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Review of the risk posed by importing Asiatic species of Caudata amphibians (salamanders and newts) into the EU

(Version edited for public release)

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Executive Summary

This document provides a review of the threat posed by importing Asiatic salamander and newt species, which carry a fatal fungal pathogen, *Batrachochytrium salamandrivorans* (*Bsal*), believed to pose an ecological threat to native salamander species, into the European Union (EU). *Bsal* was first identified in 2013 following dramatic declines among populations of European fire salamanders (*Salamandra salamandra*) in the Netherlands; it has since been found at fifteen sites across the Netherlands, Belgium and Germany. The international pet trade is widely considered the main route for the introduction of *Bsal* into the EU.

Information on *Bsal* and the threat posed by importing infected Asiatic salamanders to native salamander species in the EU was compiled through literature searches of both published and unpublished material, together with information on international trade from the CITES Trade Database, U.S. Fish and Wildlife Service LEMIS data and an online survey of EU websites. The *Amphibian Species of the World* 6.0 online reference (Frost, 2016) is used for the taxonomy and nomenclature of caudate species[1].

Based on the available information, this report finds that:

- *Bsal* is a highly contagious chytrid fungus restricted to infecting salamanders and newts (order Caudata), primarily affecting species in the Western Palearctic. Around two thirds of caudates (15 of 24) tested experimentally in one study were susceptible or lethally affected by *Bsal*, including eight out of nine European species. Not all European species have been tested.
- *Bsal* is confirmed to have caused severe localised population declines of *Salamandra salamandra* in the Netherlands and it has so-far been detected in at least fifteen sites across the Netherlands, Belgium and Germany, where similar outbreaks have been reported. It has also been detected in captive salamanders held in Germany and the UK.
- *Bsal* originated in East Asia (where it is present at low, non-detrimental levels) and is thought to have arrived in Europe via the international pet trade. Three Asiatic caudate species have been identified as potential reservoirs for *Bsal*: *Hypselotriton cyanurus*, *Cynops pyrrhogaster* and *Paramesotriton deloustali* (all susceptible to *Bsal* under laboratory conditions), with a further three Asiatic species found to be tolerant or lethally affected under laboratory conditions.
- There is a high demand for Southeast Asian salamanders and newts in the international pet trade. Whilst trade is reported to go unrecorded, high volumes of live individuals are imported into the United States, primarily via China and Hong Kong SAR.
- Analysis of CITES Trade Data and web surveys indicate a demand for Asiatic salamanders within the EU, with 17 species found offered for sale on EU websites. Nine of these are not currently included in CITES or the Annexes of the EU Wildlife Trade Regulations.
- *Bsal* is highly transmissible through direct contact and through dispersal and contact with zoospores from contaminated substrate. It can be effectively transmitted across multiple caudate species. The risk of *Bsal* entering the EU through imports of Asiatic caudates is further exacerbated by misidentification of species, mixing of different species and species from different origins in the same containers, a lack of mandatory testing before or after shipment

[1] In line with the CITES Standard Nomenclatural Reference for amphibians, taken from *Amphibian Species of the World* 5.5, as of December 2011.

and a lack of information or awareness among wholesalers, traders and hobbyists on preventing the spread of *Bsal*.

Introduction

Substantial concern has been raised within the European Union regarding the threat posed by the recently-described fungal pathogen *Batrachochytrium salamandrivorans* (*Bsal*) to native European salamanders and newts, through imports of Asian salamanders for the international pet trade.

In 2015, the Standing Committee of the Convention on the Conservation of European Wildlife and Natural Habitats (the Bern Convention) adopted Recommendation No. 176 (4 December 2015) on the prevention and control of the *Bsal* fungus. Specifically, the Committee recommended that signatories to the Convention take a number of precautions to prevent the spread of the fungus, including imposing "immediate restrictions on salamander and newt trade whilst a scientific risk assessment is being developed and until necessary measures are designed, as a preventative measure against the introduction of *Bsal* through pet trade."

In 2016, the Scientific Review Group requested a review to determine whether Asiatic salamanders and newts, which carry pathogens invasive to EU fauna, meet the criteria for listing in Annex B of the EU Wildlife Trade Regulations.

The EU Wildlife Trade Regulations contain provisions to list in Annex B, "species in relation to which it has been established that the introduction of live specimens into the natural habitat of the Community would constitute an ecological threat to wild species of fauna and flora indigenous to the Community" (Article 3.2(d) of EC Regulation 338/97). The Commission may also establish restrictions on introduction into the Community "of live specimens of species for which it has been established that their introduction into the natural environment of the Community presents an ecological threat to wild species of fauna and flora indigenous to the Community" (Article 4.6(d) of EC Regulation 338/97). A number of Invasive Alien Species have already been listed in Annex B, with their import into the EU currently prohibited: the Red-eared slider *Trachychemys scripta elegans*, American bullfrog *Lithodytes* [*Rana*] *catesbeiana*, Painted turtle *Chrysemys picta,* Ruddy duck *Oxyura jamaicensis*, Grey squirrel *Sciurus carolinensis*, Eastern fox squirrel *S. niger* and Pallas's squirrel *Callosciurus erythraeus*.

This review assesses the threat posed by trade in live Asiatic caudates (salamanders and newts) and the possible subsequent intentional/accidental release into the wild, in introducing the highly pathogenic *Bsal* fungus to native European caudate populations.

Amphibians of the order Caudata - overview

The order Caudata includes roughly 700 species of salamanders and newts, classified within nine distinct families (Frost, 2016; Table 1). These tailed amphibians have long bodies and soft, often moist skin without scales (Arnold and Ovenden, 2002). They exploit a wide range of niches, including moist forest leaf litter, grasslands, underground refuges, headwater streams, riparian ecotones, swamps, caves, ponds and seasonally inundated pools (Petranka, 1998). Their global distribution spans the Americas, Palearctic Eurasia and North Africa (Duellmann, 1999; Frost, 2016).

Table 1: Families of living caudate species and their distribution.

Family	No. of species	Common names	Distribution
Ambystomatidae	37	Mole salamanders, axolotls	North America (Canada, United States, Mexico)
Amphiumidae	3	Congo eels, amphiumas	United States
Cryptobranchidae	4	Giant salamanders, hellbenders	Two species in Asia (China and Japan), two in North America (United States)
Hynobiidae	66	Asiatic salamanders	Asia and eastern Russia
Plethodontidae	455	Lungless salamanders	Predominantly North, Central and South America, a few species in Europe and Asia
Proteidae	8	Mudpuppies, olms, waterdogs	Predominantly North America (United States), one species in southeastern Europe
Rhyacotritonidae	4	Torrent salamanders	Western North America (United States)
Salamandridae	118	True salamanders, newts	Predominantly Eurasian, a few species in North America (Canada, United States).
Sirenidae	4	Sirens	North America (United States)

Source: Frost (2016).

Thirty seven species occur within the European Union (see Appendix 1). The native European caudates include several common species with wide distributions and tolerance of a broad range of habitats (e.g. the Alpine newt *Ichthyosaura alpestris*, Common newt *Lissotriton vulgaris* and the Great crested newt *Triturus cristatus*, all Least Concern), as well as a number of globally threatened species known only from a few localities, with likely declining populations (e.g. *Speleomantes supramontis*, *Calotriton arnoldi* and *Euproctus platycephalus*) (AmphibiaWeb, 2016, Frost, 2016). Nineteen European caudates are listed in Appendix II 'Strictly Protected Fauna Species' of the Bern Convention; the remaining European caudates are all listed in Appendix III 'Protected Fauna Species' of the Bern Convention. *Triturus cristatus* is also listed in Annex II of the Habitats Directive.

