Chapter 7

Trade and sustainable use

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Abstract

The global trade in amphibians occurs at an extraordinary magnitude, involving the use of millions of animals locally and internationally every year. This activity is uniformly monitored and internationally regulated for less than 5% of described amphibian species, and the overall sustainability of present levels of trade are largely unknown. Amphibians are an important source of protein in many regions of the world and are also frequently traded as pets and scientific research organisms. Thousands of amphibian species are either directly affected by this trade through their harvest or captive production, or indirectly affected through its unintended consequences. The trade in amphibians has numerous potential negative impacts on biodiversity, including some that are unrelated to the removal of amphibians from the wild, such as the spread of non-native species and the spread of emerging infectious diseases. In this chapter, we focus on the latter since it has been associated with amphibian extinction events and is a more recently emerging phenomenon. This chapter highlights key points of concern that warrant additional investigation to ensure the long-term survival of amphibians is protected from the threat of trade and concludes with a series of recommendations for constructive conservation actions.

Introduction

Millions of amphibians are traded globally every year for purposes ranging from use as a source of protein for human consumption (Carpenter et al., 2014; Gratwicke et al., 2010; Warkentin et al., 2009), to their use as exotic pets (Altherr & Lameter, 2020; Natusch & Lyons, 2012; Stringham & Lockwood, 2018;), scientific research organisms, and for zoological conservation activities. Although a portion of these animals are produced in captivity, 42% are reported as wild caught (Hughes, Marshall & Strine, 2021), with 22% of the international amphibian trade comprised of species that are already threatened according to the IUCN Red List of Threatened Species™ (Red List). It's important to note that the aforementioned trade characteristics refer only to the portion of international amphibian trade recorded by individual numbers of animals, whereas millions more are traded in units of mass, particularly those used as a source of food (Kolby, 2016). The impacts of these activities on global amphibian populations are largely unstudied.

A major challenge preventing deeper understanding of the impact of trade on amphibians is the scarcity of species-specific population estimates together with the absence of species-specific trade data recording by most countries. Currently, over 8,000 amphibian species have been scientifically described, but most readily available international trade data collected during official government inspections (i.e. the publicly accessible CITES trade database and the USFWS LEMIS trade database available through a Freedom of Information Act Request) only include verified trade information on several hundred species. At least 17% of amphibian species are internationally traded, with the majority originating from South America, China, and Central Africa (Hughes, Marshall & Strine, 2021). Following capture or production in captivity, individuals are then either consumed locally or exported (Auliya et al., 2016; Warkentin et al., 2009).

Marsh et al. (2022) performed a comprehensive analysis of Red List data to evaluate patterns of use among species, including amphibians, and the degree to which use is or is not likely to be impacting their respective extinction risk. Among the 5,406 species of amphibians that they analysed, 576 (11%) were documented as having at least one purpose of use coded (such as pets or food), and 341 were categorized as Least Concern. Among these species listed as Least Concern, 160 species were not reported as declining, suggesting that at least for these species, trade and use may not currently be contributing to an increase in extinction risk. Many of the Red List assessments used in this study were at least 10 years old, and additional work is required to consider changes that may have occurred over the past decade and results should be prudently interpreted.

To consider whether present and future trade and use of amphibians is detrimental to the long-term survival of affected species, this chapter highlights key topics to explore, describes specific challenges in the measurement and evaluation of the impacts of trade (Box 7.1 Case study from West and Central Africa) and recommends actions for the advancement of research and policy in this field of amphibian conservation science.

Amphibian trade records

Measurement of the trade in amphibians

Millions of amphibians are traded globally every year for their use as sources of meat and medicine (Onadeko, Egonmwan & Saliu, 2011; Ribas & Poonlaphdecha, 2017; Van Vliet et al., 2017) as pets, and as subjects of pharmaceutical research (Altherr & Lameter, 2020; Auliya et al., 2016; Nijman & Shepherd, 2010; Warkentin et al., 2009; *see* Boxes 7.1, 7.2 and 7.3). Although limited information about the international trade in amphibians is available, most countries either do not maintain or provide public access to records describing their domestic amphibian trade. This information gap represents a considerable hurdle preventing comprehensive

Box 7.1: Domestic trade/biological use – Case study from West and Central Africa

Background

Vertebrate anatomy and physiology courses are the reason for a large volume of amphibian trade. In West and Central Africa, the species particularly affected by laboratory studies are the northern flat-backed toad (*Sclerophrys maculata*), the common toad (*S. regularis*), the African tiger frog (*Hoplobatrachus occipitalis*), and the grass frogs (*Ptychadena* spp.). These species have a wide distribution range and broad range of habitats across Africa (Channing & Rödel, 2019; Kouamé et al., 2015). Besides being collected for dissection, amphibians have always been used as food, medicine, or for cultural reasons by some particular West and Central African tribes (Gonwouo & Rödel, 2008; Mohneke & Rödel, 2009; Mohneke, Onadeko & Rödel, 2009; Mohneke, 2011) and a current increase in collection of these animals may be escalating beyond sustainability.

Origin of the trade

The increase in exploitation of amphibians is linked to the need for protein supplements due to rapid human population growth and a simultaneous decline in other protein resources, such as fishes. In some localities in southeastern Benin and Guinea, toads are used by villagers for treating diseases like children's cough, appendicitis or skin injuries. Meanwhile, larger frog species like *Conraua* spp., *Hoplobatrachus occipitalis*, *Ptychadena* spp., *Pyxicephalus* sp. "edulis West", or *Trichobatrachus robustus* are collected for food from a wide range of West and Central African countries, such as Benin, Burkina Faso, Cameroon, Ghana, Guinea, Côte d'Ivoire, Nigeria, and Togo (Gonwouo & Rödel, 2008; Kouamé et al., 2015; Mohneke, Onadeko & Rödel, 2009; Mohneke et al., 2010; Mohneke, 2011). The known ethnic groups from West Africa, e.g. the Gourmanché and Mossi in Burkina Faso, the Hausa in Nigeria, and the Yacouba in Côte d'Ivoire, and from Central Africa, for example the Bakossi in Cameroon, traditionally use frogs as a source of protein or for medical and cultural reasons. On the Obudu plateau in Nigeria, tadpoles are intensively collected from small rivers (Mohneke, 2011). Likewise, amphibians are collected by university students for academic purposes. However, current rates of urbanisation and city development have greatly impacted local amphibian populations, which have become less abundant in recent years.

Amphibian harvest

Frog sellers generally collect the animals by hand at night using head lamps or hand torches around water ponds and microhabitats where the species are known to call. They collect any species they encounter and mostly target large adults for the ease of anatomical observations during practical sessions. Daily hunting rates range from about 40 to about 100 frogs per hunter and vary from one locality to another. Collected animals are kept in cartons and then sold on daily bases. Frog collection for food and trade is undertaken all year round with peaks in the dry season when the levels of the streams and ponds are low and collection is easier. More organised collection techniques include night searches along streams for large frogs using flashlights, machetes, spears, hooks, and nets (for detailed techniques used in hunting for trade see Gonwouo & Rödel, 2008; Mohneke, Onadeko & Rödel, 2009).

