The disparity between species description and conservation assessment: a case study in taxa with high rates of species discovery

Word count: 5,134

Highlights

- Since 2004 there has been 25% increase in known amphibian species
- Extinction risk assessments are out-of-date or lacking for 61% of amphibian species
- Species descriptions should contain data relevant to species' conservation status

Abstract

The IUCN Red List of Threatened Species (Red List) details the extinction risk of the world's species and presents an important biodiversity indicator for conservation policy. Its continued utility relies on it containing up-to-date information on the extinction risk of species. This requires both regular reassessments and the timely assessment of newly described species. We provide an overview of the status of amphibian Red List assessments to highlight the difficulties of keeping assessments updated for species groups with high rates of species description. Since the publication of the IUCN's Global Amphibian Assessment in 2004, description rates of new species and assessment rates were initially similar; yet while the former has remained consistent, the latter has recently sharply declined. Currently 61.3% of amphibian species are either Not Evaluated or have out-of-date assessments. The situation is particularly problematic in countries with the richest amphibian diversity, which typically have the highest rates of amphibian species discovery and face the greatest threats. Efforts to keep the Red List up-to-date are primarily limited by funding, we estimate that an annual investment of US $170,478−$319,290 is needed to have an up-to-date Red List for amphibians. We propose suggestions to increase assessment rates by improving the availability of data relevant to the process: authors of species descriptions or taxonomic revisions should publish information relevant to Red List assessments. Taxonomic journals should suggest inclusion of such information in their author guidelines. We suggest that contributors with significant input into assessments should be rewarded with co-authorship of published assessments.

Keywords

Amphibian, conservation prioritization, Global Amphibian Assessment, IUCN Red List of Threatened Species, extinction risk.

Introduction

The IUCN Red List of Threatened Species (hereafter the 'Red List') is a centralised, widely accepted measure of global extinction risk used to identify threats and priority conservation actions (Lamoreux et al. 2003; Rondinini et al. 2014). The Red List tracks changes in extinction risk over time, and is important in measuring threats to biodiversity and evaluating the impact of conservation intervention on a global scale (Hoffmann et al. 2010). The Red List has significant influence over which research and conservation work is resourced as grant funding often prioritizes globally threatened species. It also underpins the Red List Index, an important biodiversity indicator steering conservation policy (Butchart et al. 2004; Butchart et al. 2007; Butchart et al. 2010).

The Red List is currently supported by fund-raising efforts carried out by the IUCN and Red List Partners, and through philanthropy (Rondinini et al. 2014; Juffe-Bignoli et al. 2016). However, once a taxonomic group has been comprehensively assessed, funding for subsequent assessments is not readily available (Rondinini et al. 2014). Much of the work required to assess a species, particularly providing data and compiling draft assessments, falls on the good will of scientists and other contributors volunteering their time, data and expertise (Juffe-Bignoli et al. 2016).

The long-term effectiveness and relevance of the Red List, and the conservation initiatives reliant on it, depend on its ability to reflect our changing understanding of biodiversity. In order to accurately gauge trends and prioritize taxa and regions, the Red List must not only ensure that assessments are sufficiently updated but also keep pace with assessing newly described species. In taxa such as birds and mammals, only a handful of new species are described annually (Ceballos & Ehrlich 2008; Avibase 2016), but in other groups species description rates are relatively high (Costello et al. 2012), presenting a challenge to the sustained relevance of the Red List.