Although a cryptic order, caudates play a key role in maintaining ecosystem stability (Davic and Welsh, 2004). As mid-level vertebrate predators, they control species diversity (through preying on invertebrates), which in turn reduces the release of carbon dioxide from leaf litter decomposition (Davic and Welsh, 2004; Best and Welsh, 2014; Gray *et al.*, 2015). They contribute to regulating soil dynamics through underground burrows (Davic and Welsh, 2004), supply high-quality energy and nutrients for tertiary consumers (i.e. carnivores) (Davic and Welsh, 2004), and maintain the exchange of energy and nutrients between terrestrial and aquatic habitats (Hocking *et al.*, 2014). Caudate species are considered so important to the ecosystems they inhabit that their presence has been used as a cost-effective indicator of ecological health and integrity (Micacchion, 2004). Many salamander species also have biomedical value, through their ability to regenerate limbs (McClusker and Gardiner, 2014) and produce chemicals with antibiotic, anaesthetic and analgesic properties (Yotsu-Yamashita and Mebs, 2001).

Amphibians are currently undergoing a global extinction crisis, with almost one-third of species considered threatened or extinct, including 47% of Caudata (Stuart *et al.*, 2004; Chanson *et al.*, 2008; Corey and Wait, 2008; Warkentin *et al.*, 2009; Rowley *et al.*, 2010). The main pressures affecting threatened caudates are habitat loss (affecting 87% of threatened caudates), fire, pollution, utilization, natural disasters, human disturbance, invasive species and disease (Chanson *et al.*, 2008). International trade is a key driver of the over-exploitation of wild amphibians (Chanson *et al.*, 2008; Rowley *et al.*, 2016), and acts an important pathway in the global spread of fungal pathogens (Fisher and Garner, 2007). A wide range of amphibian species are represented in the international pet trade, primarily wild-caught specimens from the rainforests of Africa, South America, Central America and Southeast Asia,

exported to the main international pet markets in North America, Europe and Japan (Cox *et al.*, 2008). Trade is predominantly in frogs and toads, but several salamander species are reported to be popular, including Asian fire-bellied newts (*Cynops* spp.), several newts of the Asian genus *Tylototriton* and brightly coloured salamanders such as the European fire salamander (*Salamandra salamandra*) (Cox *et al.*, 2008).

Seven caudate species are currently listed in the Appendices of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), and a further 30 species were listed in Annex D of the EU Wildlife Trade Regulations in 2009 (see Appendix 2). Of these species, the axolotl *Ambystoma mexicanum* (Appendix II) was reported to be in particularly high demand as a pet species due to its large size and ease of maintenance (Cox *et al.*, 2008), with species from the genus *Ambystoma* making up 22% of the total live trade in amphibians between 1976 and 2007 (Carpenter *et al.*, 2014).

Batrachochytrium salamandrivorans (*Bsal*)

i) Overview of the threat

Emerging infectious diseases, particularly those caused by fungi, are reducing biodiversity on a global scale (Fisher *et al.*, 2012; Martel *et al.*, 2014). The highly pathogenic chytrid fungus *Batrachochytrium dendrobatidis* (hereafter, *Bd*) is already recognised as one of the main drivers of the global amphibian crisis, causing severe population declines and extinction in more than 200 species worldwide (Wake and Vredenburg, 2008; Duffus and Cunningham, 2010; Kilpatrick *et al.*, 2010; Fisher *et al.*, 2012; Martel *et al.*, 2014).

A second highly pathogenic chytrid fungus, *Batrachochytrium salamandrivorans (*hereafter, *Bsal*) represents a previously undescribed species, first identified following dramatic declines among populations of European fire salamanders (*Salamandra salamandra*) (Martel *et al.*, 2013). *Bsal* parasitizes epidermal cells of salamanders, causing skin ulcerations with significant degradation of the epidermis, impairment of vital skin functions, and subsequent death of susceptible species within two to three weeks (Martel *et al.*, 2013; Gray *et al.*, 2015). Compared with its sister species *Bd,* which has caused skin disease and severe population declines across the three orders of amphibians (i.e. Anura: frogs and toads, Caudata: salamanders and newts, Gymnophiona: caecilians), *Bsal* seems to have a narrower host range, being restricted to Caudata (Martel *et al.*, 2013, 2014).

Bsal is transmitted through aquatic spores that can survive independently in moist environments for several days in temperatures between 10 and 15°C (Martel *et al.*, 2013). Infection occurs through direct contact with infected individuals, as well as through exposure to contaminated water and organic matter in which imported salamanders have been transported (Kilpatrick *et al.*, 2010; Martel *et al.*, 2013). Through a series of tests on captive amphibians held in pet shops, at London Heathrow airport, and at an exporter in Hong Kong, Martel *et al.* (2014) showed that *Bsal* could be effectively transmitted across multiple caudate species by direct contact. Thus *Bsal* could infect wild salamander populations within the EU through either accidental/intentional release of infected salamanders (wild or captive-bred), or through disposal of water and substrate into the environment (Stephen *et al.*, 2015). It could also spread between wild populations as a result of human activities near infected sites (e.g. spores spreading through contaminated footwear or movement of material between sites) (Natuurpunt and Natagora, 2016).

The fungus is documented to have originated in East Asia (confined to Thailand, Viet Nam, and Japan), where the disease is present among Asian salamander and newt species at low, non-detrimental levels,

(Martel *et al.*, 2014; Van Rooij *et al.*, 2015) arriving in Europe via the international pet trade (Martel *et al.*, 2014). Based on infection experiments on 35 species (10 Anura, 24 Caudata, 1 Gymnophiona), Martel *et al.* (2014) classified amphibians into four categories of response to *Bsal*[2]: resistant, tolerant, susceptible and lethal. They identified 15 out of 24 caudate species that were tested as being either susceptible or lethally affected by *Bsal*, including eight out of nine European species. The screening of caudate species from four continents (Europe, Asia, North and South America) indicates that *Bsal* mainly infects Western Palearctic (i.e. European) salamanders (Muletz *et al.*, 2014; Martel *et al.*, 2014; Bales *et al.*, 2015; Sabino-Pinto *et al.*, 2015). The only non-European species with which *Bsal* was found to have a lethal response comprised two out of the nine tested New World salamandrid species (*Taricha granulosa* and *Notophthalmus viridescens*) (Martel *et al.*, 2014). Although many European species have not been tested experimentally for their susceptibility to *Bsal*, Sabino-Pinto *et al.* (2015) hypothesized that the introduction and spread of *Bsal* into native ranges of *Salamandra*-species and closely related taxa could lead to a collapse of many, if not all populations in the near future. Furthermore, it has been suggested that additional stresses in the wild (e.g. habitat loss or deleterious substances), could supress the immune systems of wild individuals, thus facilitating the likelihood of outbreaks of infectious diseases in wild populations (Mann *et al.* 2009 in: Spitzen-van der Sluijs *et al.*, 2013).