Growing harvest and trade

Since most attempts to commercially breed frogs under artificial, farm-like conditions have failed, the majority of amphibians are still taken directly from the wild. This trade provides a valuable source of revenue to local people. This practice is generally uncontrolled and likely to have an important negative impact on the natural populations of particular frog species. Similarly, every year, thousands of toads and frogs are collected in urban and suburban areas that host higher institutions of biological studies for use in laboratories. During such sessions, each student is entitled to one or two animals for practical sessions for anatomy and physiology studies. Each animal is sold for 200–250 FCFA (about 0.5 US dollars) depending on the size. As the number of students keeps on growing at universities there will be an equivalent increase in the demand of amphibians for practical work. Students enrolled in second year of biology in west and central Africa universities carry on three dissection sessions over the academic year. Assuming that all frogs and toads used during this practical work are collected from the wild, then this represents a considerable impact to the various populations where collection is done. Every year in higher institutions in Côte d'Ivoire, for example, several hundred individuals are collected by students and subsequently killed and dissected in anatomy courses. Over-collection seems to have negatively impacted local populations up to the point where the species are becoming rare to encounter in the city (Kouamé et al., 2015). The number is far higher if extrapolated across all higher institutions involved in biological studies across the continent. On the other hand, the trade of *H. occipitalis* at the different district markets of Daloa in Côte d'Ivoire is still at a local scale with batches of five adult specimens sold for 500.00 FCFA (about 1 US dollars). The demand of amphibians for dissection in biology together with local markets for food increases the pressure on wild populations in urban areas.

Potential ecological consequences

Some amphibians species may not presently be categorised as threatened species by the Red List but may become so in the near future with the escalating combined threats. The unsustainable harvest of frogs in West Africa could likely have consequences including reduced control of arthropod pest species, especially species being vectors for human diseases such as *Anopheles* mosquitoes that transmit *Plasmodium* that cause malaria (Mohneke & Rödel, 2009). Given the targeting of large adult individuals during harvests, the reproduction of these animals is likely to be affected with consequences such as population declines (Gonwouo & Rödel, 2008; Mohneke, Onadeko & Rödel, 2009). The small-scale trade has just started to develop and it's likely to continue and even increase given the growing populations. Thus far, no actions have been taken to assess the rate of collection and its impact on wild populations. Consequently, population assessment and monitoring of *Sclerophrys maculata*, *S. regularis*, *Hoplobatrachus occipitalis* and *Ptychadena* spp. in regions where they are being collected are therefore urgently needed in addition to population-specific studies on recruitment and survival rates, to determine if populations can withstand the levels of harvest being experienced

assessments of the true impact of trade and consumption on amphibians globally.

Most of the publicly accessible amphibian trade data recorded within the English language originates from the United States Fish and Wildlife Service (USFWS) Law Enforcement Management Information System (LEMIS). The LEMIS data are made available through a Freedom of Information Act Request (FOIA) and represent the most comprehensive wildlife trade data for all amphibian species traded internationally by the USA. Although the USFWS LEMIS database provides detailed information about amphibians that were either imported or exported from the United States, it does not include data on domestic trade.

According to these LEMIS data, 769 individually recorded species of amphibians have been traded by the USA between 2000 and 2014, although the actual number might be lower since this includes an unknown quantity of taxonomic synonyms as well as taxonomic names that are no longer presently recognised as valid (Eskew et al., 2020), although it might alternatively be higher since USFWS sometimes recorded amphibian trade only at the genus level or higher, without including species information. The information maintained in this database is unique compared to the trade records collected by most other countries where only the trade in CITES-listed species is uniformly maintained and all non-CITES species are excluded from recordkeeping. Therefore, patterns of international trade in hundreds of non-protected amphibian species from around the world are only available through government records of importation to the USA, maintained in the LEMIS database. It is, however, important to note that the inclusion of other languages results in a linear increase in cases of amphibian trade (Hughes, Marshall & Strine, 2021), and while Hughes, Marshall and Strine (2021) detected 1,215 amphibian species in trade, including 575 species only found available online, additional hundreds can be found with the inclusion of two more languages in search queries: Korean and Portuguese (Koo et al., 2020; Máximo et al., 2021).

The amount of domestic harvest and use of amphibians, as well as the volume of international trade in non-CITES listed species, represent significant knowledge gaps in many parts of the world. The latter especially deserves greater effort to measure and record, because the level of international exploitation is a required piece of information for inclusion in proposals to list additional species in the CITES Appendices (https://cites.org/eng/disc/species.php). If such proposals become adopted, then standardised recordkeeping and reporting becomes a required component of legal international trade activity. At present (September 2021), only 201 of the more than 8,000 described amphibian species are CITES-listed, with a disproportionate number of species categorised as Data Deficient by the Red List. Further, many species' Red List assessments are almost or already outdated and specific data on trade in these assessments generally remains scarce. Beyond the simple lack of information, Data Deficient species are of additional concern because they are likely to be under higher risk of extinction compared to species with sufficient information on the Red List (Howard & Bickford, 2014). The volumes of global trade in all CITES-listed amphibian species can be publicly accessed from the CITES Trade Database (https://trade.cites.org/). Unfortunately, due to the aforementioned limitations, it is presently largely unknown precisely how many of the world's 8,000+ amphibian species have appeared in international trade, beyond the 201 reported to the CITES Secretariat, the few hundred non-CITES listed species traded and reported by the United States (Kolby, 2016), and those informally observed and reported from domestic markets (Altherr, Freyer & Lameter, 2020). Unlike the international trade records submitted to the CITES Secretariat, no centralised database exists to capture data that might be collected by governments describing domestic trade. Another aspect rarely considered are the mortality rates that occur from the harvest point to the exporters' premises and how this may silently impact traded species, even if transactions of live animals are recorded. A considerable research effort is therefore presently needed to integrate all sources of existing data to provide a comprehensive global snapshot of the trade in both CITES and non-CITES listed amphibians. This effort should not be restricted to the scientific research community, but should be a joint effort with regional and national governments, as well as other regional, national and international legislative agencies that can provide public access to databases of trade records.

Accuracy of species identification among trade records

The precision and accuracy of wildlife trade records varies considerably, both within and between different sources of information. In some circumstances, this is due to established institutional procedures whereby amphibian trade data are recorded at higher levels of classification, such as by genus or class, rather than by species. For example, customs border control officers often record shipments as "amphibians" or "frog legs" without any species information attached to these data. Amphibian trade records maintained by the USFWS LEMIS database contains potentially the most species-specific records accessible in English, and yet still includes many records described as "Non-CITES Amphibians" or with only the name of the genus. Therefore, the international trade in most amphibians that are not specifically protected or regulated is much less accurately and uniformly documented and is consequently difficult to objectively characterise.

