AGE, GROWTH AND YIELD PER RECRUIT ANALYSIS OF THE PINTADO *Pseudoplatystoma corruscans* (AGASSIZ, 1829) IN THE CUIABÁ RIVER BASIN, PANTANAL MATOGROSSENSE, BRAZIL

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(With 5 figures)

ABSTRACT

The age and growth of the pintado *Pseudoplatystoma corruscans* were studied during the period from May 1994 to May 1995. The standard length ranged from 52 to 145 cm and the weight from 1.3 to 41 kg. The biometric relationship between the standard length (L_s) and total length (L_{total}) and between the total weight (W_t) and the standard length (L_s) were obtained for the species, being respectively: $L_{total} = 3.296 + 1.069 * L_s$ and $W_t = 0.00624 * L_s^{3.134}$.The condition factor calculated monthly suggests the spawning season to be between the months of February and March. The age was estimated by counting growth rings present in the spines of the pectoral fins, and 10 age classes were detected. The mean distance of the last ring until the border of the spine suggests that the period of least growth is between July and September (dry period). Von Bertalaffy's equation describing the growth of the pintado is: $L_t = 183 * [1 - \exp - 0.085 * (t + 3.274)]$. Total mortality was $Z = 0.24$ year^{-1} and natural mortality $M = 0.20$ year^{-1}. As the present level of exploitation, $F = Z - M = 0.04$ year^{-1}, we conclude that the pintado stock was still underexploited in the Pantanal in the sampled period.

Key words: Pantanal, *Pseudoplatystoma*, age, growth, mortality.

RESUMO

Idade, crescimento e rendimento por recruta do pintado *Pseudoplatystoma corruscans* (Agassiz, 1829) na bacia do rio Cuiabá, Pantanal de Mato Grosso, Brasil

A idade e o crescimento do pintado *Pseudoplatystoma corruscans* foram estudados durante o período de maio de 1994 a maio de 1995. O comprimento-padrão variou de 52 a 145 cm e o peso total, de 1,3 a 41 kg. As relações biométricas entre comprimento-padrão (L_s) e comprimento total (L_{total}) e entre peso total (W_t) e comprimento-padrão (L_s) foram obtidas, sendo, respectivamente: $L_{total} = 3{,}296 + 1{,}069 * L_s$ e $W_t = 0{,}00624 * L_s^{3{,}134}$. O fator de condição, calculado mensalmente, sugere que a desova ocorreu entre os meses de fevereiro e março. A idade foi estimada pela contagem de anéis de crescimento presentes nos raios modificados (esporão) das nadadeiras peitorais, detectando 10 classes etárias. A distância média do último anel até a borda do esporão sugere que o período de menor crescimento ocorreu entre julho e setembro (seca). A equação de von Bertalaffy que descreve o crescimento do pintado é: $L_t = 183 * [1 - \exp - 0{,}085 * (t + 3{,}274)]$. A mortalidade total obtida foi $Z = 0{,}24$ ano^{-1} e a mortalidade natural $M = 0{,}20$ ano^{-1}. Com o presente nível de explotação, $F = Z - M = 0{,}04$ ano^{-1}, conclui-se que o estoque do pintado ainda não estava sobrexplotado na bacia do rio Cuiabá, Pantanal Matogrossense, na época em que foi realizado o estudo.

Palavras-chave: Pantanal, *Pseudoplatystoma*, idade, crescimento, mortalidade.

INTRODUCTION

Pseudoplatystoma are *Siluriformes* of the family *Pimelodidae*, which accomplish periodic migratory movements for reproduction (Lowe-McConnel, 1975). To this genera belong catfish species of high economic value in their occurrence areas. Therefore, they are an object of interest in fishery biology. Examples of studies of the genera are Bonetto *et al.* (1965), with the *Pseudoplatystoma corruscans* and the *Pseudoplatystoma fasciatum*, and Cordiviola (1966) with *P. corruscans* in the middle Paraná. Reid (1983) and Marques (1993) investigated, respectively, the biology of *P. fasciatum* and *P. tigrinum* in the basin of the river Apure River, Venezuela, and of *P. corruscans* in the basin of the River Paraná. Gil & Martinez (1995) examined biological and fishery aspects of *P. fasciatum* and *P. corruscans* in the high Meta River, Colombia. Ruffino & Isaac (1999) described the population dynamics of *P. tigrinum* in the middle Amazon; Loubens & Panfili (2000) studied the biology of *P. fasciatum* and *P. tigrinum* in the basin of the Mamoré River, Bolivia and, recently, García *et al.* (2001) studied reproductive aspects of *P. fasciatum* and *P. tigrinum* in Peruvian Amazonia.