Martel *et al.* (2014) recognised three Asiatic species as potential reservoirs for *Bsal*: *Hypselotriton* [*Cynops*] *cyanurus*, *Cynops pyrrhogaster* and *Paramesotriton deloustali*. *Bsal* is thought to have originated and remained in coexistence with these salamander hosts for millions of years (Martel *et al.*, 2014). These three reservoir species were found to have the ability to "shed zoospores for at least 5 months without necessarily developing any clinical disease", which coupled with increased levels of human and animal traffic, has the potential to cause high levels of extinction across native European caudate species, which have not had the opportunity to establish resistance (Martel *et al.*, 2014). Although seven caudate species are currently listed in the CITES Appendices, with a further 30 species listed in Annex D of the EU Wildlife Trade Regulations (see Appendix 2), only one out of the three Asiatic reservoir species is currently included in this list (*Paramesotriton deloustali* - Annex D). The families Hynobiidae, Plethodontidae, Salamandridae and Sirenidae were all found to contain species that were tolerant, susceptible or lethally affected by *Bsal*, thus it is assumed that all could be potential carriers of *Bsal*, posing a risk of transmission to these and other susceptible species.

ii) Impact on European salamanders and newts

There is increasing evidence of the threat of *Bsal* infection to wild populations of salamanders and newts within Europe. *Bsal* presents a serious threat to *Salamandra salamandra* in the Netherlands, given that it currently inhabits the extreme edge of its range and its distribution is limited to only three populations in the southern province of Limburg (in the woodlands of Bunderbos, Vijlenerbosch and Putberg - where it has been introduced) (Table 2, Spitzen-van der Sluijs *et al.*, 2013). The fungus was first detected in Europe within all three populations of *S. salamandra* in southern Netherlands, following an investigation into the cause of a 96% decline in abundance between 1997 and 2012 (Martel *et al.*, 2013; Spitzen-van der Sluijs *et al.*, 2013). This steep decline resulted in just two individuals being sighted across all three areas in 2012, from a maximum of 241 sighted in in 1999 (Spitzen-van der Sluijs *et al.*, 2013). The first dead animals were reported in 2008, and to date, 25 dead *S. salamandra* individuals have been found in Bunderbos and five in Putberg (Spitzen-van der Sluijs *et al.*, 2013).

[2] Resistant: no infection, no disease; tolerant: infection in the absence of disease; susceptible: infection resulting in clinical disease with possibility of subsequent recovery; lethal: infection resulting in lethal disease in all infected animals.

Similar outbreaks of *Bsal* have been reported in *S. salamandra* populations in eastern Belgium (in Eupen in December 2013, Robertville in April 2014, and Liege in 2014), as well as in *Ichthyosaura alpestris* populations in the northern Belgian region of Duffel (May 2014) (Martel *et al.* 2014; Natuurpunt and Natagora, 2016; RAVON Reptielen Amfibieën Onderzoek Nederland, 2016), causing 95% reductions in population size (Martel *et al.*, 2014). Most recently, four dead *S. salamandra* tested positive for *Bsal* in Dinant, in southern Belgium in April 2016, suggesting that a novel outbreak is underway; there is a risk that the fungus may spread further to vulnerable populations in the Alps and the Pyrenees (Natuurpunt, 2016; RAVON Reptielen Amfibieën Onderzoek Nederland, 2016). Out of a sample of 1019 individuals of free-living salamanders and newts across 55 sites in Netherlands, Belgium, and Germany, Spitzen-van der Sluijs *et al.* (2016) detected *Bsal* at 14 sites and in three species (*Salamandra salamandra*, *Ichthyosaura alpestris* and *Lissotriton vulgaris*), suggesting that *Bsal*'s distribution may extend up to 10 000 km² across the three neighbouring countries. It is not yet known whether this indicates a recent spread of the fungus or the presence of historically infected sites that were previously undetected; given that skin lesions only develop during the final stages of the disease, *Bsal* may remain unnoticed for long periods of time (Spitzen-van der Sluijs *et al.,* 2016).

Bsal has also been detected in captive salamander populations in the United Kingdom and Germany (Cunningham *et al.*, 2015; Sabino-Pinto *et al.*, 2015). In the UK, routine testing of quarantined caudates newly acquired by a zoological collection from a UK breeder revealed *Bsal* infection in three imported species, with infection found in an additional caudate species at the breeder's premises (the four caudate species affected were not specified) (Cunningham *et al.*, 2015). In Germany, a private amphibian keeper detected high rates of mortality associated with skin lesions in his collection of fire salamanders (*Salamandra salamandra*, *S. algiria*, *S. corsica* and *S. infraimmaculata*), following which *Bsal* infection was confirmed in nine subspecies of *S. salamandra* and in *S. algiria* from north Africa (Sabino-Pinto *et al.*, 2015). The origin of *Bsal* in the collection remains unknown (Sabino-Pinto *et al.*, 2015). Three captive specimens of *Tylototriton vietnamensis* in the EU were also reported to have tested positively for *Bsal*, two of which were imported from Asia in 2010 (Natuurpunt and Natagora, 2016).

Table 2. European field sites where *Bsal* has been detected

Country	Site name	Species	Common name
Netherlands	Bunderbos, deciduous forest	*Salamandra salamandra*	Fire salamander
		Ichthyosaura alpestris	Alpine newt
	Putberg, deciduous forest	*Ichthyosaura alpestris*	Alpine newt
		Salamandra salamandra	Fire salamander
	Meersen, garden pond	*Lissotriton vulgaris*	Smooth newt
	Wormdal, natural ponds in nature conservation area	*Lissotriton vulgaris*	Smooth newt
	Pepinusbeekdal, extensive agriculture	*Lissotriton vulgaris*	Smooth newt
	Berg en Dal, garden pond	*Ichthyosaura alpestris*	Alpine newt
	Vijlenerbosch, deciduous forest	*Ichthyosaura alpestris*	Alpine newt
		Salamandra salamandra	Fire salamander
Belgium	Eupen, deciduous forest	*Salamandra salamandra*	Fire salamander
	Robertville, deciduous forest	*Salamandra salamandra*	Fire salamander
	Liège, deciduous forest	*Salamandra salamandra*	Fire salamander
	Duffel, garden pond	*Ichthyosaura alpestris*	Alpine newt
	Dinant, deciduous forest	*Ichthyosaura alpestris*	Alpine newt
Germany	Weisse Wehe, deciduous forest	*Salamandra salamandra*	Fire salamander
	Solchbachtal, mixed forest	*Salamandra salamandra*	Fire salamander
	Belgenbachtal, mixed forest	*Salamandra salamandra*	Fire salamander

Source: Spitzen-van der Sluijs *et al.* (2013; 2016); Martel *et al.* (2014); Natuurpunt (2016).

International trade in Asian salamanders and newts

Amphibians are the most commonly traded animal across many regions of the world (e.g. Smith *et al.*, 2009; Nijman, 2010), though much of this trade was reported to remain unregulated and unrecorded (Rowley *et al.*, 2016). The international pet trade is considered a threat to many Southeast Asian caudates (IUCN, 2015; Rowley *et al.*, 2016). Here, we summarise the international trade in caudate species using CITES Trade Data (for species listed in CITES and the EU Wildlife Trade Regulations), U.S. Fish and Wildlife Service (USFWS) import data (from the U.S. Law Enforcement Management Information Service; LEMIS), and targeted web searches. We summarise information on the risk of spread of *Bsal* based on published literature.

Risk of transmission through trade

The principal route for the global spread in *Bsal* is considered to be the international trade in salamanders and newts (Martel *et al.*, 2014; Stephen *et al.* 2015; RAVON Reptielen Amfibieën Onderzoek Nederland 2016; U.S. Fish & Wildlife Service 2016). Similarly to *Bd*, both live and dead salamanders can transmit *Bsal* through the keratin in their skin (Berger *et al.* 1998; in U.S. Fish & Wildlife Service, 2016), which suggests that any infected individuals that die in transport are likely to continue carrying the disease to their destination (U.S. Fish & Wildlife Service, 2016). Salamander body parts may also transmit the disease, but as in the case of *Bd*, salamander eggs or gametes have not been found to carry the pathogen (Berger *et al.* 1998 in: U.S. Fish & Wildlife Service, 2016). Similarly to *Bd*, *Bsal* is highly

transmissible through direct contact, and has the potential to spread to individuals from the same species or other species when infected and susceptible individuals are transported in the same containers with shared water (Yap *et al.*, 2015; U.S. Fish & Wildlife Service, 2016). *Bsal* is also more likely to spread within crowded conditions, which create stress and weaken individuals' natural immune systems (Rachowicz *et al.*, 2005; Rowley *et al.*, 2007; Rollins-Smith *et al.*, 2011 in: U.S. Fish & Wildlife Service, 2016). *Bsal* may also be introduced to the natural environment through improper disposal of contaminated water or material to transport salamanders (Stephen *et al.* 2015; U.S. Fish & Wildlife Service, 2016). The intentional release of non-native salamanders (often as fishing baits) or unintentional escapes from enclosures are further ways in which *Bsal* might spread throughout the environment (Picco and Collins, 2008; Krysko *et al.*, 2011 in: U.S. Fish & Wildlife Service, 2016). Additional practices in the international wildlife trade that are likely to increase the risk of *Bsal* spread include a lack of mandatory testing of wild-caught species for pathogens before or after shipment, and imprecise labelling of shipment records leading to mixing of individuals (Smith *et al.*, 2009 in: U.S. Fish & Wildlife Service, 2016). Rowley *et al.* (2016) noted that many Southeast Asian caudate species are hard to identify morphologically at species-level by non-experts, hence increasing the likelihood of multiple species being shipped together in the same container and species being traded under the incorrect scientific names.

