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Perspectives on ornamental fisheries in the upper Paraná River floodplain, Brazil

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Abstract

South America has remarkable fish diversity, with many species regarded as ornamentals. Each year, ornamental fishes worth billions of dollars are traded worldwide. In Brazil, in spite of its large geographic area and many different drainage basins, the trade is restricted to the Amazon region. Considering that the ornamental potential is unknown in other basins, this work aimed to assess the potential in the last remaining floodplain of the upper Paraná River basin. Fish collections associated with the PELD-CNPq project (Site 6) from 2000 and 2001 were analyzed. Fishes were collected with gill nets and beach seines in lagoons, channels and rivers of the floodplain. To evaluate the ornamental potential, this analysis categorized all taxa recorded as: (i) ornamental, (ii) potentially ornamental, (iii) lawful, and (iv) suggested lawful. A total of 101 taxa were captured, with 40.6% cited as ornamental in the literature and an additional 42.6% are considered as potentially ornamental. Of these taxa, Brazilian legislation restricts the trade to only 10 species, mainly small Characiformes, which are abundant in many lagoons and already well known in the market. CPUE and density catches differed among environments, with higher values for ornamental and lawful taxa observed in lagoons. Some isolated lagoons showed extremely high lawful fish densities (over 3000 ind./100 m^2). Considering our results, the upper Paraná River floodplain has great potential for ornamental fisheries. The ornamental fishery could be a new economic alternative to help alleviate the social poverty found in many cities along the Paraná River. Due to the proximity of the floodplain to larger cities such as Maringá and Paranavaí, establishment of ornamental trade activities will demand less capital and at the same time reduce problems associated with transport, aviamento and fish mortality. Species richness and captures (density and CPUE) indicated an existing ornamental potential in this floodplain, but only future studies will assure if stocks can endure pressures of such a selective fishery.

Keywords: Tropical fishes; Ornamental fisheries; Resource exploitation; Wildlife conservation; Fishery establishment; Legislation; Reservoir impacts

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1. Introduction

Maintenance of fishes in aquaria and ponds for ornamental purposes began more than one thousand years ago, and is common today in both oriental and occidental cultures (Mills, 1998; Rowland and Cox, 1998). At present, fish-keeping cannot be regarded simply as a hobby, but as a worldwide market generating millions of dollars annually. Around 350 million fishes are traded each year, with the total value exceeding US$ 300 million (Bartley, 2000; Ministry of Agriculture of Netherlands, 2002).

Many questions can arise when this subject is in discussion, involving mainly fish ecology and conservation. One important concern is that despite obvious benefits of the trade, such as employing thousands of people and attenuating environmental impacts (Whittington et al., 2000; Norris and Chao, 2002), it may also bring considerable problems such as overfishing of native stocks or promoting introductions of exotic species (Andrews, 1990; Fuller et al., 1999). To match conservation and exploitation objectives, development of new fisheries should be properly organized, taking into account some limits and regulations (Gullestad, 1998).

In Brazil, even with its huge geographic area and many different drainage basins, the ornamental fish trade is basically restricted to the Amazon region (especially the Rio Negro and Xingu basins). This area supports one of the highest fish diversities in the world, with many species regarded as ornamentals (Chao, 1993, 2001). The Paraná River basin, the second largest basin of South America, also has a remarkable ichthyofauna (Agostinho and Julio, 1999). In particular, the floodplain located in the upper Paraná River is an area that harbors many fish species (Gaspar da Luz et al., 2004), being the last river-stretch free from dams and characterized by annual flood cycles. The floodplain comprises many different environments, each characterized by distinct fish assemblages (Luiz et al., 2004). Despite the high fish species richness found in this region, there is no ornamental fishery and no studies have evaluated the ornamental potential. Considering this absence of information, the present work aimed to evaluate the ornamental potential in the upper Paraná River floodplain, discussing the feasibility of future resource utilization and possible risks and benefits that could arise with its establishment.