Another caveat to the interpretation and application of wildlife trade records for conservation purposes is the variable level of scientific accuracy expressed by law enforcement officers recording these data, both with respect to taxonomical precision and visual identification. For instance, in the United States, a Declaration for Importation or Exportation of Fish or Wildlife (Form 3–177) must be presented to a USFWS Wildlife Inspector in order for the shipment to be granted clearance and allowed to enter commerce. Sometimes, these decisions are made based on document inspections without physically inspecting the animals themselves, and the actual species traded might differ from those named on the documents provided by the traders. Thus, for shipments which are not physically inspected, these misidentifications can then become the accepted records of trade. Other times, wildlife trade enforcement officers might perform physical inspections but misidentify the species present. With 8,000+ described species of amphibians, and only 201 which presently require CITES permits for legal international trade to occur, there is little global incentive to train wildlife officers to identify the thousands of amphibian species which can potentially be traded without special permits. Therefore, law enforcement officers may sometimes misidentify unprotected species because their priority is instead to ensure permits are present, when required. Additional identification and monitoring challenges arise when amphibians are traded in the form of skinless frog legs and the species traded may not be those listed on the export documents. This has been demonstrated in Indonesia where shipments of frog legs documented to included *Limnonectes macrodon*, *Fejervarya cancrivora*, *F. limnocharis*, and *Lithobates catesbeiana*, were genetically sampled and proved only to contain *F. cancrivora* (Kusrini, 2005; Veith et al., 2000).

Without the ability to retrospectively spot-check the accuracy of amphibian trade records against what was physically traded, it is not currently possible to evaluate whether errors in species identification are commonplace or infrequent among these data. Irrespective of the frequency, any amount of species misidentification among official government wildlife trade records can have significant negative repercussions on the development of effective conservation policies aimed to reduce the threat of trade. For example, in 2019, a CITES listing proposal to include the genus *Paramesotriton* in CITES Appendix II (https://cites.org/eng/disc/species.php), stated that, "According to the LEMIS Database of the U.S. Fish & Wildlife Service, imports to the U.S.A. have involved a total of 38,273 individuals of *Paramesotriton* spp. between 2000 and 2016…" (CITES CoP18 Prop. 40). A closer examination of a subset of these same LEMIS records (trade from 2006–2010) showed that 233,924 individuals of *Paramesotriton* newts had been imported to the USA in just one third of the aforementioned time span (Kolby et al., 2014). It was discovered that this discrepancy occurred in part because USFWS had recorded

Box 7.2: Domestic trade/biological use – Case study from Nepal

Amphibians, and especially frogs, are the only group of multipurpose vertebrates in Nepal that are conjectured as permissible commodities for exploitation unaffected by the law. Their utilities expand much broader, as species particularly found in the hills and mountains across the country are highly regarded for their food value, therapeutic benefit, cultural belief, and customary ritual embedded in various ethnic groups (Rai, 2003; Shah & Tiwari, 2004). Some lowland frogs also fit in this category but a larger share in this region is captured and sold to high schools of Nepal offering science programmes (Rai, 2014; Sah & Subba, 2012; Suwal et al., 2011). The formalin-preserved specimens are eventually used in teaching concepts of vertebrate anatomy to students through dissection curriculums in biology labs. Since the demand for such utility is entirely met from wild populations, this unregulated harvest poses serious threats to the survival of these frogs.

Amphibian harvest (Ethno-batrachology)

Nepal is a melting pot of various ethnic cultures and beliefs that are often shaped by human-environment interactions since bygone days. The majority of the ethnic communities in rural areas largely depend on natural resources and have championed ways to live in harmony with nature through the generation and transfer of rich traditional knowledge. They revere, protect and utilise all forms of natural resource (as food and medicine), including frogs vernacularly known as 'paha'. It is, however, an umbrella term that represents entire species used for subsistence living in different ecological belts of Nepal, particularly freshwater bodies; rivers, streams, waterfall, lake, pond, spring, irrigation canal, and wetland. The origin of paha terminology could be traced to its use by Tamang people in Nepal to denote Liebig's paa frog and related species (Dubois, 1975; Dubois, 1992). Today, the use of paha has been documented by at least 12 ethnic groups both in the low and high land regions (Lohani, 2010; Lohani, 2011; Lohani & Bharyang, 2011; Rai, 2003; Rai & Singh, 2015; Shah, 2001; Shah & Tiwari, 2004; Shrestha & Gurung, 2019; Shrestha, Pandey & Gautam, 2019). The harvest for sustenance, recreational eating, and presumed health benefits concentrates generally on fork-tongued frogs of the family Dicroglossidae, such as the genera *Paa*, *Ombrana*, and *Hoplobatrachus* (Kastle, Rai & Schleich, 2013; Shah & Tiwari, 2004). Among them, large-bodied species like Liebig's paa frog (*Paa liebigii*) are pervasively popular due to their wide distribution in the hills and high-mountains (below snowline) throughout Nepal, whereas bullfrogs (*Hoplobatrachus tigerinus* and *H. crassus*) are on the radar for lowland to small-hill communities. Because both these species take the lion's share in their multipurpose utility, they have been massively harvested across Nepal – a culture (practice) that is pervasive in villages. The rest of the frogs under Dicroglossidae can be quite specific to their purpose, for example, Sikkim Asian frog (*Ombrana sikimensis*) constitutes for food (Shrestha & Gurung, 2019). Some small-bodied species like Blanford's paa frog (*Paa blanfordii*) Polunin's paa frog (*Paa polunini*), Rostand's paa frog (*Paa rostandi*), qualify for both food and curative uses, only in absence of *P. liebigii* (Rai, 2003). Another group of frogs from the family Ranidae, especially cascade frogs of the genus *Amolops*, such as Assam cascade frog (*Amolops formosus*), marbled cascade frog (*Amolops* cf. *marmoratus*), and mountain cascade frog (*Amolops monticola*) is also harvested for subsistence over the hills of Nepal (Rai, 2003; Shah & Tiwari, 2004). Species of the genus *Xenophrys* are sometimes used for their therapeutic properties as well (Shah & Tiwari, 2004).

Harvest for subsistence and collection strategy

Those used for traditional medicines, the meat is mixed with herbs to treat several minor ailments and diseases like dysentery, diarrhoea, cough, cold, stomach ache, headache, urine problems, asthma, fever, measles, pneumonia, tuberculosis, typhoid, etc. (Rai, 2003; Shah, 2001; Shah & Tiwari, 2004; Shrestha & Gurung, 2019). Besides meat, eggs, skin secretion, and excreta are also used to heal open wounds, cuts, burns, typhoid, and rheumatism. Some communities believe that dried paha eggs cure impotency. Meat is an excellent source of nutrition for malnourished children, people recovering from illnesses, pregnant women, and nursing mothers. For aforementioned meat-related usages, paha are skinned, eviscerated, and then used either raw for meat or preserved (as smoked) for the future. Hunting paha is rampant in villages, especially that of hills and mountains where different age-group people are involved. There is no harvest limit set or monitored and one may collect almost everything during their search effort. The collection is also year-round employing specific strategies except for the winter season. Such unchecked harvest spells grave danger to the population of paha frogs. Based on the local practice, paha are collected from streams in different ways; at night when frogs come out of hiding, the collectors keep bamboo flambeau – its light blinding frog's vision temporarily, later followed by handpicking. Some divert the river water into smaller channels and place bamboo traps on the end while some are involved in daytime hunting by flipping big rocks and handpicking. In recent days, paha collection is usually aimed for recreational purposes, especially recreational eating as their meat is relished and available free compared to poultry and livestock. Some forms of trade exist in villages with goods and money, somewhere in the range of US$ 0.45–2.26 per frog (Shrestha & Gurung, 2019).

