

# E-commerce of freshwater aquarium fishes: potential disseminator of exotic species in Brazil

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**ABSTRACT.** The availability of freshwater aquarium fish species for sale was surveyed from July 2005 to June 2006 in Brazilian electronic commerce and the Orkut website. São Paulo was the leading state regarding virtual shops, auctions on Arremate/Mercado Livre, and hobbyists on Orkut, with 52, 44 and 46%, respectively. The Southeast and South regions led the offer of pest species such as *C. carpio*, *C. auratus* and *P. reticulata*. Among the 207 species for sale, 14 species considered potential pests were identified, contrasting with only one page that warned about the dangers of aquarium dumping. The easy access to fish (especially the potential pest species) through e-commerce and Orkut, together with the low total price (unitary value + shipping and handling ranging from US\$ 17.67 to 30.39), and fast interstate delivery (two-four days on average) confirm the widespread e-commerce accessibility and its high dispersal potential via postal services and home hobbyists trade. It is imperative to enforce the use of warnings or alert messages in e-commerce about the dangers of biological invasions.

**Key words:** virtual shops, hobbyists, biological invasions.

**RESUMO. Comércio eletrônico de peixes ornamentais de água doce: potencial dispersor de espécies exóticas no Brasil.** A disponibilidade para venda de espécies de peixes ornamentais de água doce foi pesquisada de julho/2005 a junho/2006 no comércio eletrônico brasileiro e no site de relacionamentos Orkut. O Estado de São Paulo foi o principal em lojas virtuais, leilões no Arremate/Mercado Livre e aquaristas vendendo peixes no Orkut, com 52, 44 e 46%, respectivamente. As regiões Sudeste e Sul são as que mais anunciaram espécies como *C. carpio*, *C. auratus* e *P. reticulata*. Entre as 207 espécies disponíveis para venda, 14 foram identificadas como potenciais praga, contrastando com apenas uma página eletrônica que alertava sobre os perigos do descarte de espécies ornamentais exóticas em novos ambientes. O fácil acesso aos peixes (notadamente espécies consideradas potenciais praga) pelo comércio eletrônico e Orkut, aliado a um preço acessível (valor unitário + embalagem + frete entre US\$ 17,67 a 30,39) e rápido transporte interestadual (média de dois a quatro dias), confirma a ampla acessibilidade do comércio eletrônico e seu alto potencial de dispersão via correios e aquaristas amadores. É obrigação do comércio eletrônico por em execução o uso de avisos ou mensagens de alerta sobre os perigos das invasões biológicas.

**Palavras-chave:** lojas virtuais, aquaristas, invasões biológicas.

## Introduction

The growth of the world commerce system, especially electronic commerce (e-commerce) has led to an increase in the number of ornamental plant and animal species introduced into a wide variety of ecosystems (GHERARDI, 2006; PERRINGS et al., 2002; WALTERS et al., 2006).

Many aquarium species, such as fishes, are highly invasive and the ecological impacts associated with these introductions are well documented (CONTRERAS-MACBEATH et al.,

1998; DUGGAN et al., 2006; LIANG et al., 2006; RIXON et al., 2005). Because their invasive reputation is largely unknown to the layperson, these species are still extremely popular among professional aquarists and home hobbyists because they are attractive, relatively cheap, and easy to maintain and breed (LIANG et al., 2006). These characteristics also make it easy for shop owners and amateurs to sell their stocks via e-commerce, through virtual shops and auctions (WALTERS et al., 2006), or to discard them later on in natural (creeks, rivers, lakes and oceans) and

artificial (dams, weirs and channels) environments, thus initiating a process of biological invasion (DUGGAN et al., 2006; SEMMENS et al., 2004).

According to Gertzen et al. (2008), the potential impact of internet trade should be investigated along with more traditional avenues of trade in aquarium fishes; therefore, the aim of this study was to assess the relevance of Brazilian e-commerce in general as a mode of dispersal of exotic freshwater aquarium fishes, especially those considered potential pest species by Froese and Pauly (<http://www.fishbase.org/>). Until now, the importance of this vector had not been appropriately fathomed in Brazil.

