

Invasão, colonização e atividade reprodutiva de um bagre de grande porte híbrido no Rio Paraopeba, bacia do Rio São Francisco, Brasil

Invasion, colonization and reproductive activity of a large hybrid catfish in the Paraopeba river, São Francisco river basin, Brazil

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Resumo

Introdução: Os bagres, cachara (*Pseudoplatystoma fasciatum*) e o pintado (*Pseudoplatystoma corruscans*) espécies migratórias de água doce no Brasil possuem grande importância ecológica e potencial para aquicultura, no entanto, o crescimento dessas espécies em cativeiro, ainda, é problemático. Nesse sentido, a produção de animais híbridos provenientes do cruzamento entre a cachara e o pintado (*Pseudoplatystoma* sp.) tem sido praticada de forma intensa no Brasil, pois os híbridos demonstram melhores taxas de sobrevivência e de desempenho de crescimento em cativeiro. **Metodologia:** No intuito de avaliar a ocorrência e a biologia de peixes híbridos na bacia do rio São Francisco, peixes foram coletados, de janeiro de 2011 a janeiro de 2012, em dois trechos do rio Paraopeba. **Resultados:** Durante as campanhas de campo realizadas, foi registrada a presença e a atividade reprodutiva desse bagre híbrido de grande porte em uma das maiores bacias hidrográficas do Brasil, uma área rica em fauna de peixes endêmicos. **Discussão:** A introdução de peixes não nativos ou mesmo híbridos em sistemas naturais, frequentemente, ocorre devido a fugas acidentais de tanques de piscicultura ou mesmo de pesque-pague. A verificação da ocorrência de *Pseudoplatystoma* sp. em grande parte da sub-bacia do rio Paraopeba e de seu sucesso reprodutivo no ambiente natural, juntamente ao fato de que este peixe é um predador de grande porte, são resultados que mostram uma ameaça real para a fauna de peixes nativos da bacia do rio São Francisco. **Conclusão:** Uma vez que o impacto ecológico da introdução de *Pseudoplatystoma* sp. na comunidade de peixes nativos pode ser desastroso, a elaboração de novos estudos com ênfase, principalmente, no desenvolvimento de técnicas para controlar sua dispersão é de fundamental importância.

Palavras-chave: Peixes não-nativo; invasão; bagre Neotropical híbrido; reprodução.

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Abstract

The catfishes cachara (*Pseudoplatystoma fasciatum*) and pintado (*Pseudoplatystoma corruscans*) are important migratory freshwater catfish in Brazil, however, the growth of these species in captivity is still problematic. Therefore, the production of hybrid animals from cachara and pintado (*Pseudoplatystoma* sp.) has been intense in Brazil due these hybrids demonstrate better growth performance. To perform our study, sampling was conducted from January 2011 to January 2012 in two sections of the Paraopeba River. We registered the invasion and reproduction of a hybrid Neotropical catfish in one of the largest rivers basin in Brazil, an area rich in endemic fish fauna. This fish was introduced into natural systems possibly as escapees from aquaculture ponds or from artificial ponds built for sport fishing. *Pseudoplatystoma* sp. are large, top predators, and therefore have the potential to be a serious threat to native fish fauna of the São Francisco River basin, particularly as we detected that it has become widespread in all Paraopeba River and their reproductive success in the natural environment was registered. The real ecological impact of *Pseudoplatystoma* sp. on the local fish community is still unknown and calls for further studies with emphasis principally on developing techniques for controlling its dispersal.

Key words: Non-native fish; invasion; hybrid Neotropical catfish; reproduction.

Introdução

The hydrographic basin of São Francisco River is formed by a network of tributaries that drain an area of 645,000 square kilometers¹. Until now, there were 208 native fish species in this basin, of which about 30 % are endemic, and at least 16 other exotic species². Of the species recorded in São Francisco River basin, 22 are officially endangered, mainly due to habitat destruction, dams, and introduction of exotic species³. Literature information⁴ also suggest that migratory fish fauna of the São Francisco River basin is threatened in some of its tributaries, as in the Paraopeba River. The main threats to endemic fishes of this basin possibly are increasing water abstraction and pollution, non-native species, water retention structures (mainly reservoirs) and agriculture.

