ECOLOGY OF *PIMELODUS MACULATUS* (SILURIFORMES) IN THE CORUMBÁ RESERVOIR, BRAZIL

by

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ABSTRACT. - The distribution, abundance and reproduction of the "mandi", *Pimelodus maculatus*, were studied in different environments of the Corumbá Reservoir and its main tributaries in Goiás State, Brazil. Samplings were carried out monthly from March 1998 to February 1999, using gillnets and longlines. The species was widely distributed, being caught at every sampling site. In gillnet samples, *P. maculatus* had high frequency at the Jacuba Reservoir site and high biomass at the site downstream from the dam. Juveniles had high frequency in every environment. Average size at first maturation was 15.6 cm standard length for males and 17.8 cm for females. All individuals were adults at 18.0 and 22.0 cm for males and females, respectively. The reproduction period (November to January) was related to the slightly acid pH, long photoperiod and high temperature and concentration of dissolved oxygen. Reproduction was documented in running water, downstream from the dam, upstream from the reservoir and in the Peixe River, the latter suggesting short migrations to reproduce.

RÉSUMÉ. - Écologie de *Pimelodus maculatus* (Siluriformes) dans le réservoir de Corumbá, Brésil.

La distribution, l'abondance et la reproduction du "mandi", *Pimelodus maculatus*, ont été étudiées dans différents biotopes du réservoir de Corumbá et dans ses principaux affluents dans l'État de Goiás, Brésil. Les échantillonnages ont été réalisés mensuellement, de mars 1998 à février 1999, en utilisant des filets maillants et des palangres. L'espèce présente une large distribution et a été capturée dans toutes les stations d'échantillonnage. Dans les pêches au filet maillant, un grand nombre d'individus a été récolté à la station Jacuba du réservoir et cette espèce a représenté la plus grande biomasse à la station en aval du réservoir de Corumbá. La première maturité sexuelle est atteinte à la longueur standard de 15,6 cm pour les mâles et de 17,8 cm pour les femelles. La totalité des individus était adulte à 18,0 et 22,0 cm, respectivement pour les mâles et les femelles. La population était composée d'une forte proportion de jeunes individus dans tous les sites. La période de reproduction, de novembre à janvier, est liée à un pH légèrement acide, à de longues photopériodes, à de hautes températures et à de hautes concentrations d'oxygène dissous. La reproduction a été observée dans les stations d'eau courante en aval et en amont du réservoir, au-delà de la rivière du Peixe, ce qui indique que les individus réalisent des migrations de faible amplitude afin de se reproduire.

Key words. - Siluriformes - Pimelodidae - *Pimelodus maculatus* - Brazil - Corumbá Reservoir - Reproduction.

Management of exploited fishes requires knowledge of the structure and dynamics of the communities and interspecific relationships. Evaluation of their stocks and autoecology studies are also necessary. The pimelodid *Pimelodus maculatus* Lacepède, 1803 is an important commercial fish species with a wide geographic distribution, comprising the main South American basins (Fowler, 1951; Ringuelet *et al.*, 1967; Britski *et al.*, 1988). In the Upper Paraná River basin *P. maculatus* is one of the four main species caught commercially (CESP, 1994; Agostinho, 1995). Studies have examined its ecology, distribution (Ubeda *et al.*, 1981; Basile-Martins *et al.*, 1986; Barbosa *et al.*, 1988) and reproductive biology (Godinho *et al.*, 1974a; Godinho *et al.*, 1974b; Basile-Martins *et al.*, 1975; Godinho *et al.*, 1977; Sato *et al.*, 1999).

Fishing activity is being implemented in the Corumbá Reservoir, with *P. maculatus* having greatest potential for exploitation. Information about the distribution, abundance and bionomics of the species is essential for management. Thus, this paper aims at answering some fundamental questions: (1) What are the spatial-temporal patterns of distribution and abundance ? (2) How is the population structured in relation to size at first maturation and spatial-temporal frequency of juveniles and adults ? (3) Where and when does the species reproduce? (4) What influence do abiotic factors have on population characteristics ?

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DESCRIPTION OF THE AREA

The Corumbá River Basin is 34,000 km^2 and the river, which flows into the Paranaíba River, is about 500 km in length. The Paranaíba River, together with the Grande River, form the Paraná River (Paiva, 1982). Created in September 1996, the Corumbá Reservoir is located in the upper third of the Corumbá River. The reservoir encompasses an area of 65 km^2 with an average depth of 23 m. Average hydraulic retention time is 30 days (De Felippo and Soares, 1996).

Sampling was carried out at 12 sites in the Corumbá River Basin. Four sites were located in the Corumbá River - three upstream from the reservoir (Peixe - COPE, Porto das Moitas - MOIT and Areia - AREI) and one downstream from the dam (JUSA). Four were located in the reservoir - (Pedra Lisa - LISA, Jacuba - JACU, Corumbá Pirapitinga - CPIR and Ponte - PONT). Four sites were located in tributaries - two in the Pirapitinga River (PIRA and SAPE) and two in the Peixe River (PFOZ and LINI) (Fig. 1). Sampling site descriptions appear in table I.