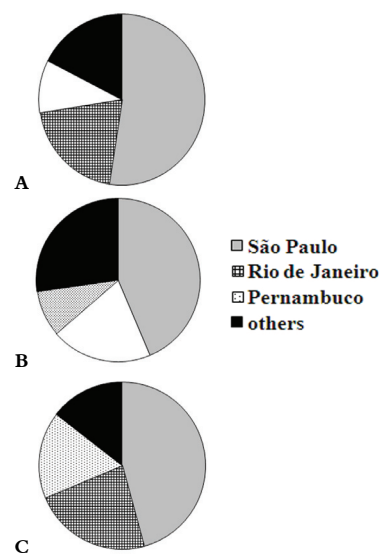
### Material and methods

The species of aquarium fishes by state (location of virtual shops, auctions and Orkut), total price in US Dollars (unitary value + packing + freight) by region-considering only state capitals, delivery methods, and warnings about the risk of introduction were surveyed in e-commerce and Orkut, from July 2005 to June 2006. The research involved a total of 580 hours of search in the internet, performed by volunteers, all biology students, 20 to 22 years old, each of whom worked during three months.

The volunteers chose their search period and, in each one, they had 48 hours to find sources of freshwater ornamental fishes available via three categories: virtual shops (search by Google: [www.google.com.br](http://www.google.com.br)), auctions on Arremate/Mercado Livre (associated with eBay: <http://www.mercadolivre.com.br/>) and Orkut (<http://www.orkut.com/About.aspx>) websites, using standardized keywords. In shops and auctions, keywords ranged from obvious ones such as fish, ornamental fish, aquaria (*peixes*, *peixes ornamentais*, *peixes de aquário*, *peixinho-dourado*, *carpa-nishikigoi*, *espadinha*, *plati*, *molinésia*, *acará*, *aquários*), to less obvious ones like floriculture and live-bait (*floriculturas* and *iscas-vivas*). In Orkut, the range was expanded with words such as guppy, goldfish, betta, cichlids, aquarism (*gupi/guppy*, *kinguio*, *betta*, *ciclídeos*, *ciclídeos africanos*, *aquarismo*, *aquários plantados*) to less related like reproducers and ornamental ponds (*reprodutores*, *lagos ornamentais*). After this procedure, all the sites and communities were accessed by their order of appearance. It was also checked which ornamental species were considered potential pests according to Froese and Pauly (<http://www.fishbase.org/>). The frequency of citation of pest species was calculated in the 261 sites by region.

### Results and discussion

Of the 261 websites found (40 virtual shops, 55 virtual auctions, and 166 aquarism communities on Orkut), the states that have virtual shops selling ornamental fishes, São Paulo has the largest percentage with 52%, followed by Rio de Janeiro with 20% (Figure 1a). Regarding auctions offering ornamental fishes, São Paulo ranked first (44%) followed by Minas Gerais with 20% (Figure 1b), and regarding home hobbyists selling fish on Orkut, once again São Paulo lead (46%), followed by Rio de Janeiro with 23% (Figure 1c).



**Figure 1.** E-commerce characteristics of freshwater ornamental fishes in Brazil. (a) virtual shops by state (n = 40), (b) auctions in Arremate/Mercado Livre by state (n = 55), (c) aquarism communities on Orkut by state (n = 166).

There is extensive interstate transport of aquarium fishes, most of which from São Paulo to the rest of the country. The average delivery time from São Paulo city to any other place is two (for near regions: Southeast and South) to four days (for distant regions: North and Northwest). The delivery means of specimens by virtual shops, auctions and Orkut was usually via postal services (Sedex) and shipping companies (VarigLog, TAM Express, JadLog).

The survey scored 207 aquarium species available for sale within Brazil. Among them, 14 species belonging to seven families are considered potential pests, with total mean prices (unitary value + packing + freight) ranging between US\$ 17.67 to 30.39 (Table 1). The Southeast and South regions lead the offer of pest species such as *C. carpio*, *C. auratus*, *P. reticulata*, *X. hellerii*, and *X. maculatus*, while the Northern region is the one that least advertises (Table 2).

