Reproduction and growth of Pimelodus clarias maculatus (Lac.1803) Pimelodidae, Pisces, in the Upper Paraná River, Argentina: Reservoir effect.

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ABSTRACT: Reproduction and growth of Pimelodus clarias maculatus (Lac.1803) Pimelodidae, Pisces, in the Upper Paraná River, Argentina: Reservoir effect. The growth and reproductive dynamics of Pimelodus clarias maculatus (Lac. 1803) in the influence area of the Yacyretá Dam, Paraná River (27° 28´S y 56° 44´ W), Argentina were analyzed. Samples were collected from experimental fisheries using gill nets of different mesh sizes, between 1990 and 1999. The data was grouped considering two periods: previous and after the filling of the Reservoir to 76 m over the sea level. In both periods, three different gonadal stages were recognized: pre-vitellogenesis, vitellogenesis and post-spawning. From the morphological point of view there were no changes in the ovocytes. The GSR was higher during the after period. P. clarias maculatus was characterized by an extended reproductive cycle with at least two events in the year and a diminution from the first maturity length. A positive correlation between the gonad somatic and hydrometric level was observed. The value of coefficient b of the length-weight relationship suggested an isometric growth in the first period and allometric negative in the after moment. The values of the condition factor oscillated along the year in a similar way in both periods, with an important increase in spring and a minor one in winter. The length distribution was unimodal. There wasn't any difference between the three samples points, however smaller lengths exemplars were the most frequent in the second period. P. clarias maculatus is a specie that although it is present in the Yacyretá Reservoir, it has modified some aspects of its biology involving the growth and reproductive strategies, that means it has plasticity to adapt to the new conditions.

Key words: Pimelodus clarias maculatus; Reservoir, Growth, Reproduction.

RESUMO: Reprodução e crescimento de Pimelodus clarias maculatus (Lac.1803), Pimelodidae, Pisces, no Alto Paraná, Argentina: Efeito do represamento. A dinâmica reprodutiva e o crescimento de Pimelodus clarias maculatus (Lac. 1803) na área de influência da represa de Yacyretá no río Paraná (27° 28´S y 56° 44´ W), Argentina foram analisados. Os exemplares foram obtidos da pesca experimental realizada com redes de emalhar de diferente abertura de malha durante os anos 1990 a 1999.

Os dados foram agrupados considerando o momento do barramento do braço principal como determinante de dois períodos prévio e posterior ao enchimento do reservatório á cota 76 m snm. Em ambos os momentos, foram reconhecidos três estágios de desenvolvimento gonadal: previtelogênese, vitelogênese e pós-desova. Morfologicamente não foram observadas mudanças nos ovócitos. O RGS foi maior durante o período posterior ao enchimento do reservatório. P. clarias maculatus caracterizou-se por um ciclo reprodutivo longo com desova parcelada, ocorrendo no mínimo dois eventos no ano e uma diminuição do comprimento da primeira maturação. Achou-se uma correlação positiva emtre RGS e o nível hidrométrico. O valor do coeficiente b da relação comprimento-peso mostrou um crescimento isométrico no primeiro período e alométrico negativo no segundo. Os valores do fator de condição oscilaram ao longo do ano de maneira similar em ambos os períodos, com um acréscimo considerável na primavera e outro menor no inverno.

A distribuição por comprimento foi unimodal; não foram observadas diferenças emtre os três pontos amostrados, no entanto os exemplares de comprimentos menores foram os mais freqüêntes durante o segundo período. Pode-se concluir que P. clarias maculatus é uma espécie que si bem está presente no reservatório, modificou alguns aspectos da sua biologia envolvendo o crescimento e a estratégia reprodutiva, o que significa que possui plasticidade para adaptase a novas condições.
Palavras chave: Pimelodus clarias maculatus, Reservatório, Reprodução, Crescimento

Introduction

The building of dams alters the natural ecosystem; however, it's an activity that has been done since the beginning of time (Agostinho, 1994) with different aims since the beginning of time.

The Paraná basin, the second largest in South America, has suffered the reduction of its lotic sector by the hydroelectric impoundments that have been carried out not only in the Argentinean territory but in the Brazilian one as well. In Argentina, in the upper Paraná River the reservoir of Yacyretá Dam with its 1140 km² surface gives account of this situation.

The effects of these constructions over the ichthyofauna have been the object of study in reservoirs such as Itaipú, Volta Grande and Segredo (Paiva, 1983; Agostinho, 1992; Agostinho et al., 1994; Cecilio et al., 1997; Braga, 2000) where it has been observed the disappearance of large migratory fish species and the replacing of them for secondary species of low commercial value (Petrere et al., 2002).