In the Pantanal Matogrossense, this genera is represented by the pintado *P. corruscans* and cachara *P. fasciatum*. According to Ferraz de Lima (1987), besides being vulnerable to fishery activity during reproduction, they are also threatened by environmental alterations due to the multiple use of fluvial systems. Due to the high commercial value of the pintado, immature individuals (< 80 cm) are landed (Ferraz de Lima & Chabalin, 1984).

The aim of this work was to estimate the age of *P. corruscans* through growth checks of the spine and to estimate the von Bertalanffy growth parameters in order to assess the present exploitation level of the stock in the Cuiabá River basin.

MATERIAL AND METHODS

The Paraguay River basin, of which the Cuiabá River is an important affluent, embraces approximately 496,000 km^2, with an extensive floodplain of 138,000 km^2, known as the Pantanal Matogrossense (Adámoli, 1982). The Pantanal presents a tropical climate, with an annual average temperature of 25.1°C. December is the hottest month, and July the coldest.

The annual hydrological regime can be defined, according to Silva (1990), into four periods: high water (HW); January, February, and March, the rainy period leading to inundation of the floodplain; descending water (DW), April, May, and June, the period of descending water, when it returns to the riverbed; dry, July, August, and September – period in which the river flows within the channel; rain water (RW), October, November, and December, beginning of the rains, period in which the level of the river begins to rise.

The total and standard length (L_{total} and L_s, respectively) of 2222 *Pseudoplatysoma corruscans* were measured from specimens landed at the fish market in the City of Cuiabá, Mato Grosso, between May 1994 and May 1995. The individual total weight of 985 fish was taken. Identification of sex of measured fish was impossible as they were going to be sold. The $L_{total} \times L_s$ relationship was calculated by the linear regression $L_{total} = c + d \cdot L_s$. The length and weight relationship was derived according to $W_t = a \cdot L_s^b$ where Wt is the total weight (g) and L_s, the standard length (cm). The allometric condition factor (ACF) was calculated monthly as follows: $ACF = W_t/L_s^b$ (Ricker, 1975).

The age and the average length of each age group were estimated from examining the hard structures. Sections of pectoral fin spines of 221 fish (5 sections per fish) were used to estimate the age, following the procedure of Barthem (1990).

To test the validity of the rings as age discriminators, data for each month were pooled to assess whether the annulus was close to the edge of the spine. The distance between the last ring and the border was measured and its mean was calculated for each month and for each hydrological period (Rossi-Wongtschowski *et al.*, 1982; Braga & Goitein, 1985). This procedure was performed for 4-year-old individuals, which was the most frequent age class, and for all ages combined.

The von Bertalanffy growth curve in length for the pintado was estimated by: $L_t = L_\infty (1 - \exp(-k(t - t_o))$ where: L_t (cm) – length at age t; L_∞ (cm) – mean asymptotic length; k ($year^{-1}$) – growth coefficient; and to (year) – the nominal age at which the length is zero (Beverton & Holt, 1957). These parameters were estimated through non-linear regression between the average standard length versus age. The von Bertalanffy growth curve in weight was estimated by: $W_t = W_\infty \cdot (1 - \exp(-k(t - to)))^b$, where

W_t is the total weight at age t, and W_∞ is the maximum weight the fish would reach if they lived indefinitely (Gulland, 1969).

Total mortality (Z) was calculated by: $Z = (n \cdot k/(n + 1))(\ln\{(L\infty - L_c)/(L\infty - e\})^{-1}$ and the Z/k variance by: $var(Z/k) = \{[n/(n + 1)^2]\}.\{n[\ln((L\infty - L_c/(L\infty -))]\}^{-2}$ (Ssentongo & Larkin, 1973) where: n is the number of measured fishes; k, the growth coefficient; L∞, asymptotic length (cm); L_c, the size of the smaller fish; and e, the average length in the catch.