This confirms the tendency pointed by Whittington and Chong (2007) that, of more than 4,000 freshwater ornamental fishes on sale, poeciliids (guppies, platies, mollies, swordtails) and cyprinids (carps, goldfishes, barbs) are the most popular among aquarists throughout the world.

The Southeast region showed the largest proportions of aquarium fish e-commerce, especially São Paulo State (the richest in the country), in the three categories of e-commerce considered. A similar situation occurs in California, a very wealthy U.S.A. state and the first in internet ornamental species sales (WALTERS et al., 2006). As in Brazil, the means of shipping and handling of animals and plants in the

U.S.A. is also via postal services and shipping companies (WALTERS et al., 2006), and in both countries this activity is still largely unregulated. Alarming, of the 90 U.S.A. websites evaluated by Walters et al. (2006), only six distributors (five retailers, one eBay auction) showed warnings explaining the dangers of discarding plants, invertebrates and aquarium fish into new environments. Among all surveyed Brazilian websites, only one urged to avoid release of ornamental species in natural or artificial environments in case the owners discarded the animals (aquarium dumping). It should be noted that the release of exotic species in Brazil is considered a crime according to Environmental Act 9605 of 1998 (WOLFF, 2000).

**Table 1.** Exotic fish species sold (US\$ 2: dollar exchange rate in 2005/06) through e-commerce considered potential pests according to Froese and Pauly (<http://www.fishbase.org/>), and their market value in the five Brazilian regions, July 2005-June 2006. T = means and standard deviation of delivery time in days, U = unit value, P = packing, F = freight (from São Paulo city).