Analysis Methods

Data was extracted from the CITES Trade Database on 21/04/2016. U.S. Fish & Wildlife Service LEMIS data was summarised from the literature and is available to download for salamander imports 2004-2014[3].

A web search of twenty-five EU websites including amphibian importers, wholesalers, retailers and classified advertisements posted by the public was used to indicate the types of species and level of demand in trade for Asiatic caudate species currently for sale within the European Union. The list of websites was compiled using a list from a 2009 review of non-CITES reptiles in trade (UNEP-WCMC, 2009), supplemented with additional EU websites identified through google search. The web search was first conducted using species' scientific name (at the genus level), and then by their common names in each website's native language. Price, source and species' origin were also recorded where available. The survey was conducted on 16 – 17th May 2016.

Analysis of CITES trade data

Over the period 2005-2014, direct imports to the EU-28 of live caudates totalled 3895 individuals, as reported by importers, of which 61% were traded for commercial purposes and 24% for scientific purposes (Table 3). Imports comprised nine species: the CITES Appendix II-listed axolotl *Ambystoma mexicanum* (making-up 25% of imports, all captive-bred, primarily from the United States) and eight Annex D Asiatic Salamandridae species (primarily from unknown sources). The Asiatic Salamandridae species were imported primarily from China (65%), Hong Kong SAR (22%) and Japan (9%). The main EU importers of live Asiatic Salamandridae were Germany (79%), Czech Republic (18%) and Spain (3%). No direct imports of Salamandridae species were reported to the EU-28 in 2014, and 2015 data is not yet available.

Indirect imports to the EU-28 of live caudates totalled 644 individuals, as reported by the importers, comprising seven species: two Appendix I species (*Andrias davidianus* and *Andrias japonicus*), one Appendix II species (*Ambystoma mexicanum*), and four Annex D Asiatic Salamandridae species (*Paramesotriton labiatus*, *Tylototriton asperrimus, T. kweichowensis* and *T. verrucosus*). The top indirect imports were *T. kweichowensis (*48%, all unknown source) and *Paramesotriton labiatus* (23%, all

[3] www.amphibians.org/resources/tradedata/

captive-bred). The majority of live indirect imports were for commercial purposes (94%), with the remainder for zoos or travelling exhibitions. The majority of indirectly traded individuals originated in China and were imported by Germany (71%), Spain (23%) and Czech Republic (5%).

Table 3: Direct imports of live caudates to the EU-28 2005-2014. (*A. mexicanum* was listed in CITES Appendix II on 01/07/1975, the remaining species were listed in EU Annex D on 22/05/2009)

Taxon	Reported by	2005	2006	2007	2009	2010	2011	2012	2013	2014	Total
Ambystoma mexicanum	Importer	22	470	50	223	95	30		35	30	955
	Exporter	60	410		15	323	30	4	35	30	907
Cynops ensicauda	Importer					100	75		38		213
	Exporter										
Laotriton laoensis	Importer								41		41
	Exporter										
Paramesotriton chinensis	Importer				762		152	128	53		1095
	Exporter										
Paramesotriton labiatus	Importer				102	75	150	187			514
	Exporter										
Tylototriton asperrimus	Importer						125	70	122		317
	Exporter										
Tylototriton kweichowensis	Importer					200	350				550
	Exporter										
Tylototriton verrucosus	Importer						200				200
	Exporter										
Tylototriton vietnamensis	Importer								10		10
	Exporter										
Total	Importer	**22**	**470**	**50**	**1087**	**470**	**1082**	**385**	**299**	**30**	**3895**
	Exporter	**60**	**410**		**15**	**323**	**30**	**4**	**35**	**30**	**907**

Source: CITES Trade Database, UNEP-WCMC, Cambridge, UK, downloaded on 21/04/2016

Analysis of Web search results

Seventeen species were found to be offered for sale on European websites, of which nine species were not listed in CITES or the EU Wildlife Trade Regulations (Table 4). For one species advertised for sale (*Ommatotriton ophryticus*), it was noted that individuals were not available at the time of the search. Two of the species offered for sale have been identified as susceptible to *Bsal* (*Neurergus crocatus* and *Cynops pyrrhogaster*, Martel *et al.,* 2014). The species' source (e.g. wild-taken, captive bred) was listed for only half of the advertisements.

Table 4: Asiatic caudate species advertised for sale on websites within the European Union.

Website	Type of site	Species advertised (CITES Appendix/EU Annex)	Price per individual	Origin (if stated)	Additional information
Europe-wide					
www.eurofauna.com	Pets classifieds	*Salamandra infraimmaculata*	-	-	-
Czech Republic					
www.animalfarm.cz	Terraristic retailer	*Neurergus kaiseri* (I/A)	-	Iran	-
		Tylototriton asperrimus (D)	-	China	-
		Tylototriton shanjing	-	China	-
		Hypselotriton [*Cynops*] *orientalis*	-	China	-
Finland					
www.tiias-pets.net	Pet retailer	-	-	-	-
France					
http://www.lftshop.com/index.cfm	Terraristic retailer/breeder	*Neurergus crocatus*	48 EUR	Iraq, Turkey	Specimens were born in captivity in 2015.
		Tylototriton asperrimus (D)	39 EUR	China, Vietnam	-
www.marche.fr	Pets classifieds	*Hypselotriton* [*Cynops*] *orientalis*	15 EUR	-	-
http://www.tropicalis.fr/animaux-terrariophilie/	Amphibian importer/ wholesaler	-		-	-
http://www.reptimania.com/	Pets classifieds	*Cynops sp.*	30 EUR	-	-
		Hypselotriton [*Cynops*] *orientalis*	8 EUR	-	One sale and one search
		Cynops pyrrhogaster	10 EUR	-	Two sales
		Paramesotriton chinensis (D)	10 EUR	-	-
		Paramesotriton [*Pachytriton*] *labiatus* (D)	10 EUR	-	Two sales
		Tylototriton verrucosus (D)	10 EUR	-	-
		Neurergus kaiseri (I/A)	35 EUR	-	-
http://animaux.vivastreet.com/	Pets classifieds	*Paramesotriton chinensis* (D)	10 EUR	-	-
exo-fauna.fr	Amphibian importer/ wholesaler	-	-	-	-
Germany					
www.terraristic-classifieds.com	Terraristic classifieds	-	-	-	-
www.hoch-rep.com	Amphibian importer/ wholesaler	-	-	-	-
http://www.terraristik.com/	Terraristic classifieds	*Tylotriton shanjing*	-	-	For sale
		Tylotriton yangi (D)	-	-	For sale
		Neurergus strauchii	-	-	For sale
		Cynops ensicauda (D)	-	-	For sale

