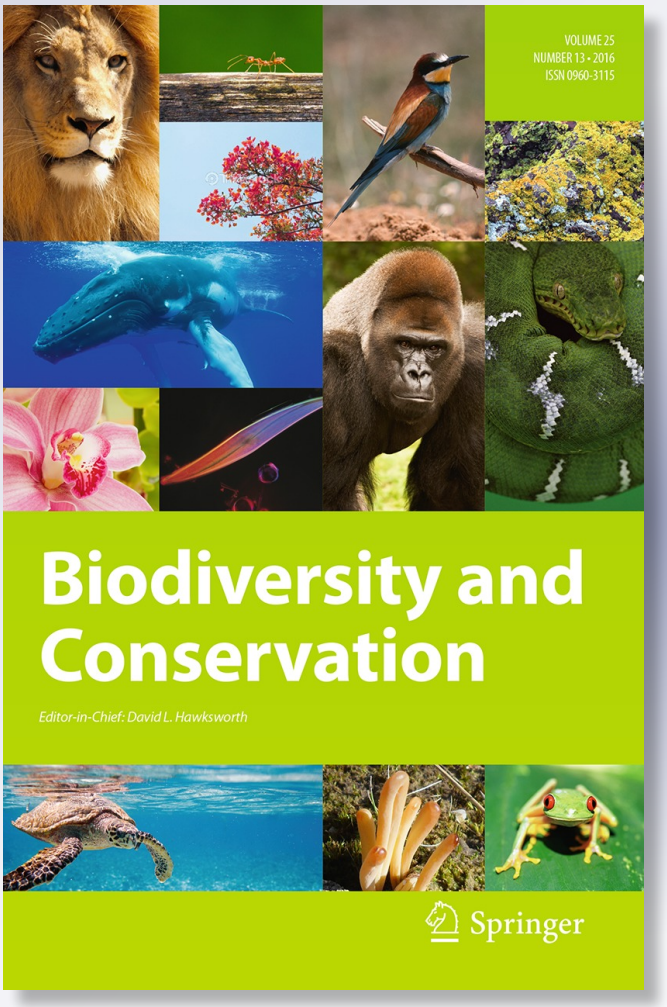
# *The global amphibian trade flows through Europe: the need for enforcing and improving legislation*

**Mark Auliya, Jaime García-Moreno, Benedikt R. Schmidt, Dirk S. Schmeller, Marinus S. Hoogmoed, Matthew C. Fisher, Frank Pasmans, et al.**

**Biodiversity and Conservation**

ISSN 0960-3115
Volume 25
Number 13

Biodivers Conserv (2016) 25:2581-2595
DOI 10.1007/s10531-016-1193-8




Springer

Biodivers Conserv (2016) 25:2581–2595
DOI 10.1007/s10531-016-1193-8

REVIEW PAPER

# The global amphibian trade flows through Europe: the need for enforcing and improving legislation

**Mark Auliya[1] · Jaime García-Moreno[2] · Benedikt R. Schmidt[3,4] · Dirk S. Schmeller[1] · Marinus S. Hoogmoed[5] · Matthew C. Fisher[6] · Frank Pasmans[7] · Klaus Henle[1] · David Bickford[8] · An Martel[7]**

Received: 15 December 2015 / Revised: 11 August 2016 / Accepted: 13 August 2016 /
Published online: 12 September 2016


**Abstract** The global amphibian trade is suspected to have brought several species to the brink of extinction, and has led to the spread of amphibian pathogens. Moreover, international trade is not regulated for ~98 % of species. Here we outline patterns and complexity underlying global amphibian trade, highlighting some loopholes that need to be addressed, focusing on the European Union. In spite of being one of the leading amphibian importers, the EU's current legislation is insufficient to prevent overharvesting of those species in demand or the introduction and/or spread of amphibian pathogens into captive and wild populations. We suggest steps to improve the policy (implementation and enforcement) framework, including (i) an identifier specifically for amphibians in the

Communicated by David Hawksworth.

This article belongs to the Topical Collection: Biodiversity legal instruments and regulations.

✉ Mark Auliya
mark.auliya@ufz.de

✉ Jaime García-Moreno
jgarciamoreno@esili.net

[1] Department of Conservation Biology, UFZ—Helmholtz Centre for Environmental Research, 04318 Leipzig, Germany

[2] ESiLi, Het Haam 16, 6846 KW Arnhem, The Netherlands

[3] KARCH, Passage Maximilien-de-Meuron 6, 2000 Neuchâtel, Switzerland

[4] Institut für Evolutionsbiologie und Umweltwissenschaften, Universität Zürich, Winterthurerstrasse 190, 8057 Zürich, Switzerland

[5] Museu Paraense Emilio Goeldi/CZO, Caixa Postal 399, Belém, Pará 66017-970, Brazil

[6] Department Infectious Disease Epidemiology, School of Public Health, Imperial College London, London UK W21PG, UK

[7] Faculty of Veterinary Medicine, Ghent University, Salisburylaan 133, 9820 Merelbeke, Belgium

[8] Department of Biological Sciences, National University of Singapore, 14 Science Drive 4, Singapore 117543, Singapore

World Customs Organisation's harmonised system, (ii) Parties to CITES should strive to include more species in the CITES appendices, and (iii) restriction or suspension of trade of threatened species, restricted-range species, and species protected in their country of origin. Commercial trade should not put survival of amphibian species further at risk.

**Keywords** Convention on international trade in endangered species of wild fauna and flora · Amphibian · Conservation · Disease · European Union · Global amphibian trade · Wildlife trade legislation

## The global amphibian trade

Amphibians show global declines as a result of multiple interacting drivers including pollution, invasive species, habitat loss and fragmentation, diseases and overharvesting for human consumption and the pet trade (e.g., Hedges 1993; Collins and Storfer 2003; Stuart et al. 2004; Andreone et al. 2006; Pounds et al. 2006; Collins and Crump 2009; Gratwicke et al. 2009; Rödder et al. 2013; Herrel and van der Meijden 2014; Martel et al. 2014).

International trade has also introduced new amphibian pathogens and spread them along trade routes (Fisher and Garner 2007; Jenkins 2013; Martel et al. 2014) and exacerbated many species' risk of extinction (Stuart et al. 2004; Fisher and Garner 2007; Bishop et al. 2012; Jenkins 2013). This heightened risk demonstrates the need to understand how species are moved within and between countries and continents. At the same time, there is an immediate need to identify, from a European perspective, loopholes and deficiencies in the trade with respect to strengthening current biosecurity legislation and (stronger) implementation of existing wildlife laws at national and international scales.