Mass harvest for dissection

Four species from the Dicroglossidae family, tiger frog (*H. tigerinus*), Jerdon's bullfrog (*H. crassus*), Terai cricket frog (*Minervarya teraiensis*), and skittering frog (*Euphlyctis* cf. *cyanophlyctis*) make up most of the animals collected for the dissection classes. There is fragmentary evidence of quantification regarding mass harvest all across Nepal, some data are primarily region-specific (Rai, 2014; Sah & Subba, 2012; Suwal et al., 2011). Each student requires an average of 2-6 frogs for dissection so the quantities technically exceed the total number of students studying biology every academic year. In 2001, around 47,000 frog specimens were used for dissection across educational institutes in the eastern region of Terai and some in Kathmandu, Nepal (Rai, 2014). For the 2010/11 academic year, a range of 52,151–102,405 frogs were dissected across high schools, mostly from Kathmandu and lowland Terai regions (Suwal et al., 2011). Between 2010-2012, almost 14,000 bullfrogs (*H. tigerinus*) were dissected by Grade XI students across high schools in Biratnagar, eastern lowland Nepal (Sah & Subba, 2012). During the same period, harvesters also collected frogs for consumption which was estimated at a minimum of a thousand individuals per night. The authors posit that such haphazard collection may have pushed the local population on a declining trend as the capture quantities became less abundant within the same collection locality in just two years. It can be assumed that in absence of regulatory mechanisms, Nepal may face a similar fate in near future as of India and Bangladesh, where the population of overly harvested species saw a major decline, if the impact of such trade remains overlooked. Since India banned exporting frogs to Nepal for dissection, all used specimens are wild-caught frogs from Nepal. The supply chain for dissection constitutes local collectors, based in Terai, who supply the frogs either to biological enterprises (who then sell it to the colleges) or directly to high schools (colleges). An individual specimen may cost somewhere between NPR 20-100 (US$ 0.18–0.90) based on the nature of the supply chain.

Probable ecological impacts of uncontrolled harvest

Many adult amphibians whose elevational range extends in the high-altitude region share several life-history traits such as body size, clutch size, and longevity (Zhang & Lu, 2012). Those living in high-altitude (> 2,500 m) compared to lowland relatives have a stunted developmental growth rate (low metabolism) throughout metamorphosis. They gain sexual maturity at older ages, thus have brief breeding seasons, rendering lesser spawning frequency with larger eggs (Morrison & Hero, 2003). The unchecked harvest for some species in line with their intraspecific differences may be detrimental to the overall population, including for example, *P. liebigii* (1,500–3,360 m), *P. polunini* (2,600-3,400 m), *P. rostandi* (2,400–3,500 m), *A. formosus* (1,190–2,896 m), *A.* cf. *marmoratus* (840-2,896 m), and *O. sikimensis* (1,210–2,500 m; Shah & Tiwari, 2004).

Because of the mass harvest for trade, frog populations in India collapsed for two species, *Euphlyctis hexadactylus* and *H. tigerinus* in 1985, compelling the authorities to list them in Appendix II of CITES (Abdulali, 1985; Altherr et al., 2011). Nepal is also a range country for *H. tigerinus* and despite the country not having international trade of frogs some forms of domestic trade exist, particularly for dissection purposes. Nepal doesn't have frog farming practices, thus all the frogs captured for human use are wild-caught. This, however, by no means advocates for introducing the concept of frog farms in the country. It is because such farms are prone to failures both ecologically and economically (Gratwicke et al., 2009; Kusrini, 2005; Schloegel et al., 2009).

Frogs are carnivorous and usually feed on insects, keeping their populations in balance. Some lowland frogs (genera *Hoplobatrachus*, *Limnonectes*, and *Euphlyctis*) have been found extremely helpful to the farmers by acting as pest control agents in the rice fields and controlling populations of harmful insects like houseflies and mosquitoes that affect human health (Khatiwada et al., 2016). In the hilly regions, *Amolops formosus* also consumes insects that are harmful to agriculturally important plants and human health. If frogs become less abundant, farmlands will see explosive growth in insect population and pesticide-use. Before they face rapid decline due to overharvesting, it is thus urgent to manage frog populations by gaining legal measures in a modality of participatory resource management. This may include but is not limited to banning destructive collection practice that harms the species and habitat, enacting open/closed harvest seasons, introducing catch limits, and imposing fines. Subsistence harvest should be monitored and allowed, without jeopardising the ability of the local population to continue their next generation. Dissecting real frogs has become obsolete in many countries, Nepal should also revamp the biology curriculum replacing real dissection with virtual programmes such as Froguts which is freely available and comprehensive (https://thesciencebank.org/pages/froguts). The existing information of species biology, niche, population ecology, and harvest rates must also be enhanced to investigate the dynamics of harvest, eventually to develop guidelines (policy) for sustainable harvesting, if needed.

216,054 animals as *Triturus hongkongensis*, used as an invalid synonym for *Paramesotriton hongkongensis*, of which only 17,870 had been accurately recorded as the latter. Additionally, two shipments which were imported in 2012 and recorded in LEMIS as *Paramesotriton hongkongensis* had been incorrectly identified by the importers and accepted by USFWS, and were instead newts of the genus *Pachytriton* (J. Kolby, personal communication). The two aforementioned shipments each contained 1,600 individuals, and it is unknown how many more of the thousands of animals imported into the USA as *Paramesotriton hongkongensis* have similarly been recorded with incorrect species identifications. Although the CoP18 CITES listing proposal for inclusion of *Paramesotriton* spp. in CITES Appendix II was successfully adopted despite the erroneously low trade data estimate (https://cites.org/eng/disc/species.php), it is plausible that similar misidentifications among wildlife trade records could have negative consequences for at-risk species in need of increased protection and regulation.

