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Letter

The Amphibian Trade: Bans or Best Practice?

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In this issue, Kriger and Hero (2009) have courageously addressed the topic of amphibian trade and its potential to mediate the introduction of amphibian infectious diseases, notably *Batrachochytrium dendrobatidis* (*Bd*). As they state, amphibian trade undoubtedly has contributed, and likely continues to contribute, to the distribution of *Bd* and other amphibian parasites. Infection with *Bd* and other important amphibian pathogens has been detected in amphibians traded for food, entertainment, and research (Picco and Collins, 2008; Fisher and Garner, 2007; Jancovich et al., 2005; Parker et al., 2002) and the link between trade, nonnative amphibian species introduction, and disease emergence in wild amphibian populations has been postulated (Fisher and Garner, 2007; Weldon et al., 2004). Even when amphibian introductions are done for the most philanthropic of reasons, disease introduction can still occur (Walker et al., 2008). Certainly, there is a need to mitigate both these real and any potential infectious disease threats posed by the amphibian trade. However, the approaches proposed by Kriger and Hero seem somewhat idealistic and impossible to implement when confronted with the realities of wildlife trade.

Wildlife trade is a multibillion dollar industry involving hundreds, if not thousands, of species and dozens of nations (Broad et al., 2003). Estimates of the volume of amphibians traded are difficult to obtain; however, the United Nation's Food and Agriculture Organization estimates the world aquaculture output of frogs and other amphibians in 2005 to be nearly 85,000 tonnes, worth a third of a billion U.S. dollars (ftp://ftp.fao.org/fi/STAT/summary/default.htm#aqua; Table B1). Schlaepfer et al. (2005) found that almost 15,000,000 living, wild-caught amphibians entered the United States legally during 1998–2002, millions of which were destined for the pet trade. A review of the U.S. Law Enforcement Management Information System (LEMIS) found that more than 26,000,000 living amphibians entered the United States legally during 2000–2004, including 172 nonnative species, many of which were presumably destined for the pet trade (Jenkins et al., 2007). Numbers of live amphibians entering the United Kingdom at Heathrow airport (one of three airports through which legal imports are allowed into the U.K.) was estimated at more than 130,000 animals in a single year (Peel, 2007). More than 2,000 tonnes of live amphibians were imported into Hong Kong in a single year (Rowley et al., 2007). Dozens of species and thousands of individuals are traded in open markets in Asia (Lee et al., 2004) and are sold live over the counter in a supermarket chain in China; a chain, we might add, 50% owned by a western corporation. There is no quick fix when confronting such a volume of trade, and indeed sharp regulatory responses to questionable wildlife trade practices have historically yielded other than the desired results. Imposing restrictions and outright bans on trade has consistently driven trade underground, and some estimate the black market trade in wildlife to be second only to drugs in terms of economic value. Amphibians are already part of this underground

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market. Seizures of hundreds of CITES-listed dendrobatids (1996, Britain, 1997, Germany, 2000, Germany, Colombia, 2004, Belgium), mantellids (1997, Britain, 1998, Taiwan, Belgium) and unlisted species from other families (1997, Belgium, 1998, Taiwan, Peru, 2003, Australia) are reported by TRAFFIC (http://www.traffic.org/seizures/). These figures are undoubtedly a gross underestimation of the scale of illegal amphibian trade, because amphibians have the dubious distinction of being some of the easiest vertebrates to smuggle in large numbers. Illegally smuggled frogs are readily available at amphibian trade shows, fetching up to £500 per frog.