Amphibians are traded nationally and internationally for many purposes and needs. Species within the family Ranidae and the genera *Ambystoma*, *Bufo*, *Notophthalmus* and *Xenopus* are commonly used for biomedical and educational research (Alworth and Harvey 2007; O'Rourke 2007). The international frog leg industry relies on fewer than ten species that are of significant economic value (Veith et al. 2000; Schlaepfer et al. 2005; Altherr et al. 2011), but many thousands of tons are produced and shipped globally (e.g., Jensen and Camp 2003; Warkentin et al. 2009). In some regions amphibians are also harvested in very large numbers for local consumption (Mohneke et al. 2010; Neang 2010). Cox et al. (2008) mention 212 species affected by overexploitation (Picco and Collins 2008). The IUCN Red List (2015) records 317 species that are regularly hunted and trapped. Of these, more than 290 are targeted for the international pet trade and consumption purposes (IUCN Red List 2015). Species from South and Central America and Madagascar are predominantly collected for the pet trade (noting that the consumption trade in several species in South America is also substantial; see Catenazzi et al. 2010; Altherr et al. 2011) whereas most species in East and Southeast Asia and West Africa are utilized for consumption and medicinal purposes on a local scale and/or are internationally traded for food (Stuart et al. 2008; IUCN Red List 2015). The commercial trade in amphibians demonstrates that species and populations are directly and indirectly impacted; direct impacts specifically target unsustainable and illegal trade and suggest local and regional overexploitation (e.g., certain *Mantella* spp. detrimentally impacted by the pet trade; Andreone et al. 2005), whereas indirect impacts indicate that species and products thereof crossing borders carry infections, and consequently can contribute to disease outbreaks in captive and wild

amphibian populations (Cunningham et al. 2015). Because of the severity of recent trade-related amphibian pathogen outbreaks in the EU (see Spitzen-van der Sluijs et al. 2013), we focus on the policies and capacity of the EU in finding sustainable solutions. In this paper we highlight issues that urgently need a rigorous control of the global amphibian trade under the premise that trade activities should not put the survival of amphibian species further at risk.

## Indirect trade effects—infectious amphibian diseases transmitted through trade

Worldwide trade in wildlife has increased the potential for translocation of diseases, and poses risks to human, crop, livestock and wildlife health (Karesh et al. 2005; Marano et al. 2007). The chytrid fungus, *Batrachochytrium dendrobatidis* (*Bd*), has led to significant declines in amphibians (Daszak et al. 2003; Alroy 2015), and is widespread in more than 50 countries across four continents with more than 520 species known to be *Bd*-infected (Olson et al. 2013; Global *Bd*-Mapping Project 2015). Since its discovery in the late 1990s, detrimental impact of the fungus on susceptible amphibian species and populations has been highlighted in hundreds of scientific publications, but standardized practical solutions still need to be implemented on an international scale (see Pessier and Mendelson 2010) and meanwhile the disease remains a formidable threat to populations of anurans (Woodhams et al. 2011; Scheele et al. 2014).

While the origin of *Bd* remains unclear (Farrer et al. 2011; Rosenblum et al. 2013), several studies have linked its spread to global amphibian commercial trade (Fisher and Garner 2007; Garner et al. 2009; Schloegel et al. 2009; Peel et al. 2012). A most worrisome issue is the potential for the generation and spread of more virulent or infectious recombinant genotypes of pathogens when previously isolated lineages come into contact through amphibian trade and this is particularly true for *Bd* (Farrer et al. 2011; Schloegel et al. 2012).

Other amphibian pathogens that have caused mass mortality in amphibians, such as ranavirus, are known to spread through amphibian pet and bait trades, sometimes even across continents (Pasmans et al. 2008; Picco and Collins 2008; Kolby et al. 2014). A new fungus, *Batrachochytrium salamandrivorans* (*Bsal*), was recently isolated in western European salamanders of the genus *Salamandra* (Martel et al. 2013); the pathogen is suspected to have entered the continent through trade in Asian salamanders and has caused severe disease outbreaks in salamanders in the Netherlands and Belgium (Martel et al. 2014). In the Netherlands, within 7 years after the supposed introduction of the fungus, a *Salamandra salamandra* population declined by 99.9 % (Spitzen-van der Sluijs et al. 2016). Lately *Bsal* has also been detected in *S. salamandra* in Germany in both wild and captive salamanders and likewise in captive salamanders in the United Kingdom (Cunningham et al. 2015; Sabino-Pinto et al. 2015; Spitzen-van der Sluijs et al. 2016). The Scientific Working Group of the European Union recently (June 2016) decided that an import stop for Asian salamanders should be implemented by placing those salamanders on Annex B of the EU regulation 338/97, but due to administrative problems (and not realizing the urgency to stop this threat), this decision probably will only become effective in 2017 (UNEP-WCMC 2016).

Commercial trade of poison arrow frogs (*Dendrobatidae*), reported by Gorzula (1996), Pepper et al. (2007) and Brown et al. (2011), spreads infection as *Bd*-infected species are

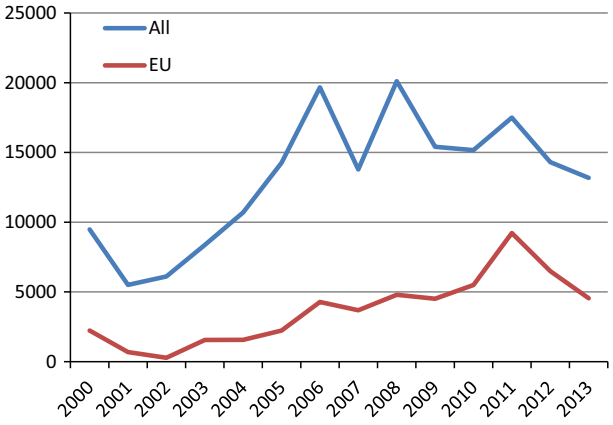



**Fig. 1** Import numbers of Dendrobatidae spp. reported by importing countries globally and the European Union. Values of 2014 and 2015 respectively, still remain incomplete in the documentation process. *Source* UNEP-WCMC trade database (2014)

imported from Central and South America into Western Europe via the pet trade. *Dendrobatidae* spp. reported by all importing countries compared to those reported by EU member States initially show an increasing trend over the last decade, and despite a slight drop of imports from 2012 onward (Fig. 1), a significant risk of introducing infectious pathogens remains because biosecurity measures at the EU level have not been implemented.

Cross-infection between Dendrobatidae spp. with other amphibian species, including salamanders, has not been ascertained; however, the presence of the chytrid fungus among pet species has been documented (Pasmans et al. 2004; Spitzen-van der Sluijs et al. 2011). Dendrobatidae spp. have regularly been identified as *Bd*-positive among tested captive individuals (reported by Mutschmann in litt. to Auliya, March 19, 2013; for species, see Table 1). Although it is not possible to ascertain exact time and location of infection, cross-infection through other captive species cannot be ruled out. A field study in French Guiana recorded *Bd*-positive specimens with low levels of infection in two wild populations of *Dendrobates tinctorius* (Courtois et al. 2012). *Bd*-positive specimens of the same species were detected in an ex situ breeding program containing confiscated animals in São Paulo State, Brazil (De Paula et al. 2012). These reported issues are considered important as *D. tinctorius* triggers high international demand (see Table 1). Individuals of most dendrobatids that tested *Bd*-positive in Germany (Table 1), originated from the species range states.