Non-native freshwater fishes are recognized as one of the major causes of the worldwide decline of aquatic fauna^{5,6}. Biological invasions are regarded as a form of global change⁷, and many human activities, such as agriculture, aquaculture, recreation and transportation, are the cause of intentional or accidental spread of species away from their natural ranges of distribution⁸. Although most new species fail to establish viable populations, those that persist can threaten native biodiversity and ecosystem functionality⁹. Compared to terrestrial ecosystems, aquatic ecosystems have proven particularly vulnerable to invasive exotic species¹⁰. The direct link between invasiveness and impact on the host ecosystems of an exotic species is not easily demonstrable¹¹. The identification and monitoring of

invasive species in natural environment has a fundamental importance to adopt measures of conservation and management of diversity¹².

Catfish of the *Pseudoplatystoma* genus belongs to the family Pimelodidae, a freshwater fish family with 93 species¹³ found in almost the entire Neotropical region. Many large-sized pimelodid species as *Pseudoplatystoma corruscans* and *Pseudoplatystoma fasciatum* are important because of their high commercial value and ecological role as voracious predators^{14,15}. From an ecological perspective, large pimelodid catfishes are known for their remarkable long- distance migratory behavior in large rivers such as the Amazon, Paraguay, Paraná and Orinoco¹⁵.

Morphologically, the *P. corruscans* and *P. fasciatum* are quite similar. Both have fusiform body and depressed head, three pairs of barbells of which one dark in the maxilla, and the other two mentonian whitish. The mouth is large, subterminal with premaxillary slightly projected in front of the lower maxilla, the teeth are viliformes, the eyes are small in the dorsal position, the caudal fin had rounded lobes and the dorsal and pectoral fins and have a hard serrate aculeus. There have scales on the body, which is coated only by thickened skin¹⁶. The color of the fish is dark gray on the back, clearing toward the ventral side, and becoming white slightly below the lateral line. However, these species can be separated by corporal pattern of spots, where: *P. fasciatum* has irregular black vertical bands, well separated from each other, starting in the dorsal region and extending to below lateral line and sometimes it has some spots rounded or elongated at the end of the bands, while *P.*

corruscans presents only rounded maculae on the back and flanks and well rounded and smaller blotches on dorsal and caudal fins. When carried out the hybridization of the two species, individuals exhibit intermediate pattern of coloration of the two-parent species, with rounded blotches scattered throughout the body, especially the dorsal part of the skull and fins, while in the back and flanks, macules prevail connected horizontally or vertically and some vertical bands or horizontal (Figure 2B and C).

The catfishes cachara *Pseudoplatystoma fasciatum* (Linnaeus, 1766) and pintado *Pseudoplatystoma corruscans* (Spix and Agassiz, 1829) are important migratory freshwater catfish in Brazil due to the quality of their meat and large size as well as having a historical importance in the regions where they are distributed. However, the growth of these species in captivity is still problematic, given their high rates of cannibalism and the sparse information regarding their initial biology and morphophysiological parameters during the early stages of life¹⁷. Moreover, the presence of dams blocking upstream migration and overfishing led to the designation of *P. corruscans* as a critically endangered species in some places¹⁸. Therefore, the production of hybrid animals from cachara and pintado has been intense in Brazil due to the empirical feedback from fish farmers who believe that these hybrids demonstrate better growth performance in captivity¹⁹.

Despite the possible advantages in the performance of hybrid fish cultivation such as *Pseudoplatystoma* sp. (cachara x pintado), it is common for fish farm levees to break or for them to flood, resulting in the release of these individuals into the natural environment. In this sense, some authors²⁰ think that hybridization between species is among the five primary causes for biodiversity loss. Therefore, there is intense pressure from the environmentalists in Brazil to prohibit the production of hybrids²¹. However, studies related to the ecological success of hybrid fish are still at an incipient stage in Brazil, and it is thus difficult to assess the effects of hybridization from an ecological point of view²².

Thus, the objective of this study is to show for the first time, the invasion of a hybrid catfish from *Pseudoplatystoma corruscans* x *Pseudoplatystoma fasciatum* into the São Francisco River basin and, reports the reproductive success of this fish in a natural environment.