Pimelodus clarias maculatus wich is a species of wide geographical distributions (Mac Donagh, 1934; Bonetto et al., 1965; 1969; 1970; 1978; Ubeda et al., 1981; Ringuelet, et al., 1967); of economy importance and frequent capture (Oldani & Oliveros, 1984; Del Barco & Panattieri, 1986; Roa & Permingeat, 1999) and adapted to captivity conditions (Parma de Croux, 1996; Sato et al., 1999).

Studies about age, growth, feeding and reproduction of this species were approached by Bonetto et al. (1963); Cordiviola & Pignalberi (1967); Pignalberi (1968); Baiz et al. (1968); Nomura et al. (1972); Godinho et al. (1974); Fenerich et al. (1975); Basile-Martins et al. (1975); Veitenheimer & Dreher Mansur (1975); Pignalberi & Cordiviola de Yuan (1976); Alonso, (1978); Lolis & Andrian, (1996); Agostinho & Ferreira Julio Jr. (1999); Montalto et al. (1999); Braga, (2000); Roa et al. (2002) and Araya et al. (2003). In Reservoirs, it is reproduced in river areas or its big tributaries (Agostinho et al., 2003).

The changes imposed on the environment by the building dam lead to the alteration in biological cycles of fish, the possibility of persistence will depend on the species capacity to adapt to and explore the new habitat.

With the aim of evaluating the reproductive behaviour and the growth of P. clarias maculatus in the Yacyretá Reservoir in the different phases, before and after to the filling of the reservoirs to 76m above the sea level, the time of gonadal maturity was analyzed, gonad somatic relationship, first maturity length, length-weight relationships, length frequencies distribution and condition factor.

Material and methods

The studies were done in a limited area from the Yacyretá Reservoir, from Ituzaingó, Corrientes to the city of Posadas in Misiones, between kilometres 1510 and 1625 of the Paraná River. This stretch of the High Paraná River, according to Bonetto et al. (1986) is known to be flat and winding forming a floodplain in the area where the dam is situated (27° 28´S and 56° 44´ W).

The samples used come from experimental fishing carried out under the agreement between the Yacyretá Power Dam and the Regional Project on Fish Biology (CIDET- Faculty of Sciences, National University of Misiones, Argentina). These were analyzed considering two periods previous and subsequent to the filling of the reservoir. The first took place between April 1990 and December 1994 and the second one from January 1995 to November 1999.

The sampling were done monthly and the points were located along the reservoir longitudinal gradient (Thornton et al. 1990), they were: 1) the Yabebiry Stream outlet, an affluent of the Paraná River at km 1.625, (55° 35´ W, 27° 18´ S) with fluvial characteristic; 2) A points nearly Puerto Nemesio Parma (Prefectura Naval Argentina), at km 1.570 of the river (56° 00´ W, 27° 20´ S) with transitional characteristic and 3) Puerto Valle, at km 1.510 (56° 25´ W, 27° 36´ S) of lacustral characteristics (Fig.1).