| Family   | Common name/Species/Origin  | Mean price (US\$) per region |         |       |             |             |
|--|---|------------------------------|---------|-------|-------------|-------------|
|  |   | T                            | U       | P     | F           | Total       |
| Cyprinidae   | common carp (Koi variety) <i>Cyprinus carpio</i><br>(native range: Russia, China, India)                    | North (4.00 ± 3.24)          | 1.50-60 | 5     | 13.75       | 20.25-78.75 |
|  |   | Northwest (3.00 ± 2.45)      | 1.50-60 | 5     | 13          | 19.50-78.00 |
|  |   | Center-west (3.00 ± 1.40)    | 1.50-60 | 5     | 11.25       | 17.75-76.25 |
|  |   | Southeast (2.00 ± 1.22)      | 1.50-60 | 5     | 7           | 13.50-72.00 |
|  |   | South (2.00 ± 1.39)          | 1.50-60 | 5     | 8.75        | 15.25-73.75 |
|  | goldfish <i>Carassius auratus</i><br>(native range: central Asia, China, Japan)                             | North (4.00 ± 3.24)          | 1-15    | 5     | 13.75       | 19.75-33.75 |
|  |   | Northwest (3.00 ± 2.45)      | 1-15    | 5     | 13          | 19-33       |
|  |   | Center-west (3.00 ± 1.40)    | 1-15    | 5     | 11.25       | 17.25-31.25 |
|  |   | Southeast (2.00 ± 1.22)      | 1-15    | 5     | 7           | 13-27       |
|  |   | South (2.00 ± 1.39)          | 1-15    | 5     | 8.75        | 14.75-28.75 |
| Cobitidae  | oriental weatherfish <i>Misgurnus anguillicaudatus</i><br>(native range: Northeastern Asia, Myanmar, China) | North (4.00 ± 3.24)          | 1-7.50  | 5     | 13.75       | 19.75-26.25 |
|  |   | Northwest (3.00 ± 2.45)      | 1-7.50  | 5     | 13          | 19-25.5     |
|  |   | Center-west (3.00 ± 1.40)    | 1-7.50  | 5     | 11.25       | 17.25-23.75 |
|  |   | Southeast (2.00 ± 1.22)      | 1-7.50  | 5     | 7           | 13-19.5     |
|  |   | South (2.00 ± 1.39)          | 1-7.50  | 5     | 8.75        | 14.75-21.25 |
| Poeciliidae  | guppy <i>Poecilia reticulata</i><br>(native range: Venezuela, Barbados, Trinidad, northern Brazil, Guyanas) | North (4.00 ± 3.24)          | 1-20    | 5     | 13.75       | 19.75-38.75 |
|  |   | Northwest (3.00 ± 2.45)      | 1-20    | 5     | 13          | 19-38       |
|  |   | Center-west (3.00 ± 1.40)    | 1-20    | 5     | 11.25       | 17.25-36.25 |
|  |   | Southeast (2.00 ± 1.22)      | 1-20    | 5     | 7           | 13-32       |
|  |   | South (2.00 ± 1.39)          | 1-20    | 5     | 8.75        | 14.75-33.75 |
|  | sailfin molly <i>Poecilia latipinna</i><br>(native range: U.S.A, Mexico)                                    | North (4.00 ± 3.24)          | 1-7.50  | 5     | 13.75       | 19.75-26.25 |
|  |   | Northwest (3.00 ± 2.45)      | 1-7.50  | 5     | 13          | 19-25.5     |
|  |   | Center-west (3.00 ± 1.40)    | 1-7.50  | 5     | 11.25       | 17.25-23.75 |
|  |   | Southeast (2.00 ± 1.22)      | 1-7.50  | 5     | 7           | 13-19.5     |
|  |   | South (2.00 ± 1.39)          | 1-7.50  | 5     | 8.75        | 14.75-21.25 |
|  | green swordtail <i>Xiphophorus hellerii</i><br>(native range: Mexico, Honduras)                             | North (4.00 ± 3.24)          | 1-8.50  | 5     | 13.75       | 19.75-27.25 |
|  |   | Northwest (3.00 ± 2.45)      | 1-8.50  | 5     | 13          | 19-26.5     |
|  |   | Center-west (3.00 ± 1.40)    | 1-8.50  | 5     | 11.25       | 17.25-24.75 |
|  |   | Southeast (2.00 ± 1.22)      | 1-8.50  | 5     | 7           | 13-20.5     |
|  |   | South (2.00 ± 1.39)          | 1-8.50  | 5     | 8.75        | 14.75-22.25 |
|  | southern platyfish <i>Xiphophorus maculatus</i><br>(native range: Mexico, Belize)                           | North (4.00 ± 3.24)          | 0.5-3.5 | 5     | 13.75       | 19.25-22.25 |
|  |   | Northwest (3.00 ± 2.45)      | 0.5-3.5 | 5     | 13          | 18.5-21.5   |
|  |   | Center-west (3.00 ± 1.40)    | 0.5-3.5 | 5     | 11.25       | 16.75-19.75 |
|  |   | Southeast (2.00 ± 1.22)      | 0.5-3.5 | 5     | 7           | 12.5-15.5   |
|  |   | South (2.00 ± 1.39)          | 0.5-3.5 | 5     | 8.75        | 14.25-17.25 |
| variable platyfish <i>Xiphophorus variatus</i><br>(native range: Mexico) | North (4.00 ± 3.24)   | 0.5-2.5                      | 5       | 13.75 | 19.25-28.75 |             |
|  | Northwest (3.00 ± 2.45)   | 0.5-2.5                      | 5       | 13    | 18.5-20.5   |             |
|  | Center-west (3.00 ± 1.40)   | 0.5-2.5                      | 5       | 11.25 | 16.75-18.75 |             |
|  | Southeast (2.00 ± 1.22)   | 0.5-2.5                      | 5       | 7     | 12.5-14.5   |             |
|  | South (2.00 ± 1.39)   | 0.5-2.5                      | 5       | 8.75  | 14.25-16.25 |             |

