Neotropical Biology and Conservation
10(1):48-52, january-april 2015

SHORT COMMUNICATION

Has the import ban on non-native red swamp crayfish (Crustacea: Cambaridae) been effective in Brazil?

A proibição legal da importação do lagostim-vermelho (Crustacea: Cambaridae) no Brasil tem sido eficaz?

André Lincoln Barroso Magalhães[1]*
andrebiomagalhaes@gmail.com

Renato Ferreira de Andrade[2]
renato@unifemm.edu.br

Abstract

In Brazil, the import as well as introduction, reintroduction, trade, culture and transport of live individuals of the non-native red swamp crayfish *Procambarus clarkii* (Girard, 1852) was determined illegal by the Brazilian Federal Ordinance No. 5 of 2008. Surveys of the availability of *P. clarkii* in five Brazilian regions were carried out to investigate whether the 2008 Brazilian imposed import ban for this species was effective. In order to address this issue, 81 aquarium stores were surveyed in years before (2007-2008) and after (2009-2011) the ban had been imposed. The results revealed that the availability of *P. clarkii* in aquarium stores decreased from pre-ban surveys in 2007-2008 to post-ban surveys in 2009-2011 (58.0% to 18.5%; χ^2=16.52, d.f.=1, P<0.05), but still persists within the country. These findings clearly demonstrate that Brazilian Federal Ordinance No. 5 of 2008 has not been effective and that the aquarium trade continues distributing red swamp crayfishes in spite of their import ban. This survey underscores the need to enhance the number of invertebrate experts in the Brazilian Customs Agency staff to monitor the aquarium trade, the inspection by IBAMA officials and environmental police aiming at confiscating *P. clarkii*, and the awareness of retailers and aquarium hobbyists, as well as electronic service providers (i.e. e-commerce).

Keywords: alien crayfish, prohibited species, aquarium trade.

Resumo

No Brasil, a importação, a introdução, a reintrodução, a comercialização, o cultivo e o transporte de indivíduos vivos do lagostim-vermelho não-nativo *Procambarus clarkii* (Girard, 1852) foram enquadrados como ilegais pela Portaria Federal No. 5 de 2008. Levantamentos da disponibilidade de *P. clarkii* em cinco regiões do Brasil foram realizados para investigar se a proibição de importação imposta em 2008 para esta espécie foi eficaz. Com o objetivo de resolver esta questão, 81 lojas de aquários foram pesquisadas em anos anteriores (2007-2008) e posteriores (2009-2011) à proibição. Os resultados revelaram que a disponibilidade de *P. clarkii* diminuiu de 2007-2008 para 2009-2011 (58,0% para 18,5%; χ^2=16,52, gl=1, P<0,05), mas ainda persiste no país. Estes resultados demonstram que a Portaria No. 5 de 2008 não tem sido eficaz, e que o comércio ornamental continua distribuindo lagostins-vermelhos, apesar de sua proibição legal. Esta pesquisa ressalta a necessidade de se aumentar o número de especialistas em invertebrados na Alfândega Brasileira para monitorar o comércio ornamental, a fiscalização por funcionários do IBAMA e da polícia ambiental visando apreender *P. clarkii* e a conscientização de lojistas e aquaristas, bem como responsáveis pelo comércio eletrônico, sobre a Portaria No. 5 de 2008.

Palavras-chave: lagostim não-nativo, espécies proibidas, comércio ornamental.

[1] Pontifícia Universidade Católica de Minas Gerais. Programa de Pós-Graduação em Zoologia de Vertebrados. Av. Dom José Gaspar, 500, Coração Eucarístico, 30535-610, Belo Horizonte, MG, Brasil.
[2] Centro Universitário de Sete Lagoas. Av. Marechal Castelo Branco, 2765, Santo Antônio, 35701-242, Sete Lagoas, MG, Brasil.
* Author for correspondence.

Regulations applied to importation of ornamental non-native crayfishes are different in several countries. For instance, import of non-native live crayfishes is prohibited in some US states, as well as in many countries such as Portugal, France, Switzerland and Japan, because of ecological concerns (Lodge *et al*., 2012). In Brazil, the importance of the aquarium trade as a potential vector for non-native crayfishes has been historically recognized (Silva and Bueno, 2005; Magalhães *et al*., 2005; Magalhães and Costa, 2007). At the end of the 1990s, the National Environmental Crime Act No. 9605 of 1998 was established to regulate the management of non-native species. This act emphasizes the trade regulation of non-native aquatic species through vectors such as ornamental snails, shrimp/prawns, crabs and crayfishes's importation (Brasil, 1998).