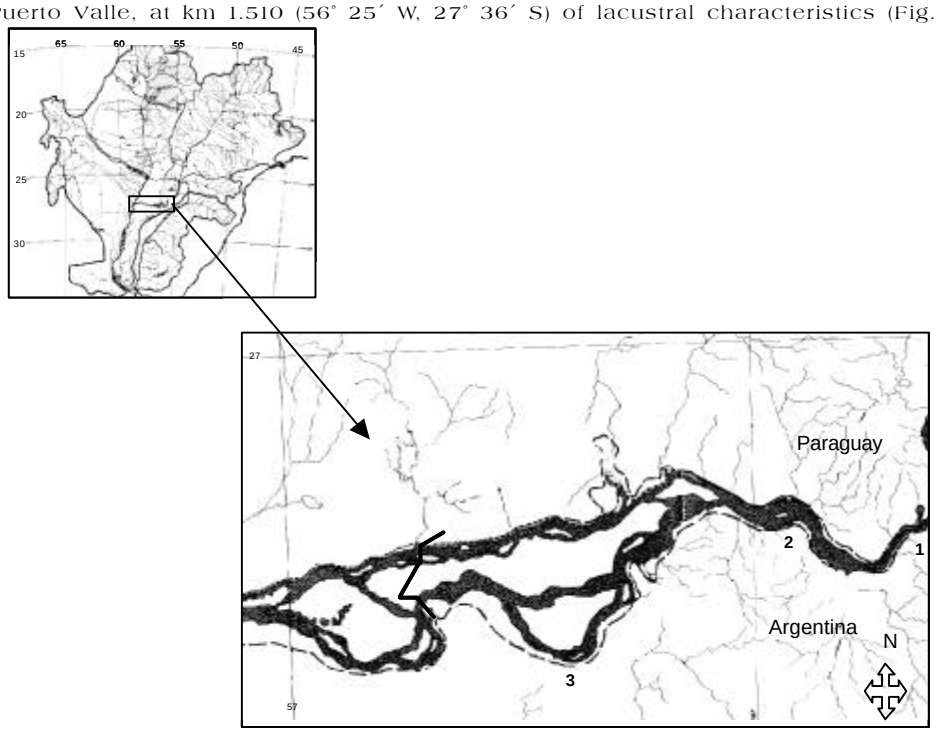

Figure 1: Study area. 1. Yabebiry Stream, 2. Nemesio Parma; 3. Puerto Valle

Fishes were captured by gillnets with mesh 40, 50, 60, 70, 80, 120, 140 y 160 mm between non adjacent knots, set out for 48 hours at each sampling station. In each one of the stations environmental parameters like surface water temperature with manual thermometer and transparency with Secchi disk were recorded. The daily records of hydrometric level were provided by Prefectura Naval from Argentina.

Standard length (SL) in mm, total weight (TW) and gonadal weight (GW) in grams were measured for each specimen caught. The sex was determined according to macroscopic characteristics and the ovaries were removed and kept in formol at 10% for its later analysis in the laboratory.

The degree of gonadal maturity was determined through the analysis of histological cuts done following the conventional technique of paraffin inclusion and haematoxylin and eosin staining The largest and the smallest diameter of 100 eggs from each sample were measured with the purpose of spotting possible morphological changes.

The mean monthly gonad somatic relationship (GSR) was calculated and for each stage of gonadal development according to the following formula: GSR =(gonadal

weight x 100)/ total weight. Correlations between environmental factors (hydrometric level, transparency and temperature) and gonad somatic relationship (GSR) were established.

For each period of study, the average size at first sexual maturity of female was obtained, grouping the immature young individuals and the mature and spawning ones separated in standard length class.

As in any stage of a fish's life its weight varies directly according to its length (Ricker, 1975), in agreement to the expression: $TW = a * SL^b$, the relationship between length and weight was calculated, where TW, total weight (g), SL, standard length (mm) a and b regression constant. The constants a and b were calculated by functional regression (Ricker, 1975.), prior logarithmic transformation: $lnTW = lna + b * lnSL$. The difference between calculated value b and hoped the 3 was determined through test t of Student.

To estimate the physiological condition of the captured samples the allometric condition factor (Ricker, 1975) was used: $K = TW/SL^b$ where: TW, total weight in g, SL, standard length in mm, b being the angular coefficient of the ratio TW/SL In order to confirm the existence of significatives differences for the condition factor between two periods of study ANOVA one-way was used.

The structure length was analysed grouping the data obtained according to standard length class (i = 20 mm), sex, sampling point and study period.

Results

Microscopic and macroscopic examination of ovaries of P. clarias maculatus showed similar anatomic and morphological characteristics in both periods of study. In immature stage they were stripped, very thin and of a pink colour nearly transparent. When the vitellogenesis starts the relevant features are the growth of size, change of colour and the presence of conspicuous eggs.

The previtellogenesis, vitellogenesis and post-spawning gonadal stages were recognized in both periods of study. The oogonies, ovocytes I and II present in the stage of previtellogenesis didn't show any differences in morphology and size. The oocytes sizes distribution was unimodal and oocytes until 359 mm of diameter was registered, with an average of 189 mm and 54.6 of standard deviation.The gonad somatic relationships medium for this stage was 0.32 in the first period and 1.23 in the second, the standard deviation was 1.28 and 1.20 respectively (Fig. 2).

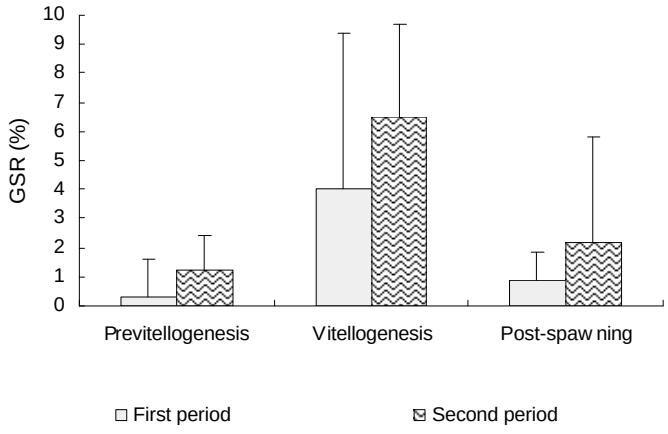

Figure 2: Mean (+SD) gonad somatic relationship of Pimelodus clarias maculatus for gonadal development stage and study period.

