



Policy Recommendation on the Restriction on Amphibian Trade Toward the Republic of Korea

Amaël Borzée^{1*}, Sera Kwon², Kyo Soung Koo³ and Yikweon Jang^{2,3}

¹ Laboratory of Animal Behaviour and Conservation, College of Biology and the Environment, Nanjing Forestry University, Nanjing, China, ² Interdisciplinary Program of EcoCreative, Ewha Womans University, Seoul, South Korea, ³ Department of Life Sciences and Division of EcoScience, Ewha Womans University, Seoul, South Korea

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*Correspondence:

Amaël Borzée
amaelborzee@gmail.com

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Amphibian diseases and invasive amphibian species are both generally introduced through the wildlife trade, either for human consumption or for the pet trade. However, adequate regulations can prevent such introductions. In the Republic of Korea, the establishment of invasive *Lithobates catesbeianus* populations resulted in the alteration of native species' ecology and in an increase in Batrachochytrid load on local species. While not exemplified yet, the same risk arises from all species in the trade, some of which are already found in the wild despite the potential threats to the ecosystems. While regulations exist for the trade of wildlife in general, they are not directly addressing the amphibian trade, especially newly traded species. Thus, we recommend a restriction on the trade of amphibians in Korea.

Keywords: amphibian, pet trade, invasive species, emerging diseases, threat, Korea

ACTIONABLE RECOMMENDATIONS

1. Regulation of amphibian trade entering the Republic of Korea (food- and pet-trade),
2. Implementation of a stricter control of amphibian species already in the trade,
3. Establishment of quarantine and testing for all amphibians entering the country.

INTRODUCTION

Invasive Species

Both amphibian pathogens and invasive amphibians are generally introduced through the wildlife trade, either for human consumption or for the pet trade, and result in extensive threats to local species (Scheele et al., 2019; Falaschi et al., 2020). A widespread culprit for being both an invasive and introducing pathogens is the American bullfrog (*Lithobates catesbeianus*; Ficetola et al., 2007; **Figure 1**), carrying both fungal (Fisher and Garner, 2007) and viral pathogens (Gray et al., 2009). The presence of the species outside of its range has been linked to numerous declines in other species (Snow and Witmer, 2010), and it is also linked to a negative economic impact (Measey et al., 2016). However, the introduction of this invasive species and linked pathogens could have been prevented in numerous



FIGURE 1 | *Lithobates catesbeianus*, the American bullfrog, in the wild in the Republic of Korea. This species has been introduced in the country where it has established feral population that have a significant negative impact on local species, likely resulting in the extirpation of some Hylid populations.

countries if adequate regulations had been in place when the species was first transported and introduced at multiple location around the earth. It is consequently the role of the current generation to step up regulations to prevent similar introductions and losses in the future.

In the Republic of Korea, the invasive *L. catesbeianus* was found to be responsible for altering the ecological landscape (Ko et al., 1991; Shim et al., 2005; Heo et al., 2014; NIE, 2014; Groffen et al., 2019; Kang et al., 2019), and its presence is linked to the extirpation of Hylid populations (Borzée et al., 2020). The presence of the species is also linked to an increase in fungal load on local species (Borzée et al., 2017). However, *L. catesbeianus* is not the only non-native amphibian species found in the wild in the country, and species such as *Duttaphrynus melanostictus*¹, *Osteopilus septentrionalis*, *Xenopus laevis*, and *Rana* spp. have also been recorded (National Institute of Ecology, 2016). As of 2014, the Republic of Korea was importing amphibians from 14 countries, accounting for several hundred tons per year (Bang et al., 2006). In 2019, this number had risen to 122 non-native species purchasable from online pet shops, for as little as 3 000 KRW (c. 2.20 euro; Koo et al., 2020), as well as native species of anuran and caudata. Some of the species available are restricted from sale or even listed as CITES (Ministry of Environment, 2018).

¹www.inaturalist.org/observations/419643

Species commonly available in the pet trade such as *Litoria caerulea*, *Rhinella marina*, *Ceratophrys* sp., *Phyllomedusa* sp., and *Kaloula pulchra* (Park et al., 2014; Koo et al., 2020) are unlikely to establish feral populations because the local climate is drastically different from the one required by the species. However, other species such as *Salamandra salamandra* and *Dryophytes cinereus* (Koo et al., 2020) are very likely to be able to establish populations due to similar ecological requirements and similar habitat characteristics as those found in the native range of these species².

In addition, the presence of *Rana chinensis* in northern Gyeonggi Province following mercy releases of unsold animals from the frog meat trade are under investigation. The presence of the species results from the governmental authorisation to import the same species as the three legally farmed local species (Ministry of Environment, 2017), despite the absence of reliable means to morphologically identify the species, and disregarding the taxonomic split between *Rana dybowskii* and *Rana uenoi* (Matsui, 2014).