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| Family        | Common name/Species/Origin   | Mean price (US\$) per region |            |   |       |             |
|---------------|--|------------------------------|------------|---|-------|-------------|
|               |  | T                            | U          | P | F     | Total       |
| Clariidae     | walking catfish <i>Clarias batrachus</i><br>(native range: Malay peninsula, Sumatra, Java, Borneo)     | North (4.00 ± 3.24)          | 5-15       | 5 | 13.75 | 23.75-33.75 |
|               |  | Northwest (3.00 ± 2.45)      | 5-15       | 5 | 13    | 23-33       |
|               |  | Center-west (3.00 ± 1.40)    | 5-15       | 5 | 11.25 | 21.25-31.25 |
|               |  | Southeast (2.00 ± 1.22)      | 5-15       | 5 | 7     | 17-27       |
|               |  | South (2.00 ± 1.39)          | 5-15       | 5 | 8.75  | 18.75-28.75 |
| Channidae     | snakehead murrel <i>Channa striata</i><br>(native range: Pakistan, Thailand, China)                    | North (4.00 ± 3.24)          | 7.5-20     | 5 | 13.75 | 26.25-38.75 |
|               |  | Northwest (3.00 ± 2.45)      | 7.5-20     | 5 | 13    | 25.5-38     |
|               |  | Center-west (3.00 ± 1.40)    | 7.5-20     | 5 | 11.25 | 23.75-36.25 |
|               |  | Southeast (2.00 ± 1.22)      | 7.5-20     | 5 | 7     | 19.5-32     |
|               |  | South (2.00 ± 1.39)          | 7.5-20     | 5 | 8.75  | 21.25-33.75 |
| Cichlidae     | peacock bass <i>Cichla ocellaris</i><br>(native range: Suriname, French Guiana, Guyana)                | North (4.00 ± 3.24)          | 0.5-25     | 5 | 13.75 | 19.25-43.75 |
|               |  | Northwest (3.00 ± 2.45)      | 0.5-25     | 5 | 13    | 18.5-43     |
|               |  | Center-west (3.00 ± 1.40)    | 0.5-25     | 5 | 11.25 | 16.75-41.25 |
|               |  | Southeast (2.00 ± 1.22)      | 0.5-25     | 5 | 7     | 12.5-37     |
|               |  | South (2.00 ± 1.39)          | 0.5-25     | 5 | 8.75  | 14.25-38.75 |
|               | convict cichlid <i>Archocentrus nigrofasciatus</i><br>(native range: El Salvador, Guatemala, Honduras) | North (4.00 ± 3.24)          | 1-2.5      | 5 | 13.75 | 19.75-28.75 |
|               |  | Northwest (3.00 ± 2.45)      | 1-2.5      | 5 | 13    | 19-20.5     |
|               |  | Center-west (3.00 ± 1.40)    | 1-2.5      | 5 | 11.25 | 17.25-18.75 |
|               |  | Southeast (2.00 ± 1.22)      | 1-2.5      | 5 | 7     | 13-14.5     |
|               |  | South (2.00 ± 1.39)          | 1-2.5      | 5 | 8.75  | 14.75-16.25 |
|               | guapote tigre <i>Parachromis managuensis</i><br>(native range: Costa Rica, Honduras)                   | North (4.00 ± 3.24)          | 1.5-7.5    | 5 | 13.75 | 20.25-26.25 |
|               |  | Northwest (3.00 ± 2.45)      | 1.5-7.5    | 5 | 13    | 19.5-25.5   |
|               |  | Center-west (3.00 ± 1.40)    | 1.5-7.5    | 5 | 11.25 | 17.75-23.75 |
|               |  | Southeast (2.00 ± 1.22)      | 1.5-7.5    | 5 | 7     | 13.5-19.5   |
|               |  | South (2.00 ± 1.39)          | 1.5-7.5    | 5 | 8.75  | 15.25-21.25 |
| Osphronemidae | snakeskin gourami <i>Trichogaster pectoralis</i><br>(native range: Laos, Thailand, Cambodia, Viet Nam) | North (4.00 ± 3.24)          | 2.5-7.5    | 5 | 13.75 | 28.75-26.25 |
|               |  | Northwest (3.00 ± 2.45)      | 2.5-7.5    | 5 | 13    | 20.5-25.5   |
|               |  | Center-west (3.00 ± 1.40)    | 2.5-7.5    | 5 | 11.25 | 18.75-23.75 |
|               |  | Southeast (2.00 ± 1.22)      | 2.5-7.5    | 5 | 7     | 14.5-19.5   |
|               |  | South (2.00 ± 1.39)          | 2.5-7.5    | 5 | 8.75  | 16.25-21.25 |
| 7             | 14   | 5                            | 1.82-14.42 | 5 | 9.98  | 17.67-30.39 |

