

symposium

AT THE ZOOLOGICAL SOCIETY OF LONDON

HALTING THE GLOBAL DECLINE IN AMPHIBIANS: RESEARCH AND PRACTICE

Thursday 20 and Friday 21 November 2008

Organised by

**Lesley Dickie
Kevin Zippel
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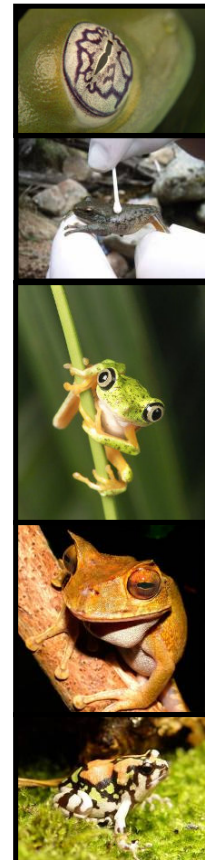


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The Meeting Rooms
The Zoological Society of London
Regent's Park
London NW1 4RY

www.zsl.org/science/scientific-meetings



9.00–9.10 **Welcome from Ralph Armond, Director General, ZSL**

SESSION I: MAJOR DETERMINANTS OF AMPHIBIAN DECLINES

Chair: Lesley Dickie (EAZA, The Netherlands)

9.10–9.40 **Habitat loss, fragmentation and alteration**
Don Church (Conservation International, USA)

According to the 2008 update to the Global Amphibian Assessment, 61% of the world's more than 6,000 species are threatened by habitat loss. Over 800 amphibian species qualify as gap species with zero percent of their distribution overlapping with a protected area. More than 400 amphibian species are restricted to a single site, making them especially vulnerable to expanding habitat loss. Most of the habitat loss affecting amphibians is a result of conversion of natural landscapes for agricultural crops (affecting 43% of all amphibian species) or timber harvest (affecting 41% of all amphibian species). Other forms of land conversion that diminish amphibian habitats include urbanization and industrial development (affecting 34% of all amphibian species) and clearing of forests for livestock (affecting 22% of all amphibian species). Whereas a few species worldwide appear to benefit from habitat alteration by humans, most species are negatively affected. Species in temperate regions are typically more resilient with populations capable of rebounding as natural habitats regenerate. Tropical species are generally more prone to extinction or local extirpation as habitats are lost or altered. This is especially a problem at higher elevations where tropical forests often do not regenerate without intensive management and where species tend to have exceptionally restricted ranges. Fortunately, studies from both temperate and tropical regions indicate that amphibians can often persist in relatively small fragments of remaining habitat. However, future research needs to evaluate the viability of populations restricted to small fragments in light of climate change and other threats. An important goal is to understand how small fragments of habitat should be managed to protect amphibian populations over the long term. For wide-ranging species, studies indicate that amphibians successfully utilize natural corridors in otherwise altered habitats, particularly when corridors are designed along riparian zones or in other areas that are most used by amphibians. Both theoretical and empirical studies indicate that the opportunity for amphibians to move among suitable breeding sites in a fragmented landscape may reduce long-term risks of extinction. Urgent measures are needed to protect remaining habitats for many of the most threatened amphibian species and new reserves should be adaptively managed to ensure persistence of resident amphibian populations.

9.40–10.10 **Global amphibian trade: overview to trade networks**
Angus Carpenter (University of East Anglia, UK)

The global trade in amphibians has been cited as a major cause of amphibian declines. A review, using CITES data collated in August 2008, that investigates trends, species and source countries, is presented here. These data highlighted three main categories: skins, meat and individuals. *Hoplobatrachus tigerinus* and *Rana catesbeiana* dominated the skin trade. Frogs have been traded for meat since 1985, with two species dominating; *H. tigerinus* and *Euphylyctis hexadactylus*. Approximately 102 million frogs were traded for meat, *H. tigerinus*

accounting for the majority (>92%), and five main exporting countries reported, although Bangladesh and Viet Nam recorded over 81% of the trade. The USA (82%) and Belgium (12%) dominated imports. The trade in amphibians destined for the pet trade was recorded from 1976, with the majority (>60%) of the trade recorded since 1996. Correcting for the *H. tigrinus* anomaly, three genera dominate the sector, *Ambystoma* spp. (>22%), *Dendrobates* spp. (>31%) and *Mantella* spp. (>40%), accounting for over 93% of the trade. *Ambystoma* recorded three species in the trade with *A. mexicanum* accounting for 99.9% of the trade in this genus, while dendrobatids recorded 26 species in the trade with *D. tinctorius* (>20%), *D. pumilio* (>22%) and *D. auratus* (>40%) totalling over 83% of the trade in this genus. *Mantella* recorded 14 species traded over a 15-year period, producing the highest yearly average of over 12,900 frogs traded per year. *M. aurantiaca* (>33%), *M. madagascariensis* (12.5%) and *M. pulchra* (nearly 8%) were the three known species to record the most trade, nearly 54% of the total trade in this genus. The structure of the trade network on Madagascar consisted of a three-tier system: exporter, intermediary and collector, with 18 of 27 known exporters trading in amphibians. At this national scale, the trade recorded a value of over £3 million. A review of the economic network highlighted a highly skewed income differential benefiting the exporters, while collectors received little income from the trade. The collection from amphibian populations did not discriminate between populations within protected areas or outside. A need exists to move the management of wildlife resources forward to cover all scales of the trade (international, national and local), whilst also working in closer partnership with local people and conservation to ensure any potential benefits from the trade help towards conservation and poverty alleviation, where possible.