In addition, there is currently no restriction on the importation of species that are not listed as threatened by CITES. This absence of restriction is critical as over 30% of reported invasive amphibian introductions have resulted in the establishment of new populations

²<https://amphibiaweb.org/>

(Bomford et al., 2005). Finally, the custom service also recognizes the threats, which resulted in a recommendation for veterinary medical inspection of imported animals (Heo, 2008a,b) and the government enacted a law restricting the import of specific exotic species (Act No.14513, 2016; Enforcement Date 28 Jun 2017). This law is regularly updated and for instance two invasive freshwater turtles, *Pseudemys concinna* and *Mauremys sinensis*, were added to the list of restricted species in March (Ministry of environment, 2020).

Emerging Diseases

Korean amphibians have known to be naturally infected by amphibian-specific emerging disease, including the chytrid fungus *Batrachochytrium dendrobatidis* (i.e., Batrachochytrid; Yang et al., 2009; Bataille et al., 2013; Borzée et al., 2017; O'Hanlon et al., 2018) and Ranaviruses (Suk et al., 2009; Kwon et al., 2017; Park et al., 2017). Emerging diseases are linked to the current extinction crisis affecting amphibians, and management measures are required to stem all risks (Stuart et al., 2004; Beebee and Griffiths, 2005; Blaustein et al., 2011; Bishop et al., 2012; Wake, 2012; Pimm et al., 2014; Scheele et al., 2019).

Deadly strands of emerging pathogens such as Batrachochytrid are of foreign origin (Suk et al., 2009; Bataille et al., 2013) and Korean amphibian species are likely to be resistant to strands originally present on the peninsula (O'Hanlon et al., 2018). However, amphibian species of foreign origin have been shown to be agents spreading pathogens (Borzée et al., 2017), potentially facilitating recombination and resulting in more virulent lineages (Farrer et al., 2011). Additionally, it has been shown that imported amphibians as pets or zoo animals increase the risk of Chytrid fungus in wild Korean populations (Kim et al., 2017). To avoid the presence of further contamination, such as the salamander chytrid fungus (*Batrachochytrium salamandrivorans*) affecting European salamanders (Martel et al., 2014) and anurans (Nguyen et al., 2017) with potential lethal implications (Martel et al., 2013; Stegen et al., 2017), it is important to regulate the trade of species susceptible to the infection and susceptible to be carrying the pathogens. An example of species with the potential to spread pathogens through the pet trade is for instance the fire salamanders (*S. salamandra*; Sabino-Pinto et al., 2015).

While there is no zoo or centre involved in breeding amphibians, pet shops import amphibians, zoos sometimes exhibit species, and specific institutions breed species for conservation purposes. For instance, the Endangered Species Restoration Center breeds *Pelophylax chosonicus* under the supervision of the National Institute of Ecology. These institutions are the first on the line to prevent the spread of invasive amphibian species and their pathogens and should therefore be strongly involved in preventing their dissemination.

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POLICY AND PRACTICE

Policies have been established but they do not prevent the import of species that were not initially found in the trade, and feral populations can become established before the amendment of the law and their addition to the list of restricted species. Thus, in view of the largely increasing number of emerging diseases targeting amphibians and the critical status of amphibians, in line with administrations aimed at regulating pet trade to prevent the spread of invasive diseases (Gray et al., 2015; Sullivan, 2018), and in agreement with the recommendations of the Amphibian Conservation Action Plan from the IUCN SSC Amphibian Specialist Group (Wren et al., 2015), we recommend a restriction on the import and trade of amphibian species into the Republic of Korea.

The restriction proposed should target all live amphibian individuals traded for leisure and consumption purposes. We recommend that all species traded for consumption should be imported after euthanasia to ascertain their impossibility to establish feral populations. Regarding species aimed at the pet trade, generally labeled as “exotic,” we recommend a total restriction to prevent the introduction of potentially invasive species and pathogens. When a species cannot be restricted from the trade, testing and quarantine procedures should be established in agreement with the Convention on International Trade in Endangered Species of Wild Fauna and Flora. In addition, only amphibian species unable to establish feral populations because of ecological requirements not matching with the ecological variables of the Republic of Korea should be exemptible from the trade restriction. We also recommend the implementation of a stricter control of amphibian species already in the trade, especially for species listed as threatened by The IUCN Red List of Threatened Species, and the enforcement of regulations such as CITES to remove all banned species from sale. However, the restriction should not preclude education and research and a potential for exemptions in the case of biological samples should also be established.

AUTHOR CONTRIBUTIONS

AB developed the idea. All authors contributed equally.

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