Amphibians provide an excellent case study of the challenges and requirements of an up-to-date Red List. Currently, amphibians are the most threatened vertebrate class with 42% of assessed species threatened with extinction (IUCN 2016). The 2004 GAA[1], the first comprehensive global assessment of amphibians on the Red List, assessed all 5,743 amphibian species described at the time and highlighted the global plight of amphibian species (Stuart et al. 2004). Updates to the GAA were published in 2006 and 2008, consisting mostly of newly described species, and the initiative was subsequently passed on to the IUCN SSC Amphibian Specialist Group, which established its Amphibian Red List Authority in 2009. Since the GAA was launched, there has been a 25% increase in known species, with more than 7,600 amphibian species currently described (Amphibian Species of the World 2017). The relatively high rate of amphibian species discovery has continued for decades due to increased survey effort, and the incorporation of molecular and bioacoustics data in delineating species and increased collaboration (Köhler et al. 2005; Vieites et al. 2009; Catenazzi 2015), and shows no signs of slowing. Given that newly described species are more likely to have smaller ranges and hence be threatened (Rodrigues et al. 2010; Pimm et al. 2014), the challenge of assessing their conservation status is an important one; this challenge is further compounded by the pressing need to reassess species on a regular basis as assessments are considered by IUCN to be out-of-date when they are over ten years old.

Here we assess the trends in species description and Red List assessment and reassessment rates for amphibians since the GAA was launched in 2004. We also examine the regional trends in species richness, amphibian species discovery and Red List assessments. We reviewed amphibian species descriptions in 2016 to determine whether or not authors of species descriptions had observed the species they describe in nature and whether or not they included specific information on threatening processes in species descriptions. Finally, we provide some basic and pragmatic solutions to discrepancies found between species assessment and description, while highlighting important hurdles which need to be overcome to facilitate an up-to-date Red List into the future.

Methods

We compiled a list of new amphibian species recognised by the Amphibian Species of the World database (http://research.amnh.org/vz/herpetology/amphibia/) per year from the 1st January 2004 to the end of our data collection period (11th December 2016); We then used the Red List (IUCN 2016) to record the number of those species that are assessed, the lag-time (in whole years) between description and first assessment, and the extinction risk category determined for each species. Using the Red List's search function, we also obtained for each country the proportion of existing up-to-date assessments (i.e. species that have undergone assessment within the last 10 years) for native amphibian species. We calculated the total amphibian species richness for each country as the sum of Not Evaluated species (ascertained by comparing all described amphibian species from Amphibian Species of the World to the Red List 2016) and of assessed native species (introduced, vagrant and uncertain species were excluded). We also calculated the percentage of native amphibian species in each country that had up-to-date Red List assessments. We assigned each newly described species to only the country from which the

[1] GAA - Global Amphibian Assessment.

holotype was collected, as the exact distributional range of newly described species is often poorly known; our estimates of diversity for some countries are therefore likely underestimates. We used the Red List's search function by year to record the number of amphibian species that had been reassessed from 2005 to 2016 inclusive. This search by year returned a number of assessments in 2016 where the taxonomy was the only part of the assessment that had been updated; these updated assessments were excluded from the analysis as they do not represent any new assessment of extinction risk. To assess whether or not authors of the most recent amphibian species descriptions could potentially comment on threats to the species they describe, we read the species descriptions for new amphibian species described between 1st January 2016 to 11th December 2016 and recorded if any potential, observed or projected threat processes to the species or localities were explicitly mentioned. We also recorded whether or not any of the describing authors had visited the site from which a species was described and had observed the species *in situ*.

We calculated a rough estimate of how much it would cost to bring the amphibian Red List up to date by using two estimates of cost. We used the figure of US $189.00 per species assessment (Juffe-Bignoli et al. 2016) and the estimated $1.6 million cost of the GAA in 2004 (A. Angulo pers. comm.) which was then adjusted for inflation over the study period (www.usinflationcalculator.com) where US $1.60 million would be equivalent to US $2.03 million in 2016. The total cost of the GAA was divided by the number of species assessed when it was launched; this resulted in a figure of US $353.98 per species assessment. We then calculated the average investment needed to keep Red List assessments for amphibians up-to-date by assuming that the mean annual rate of new species description remains constant and that 10% of assessed amphibian species will need reassessing each year if all species are to be reassessed within the desired 10 year period (we used the number of amphibian species described at the end of our data collection period).

