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FrogLog

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Promoting Conservation, Research and Education for the World's Amphibians

Documenting Threatened Species in Brazil: A Conservation Photography Project

Newly Discovered Frog is a Transparent Twin with a Strange Song

Ancient Sedentary Frogs Move Over 350kms in a Day

... and so much more!

Bolitoglossa paraesnsis. Photo: Pedro Peloso.

FrogLog

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Editorial

Dear Friends,

It is with great sadness that we are sharing this message with you. Our friend, colleague and mentor, Professor Phil Bishop, passed away after a short and unexpected illness surrounded by family on Saturday, January 23rd, 2021.

Phil was a true great and such a bright light in all our lives. Our collective hearts break for Phil's family, all his friends and an entire conservation community. He touched so many lives and meant so much to all of us.

Phil was at the very heart of building a global amphibian conservation movement, and he ensured that this heart was a kind and inclusive one.

As Chief Scientist of the Amphibian Survival Alliance (ASA) since 2011 and Co-Chair of the Amphibian Specialist Group (ASG) since 2012, he was in his element when representing ASA and ASG around the world, welcoming new people, organizations and ideas to both. Phil was a living incarnation of selflessness and generosity, always willing to help and support anyone, even if he himself was up to his eyeballs in work, and all done with his characteristic brilliance and distinctive sense of humour. No challenge was too great and no concern too small. He brought his tenacity and deep love of amphibians to everything he did, reminding us all of the true meaning behind our work. It seems impossible to imagine a time without him, and yet the imprint of his expertise, dedication and personality is on everything we do. The number of people that Phil befriended and influenced became apparent over the last few weeks, with an outpouring of messages of grief and love from literally every corner of the world. The magnitude of his influence ensures that we will always be acting in his memory, honouring his passion and approach at every step. We will miss him beyond words, and will strive to continue his mission. Our gratitude as a community is boundless. So many of us will carry his memory and the flame of his torch throughout our lives, and endeavour to pass it on, just as he did.

Phil lived his life with intense purpose. As amphibian conservationists and as people we have our work cut out to continue the legacy of the extraordinary human being that Phil was. As Phil always used to say, "Let's do it!"

Thank you, Phil, for showing us, by example, how to be better people. You exemplified living life to the fullest and leaving the world a much better place.

The *FrogLog* Editorial Board has decided that the next edition of *FrogLog* will be a special edition and a tribute to Phil. That edition will also include a memorial book of sorts where members of the community will be invited to share their memories of Phil, or what Phil meant to them. We will keep the community posted through both the ASA and ASG websites and social media platforms on how to submit your contributions.

There is a hole in our hearts. It is in the shape of Phil.

FrogLog Editorial Board

NB: Given that the current issue of FrogLog was slated to be released at the end of 2020, we have chosen to retain the sidebar contents as they truly reflected FrogLog's constitution then. We will, however, be updating roles in the next edition of FrogLog.

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Loa Water Frog tadpoles. Photo Metropolitan Park of Santiago–Parquemet.

With Fewer than 20 Loa Water Frogs Left in the World, Hatching of Tadpoles Revives Hope for Critically Endangered Species

By Lindsay Renick Mayer

Nearly 200 Loa Water Frog (*Telmatobius dankoi*) tadpoles hatched Oct. 20, at the National Zoo of Chile, a little more than a year after a team of conservationists and government officials in Chile swiftly evacuated the last-known 14 frogs from perilously dry habitat and brought them to the zoo.

"The zoo's specialists not only nursed the animals back to health after they were discovered malnourished and near-death in the wild last year, but they have now succeeded in breeding a new generation of a species that has very nearly vanished," said Lina Valencia, Global Wildlife Conservation's Andes conservation officer. "While the zoo rears these tadpoles and breeds additional pairs, it is important that the government continues the great work it started in rescuing the animals by restoring and protecting the frogs' habitat so that they can return to their home in the wild."

In June of 2019, a team of conservationists and indigenous leaders discovered that the habitat of the Loa Water Frog outside of the city of Calama, located in the middle of the Atacama desert, had dried up as the result of extraction of water for mining, agriculture and real estate development, in a region where water is a scarce resource. All of the frogs had been pushed into a tiny pool of muddy water.