2. Materials and methods

2.1. Site description and data collection

The study area is located in the last stretch of the Paraná River free from dams, delimited by Porto Primavera and Itaipu reservoirs (Fig. 1). Data were collected in association with the PELD/CNPq project (Long Term Ecological Studies – Brazilian Research Council) ‘A Planície Alagável do Alto Rio Paraná, Site 6’, during 2000 and 2001. Samples were taken quarterly from 35 sites, covering four typical floodplain environments: connected lagoons (16), isolated lagoons (12), channels (4) and rivers (3; Paraná, Ivinhema and Baía rivers). Descriptions of the habitats and their physical/chemical properties can be found in Vazzoler et al. (1997) and Agostinho et al. (2004). Fishes were collected by gill-netting (lagoons, channels and rivers) and beach seining (connected and isolated lagoons). The former comprised a set of 11 nets with different mesh sizes: 2.4, 3–8, 10, 12, 14 and 16 cm between opposite knots. Nets were exposed for 24 h and checked at morning (8:00), mid-day (16:00) and night (22:00). Shoreline areas of lagoons were seined during the day with a 20 m net with 0.5 cm mesh. Fishes were identified and abundance transformed to CPUE for gill net samples (ind./1000 m^2/24 h) and fish density for seine samples (ind./100 m^2).

2.2. Evaluating the potential

To evaluate the ornamental potential, we categorized all taxa recorded as: (i) ornamentals, when the taxon was cited in specific literature as ornamental (Axelrod et al., 1981, 1997; Mills, 1998); (ii) potentially ornamental, when only the genus was cited in specific literature; (iii) lawful, taxa allowed for capture and commercialization with ornamental purposes by IBAMA (Brazilian Institute of the Environment and Renewable Natural Resources; Decree No. 62-N, of 10 June of 1992); and (iv) suggested lawful, taxa present in the draft list proposed by Chao (1998) which expands the IBAMA list to almost 400 species.

To identify habitats containing ornamental taxa, we calculated the total number of ornamental and lawful taxa in each environment (connected and isolated lagoons, channels and rivers), collected by gill nets and seines. Fish CPUE and density were calculated