10.10–10.40 KEYNOTE ADDRESS – A world without amphibians

Sir David Attenborough, FRS

10.40–11.10 POSTER SESSION (TEA/COFFEE)

11.10–11.40 Infectious disease threats to amphibians

Andrew A. Cunningham (Institute of Zoology, Zoological Society of London, Regent's Park, London NW1 4RY, UK)

In recent decades, the populations of at least 43% of amphibian species have declined, 32% have become globally threatened, 34 species have become extinct and an additional 130 are thought to have become extinct. The Amphibia is now known to be the most threatened animal Class on Earth. Whilst exploitation and habitat loss and degradation remain significant threats, infectious disease is increasingly being found to be a major driver of species declines and extinctions. Two infectious diseases of amphibians in particular have risen to prominence in recent years: ranavirus disease and chytridiomycosis.

Ranavirus diseases of amphibians have been described since the 1960s, but since the 1990s the number of reported ranavirus disease outbreaks has increased greatly. These often are very striking, causing mass mortalities of adult and/or larval amphibians that can result in dramatic declines in the size of local populations. These declines usually are short-lived, however, with populations showing rapid recoveries over subsequent years and ranavirus disease is not considered a significant driver of amphibian declines. Typically, affected animals die of systemic haemorrhagic disease. The haemorrhages are noticeable within the coelomic

cavity of the intact tadpole, but adult animals are often found dead with no external abnormalities, although in the agonal stages animals might be seen to vomit up bloody mucus or to pass blood per cloaca. In the UK, ranavirus disease was first noted in the 1990s during investigations into unusual outbreaks of common frog (*Rana temporaria*) mortality. In addition to systemic haemorrhagic disease, a disease syndrome characterized by skin ulceration and necrosis of digits, but in the absence of internal lesions, was found to be caused by ranavirus infection in Britain. Phylogenetic analysis indicates that ranavirus was likely to have been recently introduced into Britain from North America. Interestingly, there are early indications that, unlike elsewhere, ranavirus might be having a long-term detrimental effect on some amphibian populations in Britain.

Amphibian chytridiomycosis was first described in 1998. It is caused by infection with the non-hyphal, zoosporic chytrid fungus, *Batrachochytrium dendrobatidis* (*Bd*). A wide range of chytrid fungi is known, including those that parasitise invertebrates, but *Bd* is the only chytrid fungus known to infect vertebrates. The pathogen infects only the keratinised tissues of its host: the skin of metamorphosed amphibians and the mouthparts of anuran larvae. Clinical signs of the disease include lethargy, loss of righting reflex and abnormal posture. There are reports of diseased frogs becoming rigid and trembling, with extension of the hindlimbs and flexion of the forelimbs, when handled. Gross lesions are usually not apparent, but increased epidermal sloughing, epidermal ulceration and reddening (hyperaemia) of the digital and ventral skin have been reported, as has necrosis of the digits and feet. *Bd* has low host specificity across the Amphibia and has been reported as infecting at least 14 families and over 300 species of amphibian on five continents. In contrast to ranavirus disease, amphibian chytridiomycosis has been associated with amphibian population declines and species extinctions worldwide. There is, however, a high degree of variance in species' susceptibility to this disease, with some species driven to extinction, while sympatric species remain apparently healthy carriers of the infection.

11.40–12.10 **Species susceptibility to disease-related declines**

Jon Bielby (Conservation Programmes, ZSL, UK)

In recent years declines of amphibian species as a result of infectious disease have caused major concerns for the conservation of this fascinating group of animals. At present over 100 amphibian species are thought to have gone extinct as a result of disease-related declines, and phrases like “catastrophic” and “devastating” are commonly used in conjunction with such population losses. Indeed, the impacts may be so serious that the recently produced *Amphibian Conservation Action Plan* described chytridiomycosis, one high-profile amphibian disease, as being the “the worst infectious disease ever recorded amongst vertebrates in terms of the number of species impacted, and its propensity to drive them to extinction”.

However, the impacts of amphibian diseases, particularly chytridiomycosis, are not always as clear-cut as first thought. While some species are heavily impacted by chytridiomycosis, others seem to be able to harbour infection without suffering any apparent ill-effects. Even more confusingly, while some populations of a given species will experience die-offs or even local extinction, other populations of the same species may recover or appear to be completely unharmed by the presence of the pathogen responsible for the disease. On a practical level, such variation in the response to infection greatly complicates conservation plans to mitigate the effects of the disease.

But why do such differences among species and populations exist? In this talk I shall outline a number of factors, such as climate, immune response, the strain of the pathogen and species life-history traits, that may be involved in determining the susceptibility of a species to disease-related declines, and outline why these factors matter for the conservation management of a species.

