frontiers | Frontiers in Amphibian and Reptile Science

TYPE Editorial
PUBLISHED 06 March 2025
DOI 10.3389/famrs.2025.1538480

OPEN ACCESS

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RECEIVED 02 December 2024
ACCEPTED 18 February 2025
PUBLISHED 06 March 2025

CITATION
Ruggeri J and Lesbarrères D (2025) Editorial: From landscape modifications to pathogen infections: are threats to amphibians the same in all biomes?
Front. Amphib. Reptile Sci. 3:1538480.
doi: 10.3389/famrs.2025.1538480

Editorial: From landscape modifications to pathogen infections: are threats to amphibians the same in all biomes?

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KEYWORDS

emerging infectious disease (EID), habitat modification, anthropogenic activities, population declines, conservation

Editorial on the Research Topic
From landscape modifications to pathogen infections: are threats to amphibians the same in all biomes?

Background

Anthropogenic actions have been altering ecosystems for decades, thus impacting biodiversity globally, with a special risk looming on amphibians. Threats range from the direct use of land and habitat modification to the indirect effects of biological invasions and pathogen emergence (Green et al., 2020). Articles published in this Research Topic highlight the consequences of human disturbance on the health of amphibians by either reporting the direct cause of harm or the mitigation measures aimed at their conservation.

Complexity and interplay of threats to amphibian species

Among human-induced threats to amphibians, the emergence of infectious diseases caused by novel (or more virulent) pathogens, such as *Batrachochytrium dendrobatidis* (Bd), *B. salamandrivorans* (Bsal), and *Ranavirus* (Rv), is largely associated with amphibian declines worldwide (Teacher et al., 2010; Scheele et al., 2019). Bd and Rv present a global distribution, whereas Bsal remains restricted geographically due to several efforts to contain its spread (Fisher and Garner, 2020; Olson et al., 2024). In the UK, Ball et al. detected patterns of mtDNA haplotypes in populations of the invasive Alpine newt (*Ichthyosaura alpestris*) compatible with newts from the pet trade, suggesting there is an ongoing release of the species in the territory. Such repeated introductions represent a great danger to native species, as Alpine newts usually remain asymptomatic to infection (Daversa et al., 2018) and could potentially spread diseases. For instance, harlequin frogs (*Atelopus* spp.) are flagships for those species

that have suffered severe population declines due to chytridiomycosis (La Marca et al., 2005). While some species adapted to Bd following outbreaks resulting in a few presumably extinct species reappearing (Jaynes et al., 2022), many others remain declining; thus, reestablishing populations is highly important from a conservation perspective. To this end, Klocke et al. monitored the transition of *Atelopus limosus* from captivity to sites within the species' historical range in Panama and showed that a 30-day acclimatization is crucial for successful release and survival of captivity-bred individuals.

The persistence of Bd in the environment is related to the susceptibility of hosts (Carvalho et al., 2024) and the presence of ideal microclimates for its development (Longcore et al., 1999). Santos et al. detected higher prevalence of Bd in tadpoles from forested sites than in agricultural sites in Brazil, likely due to the shading provided by canopy cover (Becker and Zamudio, 2011). The authors employed a species-indicator analysis to identify species prone to Bd infection, and used this result to infer which community would likely be Bd-positive. The study confirmed tadpoles of *Boana faber* as highly susceptible to Bd (Ruggeri et al., 2020), in addition to two species endemic to southern Brazil (*Boana curupi* and *Crossodactylus schmidti*), which could be indicators for the Bd presence in a community. The presence of Rv, another pathogen posing enormous risks to amphibians globally (Gray and Chinchar, 2024), was also investigated on 10 anuran species but was not detected. This does not refute the presence of Rv in the area as the infection may be seasonal (Hall et al., 2018) and was previously detected in the region (Ruggeri et al., 2024), indicating it should be continuously investigated. Water pollution has also been associated with Bd (Jacinto-Maldonado et al., 2023) and Jacinto-Maldonado et al. corroborate this by detecting high prevalence on sites with continuous wastewater discharge. In addition, they detected elevated concentrations of chemical elements known to pose a risk of bioaccumulation and that may transfer through the food chain on sites with amphibians coinfected by Bd and the mite.

As aforementioned, biological invasions pose a major threat to amphibians not only for disease transmission, but also due to competition and hybridization with native species (Kraus, 2015), a point highlighted by Borzée et al. with regard to the Japanese and Chinese giant salamanders. Many invasive amphibians can easily adapt and expand their distribution range rapidly. This is the case for the American bullfrog (*Lithobates catesbeianus*) worldwide, the cane toad (*Rhinella marina*) in Australia, and more recently, the Lesser Antillean frog (*Eleutherodactylus johnstonei*) in Brazil (Frost, 2024). Melo et al. explored acoustic consequences of invasions on the behavior of native species, showing that native pond breeder amphibians in Brazil ceased calling in the presence of callings from *E. johnstonei*. Both and Grant (2012) had shown how calls from invasive bullfrogs caused a shift on calls from a native species in Brazil, suggesting that such acoustic competition could impact the reproductive success of species in the same acoustic niche. Although they highlight that *E. johnstonei* is a direct-developing frog and such encounter with pond breeders would rarely occur in the wild, the reproductive season of this and most species in Brazil overlaps (Bertoluci, 1998; Tárano and Fuenmayor, 2009), and the presence of the invader could indeed cause acoustic interferences, thus impacting native anurans.

Are threats to amphibians the same in all biomes?

We learned with this Research Topic that the international movement of live animals and habitat fragmentation resulting from agriculture, urbanization, and waterway obstructions (dams and weirs) can affect amphibians differently, but the result is often the same: populations decline. While threats may be of different nature or strengths, amphibians rarely face only one of them (Green et al., 2020). Therefore, recognizing the main threats to amphibian populations is a primary step toward species conservation.

Borzée et al. reviewed the dangers faced by the Japanese giant salamander given the current state of the environment where the population persists, proposing actions to allow the species to thrive. Klocke et al. concluded that a 30-day acclimatization is crucial for the successful release and survival of captivity-bred *Atelopus limosus* in Panama, providing data to potentially improve and refine release methods for other species. Santos et al. identified potential Bd-indicator species in Brazil that would allow researchers to focus on communities composed of such species when screening for Bd, and highlighted forest patches within disturbed habitats as priority areas for conservation. In Mexico, Jacinto-Maldonado et al. showed that species from degraded areas would be highly susceptible to Bd infection and coinfection with parasite/pathogens, and the lowland leopard frog (*Lithobates yavapaiensis*), a species suffering severe population declines (IUCN, 2024), presented the highest Bd loads. We also learned that pet trade continues to play an important role in introducing alien species in the UK as reported by Ball et al. This practice compromises natural ecosystems and ecological relationships worldwide by causing biological invasions that may lead to acoustic interferences and changes in the behavior of native species, as exposed by Melo et al. Overall, threats are diverse and complex, and only a comprehensive approach to each ecosystem will help the conservation of amphibians.

Author contributions

JR: Writing – original draft, Writing – review & editing. DL: Writing – original draft, Writing – review & editing.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declare that no Generative AI was used in the creation of this manuscript.

Publisher's note

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