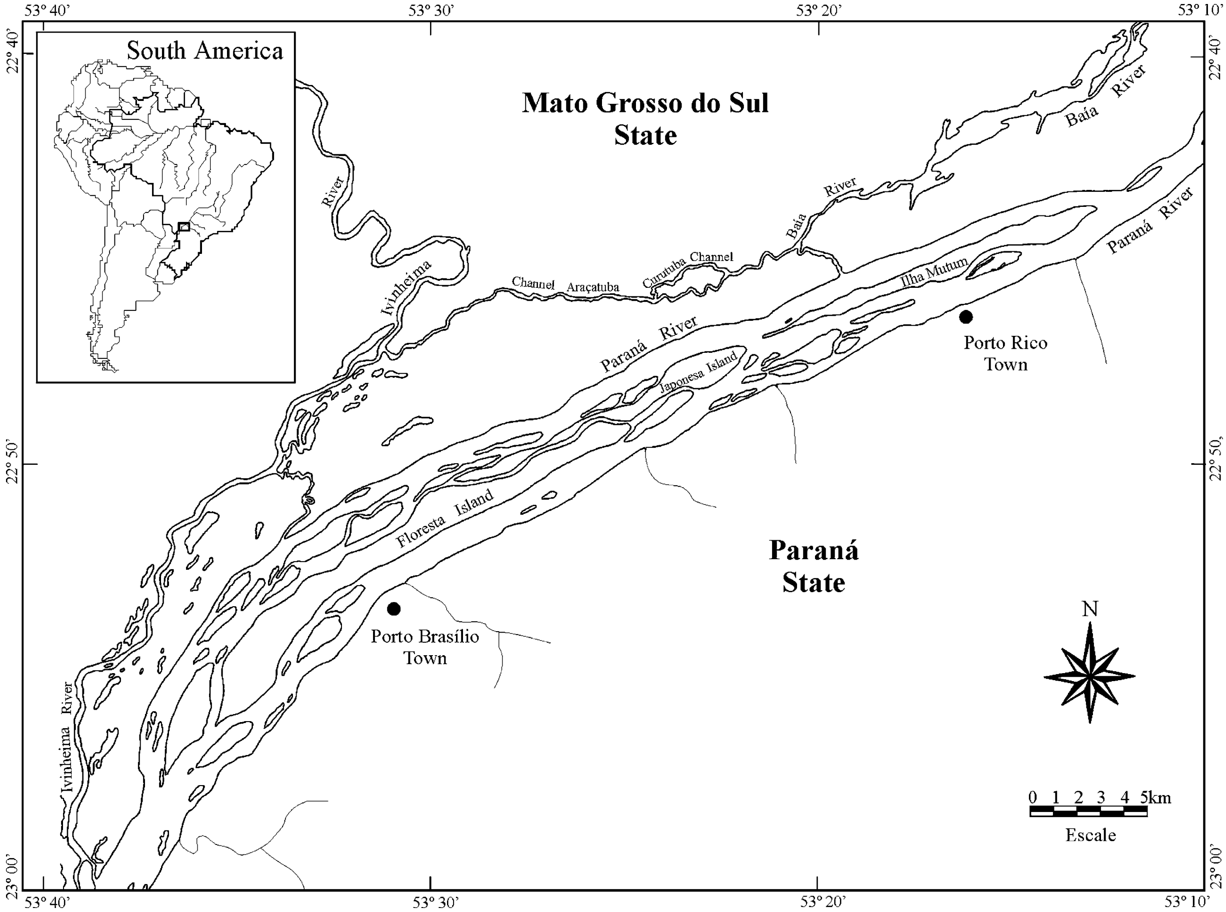

Fig. 1. Regional map illustrating the upper Paraná River floodplain, Brazil. The floodplain is formed by three main rivers (Paraná, Ivinhema and Baía rivers), and is composed of many lagoons and channels during flood cycles.

for some target taxa in each environment. Total CPUE and density were calculated for ornamental and lawful taxa among the four environments to determine which environment has the greatest ornamental fishery potential. One-way analysis of variance (ANOVA) was used to test for differences in total capture among environments. Statistically significant differences implied an $\alpha < 0.05$, and means were compared using Tukey's post hoc tests ($p < 0.05$). CPUE and density values were $\log(x+1)$ transformed to normalize distributions and correct variances. Additionally, to explore annual dynamics of lawful fish density in connected and closed lagoons, mean density, coefficient of variation and the range of densities were calculated quarterly during the 2-year period.

3. Results

3.1. Species richness

A total of 101 fish taxa was collected during the study period, belonging to the following orders: Characiformes (50), Silurifomes (30), Perciformes (10), Gymnotiformes (7), Cyprinodontiformes (1), Myliobatiformes (1), Synbranchiformes (1) and Pleuronectiformes (1). Among the 101 taxa, 41 were listed as ornamental (40.6%) and an additional 43 taxa (42.6%) were cited as potential ornamentals (Fig. 2), considering synonyms and erroneous classification. Therefore, at least 40% of the taxa have been traded in the market, by the simple fact that they are present in

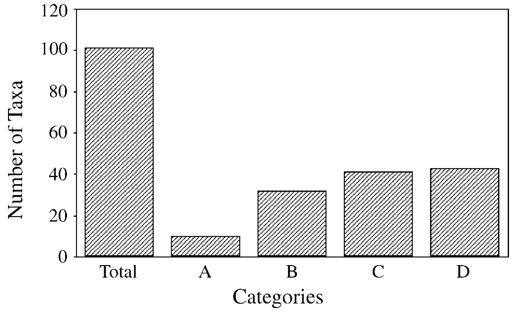

Fig. 2. Number of taxa captured in the upper Paraná River floodplain. In figure: total, total number; A, number of taxa present in the IBAMA list; B, number of taxa present in the draft list proposed by Chao (1998); C, number of ornamental taxa; D, number of potential ornamental taxa.

specialized publications. Summing both categories (84 taxa), 83.2% of all taxa recorded in the floodplain are ornamental or potentially ornamental. Some of these taxa are presented in Table 1.

Currently, Brazilian legislation allows only 180 ornamental fish species to be traded (IBAMA Decree No. 62-N, 10 June 1992; Ventura and Rambelli, 1996). In the upper Paraná River floodplain only 10 species are included in this list, almost exclusively small Characiformes (eight species, Table 1). When the list proposed by Chao (1998) is analyzed, the number of species increases to 32 (Fig. 2). The total number of ornamental and lawful taxa recorded was similar among environments (Fig. 3). The highest ornamental richness was observed in lagoons, where almost all lawful taxa were collected (a total of 9). Lagoons had a fauna

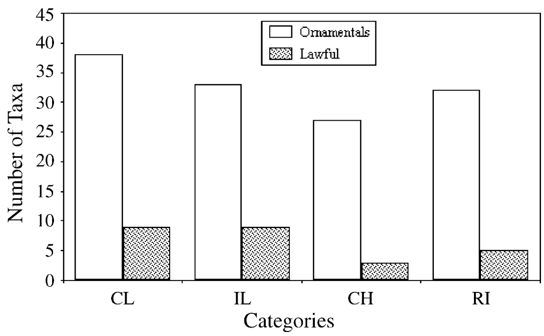

Fig. 3. Number of ornamental and lawful fish taxa registered in different environments of the floodplain. Fishes were collected with gill nets and seines (only in lagoons). Codes: CL, connected lagoons; IL, isolated lagoons; CH, channels; RI, rivers.