Natural mortality (M) was calculated according to the Pauly (1980) relationship: $\ln M = -0.0152 - 0.279 \ln L\infty + 0.6543 \ln k + 0.4634 \ln \overline{T}$, where $\overline{T}$ is the annual average water temperature in °C; as water surface temperature is close to air temperature, the latter was utilized in the equation above in order to estimate M.

Relative yield per recruit (Y/R') was performed according to the procedures of Beverton & Holt (1966): $Y/R' = EU^{M/k}[1 - (3U/1 + m) + (3U^2/1 + 2\ m) - (U^3/1 + 3\ m)]$, where $m = (1 - E)/(M/k) = k/Z$, $U = 1 - (Lc/\ L\infty)$, and $E = F/Z$ (rate of exploitation).

RESULTS

The range of the standard length between 52 cm to 145 cm, with median length of 90 cm, and the total weight of the individual fish was between 1.3 kg to 41 kg. Fig. 1 shows the standard length frequency distribution.

The relationship between the total length and standard length is described by: $L_{total} = 3.296 + 1.069\ L_s$; r = 0.996; n = 2222.

The regression between total weight (kg) and the standard length (cm) was: $W_t = 0.00624\ L_s^{3.134}$; r = 0.983; n = 985; se = 0.121, originally calculated in logarithmic scale.

The monthly average allometric condition factor showed that the largest values occurred in March 1995, followed by an abrupt fall in April 1995 (Fig. 2).

The validation of checks periodicity is observed in Fig. 3, where we can see the monthly mean of the distance between the last ring and the border of the spine for all age together and for the four age class checks. In this figure, July, August, and September present the smallest distances, demonstrating that the rings were formed in the dry season. Thus, ring formation was found to be an annual event and each group with the same number of rings was considered an age class or cohort.

The readings of translucent marks in the pectoral fin sections indicated 10 groups of rings. The individuals with 10 or more rings were classified in the same class (X+), because of the proximity between rings. As is usual in older specimens, counting was impossible beyond the tenth mark because subsequent ones were imprecise.

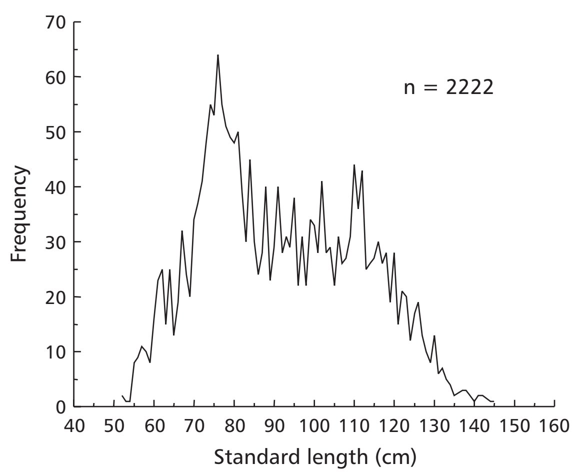

Fig. 1 — Standard length frequency distribution of *Pseudoplatystoma corruscans*, measured from May 94 to May 95 in the fish landed in Cuiabá Fish Market.

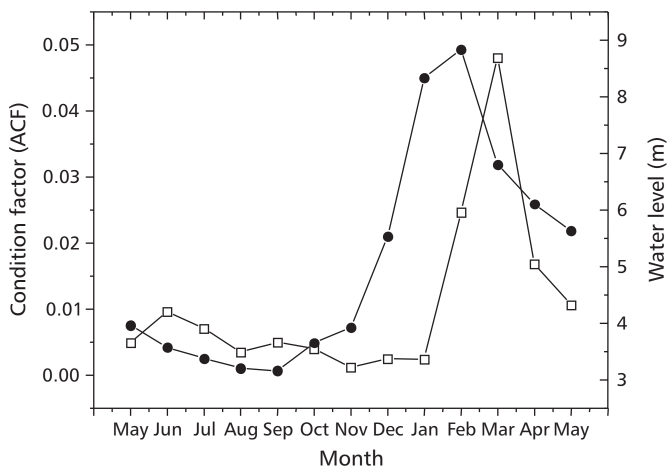

Fig. 2 — Monthly allometric condition factor (—□—) calculated for *Pseudoplatystoma corruscans* and monthly average water level (m) in the River Cuiabá (—●—) recorded in the town of Santo Antônio de Leveger (MT) from May 1994 to May 1995.