Several widely traded amphibian species are vectors for a range of different pathogens. The North American Bullfrog (*Lithobates catesbeiana*) may introduce ranavirus, which can be found even in frozen frog tissues (Duffus 2009) and *Xenopus laevis* may carry *Bd* (Weldon et al. 2004; Vredenburg et al. 2013). Mycobacteria have been demonstrated in recently imported Western Clawed Frogs (*Xenopus tropicalis*) and East Asian Bullfrogs (*Hoplobatrachus rugulosus*) intended for trade (Suykerbuyk et al. 2007; Gilbert et al. 2013).

## Direct trade effects—consumption and pet trade

Large quantities of frog legs are imported annually into the EU; however, the estimates vary among studies. According to Jensen and Camp (2003) and Altherr et al. (2011), 4600 tons of frog legs were imported annually between 2000 and 2009. Eighty-four percent of

**Table 1** *Bd*-positive *Dendrobatidae* spp. held in captivity in Germany. *Source* UNEP-WCMC trade data

| Species | Distribution | Imported no. of specimens into the EU (2000–2011) | % Exported from range states |
|---|---|---|---|
| *Ameerega trivittata* | Northern South America | 2106 | 88 |
| *Ameerega bassleri* | Peru | 725 | 9 |
| *Colostethus ruthveni* | Colombia | – | – |
| *Epipedobates anthonyi* | Ecuador, Peru | – | – |
| *Epipedobates tricolor* | Ecuador | 508 | 5 |
| *Dendrobates leucomelas* | Northern South America | 607 | 60 |
| *Dendrobates tinctorius* | Northern South America | 5150 | 83 |
| *Dendrobates auratus* | Central Americas | 19,023 | 76.7 |
| *Oophaga granulifera* | Costa Rica, Panama | 350[a] | 100 |
| *Oophaga histrionica* | Colombia | 25 | 100 |
| *Oophaga pumilio* | Nicaragua, Panama | 10,578 | 99.4 |
| *Phyllobates bicolor* | Colombia | 10 | 0 |
| *Phyllobates lugubris* | Nicaragua, Panama | 2 | 100 |
| *Phyllobates vittatus* | Costa Rica, Panama | 173 | 0 |
| *Ranitomeya amazonica* | Northern South America | – | – |

[a] Germany (sole importer of *O. granulifera*) did not document import numbers, thus the 350 refer to export numbers documented by Costa Rica. "–" indicates that no trade in that species was documented over the study period 2000–2011

which were probably caught in the wild and supplied through Indonesia (Kusrini and Alford 2006); with one kilogram of frog legs representing around 20–50 individuals. Warkentin et al. (2009) reported that 90–230 million individual frogs are destined for European frog leg trade on an annual basis. In addition to frog legs, live and frozen whole frogs are also imported (Mazzoni et al. 2003; Gratwicke et al. 2009). High volume trade can have serious detrimental impacts on amphibian species (see Cox et al. 2008).

The international pet trade causes severe pressure on amphibian diversity, especially on restricted range species (Young et al. 2000; Pasmans et al. 2004; Andreone et al. 2008; Smith et al. 2009). The Global Amphibian Assessment (GAA) (Chanson et al. 2008) identified 47 amphibian species predominantly threatened by unsustainable collection for the international pet trade (Hoffmann et al. 2008; also see Crandall 2009). Among these species, 27 are not listed on the appendices of CITES e.g., *Scaphiophryne boribory* and *Lyciasalamandra* spp.; seven of these species are assessed as threatened according to the IUCN Red List criteria (IUCN Red List 2016), and six of these seven species are over-exploited for scientific purposes, e.g., *L. billae* (Kaska et al. 2009). Several cases of illegal activities have been reported (e.g., Holden 1998; Pistoni and Toledo 2010; De Paula et al. 2012), including collection within nature reserves (Wang et al. 2004) and laundering of wild-caught animals as captive-bred (Nijman and Shepherd 2010). For example, in 2004-05 Thailand imported 1290 live "captive-bred" *Dendrobates* spp. from Lebanon, with claimed origins in Kazakhstan (UNEP-WCMC trade database 2014), but officially registered captive breeding facilities in these countries could not be verified (Nijman and Shepherd 2010).

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) regulates international trade via a controlled licensing system and regulations on quotas for harvest.

Of the more than 7400 amphibian species recognized by the scientific community (Frost 2015), 208 species (2.8 %) are currently listed in the three appendices of the convention (CITES Species Checklist 2015). The European Union (EU) Wildlife Trade Regulation implements the provisions of CITES (EU Commission Regulation 2014), which includes additional requirements, and adds a further appendix (Annex D) that monitors the import of non-CITES listed species (European Commission 2010). Annex D lists 46 species bringing the total of all species listed in Annexes A–D to 256 (3.4 % of all amphibian species)—the three Annexes A–C largely correspond with the CITES Appendices I–III; (see Table 2). Thus, international trade is monitored in only a tiny fraction of amphibian species. Despite the fact that more than almost 98 % of all amphibians can be freely shipped across borders, various trade issues are also distinct among CITES species, of which the most important ones are highlighted below.

## Most wanted—poison arrow frogs

Poison arrow frogs (family *Dendrobatidae*) represent one of the most sought-after group in the international pet trade (Lötters et al. 2007). From 2000 to 2014, more than 180,000 Dendrobatidae spp. ("live", "specimens", "bodies" and "eggs"; see UNEP-WCMC trade data, http://trade.cites.org/—accessed, April 25, 2016) were reported as legally traded by exporting countries on a global scale, but many steps within the trade chain are poorly documented, e.g., mortality rates from the point of harvest to the exporter and transport mortalities from the exporter to import destinations (but see Brown et al. 2011; Ashley et al. 2014; Wombwell 2014).

Our analysis of UNEP-WCMC trade data of imports into the EU during 2000–2014, indicates dendrobatid imports into the EU from countries where these animals naturally occur but also from countries beyond their natural distribution range. Because of its illegal nature, no estimate of the number of individuals traded can be given. Due to lax regulations and implementation, trade in illegally imported specimens in Europe is made very easy through the use and uncritical acceptance of the category "captive bred" for many of them. From rare (published) confiscations it is clear that illegal shipments may contain hundreds of specimens (Pistoni and Toledo 2010, report a confiscation of 560 dendrobatids). During one action in Brazil several hundred dead specimens that were destined for illegal export were uncovered. Therefore, based on this example, known illegal exports could easily account for a volume with a size of ca. 10 % of the legal trade, and thus increase the pressure on wild populations even more. The top five dendrobatid-exporting countries were, in increasing order of trade volume, Guyana, Costa Rica, Peru, Suriname, and Panama. Panama and Suriname were highlighted as major exporters of species occurring within their borders, with the former documenting 33,280 and the latter 6199 specimens of poison frogs exported to the EU. Canada tops the list of non-range states (66 %) exporting dendrobatids into Europe, with 11,077 exported specimens, of which 98 % were claimed as captive-bred. The main European importing countries (in increasing order of trade volume) are Spain, Switzerland, Netherlands, Belgium and Germany. Germany imported 28 % of 54,097 specimens, and its leading role in the trade of live amphibians and reptiles has been highlighted earlier (Auliya 2003; Engler and Parry-Jones 2007).

