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Ornamental exotic fish introduced into Atlantic Forest water bodies, Brazil

Peixes ornamentais exóticos introduzidos em corpos d'água na Mata Atlântica, Brasil

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Abstract

Specimens of P*untius arulius, P. ticto, P. titteya, P. oligolepis, Nannostomus beckfordi, Poecilia latipinna, P. velifera, Trichogaster pectoralis*, and *Betta splendens* were recorded in the largest ornamental aquaculture center in Brazil. These fishes were introduced in the study sites by accidental escape and intentional release. There is evidence that six species are reproducing. Measures are proposed to prevent further spread of ornamental exotic fishes in the region.

Key words: Brazil, species introduction, exotic fishes, ornamental aquaculture.

Resumo

Exemplares de *Puntius arulius, P. ticto, P. titteya, P. oligolepis, Nannostomus beckfordi, Poecilia latipinna, P. velifera, Trichogaster pectoralis* e *Betta splendens* foram registrados no maior centro de piscicultura ornamental do Brasil. Estes peixes alcançaram os locais de estudo devido a fugas acidentais e liberação intencional. Há evidências de que seis espécies estejam se reproduzindo. Medidas são propostas para se prevenir futuras introduções de peixes ornamentais exóticos na região.

Palavras-chave: Brasil, fugas, peixes exóticos, piscicultura ornamental.

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Introduction

Among the twenty-seven Brazilian states, Minas Gerais is one of the largest. It is slightly bigger than France, with an area of 585528 km^2 (IBGE, 2002). It is drained by thirteen different river basins, including two of the largest Brazilian basins, the São Francisco basin and the High Paraná basin, and contains more than 2000 small, medium, large and megadams (Alves *et al.*, 2007). The native ichthyofauna in the state is estimated in 354 species, which represents approximately 12% of the total found in Brazil (McAllister *et al.,* 1997).

The native fish fauna includes some of Brazil´s most endangered species such as Matrinchã *Brycon orbignyanus* (Valenciennes), Andirá *Henochilus weatlandii*, Garman, Armored catfish *Pogonopoma parahybae* (Steindachner), Killifish *Simpsonichthys zonatus* (Costa and Brasil), Surubim *Steindachneridion parahybae* (Steindachner), Jaú *Zungaro jahu* (Ihering) (Fundação Biodiversitas, 2007). Furthermore, Minas Gerais ranks high in the list of states in number of fish introductions, with 69 detected exotic species already, more than 50 of which are ornamental (Alves *et al.*, 2007; Magalhães, 2007a; Magalhães and Carvalho, 2007). The number of non-native species for the main river basins in the state is: 47 in Paraíba do Sul (Magalhães, 2007b; Magalhães and Carvalho, 2007), 30 in Doce, 20 in High Paraná, 16 in São Francisco, 12 in Mucuri, and 5 in Jequitinhonha (Alves *et al*., 2007). The high level of introductions in Paraíba do Sul is associated with an ornamental fish farming center, the largest in Brazil (Magalhães *et al*., 2002).

The aims of this communication are: (i) to record the occurrence of exotic fishes in three creeks and in one dam of the Paraíba do Sul basin, (ii) to analyze evidence of reproduction and (iii) to propose guidelines to circumvent further introductions.

Material and methods

Fishes were collected monthly from January to December 2005 in four sites: (i) Santo Antônio creek (20°56'S and 42°17'W), Vieiras municipality, (ii) Pinheiros creek (20°51'S and 42°23'W), Miradouro municipality, (iii) Pratinha creek (20°57'S and 42°28'W), Muriaé municipality, Glória river sub-basin, and (iv) Maurício dam (21°23'S and 42°41'W), Itamarati de Minas municipality, Pinho river sub-basin (Figure 1). All sites belong to the Paraíba do Sul basin (length: 1080 km, drainage area: 55,400 km^2), which is one of South America´s largest river systems (Lundberg *et al*., 1998) and drains part of Brazil's southeast region including the States of São Paulo (drainage area: 13,500 km^2), Minas Gerais (drainage area: 20,900 km^2), and Rio de Janeiro (drainage area: 21,000 km^2) (Pfeiffer *et al*., 1986).