Table 1
Some ornamental fish species captured in the upper Paraná River floodplain during 2000 and 2001

Fish taxa	A	B
Myliobatiformes		
Potamotrygonidae		
Potamotrygon motoro (Natterer, 1841)	–	X
Characiformes		
Characidae		
Astyanax altiparanae (Garutti and Britski, 2000)	X	X
Astyanax fasciatus (Cuvier, 1819)	X	X
Hemigrammus marginatus (Ellis, 1911)	X	X
Hyphessobrycon eques (Steindachner, 1882)	X	X
Moenkhausia intermedia (Eigenmann, 1908)	X	X
Moenkhausia sanctaefilomenae (Steindachner, 1907)	X	X
Aphyocharax anisitsi (Eigenmann and Kennedy, 1903)	X	X
Serrapinnus notomelas (Eigenmann, 1915)	X	X
Parodontidae		
Apareiodon affinis (Steindachner, 1879)	–	–
Curimatidae		
Steindachnerina brevipinna (Eigenmann and Eigenmann, 1889)	–	–
Anostomidae		
Leporellus vittatus (Valenciennes, 1849)	X	X
Leporinus octofasciatus (Steindachner, 1917)	–	X
Lebiasinidae		
Pyrrhulina australis (Eigenmann and Kennedy, 1903)	–	–
Gymnotiformes		
Rhamphichthyidae		
Rhamphichthys hahni (Meiken, 1937)	–	–
Gymnotidae		
Gymnotus spp.	–	X
Sternopygidae		
Sternopygus macrurus (Schneider, 1801)	–	X
Eigenmannia virescens (Valenciennes, 1847)	X	X
Siluriformes		
Callichthyidae		
Hoplosternum littorale (Hancok, 1828)	–	X
Perciformes		
Cichlidae		
Astronotus ocellatus (Agassiz, 1831)	–	X

A = species authorized by IBAMA for capture and commercialization with ornamental purposes; B = species included in the draft list proposed by Chao (1998).

composed by small-sized taxa, mainly Characiformes. Differently, channels showed the lowest number of lawful taxa (3), maybe because its fauna was composed predominantly by medium-sized taxa, such as *Loricarichthys platymetopon*, *Parauchenipterus galeatus*, *Serrassalmus* and *Hoplias malabaricus*, besides several anostomids and other Siluriformes. Similar to channels, few lawful taxa were recorded in rivers.

3.2. Captures (CPUE and density)

Analyzing some ornamental and potentially ornamental taxa, gill net CPUE values differed greatly between habitats and between years (Table 2). In addition, CPUE varied notably within habitats, as indicated by high standard error values. Small-sized Characiformes such as *Astyanax altiparanae*, *Moenkhausia intermedia* and *Roeboides paranensis* showed higher CPUE in lagoons. Medium-sized species were caught in all environments, but more frequently in rivers and channels. Anostomids showed high captures in channels, while *Serrasalmus marginatus*, *H. malabaricus*, *P. galeatus* and *L. platymetopon* showed high CPUE values in all habitats. Gymnotids showed low CPUE values in all environments, possibly due to gear selectivity. No trend in CPUE values was observed between years.

Similarly, density of some ornamental taxa captured with seines in lagoons differed greatly according to habitat and year (Table 3). Again, high standard error values were observed, indicating that fish density varied considerably among lagoons of a same category. Small characids such as *A. altiparanae*, *M. sanctafilomenae*, *Aphyocharax anisitsi* and *Serrapinus notomelas* predominated in isolated lagoons, showing high mean density values (over 30 ind./100 m^2). Although there was large variation in fish density between years, no trend was observed.

Species showing the highest captures in Tables 2 and 3 can be considered the most inclined to commercial harvest. Moreover, to maximize fisheries in the floodplain (focusing on principal target-species), our results suggest that the environment as much as the fishing gear should be considered.

When investigating trends for all ornamental and lawful taxa between habitats, significant differences were observed in total gill net CPUE values (ANOVA; Fig. 4A). Lagoons and rivers showed higher ornamental CPUE, with approximately 250 ind./1000 m^2 net/24 h.

