 0,059 |
| Em Repouso | 9 | 0,148 | 0,029 | | | | |

The allometric condition factor was also seen to accompany the development of gonads, with the largest values seen at the mature stage, followed by the spermiated (males) and spawned (females), as presented in Table 2. With ANOVA it was verified that there are no significant differences females ($F=2.936$; $p = 0.026$) and for the males ($F=2.262$; $p = 0.08$).

Table 2 – Average values of the allometric condition factor (K) of the maturation stages of female and male specimens of *Cichla monoculus*. (N is the number of individuals and SE is the standard error).

| Fêmeas | | | | Machos | | | |
|---|---|---|---|---|---|---|---|
| | **N** | **K Média (%)** | **EP (%)** | | **N** | **K Média (%)** | **EP (%)** |
| Imaturo | 4 | $8,29 \times 10^{-6}$ | $0,82 \times 10^{-6}$ | Imaturo | 10 | $6,62 \times 10^{-6}$ | $0,97 \times 10^{-6}$ |
| Em Maturação | 21 | $9,52 \times 10^{-6}$ | $0,85 \times 10^{-6}$ | Em Maturação | 33 | $7,10 \times 10^{-6}$ | $0,69 \times 10^{-6}$ |
| Maduro | 25 | $10,30 \times 10^{-6}$ | $1,51 \times 10^{-6}$ | Maduro | 18 | $7,34 \times 10^{-6}$ | $0,74 \times 10^{-6}$ |
| Desovada | 14 | $9,34 \times 10^{-6}$ | $2,07 \times 10^{-6}$ | Espermiado | 11 | $7,32 \times 10^{-6}$ | $0,54 \times 10^{-6}$ |
| Em Repouso | 9 | $8,92 \times 10^{-6}$ | $0,77 \times 10^{-6}$ | | | | |

The total number of oocytes found in the five mature ovaries varied from 20,720 to 24,700 (Table 3). To estimate absolute fecundity only the vitellogenic oocytes were considered. The absolute fecundity for the species analyzed varied from 7,790 to 10,260 oocytes, with an average of 8,624 oocytes. The fecundity values for the five mature ovaries analyzed are found in Table 6. The diameters of vitellogenic oocytes varied from 1,210 $\mu$m to 3,000 $\mu$m according to the oocytary phase of development in which they were found.

From the analysis of the frequency distribution of the size classes for the oocyte diameters found in the subsamples of the five ovaries analyzed (Figure 5), one may note that *C. monoculus* presents a total-type spawning pattern. The distribution is bimodal, presents a mode of small, non-developed oocytes (diameters of 200 to 600 $\mu$m), which will not be released in the current reproductive season, and a mode of large oocytes that are developed and ready for spawning.

Table 3 – Estimated absolute fecundity for five mature females of *Cichla monoculus*.

| Total Length (cm) | Weight of gonads (g) | Number of oocytes per ovary | Number of vitellogenic oocytes |
|---|---|---|---|
| 49 | 23,709 | 22.580 | 7.790 |
| 39 | 21,534 | 22.960 | 10.260 |
| 39 | 13,902 | 24.700 | 8.450 |
| 43 | 13,746 | 20.860 | 6.560 |
| 47 | 14,144 | 20.720 | 10.060 |

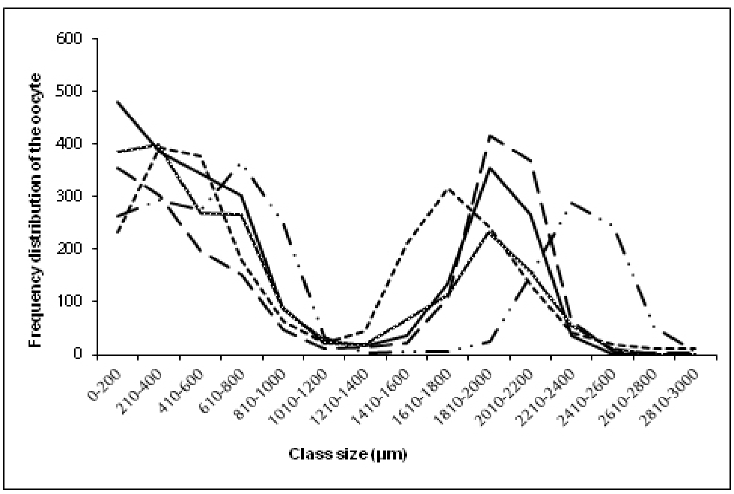


Figure 5 – Frequency distribution of the oocyte diameter of five mature females of *Cichla monoculus*.

The histological structure of the mature ovaries, seen in the slices made and illustrated in Figure 2c, demonstrate a synchronous development of these gametes, without the distinction of groups of vitellogenic oocytes of different sizes. The disposition of the oocytes in these ovaries assumed an organization into two groups, but only one was of oocytes with complete vitellogenesis, which characterizes total spawning fish species. The second group found was made up only of oocytes in the perinucleolar phase.

## DISCUSSION

In the present study the females were larger than males, but the body weight of the males was higher than that of the females. Chellappa et al. (2003) in studying *C. monoculus* in the Campo Grande reservoir, in Rio Grande do Norte, found peacock bass that were smaller and weighed less than those observed in this study. The males presented with 194-338 mm and 96-492 g, while the females presented with 178-332 mm and 52-448 g. In this study the maximum length found was 490 mm, greater than that found for *C. intermedia* (429 mm) and *C. orinocensis* (435 mm) and less than that found for *C. temensis* (720 mm), all studied in their natural habitat (JEPSEN et al., 1999). However, it is important to note that this study relied on animals obtained at the market, and which had undergone a criterion of selectivity by the fishers, who prefer larger and heavier animals which reach higher market values.