Introduction of non-native invertebrates through the release of aquarium-traded specimens occurred in Brazil, resulting in ecological impacts in some cases. The best known example is the release of the red swamp crayfish, *Procambarus clarkii* (Girard, 1852), into streams in the southeast region. People buy this crayfish specimens to keep them as pets or for ornamental purposes in aquariums and when they give up raising them, they release the animals in nearby freshwater environments. As a result, this crayfish has performed predation on native invertebrates (Huner, 1986), as well as in the native toad *Rhinella ornata* (Spix, 1824) (Banci *et al*., 2013).

Red swamp crayfish is native from northern Mexico to Florida, and north to southern Illinois and Ohio. It has been widely introduced in the US, South and Central America, Europe and other more dispersed areas in Africa and Asia. It is found in lentic and lotic freshwater habitats: sluggish streams, swamps, ditches, sloughs and ponds. It is benthic and omnivorous, feeding on insects, larvae, and detritus, with a preference for animal matter (McAlain and Romaire, 2007). Likewise most crayfish species, *P. clarkii* has sexual reproduction. Sexual maturity is reached in approximately three months and, depending on climate, it may produce two or three generations per year (Dorr *et al*., 2006). In Ethiopia and Kenya, it has replaced the native freshwater crabs *Potamonautes neumanni* Hilgendorf, 1898 (Ogada, 2007) and *Potamonautes loveni* Colosi, 1924 (Ogada *et al*., 2009). In addition, red swamp crayfish is a vector for crayfish plague fungus *Aphanomyces astaci* Schikora, 1906, which, since its first appearance in Europe, in 1860, has reduced production of native commercial crayfishes *Astacus astacus* (Linnaeus, 1758) and *Astacus leptodactylus* Eschscholtz, 1823, by up to 90% in Germany, Spain, and Turkey (Lodge *et al*., 2012). In Brazil, the species was imported probably from the US since 1980s to be used as a pet (Magalhães *et al*., 2005).

Non-native species rank second only to habitat destruction, such as deforestation, as a threat to biodiversity. The Convention on Biological Diversity, signed by Brazil, establishes in its Article eight that each country that is party to the Convention has to make efforts to prevent further introductions of non-native species (Alho *et al*., 2011). To reduce the likelihood of similar invasions, *P. clarkii* was placed on the Federal Ordinance No. 5 of 2008 for freshwater shrimps and crayfishes. This ordinance was passed by the Brazilian Institute of Environment and Renewable Natural Resources (IBAMA), a Federal agency under the Ministry of Environment (MMA). This ordinance determined illegal the import, as well as the introduction, reintroduction, trade, culture and transport of live individuals of this non-native crayfish in national territory by virtue of being very hardy and adaptive and for possessing a history of successful invasions in more than thirty countries (Brasil, 2008).

Despite the fact that the Brazilian government has ruled the importation of *P. clarkii* as illegal, the efficacy of the regulatory policy has never been evaluated. Thus, the effectiveness of the Brazilian ban on the importation of red swamp crayfish in aquarium stores is investigated herein.

Records of invertebrate imports were surveyed in early 2009. Shipment declarations and the attached commercial invoices regarding the period from January 2007 to December 2008 were obtained from aquarium store owners, namely of 11 aquarium stores in the north region, 10 in the northeast, 10 in the center-west, 40 stores in the southeast and 10 in the south region (Figure 1). From early 2009 to late 2011, the same aquarium stores originally sampled in 2007-2008 were revisited to determine the availability of *P. clarkii* three years following the Brazilian government ban.

Stores were visited once to determine the availability of red swamp crayfish for sale. Upon entering each store, tanks were visually scanned for the presence of *P. clarkii* (Figure 2). The distinguishing characteristics were compared and confirmed with those in Thorp and Rogers (2010). Differences in absolute frequencies between stores selling *P. clarkii* in each Brazilian geographic region before and after the ban were analyzed using a Chi-squared (χ^2) test (Sokal and Rohlf, 1981). The analyses were performed in the software PAST version 2.12 (Hammer *et al*., 2001).