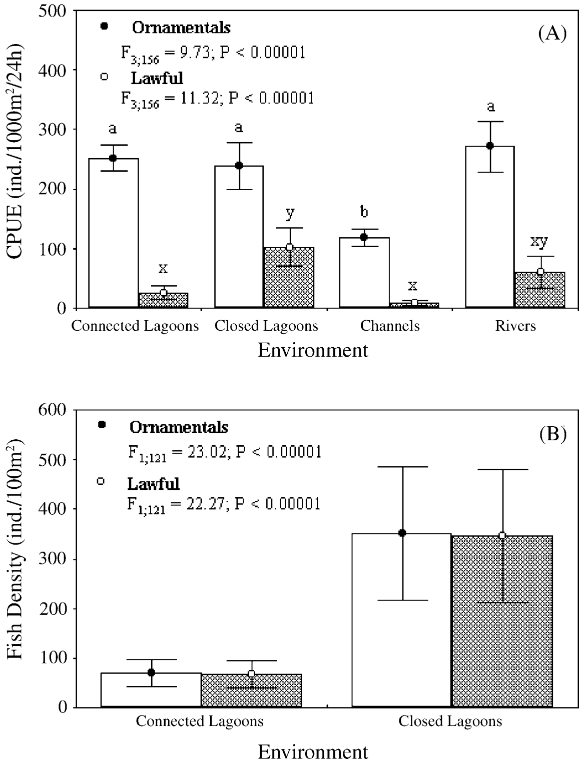

Fig. 4. Mean CPUE and fish density of ornamental taxa collected in different environments of the floodplain, using gill nets (A) and beach seines (B). Lawful taxa are those allowed for commercialization in the ornamental trade. Data presented are not transformed and bars represent standard errors of means.

Channels had the lowest value, with a mean CPUE of 120 ind./1000 m^2 net/24 h. Considering lawful taxa only, highest captures were recorded for isolated lagoons (mean of 100 ind./1000 m^2 net/24 h).

Significant differences were also observed in total density of ornamental and lawful taxa between connected and closed lagoons, sampled with seines (ANOVA; Fig. 4B). Isolated lagoons showed higher densities of both ornamental and lawful fishes, with a mean density over 350 ind./100 m^2 for both taxa categories. Interestingly, lawful density was similar to ornamental density in both classes of lagoons, indicating that the 'ornamental assemblage' is basically composed by species already allowed for the trade.

Analyzing quarterly variation in total density of lawful taxa, although isolated lagoons showed highest fish densities, no trend was detected among months and between years in the two classes of lagoons (Table 4).

Table 2
Mean CPUE values (ind./1000 m^2 net/24 h) of fish caught with gill nets in different environments of the floodplain in 2000 and 2001 (standard errors in parenthesis)

Fish taxa	Connected lagoon		Isolated lagoon		Channel		River	
	2000	2001	2000	2001	2000	2001	2000	2001
Characidae								
Astyanax altiparanae	2.87 (1.11)	6.04 (2.61)	29.55 (16.24)	76.43 (30,00)	2.72 (0.99)	6.11 (2.85)	6.79 (3.61)	19.48 (10.11)
Moenkhausia intermedia	15.50 (9.44)	25.51 (17.46)	69.97 (38.47)	26.50 (18.49)	7.13 (6.42)	1.02 (0.55)	64.31 (46.89)	22.19 (14.43)
Roeboides paranensis	7.095 (2.746)	17.67 (6.11)	36.69 (15.61)	44.16 (14.68)	3.06 (0.99)	6.79 (3.31)	15.85 (4.98)	11.77 (3.83)
Serrasalmus marginatus	147.80 (41.79)	84.54 (13.92)	69.63 (17.11)	30.57 (8.12)	37.70 (8.55)	35.33 (11.18)	47.55 (20.08)	37.78 (15.29)
Parodontidae								
Apareiodon affinis	–	–	–	–	0.34 (0.34)	–	52.99 (36.78)	33.06 (17.04)
Anostomidae								
Leporinus lacustris	26.57 (6.31)	15.55 (4.10)	52.65 (14.25)	13.93 (3.81)	13.25 (6.05)	16.98 (9.43)	6.79 (4.54)	6.34 (2.82)
Schizodon borellii	25.51 (4.59)	14.64 (2.24)	26.50 (4.73)	4.75 (2.62)	27.17 (5.37)	30.91 (11.26)	17.21 (4.48)	8.15 (3.44)
Erythrinidae								
Hoplias malabaricus	34.72 (5.61)	43.78 (12.18)	25.81 (5.05)	13.25 (3.40)	20.04 (4.17)	31.25 (6.72)	12.23 (3.07)	16.76 (3.75)
Doradidae								
Trachydoras paraguayensis	37.74 (25.20)	13.28 (4.83)	–	–	5.10 (2.19)	8.15 (6.84)	59.33 (27.14)	8.61 (3.81)
Auchenipteridae								
Parauchenipterus galeatus	69.44 (8.80)	51.18 (10.33)	64.20 (20.64)	32.61 (13.15)	14.61 (4.20)	32.27 (7.15)	30.80 (14.20)	17.66 (11.24)
Loricariidae								
Liposarcus anisitsi	19.02 (3.37)	20.53 (4.65)	10.87 (3.02)	6.11 (1.48)	2.04 (0.84)	1.70 (0.82)	6.79 (2.85)	20.38 (11.14)
Loricariichthys platymetopon	114.28 (15.86)	96.17 (13.64)	79.82 (16.81)	90.35 (19.22)	28.53 (6.29)	49.93 (14.17)	44.38 (16.39)	73.82 (28.67)