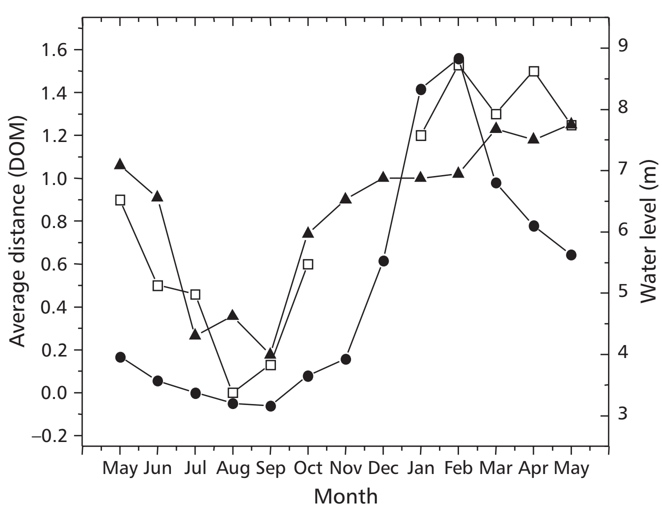

Fig. 3 — Monthly average distance (DOM – Divisions of Ocular Micrometer) between the last ring and the border of the spine for all ages combined (—▲—) and for 4-years-old individuals (—□—) for *Pseudoplatystoma corruscans* (note the lack of data for November and December) and monthly average water level (m) in the River Cuiabá (—●—) recorded in Santo Antônio de Leveger (MT) from May 1994 to May 1995.

As was already pointed out, the final age was only taken into account for the slides in which at least 2 of the 3 readings coincided. In this way, 210 fish had their ages confirmed. Table 1 summarizes these findings and presents the size variability within age classes. Table 2 presents the frequency distribution of the standard length (L_s, cm) classes by age.

Experienced fishermen at Cuiabá Fish Market informed us that the maximum total length of pintado years ago was about 200 cm (L_s = 183 cm). Forcing this value in the von Bertalanffy growth curve, we estimated k = 0.085 $year^{-1}$ (ASE = asymptotic standard error = 0.003 $year^{-1}$) and t_o = –3.274 years (ASE = 0.261 years), r^2 = 0.992, n = 9. This result is robust as it was found independent of any initial value of k and t_o. The equations which describe the growth in length (cm) and weight (kg) for *P. corruscans* are respectively: $L_t = 183[1 - \exp - 0.085(t + 3.274)]$ and $W_t = 77[1 - \exp - 0.085(t + 3.274)]^{3.134}$. Fig. 4 shows the length on age growth curve.

The mean standard length of first capture was adopted as 52 cm, and the mean length in the catch, $\bar{e}$ = 91 cm. Using these and adopting k = 0.085 $year^{-1}$ gives Z = 0.24 $year^{-1}$ and var(Z/k) = $0.85*10^{-6}$. Considering T = 25.1°C, Pauly's formula gives M = 0.20 $year^{-1}$. Fig. 5 shows the yield per recruit plot where F_{max} = 0.20 $year^{-1}$. As the present level of exploitation is F = Z – M = 0.04 $year^{-1}$, we can conclude that pintado stock was still underexploited in the Pantanal in the sampled period.

TABLE 1
Minimum, maximum, and mean standard length, the standard deviation and the examined number of individuals for each age class (1 year interval) of the standard length (L_s, cm) of *Pseudoplatystoma corruscans*. Readings from the pectoral fin spine.