Methodology

Sampling was conducted from January 2011 to January 2012 in two sections of the Paraopeba River, section A - 19°57' S - 44°17' W and section B - 18°52' S - 44°46' W, using gill nets, casting net and spearfishing. To obtain total length (TL), body weight (BW), and gonad weight (GW), as well as samples of ovarian tissue, fish were killed by transversal section of the cervical medulla following the ethical principles for animal manipulation established by the Brazilian

College for Animal Experimentation (COBEA, <http://www.cobea.org.br>). For each female, the gonadosomatic index were calculated according to the following equation: $GSI = GW \times 100/BW$. Data were presented as mean $\pm$ standard deviation.

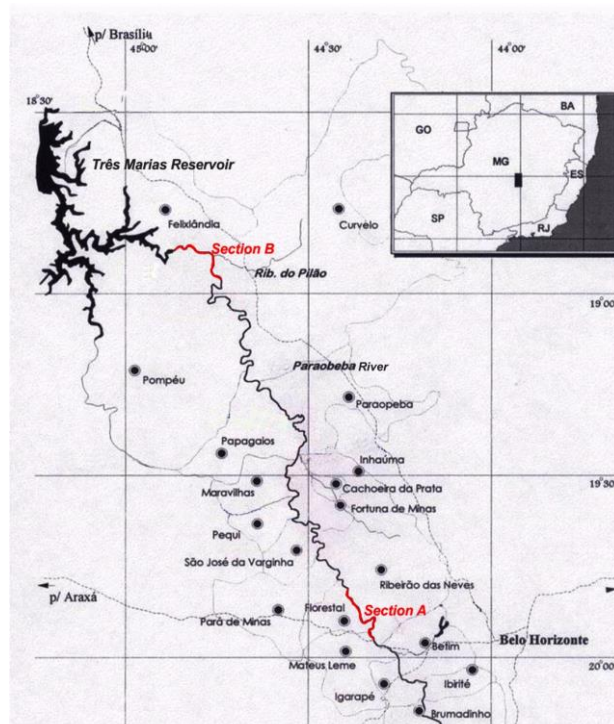


FIGURE 1- Map of the Paraopeba River basin showing the sampling locations

To assess gonadal maturation, ovarian samples were fixed in Bouin's solution for 12 h, embedded in paraffin, sectioned at 5 μ m, and stained with hematoxylin-eosin and Gomori's trichrome for histological analyses. Based on macro and microscopic characteristics of the ovaries, the maturation stages were determined: F1 resting (thin, translucent, with little vascularization of the ovaries, and presenting initial and advanced perinucleolar follicles); F2 mature (yellowish, and very voluminous ovaries, with numerous follicles visible to the naked eye, blood vessels evident in the ovaries, and presenting follicles in different development stages with abundant vitellogenic follicles); F3 spawning (yellowish, voluminous, with a large number of follicles visible to the naked eye, blood vessels more evident, and presenting perinucleolar, vitellogenic and postovulatory follicles in the ovigerous lamella); F4 post-spawning (reddish, minimally voluminous, with opaque follicles visible to the naked eye, intense blood vascularization, and presenting eventual postovulatory follicles, perinucleolar follicles, vitellogenic follicles in atresia).

The distribution of the frequency of length classes of fish was obtained from the "Sturge's rule". Were the numbers of intervals (k) for each number of observations with (n) values can be calculated as: $k = 1 + 3,322(\log_{10} n)$.

Results

A total of 14 individuals of *Pseudoplatystoma* sp. were captured, of which eight from section A and six from section B. All individuals collected were females (08 juveniles and 06 adults). Females from section A had 105.2 ± 16.7 cm TL and 10.3 ± 4.6 kg BW, while those from section B had 91.9 ± 23.6 cm TL and 7.5 ± 5.9 kg BW (data expressed as means $\pm$ standard deviation). The presence of juvenile and adult's fishes in the two sampled sections indicate that hybrid catfish *Pseudoplatystoma* sp. became widespread in all of the Paraopeba River since the places where this fish was caught are about 250 km distant from each other.

