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Protected areas network and conservation efforts concerning threatened amphibians in the Brazilian Atlantic Forest

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Abstract. One of the most common conservation strategies used to preserve threatened species is the establishment of protected areas (PAs), providing a maximum representation of biodiversity with the smallest possible cost. The Brazilian Atlantic Forest is one of the 35 global biodiversity hotspots for conservation priorities, having high rate of habitat loss, which is one of the main factors driving threatened amphibians to extinction. Considering that amphibians are the vertebrate group with the largest number of species geographically excluded from global PAs, gap analysis was employed to evaluate whether or not the PAs of the Brazilian Atlantic Forest safeguard the threatened amphibian species in this region. Species status were compared through the official list of threatened species of the Brazilian Fauna and occurrence maps were obtained from the IUCN (International Union for Conservation of Nature) Red List database. Thirty-eight threatened amphibian species were found, accounting for 17 critically endangered (CR), 10 endangered (EN), and 11 vulnerable (VU). The PAs distributed in the Brazilian Atlantic Forest corresponds to only 9 % of the region's entire area. This protected network covers only 30 % of the total geographical range of the assessed species. Besides, a shift in Brazil's environmental policy has led to PAs downgrading. Therefore, the maintenance of PAs integrity is essential, as well as further investment is necessary for the creation of new reserves, avoiding species loss and reducing the extinction risk of the threatened amphibian species in the Brazilian Atlantic Forest.

1   Introduction

The establishment and maintenance of protected areas (PAs) are the most effective methods for natural environment conservation, acting as a cornerstone of conservation policies (Le Saout et al., 2013). Given that habitat loss is the most important threat to species survival, the protected sites chosen by decision-makers determine what species and how many of these are able to survive in the nature (Jenkins et al., 2015). In this sense, the most important criterion for locating and

designing PAs should be to achieve maximum representation of biodiversity with the smallest possible cost (Margules and Pressey, 2000).

The Brazilian Atlantic Forest is one of the 35 global biodiversity hotspots for conservation priorities, having high rate of habitat loss (Mittermeier et al., 2011), which is the main factor driving threatened amphibians to extinction (Becker et al., 2007). Among all the vertebrates, amphibians are the group with the largest number of species geographically excluded from global PAs, which corresponds to 24 % of the

living amphibian species (Nori et al., 2015). Some attempts to conserve threatened amphibians were proposed by previous studies which highlight parts of the Atlantic Forest as high priority areas (e.g., Loyola et al., 2008; Campos et al., 2013). In addition, some taxonomic groups of amphibians from small areas within the Atlantic Forest were identified as potential surrogates of biodiversity (Campos et al., 2014). However, the survival of threatened amphibians in fragmented landscapes is dependent on PAs, which ensure the habitat quality for these species (Urbina-Cardona, 2008; Ochoa-Ochoa et al., 2009). Therefore, this study aimed to evaluate if the PAs network of the Brazilian Atlantic Forest safeguards the populations of threatened amphibians that occur in this region.

2   Material and methods

Spatial data on the PAs were obtained from Brazil's Ministry of Environment database (http://www.mma.gov.br/areas-protegidas/cadastro-nacional-de-ucs; MMA, 2015b), including their categories and land coverage. ArcGIS 9.3® software (ESRI, 2008) was used to overlap the PAs data set on the geographical range of the threatened amphibians from the Brazilian Atlantic Forest. The distribution of each species was designed from a presence/absence matrix based on the IUCN (International Union for Conservation of Nature) Red List of Threatened Species database (IUCN, 2015).

Gap analysis (see Scott and Schipper, 2006) was performed to assess if the PAs network of Brazilian Atlantic Forest is able to support the distribution of the threatened amphibian species that occur in this region. The PAs were separated into two categories (IUCN, 2015): strict protection (IUCN categories I–II) and sustainable use (IUCN categories III–VI), identifying relative differences in the allocation of protection by each category. National, state and municipal areas were considered in the PAs network evaluated.

Finally, the conservation status of the assessed species were compared using the National Red List categories, through the official list of threatened species of the Brazilian fauna (e.g., critically endangered – CR, endangered – EN, and vulnerable – VU; MMA, 2015a).