In the periods of pre-ban (2007-2008), *P. clarkii* were sold at a low frequency in the north region, followed by center-west and south regions (Table 1). Overall, the availability of *P. clarkii* in aquarium stores decreased markedly from pre-ban surveys in 2007-2008 to post-ban surveys in 2009-2011 (χ^2=16.52, d.f.=1, P<0.05). A large, but no significant, decrease in availability of species was observed in the north, northeast and center-west regions, respectively (χ^2=3.00; χ^2=2.66; χ^2=1.00, d.f.=1, P<0.05). On the other hand, the frequency of availability of *P. clarkii* decreased substantially to

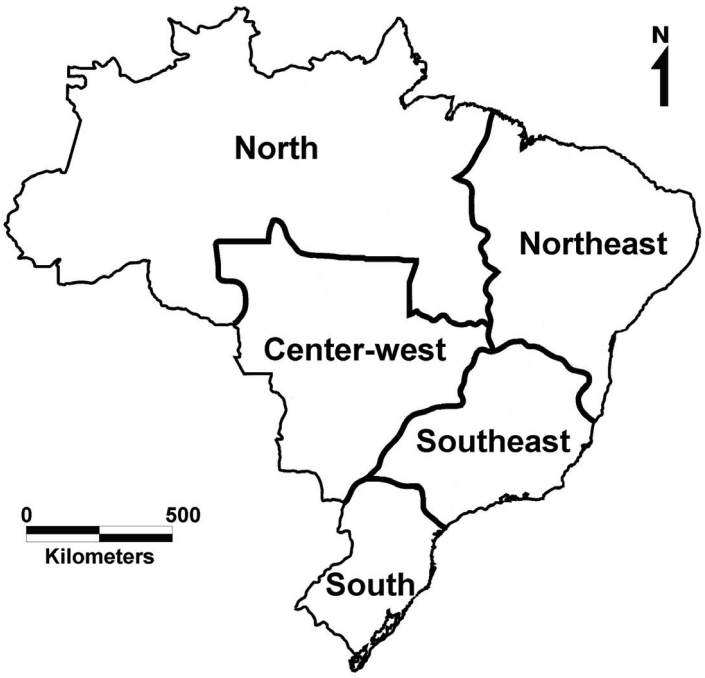

Figure 1. Brazilian geographic regions where aquarium stores were visited and surveyed.

Figure 2. A specimen of *Procambarus clarkii* in an aquarium store located in the city of Belo Horizonte, Minas Gerais State, southeast Brazil, photographed in January 2009.

30% in the southeast region (χ^2=10.52, d.f.=1, P<0.05) (Table 1).

A literature review showed that the commercial offering of prohibited crayfish species occurs at least in the United Kingdom. For instance, the availability and ease of purchase of illegal crayfishes, such as Turkish crayfish *Astacus leptodactylus* Eschscholtz, 1823, red swamp crayfish *P. clarkii*, marbled crayfish *Procambarus* sp., blue crayfish *Procambarus alleni* (Faxon, 1884), yabbie *Cherax destructor* Clark, 1936, hairy marron *Cherax tenuimanus* (Smith, 1912), yabby *Cherax misolicus* Holthuis, 1949, Lorentz yabby *Cherax lorentzi* Roux, 1911, zebra crayfish *Cherax papuanus* Holthuis, 1949, spiny-cheeked crayfish *Orconectes limosus* (Rafinesque, 1817), acocil crayfish *Cambarellus zempoalensis* Villalobos 1943, and Mexican dwarf crayfish *Cambarellus patzcuarensis* Villalobos, 1943 indicate that compliance of Prohibition Order of 1996 is not being respected (Clarke, 2007; Hill, 2012).

The sharp decline of *P. clarkii* is probably due to appearance of new species of freshwater shrimps and crayfishes in the Brazilian aquarium trade, namely the cherry shrimp *Neocaridina davidi* Klotz and Karge, 2013 *(*previously *Neocaridina heteropoda),* African giant filter shrimp *Atyopsis gabonensis* (Giebel, 1875)*,* Malawa shrimp *Caridina pareparensis* var. *parvidentata* Roux, 1904 *and crayfishes Cambarus* spp. and *Parastacus* spp. (Aquarismo Online, 1999; Aquaflux, 2008; Sera, 2012). Nevertheless, the persistent availability of prohibited *P. clarkii* found in this study suggests an ineffectiveness of the Brazilian ban. Non-native invertebrates constitute a serious threat to aquatic biodiversity, especially in megadiverse countries, such as Brazil (Magalhães *et al*., 2005; Magalhães and Costa, 2007).