Kriger and Hero (2009) state that the majority of amphibians in the food trade are harvested and consumed locally, a premise that predicates their assumption that restrictions on long distance food trade will be easy to impose. This may be true for the majority of amphibian species in the food trade: in Lao PDR, amphibians may make up a third of the local aquatic animal harvest from rice fields and represent a substantial proportion of food security; in Cameroon, tadpoles of *Leptodactylodon bicolour*, *Trichobatrachus robustus*, and other species become increasingly important local sources of protein when the availability of other bushmeat is poor; in Taiwan, *Bufo bankorensis* is collected and consumed locally for food; *Leptodactylous fallax* remains the national dish of Dominica, one of only two island states that it occurs on, although it is no longer legally harvested due to the decimation of the species through the emergence of chytridiomycosis in 2002 (Halwart, 2008; http://www.globalamphibians.org; Malhotra et al., 2007). Nevertheless, the overwhelming majority of the food amphibian harvest is through aquaculture (85,000 tonnes reported in 2005 as opposed to just under 2,500 tonnes reported as collected from the wild (http://faostat.fao.org/site/629/default.aspx), and one species, the North American bullfrog (*Rana catesbeiana*) predominates this trade. The species is farmed in the United States, Mexico, Guatemala, Salvador, Panama, Ecuador, Argentina, Thailand, Indonesia, Laos, Vietnam, Malaysia, Uruguay, Taiwan PC, and mainland China (http://www.fao.org/fishery/culturedspecies/Rana_catesbeiana). Asia and the Americas are amphibian-consuming continents, but a substantial proportion of the overall production of bullfrogs for food (anywhere from 700 to 1,700 tonnes per annum) is destined for intercontinental trade (Tyler et al., 2007). Although Kriger and Hero call for the eventual phasing out of long-distance food trade of amphibians, the World Trade Organization's Agricultural Agreement seeks to reform trade in agricultural products so that policies are more, rather than less, market-orientated. In the face of current economic crises, food and fuel price instabilities and lack of credit availability, it is highly unlikely governments would dismiss any component of the food trade that brings economic benefit and some degree of food security to developing nations and poorer communities. Even in cases where trade in agricultural products carries the risk of zoonotics, bans tend to be limited both in space and time and consider the relative risk of disease transport rather than the absolute possibility of infectious disease: examples include bovine spongiform encephalopathy in the beef trade and H5N1 in the commercial poultry trade.

Kriger and Hero state that a reduction in the trade of amphibians for research purposes could be enacted with relative ease. This is simply not true. In the United Kingdom, the number of Home Office-regulated procedures involving amphibians has increased from 11,300 in 1988 to 20,970 in 2005 (Home Office, 2005). This increase in use is predominated by *Xenopus* and has come with an associated increase in trade. It is simply impossible to maintain all necessary *Xenopus* lines at all research facilities, and doing so would unnecessarily increase the volume of animals kept in laboratory facilities, in direct contravention of the legal requirements for reducing the number of animals kept for experimental purposes [Animals (Scientific Procedures) Act 1986]. Other countries involved in *Xenopus* research face similar restrictions. The trend in policy is more toward establishing regional *Xenopus* resource centers that maintain *Xenopus* lines and provide research animals when required to research facilities. Reducing or banning the trade and transport of research amphibians would directly and negatively impact the research community and may actually increase the risk of disease release as independent research facilities attempt to accommodate more *Xenopus* lines.

We agree that the financial benefits of the amphibian pet trade may currently be less than the food or research trades and that this component of the amphibian trade may be more difficult to justify. Nevertheless, it is still a reality and we suggest that regulation should first be made for the benefit of the trade rather than in direct opposition to it. Early experiences with the pet trade in Europe have been quite encouraging. Most exhibitors at a regional dendrobatid trade show were willing to participate in swab sampling for qPCR testing, pet shop owners in the United Kingdom were far more likely to participate in a survey than were zoo and research staff, and the general outcome of survey work is that most involved in the pet trade would not be adverse to improving amphibian health surveillance

and certification (E. Wombwell, unpublished data, 2008). Costs of surveillance and certification would be passed on directly to the consumer and could serve to reduce the volume of trade without impacting the economic benefits to wholesalers and retailers. Ideally, the move should be toward captive bred species (a move that is already to some degree underway), which would facilitate both screening and treatment if and when infectious disease is detected. However, there are conservation benefits to be accrued from the pet trade sector as it stands (see below). We have little information regarding the trade of amphibians as fishing bait, but to the best of our knowledge this trade is primarily located in the United States and, to a large extent, unregulated. Ranavirus is prevalent in this trade, *Bd* less so (Picco and Collins, 2008). Regulation of this trade would need to be self-imposed in the United States; however, a ban on trade seems highly unlikely given the United States' tendency not to support nonpolitical trade bans both nationally and internationally when production is based in the United States. Picco and Collins (2008) call for certification of "disease-free" bait shops and education of both shop owners and anglers; we suggest extending this to include certified captive breeders providing bait species and subsidized "buy-back" programs that encourage anglers to return any unused bait amphibians to the origin of purchase or some alternative facility.