The classification obtained for gonadal maturation in *C. monoculus* suggests that there is a regular pattern of development, in which each stage of maturity has defined characteristics. This conclusion coincides with the results found for *C. monoculus*, in Rio Grande do Norte by Câmara et al. (2002). In this study immature females were not found, and the probable reason for that absence is the fact that the specimens analyzed had been obtained at the market, where small-sized individuals are not commonly offered.

The morphological and histological analysis of gonads from *C. monoculus* indicated that the species presents the same general pattern as the majority of teleosts, in which the gonads present homogenous development, as is the pattern for other cichlids such as *Symphysodon discus* (CHELLAPPA et al., 2005). The gonads of *C. monoculus* are morphologically similar to gonads from the same species studied in Rio Grande do Norte (CÂMARA et al., 2002; CHELLAPPA et al., 2003).

It is possible to differentiate the sex of *C. monoculus* macroscopically even when the ovaries are at rest, when there is no presence of oocytes easily visible to the naked eye. The testicles of *C. monoculus* are longer than the ovaries, but are less voluminous. Consequently, the ovaries have a relatively higher weigh and higher GSR. This pattern was different from the one found for the same species in northeastern Brazil, where apparently the testicles were heavier that the ovaries, considering the average values obtained (CHELLAPPA et al., 2003).

In that same study, Chellappa et al. (2003) observed in this same species introduced into Rio Grande do Norte a single pattern of um testicular development, similar to that found in this study. In the species studied here, the process of gonad maturation was followed by the increase in volume and thus of weight, which led to an increase in the GSR value. The highest average values of the GSR were found in the mature state for both sexes. This elevated value was followed by a small reduction after spawning and elimination of spermatozoids, which was reflected in the morphology of the gonad, which reduced its volume and became flaccid. That same pattern of development was observed by Gomiero et al. (2009) for *C. kelberi* in an artificial lake in the municipality of Leme (SP). However, the species studied by those authors achieved higher values for GSR. One example is the mature stage, which reached values higher than 2.3% in females, while *C. monoculus* in this study reached 2.0% in the same stage for the females. Since the average values of the GSR did not show significant differences between all of the stages, we did not consider GSR to be a good indicator of the functional situation of the gonads in the species studied.

With regard to the condition factor, in this study we observed that the values encountered accompanied development of the gonads, as also observed in another study with the same species (CÂMARA et al., 2002). But we verified that there were no significant differences in K between the stages of maturation studied, which disables the condition factor as a good reproductive indicator for *C. monoculus*.

Fecundity is normally intimately linked with the length of the female's body, even though this relation can present some variations (ZARET, 1980). The absolute average fecundity of *C. monoculus* was 8,624 oocytes, which is relatively high when compared with the results for the same species, studied by Câmara et al. (2002) and by Chellappa et al. (2003). In those studies, the absolute average fecundity was 3,100 oocytes per lot. Our average results were also superior to the averages found for *C. kelberi* in the Lobo reservoir (SP), which was 6,072 oocytes (SOUZA et al., 2008), but only slightly larger than average found in the Três Marias reservoir, on the São Francisco river, which had 8,060 oocytes (NORMANDO et al., 2009).

In this study it was found that *C. monoculus* has a synchronous oocytary development in two groups, which, together with the tissue analysis, pointed to evidence of a total spawning pattern, something not very common for the species of *Cichla* studied by other authors. This spawning pattern was only identified by Devick (1972) *apud* Jepsen et al. (1999), for *C. ocellaris* in a Hawaiian reservoir. Jepsen et al. (1999) mention that the spawning type for *Cichla* species depends on the type of environment in which they live. If the species lives in its natural habitat, the energy cost to defend is young is possibly higher, since it has natural predators and competitors. Probably, due to those conditions, they spawn only once a year. In artificial conditions, such as the reservoirs where species of *Cichla* have been introduced, there is agreement among the authors as to the occurrence of more than one spawn per year for the species *C. ocellaris*, *C. monoculus*, *C. kelberi* and *C. piquiti* (MAGALHÃES et al., 1996; CÂMARA et al., 2002; CHELLAPPA et al., 2003; GOMIERO; BRAGA, 2004; GOMIERO et al., 2009; VIEIRA et al., 2009). This strategy of staged spawning is possibly a response to characteristics in locations where they were introduced, and where they have not natural predators or competitors (GOMIERO et al., 2009).

The diameters of vitellogenic oocytes de *C. monoculus* revealed in this study were relatively high, slightly higher than those found for *C. Kelberi* (GOMIERO et al., 2009), *C. ocellaris and*

*C. monoculus* (GOMIERO; BRAGA, 2004). This characteristic guarantees the supply of a large amount of high energy food for the larva (SOUZA et al., 2008). This is apparently a strategy based on total spawning, accompanied by the production of oocytes with large diameters that have a large reserve of vitellus, allowing the development of larger and more developed larvae, which favors the reproductive success of *C. monoculus* in its natural habitat, such as the Middle Solimões region, an environment with a high diversity of fish species, with competitors and natural predators. However, those notable characteristics for reproduction of the species, revealed by the present work, need to be confirmed by studies that do not rely solely on animals obtained at the market, and which analyze the fecundity and the diametric distribution of the oocytes of a greater number of females.

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