The incipient vitellogenesis and developed stages propose by Araya et al. (2003) were registered in both periods and its cells did not show morphological differences.

The ovocitary diameters distribution showed the cells presence that sized between 90 and 1260 micrometers, being the cells vitellogenesis the ones to overcome 360 micrometers.The medium gonad somatic relationships for this stage was 4.04 for the first period and 6.46 for the second, and the standard deviation was 5.32 and 3.21 respectively (Fig. 2).

The post-spawning stage to propose by Araya et al. (2003), was registered in both periods.The medium gonad somatic relationships for this stage in the first period was 0.84 and 2.19 in the second, and the standard deviation was 1.03 and 3.6 respectively (Fig. 2).

Environmental parameters and gonad somatic relation

The correlation of the mean monthly GSR with the temperature was negative in the first period of study and it was positive in the second period. While in both periods it was positive with the hydrometric level and the results were negative with the transparency (Tab. I).

Table I: Pearson correlation coefficient values (r) between environmental factors and mean monthly gonad somatic relationship of Pimelodus clarias maculatus.

	r first period	r second period
Temperature	-0.26	0.15
Hydrometric level	0.50	0.56
Transparency	0.36	0.56

In the period before the impounding one moment of maximum gonadal activity was detected, coincident with high values of hydrometric levels. In the period after to the filling of the reservoir, the behaviour of the hydrometric level showed three point of rising, which would be the factor that the three gonadal development moments was produced.

There was no difference in the beginning of the reproductive time; however the mean monthly GSR was higher in the second period. In both periods the lowest values were registered between April and June, starting to grow since August to reach the maximum register in October. The GSR average in the first period was 4.15 (6.1 SD) and 7.23 in the second period (2.91 SD) associated to flood pulses and low value of transparency (Fig. 3 and 4).

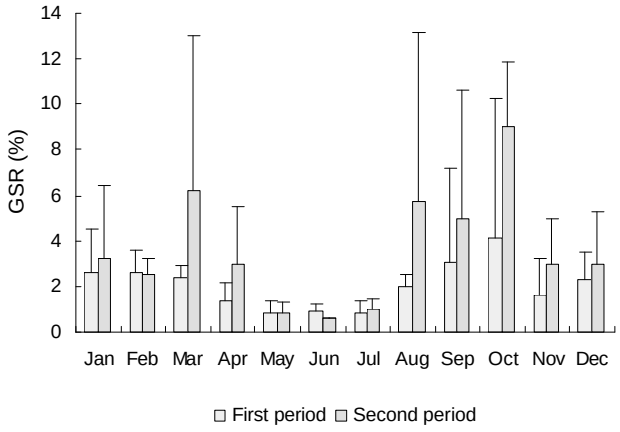

Figure 3: Variations mean monthly gonad somatic relationship for Pimelodus clarias maculatus.