Table 3
Mean fish densities (ind./100 m^2 ± S.E.) observed in floodplain lagoons, sampled with beach seines in 2000 and 2001 (standard errors in parenthesis)

Taxa	Connected lagoon		Isolated lagoon	
	2000	2001	2000	2001
Characidae				
Astyanax altiparanae	2.85 (0.90)	2.61 (0.87)	67.51 (38.84)	74.98 (56.99)
Hemigrammus marginatus	12.46 (7.33)	7.99 (5.10)	13.75 (7.90)	3.29 (2.87)
Hyphessobrycon eques	3.54 (2.08)	31.74 (19.40)	8.58 (3.14)	17.84 (12.73)
Moenkhausia intermedia	5.12 (3.61)	0.92 (0.55)	22.86 (8.43)	1.61 (1.03)
Moenkhausia sanctaefilomenae	5.95 (1.98)	3.97 (2.10)	42.58 (23.88)	49.62 (38.57)
Aphyocharax anisitsi	2.09 (0.750	2.90 (1.16)	17.08 (8.90)	61.79 (41.90)
Serrapinus notomelas	7.87 (2.68)	44.42 (31.71)	137.61 (47.79)	175.64 (121.65)
Curimatidae				
Steindachinerina insculpta	4.33 (2.18)	0.55 (0.23)	60.83 (29.26)	28.84 (24.72)

Furthermore, a high variability within habitats and among months characterized fish density dynamics, evidenced by high coefficients of variation and the range of densities observed. It is worthwhile to mention that 2000 and 2001 were atypical years, characterized by an intense drought and the lack of flood cycles.

3.3. Attractive species

Focusing on the most attractive taxa, *M. sanctaefilomenae*, *A. anisitsi*, *S. notomelas* and *Hyphessobrycon eques* are the species very popular in both national and international markets (Hunziker, 1986). Additionally, *A. altiparanae*, *Hemigramus marginatus*, *M. intermedia*, *Pyrrulina australis* and *Hoplosternum littorale* are the species well known in the Brazilian market. Other taxa of the genera *Aphyocharax*, *Astyanax*, *Serrapinus*, *Leporinus*, *Ageneiosus*, *Loricaria*, *Hypostomus*, *Eigenmania*, *Rivulus*, *Crenicichla*, *Myleus*, *Cichlassoma* and *Laetacara*, seem to show market favorability. Furthermore, taxa such as *Potamotrygon motoro*, *Astronotus ocellatus*, as well as some species of *Cichla* and various Gymnotiformes can aggregate high individual values (however, it is important to note that *A. ocellatus* and *Cichla* are introduced in this floodplain and must be viewed with care, because they are piscivores and have caused impacts in other environments (Latini and Petrere, 2004)).

Although esthetically attractive and peculiar, several captured taxa are not cited as ornamental: *Odontostilbe*, *Galeocharax*, *Erythrinus*, *Brachyhypopomus*, *Poropterogus*, *Loricariichthys*, *Megalancistrus* and *Catathyrid-*

Table 4
Mean density of lawful ornamental fishes collected with seines in lagoons of the upper Paraná River floodplain during 2000 and 2001

	Connected lagoons				Isolated lagoons			
	n	$\bar{x}$	CV	Range	*n*	$\bar{x}$	CV	Range
2000								
February	7	32.21	1.32	5.32–124.71	9	255.98	1.23	13.79–1037.46
May	7	60.66	1.14	0–205.31	9	228.19	1.48	2.46–1086.63
August	7	6.49	1.06	0–17.31	9	408.00	2.34	0.38–2928.75
November	7	60.26	0.91	8.29–157.32	9	347.74	2.18	19.09–2355.32
2001								
February	7	17.07	0.83	2.6–41.73	9	97.07	1.35	4.91–345.34
May	7	30.63	0.76	0–60.15	9	923.83	2.90	5.15–8071.12
August	7	197.08	2.59	0.61–1355.67	7	363.52	2.24	4.31–2202.42
November	7	133.43	2.05	0–742.13	6	44.64	0.91	14.98–123.55