3   Results and discussion

A total of 9309 km^2 of PAs were identified in the Brazilian Atlantic Forest, which corresponds to only 9 % of the region's entire area. In total, 38 threatened amphibian species were found, accounting for 17 critically endangered – CR, 10 endangered – EN, and 11 vulnerable – VU (see Table S1 in the Supplement). The PAs network evaluated comprises 2316.74 km^2 strict protection areas and 6992.41 km^2 sustainable use areas. This network covers only 30 % of the total geographical range of the assessed species, leaving out 70 %
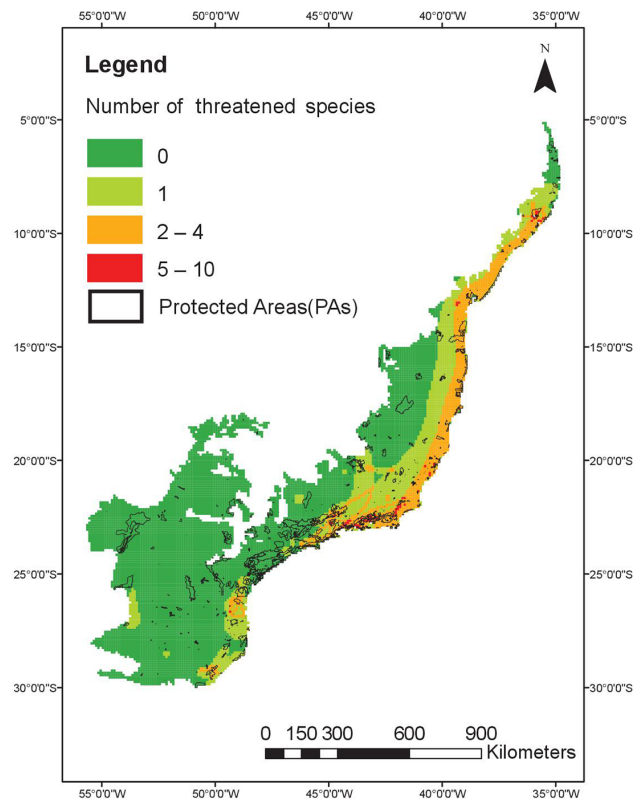
Figure 1. Map of protected areas network and geographical range of the threatened amphibian species that occur in the Brazilian Atlantic Forest.

of the threatened amphibian species that occur in this region (Fig. 1).

The selection of PAs is often aimed to preserve species of different taxonomic groups, communities of high biological relevance or combinations of different abiotic conditions favourable to local ecosystems, assuming that these sites will protect a wider range of biodiversity (Lawler and White, 2008). However, many case studies have revealed the inefficiency of the PAs network in representing species diversity (Rodrigues et al., 2004). In North-eastern Brazil, Campos et al. (2013) showed that the size of the PAs along the geographical range of threatened amphibian species do not necessarily safeguard their persistence in the future, as well as observed in this study. Moreover, the number of amphibian species of the Brazilian Atlantic Forest will decline within the PAs network due to the changing climate conditions (Lemes et al., 2014). Furthermore, there is an additional risk regarding this network as it is situated within the economic core of Brazil (Ribeiro et al., 2009), with a high human population density, and the presence of mining and logging industries in the region (Lemes et al., 2014). Despite the legal restrictions on deforestation, vegetation is still extracted illegally, representing a mean rate of forest loss of around 0.15 % per year (SOS Mata Atlântica and INPE, 2015).

Most PAs in the Atlantic Forest were designed in absence of any ecological criterion and lacked consideration of species representation needs (Lemes et al., 2014). To make matters worse, a shift in Brazil's environmental policy has led to PAs downgrading, downsizing and degazettement (Bernard et al., 2014). Given this context, the results of this study are worrying and reveal that local conservation policies aimed at Brazilian Atlantic Forest PAs do not guarantee the survival of the majority of threatened amphibian populations present in this region. Despite this, the present study does not provide quantitative estimates of species extinction risk, but it does show evidence of inefficient protection for the threatened amphibian species that are covered by the current PAs network.

With the intention of proposing a cost-effective solution for local regions to implement new PAs in a stepwise fashion, Bode et al. (2008) established an economic cost of USD 68 733 for each km^2 of Brazilian Atlantic Forest. This value corresponds to only 0.2 % of the mean annual budget of the Brazilian Ministry of the Environment, which has increased in recent years (MMA, 2015b). However, this budget increase has not prevented a shift in Brazil's environmental policy, negatively affecting resources for improved PAs.

This brief overview highlights not only the crisis faced by unprotected amphibians, but it also sounds the alarm regarding the situation of species covered by the PAs network. Such context renders political will and improved environmental actions essential for the maintenance of PAs integrity, avoiding species loss and reducing the extinction risk of the threatened amphibian species in the Brazilian Atlantic Forest.

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