Two species of dendrobatid frogs (CITES Appendix II) from northern South America merit special attention because of known ongoing illegal trade (e.g., Pistoni and Toledo 2010): *Dendrobates tinctorius*, a species occurring in the Guianas and northern Brazil, and

**Table 2** Number of amphibian species listed in Appendices of CITES and on Annexes of the EU Wildlife Trade Regulations according to Frost (2015; accessed: July 13, 2015)

| Taxa | No. species in the CITES Appendices | | | No. species in the Annexes of the European Wildlife trade regulations | | | |
|---|---|---|---|---|---|---|---|
| | I | II | III | A | B | C | D |
| Totals | 23 | 182 | 3 | 23 | 184 | 3 | 46 |
| *Altiphrynoides* spp. | 2 | | | 2 | | | |
| *Amietophrynus superciliaris* | 1 | | | 1 | | | |
| *Andrias* spp. | 2 | | | 2 | | | |
| *Atelopus zeteki* | 1 | | | 1 | | | |
| *Dyscophis antongilii* | 1 | | | 1 | | | |
| *Incilius periglenes* | 1 | | | 1 | | | |
| *Nectophrynoides* spp. | 13 | | | 13 | | | |
| *Neurergus kaiseri* | 1 | | | 1 | | | |
| *Nimbaphrynoides occidentalis* | 1 | | | 1 | | | |
| *Adelphobates* spp.[a] | | 3 | | | 3 | | |
| *Agalychnis* spp. | | 15 | | | 15 | | |
| *Allobates* spp.[a] | | 50 | | | 50 | | |
| *Ambystoma* spp. | | 2 | | | 2 | | |
| *Ameerega* spp.[a] | | 32 | | | 32 | | |
| *Andinobates* spp.[a] | | 14 | | | 14 | | |
| *Conraua goliath*[b] | | – | | | 1 | | |
| *Dendrobates* spp. | | 5 | | | 5 | | |
| *Epipedobates* spp.[a] | | 7 | | | 7 | | |
| *Euphlyctis hexadactylus* | | 1 | | | 1 | | |
| *Excidobates* spp.[a] | | 3 | | | 3 | | |
| *Hoplobatrachus tigerinus* | | 1 | | | 1 | | |
| *Hyloxalus azureiventris* | | 1 | | | 1 | | |
| *Mantella* spp. | | 16 | | | 16 | | |
| *Lithobates catesbeianus* | | – | | | 1 | | |
| *Minyobates steyermarki*[a] | | 1 | | | 1 | | |
| *Oophaga* spp.[a] | | 9 | | | 9 | | |
| *Phyllobates* spp. | | 5 | | | 5 | | |
| *Ranitomeya* spp.[a] | | 16 | | | 16 | | |
| *Scaphiophryne gottlebei* | | 1 | | | 1 | | |
| *Calyptocephalella gayi* | | | 1 | | | 1 | |
| *Cryptobranchus alleganiensis* | | | 1 | | | 1 | |
| *Hynobius amjiensis* | | | 1 | | | 1 | |
| *Limnonectes macrodon*[b] | | | | | | | 1 |
| *Phyllomedusa sauvagii*[b] | | | | | | | 1 |
| *Leptodactylus laticeps*[b] | | | | | | | 1 |
| *Pelophylax shqiperica*[b] | | | | | | | 1 |
| *Ranodon sibiricus*[b] | | | | | | | 1 |
| *Bolitoglossa dofleini*[b] | | | | | | | 1 |
| *Cynops ensicauda*[b] | | | | | | | 1 |

**Table 2** continued

| Taxa | No. species in the CITES Appendices | | | No. species in the Annexes of the European Wildlife trade regulations | | | |
|---|---|---|---|---|---|---|---|
| | I | II | III | A | B | C | D |
| *Echinotriton andersoni*[b] | | | | | | | 1 |
| *Laotriton laoensis*[b] | | | | | | | 1 |
| *Paramesotriton* spp.[b] | | | | | | | 14 |
| *Salamandra algira*[b] | | | | | | | 1 |
| *Tylototriton* spp.[b] | | | | | | | 22 |

The two listed species of the genus *Rheobatrachus* are considered extinct, thus were excluded in CITES Appendix II and Annexes A and B of the EU Wildlife Trade Regulations (cf. http://checklist.cites.org/#/en/about, accessed: July 15, 2015)

Note that Grant et al. (2006) split the genus *Dendrobates* into several genera after the genus was included in CITES Appendix II in 1987; taxonomic change was only adopted at the CITES CoP16, in March 2013

[a] Taxa that were formerly included in the genus *Dendrobates*

[b] Non-CITES species

*Adelphobates galactonotus*, a species endemic to the southeastern Amazon basin in Brazil. Both occur in isolated populations, with high variation in color pattern among them (Lötters et al. 2007; Hoogmoed and Avila-Pires 2012).

Brazil prohibits the export of all native fauna and flora. It has never issued any export permit for *D. tinctorius* (UNEP-WCMC trade database 2014), and only a few export permits for *A. galactonotus* covering 27 specimens for scientific purposes issued between 1993 and 1997. Given this lack of export permits, live *A. galactonotus* should not be found outside Brazil, but twelve specimens were illegally imported into Germany, in 1996 (Pieper and Pieper 1997). These specimens are very likely the founding stock for most captive specimens; trade in captive-bred specimens flourished, in spite of alerts to CITES authorities in several European countries and the CITES Secretariat. *Adelphobates galactonotus* were regularly traded as captive-bred, although a newly discovered colour morph from Brazil (at least 40 specimens) with restricted distribution surfaced in Germany in 2013, only weeks after it had been officially described in a scientific publication, fetching prices of € 350–700 ($400–800 USD) per specimen (pers. comm., M. Hoogmoed). The continued presence of a large, mainly captive-bred population in Germany, enabled continued illegal imports of this species, with wild-caught smuggled animals entering the market disguised as captive-bred.

As to *D. tinctorius*, Guyana and Suriname allow legal export of this species under a voluntary yearly quota, whereas Brazil and French Guiana prohibit exports. This situation permits laundering of Brazilian specimens under the quota of exporting countries due to poor border control among countries. An illegal export from Brazil was prevented when a shipment of 281 *D. tinctorius* and 279 *A. galactonotus,* destined for Germany, was confiscated in 1999 at the airport in São Paulo (Pistoni and Toledo 2010)—as with *A. galactonotus*, different populations of *D. tinctorius* have unusual colour patterns that allow to identify the origin of individuals. In 2000, the CITES Animal's Committee requested Suriname to provide details about the sustainability of its *D. tinctorius* trade, and in 2001 the CITES Standing Committee suspended imports until this information was provided (https://cites.org/sites/default/files/eng/com/ac/17/E17i-04.pdf—accessed April 23, 2016). However, the ban was lifted in 2008 even though Suriname never provided the requested

data, and the country continues to export this species under the same quota it has maintained since 1995.