Codes: *n*, number of lagoons; $\bar{x}$, mean density; CV, coefficient of variation; Range, range of density.

ium. These taxa have potential to be valued in the market. Some other genera, regarded as ornamental and registered in previous surveys of this floodplain (Agostinho et al., 1997; Agostinho and Julio, 1999), were not caught in this study: *Apteronotus*, *Phalloceros*, *Poecilia*, *Aequidens*, *Tatia*, *Callychthys*, *Pseudocetopsis*, *Trichomycterus*, *Corydoras*, *Farlowella*, *Bunocephalus* and some small pimelodids.

4. Discussion

In terms of taxa richness the upper Paraná River floodplain seems to have great potential to develop an ornamental fishery. Our results showed that 40.6% of all taxa recorded were ornamentals and an additional 42.6% were potentially ornamental. Therefore, qualitatively, almost the entire fish assemblage is appreciated in the ornamental trade. In addition, several other taxa not cited in specific literature may be attractive to the market (colorful patterns and unique morphologies/ecologies). This perspective enhances the ornamental potential, and we presume that the upper Paraná River floodplain would not experience problems associated with lack of demand.

Previous studies reported that fish assemblages in this floodplain are correlated with habitats characteristics, e.g. lagoons, channels and rivers (Agostinho et al., 1997; Luiz et al., 2004). Although each environment tends to have a particular fauna, the number of ornamental species was similar among them. Lagoons showed the highest ornamental species richness, probably due to presence of small-sized taxa, which are more appreciated in the trade. Therefore, to preserve high ornamental species richness in the floodplain, habitat integrity and functioning must be maintained.

The biota of the upper Paraná River floodplain, as well as its dynamics, is strongly influenced by flooding cycles (Agostinho and Zalewski, 1995; Agostinho et al., 1997; Vazzoler et al., 1997). However, the two years surveyed were characterized by the lack of a typical flood pulse (Petry et al., 2004). After closure of Porto Primavera dam in 1998, water control has changed flood cycles, imposing severe reduction of water levels. Flood interruption, in the long term, may negatively influence fish populations of this system, particularly species-dependent to some degree on the flood period (Suzuki et al., 2004). Analyzing lawful fish density dynamics in lagoons during 2000 and 2001, alterations in fish density did not correlate with seasonal periods. In addition to capture variability, the absence of some species in this survey that were previously recorded in other studies (Agostinho and Julio, 1999), should bring some concern due to the lack of a historical exploitation. The flow regulation imposed by Porto Primavera Reservoir may be causing strong modifications on fish community structure.

In spite of the world famous fish diversity that characterizes many Brazilian basins (Lowe-McConnell, 1999), Brazilian legislation allows the capture and commercialization of only 180 fish species for ornamental purposes, most of them found in the Amazon region. Only 10 species are considered lawful in the upper Paraná River floodplain. Implementation of a broader list (Chao, 1998) could both: (i) diminish effects of overfishing of some stocks by creating a more balanced exploitation, and (ii) improve the fishing yield by increasing the number of lawful species. Nevertheless, legislation alone does not control biological commerce such as ornamental fisheries. Inspection failures and problems with taxonomic identification are the main difficulties. Improvements are necessary within the agency responsible for overseeing biological commerce in Brazil (IBAMA), from planning to inspections.

A large amount of ornamental fish is harvested in the Amazon region, mainly in floodplain habitats of the Rio Negro Basin (Chao, 2001). Total ornamental fish exported from Manaus can exceed 20 million individuals annually, 80% of a single species (*Paracheirodon axelrodi*). A single family involved in the trade can capture and sell over 800,000 fishes during a single season (Chao, 1993). This raises an important question: are the ornamental fish stocks in the upper Paraná River floodplain similar to those found in the Amazon region? For several Amazonian rivers, Santos and Ferreira (1999) reported that total fish CPUE might range from 0.07 to 0.62 ind./m^2/24 h, a value close to the mean fish CPUE observed in the present study (0.60 ind./m^2/24 h, pooling data from lagoons, channels and rivers). Gill nets tend to selectively catch medium and large-sized individuals, and possibly these data do not include a large amount of small-sized taxa, the most esteemed in the trade. Although direct comparisons are difficult, density catches seem to indicate lower ornamental fish densities in the upper Paraná River floodplain when compared to the number of fish exported from the Amazonian rivers quoted above. It is likely that ornamental fish productivity in the Paraná floodplain will not match that of the Amazon, but our results suggest that ornamental fish density is high enough in some environments to support a controlled fishery system. Seine captures showed high ornamental fish density in lagoons, exceeding 5000 ind./100 m^2 (Table 4) in some isolated lagoons, predominantly composed of lawful specimens. Therefore, quantitatively, the floodplain has a suitable ornamental potential. Because fish mortality is high when lagoons are almost dried (Okada et al., 2003), Súarez et al. (2001) suggest that some fishes could be collected before isolated lagoons dry completely in the Pantanal system, although not all isolated lagoons dry out in the Paraná River floodplain. To maximize captures, ornamental fisheries could focus mainly on such habitats.