Amphibian trade data accessibility and biased communication of impacts

In addition to legal amphibian harvest and trade, which is sometimes but not implicitly sustainable, a large portion of amphibians are also harvested and traded illegally both domestically and across international borders. The illegal international trade in wildlife is often considered sensitive information by law enforcement agencies, and even for CITES-listed species, these data are infrequently openly shared. Only recently, Parties to CITES have been requested by the CITES Secretariat to begin submitting reports of illegal wildlife trade, but unlike the reports of legal trade that are made publicly available, these illegal trade reports are not. Therefore, most of the publicly available government data describing the nature of global amphibian trade are restricted to records that describe primarily legal trade in CITES-listed species. Outside of the CITES framework, amphibian trade monitoring is equally deficient and the data available from organisations such as the World Customs Organization cannot be used adequately (Chan et al., 2015). Despite requests for improvements at the IUCN's 5th World Conservation Congress (WCC-2012-Res-020) in 2012, the changes are so far not implemented.

As with most issues involving multiple countries and regions, identification of data collected on amphibian trade is sometimes limited by language barriers. Official documents from government and non-government agencies are recorded using the respective language of a given country. Consequently, most of the primary literature and secondary syntheses visible to the international scientific community are restricted by the data and information researchers are able to not only access but also comprehend. As such, the apparent lack of data from certain regions may instead be an artifact of the presence of language barriers. For example, Altherr, Freyer and Lameter (2020) provided a report describing surveys of reptiles and amphibians offered for sale online and at exotic pet markets in Germany, published in German, which English-based data queries would fail to locate. It is also true that some countries don't gather this information or there is no system where all these data can be gathered.

When discussing harvest and consumption, there is a history and tendency to place the emphasis, and in essence the blame, on resource management within export countries. This prevalent but problematic view ignores the socioeconomic inequalities that are at least partially responsible for driving amphibian trade and harvesting. Aside from the biases it creates in the literature, failure to address the inequalities in trade can impede efforts to prevent further exploitation of amphibians. Major frogs' legs importing countries, for instance, are generally high-income countries, such as France, United States, Belgium, and Luxembourg (United Nations' Commodity Trade Statistics Database, United Nations Statistic Division, 2008; Warkentin et al., 2009). However, despite being one of the leading amphibian importers, policies and regulations in the EU are often insufficient to prevent overharvesting in export countries (Auliya et al., 2016). Even within regional markets, consumerism is largely driven by higher income countries such as Singapore and Hong Kong (Kusrini & Alford, 2006). While improving local and regional policies are fundamental to regulating amphibian trade, greater consumer responsibility and an investment in addressing this

Box 7.3: Domestic and international trade/medicinal and tourist use – Case study from Bolivia

Background

Bolivia holds more than 270 species of amphibians and in general, with the exception of a couple of species (*Telmatobius culeus* and *Rhinella spinulosa*), amphibians are not used for any purpose and are not seen as a protein source, although there are isolated reports of food source use in the lowlands. One of the two species used is the Titicaca water frog (*Telmatobius culeus*), consumed as a protein source in surrounding towns of Lake Titicaca and some Peruvian and Bolivian cities. Domestic pet trade is not officially reported in Bolivia, but there are informal reports of native species such as *Boana riojana, Boana geographica* and *Phyllomedusa camba,* offered together with non-native species such as albino clawed frogs (*Xenopus* spp.) and axolotl (*Ambystoma* spp.), being sold in pet markets in two main cities (La Paz and Cochabamba). There are no official reports of Bolivian species in the international pet trade, but there are Bolivian species in European pet shops. Local markets sell mainly high Andean amphibians such as ***Rhinella spinulosa,*** *Pleurodema cinereum* and *Telmatobius* spp. for traditional use, where different products and animals (including amphibians) are offered to Pachamama or Mother Earth. Previously, it was common to find hundreds of dissected frogs and toads with money in their mouths as a symbol of prosperity in local markets.

The Titicaca water frog and frog "juice"

The Titicaca water frog is an iconic amphibian species. Listed as Endangered on the Red List (IUCN, 2020), as Critically Endangered in the Bolivian Red Book of Vertebrates (Ministerio de Medio Ambiente y Agua, 2009), and listed in Appendix I of CITES, it is endemic to Titicaca Lake and smaller surrounding lakes of Bolivia and Peru, where it is offered in different markets. Previously (early 1900s), *T. culeus* did not appear to be used for human consumption; at this time Allen (1922) reported that despite being a potential good source of protein, frogs were not used by local communities. There is evidence that traditional use of the frog by local communities for rituals in Puno, Peru, continues (Elías et al., 2019). Nowadays frogs are intensively harvested for human consumption, where in some cases between 2,000 and 4,500 individuals are reportedly illegally traded and confiscated, especially in Peru. In the 1970s and 1980s local communities were consuming the species, mainly in soup form. At the same time, they were actively harvesting large individuals to sell them as frog legs in local restaurants and restaurants in La Paz. In the last decade there has been an increasing demand for Peruvian and Bolivian markets, where the frog is used together with other ingredients for frog "juices", offered as a nutritional booster and presumed to have medicinal properties or potions presumed to improve the energy and sexual condition of consumers. Thousands of frogs are actively collected every month to be sold in markets; they are transported to Cuzco, Lima and other main cities in Peru, and La Paz, El Alto, Oruro and Cochabamba in Bolivia. These juices are even offered as part of tourist packages.

Other reports indicate that, in several towns on the Bolivian side of the lake, buyers come to buy hundreds of frogs per week from local fishermen, destined to go to Peru. Around 15,000 individuals were confiscated in 2006, and in 2011 visitors from Asia stopped in several towns around the lake seeking to buy large live individuals, destined either for domestic use or international trade.

Legal instruments for Titicaca water frog conservation

There are different legal instruments in Bolivia to protect species like the Titicaca water frog, such as Environmental Law No. 1333, which establishes the obligation to carry out the sustainable use of authorised species; the General and Indefinite Ban No. 25458, that prohibits any use of Bolivian fauna; Resolution No. 309 of December 2006 issued by the National Competent Environmental Authority, which presents the technical standard with Guidelines for Wildlife Management Plans; and finally resolution No. 024 of 2009 issued by the National Competent Environmental Authority, which regulates scientific research on biological diversity in Bolivia. In Peru, the Titicaca water frog is listed as Critically Endangered by Supreme Decree Nº 004-2014-MINAGRI, where all commercial activity is banned for this and other species listed in the decree. Internationally, the species was adopted into Appendix I of CITES in 2017, which prohibits commercial international trade.

Despite these legal instruments, the illegal use or domestic trade of this Endangered species continues. Also, the international trade between Peru and Bolivia in violation of CITES provisions is still very active, with insufficient law enforcement. Regarding trade to other countries, there have been confiscations of individuals of this species in Ecuador and until recently, it was still possible to find websites listing the species for sale in Europe. Due to the unique characteristics of this frog and interest in this species by the pet trade, stronger global monitoring and law enforcement responses are needed to better protect it from illegal trade, as is normally afforded to larger charismatic megafauna such as jaguar.

issue by high-income, import countries is a key step that needs to be taken. A simple parallel can be seen in the shift in public consciousness from putting the burden of addressing deforestation on the export countries to acknowledging the role import countries play in driving the market and demand.

Sustainable amphibian trade

What is sustainable amphibian trade?