All adult females captured in the rainy season presented macro (Figure 2E) and microscopic (Figures 2G-I) characteristics of initial (presenting eventual postovulatory follicles, perinucleolar follicles and many vitellogenic follicles) or total spawning (presenting many postovulatory follicles, eventual healthy vitellogenic follicles and vitellogenic follicles in atresia), indicating their reproductive activity in the study area. Fish with ovaries in the resting stage showed the lowest values of GSI (1.39 ± 0.55), while mature females presented higher values of GSI (4.71 ± 0.24). Fish with histological features of spawning, showed intermediate values of GSI (1.82 ± 0.90).

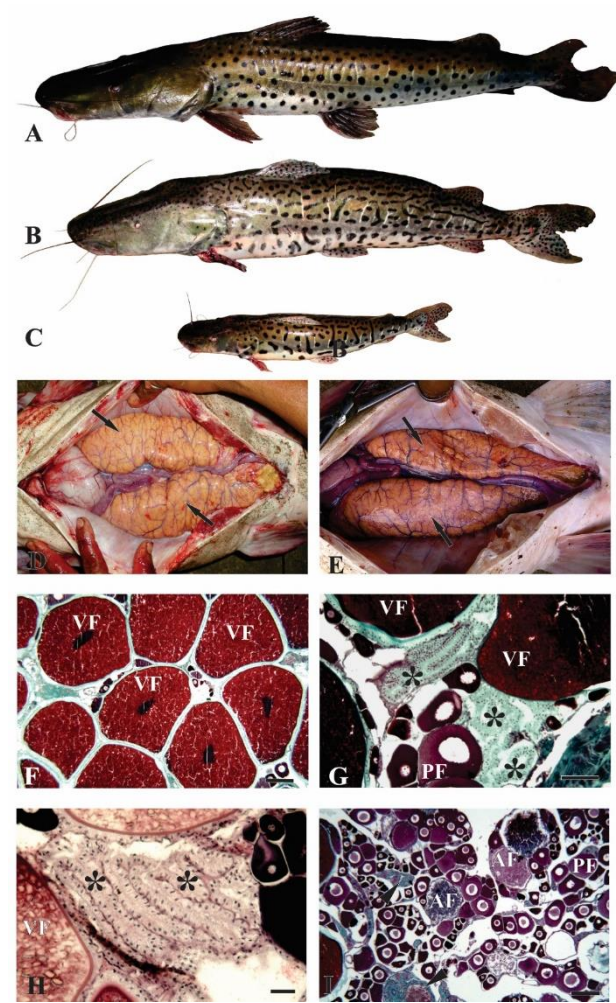


FIGURE 2- Macro and microscopic views of *Pseudoplatystoma corruscans* (A) adult (119 cm) *Pseudoplatystoma* sp. specimens and ovaries. (B) adult (128 cm), (C) juvenile (74 cm), (D) mature ovaries (macroscopic view), (E) partially spawned ovaries (macroscopic view), (F) mature ovaries (microscopic view), (G-H) partially spawned ovaries (macroscopic views), (I) spawned ovaries (microscopic view). Arrows=ovaries in macroscopic views; asterisks=postovulatory follicles; VF=vitellogenic follicles; PF=perinucleolar follicles; AF=atretic follicles; arrow heads=vascularization. Scale bar (E-H=200 μ m; F-G=100 μ m).

The total length varied from 74 to 128 cm, distributed into 3 classes with amplitude of 10 cm (Figure 3). Individuals of the smallest size class

represent juvenile individuals, while individuals of the middle length class were represented by females that showed histological characteristics of ovarian

maturation and spawning. The largest specimen was a female collected in January of 2010, measuring 128 cm in total length and weighing 17 kg. The absence of male form sampling should also be noted.