MATERIALS AND METHODS

Fishing was carried out monthly from March 1998 to February 1999 using three arrays of gillnets and one longline. Three arrays with 15 different mesh sizes, varying from 2.4 to 16.0 cm stretched, were installed near the banks and in open surface and bottom regions of the reservoir. Longlines with 50 hooks were set at the Corumbá River and Reservoir sites, and those with 20 hooks in the tributaries. The hooks were baited with live fish (*Gymnotus carapo*) and positioned near the bottom. All the fishing equipment was set for 24 hours, with examinations in the morning (8:00 to 9:00), in the afternoon (16:00 to 17:30) and at night (22:00 to 23:50).

The date, sampling site, fishing equipment, catch period, fish standard length (cm), total weight (g), gonadal weight (g), sex and stage of gonadal development were recorded for each individual. The gonadal maturation scale described by Godinho *et al.* (1974a) (young, resting, maturing, mature and spent) was used for this species.

The physical and chemical water variables, measured at the moment of fishing equipment installation and fish removal, were water temperature (°C), Secchi depth (m), pH, conductivity (µS/cm) and dissolved oxygen (mg/l).

Catch per unit of effort (CPUE) was used to express the monthly distribution and abundance for each site. CPUE was estimated in number and weight of individuals per 1,000 square meters of net in 24 hours and 100 hooks exposed for 24 hours on each longline. CPUE in number of individuals and weight was correlated with the environmental factors summarized in the axis of a PCA (Principal Components Analysis), in order to evaluate how environmental factors are related to *P. maculatus* abundance. In the PCA, only the axes with eigenvalues greater than 1.0 were retained for interpretation (criterion of Kaiser-Guttman; Jackson, 1993). The program PC-ORD 2.0 (McCune and Mefford, 1995) was used to perform the PCA and Statistic™ was used in the correlation analyses between the PCA axis retained for interpretation and the abundance (CPUE) in number and weight for gillnets and longlines.

In order to analyze the monthly abundance patterns, the sampling sites were grouped into downstream (JUSA), reservoir (LISA, JACU, CPIR and PONT), upstream (COPE, MOIT and AREI) and tributaries - Pirapitinga (PIRA and SAPE) and Peixe (PFOZ and LINI).

The average size at first maturation and the size at which

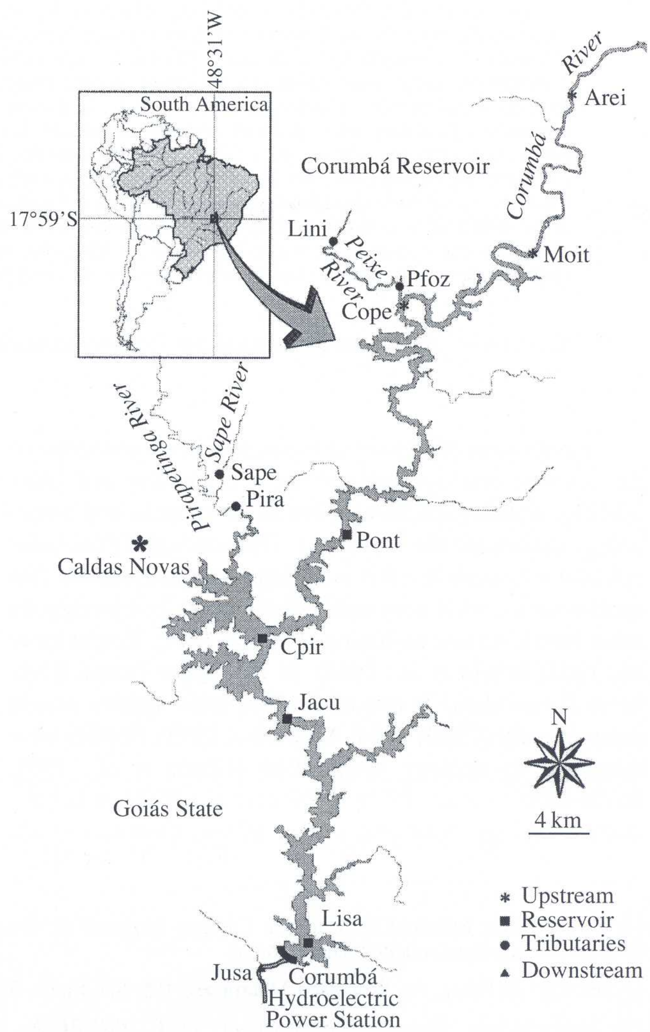

Figure 1. - Location of the sampling sites in the area of influence of the Corumbá Reservoir.

Table I. - Morphometric and physiographic characteristics of the sampling sites.

