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LETTER TO THE EDITOR

The "Tilapia Law" encouraging non-native fish threatens Amazonian River basins

André A. Padial[1] · Ângelo A. Agostinho[2] · Valter M. Azevedo-Santos[3] · Fabrício A. Frehse[1] · Dilermando P. Lima-Junior[4] · André L. B. Magalhães[5] · Roger P. Mormul[2] · Fernando M. Pelicice[6] · Luis A. V. Bezerra[1] · Mário L. Orsi[7] · Miguel Petrere-Junior[8,9] · Jean R. S. Vitule[1]

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Freshwater ecosystems in Brazil, arguably the most diverse on the planet, have been disturbed by several threats in the past years, particularly competition for water and subsequent water abstraction, urbanization, severe drought, dam construction/water diversion, pollution from different sources, commercial exploitation, and the introduction of non-native species (Agostinho et al. 2005; Vitule et al. 2015; Lima et al. 2015; Winemiller et al. 2016). A worrying example is the federal law 5989/2009 that intends to naturalize non-native fish species by decree in Brazil, some of which have a high invasion potential, such as the carps *Aristichthys nobilis*, *Ctenopharyngodon idella*, *Cyprinus carpio*, *Hypophthalmichthys molitrix* and tilapias *Oreochromis* spp. (Lima et al. 2012; Vitule

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✉ André A. Padial
aapadial@gmail.com

[1] Pós-graduação em Ecologia e Conservação; Laboratório de Análise e Síntese em Biodiversidade, Departamento de Botânica; Laboratório de Ecologia e Conservação, Departamento de Engenharia Ambiental, Universidade Federal do Paraná, Curitiba, Brazil

[2] Pós-Graduação em Ecologia de Ambientes Aquáticos Continentais (PEA), Universidade Estadual de Maringá, Maringá, Brazil

[3] Laboratório de Ictiologia, Universidade Estadual Paulista, Botucatu, Brazil

[4] Laboratório de Ecologia e Conservação de Ecossistemas Aquáticos, Universidade Federal do Mato Grosso, Pontal do Araguaia, Brazil

[5] Pós-graduação em Tecnologias para o Desenvolvimento Sustentável, Universidade Federal de São João Del Rei, Ouro Branco, Brazil

[6] Núcleo de Estudos Ambientais, Universidade Federal de Tocantins, Porto Nacional, Brazil

[7] Departamento de Biologia Animal e Vegetal, Universidade Estadual de Londrina, Londrina, Brazil

[8] Programa de Pós-Graduação em Planejamento e Uso de Recursos Renováveis, Universidade Federal de São Carlos, Sorocaba, Brazil

[9] Programa de Pós-Graduação em Sustentabilidade de Ecossistemas Costeiros e Marinhos, UNISANTA, Santos, Brazil

et al. 2012; Pelicice et al. 2014). After naturalized, such species could be used without legal restrictions in aquaculture, for instance. Although aquaculture has been raising non-native species in the Amazon for at least 7 years (Gama 2008; Portal dos Convênios 2016), the Amazon system is the last in the country where non-native species are still scant or absent (Pelicice et al. 2014). It is also the least studied considering non-native species (Frehse et al. 2016). However, this situation is about to change. Without consulting environmental institutions or the public, José Melo, the Governor of the State of Amazonas, sanctioned another worrying law: the state law 79/2016 on 30 May 2016, which allows aquaculture with non-native species in Amazonian River basin, the most diverse area for freshwater fish in the world with about 2500 described species (Winemiller et al. 2016). The law, already referred to amongst academics as "Tilapia Law", relied on proposals from the National Agriculture Confederation to allow the damming of Amazonian streams ("igarapés"), for fish culture and the construction of fish farms inside Permanent Preservation Areas (i.e. riparian zones). The Confederation also supported initiatives for the culture of non-native species in other states in western Amazon, notably Acre and Rondônia States.