Results

The description of new amphibian species has remained relatively constant over the last decade (Fig. 1), with a mean of 144 (128-172) species described per year (2004-15 inclusive). Further, in the year following the publication of the GAA, the rate of assessments for new species almost matched the rate of species description, and 73% of species described in 2005 were assessed within one year. However, post 2007, the assessment rate for newly described species declined, leading to an increasing disparity between species description and subsequent assessment (Fig. 1). Since 2004, only 786 of 1,730 (45.4%) newly described species have been assessed; between 2013 and 2015 (inclusive) only 35 of the 441 (7.9%) species described in that period have been assessed; only one of the 99 (1.01%) species of amphibians described in 2016 has been assessed (Fig. 1). This has caused an accumulation of 1,042 new species of amphibian, described since 2004, that have not been assessed. The mean lag-time between species description and Red List assessment for species described between 2004 and 2015 (for species that have been assessed) is 2.2 years with a mode of one year. There has been no significant change in lag-time year-on-year since the launch of the GAA (Spearman's Rank; ρ_{10}= 0.06, p=0.86). Since 2004, the percentage of Not Evaluated amphibian diversity has increased from 0% (i.e. all then-known species assessed) to 13.8% in December 2016.

The great majority of assessments on the Red List for birds and mammals have been completed or updated within the last 10 years and are considered up-to-date (99-100% in both groups; IUCN 2016). This compares to only 86.2% of the 7,579 known amphibian species which have ever been assessed. 61.3% of all known amphibian species have either not been evaluated or if assessed, the assessments are more than ten years old (Fig. 1). A substantially greater proportion of species newly described between 2004 and 2016 are assessed as Data Deficient (39.8%) compared to 23.6% of all assessed amphibians (IUCN Red List 2016). The reassessment rate of amphibian species over the study period was a mean of 171 species (0-462) per year (2005-2016 inclusive)

The IUCN estimates the percentage of the total number of threatened amphibian species (including Data Deficient species) by using best estimates of threats; these are calculated by making the assumption that the same proportion of Data Deficient species in a particular Class are as threatened as assessed extant species. In that way, the IUCN estimated 42% of amphibian species as threatened (IUCN 2016); yet newly described amphibians are more threatened: 53% of amphibian species that have been described since the start of 2004 and subsequently assessed for the Red List are threatened if best estimates of threats are used.

The countries with the greatest amphibian species richness are the countries with the greatest number of new amphibian species described (Table 1; Fig. 2A-2B; Spearman's Rank; $\rho 242 = 0.74$, $p<0.001$). Countries with the greatest rates of new species descriptions were also the countries with the most out-of-date (Not Evaluated or assessed <10 years ago) Red List assessments (Fig. 2C; Spearman's Rank; $\rho 196= -0.55$, $p<0.001$). Madagascar is the only country in the top 10 countries for both amphibian species richness and number of newly described amphibian species that is nearly up-to-date with amphibian Red List assessments (95.7% of amphibian species assessed within 10 years).

In 97.0% of new species descriptions between 1st January 2016 to 11th December 2016, at least one describing author had visited a type locality for the species. A reference to a threat process affecting the species, habitat or surrounding area was made in 31.3% of these new species descriptions.

The cost of assessing amphibian species described since 2004 and that have not been assessed ranges from US $196,938−$368,847 and the cost of assessing all amphibian species with out-of-date Red List assessments ranges from US $687,771−$1,288,133. The total cost of bringing the amphibian Red List up-to-date is an estimated US $884,709 −$1,656,980. Going forward, an annual investment of $170,478−$319,290 is needed to have an up-to-date Red List if assessment processes carry on using current procedures.