Sites	Code	Width (m)	Depth (m)	Characteristics	
				Bottom	Banks
Corumbá River/Reservoir					
Downstream	JUSA	110	9	Rocky with deposits of gravel and sand	Steep; arboreal and shrubby (high density of palms intermingled with pastures)
Pedra Lisa	LISA		90	Clayey-sandy; predominance of organic detritus and some small stones	Scrub intermingled with pastures
Jacuba	JACU			Heterogeneous, with a predominance of rocks, fine pebbles and a small quantity of clay	Scrub intermingled with pastures
Corumbá Pirapitinga	CPIR	940	30	Predominance of clay and a few pebbles	Scrub intermingled with pastures
Ponte	PONT	430	37	Sandy-clayey with large quantities of detritus	Scrub intermingled with pastures
Corumbá Peixe	COPE	110		Rocky	Narrow strip (10 m) with large trees, shrubs and creepers
Porto das Moitas	MOIT	120	6	Flagstone and accumulations of gravel and sand	Clean and dirty pastures with some trees, a lot of shrubs and mainly grasses
Areia	AREI	90	9	Rocky with deposition of sandy material and fine gravel	Heterogeneous vegetation; some sectors with large trees and others with shrubs and grasses
Pirapitinga River					
Ponte	PIRA	35	5	Rocky with deposits of coarse sand and fine gravel	Riparian vegetation surrounded by a large scrub area and cattle
Sapé River (tributary)	SAPE	13	1.5	Rocky with deposits of sand and gravel	Scrub and pastures
Peixe River					
Foz	PFOZ	40	4	Sandy-clayey with deposits of leaves and mud cover	Arboreal vegetation and empty area with grasses
Linígrafo	LINI	28	4.5	Rocky with areas of gravel and coarse sand, with a little clay	Predominance of cattle-raising activity

100% of individuals had reproduced at least once were determined according to Vazzoler (1996). Juveniles were those with gonads in the young stage and adults those in the other stages. The frequency of juveniles in catches (months and sites) was used as an indicator of reproductive success and recruitment.

The Index of Reproductive Activity (IRA) (Suzuki and Agostinho, 1997) was used to establish reproduction periods and sites, as follows:

$$IRA = \frac{\ln N_i \left(\frac{n_i}{\sum n_i} + \frac{n_i}{N_i} \right) \text{x} \left(\frac{GSR_i}{GSR_e} \right)}{\ln N_m \left(\frac{n_m}{\sum n_i} + 1 \right)} \text{ x } 100$$

N_i = number of female individuals in sample unit i;
n_i = number of mature female individuals in sample unit i;
N_m = number of female individuals in the largest sample unit;
n_m = number of mature female individuals in the sample unit with the largest n;
GSR_I = Gonad-Somatic Relationship average of mature female individuals mature in sample unit i;
GSR_e = largest female individual value of GSR;
GSR = gonad weight/total weight x 100.

Reproductive activity was classified as incipient ($0 < IRA \leq 5$), moderate ($5 < IRA \leq 10$) and intense ($IRA > 10$).

Only females were considered because the weight variation of the ovaries was much greater than that of the testes. IRA values for sites were correlated with the environmental factors summarized by the PCA axis to assess if any of the factors were related to reproduction. The results were considered statistically significant at $p < 0.05$.

RESULTS

Distribution and abundance

The "mandi" was caught in gillnets at all sampling sites (Fig. 2A). Highest density was at the JACU site (52.02 ind./1,000 m²/24h), while highest biomass (2.3 kg/1,000 m²/24h) was at JUSA. Catches in the upstream stretches (COPE, MOIT and AREI) and in the tributaries (PIRA, SAPE, PFOZ and LINI) were lower.

In general, the use of longlines resulted in low catches; however, in some cases, biomass was high. The highest abundance was at the COPE site, both in terms of frequency and weight (14.17 ind. and 6.36 kg/100 hooks/24h).

CPUE of the sampling sites was correlated with site scores derived from the PCA that summarized the abiotic data. The first three axes together explained about 90% of the variance (Tab. II). The catches, in number of individuals and in weight, using gillnets and longlines were significantly correlated (negatively) with axes 1 and 3 of the PCA. This indicates that the highest catches occurred at sites with high water temperature and low transparency.

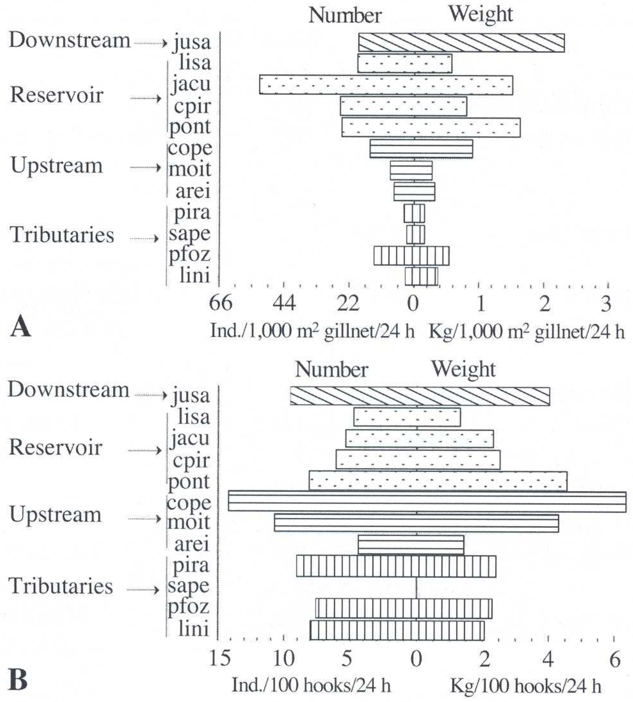

Figure 2. - Catches per unit of effort of *Pimelodus maculatus* with gillnets (**A**) and with longlines (**B**) (See Table I for the names of the sampling sites).