Specimens were captured with 0.5 cm-mesh sieves, killed by over-anaesthetization with ether, fixed in a 10% formalin solution, and preserved in 70% alcohol. Species identification was based on Nelson (1994) and Axelrod *et al*. (1998). Fish pictures and descriptions of colors on the websites Froese and Pauly (2006), FishIndex (2006), Badman's Tropical Fish (2006), and Aquatic Community (2006) were used to confirm the fish species identification. In laboratory, all individuals were measured, adult females and males were dissected and their gonads checked for indications of reproductive activity. Fish were classified as rest, mature, spawned for females and spermiated for males (in oviparous species) according to Magalhães and Ratton (2005), and as gravid/non-gravid for females of viviparous species according to Milton and Arthington (1983). Voucher specimens used in this study

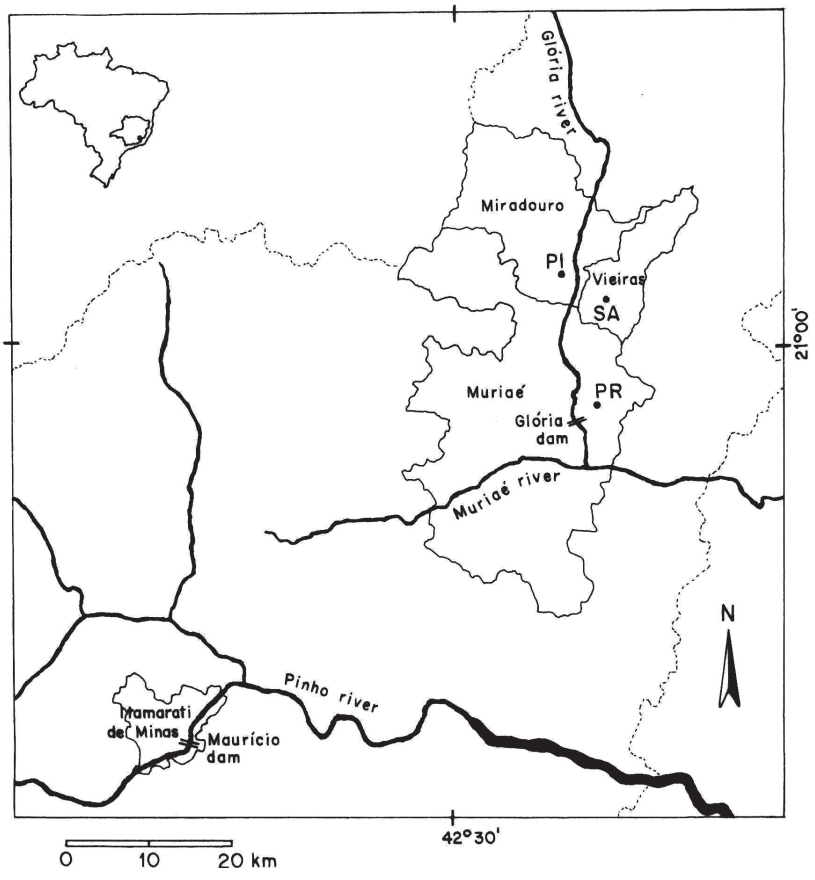

Figure 1. Map showing the four study sites in the state of Minas Gerais, Brazil: Pinheiros creek (PI), Santo Antônio creek (SA), Pratinha creek (PR), and Maurício dam.

are deposited under their respective catalogue numbers (Table 1) in the Museum of Science and Technology (MCP), Pontifical Catholic University of Rio Grande do Sul, Brazil.