12.10–12.40 Effects of pesticides: contributors to amphibian disease and decline

Frances Orton & Tyrone B. Hayes (University of California, Berkeley, USA)*

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Amphibian population decline is a recognised phenomenon spanning at least the last 40 years. It is likely that a number of distinct but interacting factors have contributed, including environmental contamination. Indeed, the Global Amphibian Assessment (2004) ranked pollution as the second most important cause of amphibian decline, after habitat loss. Amphibians are vulnerable to agrochemical uptake as they must return to water to breed, have permeable skin and spend the aquatic phase of their lifecycle in water bodies, many of which are contaminated with agricultural chemicals. The relative impacts of pesticides on amphibian declines are not well understood. However, they have been shown to elicit a range of sublethal effects, including endocrine disruption, a compromised immune system, neurotoxicity and limb malformations. These factors could have major effects on the survival of populations, either separately or, more likely, in combination. Recent studies have demonstrated sublethal effects of pesticides in the laboratory and in the field environment. A recent *in vitro* study demonstrated endocrine disrupting effects of 85% of the tested pesticides, with half of these eliciting effects at environmentally relevant concentrations. The most thoroughly investigated pesticide is atrazine, a herbicide that has been shown to cause hermaphroditism in the laboratory and field environment. The impact of intersex on fecundity of amphibian populations is unclear; however, it has been shown to reduce the reproductive capability of fish. Atrazine also compromises the immune system, leading to increased parasite infection and, ultimately, a decrease in overall survival of native species. Pesticides have also been shown to compromise survival of amphibians indirectly by changing ecosystem dynamics, including the prevalence of intermediate parasite hosts. Organophosphate insecticides are neurotoxic and reduce the activity of acetylcholinesterase, leading to altered behaviour and may be associated with population declines. There is also field-based evidence from Costa Rica that organic banana plantations support a higher amphibian biodiversity than conventional plantations. In order to prevent amphibian extinctions it is imperative to understand the causes of decline, which are undoubtedly interlinked and comprise interactive causal factors. Pesticide contamination is likely to be a contributive factor and investigation into the effects of pesticides, especially in combination with other stressors, is warranted.

12.40–13.40 LUNCH

13.40–14.10 The role of climate change vs climatic variability in amphibian decline

Anton Seimon (Latin America and Caribbean Program, Wildlife Conservation Society, USA)

The current consensus perspective on global amphibian decline is that primary causation lies with chytridiomycosis, a rapidly globalizing emerging infectious disease. Less clear is the role of climate in controlling the disease, its propagation, and severity of its impacts upon

amphibians. Multi-decadal climate trends (“climate change”) and year-to-year climatic variability both hold the potential to impact amphibian ecology and mortality rates. This presentation will survey recent scientific literature and evaluate observational evidence on the relationship between climate and amphibian decline from the perspective of a climatologist.

In assessments of ongoing global amphibian decline, “climate change” is commonly invoked whenever climatic forcing is believed to be at least partly responsible for reported negative effects on amphibian populations. Recent climate change is furthermore considered to be anthropogenic – forced by greenhouse-gas emissions – and thus abnormal relative to historic climatic behavior. The implication is therefore that global amphibian decline might be significantly related to human interference with the global climate system.

An assessment of climatological data records suggests that, to the present, it is actually climatic variability, largely manifest through phases of the El Niño-Southern Oscillation (ENSO), that might play a relatively minor secondary role to chytridiomycosis in amphibian decline, rather than anthropogenic climate change. Nevertheless, it is unquestionable that climate change looms as a serious and building threat to many amphibian species in the present, and ever more so in the future for amphibian populations that survive the current chytrid-driven extinction events.

14.10–14.40 Why are there species differences in susceptibility to chytrid? Basking treefrogs could hold the answer...

Andrew R. Gray (Department of Zoology, Manchester Museum, The University of Manchester, UK). E-mail: andrew.gray@manchester.ac.uk

In many parts of Central America, amphibian populations have been decimated by the spread of the fungal pathogen, *Batrachochytrium dendrobatidis*. Nevertheless, some species continue to thrive, even in the worst-affected areas. These species could provide a valuable insight into worldwide patterns of amphibian decline.

Phyllomedusine and *Centrolenid* species in particular display relatively good resistance to chytrid, which may be afforded by their unusual basking behaviour. Amphibians generally do not bask because the risks of dehydration and overheating are too great. Here we used a multidiscipline approach to assess optical, structural and biochemical properties of amphibian skin. Our aim was to investigate why some species bask, and how this behaviour relates to chytrid resistance. The pigment pterorhodin, which is unique to certain species of tropical treefrogs, was associated with unusually high near infrared reflectance (NIR). Basking may therefore allow frogs to prolong their exposure to UV and elevate skin temperature, thus killing harmful fungal pathogens. Protection against intolerable elevations in body temperature may be offered by pterorhodin induced NIR reflectance. The results provide an insight into the impact climate change may have on the susceptibility of some species to chytrid infection.

At Manchester Museum, where the UK’s largest captive collection of these frogs has been established, research focuses on a multi-disciplined collaborative approach that uses innovative non-invasive techniques to determine causes. Here, the importance of collaboration, which fully extends to *in situ* support for species concerned and the continuing role of education, proves crucial to the amphibian conservation efforts being made.

SESSION II: *IN SITU* AND *EX SITU* RESPONSES: METHODOLOGY AND PRACTICE

Chair: Don Church (Conservation International, USA)

14.40–15.10 ***Amphibian Conservation Action Plan: priorities and challenges to implementation***

Robin Moore (Conservation International, USA and IUCN/SSC Amphibian Specialist Group)

In September 2005, in response to the scale of the amphibian extinction crisis, around 80 experts in amphibian conservation and research convened in Washington, DC, to devise a plan of action. The *Amphibian Conservation Action Plan* (ACAP; www.amphibians.org) was subsequently published to serve as a guide to address the most pertinent threats to amphibians around the world and as a blueprint for action. The ACAP has since been adopted as a framework for developing National and Regional Action Plans around the world that are relevant within respective geographical and cultural settings.