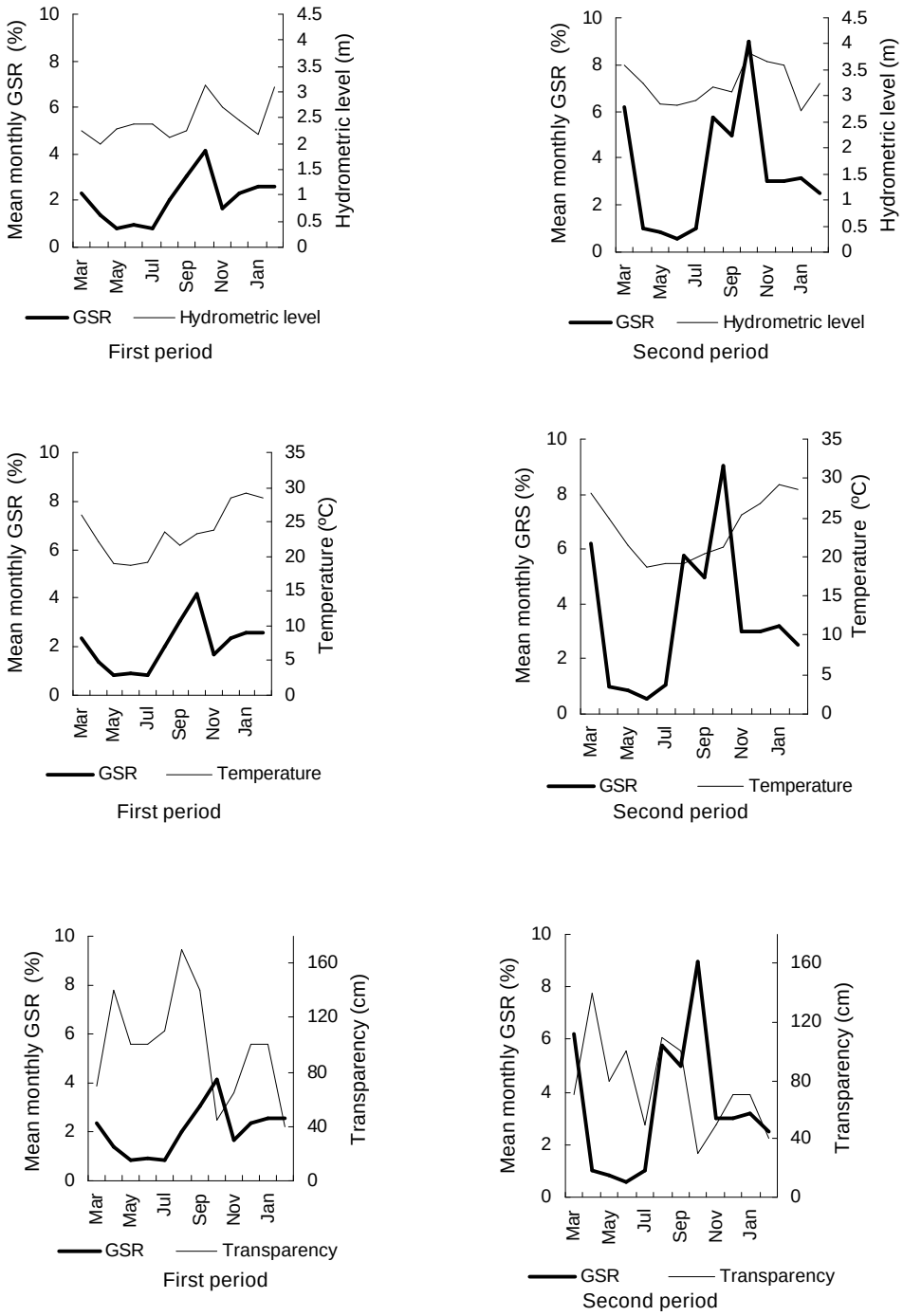

Figure 4: Environmental factors and mean monthly gonad somatic relationship for Pimelodus clarias maculatus.

First Maturity

In the period before impounding, the decreasing of L_{50} of P. clarias maculatus was observed, verifying the fact that species can reach sexual maturity in different length according to the environmental conditions.

In both periods the highest percentage of female maturity was between 140 and 179 mm standard length. In the first period 50% of female reached first maturity with 190 mm length but in the second period the length was 150 mm.

Length-weight relationships

The relationships between SL and TW were:

$TW = 3x10^{-5} * SL^{2,94}$ r= 0.96, n = 200 first period study

$TW = 2X10^{-4} * SL^{2,61}$ r = 0.86, n = 377 second period study.

In the first period of studies there were not significante differences between b values calculate and the expecting 3 ($t_{0.05;\ n-2}$=0.398), but in the second period it was significantly lower than 3 ($t_{0.05;\ n-2}$=-7.09). These results show that P. clarias maculatus had an isometric growth before the dam formation and it had a negative allometric growth after the dam formation, which mean that fish have lowets weigth with the same length.

Condition factor

Braga (1986, 1997) proposes the numerical value of constant a the relationships between length and weigh like condition factor K. In this study, this method once present individuals low number in some months of sampling was given could not be utilized. For that the allometric condition factor was used.

K mean values grouped by sex and period of studies are presented in Tab. II.

Table II: Condition factor (K) of Pimelodus clarias maculatus for sex and study period. SD: standard deviation, n: number of individuals analyzed.