Website	Type of site	Species advertised (CITES Appendix/EU Annex)	Price per individual	Origin (if stated)	Additional information
		Salamandra infraimmaculata	-	-	One search
Italy					
http://www.agripetgarden.it/	Amphibian importer/ wholesaler	-	-	-	-
http://www.rettiljungle.com/	Pet retailer	-	-	-	-
http://www.tropicaliaonline.it/	Amphibian importer/ wholesaler	*Hypselotriton [Cynops] orientalis*	15 EUR	-	-
Spain					
http://www.animalcenter.es/	Amphibian importer/ wholesaler	*Hypselotriton* [*Cynops*] *orientalis*	-	-	-
		Pachytriton [*Paramesotriton*] *labiatus* (D)	-	-	-
http://www.bichosfera.com/	Amphibian importer/ wholesaler	-	-	-	-
http://tierraexotica.es/	Amphibian importer/ wholesaler	-	-	-	-
http://reptilesyanfibiosonline.blogspot.co.uk/	Amphibian importer/ wholesaler	-	-	-	-
http://exofauna.com/	Amphibian importer/ wholesaler	-	-	-	-
Poland					
www.terrarium.com.pl	Stock list posted on a forum	*Hypselotriton* [*Cynops*] *orientalis*	-	China	-
		Cynops pyrrhogaster	-	Japan	-
		Cynops ensicauda (D)	-	Japan	-
		Tylototriton podichthys	-	Lao PDR	-
United Kingdom					
www.faunaimportuk.com	Amphibian importer/ wholesaler	-	-	-	-
www.southcoastexotics.com	Amphibian importer/ wholesaler	-	-	-	-
http://faunatech.co.uk/	Pet retailer	-	-	-	-
http://www.exotic-pets.co.uk/	Amphibian importer/ wholesaler	*Neurergus crocatus*	49 GPB	Iran, Iraq, Turkey, Israel	-
		Hypselotriton [*Cynops*] *orientalis*	Currently unavailable	-	-
		Cynops pyrrhogaster	Currently unavailable	-	-
		Ommatotriton ophryticus	Currently unavailable	-	-
		Paramesotriton [*Pachytriton*] *labiatus* (D)	Currently unavailable	-	-
http://www.dartfrog.co.uk/	Amphibian importer/ wholesaler	*Echinotriton andersoni* (D)	125 GPB	Japan	Captive bred
		Hynobius dunni	30 GPB	Japan	Captive bred
		Hypselotriton [*Cynops*] *orientalis*	7.50 GPB	China	Captive bred
		Neurergus crocatus	50 GPB	Turkey, Iraq, Iran	F1 individuals

Website	Type of site	Species advertised (CITES Appendix/EU Annex)	Price per individual	Origin (if stated)	Additional information
		Neurergus strauchii	35/50 GPB	Turkey	Larger individuals offered at higher price.
		Salamandra infraimmaculata	125 GPB	Turkey, Lebanon	Very large form. Captive bred in Germany.

Key: All species were for sale unless otherwise stated in the additional information. 'Search' refers to adverts looking to purchase a particular species.

Analysis of U.S. LEMIS trade data

According to LEMIS data, salamanders made up 5.5% of the amphibians imported into the United States from 2004 to 2014, 95% of which belonged to the genera *Cynops*, *Paramesotriton*, *Salamandra* and *Tylototriton* (Gray *et al.*, 2015). All four genera are known to contain at least one species that is susceptible to *Bsal* infection (Martel *et al.* 2014). *Pachytriton* (Chinese newts) made up approximately 4.5% of live salamander imports during this period and were considered a further genera under threat as they had not yet been be tested for susceptibility to *Bsal* (Gray *et al.*, 2015). The species with the highest number of imports into the U.S. during this period was *Hypselotriton* [*Cynopus*] *orientalis*, comprising 54% of the total number of imported salamanders (U.S. Fish & Wildlife Service, 2015). The total market value for salamanders imported to the U.S. in 2014 was estimated to be USD 924 707 (assuming that all animals were sold at the median market value) (Gray *et al.*, 2015).

Of the live imports of Asiatic caudates to the U.S. 2004-2014, eleven species were not listed in CITES or the EU Annexes (Table 5), four of which were also found offered for sale in the online survey of EU websites (*Cynops pyrrhogaster*, *Hypselotriton* [*Cynops*] *orientalis*, *Neurergus crocatus*, *Tylototriton shanjing*). An additional 431 230 live individuals were imported at genus level, for genera which contain Asiatic species: *Cynops* spp. (50%), *Triturus* spp. (47%), *Pachytriton* spp. (1.8%), *Tylototriton* spp. (0.9%), *Salamandra* spp., *Hynobius* spp., *Neurergus* spp. and *Batrachuperus* spp.

Table 5: Live Asiatic caudate species imported into the United States 2004-2014 which are not currently listed in CITES or the EU Wildlife Trade Regulations (Source: USFWS LEMIS data[4]). The majority of imports were for commercial purposes.

Species	No. individuals imported	Main source
Onychodactylus japonicus	33	F/C/W
Pachyhynobius shangchengensis	413	W
Salamandrella keyserlingii	2	C
Cynops pyrrhogaster	196873	W/C
Hypselotriton [*Cynops*] *cyanurus*	2291	C/W
Hypselotriton [*Cynops*] *orientalis*	1340680	C/W
Neurergus crocatus	205	C
Ommatotriton [*Triturus*] *vittatus*	25	C
Pachytriton brevipes	78356	C/W
Tylototriton shanjing	640	W/F/C

Prevention and management of *Bsal*

At EU level

In adopting Recommendation No. 176 on the prevention and control of the *Bsal* fungus, the Bern Convention Standing Committee recommended that signatories to the Convention take a number of precautions to prevent the spread of the fungus, including [*inter alia*]: applying biosafety rules when working within fire salamander and newt sites and with captive collections of amphibians; carrying out

[4] www.amphibians.org/resources/tradedata/

pre-import risk screening for infectious diseases of live animals; imposing immediate restrictions on salamander and newt trade while a scientific risk assessment is being developed; establishing monitoring programmes to control the possible spread of the disease; supporting research into the epidemiology of the *Bsal* fungus and the conservation biology of European salamanders and newts.

Recommendation No. 176 also recalled a technical report on "Pets, aquarium, and terrarium species: best practices for addressing risks to biodiversity", which advocates the need for risk assessment and legislation to prevent, manage and control the introduction, release or escape of alien invasive species (including those that may introduce infectious diseases to native species) (Secretariat of the CBD, 2010). It was suggested that the approach would work best together with public awareness campaigns and involvement of local communities; prevention was considered a more cost-effective strategy than eradication (Secretariat of the CBD, 2010).

Given that no immediate action under the EU Animals Health Law (Regulation (EU) 2016/429) is foreseen, no other measures to prevent or manage *Bsal* within the EU are in place.

At national levels

United States: On the 12th January 2016, the U.S. Fish and Wildlife Service declared 201 salamander species as "injurious wildlife" under the Lacey Act (prohibiting the import and interstate trade of listed species), on account of the risk they pose in spreading the *Bsal* fungus to the highly diverse native salamander populations (in effect since the 28th January 2016) (U.S. Fish & Wildlife Service, 2016). The *Bsal* fungus is not currently present in the U.S., but was considered to pose "an imminent threat to U.S. wildlife" (U.S. Fish & Wildlife Service, 2016). This interim rule covers all species of salamander from 20 genera, including European species. Permits may be granted by the U.S. Fish and Wildlife Service for the import and transport of restricted salamander species for scientific, medical, educational or zoological purposes. Owners of any listed animals are allowed to keep them, however, their interstate transport is prohibited under this ruling (U.S. Fish & Wildlife Service, 2016).

The U.S. Fish & Wildlife Service is reported to be working with the U.S. Geological Survey to analyse 10 000 individual salamanders across North America, to test for the presence of *Bsal* among native species (Navarro, 2016).