There is no silver-bullet approach to reversing amphibian declines. In light of the varied and synergistic nature of numerous threats, a multi-faceted approach is necessary. Priority must be given to developing techniques for mitigating the impact of incipient threats in the wild, such as disease and climate change, and to implementing conservation actions that address major drivers of decline. Habitat loss remains the single biggest threat to the survival of amphibians around the world, and safeguarding critical habitat should be an integral component of any long-term conservation agenda.

To effectively protect amphibian habitats, and to mainstream the needs of amphibians within broader conservation efforts, it is imperative to forge partnerships among a diverse suite of stakeholders. As spokespersons for amphibians, we need to engage conservation practitioners and help them to incorporate amphibians into conservation planning and implementation. I will discuss examples of how this strategy has worked effectively to create new protected areas for amphibians.

With the challenges posed by the current amphibian crisis comes also opportunity. As many countries seek to meet their 2010 targets for reducing biodiversity loss, we can assist them in protecting a major source of such loss. Now is the time to build upon the momentum that has been generated by an active and energized community filled with individuals who share a common concern for the future of amphibians and life on our planet.

15.10–15.40 ***What zoos and you can do: captive-breeding efforts around the world***

Jennifer B. Pramuk (Curator of Herpetology, Wildlife Conservation Society/Bronx Zoo, USA). E-mail: jpramuk@wcs.org

The 2005 IUCN/SSC *Amphibian Conservation Action Plan* urged that in some cases captive assurance colonies are the only viable option for saving amphibian species undergoing enigmatic declines. This is particularly true in situations where emergent disease is affecting amphibians found in relatively pristine habitats.

At the Wildlife Conservation Society, we have been involved in the *ex situ* Kihansi spray toad propagation programme since its inception eight years ago. A brief history of this project and

its various trials and successes are presented. In partnership with the Tanzanian government, and the Toledo Zoo, we currently are planning the next stage of returning toads to their native country with a goal of eventual reintroduction. To meet this objective, we are training Tanzanian scientists on Kihansi spray toad husbandry and working with pathologists to perform intensive disease screening on individuals earmarked for reintroduction. What remains elusive is how to know when animals intended for reintroduction are free of infectious agents. This very problem was highlighted recently by the reported spread of amphibian chytrid fungus (*Batrachochytrium dendrobatidis*) from reintroduced captive-bred Mallorcan midwife toads to wild, naïve stock.

Ex situ efforts have been employed all over the world to buy time for species on the brink of extinction. I will provide highlights of projects from Europe, Latin America, North America and Australia. Without concerted captive-conservation efforts, the IUCN's Amphibian ARK estimates 500 amphibian species are at risk of going extinct. It is apparent that much work remains to be done in the amphibian rescue species arena. This important effort will only be accomplished through greater institutional capacity and investment, and an unwavering commitment to mitigating the spread of known and potential pathogens from released animals into the wild.

15.40–16.10 **POSTER SESSION (TEA/COFFEE)**

16.10–16.40 **Amphibians on the EDGE: combining phylogeny and threat**

Helen M. R. Meredith¹; Nick J. B. Isaac²; Sally E. Wren¹; Trent W. J. Garner²; Ian Stephen³; Carly Waterman¹; Samuel T. Turvey²; & Jonathan E. M. Baillie¹
¹ZSL Conservation Programmes Department; ²ZSL Institute of Zoology; ³ZSL Living Collections.

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Conservation-priority setting based on phylogenetic diversity has been frequently proposed but rarely implemented. We have defined a simple index that measures the contribution made by different species to phylogenetic diversity and use this index to define species-based conservation priorities. The approach has been applied to a near-complete species-level phylogeny of the Mammalia to generate a global priority list incorporating both phylogenetic diversity and extinction risk. It was subsequently used to define a priority list for the Amphibia based on the most complete phylogenetic information available. The 100 highest-ranking amphibian species represent a high proportion of total amphibian diversity and include many species not usually recognised as conservation priorities. A large proportion of species that are both evolutionarily distinct and globally endangered (EDGE species) do not benefit from existing conservation projects or protected areas. The results suggest that global conservation priorities may need to be reassessed in order to prevent a disproportionately large amount of amphibian evolutionary history becoming extinct in the near future. Now in its second year, the EDGE Programme (www.edgeofexistence.org) at the Zoological Society of London (ZSL) is forging ahead with conservation projects for focal amphibian species, including *Andrias davidianus*, *Nasikabatrachus sahyadrensis* and *Boulengerula niedeni*. The conservation projects under development focus on three major areas: local capacity building; scientific-information collection to aid the production of Conservation Action Plans; and local and global awareness-raising of the amphibian extinction crisis. ZSL coordinates some 45 conservation

projects in more than 30 countries worldwide, collaborating with a vast network of international partners. Furthermore, we participate in conservation-breeding programmes coordinated by the Amphibian Ark (www.amphibianark.org) and the EDGE Programme utilises the ZSL Institute of Zoology's expertise in amphibian disease surveillance wherever relevant.