Furthermore, it is essential to warn that the risk of introductions of *P. clarkii* conducted by aquarium hobbyists tends to spread all over the country because they are being sold via face-to-face personal contacts and e-commerce through the social network Facebook (Aquarismo Jumbo Vendas, 2012; Aquarismo: Venda, Compra e Trocas, 2012; Aquarismo pra Vender e Comprar Venha Fazer Negócio!!, 2013). Once a non-native

Table 1. Absolute and relative frequency of aquarium stores selling *Procambarus clarkii* in each Brazilian geographic region during both pre-ban and post-ban periods. The total number of stores is given in brackets.

Brazilian regions	Pre-ban 2007-2008	%	Post-ban 2009-2011	%	X^2
North	3 (11)	27.3	0 (11)	0.0	3.00
Northeast	5 (10)	50	1 (10)	10	2.66
Center-west	3 (10)	30	1 (10)	10	1.00
Southeast	34 (40)	85	12 (40)	30	10.52*
South	2 (10)	20	1 (10)	10	0.34
Total	47 (81)	58.0	15 (81)	18.5	16.52*

Note: (*) Significantly different ($P<0.05$; $\chi^2_{0.05}=3.84$; df=1).

species has been introduced to a new country, there is no such thing as zero risk of release. The risk by an individual hobbyist who may keep just a few animals will usually be small. However, when this risk is multiplied by hundreds of hobbyists due to the huge range of e-commerce, then releases are inevitable (Henderson and Bomford, 2011). Thus, it is necessary that: (i) Brazilian Customs Agency controlling borders enhance the number of invertebrate or crayfish experts to properly identify species imported by wholesalers, (ii) IBAMA should work with Facebook Serviços Online do Brasil Ltda. to provide warnings to hobbyists about Federal Ordinance No. 5 of 2008 showing that the sale of *P. clarkii* is an environmental crime, (iii) inspection of e-commerce, wholesalers and retailers be routinely performed jointly by IBAMA officials through 'Operation Nemo' and environmental police of Brazilian states aiming at confiscating *P. clarkii*, and (iv) awareness about law No. 5 be raised among e-commerce, retailers and aquarium hobbyists.

Acknowledgments

We would like to thank local aquarium stores for access to their invoices; to Marcos Maldonado-Coelho (Universidade de São Paulo - USP) for reviewing and providing comments on the manuscript, to Dr. Ana Maria Leal -Zanchet (Universidade do Vale do Rio dos Sinos - Unisinos) for critical review of the manuscript and two anonymous referees who have greatly contributed to the final version of this paper.

References

ALHO, C.J.R.; MAMEDE, S.; BITENCOURT, K.; BENITES, M. 2011. Introduced species in the Pantanal: implications for conservation. *Brazilian Journal of Biology*, **71**(1):321-325.

BANCI, K.R.S.; VIEIRA, N.F.T.; MARINHO, P.S.; CALIXTO, P.O.; MARQUES, O.A.V. 2013. Predation of *Rhinella ornata* (Anura, Bufonidae) by the alien crayfish (Crustacea, Astacidae) *Procambarus clarkii* (Girard, 1852) in São Paulo, Brazil. *Herpetology Notes*, **6**:339-341.

AQUAFLUX. 2008. Meu aquário de Malawas (*Caridina pareparensis parvidentata*). Available at: http://www.aquaflux.com.br/forum/viewtopic.php?f=151&t=11233&start=40. Accessed on: April 20, 2014.

AQUARISMO JUMBO VENDAS. 2012. Available at: https://www.facebook.com/groups/159717427486506/. Accessed on: 03/11/2014.

AQUARISMO: VENDA, COMPRA E TROCAS. 2012. Available at: https://www.facebook.com/groups/453992067963871/. Accessed on: 10/04/2014.

AQUARISMO PRA VENDER E COMPRAR VENHA FAZER NEGÓCIO!!. 2013. Available at: https://www.facebook.com/groups/299609296847249/?fref=ts. Accessed on: 04/11/2014.

AQUARISMO ONLINE. 1999. Qual é o nome desse lagostim? Available at: https://aquaonline.websiteseguro.com/forum/viewtopic.php?f=61&t=35297#p231086. Accessed on: 27/01/2014.

BRASIL. 1998. Lei 9.605 de 12 de fevereiro de 1998. Dispõe sobre as sanções penais e administrativas derivadas de condutas e atividades lesivas ao meio ambiente, e dá outras providências. Brasília, Ministério do Meio Ambiente, 16 p.

BRASIL. 2008. Portaria N° 5, de 28 de janeiro de 2008. Não autorizar, em todo território nacional, a introdução, reintrodução, importação, comercialização, cultivo e transporte de indivíduos vivos da espécie *Procambarus clarkii*. Brasília, Ministério do Meio Ambiente, 57 p.