Efforts to assess sustainability of domestic and international use and trade in amphibians should

Table 7.1: Generalised types of use and primary sources of supply and demand of the global amphibian trade

Type of use	Primary origin of supply	Primary market driving demand	Source (CITES)	Notes
Human consumption for food (subsistence, local consumption markets)	Africa, Asia, South America	Africa, Asia, South America	W, C	
Human consumption for food (exotic gastronomy, global consumption markets)	Asia	North America, Europe	W, C	Bullfrogs constitute a notable case as they are traded globally but also imported into the US (where they are native)
Medicinal use	Africa, Asia, South America	Africa, Asia, South America	W, C, O	
Pet trade	Central and South America, Asia	Mostly North America, Europe	W, C, F, R, O	
Cultural use	Africa, Asia, Americas	Africa, Asia, Americas	W, C	
Educational use	Africa, Asia, Americas	Africa, Asia, Americas	W, C, F, O	
Zoological use	North America, Europe	North America, Europe	W, C, F, R	

See Table 7.2 for source codes

be founded upon a common understanding of the term "sustainable", to provide objective context for its use (Table 7.1). According to the Convention on Biological Diversity (CBD) from 1993, "Sustainable use" means "the use of components of biological diversity in a way and at a rate that does not lead to the long-term decline of biological diversity, thereby maintaining its potential to meet the needs and aspirations of present and future generations" (https://www.cbd.int/doc/legal/cbd-en.pdf, accessed 10 May 2021). This CBD definition is also the working definition adopted by the Parties to CITES (CITES Resolution Conf. 13.2 Rev. CoP14; https://cites.org/sites/default/files/document/E-Res-13-02-R14.pdf). In this chapter, we similarly apply the term "sustainable" to describe use and trade activities that do not reduce wild populations of amphibians to levels likely to threaten their survival. Additionally, we define unsustainable amphibian trade to include any illegal trade activity, because the illegal trade in wildlife inherently undermines any nations' rules and regulations enacted to protect affected species from overexploitation. Published examples of sustainable amphibian trade are rare (but see efforts by Kusrini (2005) to evaluate sustainability of the frog legs trade in Indonesia). Moreover, extinction risks associated with the trade of wild caught specimens is increasing (Hughes, Marshall & Strine, 2021), a trend that is likely to persist until additional regulations are implemented where appropriate (Borzée et al., 2021).

Trade in wild-collected amphibians reported as bred in captivity

The trade in animals bred in captivity is often considered to exert reduced or negligible negative impacts on wildlife populations in their native environments compared to the trade in wild-collected animals. For this reason, the trade in wildlife produced in captivity is generally allowed to occur with fewer governmental restrictions in many countries. Particularly with respect to CITES-listed species, many countries that prohibit commercial exportation of wild-collected specimens allow for the regulated export of animals produced in captivity. Unfortunately, systems of relaxed provisions are sometimes exploited and there is growing evidence of illegal trade in wild-caught specimens of CITES-listed species traded with fraudulent documentation, particularly using incorrect source codes. The CITES source codes that are commonly used to describe the origin of a traded animal include W (wild: specimens taken from the wild), C (bred in captivity: Animals bred in captivity in accordance with CITES Resolution Conf. 10.16 (Rev.); https://cites.org/sites/default/files/document/E-Res-13-02-R14.pdf), F (born in captivity: animals born in captivity (F1 or subsequent generations) that do not fulfil the definition of 'bred in captivity' in Resolution Conf. 10.16 (Rev.)), and R (ranched: specimens of animals reared in a controlled environment, taken as eggs or juveniles from the wild, where they would otherwise have had a lower probability of surviving to adulthood; Table 7.2). To investigate and respond to this concern, in 2016 the Parties to CITES adopted Resolution Conf. 17.7 (Rev. CoP18) *Review of trade in animal specimens reported as produced in captivity* which stated that, "…the incorrect application of source codes and/or misuse or false declaration of source codes can reduce or negate such benefits where they exist, have negative implications for conservation and undermine the purpose and effective implementation of the Convention".

This Resolution established a process of review, dialogue, and evaluation to improve the capacity of CITES Parties to determine whether animals genuinely originated from the declared source or production system and to ascertain the legal origin of parental

Table 7.2: Definitions of commonly used CITES source codes for traded amphibians

Source Code	Code Name	Code Definition
W	Specimens taken from the wild	Specimens taken from the wild.
C	Animals born in captivity	Animals bred in captivity in accordance with Resolution Conf. 10.16 (Rev.), as well as parts and derivatives thereof, exported under the provisions of Article VII, paragraph 5, of the Convention.
F	Animals bred in captivity that do not qualify for a "C" code	Animals born in captivity (F1 or subsequent generations) that do not fulfil the definition of 'bred in captivity' in Resolution Conf. 10.16 (Rev.), as well as parts and derivatives thereof.
R	Ranched specimens	Specimens of animals reared in a controlled environment, taken as eggs or juveniles from the wild, where they would otherwise have had a very low probability of surviving to adulthood
O	Pre-convention	Specimens of animals acquired before the Convention applied to them

Source: CITES Trade Database – User guide, version 8. Available at https://trade.cites.org/cites_trade_guidelines/en-CITES_Trade_Database_Guide.pdf stock of captive bred specimens, especially those that may have been sourced outside their native ranges. This review process occurs in multiple stages and is meant to complete one full cycle every 2-3 years, bookended by the start of each CITES Convention of the Parties. At present (September 2021), this cycle has occurred only once, and the start of the second cycle, beginning with the selection of new species/country combinations for review, is now postponed until after CITES CoP19 due to delays caused by the COVID19 pandemic (CITES AC31 Doc. 19.1; https://cites.org/sites/default/files/eng/com/ac/31/Docs/E-AC31-19-01.pdf). In the first iteration of this review process, two countries and two amphibian species were included for consideration: Panama for the strawberry poison frog (*Oophaga pumilio*) and Nicaragua for both the strawberry poison frog (*O. pumilio*) and the red-eyed tree frog (*Agalychnis callidryas*). Both countries were sent a list of questions by the CITES Secretariat requesting information including the scientific basis by which these countries determined their exports were non-detrimental to these species, descriptions of the production methods by which they were producing frogs in captivity, wildlife trade and management methods, and additional details. The CITES Animals Committee then reviewed the responses received (*see* AC30 Doc. 13.1 A2 (Rev. 3); https://cites.org/sites/default/files/eng/com/ac/30/E-AC30-13-01-A2-R3.pdf) and determined that the trade in specimens of *A. callidryas* by Nicaragua reported as bred in captivity was in compliance with Article III and Article IV of the CITES Convention, as well as Article VII, paragraphs 4 and 5, meaning that their use of source code "C" was found to satisfy all requirements. In September 2018, in accordance with paragraph 2 g) of the Resolution, this species-country combination was excluded from further review (CITES AC31 Doc. 19.1).