Discussion

Our present inability to assess newly described, and potentially disproportionately threatened (Pimm et al. 2014), species and to update existing assessments hinders our ability to make informed threat evaluations and conservation decisions, track our progress against biodiversity policy targets (e.g., the Aichi Targets) and monitor conservation outcomes. Our case study shows that since the comprehensive GAA in 2004, 45.4% of new amphibian species described since then have not yet been assessed. Although amphibians are one of the most highly threatened species groups on the Red List and a clear conservation priority, with 42% of species threatened in 2004 (Stuart et al. 2004) compared to the lower extinction risks estimated for birds (13%; IUCN 2016), mammals (25%; Schipper et al. 2008) and reptiles (19%; Böhm et al. 2013), we currently lack the necessary information to robustly assess trends in amphibian status since 2004.

Most newly described amphibian species have been discovered in countries with the greatest amphibian species diversity; these countries often fare worst in terms of the percentage of up-to-date Red List assessments for amphibians. Moreover, many of these countries (e.g. Brazil and Indonesia) are amongst countries with the highest rates of deforestation (FAO 2015), the primary threat facing amphibian and other species globally (Chanson et al. 2008; Ficetola et al. 2014). It is therefore critical that the extinction risk of amphibians and other species in these countries is determined so that regional priorities for conservation can be determined in the face of rapid change.

Collaboration with country-level assessment projects, carried out to Red List standards, can aid to fill the assessment gap for country-endemic species, especially since there is currently an increased focus on national Red Listing as a means of tracking national progress towards international biodiversity targets. This may be a potentially useful strategy to adopt for countries where the greatest amphibian richness, high rates of new species discovery and most out-of-date global Red List assessments coincide (e.g. Brazil, India, China, Papua New Guinea, Indonesia, Malaysia, Bangladesh and Nepal). There is a continued need to identify individuals in these countries who will take the lead on

coordinating and completing Red List assessments. These individuals may already be those involved in existing national-level assessment processes, and include these key players in the global Red List process. Capacity to do so increasingly exists in many countries. For example, Brazil, China and Bangladesh have all recently assessed their vertebrate fauna, including amphibians, at a national level and to the IUCN standard (ICMBio 2014; IUCN Bangladesh 2015; Jiang et al. 2016). Strong leadership is a common factor in regions with high amphibian diversity, high rates of species discovery and relatively up-to-date Red List assessments (e.g. Tanzania and Madagascar). In addition, funding should be sought by the IUCN for regional or country Red List Authorities to undertake the work needed to assess newly described amphibian species and update out-of-date Red List assessments for amphibians. Regional or country Red List Authorities are more productive with completing and updating Red List assessments when dedicated funding was provided (J. Luedtke pers. obs.; J. Rowley unpublished data); indeed, the 2004 GAA was only made possible due to substantial funding (IUCN 2016).

Species-focused conservation is heavily reliant on taxonomy (Mace 2004), so those who contribute to species descriptions are often well placed to facilitate Red List assessments and may be vital in ensuring that the considerable task of assessing newly described species is realised in a timely and robust fashion (Hjarding et al. 2015). Our data show that authors describing species typically observe species *in situ* and are thus well-positioned to provide much of the basic species information relevant to the Red List process: georeferenced distribution data, habitat and ecology information, and information on ongoing, potential and projected threats to a species. In certain cases, authors may also be able to provide invaluable insights on more detailed species data, such as general abundance of a species, actual or inferred population declines and the likely extent of suitable habitat of a newly described species (e.g. Parra-Olea et al. 2016; Tapley et al. 2017); these are the basic prerequisites for robust extinction risk assessments.

Many new species are also the result of revisions of species groups and the distribution status and threats are well known; in the case of taxonomic splits, authors of newly described species may also be able to present data that would facilitate the reassessment of the species from which the newly described species has been split. It is particularly important to reassess the species from which a new species has been split as it is likely to have a smaller range size and therefore be more threatened than previously thought. Whilst it would be impractical for authors of species descriptions to carry out full assessments of species to Red List standards – a process which requires training in the Red List Categories and Criteria – we urge authors to explicitly present data underlying Red List assessments in their publications. The most important information for describing authors to consider including is: detailed georeferenced locality data, including where possible lower and upper elevation limits; habitat information and, where possible, information on the extent of suitable habitat; ecological and demographic information which may impact reproduction or dispersal rates and hence extinction risk (e.g. clutch sizes); potential and projected threats to a species or its habitat or to similar habitats/species nearby; information on population status, size and/or trend, which can range from qualitative assessments (e.g., rare, abundant) to quantitative numbers on population size and actual or inferred population trends. This could be facilitated if relevant journals recommend in their author guidelines the inclusion of information pertinent to Red List assessments. Given that some locality data may be sensitive due to potential collection for the wildlife trade (Stuart et al. 2006; Lindenmayer & Scheele 2027), precise localities for threatened or exploited species may be obscured in published Red List assessments, and locality data may be passed on directly to the relevant Red List Authority.