Trade and transport of amphibians by zoos also is set to increase in direct response to the emergence of *Bd*. The Amphibian Conservation Action Plan (ACAP, http://amphibiaweb.org/declines/acap.pdf) specifically calls for captive breeding programs targeted at species that are at high risk of extinction in the wild due to chytridiomycosis, habitat destruction, and other threats. In response to this call, the Amphibian Ark was formed to mobilize zoos internationally to develop ex situ captive breeding programmes. It is generally recognized that captive breeding within native species ranges is, to a large extent, logistically impossible to implement, maintain, and biosecure. Instead, regional centers are required that, as with *Xenopus*, concentrate captive breeding capacity, which is a fundamental component of the Amphibian Ark program. We agree that quarantine procedures need to be set in place, because many species coming into these breeding programs are or will be affected by infectious diseases, and those already present in zoos are at risk of cross-infection if biosecurity is not maintained (Walker et al., 2008). However, most accredited zoos have such procedures in place, although there is a need to upgrade and standardize. As well, synergies amongst components of the amphibian trade may actually benefit this global conservation effort. Many species in the pet trade are closely related both phylogenetically and ecologically to important target conservation species. These species can be used to train staff at regional centers so that when target species are brought into captivity the likelihood of successful ex situ programs will improve. In cases where target species are in the pet trade, they may prove to be the best or only source of breeding stock. This is no small beer; most zoos have far better developed reptile husbandry and very few institutions boast of breeders and keepers who are specialized in amphibian care, health, and reproduction. Some zoos are already using amphibians purchased from the private sector to develop the skills necessary to implement the Amphibian Ark plans. From a conservation perspective, this is not the time to alienate the pet trade sector, which may be the most useful repository of captive breeding and husbandry know-how and arguably has the greatest success rate at breeding rare, difficult to keep, and difficult to breed species.

Given that the amphibian trade is already enormous in the United States, Asia, and Europe (Schlaepfer et al., 2005; Tyler et al., 2007) and the pet trade is rapidly emerging in Asia (Rowley et al., 2007), blanket bans and radical restrictions are going to be impossible to implement. Imposing trade restrictions will require substantial time and effort with no guarantee of success and may result in a substantial increase in unregulated trade. The better and more rapid option is to regulate trade for the control of the spread of infectious disease. Strategies for this are in place in most countries and should easily be modified for amphibians. For example, on Dominica, agricultural trade has already been modified to reduce the risk of transporting amphibians passively around the Lesser Antilles. Toward this, the Aquatic Animal Health Code of the World Organization for Animal Health (WOAH, or the OIE) has been amended this year to include both *Bd* and ranavirus and now includes recommendations for certifying disease status of countries and amphibian products. By using the WOAH guidelines, we believe that the risk of disease transport will be, to a great extent, eliminated. For certain cases (e.g., Madagascar), more stringent restrictions may be put in place. Along with trade regulations, we need to educate stakeholders in the amphibian trade about the risk of pathogens to wild populations and to their livelihoods. Many amphibian traders, notably those in the pet trade, currently feel alienated from zoos and the scientific community but would welcome the opportunity to increase their knowledge of infectious diseases and implement better practices. Our research has shown pet traders in the United

Kingdom feel that there is a lack of available information regarding the risk of amphibian infectious disease; however, the majority of pet shop owners surveyed feel import regulations are not stringent enough!

Lastly, Kriger and Hero downplay the possibility of control in the wild, an option that we feel should not be overlooked. Eradication of diseases in the wild is highly unlikely, but controlling the spread and reducing the environmental burden of an infectious disease may be possible and is done on a regular basis for human and livestock parasites. Surveillance has shown that the distribution of *Bd* is patchy in the temperate zone (Walker et al., 2008; Garner et al., 2005; Ouellet et al., 2005), suggesting that pond or stream-level applications may mitigate *Bd* under some circumstances, especially in biologically simple communities. The development of appropriate quarantine and biosecure methods for the amphibian trade may lead to developments applicable to some wild settings and may be achievable through partnerships between public and private research organizations. We believe that research on environmental-level solutions to the emergence of chytridiomycosis should remain high on the research agenda.

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