First period (1990-1994)						
Month	**K males**	**SD**	**n**	**K females**	**SD**	**n**
1	0.0244	0.002	3	0.0275	0.002	4
2	0.0244	0.002	4	0.0300	0.003	3
3	0.0256	0.002	8	0.0237	0.003	4
4	0.0251	0.003	5	0.0239	-	1
5	-	-	-	-	-	-
6	0.0260	0.003	2	0.0269	0.002	6
7	0.0269	0.003	10	0.0271	0.003	23
8	0.0245	0.006	15	0.0256	0.002	3
9	0.0323	0.003	11	0.0303	0.004	12
10	0.0289	0.002	10	0.0291	0.006	12
11	0.0293	0.006	16	0.0275	0.004	21
12	0.0263	0.001	4	0.0258	0.005	5
Second period (1995-1999)						
Month	**K males**	**SD**	**n**	**K females**	**SD**	**n**
1	0.1589	0.020	28	0.1560	0.018	23
2	0.1507	0.017	25	0.16	0.026	19
3	0.1603	0.022	14	0.1603	0.020	8
4	0.1521	0.009	4	0.1554	0.020	3
5	0.1427	0.014	3	-	-	-
6	0.1448	0.009	3	0.1616	0.015	7
7	0.1563	0.014	7	0.1341	0.037	5
8	0.1679	0.019	41	0.1705	0.027	30
9	0.1718	0.022	31	0.1783	0.028	17
10	0.1845	0.020	31	0.2015	0.031	26
11	0.1708	0.035	13	0.1804	0.022	9
12	0.1594	0.020	7	0.1672	0.015	12

It was observed that condition factor values changed in a similar way during the year in both periods with a considerable increase in spring and smaller increase in winter.

An important difference in the condition factor between both periods was registered by testing of variance (ANOVA) ($F = 2.32$; $p < 0.05$, d.f.= 182), indicating one better condition in the second period.

During both periods K increases were accompanied with GSR value increase (Fig 5). However in the second period of studies it was observed that the index value was kept in high position for a longer time (August, September, October, November and December).

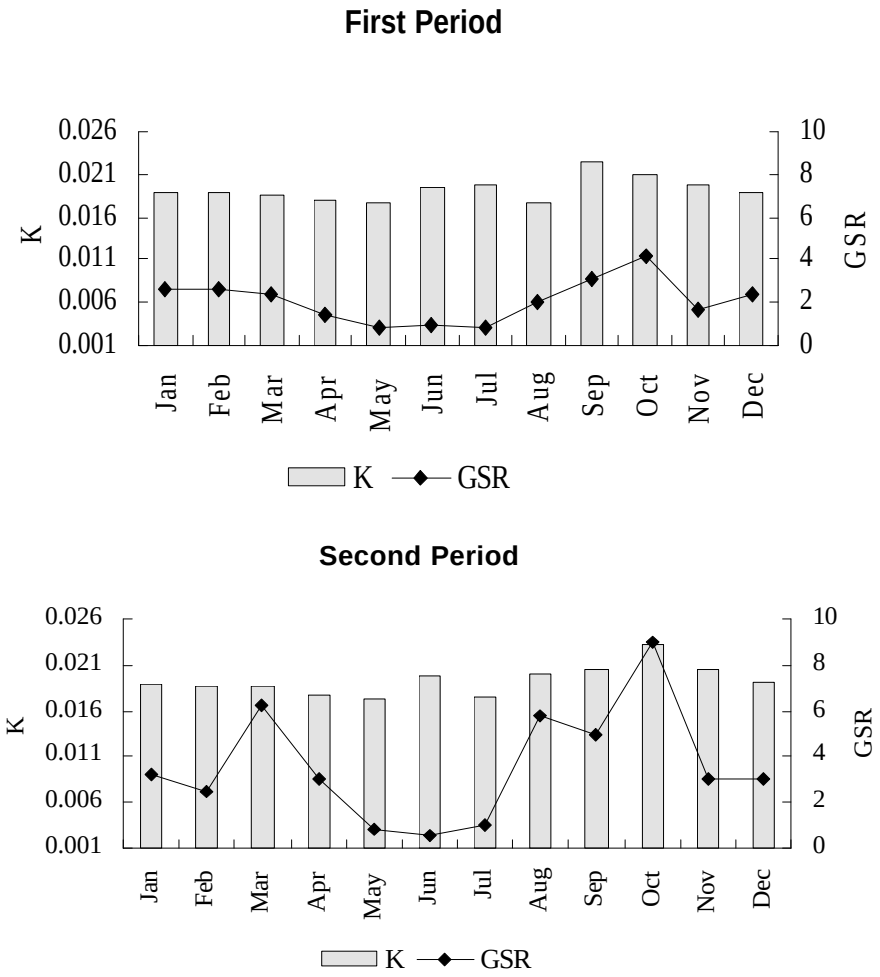

Figure 5: Mean Gonad somatic relationship (GSR) by condition factor (K) and study period.

Length Structure

Standard length of female samples of yellow catfish was 243 mm changing between 112 and 389 mm and for the male samples the average was 232 mm with a minimum of 107 and a maximum of 312 mm.