Our case study showed that amphibian species described since 2004 are disproportionately assessed as Data Deficient, likely the result of less information being available for recently described species. Even if newly described species are assessed as Data Deficient, this is far more useful to conservation prioritisation than leaving them Not Evaluated. Species listed as Data Deficient may often be threatened (Şekercioğlu et al. 2004; Pimm et al. 2014) and conservation attention and additional research should be

afforded to these species; this is unlikely to be given to Not Evaluated species. Whilst it is encouraging that some funding agencies now specifically account for Data Deficient species within their funding schemes (e.g. Mohamed Bin Zayed Species Conservation Fund), and significant progress has been made in predicting the likely status of Data Deficient species on the Red List (Bland et al. 2015; Bland & Böhm 2016), currently, only 2% of funds awarded by the Mohamed Bin Zayed Species Conservation Fund has gone toward Data Deficient species (MBZSC 2014, in Bland & Böhm 2016). This funding may result in research that may further clarify the extinction risk of a particular species and this may facilitate future Red List assessment updates. However, we recommend that more funding should be awarded to species listed as Data Deficient.

The reasons why assessment rates have declines sharply post 2007 are linked to funding deficits, understaffing, the reliance on volunteers and a lack of incentives for contributors and assessors. The average cost of species assessment and reassessment are unknown for amphibians. There are obvious limitations to our estimation of costs; data collection itself is not included, the time of assessors and contributors has not been quantified and the cost of maintenance of the Red List itself has not been calculated (see Rondinini et al. 2014). Our estimated cost of updating the amphibian Red List assessment and future annual investment is a significant sum of money, and is likely to increase with time as the cumulative number of assessed amphibians increases and the task of reassessment becomes ever greater. One of the main factors precluding an up-to-date Red List is funding limitations: philanthropy supplies most of the funding for the Red List, with most of this spent on personnel cost (Juffe-Bignoli et al. 2016). Previous authors have suggested strategies of reducing assessment costs through online assessment workshops (Rondinini et al. 2014) but these have had limited success (L. Leudtke pers. obs.). In addition, streamlining data collection by including data pertinent to Red List assessments in species descriptions and channeling national-level assessment data onto the global Red List may help cut costs by saving personnel time on otherwise lengthy data gathering processes.

The contribution of experts to the assessment process itself is vital and must be acknowledged. At present, the Amphibian Red List Authority is recognised as the author of amphibian Red List assessments, but as Red List assessments are now recognised as an online scientific publication, significant contributions of data or other intellectual input into amphibian Red List assessments need to be recognised via co-authorship as is the case with other scientific publications and Red List assessments for other taxa (e.g. mammals, reptiles and molluscs). Recognising significant input in such a way may encourage more expert participation in the assessment process, especially experts in academic sectors who often have to balance the burden of publication quotas and paid work with the contribution of valuable scientific input and unpublished data to the Red List assessment process. Creating incentives for speedy and accurate updates of Red List assessments is key to sustaining an up-to-date Red List.

Conclusion

As a group, amphibians are both poorly-known and highly threatened, making them a priority group for conservation assessment. However, our suggestions are likely to be relevant to other taxonomic groups which are similarly threatened and also have high rates of species discovery. Adopting these suggestions and developing others through collaboration with other assessment groups is an achievable goal that would greatly facilitate the accurate assessment of species in a timely manner which is critical in the face of rapid global change. As we face unprecedented levels of human-mediated extinction (Ceballos et al. 2015), the implementation of measures which improve our ability to assess extinction risk is more important than ever.