16.40–17.10 Romer's tree frog conservation – a successful case of research, rescue, captive breeding and translocation

Michael Lau (Head of China Programme, Kadoorie Farm & Botanic Garden, Hong Kong SAR)

Romer's tree frog is considered endemic to Hong Kong and is naturally restricted to four offshore islands. One of these islands, Chek Lap Kok, was chosen as the site for the new airport and a project to study and conserve this species was initiated in 1991. Over 220 frogs, some tadpoles and egg clutches were collected from this island. This species was maintained and bred in captivity in the University of Hong Kong and Melbourne Zoo. Research was carried out to study its ecology, in particular habitat requirements. Findings showed that Romer's tree frog is a leaf-litter species that breeds in fish-free, slow-flowing or stagnant waters in forests. The information was used to identify suitable release sites for the rescued frogs and their progeny. Different insular populations were found to have slightly different genetic make-up and it was decided to release the frogs outside the natural range of the species. A total of 1170 frogs and over 1600 tadpoles was released at eight sites from 1993 to 1996. Post-release monitoring indicated that this species established in seven sites while one site failed.

17.10 *End of Day One*

19.00–21.30 *Symposium dinner for speakers and guests with tickets*

SESSION III: DEVELOPING THE ARK RESPONSE

Chair: Gordon McGregor Reid (WAZA and North of England Zoological Society, UK)

9.00–9.30 **Launching the Ark: concept, role and function**

Kevin Zippel (Amphibian Ark, USA)

The *Amphibian Conservation Action Plan* calls for *ex situ* conservation as one aspect of an integrated response under the direction of the IUCN/SSC Amphibian Specialist Group (ASG). Other conservation organizations mandate *ex situ* intervention when a species' extinction is imminent. However, unlike other aspects of the Plan, there was no organization of experts for *ex situ* conservation of amphibians under the umbrella of the ASG. The ASG therefore called upon the IUCN/SSC Conservation Breeding Specialist Group, which joined forces with the World Association of Zoos and Aquariums, and formed the Amphibian Ark (AArk). With a mission focusing on amphibian species that cannot be safeguarded in nature, the AArk gives the ASG a single organization to oversee implementation of the *ex situ* aspects of the ACAP, while providing the existing *ex situ* community with unity, a communication network, a jump-start on capacity building and an awareness campaign designed to help our partners around the world raise the funds to develop new programs.

9.30–10.00 **So many species, so little time: which species to work with first?**

Kevin Johnson (Amphibian Ark Taxon Officer and ARAZPA, Australia) & Richard Gibson (Amphibian Ark Taxon Officer and North of England Zoological Society, UK). E-mail: kevinj@amphibianark.org; richard@amphibianark.org

In 2006 the IUCN's Conservation Breeding Specialist Group (CBSG) and the World Association of Zoos and Aquariums (WAZA) held an amphibian *ex situ* conservation planning workshop in Panama. Fifty amphibian biologists from fourteen countries attended the workshop, with fourteen of these participants forming a Species Selection Working Group for the duration of the four-day workshop.

A species prioritization tool was designed by the working group and this has subsequently been used at a number of regional species prioritization workshops. A wide range of amphibian experts worked with the tool at each of these workshops, and a number of changes to the tree have been suggested, subsequently reviewed and adopted. Further changes are planned to streamline the process and to ultimately link these data to the data from the Global Amphibian Assessment workshops.

The prioritization tool is in the form of an Excel spreadsheet, with a series of questions which are answered for all species where the participants have sufficient knowledge of the species in the field. The responses to each question are selected from pick-lists in the spreadsheet, ensuring that consistency is maintained, and minimizing the risk of data entry error. A prioritization "score" is updated as each question is answered, providing a total that can then be sorted via any question and/or its answer to generate a range of priority lists for different *ex situ* roles.

To date, amphibian species have been prioritized for *ex situ* conservation in twelve regions and/or countries in five continents, with additional workshops planned in the coming months. A total of 3,088 species occurs within these countries, with 1,654 of these being prioritized for

their *ex situ* conservation requirements. Where possible, the prioritization tool has been translated into the local languages, to ensure ease of use.

The workshops include the leading field experts, as well as a wide range of stakeholders from zoos and aquariums, government agencies, museums and universities. It is critical that the prioritization process be transparent, and be understood and agreed on by all workshop participants, to ensure that there is sufficient trust in the results to ensure good stakeholder buy-in.

10.00–10.30 Taking the Ark on the road: capacity building where it counts

Richard Gibson & Kevin Johnson (Amphibian Ark Taxon Officers).

E-mail: richard@amphibianark.org

Following the IUCN/SSC Amphibian Conservation Summit in 2005, and its output the *Amphibian Conservation Action Plan* (ACAP; <http://amphibiaweb.org/declines/acap.pdf>), the IUCN's Conservation Breeding Specialist Group (CBSG) and the World Association of Zoos and Aquariums (WAZA) held an amphibian *ex situ* conservation-planning workshop in Panama. At this meeting the Amphibian Ark was "spawned" with a daunting remit of delivering, through its partners and collaborators, the *ex situ* components of the ACAP.

However, the world's *ex situ* conservation community is far from prepared to meet the challenge of instigating and maintaining dozens, perhaps hundreds, of conservation-breeding and research programmes for threatened amphibians. Even within the world's most accomplished zoos and aquariums, amphibian-related expertise, facilities and other resources are extremely limited while in those countries with the majority of threatened species such resources may be lacking altogether.

There is, therefore, an urgent need to develop amphibian expertise and expand spatial capacity through training and the development of facilities in the regions of the world where it is most critical. Furthermore, we must increase the conservation output from the *ex situ* community through the establishment of international partnerships and collaborative programmes.

Training needs are increasingly being met through the combined efforts and financial support of multiple organizations providing a variety of taught courses, practical workshops and placement schemes covering all aspects of amphibian biology, conservation and husbandry. At the same time, and often through the training courses, new and established international partnerships are growing in number and strength, delivering effective amphibian conservation programmes around the world.