## Insufficient legislation, implementation, harmonization, and policy

Poor international trade regulation and monitoring enables exploitation and threatens many amphibian species. Commercial trade of around 98 % of the world's amphibian (non-CITES) species is currently not regulated. The first and principal problem is that the World Customs Organisation (WCO) lacks a unique identifier (code) for amphibians in its harmonized system (http://www.wcoomd.org/en/topics/nomenclature/overview/what-is-the-harmonized-system.aspx—accessed July 13, 2016). Without a unique identifier that allows all parties to be aware that a shipment contains amphibians, it will continue to be difficult to trace flow of the European amphibian trade, and thus virtually impossible to implement measures, e.g., compliance with international standards related to transport, disease control, hygiene, or quarantine measures.

As a result, amphibians are either lumped in the category "other" or are categorized as tropical fish (Gerson et al. 2008). This deficiency makes it almost impossible to document any trade in species or numbers imported into the EU. Even though trade in CITES-listed species is regulated through permits from exporting and importing countries, listed species can be smuggled across international borders to take advantage of legal export markets (e.g., Pepper et al. 2007; Pistoni and Toledo 2010; Nijman and Shepherd 2011; De Paula et al. 2012). The import/export permit system does little to monitor or prevent international transport mortalities or along the trade chain prior to export—a conservation and animal welfare concern which is largely neglected (Brown et al. 2011). While population monitoring is supposed to occur for CITES-listed species to assure sustainable harvest, monitoring of natural populations and surveillance of domestic trade and consumption to prevent overharvest is widely lacking (Warkentin et al. 2009).

It is obviously difficult to quantify a market that is small by international standards in terms of both tonnage and money. However, this trade is enormous in terms of individuals (see above for frog legs); it has the potential to have serious detrimental impact on some species, and carries the risk of spreading pathogens and transmitting infectious diseases with very large impacts on amphibian biodiversity (Catenazzi et al. 2010).

The current global distribution of *Bd* has not been explicitly recognized by the World Organisation of Animal Health (OIE). Ongoing global expansion of *Bd* and its potential detrimental impact on local species and populations is an essential information source that needs to be taken into account by OIE to bring standards up to date; e.g., biosecurity measures along trade routes. Although the OIE rapidly updates standards (*Bd* and Ranavirus were included as notifiable amphibian diseases in 2008; see OIE Aquatic Animal Health Code 2011), no further updates have been made in the context of mitigating and controlling their spread or to establish sanitary safety of internationally traded amphibians (Schloegel et al. 2010). The very recent agreement between OIE and CITES to collaborate on global animal health issues is an important step forward, but in order to truly fulfill the goal of protecting CITES-listed species and biodiversity, this joint-venture also needs to consider wildlife diseases (see CITES and OIE Initiative 2015, accessed, April 10, 2016). Recently, the Standing Committee of the Bern Convention adopted a recommendation on prevention and control of *Bsal* that calls for "appropriate science-based pre-import risk screening for infectious diseases of live animals in animal trade" and "impose immediate

restrictions on salamander and newt trade while a scientific risk assessment is being developed and until necessary measures are designed, as a preventive measure against the introduction of *Bsal* through pet trade" (Bern Convention 2015). Trade restrictions are consistent with the widely implemented precautionary approach and will help prevent the introduction of pathogens such as *Bsal* (UNEP-WCMC 2016).

The combination of overexploitation and spread of diseases can result in the loss of amphibians from some habitats and can affect the functioning of ecosystems and the services they provide. Disappearance of amphibians is predicted to have cascading effects both in terrestrial and aquatic food-webs given the central positions they occupy in those webs, both as tadpoles and as adults. For example, at Hubbard Brook in New Hampshire the biomass of salamanders easily outweighs the combined biomass of birds and mammals and they have a substantial effect on the forest-floor part of the ecosystem (summarized by Hairston 1987). Moreover, they are indicators of the healthiness of terrestrial biomes owing to their sensitivity to environmental changes (Stebbins and Cohen 1995). The enormous ecological value that amphibians contribute to e.g., neotropical ecosystems has been recently outlined by Cortéz-Gómez et al. (2015). Because in many species tadpoles and adults occupy different (ecological) niches, it is said that "the loss of a single amphibian species is akin to losing two species" (Whiles et al. 2006; Mendelson 2011; Whiles et al. 2013).

Issues related to the global conservation of amphibian species are manifold and urgently need to be addressed (Bishop et al. 2012), including the major challenge to prevent introduction of infected disease vector species into naïve amphibian populations (Cunningham et al. 2003; UNEP-WCMC 2016).

## Conclusions and recommendations

Current trade regulations need to be vastly improved and rigorously enforced to ensure protection of threatened species and to allow a responsible and sustainable global amphibian trade. In this context, we suggest the following measures to improve capacity of monitoring and regulating amphibian trade:

1. Recommend to the World Customs Organization (WCO) that its Harmonized System (HS) be amended to specifically include codes for live amphibians and amphibian meat and encouraging member administrations to make provisions for amphibians in their domestic tariffs. The resolution "Further steps to combat the amphibian crisis" that was passed at the IUCN's 5th World Conservation Congress (WCC-2012-Res-020) already contains a suggestion in this direction, but we are unaware of any progress towards harmonization. WCO partners such as CITES, the EU and the European Free Trade Association (EFTA), UNEP, UNESCO, and many others should raise awareness within the WCO of this need to update the Harmonized System.
2. Given the unregulated and unsustainable trade of many range-restricted non-CITES amphibian species, a listing of more species on the CITES appendices is required. The IUCN SSC Amphibian Specialist Group is in a position to support CITES parties developing proposals for listing of species with expert advice.
3. In line with recommendations formulated by the Standing Committee of the Bern Convention (see above), appropriate biosecurity needs to be established to assure importation of disease-free animals, in case these originate from countries/regions where particular diseases have been detected. We further suggest that current EU

legislation should be strengthened for all non-CITES species along the following guidelines:

- Restrict or ban trade of species that have been illegally obtained in order to prevent laundering of wild specimens as farmed or captive bred.
- (Temporarily) Suspend trade until sufficient controls are set up in countries of origin/export and countries of import, and status of exploited populations is monitored sufficiently through independent agencies or certification schemes, for those species that fulfill at least one of the following criteria:

(a) Species listed in one of the IUCN Red List of Threatened Species threat categories (Critically Endangered, Endangered or Vulnerable).
(b) Species with an extent of occurrence (EOO) of <20,000 $km^2$, or area of occurrence (AOO) of <2000 $km^2$ (IUCN 2012; also cf. Sodhi et al. 2008; Jenkins et al. 2013).
(c) Species that are nationally protected in their country of origin.

We believe that these aforementioned guidelines support the need to improve and implement rigorous international standards based on current legislation, taking new scientific knowledge into account. These suggestions will facilitate implementation of improved trade controls in agreement with situations faced by traded species from around the world into Europe, and help conserve amphibian biodiversity globally.