Age class	L_s min.	L_s max.	L_s med.	SD	N
I	55.0	66.5	58.75	5.23	4
II	59.0	73.0	65.26	4.04	27
III	70.0	84.0	75.78	3.54	29
IV	74.0	89.0	83.16	3.63	25
V	83.0	97.0	90.36	4.32	25
VI	90.0	108.0	98.06	4.42	24
VII	100.0	114.0	107.58	4.27	19
VIII	105.0	123.0	114.60	4.65	24
IX	115.0	127.0	121.25	3.22	12
X+	120.0	145.0	131.05	6.45	21

TABLE 2
Standard length (L_s, cm) frequency distribution for each age of *Pseudoplatystoma corruscans*, from readings in the pectoral fin spine.

L_s (cm)	Age										
	I	II	III	IV	V	VI	VII	VIII	IX	X+	N
50-60	3	3	–	–	–	–	–	–	–	–	6
61-70	1	20	3	–	–	–	–	–	–	–	24
71-80	–	4	25	6	–	–	–	–	–	–	35
81-90	–	–	1	19	12	2	–	–	–	–	34
91-100	–	–	–	–	13	16	1	–	–	–	30
101-110	–	–	–	–	–	6	13	5	–	–	24
111-120	–	–	–	–	–	–	5	16	5	1	27
121-130	–	–	–	–	–	–	–	3	7	10	20
131-140	–	–	–	–	–	–	–	–	–	8	8
141-150	–	–	–	–	–	–	–	–	–	2	2
											Total = 210

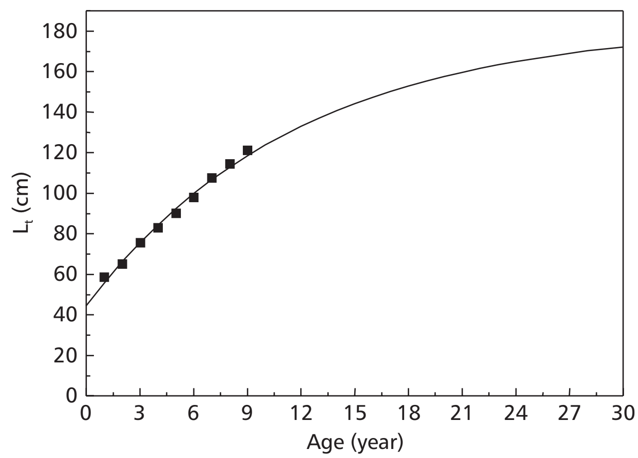

Fig. 4 — Length growth curve estimated (line) L_t = 183*[1 – exp – 0.085*(t + 3.274)] and observed mean length at age (■) of *Pseudoplatystoma corruscans* in the Cuiabá River basin.

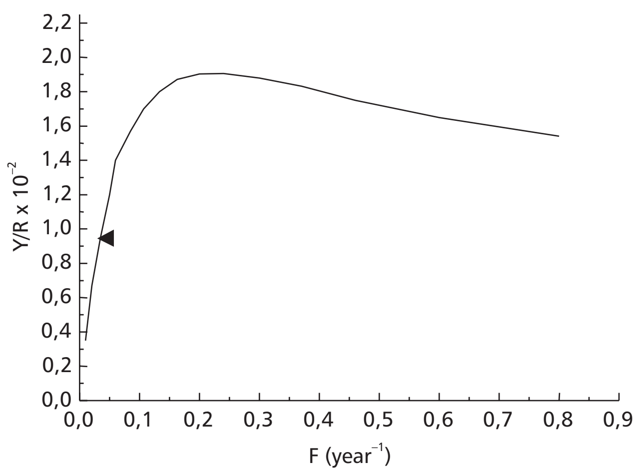

Fig. 5 — Relative yield per recruit (Y/R') versus fishing mortality (F) for *Pseudoplatystoma corruscans* in the Cuiabá River basin, (◄) present value of F.

DISCUSSION

Pseudoplatystoma corruscans is a species, which can reach a large size. As we said, fishermen with long experience in the Pantanal report that it can attain 200 cm in total length (and 183 cm in standard length, calculated by the equation: Ls = –2.392 + 0.928 L_{total}). Godinho *et al.* (1993) reported individual fish of 182 cm (L_{total}) in the São Francisco River. Probably this is one of the representatives of the genera that reach larger lengths, considering that *P. fasciatum* and *P. tigrinum*, do not surpass 130 cm in total length (Reid, 1983). In the present study, the largest pintado measured L_{total} = 152 cm.