There is still a very long way to go in the field of amphibian *ex situ* conservation and the number of species secured *ex situ* is still desperately low. Nevertheless the capacity to deliver the AARK mission grows every day.

10.30–11.00 POSTER SESSION (TEA/COFFEE)

11.00–11.30 **Conservation research for amphibians**

*Robert K. Browne (Research Officer, IUCN/WAZA Amphibian Ark, Royal Zoological Society of Antwerp, Koningin Astridplein 26, 2018 Antwerp Belgium).
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The amphibian conservation crisis needs a multidisciplinary, multiregional and multinational scientific response to provide for the requirements of the *Amphibian Conservation Action Plan* (ACAP). The ACAP supports the sustainable population management of amphibians through the maintenance of ecosystem function, services and biodiversity. The ACAP accepts the need for Amphibian Ark (AArk) conservation-breeding programs in providing for rescue populations of species facing extinction.

Therefore, conservation research for amphibians needs to provide for conservation-breeding programs, be predictive of threats to amphibian survival, and address the needs for future rehabilitation. Fundamental to this goal is accurate assessment of clades, species and genetic sub-populations. Threats to phylogenetic entities can then be related to climate change, disease, toxicology and other stressors. Together, these give a structure to guide priorities and targets for the sustainable population management of amphibians.

AArk conservation-breeding programs provide a range of unique and valuable research opportunities. These include research that directly supports conservation-breeding populations, research to support sustainable population management, and research providing direct benefit to humanity through medicine, biotechnology and micro-economic development. Within these programs the particular skills and facilities of zoos provide critical support for maintaining populations of unique and rare amphibians. These populations can be used for internal studies in zoos and other conservation-breeding programs, or to supply samples or amphibians for research to external institutions.

Conservation-breeding programs are ideal research partners for governments, universities and museums, elementary to tertiary education, communities and biomedical industries. Outreach can inform public policymakers, develop data to inform management, and direct funds toward conservation and research, and other capacity building, including regional amphibian conservation-breeding facilities and conservation projects.

Many examples of successful research programs have developed in partnership with amphibian conservation-breeding programs. Research programs by zoos and other institutions include the maintenance of genetic variation, chytrid pathology and treatment, improved amphibian health, and studies of cryobiology, endocrinology, nutrition, growth and development, pathology and cell lines. Zoos are also contributing to studies of skin peptides for biomedical use, as pheromones and agents for immunity. The microbiology of skin symbionts and gut flora are also yielding new insights about health and disease resistance.

In conclusion, research is crucial in predicting the amphibian populations most in need of conservation-breeding programs. Conservation-breeding programs in turn need specific lines of research and, in particular, programs in zoos offer unique research opportunities. Innovative research partnerships can be formed to support the needs of amphibian conservation and to provide direct benefits to humanity.

11.30–12.00 **Containers for conservation: the effectiveness of stand alone bio-secure units**

Gerardo García¹, Kay Bradfield¹ & Kevin Buley²

¹Durrell Wildlife Conservation Trust, Jersey; ²North of England Zoological Society, UK

The *Amphibian Conservation Action Plan* (ACAP 2005) recommended developing and implementing captive-breeding programmes on a scale appropriate to respond to the global amphibian decline crisis. Traditional zoological institutions tend to have multi-species facilities that house a geographically diverse range of species and, hence, diseases. For conservation purposes, it is necessary to retain pathogens the species is exposed to in the wild, but exclude others. It is therefore imperative that institutions participating in *ex situ*-conservation initiatives employ the highest level husbandry standards and bio-secure protocols to prevent transmitting diseases amongst species within the collection and potentially introducing diseases to new areas in the wild. It is essential that institutions develop and adhere to stringent quarantine and bio-security standards in parallel with the highest possible husbandry standards. Unfortunately, the concepts of bio-security and quarantine in relation to amphibians are new for many zoological institutions, and their current facilities do not meet the biosecurity standards required to support captive-breeding and release programmes. A new generation of facilities has been developed over the last few years: bio-secure units. These allow the regulation of a range of environmental parameters while addressing the need for high-level biosecurity that is integral to breed-for-release programmes, both for the target species and the native species that occupy the habitat surrounding the facilities.

The threat of infectious diseases such as chytridiomycosis poses a serious challenge for institutions participating in amphibian-conservation programmes. A review of the use of modified shipping containers as bio-secure units, including detailed examples of units in operation at Durrell and Chester Zoo, will be presented. It is also important to note that other initiatives that address the same objectives but in different ways have been developed in other parts of the world. It is becoming apparent that there are two major issues associated with biosecure facilities: how many zoological institutions are currently able to commit the resources required to achieve these high standards? And is this an opportunity to direct efforts, even more than we have in the past, to providing support for the conservation of wild amphibian populations in country? Critical to the success of our efforts are multi-disciplinary teams that include skilled professionals in the areas of captive husbandry, both *ex situ*- and *in situ*-conservation initiatives, and scientific research (particularly disease and ecology).