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461 Table 1. The 15 countries with the highest rates of new amphibian discoveries from 2004-
462 2016.
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Country	Number new amphibian species 2004-16 (inclusive)	Country ranking for amphibian species richness	Total number of amphibian species known	Percentage of Red List assessments for amphibians up-to-date
Brazil	262	1	1009	26.46
India	155	7	381	14.96
Peru	146	3	552	37.14
Papua New Guinea	126	11	308	2.27
Ecuador	101	4	552	29.53
China	91	5	408	10.29
Madagascar	85	10	325	95.69
Vietnam	71	18	213	37.56
Venezuela	66	9	350	33.43
Indonesia	64	6	405	13.58
Malaysia	61	13	263	17.49
Sri Lanka	53	28	121	22.31
Colombia	50	2	754	29.58
Tanzania	43	21	196	98.47
Bolivia	34	14	242	41.32

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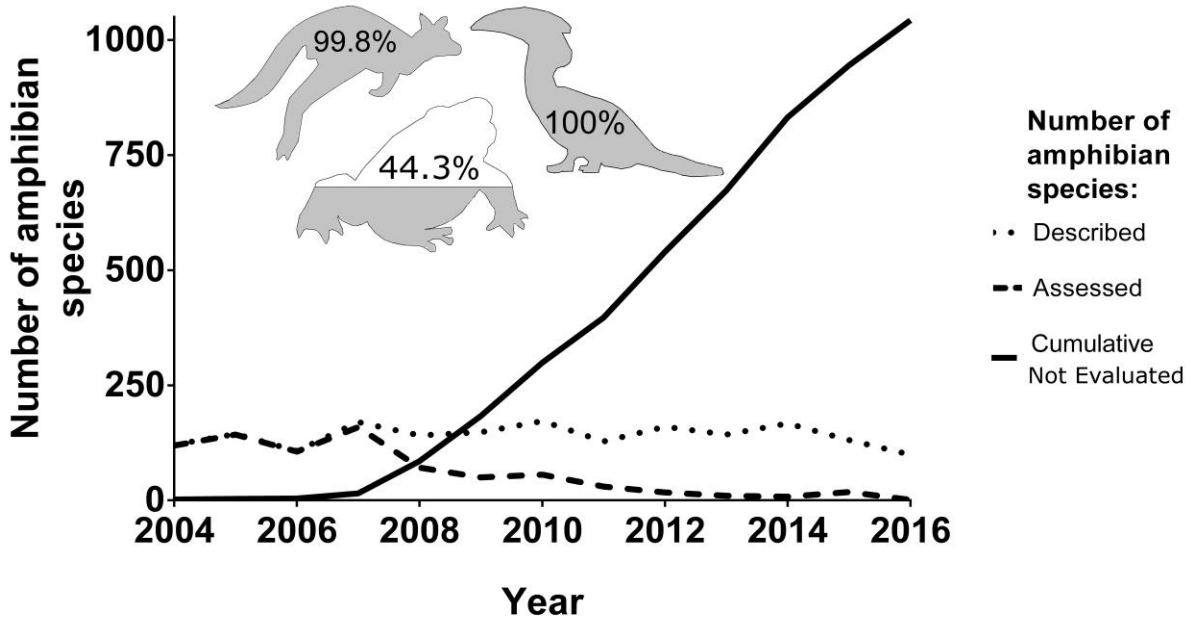

Figure 1. Graph: Numbers of new amphibian species described each year, the number of those that have been assessed and the cumulative number of Not Evaluated amphibian species. Animal outlines show the percentage of Red List assessments still up-to-date for amphibians, birds and mammals.