Frequency distribution by standard length class (Fig.6) is relatively similar in three sample points.

Length structure (Fig. 7) shows a unimodal distribution in both periods, with a mode displacement fully to the smallest length in the second period of study (220mm).

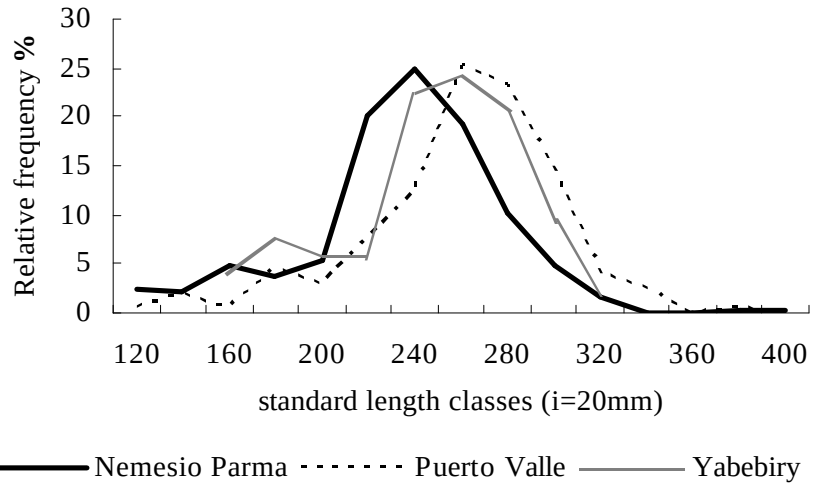

Figure 6: Relative frequency by standard length class and sample points.

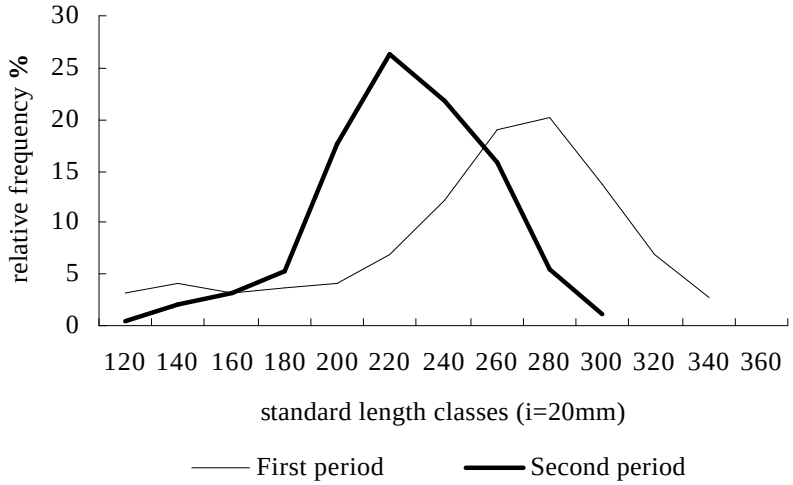

Figure 7: Relative frequency by standard length class and study period.

Discussion

From reproductive strategies point of view, P. clarias maculatus belongs to the external fecundation group, with no migration and without parental care (Miyamoto, 1990; Vazzoler & Menezes, 1992). Agostinho et al. (2003) talk about it as migrating of medium size and Araya et al. (2003) characterize it with a modality of partial spawnings.

According to Dias (1989) time and habitat of spawning are the most flexible reproductive strategies. In this way histological analysis of the gonads and ovocitary diameter distribution give information about reproductive time and spawning modality in a specie and results show that P. clarias maculatus has presented partial spawnings in both period of studies, showing lengthening of time in the reproductive period with at least two reproductive moments, a more important one in the August – December and the other less important in February and April. These observations agree with the ones made for the same specie by Godinho et al. (1974).

Gonads stages of previtellogenesis, vitellogenesis and post spawning were recognized in both periods of study, histological differences were not observed,

being 1260 micrometers the biggest diameter reached by vittellus cells. This value is similar to the one indicated by Vazzoler (1996) in High Paraná River in Brazil.

GSR is a good indicator of functional state of ovaries (Wooton, 1990), which in the final ovocitary development phase goes through a remarkable increase caused by the growth of volume and weight of gonads. GSR was higher after the dam filling, higher values to the ones found by Vazzoler (1996), while the values from the first periods are similar to the ones found by Silva et al. (1999) for de Miranda Dam in Minas Gerais, Brazil.