Meanwhile, the trade in *O. pumilio* remained in review for both countries and the CITES Animals Committee recommended that by 1 February 2019, both Panama and Nicaragua should confirm that they would export specimens from facilities breeding this species only using the source code "W" or "F" and stop using the source code "C", and will also make legal acquisition and non-detriment findings prior to authorising export (CITES SC70 Doc.31.3). At CITES Standing Committee 71 in August 2019, it was reported that Nicaragua confirmed it would implement this recommendation, but no response was received from Panama (CITES SC71 Doc. 13). The Standing Committee then requested that the CITES Secretariat publish an interim zero export quota for specimens of *O. pumilio* from Panama in the absence of their response (CITES AC31 Doc. 19.1). Panama did subsequently respond to the CITES Secretariat, but at present (September 2021), the content and evaluation of this response has not yet been made publicly available in either the CITES Animals Committee or Standing Committee documents posted on the CITES website and this issue does not yet appear to be resolved.

Spread of diseases by the amphibian trade

Highly pathogenic amphibian pathogens

The national and international trade in amphibians is the greatest contemporary source of global spread of amphibian pathogens (Kolby, 2016; Nguyen et al., 2017; O'Hanlon et al., 2018). The most devastating amphibian pathogens with respect to the number of species impacted and propensity to cause mass mortality are the two species of amphibian chytrid fungus (*Batrachochytrium dendrobatidis* and *B. salamandrivorans*) and ranaviruses. It has been estimated that approximately 500 species have already been negatively affected by chytridiomycosis, the disease caused by infection with chytrid fungus, and nearly 100 species may already be extinct due to this pathogen, in connection with other threats (Scheele et al., 2019).

Despite a growing body of scientific literature showing that the trade in amphibians is spreading deadly pathogens (Kolby et al., 2014; Kolby et al., 2015; Kolby, 2016; Nguyen et al., 2017; O'Hanlon et al., 2018; Schloegel et al., 2009; Schloegel et al., 2012), most governments have implemented relatively minimal biosecurity actions, if any at all. Novel regional strains of *B. dendrobatidis* with high virulence and the propensity to cause increased declines and extinctions if they spread continue to be identified (Schloegel et al., 2012), but there seems to be a general perception that since it's already been detected in dozens of countries, it's already too late for any meaningful efforts to reduce the continued global spread of this pathogen. Instead, most governmental attention, particularly in North America, has been directed towards controlling the spread of salamander chytrid fungus (*B. salamandrivorans*), as it has only recently emerged in Europe following introduction from Asia, and it has not yet been detected in the Western Hemisphere (Grear et al., 2021; Martel et al., 2014).

In 2016, the United States Fish and Wildlife Service banned the importation of 201 species of salamanders by listing them as injurious species under the Lacey Act. The intention was to prevent the introduction of species likely to carry this pathogen into the USA, based on results from laboratory exposure trials on a small number of tested species (Martel et al., 2014). If a species was found to be susceptible to infection, the entire genus was then listed as injurious. The USA is the global hotspot of salamander biodiversity and thus has good reason to take every reasonable measure to prevent a biodiversity catastrophe if native wild amphibians were to become exposed to this pathogen. Still, the US chose not to take a more precautionary approach, and does not prohibit the import and trade of species within genera for which susceptibility to infection is unknown. In 2017, it was discovered that frogs can also become infected with and vector *B. salamandrivorans* (Nguyen et al., 2017), but following this announcement, USFWS has continued allowing the importation of millions of frogs each year without any increased restrictions to control the possible presence of this pathogen among anurans.

In contrast to the approach adopted by the USA, where only one-third of described salamander species have been prohibited from importation, Canada has enacted legislation which prohibits the importation of all species of salamanders based on "...the precautionary principle, and takes into consideration the limited and evolving understanding of the disease, as well as the enforcement challenges associated with identifying different salamander species at Canada's numerous ports of entry" (Government of Canada, 2017). Although initially enacted for one year pending further study, this import prohibition continues at present (September 2021).

In the European Union, in June 2016, the Scientific Working Group of the European Union decided that an import prohibition for Asian salamanders should be implemented by placing those salamanders on Annex B of the EU regulation 338/97 (Auliya et al., 2016), and Switzerland has also banned their trade in amphibians (Schmidt, 2016). Although not specifically aimed to prevent the spread of amphibian diseases, shortly following the emergence of the COVID19 pandemic, Vietnam enacted a ban on its wildlife trade, including amphibians, and the Republic of Korea now also prohibits the importation of non-native amphibians (Borzée et al., 2021).

Zoonotic pathogens carried by amphibians

In addition to pathogens that cause harm to amphibians, some pathogens transported through handling and consuming these animals can also cause disease in humans. For example, *Spirometra erinaceieuropaei*, a highly pathogenic tapeworm parasite responsible for the human disease sparganosis, was detected in 9.8% of frogs sampled from food markets in Guangdong, China (Wang et al., 2018). Research in Thailand found that 90% of amphibians sampled from frog farms were infected with *Salmonella*, demonstrating how the trade in frogs for food can serve as a pathway of *Salmonella* dispersal and exposure (Ribas & Poonlaphdecha, 2017). Additionally, frogs sampled from the pet trade in Japan have recently been discovered to carry *Veronaea botryosa*, a pathogenic fungus that caused lethal chromomycosis in many of the affected amphibians (Hosoya et al., 2015). Previously, humans were the only animal known to be susceptible to this pathogen. Sampling of confiscated frogs in Peru designated for human consumption showed a predominance of *Aeromonas* spp. and *Vibrio* spp. on Lake Titicaca frogs (Edery et al., 2021). As millions of farmed frogs are internationally traded as a source of protein for humans (Altherr, Goyenechea & Schubert, 2011; Warkentin et al., 2009;), it is possible that the trade in amphibians for food may spread zoonotic pathogens more commonly than presently recognised. Major importing nations of live wildlife, such as the USA, do not sample amphibians for pathogens upon importation, and so there are few data to evaluate the frequency of zoonotic pathogen introduction through this dispersal pathway (Kolby, 2019).

Discussion

The global trade and use of amphibians are known to affect thousands of species (Hughes, Marshall & Strine, 2021), but records of amphibian trade are not often collected, maintained, or made publicly accessible for research purposes. Improved monitoring efforts are sorely needed to better understand whether additional species are threatened by local or international use and how these activities may be managed in a more sustainable fashion. The role of trade in the spread of batrachochytrids is particularly alarming because these pathogens are frequently detected among amphibians traded internationally (Kolby, 2016), and have caused more species declines and extinctions than any other disease in recorded history (Scheele et al., 2019). Despite the various uncertainties described in this chapter regarding regional and species-level amphibian population estimates, numbers of animals collected from the wild versus those bred in captivity, and how these factors relate to sustainable use, the overall trade in amphibians precautionarily appears unsustainable at the present time. This is particularly alarming due to the high frequency of disease vectors being transported without biosecurity measures to prevent pathogen transmission and the severely negative consequences of emerging infectious diseases on wild amphibians around the world today. Further research is needed to explore the feasibility of "pathogen-free" trade methods and governments should consider requiring animals to be free of chytrid, ranavirus, or other pathogens prior to allowing trade to occur. Although published case studies of species-specific sustainable amphibian trade are uncommon, this does not imply the absence of sustainable amphibian trade, as the annual legal trade in thousands of CITES Appendix-II listed amphibians occurs with governmental scientific evaluations that this trade is not detrimental to these species (https://cites.org/eng/prog/ndf/index.php). Still, it is likely that some of the 7,000+ non-CITES listed amphibian species may qualify for future listing actions as more information becomes available to evaluate. Taking into consideration the data challenges, uncertainties, and recommendations described in this chapter, efforts to better characterise the nature of amphibian trade and reduce known and potential negative impacts are urgently needed to help protect global amphibian biodiversity.