Monthly abundance patterns

Catches were high in the reservoir during the dry period from April to September and decreased during the rainy period (November to February) (Fig. 3). Catches downstream (JUSA) were high from October to February with high CPUE recorded in November (78.99 ind./1,000 m² net/24h). Upstream (COPE, MOIT and AREI), the catches were high starting from September with the highest value in November (33.51 ind./1,000 m² net/24h). *P. maculatus* was not caught in the Pirapitinga River from October to January. The peak catch period in the Pirapitinga River (PIRA and SAPE) occurred in February (28.73 ind./1,000 m² net/24h) and in the Peixe River (PFOZ and LINI) in January (35.91 ind./1,000 m² net/24h).

Daily abundance patterns

The "mandi" was caught in the morning, daytime and evening (Fig. 4). However, the collections during periods of low illumination contributed to 90% of the total catches downstream, 78% in the reservoir, 79% upstream, 69% in the Pirapitinga River and 81% in the Peixe River. The daytime catches were the highest in the Pirapitinga River (31%). Temporal analysis showed a high catch rate in low luminosity, with the exception of March in the Pirapitinga River in which there were only daytime catches.

Variable	PC 1	PC 2	PC 3
Eigenvectors			
Water temperature (°C)	**0.663**	0.107	0.253
Secchi depth (m)	-0.367	0.265	**-0.656**
pH	0.137	**-0.688**	-0.365
Conductivity (mS/cm)	0.532	0.146	-0.542
Dissolved oxygen (mg/l)	-0.317	**-0.650**	0.281
Eigenvalue	1.783	1.507	1.238
Explained variance (%)	35.68	30.14	24.76
Correlations			
$CPUE_n$ (gillnets)	**-0.375 p = 0.000**	0.148 p = 0.077	**-0.313 p = 0.000**
$CPUE_n$ (longlines)	**-0.216 p = 0.009**	-0.122 p = 0.145	**-0.303 p = 0.000**
$CPUE_{weight}$ (gillnets)	**-0.356 p = 0.000**	-0.135 p = 0.106	**-0.334 p = 0.000**
$CPUE_{weight}$ (longlines)	**-0.238 p = 0.004**	-0.105 p = 0.211	**-0.313 p = 0.000**

Table II. - Eigenvectors, eigenvalues and explained variance (%) of each PCA axis based on abiotic data. Pearson correlation values on the probability of rejecting H_0 between the CPUE (number and weight) of the different fishing equipment, with the scores of each PCA axis are also presented. The high eigenvectors and significant correlations are presented in bold print.

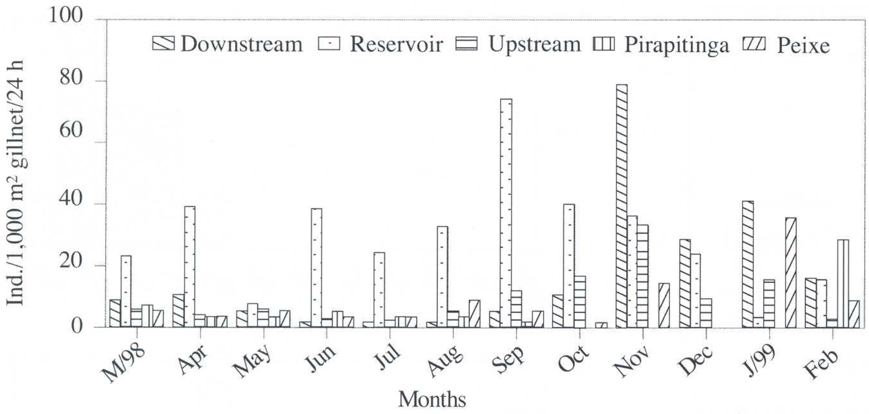

Figure 3. - *Pimelodus maculatus* catches per 1,000 m^2 of gillnets in 24 hours, per environment.