**Acknowledgments** We are grateful to Amanda Linda Jean Duffus (Gordon State College, Georgia, USA), Kelly Malsh (UNEP-WCMC, Cambridge, UK), and Bruce J. Weissgold, (US Fish and Wildlife Service), for providing data and literature.

## References

Alroy J (2015) Current extinction rates of reptiles and amphibians. PNAS 112:13003–13008. doi:10.1073/pnas.1508681112

Altherr S, Goyenechea A, Schubert D (2011) Canapés to extinction—the international trade in frogs' legs and its ecological impact. A report by Pro Wildlife, Defenders of Wildlife and Animal Welfare Institute (eds), Munich (Germany), Washington, DC (USA)

Alworth LC, Harvey SB (2007) IACUC issues associated with amphibian research. ILAR J 48:278–289

Andreone F, Cadle JE, Cox N et al (2005) Species review of amphibian extinction risks in madagascar: conclusions from the global amphibian assessment. Conserv Biol 19:1790–1802. doi:10.1111/j.1523-1739.2005.00249.x

Andreone F, Mercurio V, Mattioli F (2006) Between environmental degradation and international pet trade: conservation strategies for the threatened amphibians of Madagascar. Nat Soc it Sci nat Museo civ Stor nat Milano 95:81–96

Andreone F, Carpenter AI, Cox N et al (2008) The challenge of conserving amphibian megadiversity in Madagascar. PLoS Biol 6:e118. doi:10.1371/journal.pbio.0060118

Ashley S, Brown S, Ledford J et al (2014) Morbidity and mortality of invertebrates, amphibians, reptiles, and mammals at a major exotic companion animal wholesaler. J Appl Anim Welf Sci 4:308–321. doi:10.1080/10888705.2014.918511

Auliya M (2003) Hot trade in cool creatures: a review of the live reptile trade in the European Union in the 1990s with a focus on Germany. TRAFFIC Europe, Brussels

Bern Convention (2015) 35th Meeting of the Standing Committee, Strasbourg 1–4 Dec 2015; List of decisions and adopted texts. http://www.coe.int/en/web/bern-convention/-/35th-standing-committee-meeting. Accessed 8 Dec 2015

Bishop PJ, Angulo A, Lewis JP et al (2012) The Amphibian Extinction Crisis—what will it take to put the action into the Amphibian Conservation Action Plan? S.A.P.I.E.N.S 5.2, 2012, online since August 23, 2012. http://sapiens.revues.org/1406. Accessed 3 March 2015

Brown JL, Twomey E, Amézquita A et al (2011) A taxonomic revision of the neotropical poison frog genus *Ranitomeya* (Amphibia: Dendrobatidae). Zootaxa 3083:1–120

Catenazzi A, Vredenburg VT, Lehr E (2010) *Batrachochytrium dendrobatidis* in the live frog trade of *Telmatobius* (Anura: Ceratophryidae) in the tropical Andes. Dis Aquat Org. doi:10.3354/dao02250

Chanson J, Stuart S, Cox N et al (2008) The Global Amphibian Assessment (GAA): history, objectives and methodology. In: Stuart SN et al (eds) Threatened amphibians of the world. Lynx Ed., Barcelona; IUCN, Gland; Conservation international, Arlington

CITES Species Checklist (2015) Checklist of official listed CITES species. http://checklist.cites.org/#/en/about. Accessed 15 Jul 2015

OIE Aquatic Animal Health Code (2011) Aquatic animal health code of the OIE (World Organization for Animal Health). http://wahis2devt.oie.int/fileadmin/Home/eng/Health_standards/aahc/2010/en/chapitre_1.8.1.pdf. Accessed 15 Nov 2011

Collins JP, Crump ML (2009) Extinction in our times: global amphibian decline. Oxford University Press, Oxford, p 304

Collins JP, Storfer A (2003) Global amphibian declines: sorting the hypotheses. Divers Distrib 9:89–98

Cortéz-Gómez AM, Ruiz-Agudelo CA, Valencia-Aguilar A, Ladle RJ (2015) Ecological functions of neotropical amphibians and reptiles: a review. Univ Scient 20:229–245. doi:10.11144/Javeriana.SC20-2.efna

Courtois EA, Pineau K, Villette B et al (2012) Population estimates of *Dendrobates tinctorius* (Anura: Dendrobatidae) at three sites in French Guiana and first record of chytrid infection. Phyllomedusa 11:63–70

Cox N, Berridge RJ, Church D et al (2008) Why safe amphibians. In: Stuart S, Hoffmann M, Chanson J et al (eds) Threatened amphibians of the World. Lynx Editions, Barcelona, pp 23–27

Crandall KA (2009) A multifaceted approach to species conservation. Anim Conserv 12:105–106. doi:10.1111/j.1469-1795.2009.00254.x

Cunningham AA, Daszak P, Rodrıguez JP (2003) Pathogen pollution: defining a parasitological threat to biodiversity conservation. J Parasit 89:78–83

Cunningham AA, Beckmann K, Perkins M et al (2015) Emerging disease in UK amphibians. Vet Rec. doi:10.1136/vr.h2264

Daszak P, Cunningham AA, Hyatt AD (2003) Infectious disease and amphibian population declines. Divers Distrib 9:141–150

De Paula CD, Pacífico-Assis EC, Catão-Dias JL (2012) *Batrachochytrium dendrobatidis* in amphibians confiscated from illegal wildlife trade and used in an ex situ breeding program in Brazil. Dis Aquat Org 98:171–175

Duffus ALJ (2009) Ranavirus ecology in common frogs (*Rana temporaria*) from the United Kingdom: transmission dynamics, alternate hosts and host-strain interactions. Doctoral thesis. School of Biological and Chemical Sciences Queen Mary, University of London and Institute of Zoology, Zoological Society of London, London

Engler M, Parry-Jones R (2007) Opportunity or threat: The role of the European Union in global wildlife trade. TRAFFIC Europe, Brussels

EU Commission Regulation (2014) COMMISSION REGULATION (EU) No 1320/2014 of 1 December 2014 amending Council Regulation (EC) No 338/97 on the protection of species of wild fauna and flora by regulating trade therein. http://eurlex.europa.eu/legalcontent/EN/TXT/HTML/?uri=CELEX:32014R1320andfrom=EN. Accessed 14 Jul 2015

European Commission (2010) Wildlife Trade Regulations in the European Union, Luxembourg, p 24. http://bookshop.europa.eu

Farrer RA, Weinert LA, Bielby J et al (2011) Multiple emergences of genetically diverse amphibian-infecting chytrids include a globalized hypervirulant recombinant lineage. PNAS. doi:10.1073/pnas.1111915108

Fisher MC, Garner TWJ (2007) The relationship between the emergence of *Batrachochytrium dendrobatidis,* the international trade in amphibians and introduced amphibian species. Fungal Biol Rev 21:2–9

Frost DR (2015) Amphibian species of the World: an online reference. Version 6.0 (07/13/2015). American Museum of Natural History, New York. Electronic database http://research.amnh.org/herpetology/amphibia/index.html