Canada: The Canadian Wildlife Authorities have carried out an assessment of the risk posed by the *Bsal* fungus (Stephen *et al.*, 2015). Two species (N*otophthalmus viridescens* and *Taricha granulosa)* have been identified as the most vulnerable native species to *Bsal* on account of their widespread distribution, migratory terrestrial stages, involvement in the pet trade, and lethal susceptibility to the fungus (Stephen *et al.*, 2015).

Belgium: On the 9th February 2016, the Belgian Minister of Energy, Environment, and Sustainable Development, Marie Christine Margem, asked her administration to examine the legal basis for prohibiting the import of Asian salamander species, in order to stop *Bsal* from spreading any further (Information and Services of the Belgian Government, 2016). Minister Margem proposed creating a working group of federal and regional environmental representatives to jointly determine what measures must be undertaken at the national level to prevent the spread of *Bsal*. The goal of this working group will be to develop a comprehensive plan to combat the pathogen.

The Netherlands: Following the severe population crash of the Bunderbos population of *S. salamandra*, 11 juveniles and 28 sub-adult fire salamanders were removed and kept in captivity to safeguard them from further threats (Spitzen-van der Sluijs *et al.*, 2013). These individuals will be intensively examined for the presence of pathogens, and will form the foundation of a breeding programme for future reintroductions once the causes of the decline have been removed (Spitzen-van der Sluijs *et al.*, 2013).

Treatment methods

It has been demonstrated that *Salamandra salamandra* infected by *Bsal* can be successfully treated by exposing them to a temperature of 25˚C for 10 days, in both laboratory and in the wild (Blooi *et al.*, 2015a). Since this treatment method cannot be used for all caudates (25˚C approaches the critical thermal maximum for certain species; Bury, 2008), further research discovered a new topical treatment that can clear *Bsal* infections at a temperature of 20˚C (Blooi *et al.*, 2015b).

Findings

Based on the available information, this report finds that:

- *Bsal* is a highly contagious chytrid fungus restricted to infecting salamanders and newts (order Caudata), primarily affecting species in the Western Palearctic. Around two thirds of caudates (15 of 24) tested experimentally in one study were susceptible or lethally affected by *Bsal*, including eight out of nine European species. Not all European species have been tested.
- *Bsal* is confirmed to have caused severe localised population declines of *Salamandra salamandra* in the Netherlands and it has so-far been detected in at least fifteen sites across the Netherlands, Belgium and Germany, where similar outbreaks have been reported. It has also been detected in captive salamanders held in Germany and the UK.
- *Bsal* originated in East Asia (where it is present at low, non-detrimental levels) and is thought to have arrived in Europe via the international pet trade. Three Asiatic caudate species have been identified as potential reservoirs for *Bsal*: *Hypselotriton cyanurus*, *Cynops pyrrhogaster* and *Paramesotriton deloustali* (all susceptible to *Bsal* under laboratory conditions), with a further three Asiatic species found to be tolerant or lethally affected under laboratory conditions.
- There is a high demand for Southeast Asian salamanders and newts in the international pet trade. Whilst trade is reported to go unrecorded, high volumes of live individuals are imported into the United States, primarily via China and Hong Kong SAR.
- Analysis of CITES Trade Data and web surveys indicate a demand for Asiatic salamanders within the EU, with 17 species found offered for sale on EU websites. Nine of these are not currently included in CITES or the Annexes of the EU Wildlife Trade Regulations.
- *Bsal* is highly transmissible through direct contact and through dispersal and contact with zoospores from contaminated substrate. It can be effectively transmitted across multiple caudate species. The risk of *Bsal* entering the EU through imports of Asiatic caudates is further exacerbated by misidentification of species, mixing of different species and species from different origins in the same containers, a lack of mandatory testing before or after shipment and a lack of information or awareness among wholesalers, traders and hobbyists on preventing the spread of *Bsal*.

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Appendices

Appendix 1. List of caudate species found within the European Union together with their response to *Batrachochytrium salamandrivorans* (*Bsal*) (Source: AmphibiaWeb, 2016, Frost, 2016).

Species[5]	Common name	Response to *Bsal*[6]	IUCN Red List	Distribution
Plethodontidae				
Speleomantes ambrosii	Ambrosi's cave salamander		NT	Italy, Spain (int)
Speleomantes flavus ∞	Monte albo cave salamander		VU	Italy
Speleomantes genei ∞	Gene's cave salamander		VU	Italy
Speleomantes imperialis ∞	Scented cave salamander		NT	Italy
Speleomantes italicus ∞	Italian cave salamander		NT	Italy
Speleomantes sarrabusensis	-		VU	Italy
Speleomantes strinatii	French cave salamander	Lethal	NT	France, Italy
Speleomantes supramontis ∞	Supramontane cave salamander		EN	Italy
Proteidae				
Proteus anguinus ∞	Olm, Blind cave salamander		VU	Bosnia and Herzegovina, Croatia, Italy, Slovenia, France (int).
Salamandridae				
Calotriton arnoldi	Montseny brook newt		CR	Spain

[5] ∞ Appendix II Strictly Protected Fauna Species of the Bern Convention

[6] Response to *Bsal* infection according to Martel *et al*. (2014). **Resistant:** no infection, no disease; **tolerant:** infection in the absence of disease; **susceptible:** infection resulting in clinical disease with possibility of subsequent recovery; **lethal:** infection resulting in lethal disease in all infected animals. Many caudate species have not yet been tested experimentally for their susceptibility to *Bsal*, hence cells are left blank. [Species found to be infected in the wild by Spitzen-van der Slujis *et al*. (2016) are noted in square brackets].

Appendix 1. List of caudates found within the EU

Species[5]	Common name	Response to *Bsal*[6]	IUCN Red List	Distribution
Calotriton asper ∞	Pyrenean brook newt		NT	Andorra, France, Spain
Chioglossa lusitanica ∞	Golden-striped salamander		VU	Portugal, Spain
Euproctus montanus ∞	Corsican brook newt		LC	France
Euproctus platycephalus ∞	Sardinian brook newt	Lethal	EN	Italy
Ichthyosaura alpestris	Alpine newt	Lethal [Affected in wild]	LC	Albania, Austria, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Denmark, France, Germany, Greece, Hungary, Italy, Liechtenstein, Luxembourg, the Former Yugoslav Rep. of Macedonia, Montenegro, Netherlands, Poland, Romania, Serbia, Slovakia, Slovenia, Spain, Switzerland, Ukraine. New Zealand (int), United Kingdom (int).
Lissotriton boscai	Bosca's newt		LC	Portugal, Spain
Lissotriton helveticus	Palmate newt	Resistant	LC	Belgium, Czech Republic, France, Germany, Italy, Luxembourg, Netherlands, Portugal, Spain, Switzerland, United Kingdom
Lissotriton italicus ∞	Italian newt	Lethal	LC	Italy
Lissotriton montandoni	Montandon's newt		LC	Czech Republic, Poland, Romania, Slovakia, Ukraine
Lissotriton vulgaris	Common newt, Smooth newt	[Affected in wild]	LC	Albania, Austria, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Kazakhstan, Latvia, Lithuania, Luxembourg, the Former Yugoslav Rep. of Macedonia, Republic of Moldova, Montenegro, Netherlands, Norway, Poland, Romania, Russian Federation, Serbia, Slovakia, Slovenia, Sweden, Switzerland, Turkey, Ukraine, United Kingdom, Australia (int)
Lyciasalamandra helverseni	-		VU	Greece
Lyciasalamandra luschani ∞	Luschan's salamander		VU	Greece, Turkey
Pleurodeles waltl	Sharp-ribbed newt	Lethal	NT	Morocco, Portugal, Spain
Salamandra atra ∞	Alpine salamander		LC	Albania, Austria, Bosnia and Herzegovina, Croatia, France, Germany, Italy, Liechtenstein, Montenegro, Serbia, Switzerland
Salamandra corsica	Corsican fire salamander		LC	France
Salamandra lanzai,	Lanza's alpine salamander		VU	France, Italy
Salamandra salamandra	Fire salamander	Lethal [Affected in	LC	Albania, Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, France, Germany, Greece, Hungary, Italy, Luxembourg, the Former Yugoslav Rep. of