Recommended actions (in no order of priority):

- **New international legal framework for diseases**: consider the development of a new Convention based upon principles similar to those of CITES, but specifically for monitoring and regulating the spread of wildlife diseases. Although the OIE functions in a similar manner, it primarily focuses on the spread of diseases among traded domesticated/farmed animals. An agreement was signed in 2015 between CITES and the OIE to cooperate in the control of diseases spread through wildlife trade, but no concrete actions have yet been taken to reduce the spread of amphibian pathogens.

- **Surveys and monitoring**: support population assessments and monitoring of species that are collected and potentially overharvested for domestic use, including those used for food, pets, and biological purposes (e.g. dissection in university classes).

- **Research on mortality**: perform studies on mortality rates among traded amphibians in specific countries prior to export and during intercontinental trade to help estimate the quantity of amphibians that die prior to use and that may not normally be accounted for among trade data reports.

- **DNA library**: build a DNA reference library for forensic purposes that can help assist law enforcement agencies when it is suspected that shipments of amphibians have been accompanied by fraudulent documents to obscure the identity of the species or its source (e.g. wild-collected or bred in captivity).

- **Evidence-based policy**: encourage countries to establish stronger science-based policy actions to reduce the risk of *B. salamandrivorans* introduction through trade, based on recent publications showing that traded frogs also spread this pathogen, and not just salamanders. This should be particularly urged among countries where native salamanders are found.
- **Disease surveillance programme**: urge all governments of countries that trade amphibians to develop and implement a disease surveillance programme among amphibians being imported and exported. This should minimally include ranavirus and the two known amphibian chytrid fungi (*Bd* and *Bsal*).
- **Biosecurity policy**: draft biosecurity policies to effectively control the spread of amphibian diseases through international trade. Particularly consider any unrestricted trade in species such as the American bullfrog (*Lithobates catesbeiana*) and African clawed frog (*Xenopus laevis*), which are known reservoir host species of amphibian chytrid fungus and ranavirus and traded in high quantities and densities.
- **Record-keeping of non-CITES species:** issue a formal call for countries to begin recording their domestic and international trades in non-CITES listed amphibians, in any language (not restricted to English), and make these data available for scientific review upon request.
- **Reporting of non-CITES species**: encourage governments, NGOs, and academics to report to the IUCN SSC ASG Secretariat whether they have recorded in any language (not restricted to English), domestic and/or international amphibian trade data for non-CITES listed species. If available, these data should contribute towards future studies to better estimate threats to these species and help in the development of improved management plans to ensure amphibian trade sustainability, as appropriate.
- **Identification of social drivers**: examine the socioeconomic inequalities that are driving amphibian exports and establish a dialogue on how policies can be improved on both the import and export sides of the trade.
- **Livelihood alternatives**: explore livelihood alternatives to amphibian consumption and their potential impacts on wild populations.
- **Identification of locally traded species**: identify species in trade in local markets and develop an identification guide for these species to help build awareness.
- **Capacity-building**: build capacity to conduct surveys in local markets and support subsequent analysis of data.
- **Database development**: develop infrastructure for local or regional databases to track the dynamics of domestic amphibian harvesting and trade and allow for improved traceability.
- **Augment Red List data**: investigate sources of information used by Red List amphibian subject matter experts to populate the “Use and Trade Information” section of the amphibian Red List assessments to explore sources of trade and use data for species not present among the CITES Trade Database or the USFWS LEMIS database.

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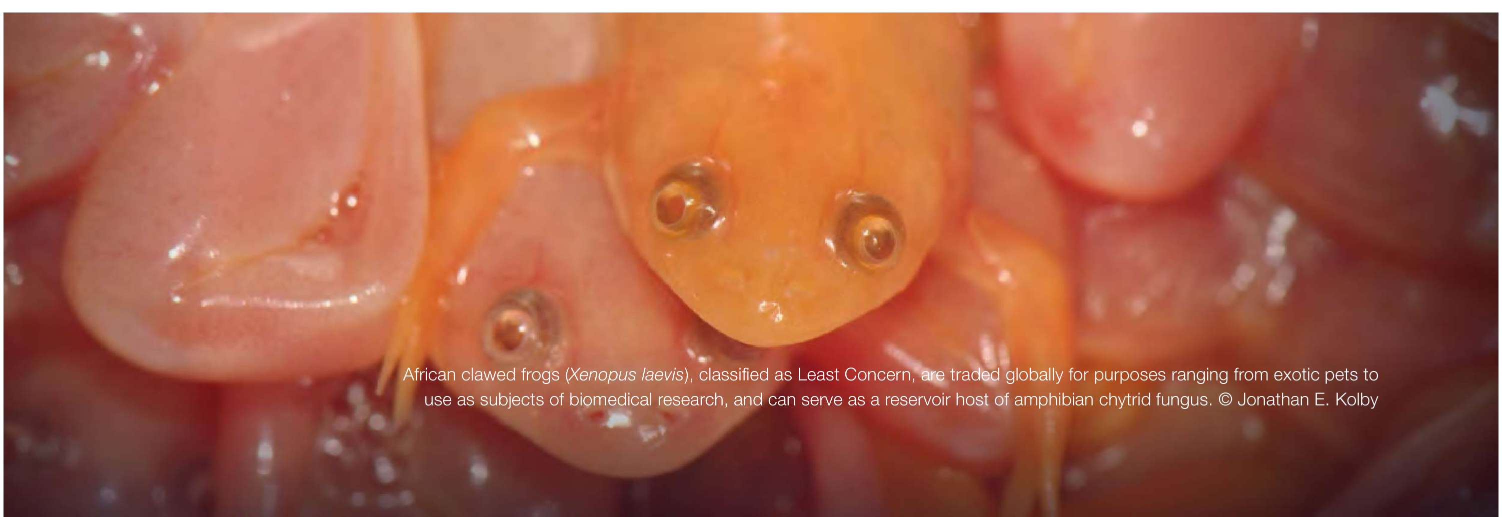

African clawed frogs (*Xenopus laevis*), classified as Least Concern, are traded globally for purposes ranging from exotic pets to use as subjects of biomedical research, and can serve as a reservoir host of amphibian chytrid fungus. © Jonathan E. Kolby