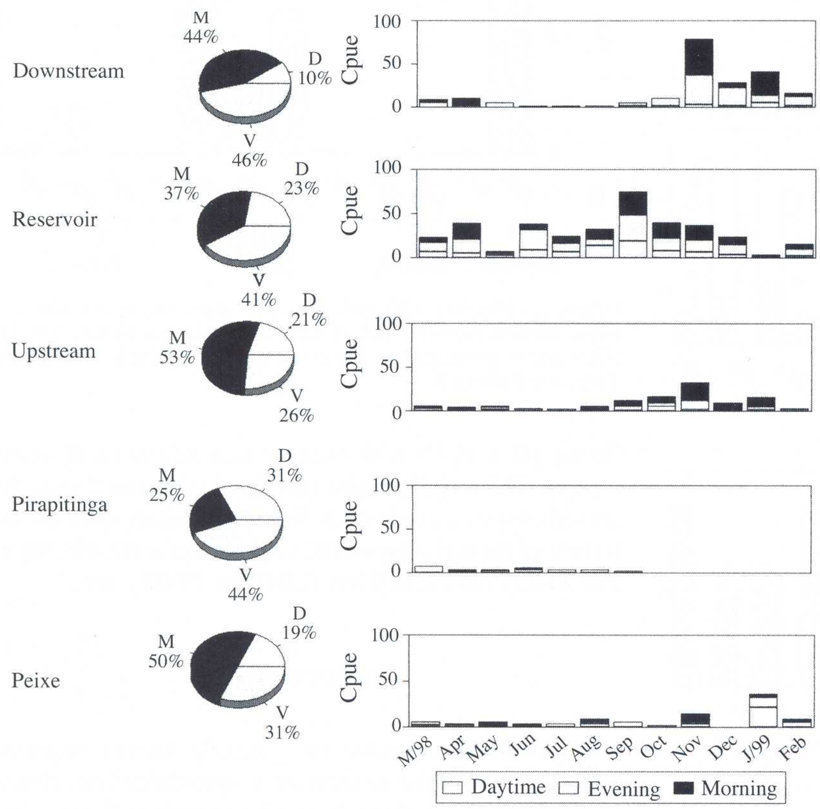

Figure 4. - Proportion of *Pimelodus maculatus* catches by day turns gillnets (D = daytime, M = morning, E = evening).

Size at first maturation

The size at first maturation of the *P. maculatus* was estimated to be 15.6 cm SL for males and 17.8 cm SL for females. The average standard length at which all individuals were adults was 18.0 and 22.0 cm for males and females, respectively (Fig. 5). The maximum length recorded for this species was 37.5 cm SL and 48.5 cm TL.

Temporal and spatial variation in frequencies of juveniles and adults

Juveniles represented more than 65% of the total catch each month (Fig. 6A). Highest catches of juveniles (more than 70%) were obtained at reservoir sites LISA, JACU, CPIR and PONT. The pattern tended to be the reverse at sites outside of the reservoir (Fig. 6B).

Reproduction period and sites

The reproduction of *P. maculatus* occurred from November to January, when the highest monthly IRA values were verified (Fig. 7A). No females in reproductive condition were caught at the reservoir sites. They were caught only in the downstream (JUSA), upstream (COPE, MOIT and AREI) and Peixe River (LINI and PFOZ) locations (Fig. 7B).

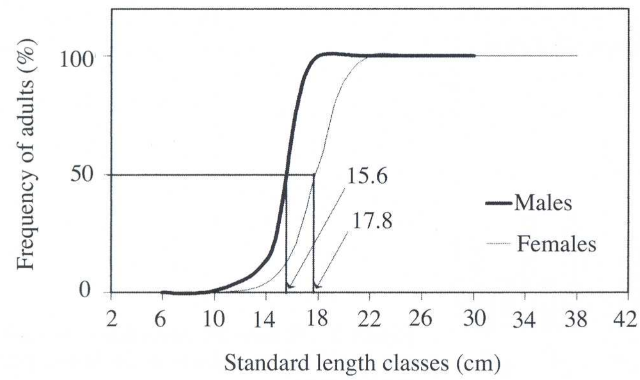

Figure 5. - Frequency of adults by standard length class for *P. maculatus* males and females.

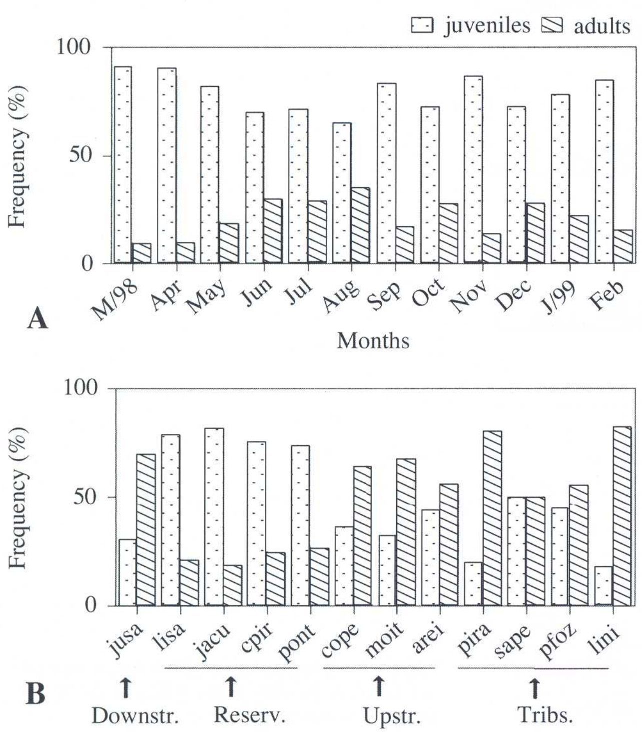

Figure 6. - Frequency of *P. maculatus* juveniles and adults by months (**A**) and sampling sites (**B**). (Downstr = downstream; Reserv = reservoir; Upstr = upstream; Tribs = tributaries).