It is important to consider several social and ecological aspects before establishment of fisheries. At first, acquisition of data concerning species biology, as well as spatial and temporal variations in population and community structure should precede any resource exploitation plan. Unfortunately, much of this information is unavailable in most tropical environments, including the Amazon region where a fishery has been conducted for many decades without precise monitoring (although this situation has changed in the last decade; Chao, 2001). The Paraná River floodplain may be an ideal region to establish an ornamental fish trade due to 20 years of research by the Núcleo de Pesquisas em Limnologia, Ictiologia e Aqüicultura (NUPELIA; Nucleus of Research in Limnology, Ichthyology and Aquaculture) of the Universidade Estadual de Maringá. Much information is still unavailable, but initial evaluations can be reasonably conducted.

Problems related to the formation of aviamento systems (sensu Prang, 2001) and fish mortality (Waichman et al., 2001) could be minimized in the Paraná River floodplain, since it is located near well-developed cities such as Paranavaí and Maringá (including an airport, only 170 km from the floodplain). Fishes could be sold in these cities or transported to other centers in the near vicinity. Another advantage is the need of minor capital to establish exportation activities, which could come from the private sector (as a new economic niche) as much as from the government.

Maintenance of ornamental fisheries in the Rio Negro basin is a good example of exploitation allied to conservation of natural resources (Chao, 2001; Norris and Chao, 2002). Employment of local people in the sustainable ornamental fish trade resulted in a decrease of other deleterious economic activities (e.g., slash-and-burn agriculture and cattle raising). In addition, ornamental fishery yield has not declined even after some decades of intense fishery activity (Chao, 2001). Similarly, establishment of an ornamental fishery may help relieve the poverty that is commonplace in many towns bordering the Paraná River and its floodplain. Specifically, in Porto São José and Porto Rico districts (Paraná State), serious social problems are related to low per capita income and unemployment, which reaches rates around 49% in Porto Rico and 54% in São José (Godoy, 2002a). Fishermen only represent 3.5% in each population (Godoy, 2002b), in spite of river proximity and the abundance of natural resources. With decreasing captures of commercially important migratory fishes in recent years (Suzuki et al., 2004), ornamental fishes could gain considerable importance as an alternative income for these towns. Fisheries conducted in a sustainable fashion may be antagonistic to other more harmful activities (Norris and Chao, 2002), such as deforestation, broad scale burning (common in *Pfaffia* extraction, a commercially important root similar to *Ginseng*; Agostinho, 1997), cattle raising, overfishing and mining.

5. Conclusion

The general consensus is that establishment of exploratory activities involving sustainable collecting, primarily regarding the amount of information required as well as legislative procedures is difficult. Additionally, taking problems related to introduction of exotics as an example (the ornamental trade has been the second main cause in the USA; Fuller et al., 1999), a great abyss exists between the scientific community and the ornamental fish industry. Problems due to ignoring or using existing information improperly could compromise the feasibility of a profitable industry, with the loss of biodiversity as the final outcome. Any attempt at resource utilization must heed all topics discussed here, especially because the upper Paraná River floodplain is the last remaining natural stretch of this basin above Itaipu Reservoir and comprises an Environmental Protection Area (Ilhas e Várzeas do Rio Paraná) and a State Park (Parque Estadual do Ivinhema).

Our objective was not to encourage resource exploitation. This study was essentially aimed at information and knowledge generation, demonstrating an additional economic opportunity in the floodplain. Knowledge generation is fundamental and prerequisite to the development of rational and sustainable resource utilization. Bringing this information to the public domain becomes an essential task, especially when the objective holds conservation purposes. The floodplain has a huge potential to be responsibly exploited and establishing an ornamental fish trade may also facilitate biological conservation. However, the utilization of this potential resource will demand more complex procedures than provided by our evaluation (for instance, see Begg et al., 1999), and only the initiation of activities along with subsequent monitoring and research will reveal if the region can endure this kind of exploitation.

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