The length reached by the fish in their first gonad period is a labile reproductive tactic, which is the result of interaction between genotype and the environment. Researches like Nikolski (1969) and Cushing (1981 apud Vazzoler et al. 1997) affirm that size is more than age determines that the gonads maturity begins. Authors like Stearns & Crandall (1984) admit that fish reach maturity at a certain age and length depending on demographic conditions.

In general first maturity is connected with a minimum length. This length depends on the somatic growth that is why plasticity in sample growth can be an adaptation response to environmental changes (Weatherley & Gill, 1987; Meien, 1939 apud Wootton, 1990).

Results of the first maturity analysis show a decrease of L_{50} of P. clarias maculatus in the period after the closing of the main branch. For the same specie, other authors have found that in Jaguarí and Piracicaba River female first maturity was reached in 180 mm total lengths (Fenerich et al. 1975). Vazzoler et al. (1997) informs that in the flood plain of High Paraná River first maturity is reached in 123 mm of total lengths, while according to Braga (2000) it can be reached in 278 mm of total length in Volta Grande Dam.

There is not so much information about the influence of environmental causes in the reproductive season of tropical fish from freshwater and about their effect on reproductive processes Vazzoler et al. (1997). According to Munro, (1990) there is some evidence which show that temperature can be one of the causes that indicate appropiate conditions for the spawning. The positive correlation found between GSR and hydrometric level let us suppose that in both periods of studies variation of hydrometric level would be one of the abiotic causes that influence in gonad maturity, as it is considered by Basile-Martins et al. (1975), a stimulus for the spawning of this specie.

Parameters of length-weight relationship vary between years and seasons. There are many responsible causes for these differences such as temperature, food, sex and gonad maturity (Dulcic & Kraljeviic, 1996). Values of angular coefficient b of P. clarias maculatus for the Yacyretá Dam indicate an isometric growth in the period before the lake formation and it was negative allometric after filling up. An otherwise situation was registered in Volta Grande Dam, where growth was allometric positive for the same specie (Braga, 2000). On the other hand; it was the same fact for Yacyretá Dam downstream (Bechara et al., 1999).

Variation of K estimate can be explained due to changes in the biological characteristic enviromental adaption, fecundity, reproduction and growth rate (Anderson & Neuman, 1996). Moyle & Cech (1988) explained that when values are high there is a probability of abundant food that can produce somatic growth as much as the gonad growth. Doria et al. (1997) analyces the condition cause of P. clarias maculatus finding that energetic consumption of gonad maturity does not influence in somatic growth, while Bennemann et al. (1996) informs that Tibagy River the specie did not present food variation neither fat storing that can be connected with reproduction. Values obtained in this research for the same specie are smaller than the ones informed by Braga (2000) for this razon it shows that food available only lasted for the gonad growth.

This fact is guaranteed by allometric negative growth, fish with the same length for the same weight and higher values of GSR registered during the second period of study.

In Yacyretá Dam the effect produced by blockade of fish migration to upper water, is trying to be mitigated with a construction that will let fish pass. In researches done in these systems P. clarias maculatus predominated in biomass and in number of elevator transfer population (Roncati et al., 2002), fact that in association with strategies like small ovocites, without progeny care, spawning in lots in a long period of time and diminution of size in first maturity can take the specie to a successful colonization in that environment as it was observed in Corumbá Dam by Agostinho et al. (1999).

Length frequency distribution shows the interaction in reproductive rate, recruiting, growth and mortality of eateries group present.

This distribution and changes in time can help to understand population dynamics, low growth or a lot of mortality too (Anderson & Neumann, 1996). Medium sizes registered in this research are similar to the ones reported in Itaipú Dam (FUEM-NUPELIA -Itaipu, Binacional, 1987) however; P. clarias maculatus specimens are bigger in Volta Grande Dam (Braga, 2000).

Researches about fish population structure in dams (Bini & Agostinho, in press; Benedito & Agostinho, 1997) show that specie is segregated by size occupying the different environments. In Yacyretá Dam as in Corumbá Dam (Bini & Agostinho, in press.) the yellow catfish presented average standard length distribution quite similar in the three samples points.

Comparing the size distribution frequency between the two phases (before and after the dam filling) it was proved that in the last one the specimens registered are smaller fish than in the first period.

Size distribution was unimodal; it was not observed difference in the three samples point, however smaller fish were more frequent in the second period of study.

In conclusion, P. clarias maculatus, in spite of having modified some aspects of growth and reproductive strategy, showing that it has plasticity to adapt to new conditions, it is present in Yacyretá Dam, as it is in others like Volta Grande and Itutinga (De-Souza-Braga & Gomiero, 1997; Alves et al. 1998) representing a high percentage in experimental and commercial capture.

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