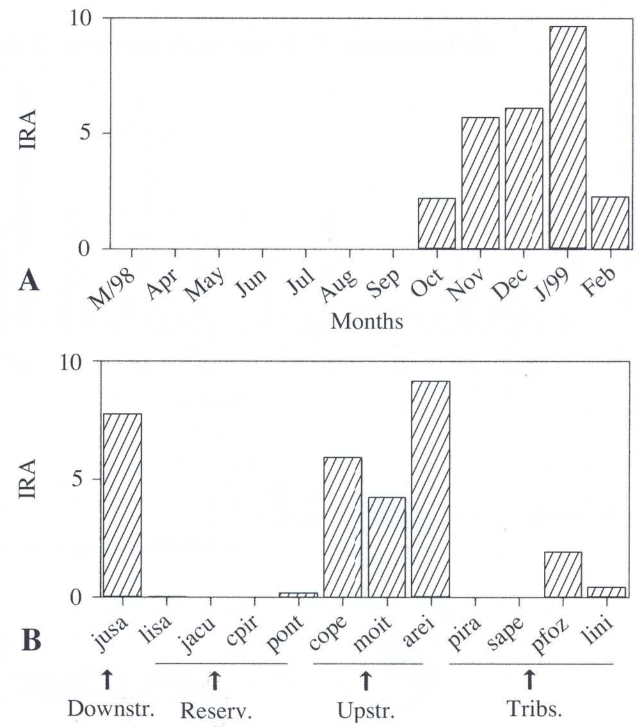

Figure 7. - Monthly (**A**) and site (**B**) variations of the Index of Reproductive Activity (IRA) for *Pimelodus maculatus* females. (Downstr = downstream; Reserv = reservoir; Upstr = upstream; Tribs = tributaries).

Relationship of the reproduction period with the abiotic factors

The correlation between the IRA by sampling sites and scores on axes 1, 2 and 3 of the PCA, which summarized the abiotic data, was -0.09 ($p = 0.60$), -0.34 ($p = 0.04$) and 0.25 ($p = 0.14$), respectively. These results indicate that during the reproductive period, which coincides with the peak of the rainy season and increases in temperature and photoperiod, the "mandi" tended to reproduce at slightly acidic sites (mean pH = 6.72) with high concentrations of dissolved oxygen. The variables most correlated with axis 2 were dissolved oxygen and pH (Tab. II). These values were characteristic of the downstream (JUSA), upstream (COPE, MOIT and AREI) and Peixe River (LINI and PFOZ) sites.

DISCUSSION

P. maculatus, despite its generally known migratory behaviour, presented an increase in abundance after closure in some reservoirs of the Paraná Basin such as Rosana, Três Irmãos and Corumbá (Agostinho *et al.*, 1999). From March 1998 to February 1999, the "mandi" was more broadly distributed in the region around the reservoir than in the same area just after impoundment when the species did not occur in Sapé, a small tributary of the Pirapitinga River. Later, the catch increased considerably with the capture of juveniles resulting from successful reproduction between October and December 1996 (UEM.Nupélia, 1999), showing that the amplification of favorable environments resulted in the proliferation of this species and its consequent dispersal to other areas. The richness of allochthonous material resulting from the flooding of extensive vegetation probably contributed to the maintenance of the species. However, after this period, with the diet shifting towards more stable and autochthonous resources, the population declined (Agostinho *et al.*, 1999). This fact should be considered in the preparation of a management plan for this species.

High temperatures and low transparency were correlated with the *P. maculatus* catches. This, associated with the fact that these catches occurred essentially in periods of low luminosity, suggests high activity of the species under these conditions. Thus, high catches were related to the negative phototaxis of the species, with higher activity (movement and feeding) under twilight and darkness (De Croux, 1996).

Catch variation in abundance (considering the sites and months) probably results from reproductive migration. The fact that CPUE rose in the reproductive period at sites above the reservoir and showed opposite tendencies outside of the spawning period demonstrates that the species uses lotic areas upstream to spawn. The high densities verified in the stretch immediately downstream from the dam during the spawning periods is another indicator of reproductive migration. The migratory behaviour of the species is described by Bonetto (1963) and Godoy (1967), who estimated movements greater than 1,000 km. Agostinho *et al.* (in press) report that this species needs fewer free stretches than other migratory species in the Paraná River, as demonstrated by its abundance in reservoirs in the Tiête River, which has short tributaries and limited reaches of fluvial habitat.

Barbosa *et al.* (1988), studying *P. maculatus* in the Bariri Reservoir, found that males reached first maturation at 12.5 and females at 12.0 cm of total length. All individuals with sizes of more than 15.5 cm were capable of participating in the reproductive process. On the other hand, Fenerich *et al.* (1975) showed that the first sexual maturation sizes of this species in the Piracicaba and Jaguari rivers were 18.0 and 19.0 cm of total length for males and females, respectively. However, Vazzoler (1996) found that *P. maculatus*, from the Upper Paraná River Basin, reached first maturation at a standard length of 12.3 cm and all individuals were capable of reproducing at 17.0 cm.

In an earlier study of *P. maculatus* in the Corumbá River (Nupélia, 1997) first maturation was at 13.0 and 11.5 cm SL, and all individuals were adults at 20.5 and 17.5 cm for females and males, respectively. During the filling of the Corumbá Reservoir the standard length at first maturation was 15.4 cm for males and 18.0 cm for females (UEM.Nupélia, 1999). Starting from 19.0 cm all individuals were adults. Thus, in the different years of studies of this species in the Corumbá Reservoir, stable minimum sizes for first sexual maturation and adulthood were not observed. Differences in size at first sexual maturation reflect genetic variations and environmental effects. Environmental factors change the timing of maturation through their effect on growth rates. Wootton (1990) reported that a common response to increments in the availability of food supplements is an increase in the growth rate of the fish, generally leading to a reduction in maturation age.