CLARKE, M. 2007. Shops selling illegal tropical crayfish. Available at: http://www.practicalfishkeeping.co.uk/content.php?sid=1425. Accessed on: 26/10/2014.

DORR, A.J.M.; LA PORTA, G.; PEDICILLO, G.; LORENZONI, M. 2006. Biology of *Procambarus clarkii* (Girard, 1852) in Lake Trasimeno. *Bulletin Français de la Peche et de la Pisciculture*, **380**(381):1155-1167. http://dx.doi.org/10.1051/kmae:2006018

HAMMER, O.; HARPER, D.A.T.; RYAN, P.D. 2001. PAST: Paleontological statistics software package for education and data analysis. *Palaeontolia Electronica*, **4**(1):9.

HENDERSON, W.; BOMFORD, M. 2011. *Detecting and preventing new incursions of exotic animals in Australia*. Canberra, Invasive Animals Cooperative Research Centre, 55 p.

HILL, N. 2012. Illegal fish still on sale in the UK. Available at: http://www.practicalfishkeeping.co.uk/content.php?sid=4920. Accessed on: 10/02/2014.

HUNER, J.V. 1986. Distribution of the red swamp crawfish. *Crawfish Tales*, **5**(3):16-18.

LODGE, D.M.; DEINES, A.; GHERARDI, F.; YEO, D.C.J.; ARCELLA, T.; BALDRIDGE, A.K.; BARNES, M.A.; CHADDERTON, W.L.; FEDER, J.L.; GANTZ, C.A.; HOWARD, G.W.; JERDE, C.L.; PETERS, B.W.; PETERS, J.A.; SARGENT, L.W.; TURNER, C.R.; WITTMANN, M.E.; ZENG, Y. 2012. Global introductions of crayfishes: evaluating the impact of species invasions on ecosystem services. *Annual Review of Ecology, Evolution and Systematics*, **43**:449-472. http://dx.doi.org/10.1146/annurev-ecolsys-111511-103919

MAGALHÃES, A.L.B.; COSTA, T.M. 2007. Escape of the fiddler crab *Uca rapax* (Smith, 1870) (Crustacea, Ocypodidae) in the state of Minas Gerais, Brazil. *Lundiana*, **8**(1):65-68.

MAGALHÃES, C.; BUENO, S.L.S.; BOND-BUCKUP, G.; VALENTI, W.C.; SILVA, H.L.M.; KIYOHARA, F.; MOSSOLIN, E.C.; ROCHA, S.S. 2005. Exotic species of freshwater decapod crustaceans in the state of São Paulo, Brazil: records and possible causes of their introduction. *Biodiversity and Conservation*, **14**(8):1929-1945. http://dx.doi.org/10.1007/s10531-004-2123-8

McALAIN, W.R.; ROMAIRE, R.P. 2007. Cultured Aquatic Species Information Programme - *Procambarus clarkii*. FAO Fisheries and Aquaculture Department. Available at: http://www.fao.org/fishery/culturedspecies/Procambarus_clarkii/en. Accessed on: 11/09/2014.

OGADA, M. 2007. On the otter trail. *SWARA East African Wildlife Society*, **30**(2):48-50.

OGADA, M.O.; ALOO, P.A.; MURUTHI, P.M. 2009. The African clawless otter *Aonyx capen-*

sis (Schinz, 1821) and its diet as an indicator of crayfish invasion dynamics in aquatic systems. *African Journal of Ecology*, **47**(1):119-120. http://dx.doi.org/10.1111/j.1365-2028.2007.00910.x

SERA. 2012. Sera Manual: Camarões e crustáceos. Available at: http://www.sera.de/pt/pages/servico-sera/manuais.html. Accessed on: 20/04/2014.

SILVA, H.L.M.; BUENO, S.L.S. 2005. Population size estimation of the exotic crayfish *Procambarus clarkii* (Girard) (Crustacea, Decapoda, Cambaridae) in the Alfredo Volpi City Park, São Paulo, Brazil. *Revista Brasileira de Zoologia*, **22**(1):93-98. http://dx.doi.org/10.1590/S0101-81752005000100012

SOKAL, R.R.; ROHLF, F.J. 1981. *Biometry: the principles and practice of statistics in biological research*. New York, W.H. Freeman and Company, 859 p.

THORP, J.H.; ROGERS, D.C. 2010. *Freshwater Invertebrates of North America*. Boston, Academic Press, 274 p.

Submitted on April 21, 2014
Accepted on November 22, 2014