**Table 2.** Frequency (%) of citation of pest species in the 261 sites, per region.

| Family      | Species                            | Region |            |             |            |       |
|-------------|------------------------------------|--------|------------|-------------|------------|-------|
|             |                                    | North  | North-west | Center-west | South-east | South |
| Cyprinidae  | <i>Cyprinus carpio</i>             | 40     | 60         | 60          | 90         | 80    |
|             | <i>Carassius auratus</i>           | 45     | 60         | 60          | 95         | 95    |
| Cobitidae   | <i>Misgurnus</i>                   | 5      | 15         | 10          | 50         | 45    |
|             | <i>anguillicaudatus</i>            |        |            |             |            |       |
| Poeciliidae | <i>Poecilia reticulata</i>         | 40     | 70         | 70          | 90         | 85    |
|             | <i>Poecilia latipinna</i>          | 10     | 15         | 15          | 50         | 30    |
|             | <i>Xiphophorus hellerii</i>        | 20     | 60         | 40          | 95         | 60    |
|             | <i>Xiphophorus maculatus</i>       | 4      | 35         | 20          | 90         | 60    |
|             | <i>Xiphophorus variatus</i>        | 2      | 20         | 10          | 45         | 20    |
| Clariidae   | <i>Clarias batrachus</i>           | 1      | 10         | 5           | 30         | 5     |
| Channidae   | <i>Channa striata</i>              | 0      | 2          | 0           | 5          | 1     |
| Cichlidae   | <i>Cichla ocellaris</i>            | 30     | 20         | 10          | 45         | 10    |
|             | <i>Archocentrus nigrofasciatus</i> | 5      | 30         | 10          | 50         | 20    |
|             | <i>Parachromis managuensis</i>     | 0      | 10         | 0           | 20         | 1     |
|             | <i>Trichogaster pectoralis</i>     | 0      | 0          | 0           | 5          | 0     |

Of the 14 species considered potential pests and commercialized in Brazil, 10 (*Cyprinus carpio* var. Koi, *Carassius auratus*, *Misgurnus anguillicaudatus*, *Poecilia reticulata*, *Poecilia latipinna*, *Xiphophorus hellerii*, *Xiphophorus maculatus*, *Xiphophorus variatus*, *Cichla ocellaris*, and *Trichogaster pectoralis*) are introduced in

Minas Gerais State and, with the exception of *T. pectoralis*, all of them are reproductively active in the basins of São Francisco (*C. ocellaris*) and Paraíba do Sul rivers (*C. carpio* var. Koi, *C. auratus*, *M. anguillicaudatus*, *P. reticulata*, *P. latipinna*, *X. hellerii*, *X. maculatus* and *X. variatus*) (MAGALHÃES et al., 1996; 2002; MAGALHÃES, 2006). The carp *C. carpio* is reproducing in the mid Uruguay river basin, Rio Grande do Sul state, *P. reticulata* reproduces abundantly in Paraíba do Sul river, Rio de Janeiro state, and *C. cf. ocellaris* keeps reproductive populations in the Grande river, which divides the states of Minas Gerais and São Paulo (ARAÚJO et al., 2009; GOMIERO; BRAGA, 2003; QUEROL et al., 2005).