The vision of "sustainable aquaculture" promises a social paradise with state and federal agencies combining efforts to improve non-native fish production (Pelicice et al. 2014; Lima et al. 2016). The "Tilapia Law", and Federal Law 413/2009 facilitating aquiculture in Brazil, mean that there is a prospect of increasing propagule pressure from non-native fish and a risk of successful and potentially explosive invasions into the Amazon river systems. Negative impacts, such as biotic homogenization, from non-native species, particularly tilapias of the genera *Oreochromis* and *Tilapia* which are the dominant introductions in Brazilian inland waters, are already documented in the scientific literature, covering all ecological levels and different ecosystems (Canonico et al. 2005; Figueredo and Giani 2005; Vitule et al. 2009; Lima et al. 2016). Synergistic disturbances are particularly evident in altered environments such as reservoirs (Agostinho et al. 2005), which have increased to 239 Amazonian basins (Lima et al. 2015; Lees et al. 2016). An additional cause for our concern is that tilapias have already caused ecological impacts in Amazon River tributaries (Bittencourt et al. 2014). Negative impacts have been recorded in populations of 16 native cichlid species, and there has been a dissemination of parasites (*Ichthyophthirius multifiliis*, *Trichodina centrostrigeata*, *Paratrichodina africana*, *Trichodina nobilis* and *Cichlidogyrus*), and transmission of the non-native trichodinid *T. nobilis* of the Nile tilapia (*Oreochromis niloticus*) to the native cichlid *Aequidens tetramerus* (Bittencourt et al. 2014).

The use of non-native species in aquaculture is the norm in Brazil (Vitule et al. 2012; Pelicice et al. 2014; Lima et al. 2016), and escapes occur to the environment (Azevedo-Santos et al. 2011, 2015; Ortega et al. 2015), leading to an exponential increase on propagule pressure of non-native species, one of the main factors behind invasions (Simberloff 2009). While several countries are taking steps toward restoring aquatic ecosystems through the development of better controls over the introduction of non-native species (Lima et al. 2015), Brazil is adopting measures moving in the opposite direction. The governmental plan for the development of aquaculture in Brazil presents a worrying scenario for the conservation of aquatic biodiversity. The expansion of Aquaculture Parks (i.e. areas in public waters where the development of aquaculture in cage nets is permitted) is based an intensive cultivation of non-native species (Lima et al. 2016). For instance, fish farmers who encourage the culture of tilapias in Amapá State, eastern Amazon, claim that "it would be great if all state rivers were populated by tilapias" (Gama 2008). Recent changes in Brazilian laws also allow the transportation and cultivation of more than 2000

fish species for ornamental aquaculture (Lima et al. 2015). As an additional concern, aquarium trade and aquaculture are among the most important vectors of non-native species in Brazil (Frehse et al. 2016). The increase of propagule pressure from cultivated species and the consequent risk of secondary introductions (e.g. molluscs, parasites, pathogens) can be expected to accentuate the negative ecological impacts.

We can only conclude that the Brazilian authorities are focused on possible short-term gains in fish production to the detriment of the maintenance of native biodiversity and ecosystem services. However, the short-term gains will be largely to the economic benefit of a few people (Moura et al. 2016). In general, poorer populations do not practice aquaculture due to the high inputs necessary for production (Agostinho et al. 2007).

We wish to initiate a debate involving different societal sectors, including public authorities, decision makers, regulatory and environmental agencies, universities/research centers, professionals who work with animal production, aquaculture associations, importers/exporters, fry producers, fish farmers and laymen, to increase awareness of the current knowledge about risks and negative effects associated to non-native species (Vitule et al. 2009; Lima et al. 2016; Simberloff et al. 2013; Azevedo-Santos et al. 2015) with a view to an application of the precautionary principle. In addition, public authorities should be encouraged to take note of the scientific community to set policies and avoid environmental catastrophes (Rochman 2016). We would like to see policies aimed at promoting aquaculture promoting the use of native species and being aware of the need to conserve native fish stocks and biodiversity.

The "Tilapia Law" has already been questioned by the Federal Public Ministry, and many other conservation bodies and universities. However, it remains a prelude to a potentially imminent environmental catastrophe, also involving the disruption of natural cycles of flooding, destruction of riparian vegetation of the special "igarapé" ecosystems, and impoverishment of the unparalleled Amazonian native fish biota.

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