12.00–12.30 **The reality of reintroduction: opportunities and constraints**

Richard A. Griffiths (*Durrell Institute of Conservation and Ecology, University of Kent, Marlowe Building, Canterbury, Kent CT2 7NR, UK*)

Reintroduction forms one of the 11 priority areas for conservation and research within the IUCN/SSC *Amphibian Conservation Action Plan*. Although amphibians display a diverse array of life histories and reproductive modes, many species possess characteristics that make them potentially model organisms for reintroduction programmes. Compared to higher vertebrates, many amphibians display high fecundity, can breed rapidly and can build up population sizes quickly. Because many of their behaviours are “hard wired” they rarely require periods of pre- or post-release training in order to equip them for life in the wild. On the other hand, amphibians face complex, and often synergistic threats that are difficult to identify let alone neutralize in the wild: this can create uncertainties in the likely outcomes of reintroduction.

Equally, cryptic lifestyles coupled with natural population fluctuations mean that assessing reintroduction “success” may require a long-term and intensive population assessment strategy. Historically, such issues have rarely been appraised when deciding which amphibian species are suitable candidates for reintroduction programmes. To date, most reintroduction programmes have focused on threatened species, although most of these have been taxa from industrialized countries in temperate regions with relatively low amphibian diversity. Fifty-eight species that have been reintroduced as part of conservation programmes have subsequently bred in the wild, and at least 13 species have established self-sustaining populations. The majority of reintroduction programmes have had a captive component, involving either head-starting of wild-bred stock or breeding in captivity. The most successful reintroduction programmes are those that have been long term (>20 yrs), and it is likely that the number of successful programmes will continue to rise as reintroduction protocols improve and long-term monitoring starts to yield rigorous population data. Reintroduction programmes are increasingly being integrated into wider conservation projects that combine threat neutralization, habitat protection and management, public relations and education. In addition, there is now more rigorous appraisal of the suitability of species for reintroduction than there has been in the past. Nevertheless, there remain major issues. Emerging infectious diseases pose significant challenges to species management and reintroduction protocols, and if limited conservation funds are to be spent wisely, the cost-effectiveness of reintroduction needs assessing against alternative conservation actions and outcomes.

12.30–13.30 LUNCH

**SESSION IV: DEVELOPING TECHNOLOGIES AND RESPONSES
IN THE FACE OF A CRISIS**

Chair: Richard A. Griffiths (Durrell Institute of Conservation and Ecology, University of Kent, UK)

13.30–14.00 Assisted reproductive techniques and cryobanking for amphibian conservation, hope and reality

Rhiannon E. Lloyd & William V. Holt (Institute of Zoology, Zoological Society of London, Regent's Park, London NW1 4RY, UK)

Due to the alarming speed at which amphibian populations are declining and becoming extinct worldwide and the difficulties associated with mitigating the factors that are causing these declines and extinctions, several of the most threatened of amphibian species are destined for *ex situ* captive-breeding programmes. However, establishing self-sustaining amphibian populations in captivity can be challenging from the very beginning due to, for example, the difficulty in distinguishing the gender of individuals for establishing breeding pairs and/or a general lack of understanding of the basic reproductive biology of the species in question. Assisted reproductive techniques (ARTs) not only have the potential to boost the numbers within captive populations but also to help maintain their genetic health by incorporating the use of cryobanks containing spermatozoa as well as other cell types. The aim of this presentation is to review several emerging ARTs of differing complexity (for example: non-invasive hormone monitoring, *in vitro* fertilisation, intracytoplasmic sperm injection and cloning) that have arisen from the study of laboratory amphibians, fish and mammalians, and to discuss

their potential value (and limitations), along with that of cryobanks, as support tools for amphibian conservation.

14.00–14.30 **Mitigating *Batrachochytrium dendrobatidis* in the wild: where are we now and where are we going?**

Trent Garner (Institute of Zoology, ZSL, UK)

Batrachochytrium dendrobatidis (*Bd*) is a globally emerged pathogen of amphibians contributing significantly to the global amphibian decline. As a disease of wildlife, *Bd* is novel in its propensity to cause host species to go extinct. Control of *Bd* in captive settings is relatively straightforward, as infection can be treated effectively with standard antifungals and many standard disinfectants are effective at killing *Bd*. Translating the lab-based scenario to the wild is definitely not straightforward. However, the goals of mitigation in the wild setting may not be the same as in the captive one, as disease control may be more appropriate than disease elimination. To the best of my knowledge, no field mitigation has been attempted for *Bd*, however any attempt to mitigate in the wild must account for local environmental conditions, amphibian community composition and species life history, and identify routes of infection and contamination. For instance, most temperate-zone amphibians annually migrate to water bodies to breed and exhibit complex life histories. Thus mitigation under these circumstances may focus on applying antifungals to breeding assemblages and treating water bodies at sensitive periods during larval development: these approaches are unlikely to be successful in the tropics, where adult amphibians are often more dispersed and development is often direct. No matter what mitigation is attempted, it is clear that mitigation will have to be adopted as part of a long-term conservation strategy. The Institute of Zoology, Imperial College and the CSIC will be using some of these principles when attempting the first field mitigation of *Bd* in Europe.