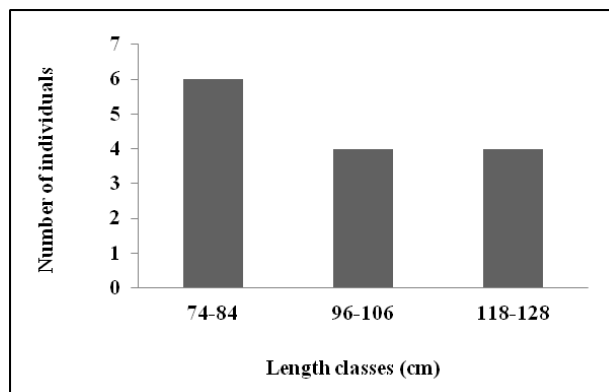


FIGURE 3 - Distribution of the absolute frequencies of occurrence of *Pseudoplatystoma* sp. grouped into classes by total length from the Paraopeba River during the study period.

Discussion

The aim of this paper is the finding that a hybrid fish introduced artificially in natural environments, is capable to reproduce and colonize new habitats, which could generate competitive pressure on the species endemic. The introduction of non-native species is the second greatest cause of species extinction, surpassed only by degradation of habitats²³. Besides the local extinction of native species, the introduction of exotic or allochthonous species is responsible for other impacts, such as changes in the trophic webs and population balance of the communities and alterations in the functional processes of ecosystems²⁴. These changes occur due to the competition for food and space between native and introduced species, predation of native species, introduction of new pathogens and parasites, possible hybridization between proximate species²⁴ and invasion of areas of high endemism²⁵. Invasive species can cause the decline of native species⁵. The data of our study indicate that hybrid catfish *Pseudoplatystoma* sp. became widespread in all of the Paraopeba River since places where this fish was caught are about 250 km distant from each other.

The success of biological invasions involves complex interactions between the invading species and the physical and biological characteristics of the recipient environment. These interactions are made more complex by the case-specific characteristics of the introduction event and a variety of ecological phenomena including: Allee effects²⁶; behavioral changes²⁷; adaptation and phenotypic plasticity²⁸, and, the potential lag between invasion and establishment²⁹. Therefore, the ecological success of an introduced species is generally difficult to predict³⁰, however, in the Paraopeba River, southeast Brazil, the colonization of the catfish *Pseudoplatystoma* sp. appears to be particularly successful, as adults in reproductive activity and juveniles of

Pseudoplatystoma sp. were captured in our study from both sections of the Paraopeba River.

The macroscopic aspect of spawned ovaries is generally flaccid and reddish in colour organs, presenting an intense blood vascularization, moreover, the spawning success is histologically characterized by the presence of postovulatory follicles³¹. In our study, all adult females captured in the rainy season presented macro and microscopic characteristics of total or partial spawning, indicating their reproductive activity in the study area. Even in native and healthy fish, the presence of post-ovulatory and atresic follicles is common at the same time, especially in total spawning fish such as those belonging to the genus *Pseudoplatystoma*, when vitellogenic oocytes remaining after the spawning cycle begin the process of atresia. Moreover, the presence of juvenile individuals in a population is an indication that the recruitment of new individuals into this population is occurring, and can demonstrate that these habitats are favorable to the development of the species³². Literature information³³ suggests that the structure of populations of freshwater fish in some locations coincides with the appearance of different stages of development, which may characterize their ability to occupy effectively the ecosystem in question. The successful colonization of environments by exotic species has been reported for other catfish³⁴. In this sense, the results of our study indicate that a hybrid fish such as *Pseudoplatystoma* sp. might be able to invade, reproduce and colonize natural environments.

In conclusion, it is important to determine the extent of spread of *Pseudoplatystoma* sp. in all the São Francisco River basin and to verify its impact on native fish and fisheries since it is a top predator, which according to literature¹⁹, has a higher survival rate in the early stages of life, supporting thus the most

adverse environmental conditions than the *P. corruscans*, species native to the basin. Therefore, a study should be developed to verify whether *Pseudoplatystoma* sp. is already established in this hydrographic basin of the São Francisco River, and what impacts it may have on the native fish community, and which methods are best for capture

and control of this species. This information could drive future decisions concerning new introductions, including any eventual benefits they can bring to sport fishing and local economies, considering the possible loss of biodiversity, as well as contributing to the development of management plans that minimize potential impacts of this invasive species.

Declaration of conflicts of interest

The authors of the article affirm that there was no conflict of interest situation, such as proposals for financing, issuing opinions, promotions or participation in advisory committees or boards, among others, that could influence the development of the work

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