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COMMENTARY

A global problem requires a global multifaceted solutionB. Tapley¹, C. J. Michaels¹, K. Johnson² & D. Field¹¹ Zoological Society of London, Regent's Park, London, UK² Amphibian Ark, c/o IUCN SSC Conservation Breeding Specialist Group (CBSG), Apple Valley, MN, USA**Correspondence**

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Amphibians are disproportionately threatened and *ex situ* programmes are often considered the last line of defence against amphibian population and or species extinction. Biega *et al.* (2017) examined whether zoos and other *ex situ* partners house amphibian species that are considered priorities for conservation. The authors recommend that zoos continue to increase their holdings of threatened amphibian species; a recommendation that echoes that of Dawson *et al.* (2015) who also examined zoo holdings of threatened amphibian species. We feel that this recommendation is overly simplistic as there are a number of important considerations other than threat status that should be considered when selecting whether a species is suitable for a conservation breeding programme (CBP). Considerations include species biology, existing husbandry knowledge, ability to obtain enough founding stock to support genetically robust populations, political support and stability in founder countries and exit strategies (Tapley *et al.*, 2015); range-restricted habitat specialists may not always be the most suitable species for CBPs.

Amphibian Ark (AArk), the international body established to co-ordinate the captive breeding components of the Amphibian Conservation Action Plan (Wren *et al.*, 2015), endorses the establishment of captive facilities within range countries (Zippel *et al.*, 2011) as opposed to hosting conservation programmes for threatened amphibians in zoos elsewhere. The acquisition of more threatened amphibians for CBPs, especially non-native taxa, may not reflect the optimal scenario for the *ex situ* management of amphibians. The IUCN has produced *ex situ* management guidelines, which suggest that *ex situ* programmes should only be undertaken when the expected positive impact on the conservation of the species in question outweighs the potential risks to, or negative impact on, the local population, species, habitat or ecosystem, and when it will be a prudent use of resources (IUCN/SSC 2014). Developing CBPs for threatened amphibians in zoos outside of range countries instead of the development of programmes in range countries, where such programmes are logistically possible, likely goes against this

guidance. This is due to the risk of pathogen transfer and the disproportionate costs involved.

Most of the pathogens that have played a significant role in amphibian declines have been detected in cosmopolitan captive collections and not all of these pathogens can be reliably detected with existing screening protocols and treatment options may be complex or non-existent. Chytridiomycosis (a disease caused by the fungal pathogen *Batrachochytrium dendrobatidis*) was detected on Mallorca after zoo-bred toads were released; they had been infected before the disease had been identified and diagnostic tools developed (Walker *et al.*, 2008). Captive individuals of a focal species may not be clinically affected by a given disease, but the same pathogen may negatively affect sympatric species at release sites. With increasing numbers of non-sympatric threatened amphibians and their native pathogens and parasites held in a single CBP facility or location, which would be much more likely in a zoo setting, the risk of transferring novel pathogens to naive amphibian populations destined for release increases.

This reinforces AArk's stance on in versus out of country captive breeding programmes. The number of programmes involving threatened amphibians hosted outside of zoos is increasing and the proportion of amphibian CBPs in such facilities is now larger than those in zoos (Harding, Griffiths & Pavajeau, 2015). The zoo community is nonetheless key in supporting many of these programmes, particularly with regard to building regional amphibian husbandry capacity (e.g. Gagliardo *et al.*, 2008) through training, mentorship, ongoing technical advice and financial support.

Apart from disease, there are financial implications resulting from choice of host institution for conservation breeding (Gagliardo *et al.*, 2008; Zippel *et al.*, 2011). Husbandry expertise is generally associated with economically developed countries while amphibian conservation need is biased toward less economically developed regions. Funding for amphibian conservation is limited and maintaining amphibian CBPs in a zoo in more economically developed regions is disproportionately expensive (Tapley *et al.*, 2015). Zoos have proven themselves capable of acting to prevent imminent

extinction by establishing captive programmes out of range (Gagliardo *et al.*, 2008; Zippel *et al.*, 2011), but the safest and most cost-effective route will often entail sharing information and expertise with, and investing money in, facilities within the distributional range of the species where costs, as well as biosecurity risks, are relatively low. Such linkages (e.g. Gagliardo *et al.*, 2008) would not be apparent by searching the Zoological Information Management System (ZIMS; International Species Information System) which would only record individuals held by an institution.

There is of course great conservation value in holding threatened amphibians in zoos. Zoos and their *ex situ* partners are in a unique position to undertake research that may underpin conservation efforts (see review in Browne *et al.*, 2011). Key areas of research include the development of husbandry techniques, which are frequently subtle, complex and highly specific (e.g. Michaels *et al.*, 2015) and elucidation of species biology, which is often difficult to observe in nature. Threatened amphibians held in zoos for research, rather than CBPs, can address these questions and generate multiple data sets from a single threatened species (e.g. Michaels *et al.*, 2015). The knowledge gained, rather than the animals produced, can then be exported to dedicated non-zoo facilities that breed threatened amphibians for release within the distributional range of the species, or used to understand and address the conservation needs of a taxon in the wild.

As well as developing conservation research programmes, zoos can generate awareness of and interest in amphibians and raise funds for range country facilities. However, the acquisition of more threatened amphibian species for educational and research purposes must be of secondary priority to generating sufficient offspring, ideally in dedicated in-range facilities to sustain biosecure populations and, where appropriate, to produce sufficient release cohorts.

By implementing programmes designed to minimize biosecurity risks, maximize cost-effectiveness and to strategically address the three core areas of conservation, research and education, zoos and other *ex situ* partners can play multiple key roles in the multifaceted approach needed to conserve threatened amphibian species. However, conservation impact will not be achieved by simply maximizing the number of threatened amphibians in collections, but also by the conservation value derived from direct and tangible links to conservation initiatives. It is extremely encouraging that non-traditional organizations, often with the support of zoos, are increasing holdings of threatened amphibians as this demonstrates that the *ex situ* community is following best practice guidance. This trend should be actively promoted rather than used to imply that zoos could do more by holding more threatened amphibian species.

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