Results and discussion

Nine exotic species belonging to four families, native to four continents were captured, totaling 583 specimens (Table 1). The occurrence of alevins, juveniles and adults of the Arulius barb *Puntius arulius* (Jerdon), Ticto barb *Puntius ticto* (Hamilton), Checkered barb *Puntius oligolepis* (Bleeker), Golden pencilfish *Nannostomus beckfordi* Günther, Sailfin mollies *Poecilia latipinna* (Lesueur), and *Poecilia velifera* (Regan) was evidenced by the heterogeneity of the standard length. *Puntius arulius*, *P. ticto*, *P. oligolepis* and *N. beckfordi* females and males showed reproductive activity. The single male specimens of the Cherry barb *Puntius titteya* Deraniyagala and the Snakeskin gourami *Trichogaster pectoralis* (Regan), and the only female caught of the Siamese fighting fish *Betta splendens* Regan were with the gonads in rest. Most *P. latipinna* and *P. velifera* females were pregnant with developing embryos (Table 1).

Table 1. General data about the nine ornamental exotic fishes.

Species *	N	Family *	Native range *	Site	Standard length (mm)		Gonads of adult specimens
Oviparous					**Min.**	**Max.**	
Puntius arulius Arulius barb MCP 39006	37	Cyprinidae	India	Pinheiros creek	35	72	Ovaries: rest (26%), mature (56%), spawned (18%) Testes: rest (32%), mature (50%), spermiated (18%)
Puntius ticto Ticto barb MCP 39005	14	Cyprinidae	India, Thailand, Nepal, Pakistan, Sri-Lanka, Bangladesh, Myanmar	Pinheiros creek	22	54	Ovaries: rest (20%), mature (70%), spawned (10%) Testes: rest (25%), mature (50%), spermiated (25%)
Puntius titteya Cherry barb MCP 38998	1	Cyprinidae	Sri Lanka	Pinheiros creek	33		Rest testis (100%)
Puntius oligolepis Checkered barb MCP 38999	4	Cyprinidae	Sumatra, Indonesia	Pinheiros creek	10	46	Ovaries: mature (67%), spawned (33%) Mature testes (100%)
Nannostomus beckfordi Golden pencilfish MCP 39000	167	Lebiasinidae	Guyana, N Brazil	Maurício dam	21	45	Ovaries: rest (22%), mature (67%), spawned (11%) Testes: rest (32%), mature (39%), spermiated (29%)
Trichogaster pectoralis Snakeskin gourami MCP 38996	1	Osphronemidae	Cambodia, Laos, Thailand, Vietnam	Pinheiros creek	128		Rest testis (100%)
Betta splendens Siamese fighting fish MCP 39001	1	Osphronemidae	Laos, Thailand, Cambodia, Malaysia	Pratinha creek	40		Rest ovary (100%)
Viviparous							
Poecilia latipinna Sailfin molly MCP 39008	24	Poeciliidae	U.S.A., Mexico	Santo Antônio creek	8	61	Gravid (61%), non-gravid (39%)
Poecilia velifera Sailfin molly MCP 39003	334	Poeciliidae	Mexico	Santo Antônio creek	9	69	Gravid (52%), non-gravid (48%)

* Scientific and common names; Family and Native range from Froese and Pauly (2006).

The region where these exotic fishes were recorded comprises 12 municipalities and has around 250 producers who breed approximately 60 different ornamental species, such as the Goldfish *Carassius auratus* (L.), Common carp *Cyprinus carpio* L., Common serpa tetra *Hyphessobrycon eques* (Steindachner), Guppy *Poecilia reticulata* Peters, *P. velifera*, Green swordtail *Xiphophorus hellerii* Heckel, Southern platyfish *X. maculatus* (Günther), Dwarf gourami *Colisa lalia* (Hamilton), Freshwater angelfish *Pterophyllum scalare* (Schultze), and Ram cichlid *Mikrogeophagus ramirezi* (Myers and Harry), in more than 3000 earthen and concrete ponds (Rasguido and Albanez, 2000; Vidal Júnior and Costa, 2000). Besides fish, there are small-scale cultures of ornamental plants, crustaceans, snails and frogs (Magalhães, personal observation). For 40% of these producers, this activity is the main source of income, which makes this region the largest ornamental aquaculture center in South America since the end of the 1970's (Vidal Júnior and Costa, 2000), and the main source of plant, invertebrate, fish and frog introductions in the continent (Magalhães *et al*., 2002; Magalhães, 2006, 2007b). Paradoxically, the region where these exotic fish are grown is enclosed in an area of Atlantic Forest, a hotspot classified by the Brazilian Ministry of Environment (2000) as a priority for native fish conservation.