Spawning appeared to be most frequent in the Corumbá area of influence from November to January. However, it occurred in an incipient form in October and February. Spawning periods between October and February are coincident with recordings of the species at other locations such as the Jaguari River Basin (Godinho *et al.*, 1974b; Basile-Martins *et al.*, 1975), the Paraná River (Vazzoler *et al.*, 1997) and the São Francisco River (Sato *et al.*, 1999).

The fact that the reproduction of the majority of the species, particularly the migrators, coincides with the rainy season and high temperatures is widely known in the literature (Lowe-McConnell, 1975; Lam, 1983; Santos and Ferreira, 1987; Vazzoler *et al.*, 1997). These conditions affect the concentrations of oxygen and water pH through the input of organic material and its decomposition. *P. maculatus* probably searches for lotic areas with high concentrations of oxygen and a slightly low pH for spawning. The species did not reproduce in the reservoir, which was widely used by juveniles.

Considering that there is no information about post-impoundment stabilization time in reservoirs of the Neotropical region (Agostinho *et al.*, 1999), monitoring studies should be conducted to evaluate possible alterations in the population of the species. Therefore, it seems clear that tributaries and the remaining stretches upstream from the reservoir are important for the reproduction of *P. maculatus* and should be preserved in order to insure the success of this species in the reservoir, which has the potential to support professional fisheries.

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REFERENCES

AGOSTINHO A.A., 1995. - Considerações sobre a atuação do setor elétrico na preservação da fauna aquática e dos recursos pesqueiros. *In:* COMASE; ELETROBRAS. Seminário sobre Fauna Aquática e o Setor Elétrico Brasileiro. Reuniões temáticas preparatórias. p. 8-19. Rio de Janeiro.

AGOSTINHO A.A., MIRANDA L.E., BINI L.M., GOMES L.C., THOMAZ S.M. & H.I. SUZUKI, 1999. - Patterns of colonization in neotropical reservoir, and prognoses on aging. *In:* Theoretical Reservoir Ecology and its Applications (Tundisi J.G. & M. Straskraba, eds), pp. 227-265. Leiden: Backhuys Publishers.

AGOSTINHO A.A., GOMES L.C., SUZUKI H.I. & H.F. JÚLIO Jr., (in press). - Migratory fish of the upper Paraná River Basin, Brazil. *In:* Migratory Fishes of South America: Biology, Social Importance and Conservation Status (Carolsfeld J., Harvey B., Baer A. & C. Ross, eds). World Fisheries Trust Edition.

BARBOSA J.M., MORAES M.N., FERREIRA A. & E.C. CAMPOS, 1988. - Aspectos da estrutura populacional da mandiuva *Pimelodus maculatus* Lacepède, 1803 (Osteichthyes, Pimelodidae) na represa Bariri, rio Tietê, Estado de São Paulo. *Bol. Inst. Pesca*, São Paulo, 15(2): 123-133.

BASILE-MARTINS M.A., GODINHO H.M., FENERICH N.A. & J.M.B. BARKER, 1975. - Influência de fatores abióticos sobre a maturação dos ovários de *Pimelodus maculatus* Lac., 1803 (Pisces, Siluroidei). *Bol. Inst. Pesca*, São Paulo, 4(1): 1-28.

BASILE-MARTINS M.A., GODINHO H.M., NARAHARA M.Y., FENERICH-VERANI N. & M.N. CIPOLI, 1986. - Estrutura da população e distribuição espacial do mandi, *Pimelodus maculatus* Lacepède, 1803 (Osteichthyes, Pimelodidae), de trechos dos rios Jaguari e Piracicaba, São Paulo-Brasil. *Bol. Inst. Pesca*, São Paulo, 13(1): 1-16.

BONETTO A.A., 1963. - Investigaciones sobre migragiones de peces en los rios de la cuenca del Plata. *Cienc. Invest.*, 19(1-2): 12-26.

BRITSKI H.A., SATO Y. & A.B.S. ROSA, 1988. - Manual de identificação de peixes da região de Três Marias (com chaves de identificação para os peixes da bacia do São Francisco). 115 p. Brasília: Câmara dos Deputados, Coordenação de Publicações - CODEVASF.

CESP - Companhia Energética de São Paulo, 1994. - Aspectos limnológicos, ictiológicos e pesqueiros de reservatórios da CESP no período de 1986 a 1994. 81 p. São Paulo: CESP.

DE CROUX M.J.P., 1996. - Crescimiento de juveniles de *Pimelodus clarias maculatus* (Pisces, Pimelodidae) em condiciones experimentales. Efecto del fotoperiodo. *Rev. Asoc. Cienc. Nat. Litoral*, 27(2): 95-102.

DE FILIPPO R. & C.B.P. SOARES, 1996. - Caracterização Limnológica e da Qualidade da Água do Rio Corumbá e de seus Principais Afluentes nas Áreas de Influência da UHE Corumbá. FURNAS - Centrais Elétricas S.A. 21 p. Departamento de Meio Ambiente, Rio de Janeiro, (Relatório).

FENERICH N.A., NARAHARA M.Y. & H.M. GODINHO, 1975. - Curva de crescimento e primeira maturação sexual do mandi, *Pimelodus maculatus* Lac., 1803 (Pisces, Siluroidei). *Bol. Inst. Pesca*, São Paulo, 4(1): 1-28.