The smallest individual measured in this work was 59 cm in total length (L_s = 52 cm), albeit the minimum allowable marketable size was L_{total} = 80 cm (recently that was changed to 85 cm by fishery regulation). Therefore, fish below this size are illegally marketed.

Smaller samples were measured in November, December, and January because during this period, fishing is limited due to its being a closed season (which is not entirely respected) in order to protect the spawning fish.

The condition factor expresses the physiological state of the fish, which results from the interaction between biotic and abiotic factors, indicating the recent nutrition conditions and varying according to the cycle of sexual maturity which associated with other evidence, roughly indicates when fish reproduction begins (Vazzoler, 1996). For pintado, a high value of the condition factor in March may indicate the period of pre-spawning, as is also evidenced by the fact that this high value is preceded by a gradual increase of ACF in January and February, which points to fat accumulation and investment in gonad maturation. In April, the ACF suffers a sudden fall, probably caused by the energy demand during spawning. Therefore, the condition factor corroborates spawning time in the high water season, as pointed out by Ferraz de Lima (1987). The same was observed by Marques (1993), who verified a direct relationship between the reproductive peak of *P. corruscans* and the high water season of the upper Paraná River, and also by Godinho *et al.* (1993) for the São Francisco River.

The period of growth activation as indicated by a slight ACF increase was in May and June when the waters recede. In this period, the shoals begin to leave flooded areas, and head back to the riverbed, in what is a period of great for opportunity fish-eating animals. In July, the ACF decreases, remaining low till December, indicating growth deceleration. Similar results were found by Reina *et al.* (1995) who verified formation of translucent marks in the jaú *Paulicea luetkeni*, during low water in the high Meta River, Colombia.

The pectoral fin spines proved reliable structures for ageing the pintado since they generally presented, distinct and well-marked rings. Besides, Table 2 shows the consistant relationship between the average standard length and the number of rings, indicating clearly that large individuals present more rings.

The smallest mean values observed in the distance between the last ring and the border of the spine in July, August, and September (dry period) suggest that this is when the translucent marks form, accompanied by growth deceleration which is also indicated by a low ACF. Therefore, the annual age ring probably forms in this period.

Resende *et al.* (1986) also verified ring formation in the dry season for pintado caught in the Miranda River basin (Southern Pantanal). Reid (1983), in the Apure River basin, Venezuela, and Loubens & Panfili (2000), in the Mamoré River basin, reported similar observations in the case of *P. fasciatum* and *P. tigrinum*

P. corruscans presents a comparatively low growth rate (k = 0.085 year^{-1}). Reid (1983) observed the same thing for *P. tigrinum* (k = 0.088 year^{-1}) and *P. fasciatum* (k = 0.097 year^{-1}) in the Apure River basin in Venezuela.

As is common in tropical multispecies inland fisheries, there is no easier and readier way to estimate natural mortality than by using Pauly's formula and, as the estimates of M and Z are coherent (M < Z, as it should be in an exploited stock), we have adopted it since informed advice is urgently required in heuristically-managed fishery.

As for the classical criticisms of the Beverton & Holt (1957) model, are they viewed by us as a case in point of excessive zeal. Furthermore, this model a currently is the only one we can use in a region for which data are scarce. Vaz (2001) and Mateus & Estupiñán (2002) used this model in order to assess, respectively, the pacu *Piaractus mesopotamicus* and piraputanga *Brycon microlepis* fish stocks in the Cuiabá River basin. The first author concluded that pacu is overfished and the second found that piraputanga is not overfished, yet.

Experienced fishermen say that the average size of pintado is consistently decreasing, however, the mean size related by Ferraz de Lima & Chabalin (1984) between 1980 to 1983 was not much larger than that estimated in this work. Moreover our findings suggest that the survival rate is still high (S = exp – Z = 79%) and growth overfishing has not been reached by the pintado fish stock in the Cuiabá River basin. Catella (2001) found the same result for the Paraguai River basin, having assessed effort and catch between 1994 and 1999 in the state of Mato Grosso do Sul. However, due to the great commercial value of the species regular attention must be paind to the stock in order to avoid growth (and recruitment) overfishing. Environmental care is also needed, due to deforestation and water pollution.

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