Appendix 1. List of caudates found within the EU

Species[5]	Common name	Response to *BsaI*[6]	IUCN Red List	Distribution
		wild]		Macedonia, Montenegro, Netherlands, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Switzerland, Turkey, Ukraine
Salamandrina perspicillata	Northern spectacled salamander	Lethal	LC	Italy
Salamandrina terdigitata ∞	Spectacled salamander		LC	Italy
Triturus carnifex ∞	Italian crested newt		LC	Austria, Bosnia and Herzegovina, Croatia, Czech Republic, Hungary, Slovenia, United Kingdom (int)
Triturus cristatus ∞	Great crested Newt	Lethal	LC	Austria, Belarus, Belgium, Bulgaria, Czech Republic, Denmark, Estonia, Finland, France, Germany, Latvia, Liechtenstein, Lithuania, Luxembourg, Rep. of Moldova, Netherlands, Norway, Poland, Romania, Russian Federation, Serbia, Slovakia, Sweden, Switzerland, Ukraine, United Kingdom
Triturus dobrogicus ∞	Danube crested newt		NT	Austria, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Hungary, Rep. of Moldova, Romania, Serbia, Slovakia, Ukraine
Triturus ivanbureschi	Balkan crested newt		-	Bulgaria, Greece, the Former Yugoslav Rep. of Macedonia, Serbia, Turkey
Triturus karelinii ∞	Southern crested newt		LC	Azerbaijan, Georgia, Iran, Russian Federation, Turkey, Ukraine
Triturus macedonicus ∞	-		-	Albania, Bosnia and Herzegovina, Greece, the Former Yugoslav Rep. of Macedonia, Montenegro, Serbia
Triturus marmoratus	Marbled newt		LC	Portugal, Spain, France, Netherlands (int)
Triturus pygmaeus	Southern marbled newt		NT	France, Portugal, Spain, Netherlands (int)

Appendix 2. Overview of caudate species currently listed in CITES and the EU Wildlife Trade Regulations.

Appendix/Annex Family	Species	Common name	Response to *Bsal*[7]	IUCN Red List	Distribution
Appendix I/Annex A					
Cryptobranchidae	*Andrias davidianus*	Chinese giant salamander		CR	China, Taiwan, POC
	Andrias japonicus	Japanese giant salamander		NT	Japan, Russian Federation
Salamandridae	*Neurergus kaiseri*	Kaiser's spotted newt		CR	Iran, Iraq, Turkey
Appendix II/Annex B					
Ambystomatidae	*Ambystoma dumerilii*	Achoque		CR	Mexico
	Ambystoma mexicanum	Axolotl		CR	Mexico
Cryptobranchidae	*Cryptobranchus alleganiensis*	Hellbender		NT	United States
Appendix III/Annex C					
Hynobiidae	*Hynobius amjiensis*	-		CR	China
Annex D					
Hynobiidae	*Ranodon sibiricus*	Semirechensk salamander		EN	China, Kazakhstan
Plethodontidae	*Bolitoglossa dofleini*	Alta Verapaz salamander		NT	Belize, Guatemala, Honduras
Salamandridae	*Cynops ensicauda*	Sword-tailed newt		EN	Japan
	Echinotriton andersoni	Anderson's newt		EN	Japan, Taiwan, POC
	Laotriton laoensis	-		EN	Lao PDR

[7] Response to *Bsal* infection according to Martel *et al*. (2014). **Resistant:** no infection, no disease; **tolerant:** infection in the absence of disease; **susceptible:** infection resulting in clinical disease with possibility of subsequent recovery; **lethal:** infection resulting in lethal disease in all infected animals. Many caudate species have not yet been tested experimentally for their susceptibility to *Bsal*, hence cells are left blank.

Appendix 2. Overview of caudate species currently listed in CITES or the EU Wildlife Trade Regulations

Appendix/Annex Family	Species	Common name	Response to *Bsal*[7]	IUCN Red List	Distribution
	Paramesotriton caudopunctatus	Guizhou warty newt		NT	China
	Paramesotriton chinensis	Chinese warty newt		LC	China
	Paramesotriton deloustali	Tam Dao salamander	Susceptible	VU	China, Viet Nam
	Paramesotriton fuzhongensis	Wanggao warty newt		VU	China
	Paramesotriton guanxiensis	Guangxi warty newt		EN	China
	Paramesotriton hongkongensis	-		NT	China, Hong Kong, SAR
	Paramesotriton labiatus	Unterstein's newt		-	China
	Paramesotriton longliensis	-		-	China
	Paramesotriton maolanensis	-		-	China
	Paramesotriton yunwuensis	-		-	China
	Paramesotriton zhijinensis	-		-	China
	Salamandra algira	-		VU	Algeria, Morocco, Spain, Tunisia
	Tylototriton asperrimus	Black knobby newt		NT	China, Viet Nam
	Tylototriton broadoridgus	-		-	China
	Tylototriton dabienicus	-		-	China
	Tylototriton hainanensis	Hainan knobby newt		EN	China
	Tylototriton kweichowensis	Kweichow crocodile newt		VU	China
	Tylototriton lizhengchangi	-		-	China
	Tylototriton notialis	-		-	Lao PDR, Viet Nam
	Tylototriton pseudoverrucosus	-		-	China
	Tylototriton taliangensis	Pusakang crocodile newt		-	China
	Tylototriton verrucosus	Crocodile newt		LC	Bhutan, China, India, Lao PDR, Myanmar, Nepal, Thailand, Viet Nam
	Tylototriton vietnamensis	-		NT	China, Lao PDR, Viet Nam

Appendix 2. Overview of caudate species currently listed in CITES or the EU Wildlife Trade Regulations

Appendix/Annex Family	Species	Common name	Response to *BsaI*[7]	IUCN Red List	Distribution
	Tylototriton wenxianensis	Wenxian knobby newt	Lethal	VU	China
	Tylototriton yangi	Tiannan crocodile newt		-	China

Appendix 3. List of Asiatic caudate species not currently listed in CITES or the EU Wildlife Trade Regulations. (Source: Frost (2016), supplemented with information from the IUCN Red List (IUCN, 2015).

Species	Common name	Response to *Bsal*[8]	IUCN Red List	Distribution
Hynobiidae				
Afghanodon mustersi	Paghman mountain salamander		CR	Afghanistan
Batrachuperus karlschmidti	Chiala mountain salamander		VU	China
Batrachuperus londongensis	Longdong stream salamander		EN	China
Batrachuperus pinchonii	Western Chinese mountain salamander		VU	China
Batrachuperus taibaiensis	Taibai stream salamander		DD	China
Batrachuperus tibetanus	Alpine stream salamander		VU	China
Batrachuperus yenyuanensis	Yenyuan stream salamander		VU	China
Hynobius abei	Abe's salamander		CR	Japan
Hynobius amakusaensis	-		-	Japan
Hynobius arisanensis	-		VU	Taiwan, POC
Hynobius boulengeri	Odaigahara salamander		VU	Japan
Hynobius chinensis	Chinese salamander		EN	China
Hynobius dunni	Oita salamander		EN	Japan
Hynobius formosanus	Taiwan Salamander		EN	Taiwan, POC

[8] Response to *Bsal* infection according to Martel *et al*. (2014). **Resistant:** no infection, no disease; **tolerant:** infection in the absence of disease; **susceptible:** infection resulting in clinical disease with possibility of subsequent recovery; **lethal:** infection resulting in lethal disease in all infected animals. Many caudate species have not yet been tested experimentally for their susceptibility to *Bsal*, hence cells are left blank