The data above attests to the risk of imminent aquarium dumping and reinforces the need to regulate e-commerce of exotic organisms. Although there are no studies showing the adverse ecological effects of introduced *C. carpio*, *C. auratus*, *M. anguillicaudatus*, *P. latipinna* and *X. maculatus*, the effect of other species is already known. *P. reticulata* changed the native fish community structure in Cedro stream, São Paulo State (LEMES; GARUTTI, 2002), the upper course of Paraíba do

Sul river, Rio de Janeiro State (PINTO et al., 2006), Esperança, Mandacaru, Miosóti, Nazaré streams, Paraná State (CUNICO et al., 2006; VIEIRA; SHIBATTA, 2007) and Meia Ponte, Inhumas, Dourados rivers and 28 streams in Goiás State (FIALHO et al., 2007). *X. hellerii* and *X. variatus* (besides *P. reticulata*) also altered the native community structure in Santo Antônio stream, Minas Gerais State (MAGALHÃES, 2006). Due to its large size and predator habit, the exotic *C. ocellaris* caused the extinction of pacu *Metynnis cf. roosevelti* in Rio Grande do Norte State (MOLINA et al., 1996). *Clarias batrachus*, *Channa striata*, *Archocentrus nigrofasciatus* and *Parachromis managuensis* have not yet been detected in Brazilian inland waters, but have already caused adverse ecological effects in the countries where they have become naturalized (CONTRERAS-MACBEATH et al., 1998; COURTENAY JR. et al., 2004; LIANG et al., 2006). The risk that these last four species may be released mainly by amateur aquarists in Brazilian water bodies is real because, according to Duggan et al. (2006), ornamental fishes with exaggerated growth in captivity have costly maintenance, causing the rejection of their owners and the consequent aquarium dumping into the new environments.

Access on e-commerce and Orkut to ornamental exotic fishes, especially the most popular in the hobby and considered potential pests such as the common carp var. Koi, goldfish, guppy, sailfin molly, green swordtail, southern platyfish, variable platyfish, is undemanding. This, together with the relatively low price for the e-consumers, whose income is larger than the national average (US\$ 318) (GUASTI, 2006), speedy interstate delivery, and lack of knowledge of the consumers about the concept of 'exotic species', represents a serious threat to Brazilian water bodies regarding non-native introductions by hobbyists.

Although regular (physical) ornamental pet shops in the country were not surveyed, their effect in pest introduction should also be taken into account, because they are easily accessed and species (pests or not) are generally cheaper than those obtained by e-commerce. Consequently, the propagule pressure is still larger, as well as the probability of release of certain species in body waters.

Finally, a better regulation of ornamental fish trade via e-commerce is necessary to attenuate potential internet-assisted invasions. Three measures would be to: 1) instruct Brazilian web administrators like Google and eBay to request warnings from retailers, auctioneers and Orkut about the dangers of aquarium dumping,

independently of whether or not the species is considered invasive, 2) post alert messages in the pictures of fishes sold in the sites, indicating those who are pests or potential pests, suggesting the purchase of those who are not, and 3) intensify educational campaigns by virtual shops, auctions and Orkut about the subject of exotic species.

## Conclusion

This study showed the potential of e-commerce in spreading freshwater exotic species, including some with a history of invasion, in Brazilian inland waters. Given the novelty and the lack of regulation of live-animals trade via e-commerce, it is realistic to suppose that other commercially appealing non-native groups, such as saltwater aquarium fishes (red lionfish *Pterois volitans*), freshwater ornamental invertebrates (apple snail *Pomacea* spp.), ornamental plants (Brazilian waterweed *Egeria densa*), non-ornamental freshwater fishes considered pests (tilapia *Tilapia rendalli*, carp *Ctenopharyngodon idella*, largemouth bass *Micropterus salmoides*), non-pest aquarium fishes that have caused environmental damages (red piranha *Pygocentrus nattereri*, oscar *Astronotus ocellatus*, firemouth cichlid *Thorichthys meeki*), and the newly available for sale freshwater stingrays *Potamotrygon cf. henlei*, *Potamotrygon hystrix* and *Potamotrygon motoro* are following the same path and will pose similar environmental and public health risks (venomous freshwater stingrays). Therefore, it is necessary to evaluate the influence and threats posed by e-commerce and virtual communities selling ornamental exotic fishes, and to foster discussions of further containment measures.

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