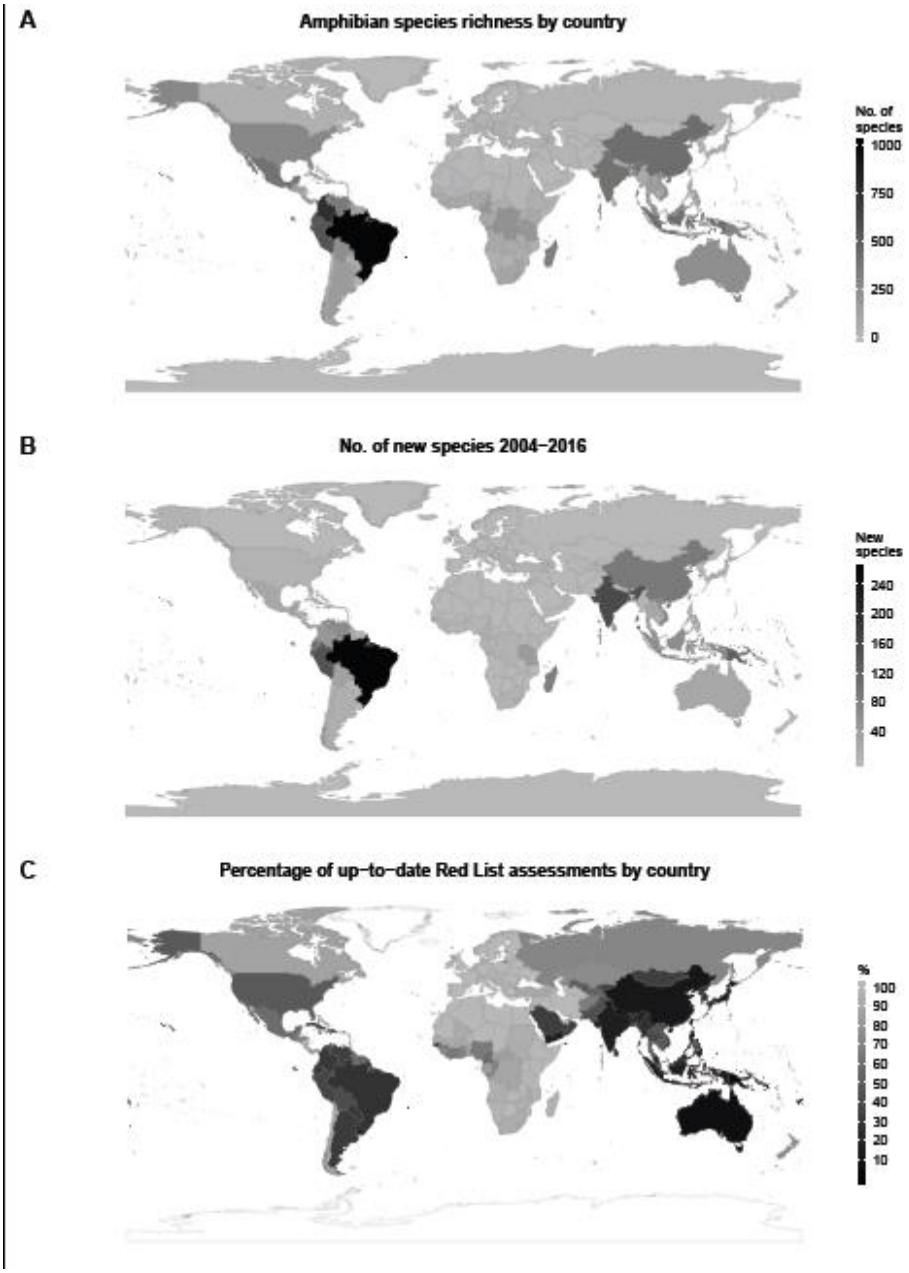

Figure 2. (A) Amphibian species richness by country; (B) Number of newly described amphibian species from 2004-2016 by country; (C) Percentage of up-to-date Red List assessments for amphibians by country.