Appendix 3. Overview of Asiatic caudate species not currently listed in CITES or the EU Wildlife Trade Regulations

Species	Common name	Response to *BsaI*[8]	IUCN Red List	Distribution
Hynobius fucus	Taiwan lesser salamander		-	Taiwan, POC
Hynobius glacialis	Nanhu salamander		-	Taiwan, POC
Hynobius guabangshanensis	Guabangshan hynobiid		DD	China
Hynobius kimurae	Hida salamander		LC	Japan
Hynobius leechii	Gensan salamander		LC	China, Dem. People's Rep. of Korea, Rep. of Korea
Hynobius lichenatus	Tohoku salamander		LC	Japan
Hynobius maoershanensis	-		DD	China
Hynobius naevius	Blotched salamander		LC	Japan
Hynobius nebulosus	Clouded salamander		LC	Japan
Hynobius nigrescens	Japanese black salamander		LC	Japan
Hynobius okiensis	Oki salamander		CR	Japan
Hynobius osumeinsis	-		-	Japan
Hynobius quelpaertensis	Cheju salamander		DD	Rep. of Korea
Hynobius retardatus	Ezo salamander	Resistant	LC	Japan
Hynobius shinichisatoi	-		-	Japan
Hynobius sonani	Taichu salamander		EN	Taiwan, POC
Hynobius stejnegeri	Amber-coloured salamander		VU	Japan
Hynobius takedai	Hokuriku salamander		EN	Japan
Hynobius tokyoensis	Tokyo salamander		VU	Japan
Hynobius tsuensis	Tsushima salamander		LC	Japan
Hynobius turkestanicus	Turkestanian salamander		DD	Kyrgyzstan, Tajikistan, Uzbekistan
Hynobius yangi	-		EN	Rep. of Korea
Hynobius yatsui	-		LC	Japan

Appendix 3. Overview of Asiatic caudate species not currently listed in CITES or the EU Wildlife Trade Regulations

Species	Common name	Response to *Bsal*[8]	IUCN Red List	Distribution
Hynobius yiwuensis	Yiwu hynobiid		VU	China
Iranodon gorganensis	Gorgan mountain salamander		CR	Iran
Iranodon persicus	Persia mountain salamander		-	Iran
Liua shihi	Sichuan salamander		-	China
Liua tsinpaensis	Shaanxi salamander		VU	China
Onychodactylus fischeri	Fischer's clawed salamander		LC	China, Dem. People's Rep. of Korea, Rep. of Korea, Russian Federation
Onychodactylus fuscus	Tadami clawed salamander		LC	Japan
Onychodactylus intermedius	Bandai clawed salamander			Japan
Onychodactylus japonicas	Japanese clawed salamander		LC	Japan
Onychodactylus kinneburi	Shikoku clawed salamander		-	Japan
Onychodactylus koreanus	Korean clawed salamander		-	Rep. of Korea, Dem. People's Rep. of Korea (?)
Onychodactylus nipponoborealis	Tohuku clawed salamander		-	Japan
Onychodactylus tsukubaensis	Tsukuba clawed salamander		-	Japan
Onychodactylus zhangyapingi	Jilin clawed salamander		-	China, Dem. People's Rep. of Korea (?)
Onychodactylus zhaoermii	Liaoning clawed salamander		-	China
Pachyhynobius shangchengensis	Shangcheng salamander	Resistant	VU	China
Pseudohynobius flavomaculatus	Yellow-spotted salamander		VU	China
Pseudohynobius guizhouensis	-		-	China
Pseudohynobius jinfo	Jinfo salamander		-	China
Pseudohynobius kuankuoshuiensis	-		DD	China
Pseudohynobius puxiongensis	-		DD	China
Pseudohynobius shuichengensis	-		VU	China
Salamandrella keyserlingii	Dybowski's salamander	Tolerant	LC	China

Appendix 3. Overview of Asiatic caudate species not currently listed in CITES or the EU Wildlife Trade Regulations

Species	Common name	Response to *BsaI*[8]	IUCN Red List	Distribution
Salamandrella tridactyla	-		LC	Russian Federation, Dem. People's Rep. of Korea, China
Plethodontidae				
Karsenia koreana	Korean crevice salamander		LC	Rep. of Korea
Salamandridae				
Cynops pyrrhogaster	Japanese fire-bellied newt	Susceptible	LC	Japan
Echinotriton chinhaiensis	Chinhai spiny newt		CR	China
Echinotriton maxiquadratus	Mountain spiny newt		-	China
Hypselotriton chenggongensis	Chenggong fire-bellied newt		DD	China
Hypselotriton cyanurus	Chuxiong fire-bellied newt	Susceptible	LC	China
Hypselotriton fudingensis	Fuding fire-bellied newt		-	China
Hypselotriton glaucus	-		-	China
Hypselotriton orientalis	Oriental fire-bellied newt		LC	China
Hypselotriton orphicus	Dayang newt		EN	China
Hypselotriton wolterstorffi	Yunnan Lake newt		EX	China
Hypselotriton yunnanensis	Chuxiong fire-bellied newt		-	China
Liangshantriton taliangensis	Taliang knobby newt		NT	China
Neurergus crocatus	Lake Urmia newt	Lethal	VU	Iran, Iraq, Turkey
Neurergus microspilotus	Kurdistan newt		CR	Iran
Neurergus strauchii	Anatolia newt		VU	Turkey
Ommatotriton ophryticus	Northern banded newt		NT	Armenia, Georgia, Russian Federation, Turkey
Ommatotriton vittatus	Southern banded newt		LC	Israel, Jordan, Lebanon, Syrian Arab Republic, Turkey
Pachytriton archospotus	Guidong stout newt			China
Pachytriton brevipes	Black-spotted stout newt		LC	China

Appendix 3. Overview of Asiatic caudate species not currently listed in CITES or the EU Wildlife Trade Regulations

Species	Common name	Response to *Bsal*[8]	IUCN Red List	Distribution
Pachytriton changi	Chang's stout newt		-	China
Pachytriton feii	Fei's stout newt		-	China
Pachytriton granulosus	Pingchi's newt		-	China
Pachytriton inexpectatus	-		-	China
Pachytriton moi	Mo's stout newt		-	China
Pachytriton wuguanfui	-		-	China
Pachytriton xanthospilos	-		-	China
Paramesotriton qixilingensis	-		-	China
Paramesotriton wulingensis	-		-	China
Salamandra infraimmaculata	Spot-bellied salamander		NT	Turkey, Syria, Lebanon, Iraq, Iran
Triturus karelinii	Southern crested newt		LC	Azerbaijan, Georgia, Iran, Russian Federation, Turkey, Ukraine
Tylototriton anguliceps	Angular-headed newt		-	China, Lao PDR, Thailand, Viet Nam
Tylototriton himalayanus	-		-	Nepal, India
Tylototriton liuyangensis	-		-	China
Tylototriton panhai	-		-	Thailand, Lao PDR
Tylototriton podichthys	-		-	Lao PDR
Tylototriton shanjing	-		NT	China, Thailand, Myanmar
Tylototriton shanorum	-		-	Myanmar
Tylototriton uyenoi	-		-	Thailand
Tylototriton ziegleri	-		-	Viet Nam

Appendix 4. Country name abbreviations.

Abbreviation	Country
China	People's Republic of China
Dem. People's Rep. of Korea	Democratic People's Republic of Korea
Hong Kong SAR	Hong Kong Special Administrative Region of China
Israel	State of Israel
Iran	Islamic Republic of Iran
Iraq	Republic of Iraq
Lao PDR	Lao People's Democratic Republic
Rep. of Korea	Republic of Korea
Rep. of Moldova	Republic of Moldova
Taiwan, POC	Taiwan, Province of China
The former Yugoslav Rep. of Macedonia	The former Yugoslav Republic of Macedonia
United States	United States of America