Garner TWJ, Stephen I, Wombwell E et al (2009) The amphibian trade: bans or best practice? EcoHealth. doi:10.1007/s10393-009-0233-1

Gerson H, Cudmore B, Mandrak NE et al (2008) Monitoring international wildlife trade with coded species data. Conserv Biol 22:4–7
Gilbert M, Bickford D, Clark L et al (2013) Amphibian pathogens in Southeast Asian frog trade. EcoHealth 9:386–398
Global *Bd*-Mapping Project (2015) www.Bd-maps.net. Accessed 15 Jul 2015
Gorzula S (1996) The trade in dendrobatid frogs from 1987 to 1993. Herpetol Rev 27:116–123
Grant T, Frost DR, Caldwell JP et al (2006) Phylogenetic systematics of dart-poison frogs and their relatives (Amphibia: Athesphatanura: Dendrobatidae). Bull Am Mus Nat Hist 299:1–262
Gratwicke B, Evans MJ, Jenkins PT et al (2009) Is the international frog legs trade a potential vector for deadly amphibian pathogens? Front Ecol Environ. doi:10.1890/090111
Hairston NG (1987) Community ecology and salamander guilds. Cambridge University Press, Cambridge
Hedges SB (1993) Global amphibian declines: a perspective from the Caribbean. Biodivers Conserv 2:290–303
Herrel A, van der Meijden A (2014) An analysis of the live reptile and amphibian trade in the USA compared to the global trade in endangered species. Herpetol J 24:103–110
Hoffmann M, Church D, Collins JP et al (2008) Amphibian Conservation—responding to the global decline of amphibians. In: Stuart SN et al (eds) Threatened amphibians of the World, Lynx Ed., Barcelona; IUCN, Gland; Conservation International, Arlington, pp 114–124
Holden J (1998) By Hook or by Crook. A reference manual on illegal wildlife trade and prosecutions in the United Kingdom. The Royal Society for the Protection of Birds, The World Wide Fund for Nature, TRAFFIC International, Cambridge
Hoogmoed MS, Avila-Pires TCS (2012) Inventory of color polymorphism in populations of *Dendrobates galactonotus* (Anura: Dendrobatidae), a poison frog endemic to Brazil. Phyllomedusa 11:95–115
IUCN (2012) IUCN red list categories and criteria: version 3.1, Second edition. IUCN, Gland. p iv+32
IUCN Red List (2015) The IUCN Red list of threatened species. Version 2015.2. http://www.iucnredlist.org. Accessed 14 Jul 2015
IUCN Red List (2016) The IUCN red list of threatened species. Version 2016.1. http://www.iucnredlist.org. Accessed 30 Jun 2016
Jenkins PT (2013) Invasive animals and wildlife pathogens in the United States: the economic case for more risk assessments. Biol Invasion 15:243–248
Jenkins CN, Pimm SL, Joppa LN (2013) Global patterns of terrestrial vertebrate diversity and conservation. www.pnas.org/cgi/doi/10.1073/pnas.1302251110
Jensen JB, Camp CD (2003) Human exploitation of amphibians: direct and indirect impacts. In: Semlitsch RD (ed) Amphibian conservation. Smithsonian Institution, Washington, DC, pp 199–213
Karesh WB, Cook RB, Bennet EL et al (2005) Wildlife trade and global disease emergence. Emerg Infect Dis 11:1000–1002
Kaska Y, Kumluta Y, Avci A et al (2009) *Lyciasalamandra billae*. The IUCN red list of threatened species 2009: e.T61915A12571852. http://dx.doi.org/10.2305/IUCN.UK.2009.RLTS.T61915A12571852.en. Accessed 13 Jul 2016
Kolby JE, Smith KM, Berger L et al (2014) First evidence of amphibian chytrid fungus (*Batrachochytrium dendrobatidis*) and ranavirus in Hong Kong amphibian trade. PLoS One 9:e90750. doi:10.1371/journal.pone.0090750
Kusrini MD, Alford RA (2006) Indonesia's exports of frogs' legs. TRAFFIC Bull 21:13–24
Lötters S, Jungfer KH, Henkel FW et al (2007) Poison Frogs, Edition Chimaira. Biology, Species and Captive Husbandry, Frankfurt a. Main, p 668
Marano N, Arguin PA, Pappaioanou M (2007) Impact of globalization and animal trade on infectious disease ecology. Emerg Infect Dis 13:1807. http://www.cdc.gov/EID/content/13/12/1807.htm
Martel A, Spitzen-van der Sluis A, Blooi M et al (2013) *Batrachochytrium salamandrivorans* sp. nov. causes lethal chytridiomycosis in amphibians. Proc Nat Acad Sci USA 110:15325–15329
Martel A, Blooi M, Adriaensen C et al (2014) Recent introduction of a chytrid fungus endangers Western Palearctic salamanders. Science 346:630–631
Mazzoni R, Cunningham A, Daszak P et al (2003) Emerging pathogen of wild amphibians in frogs (*Rana catesbeiana*) farmed for international trade. Emerg Inf Dis 9:995–998
Mendelson JR III (2011) Shifted baselines, forensic taxonomy, and Rabbs' fringe-limbed treefrog: the changing role of biologists in an era of amphibian declines and extinctions. Herpetol Rev 42:21–25
Mohneke M, Onadeko AB, Hirschfeld M et al (2010) Dried or fried: amphibians in local and regional food markets in West Africa. TRAFFIC Bull 22:117–128
Neang T (2010) An Investigation into Frog Consumption and Trade in Cambodia. Fauna and Flora International Cambodia Programme, Cambodia, p 24