14.30–15.00 **Global mapping and spatial epidemiology of *Batrachochytrium dendrobatidis***

Matthew C. Fisher (Department of Infectious Disease Epidemiology, St. Mary's, Imperial College, London W2 1PG, UK)

The chytrid fungal pathogen *Batrachochytrium dendrobatidis* (*Bd*) is now recognised as a proximate driver of amphibian declines. Population genetics and histological examinations of museum specimens indicate that *Bd* has only emerged in the latter half of the 20th century, and is spreading to infect new regions and naïve populations and species. There is now an urgent need to map the spread of *Bd* and to develop tools to identify the principle sources of infection. To fulfil this need there exist two projects that involve scientists from around the world. The first is “The *Bd* mapping project”. Here, I summarise the major findings from the worldwide surveillance of amphibian populations for infection by *Bd*. The second is “The *Bd* genotyping project”. Here, I show how genotyping lineages of *Bd* shows that this provides information about patterns of pathogen dispersal. A widely collaborative group of scientists has been merging these two datasets into a publicly accessible tool to map the global epidemiology of *Bd* (www.spatial-epidemiology.net/bd). I demonstrate that this dataset has the potential to predict the trajectory of disease by showing how *Bd* genotypes have different virulence in natural populations, and how these differences can be “tracked” using spatial epidemiological techniques and mapping. I finally talk about how these techniques are being brought together under a new EU initiative to combat the emergence of *Bd*—*RACE: Risk Assessment of Chytridiomycosis to European Amphibian populations*.

15.00–15.30 **POSTER SESSION (TEA/COFFEE)**

**SESSION V: WILL THE WORLD TAKE NOTICE? THE YEAR OF THE FROG AND
GENERATING PUBLIC/POLITICAL AWARENESS**

Chair: Jennifer Pramuk (Wildlife Conservation Society, USA)

15.30–16.00 **The 2008 Year of the Frog: raising awareness in a charismatic mega-fauna
obsessed public**

Lesley Dickie (European Association of Zoos and Aquaria, The Netherlands)

The global amphibian crisis is an unprecedented extinction event in the history of humanity and therefore requires an unprecedented global response to halt the current rates of decline. An effective conservation response will not be generated unless wide-spread multiple stakeholders, including zoos, aquariums, botanic gardens, NGOs, government and public, lend their expertise and/or support to intensive and costly conservation actions. To this end Amphibian Ark set about creating worldwide media interest in amphibians through the 2008 Year of the Frog campaign. Amphibians, however, risk being overshadowed while competing for attention in a crowded media environment alongside other threatened species, habitats and ecosystems. While large mammals frequently figure in public-voted lists of “most popular animals” amphibians rarely receive such attention, making conservation initiatives that attempt to generate public attention and support particularly challenging. Even for mega-mammals, the perennial public favourites, there have been few attempts to coordinate global conservation campaigns aimed at generating awareness, interest and thereafter action across multiple stakeholders. This presentation will describe the aims and scope of the current global 2008 Year of the Frog campaign and its success and failures to date. It will also review the response to the campaign in encouraging zoos to invest in more comprehensive biosecure captive facilities for amphibians and will ask what happens next after the year ends, and can the Year of the Frog become the Decade of the Amphibian?

16.00–16.30 **The role of government in responding to the amphibian crisis: the United
States as a case study**

Jeffrey Bonner (St Louis Zoo, USA)

It is clear that governments in general, and the government of the United States in particular, have the capacity to single-handedly fund the global effort to bring the 10% of critically threatened amphibian species into organized conservation-breeding programs in short order. This presentation examines the problems associated with tapping the incredible capacity of governments to respond to this crisis, using the United States as a case study. The presentation offers a short primer on the structure of the United States government and on government funding with special reference to earmarks, agency reporting language and introduced legislation as funding strategies. It goes on to detail the problems associated with each approach. We then examine the specific strategies that could be employed to generate an appropriately scaled governmental response and assess the likelihood of success associated with each strategy. An idealized approach is discussed, along with a critical analysis of this approach.

The main impediments to implementing a funding strategy relate to the lack of sufficient information on the priorities, capabilities, needs and specific costs of range state recovery efforts; the problems that arise due to our reluctance to import/export animals for conservation breeding; the lack of an organizational champion that can galvanize the required political pressure needed to force the government to act; the lack of support of our regional association to embark on such an effort (given other funding priorities and existing staff resources); the inability of other regional associations to support a United States-based recovery effort; the unwillingness of key conservation-breeding organizations to defer their specific institutional needs and interests to those of the greater good; the relatively poor history of the key conservation-breeding organizations to work together toward a common goal; and the unknowns surrounding the inevitable changes to the United States government and its functioning as a direct result of the 2008 elections.

16.30–17.00 **Amphibian survival alliance: the future of global amphibian conservation?**
Brian Gratwicke (Smithsonian National Zoological Park, USA)

We have recently made great strides in understanding global amphibian declines so that today, we can proudly point to several great examples of amphibian conservation. Nonetheless, the cumulative sum of these efforts is still inadequate to effectively arrest the global amphibian crisis. This is due in large part to the dearth of resources and people who are employed full-time to work specifically on amphibian conservation. The formation of an alliance of organizations—working to ensure the survival of the world’s amphibians—is required to build this much-needed capacity.

Two main strategies are envisioned to develop this goal: (1) To encourage major conservation organizations with significant existing capacities (e.g. communications, conservation policy, and fund-raising) to employ one or more staff who would be exclusively devoted to amphibian conservation—who would work internally to leverage new and existing resources and tap into existing institutional networks; (2) To create an independent, membership-based organization that will focus on building a global network of supporters to raise funds for amphibian conservation. This umbrella group would specifically be devoted to building capacity within nascent regional or topical organizations that are working to conserve the world’s amphibians, both through grants and by helping them to partner with larger conservation organizations.

SESSION VI: SUMMARY

Chair: Gordon McGregor Reid (WAZA and North of England Zoological Society, UK)

17.00–17.20 **Perspectives and outputs**

17.20–17.30 **Closing remarks**
Gordon McGregor Reid (WAZA and North of England Zoological Society, UK)

17.30 ***End of symposium***