FOWLER H.W., 1951. - Os Peixes de Água doce do Brasil. Vol. 6 (3ª. entrega). *Arq. Zool. Estado, São Paulo*: 405-625.

GODINHO H.M., FERRI S., MADEIROS L.O. & J.M.B. BARKER, 1974a - Morphological changes in the ovary of *Pimelodus maculatus* Lacepède, 1803 (Pisces, Siluroidei) related to the reproductive cycle. *Rev. Bras. Biol.*, 34(4): 581-588.

GODINHO H.M., FENERICH N.A., BASILE MARTINS M.A. & J.M.B. BARKER, 1974b. - Maturation curve of the ovary of *Pimelodus maculatus* Lac. (Siluroidei, Teleostei). *Bol. Inst. Pesca, São Paulo*, 3(1): 1-20.

GODINHO H.M., BASILE MARTINS M.A., FENERICH N.A. & N.Y. NARAHARA, 1977. - Fecundidade e tipo de desova do mandi *Pimelodus maculatus* Lacepède, 1803 (Pisces, Siluroidei). *Rev. Bras. Biol.*, 37(4): 737-744.

GODOY M.P., 1967. - Dez anos de observações sobre a periodicidade migratória de peixes do rio Mogi Guassu. *Rev. Bras. Biol.*, 27(1): 1-12.

JACKSON D.A., 1993. - Stopping rules in principal component analyses: A comparison of heuristical and statistical approaches. *Ecology*, 74(8): 2204-2214.

LAM T.J., 1983. - Environmental influences on gonadal activity in fish. *In:* Fish Physiology: Reproduction. Part B: Behavior and Fertility Control (Hoar W.S., Randall D.J. & E.M. Donalson, eds), pp. 65-116. New York: Academic Press.

LOWE-McCONNELL R.H., 1975. - Fish Communities in tropical Freshwaters: Their Distribution, Ecology and Evolution. 337 p. London: Longman.

McCUNE B. & M.J. MEFFORD, 1995. - PC-ORD: Multivariate Analysis of ecological Data. Version 2.0. 125 p. Oregon: MJM Software Design.

PAIVA M.P., 1982. - Grandes Represas do Brasil.(1ª. ed.). 304 p. Brasília: Editerra.

RINGUELET R.A., ARANBURU R.H. & A.A. ARAMBURU, 1967. - Los Peces argentinos de Agua dulce. 302 p. Argentina: Com. Inv. Cienc. Prof. B. Aires.

SANTOS G.M. & E.J.G. FERREIRA, 1987. - Peixes da Bacia Amazônica. *In:* Estudos ecológicos de Comunidade de Peixes tropicais (Lowe-McConnell R.H., ed.), pp. 345-373. São Paulo: Editora da Univ. de São Paulo.

SATO Y., FENERICH-VERANI N., VERANI J.R., GODINHO H.P. & E.V. SAMPAIO, 1999. - Reproductive traits of the yellow-mandi catfish *Pimelodus maculatus* Lacepède (Osteichthyes, Siluriformes) in captive breeding. *Rev. Bras. Zool.*, 16(4): 981-986.

SUZUKI H.I. & A.A. AGOSTINHO, 1997. - Reprodução de peixes do reservatório de Segredo. *In:* Reservatório de Segredo: Bases Ecológicas para o Manejo (Agostinho A.A. & L.C. Gomes, eds), pp. 163-182. Maringá: Eduem.

UBEDA C.A., VIGNES I.E. & L.P. DRAGO, 1981. - Contribucion para el conocimiento del bagre amarillo (*Pimelodus maculatus* Lacepède, 1803) (Pisces, Pimelodidae) del rio de La Plata: redescripcion, biologia, distribucion geografica, importancia economica. *Physis, Buenos Aires*, 40(98): 63-76.

UEM.NUPÉLIA - UNIVERSIDADE ESTADUAL DE MARINGÁ. NÚCLEO DE PESQUISAS EM LIMNOLOGIA, ICTIOLOGIA E AQÜICULTURA, 1997. - Estudos ictiológicos na área de influência do AHE Corumbá - Fase Rio - relatório parcial, UEM/NUPÉLIA (Annual Reporter). 284 p. Maringá: UEM/Nupélia.

UEM.NUPÉLIA - UNIVERSIDADE ESTADUAL DE MARINGÁ. NÚCLEO DE PESQUISAS EM LIMNOLOGIA ICTIOLOGIA E AQÜICULTURA, 1999. - Estudos ictiológicos na área de influência AHE Corumbá - Fase reservatório - relatório parcial, UEM/NUPÉLIA (Annual Reporter). 290 p. Maringá: UEM/Nupélia.

VAZZOLER A.E.A.M., 1996. - Biologia da Reprodução de Peixes teleósteos: Teoria e Prática. 169 p. Maringá: Eduem.

VAZZOLER A.E.A.M., LIZAMA, M.A.P. & P. INADA, 1997. - Influências ambientais sobre a sazonalidade reprodutiva. *In:* A Planície de Inundação do Alto Rio Paraná (Vazzoler A.E.A.M., Agostinho A.A. & N.S. Hahn, eds), pp. 267-280. Maringá: Eduem.

WOOTTON R.J., 1990. - Ecology of Teleost Fishes. (1st edit.). 404 p. New York: Chapman and Hall.

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