The present study raised the number of exotic fish species to 56 (51 of which ornamental) for the basin, and to 78 in the state of Minas Gerais (before the present study: 47 for Paraíba do Sul basin, 69 for the state of Minas Gerais). For comparison purposes, 72 exotic fish species had been detected in Chinese inland waters (Ma *et al*., 2003). In the study area, the presence of adult individuals in the dam and in the three creeks can be due to: (i) accidental release during pond drainage, discharging water directly into adjacent water bodies (most of the ponds do not have protective screens in the effluent pipes to prevent escapes); (ii) heavy rains that often flood fish farms, flushing fishes into non-managed waters; (iii) disposal of specimens of low commercial value (undersized individuals of *P. latipinna*, *P. velifera* and *B. splendens*) into nearby creeks; and (iv) intentional release of commercially important species so that their offspring be collected for sale.

The release of adult forms may have benefited representatives of fish families that display survival strategies such as uni-parental care (Poeciliidae, Osphronemidae), school formation (Lebiasinidae), and broad dietary habits (Cyprinidae, Lebiasinidae, Poeciliidae, Osphronemidae), considered important strategies for the survival of teleost species introduced into new habitats (Welcomme, 1988). The differences in standard length observed in *P. arulius*, *P. ticto*, *P. oligolepis*, *N. beckfordi*, *P. latipinna* and *P. velifera*, along with the presence of mature/spawned females, mature/spermiated males, and pregnancy attest that they are reproducing in the wild. Reproductive evidence in females and males of the exotic Sumatra barb *Puntius tetrazona* (Bleeker), *C. carpio*, Black tetra *Gymnocorymbus ternetzi* (Boulenger), Spotted metynnis *Metynnis maculatus* (Kner), *M. ramirezi*, Flag acara *Laetacara curviceps* (Ahl), *P. scalare*, *X. maculatus,* and *X. hellerii* have already been recorded in the region (Magalhães *et al*., 2002). Special attention should be given to *P. latipinna* and *T. pectoralis*, as they are considered pests in other countries (Froese and Pauly, 2006). The Sailfin molly competes for food with the native Milkfish *Chanos chanos* (Forsskål) in the Philippines (Juliano *et al*., 1989), and the Snakeskin gourami competes for reproductive sites with the native Three spot gourami *Trichogaster trichopterus* (Pallas) in Malaysia (Ang *et al*., 1989).

According to Hilsdorf and Petrere Jr. (2002), one of the main threats to the Paraíba do Sul basin diversity is the presence of non-native fish species. Therefore, records of exotic fish are necessary to create a database for mitigatory purposes and the conservation of the native freshwater fauna. Also, studies of diet and reproduction overlap and relative density of all species are needed to assess the negative impacts upon native fish species in the region, such as the Twospot astyanax *Astyanax bimaculatus* (L.), Yellow tetra *Hyphessobrycon bifasciatus* Ellis, Armored catfishes *Hypostomus affinis* (Steindachner), *Neoplecostomus microps* (Steindachner), *Parotocinclus maculicauda* (Steindachner), Catfishes *Rhamdioglanis transfaciatus* Miranda Ribeiro, *Trichomycterus* spp., Pearl cichlid *Geophagus brasiliensis* (Quoy and Gaimard) (Magalhães, personal observation), and the endangered endemic *P. parahybae* (Fundação Biodiversitas, 2007).

The release of exotic organisms is a federal offense according to Brazilian legislation and ornamental aquaculture in Brazil should be conducted strictly in accordance with specific regulations, control and effective inspections (Magalhães *et al*., 2002). Some immediate remedial measures to prevent further introductions from farm ponds should be: (i) to reroute all effluent waters from fish rearing facilities through an underground or above-ground dry well; (ii) to install adequate sand and gravel filter which will allow passage of water but not livestock; (iii) outdoor fish ponds located on floodable land should be diked; and (iv) to promote environmental awareness of those directly involved with ornamental fish farms. Otherwise, fish escapes out of most of the 3000 ponds will negatively change the native diversity scenario in the near future.

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