Nijman V, Shepherd CR (2010) The role of Asia in the global trade in CITES II-listed poison arrow frogs: hopping from Kazakhstan to Lebanon to Thailand and beyond. Biodiv Conserv 19:1963–1970
Nijman V, Shepherd CR (2011) The role of Thailand in the international trade in CITES-listed live reptiles and amphibians. PLoS One 6:e17825
O'Rourke DP (2007) Amphibians used in research and teaching. ILAR J 48:183–187
CITES & OIE Initiative (2015) World Animal Health Organisation (OIE) and CITES agree to collaborate on animal health and welfare issues worldwide to safeguard biodiversity and protect animals. https://cites.org/eng/news/pr/oie_and_cites_agree_to_collaborate_on_animal_health_and_welfare_issues_worldwide_to_safeguard_biodiversity_and_protect_animals_04122015. Accessed 25 April 2016
Olson DH, Aanensen DM, Ronnenberg KL et al (2013) Mapping the global emergence of *Batrachochytrium dendrobatidis*, the Amphibian chytrid fungus. PLoS One 8:e56802. doi:10.1371/journal.pone.0056802
Pasmans F, Zwart P, Hyatt AD (2004) Chytridiomycosis in the Central American bolitoglossine salamander (*Bolitoglossa dofleini*). Vet Rec 154:153
Pasmans F, Blahak S, Martel A, Pantchev N, Zwart P (2008) Ranavirus-associated mass mortality in imported red tailed knobby newts (*Tylototriton kweichowensis*): a case report. Vet J 176:257–259
Peel AJ, Hartley M, Cunningham AA (2012) Qualitative risk analysis of introducing *Batrachochytrium dendrobatidis* to the UK through the importation of live amphibians. Dis Aquat Org 98:95–112
Pepper MP, Twomey E, Brown JL (2007) The smuggling crisis. Leaf Litt Mag Tree Walk Int 1:5–7
Pessier AP, Mendelson JR (2010) A manual for control of infectious diseases in amphibian survival assurance colonies and reintroduction programs. IUCN/SSC Conservation Breeding Specialist Group, Apple Valley
Picco AM, Collins JP (2008) Amphibian commerce as a likely source of pathogen pollution. Conserv Biol 22:1582–1589
Pieper B, Pieper R (1997) Pflege und zucht des gesprenkelten baumsteigerfrosches *Dendrobates galactonotus*. Reptilia 72:49–52
Pistoni J, Toledo LF (2010) Amphibian Illegal Trade in Brazil: what do we know? S Am J Herpetol 5:51–56
Pounds JA, Bustamante MR, Coloma LA et al (2006) Widespread amphibian extinctions from epidemic disease driven by global warming. Nature. doi:10.1038/nature04246
Rödder D, Schulte U, Toledo LF (2013) High environmental niche overlap between the fungus *Batrachochytrium dendrobatidis* and invasive bullfrogs (*Lithobates catesbeianus*) enhance the potential of disease transmission in the Americas. N West J Zool 9:178–184
Rosenblum EB, James TY, Zamudio KR et al (2013) Complex history of the amphibian-killing chytrid fungus revealed with genome resequencing data. Proc Natl Acad Sci USA 110:9385–9390
Sabino-Pinto J, Bletz M, Hendrix R et al (2015) First detection of the emerging fungal pathogen *Batrachochytrium salamandrivorans* in Germany. Amph-Rept. doi:10.1163/15685381-00003008
Scheele BC, Hunter DA, Grogan LF et al (2014) Interventions for reducing extinction risk in chytridiomycosis-threatened amphibians. Conserv Biol. doi:10.1111/cobi.12322
Schlaepfer MM, Hoover C, Dodd CK Jr (2005) Challenges in evaluating the impact of the trade in amphibians and reptiles on wild populations. Bioscience 55:256–264
Schloegel LM, Picco AM, Kilpatrick AM et al (2009) Magnitude of the US trade in amphibians and presence of *Batrachochytrium dendrobatidis* and ranavirus infection in imported North American bullfrogs (*Rana catesbeiana*). Biol Conserv 142:1420–1426
Schloegel LM, Daszak P, Cunningham AA et al (2010) Two amphibian diseases, chytridiomycosis and ranaviral disease, are now globally notifiable to the World Organization for Animal Health (OIE): an assessment. Dis Aquat Org 92:101–108
Schloegel LM, Toledo LF, Longcore JE et al (2012) Novel, panzootic and hybrid genotypes of amphibian chytridiomycosis associated with the bullfrog trade. Mol Ecol 21:5162–5177
Smith KF, Behrens M, Schloegel LM et al (2009) Reducing the risks of the wildlife trade. Science 324:594595
Sodhi NS, Bickford D, Diesmos AC et al (2008) Measuring the meltdown: drivers of global amphibian extinction and decline. PLoS One 3:e1636. doi:10.1371/journal.pone.0001636
Spitzen-van der Sluijs A, Martel A, Wombwell E et al (2011) Clinically healthy amphibians in captive collections and at pet fairs: a reservoir of *Batrachochytrium dendrobatidis*. Amph-Rept 32:419–423
Spitzen-van der Sluijs A, Spikmans F, Bosman W et al (2013) Enigmatic decline drives *Salamandra salamandra* to the edge of extinction in The Netherlands. Amph-Rept 34:233–239
Spitzen-van der Sluijs A, Martel A, Asselberghs J et al (2016) Expanding distribution of lethal amphibian fungus *Batrachochytrium salamandrivorans* in Europe. Emerg Inf Dis 22:1286–1288
Stebbins RC, Cohen NW (1995) A natural history of amphibians. Princeton Univ. Press, New Jersey
Stuart SN, Chanson JS, Cox NA et al (2004) Status and trends of amphibian declines and extinctions worldwide. Science 306:1783–1786

Stuart SN, Hoffmann N, Chanson JS et al. (eds) (2008) Threatened amphibians of the world. Lynx Ed., Barcelona; IUCN, Gland; Conservation International, Arlington

Suykerbuyk P, Vleminckx K, Pasmans F et al (2007) *Mycobacterium liflandi* Infection in European Colony of *Silurana tropicalis*. Emerg Inf Dis 13:743–746

UNEP-WCMC (2016) Review of the risk posed by importing Asiatic species of Caudata amphibians (salamanders and newts) into the EU. Prepared for the European Commission, Directorate General Environment, Directorate E—Global & Regional Challenges, LIFE ENV.E.2.—Global Sustainability, Trade & Multilateral Agreements, Brussels, Belgium

UNEP-WCMC trade database (2014). http://trade.cites.org/. Accessed 7 March 2014

Veith M, Kosuch J, Feldmann R et al (2000) A test for correct species declaration of frog legs imports from Indonesia into the European Union. Biodivers Conserv 9:333–341

Vredenburg VT, Felt SA, Morgan EC et al (2013) Prevalence of *Batrachochytrium dendrobatidis* in *Xenopus* collected in Africa (1871–2000) and in California (2001–2010). PLoS One 8:e63791. doi:10.1371/journal.pone.0063791

Wang X-M, Zhang K-J, Wu W et al (2004) The decline of the Chinese giant salamander and applications for its conservation. Oryx 38:197–202

Warkentin IG, Bickford D, Sodhi NS et al (2009) Eating frogs to extinction. Conserv Biol 23:1056–1059

Weldon C, Du Preez LH, Hyatt AD et al (2004) Origin of the amphibian chytrid fungus. Emerg Inf Dis 10:2100–2105

Whiles MR, Lips KR, Pringle CM et al (2006) The effects of amphibian population declines on the structure and function of Neotropical stream ecosystems. Front Ecol Environ 4:27–34

Whiles MR, Hall RO Jr, Dodds WK et al (2013) Disease-driven amphibian declines alter ecosystem processes in a tropical stream. Ecosyst 16:146–157

Wombwell EL (2014) Emerging Infectious Disease and the Trade in Amphibians. Doctoral thesis. Durrell Institute of Conservation and Ecology, School of Anthropology and Conservation, University of Kent. https://kar.kent.ac.uk/48014/1/121THESIS.pdf

Woodhams DC, Bosch J, Briggs CJ et al (2011) Mitigating amphibian disease: strategies to maintain wild populations and control chytridiomycosis. Front Zool 8:1–23

Young BE, Lips KR, Reaser JK et al (2000) Population declines and priorities for amphibian conservation in Latin America. Conserv Biol 15:1213–1223