The team collected the last 14 individuals and brought them to the National Zoo of Chile—which belongs to the Metropolitan Park of Santiago, a public service of Chile's Ministry of Housing and Urbanism—to improve their health, learn to care for them, and establish a

A healthy Loa Water Frog in 2015 (left), compared to the malnourished Loa Water Frog (right) rescued this month from their dried-up habitat in Chile and taken to the National Zoo of Chile to be nursed back to health. Left photo: Claudio Soto Azat. Right photo: the Ministry of Housing and Urbanism of Chile)

Loa Water Frog specialists at National Zoo of Chile. Photo: Metropolitan Park of Santiago-Parquemet.

conservation breeding program. Now the zoo will navigate the challenging task of rearing a species that nobody has tried to care for before.

"When we brought these animals to the zoo, I didn't even know if they were going to survive the transfer from Calama on the plane to Santiago," says rescue team member Andrés Charrier, a herpetologist affiliated with the Chilean Herpetological Society. "Now we have the great news that these animals were able to reproduce, though we have a tremendous new challenge now to learn how to feed and care for the tadpoles. There is an incredible group of specialists—including all of the people at the National Zoo—working to save these frogs and making history."

The Loa Water Frog is considered Critically Endangered by the IUCN Red List of Threatened Species and was once found only in a single stream in Chile. Experts say there may be between five and eight individuals still living in the wild. Returning the species to the wild someday will require identifying a safe home for the frogs and protecting that habitat from the threat of illegal water extraction and habitat destruction.

"We are very happy that we have already achieved two of our three objectives," said Martin Andrade, director of Metropolitan Park of Santiago. "The first was the survival of the frogs that arrived from Calama as part of an emergency rescue operation, the second was the reproduction of these animals, and the third objective, which will take longer, is the reintroduction of this species back into its natural habitat."

There are at least 63 known species of water frogs, or *Telmatobius* species, found from Ecuador to Chile, including in Peru, Bolivia and Argentina. Many of these species, like the Loa Water Frog, are micro-endemic, which means they live in just one small place. Water frogs are semi-aquatic or entirely aquatic, making them very sensitive to any changes in their environment. Habitat destruction, pollution, disease and invasive trout are among the biggest threats they face. About 10 species of water frog live in Chile, and many of them are likely facing the same threats as the Loa water frog.

"This would not have been possible if it had not been for the tireless work of the National Zoo staff, who even had to replicate the exact conditions of the water in the streams of the deserts in the northern part of our country in order to keep them alive," says Alejandra Montalba, director of the National Zoo of Chile.

Global Wildlife Conservation, the IUCN SSC Amphibian Specialist Group, the Amphibian Survival Alliance, and the Santiago Metropolitan Park are asking people around the world to spread the word about the Loa Water Frogs using the hashtags #SaveTheLoaFrog and #SalvemosLasRanitasDelLoa to show their international support for these and other species of endangered frogs.

Oaxaca Treefrog (*Sarcohyla celata*). Photo: Luis Canseco Márquez.

IUCN Red List update!

By Kelsey Neam & Amaël Borzée

The IUCN Red List update 2020-3 is now online! This update is a huge accomplishment for the Amphibian Red List Authority (ARLA) as a record number of 1,333 amphibian assessments was published, an historical update in the history of the ARLA. This comes with some sad news, as three species are now listed as Extinct (EX) and a total of 99 species are in a higher threat category than in the past, 32 of which are uplistings due to genuine worsening of threats. Not everything is gloomy, however. The genuine improvement of 16 species in Mesoamerica gives us hope that some amphibians are showing resilience. Habitat loss and degradation, chytridiomycosis and climate change remain the main factors of declines.

Newly declared EX frogs:

Chiriqui Harlequin Toad (*Atelopus chiriquiensis*), changed from CR(PE) to EX. (Costa Rica & Panama). This once abundant toad has not been recorded since 1996, and extensive searches in the appropriate habitat, during the appropriate season and within the known range, have failed to locate this species. Its disappearance has been attributed, at least in part, to chytridiomycosis-related declines.

Wizened Harlequin Toad (*Atelopus senex*), changed from CR to EX. (Costa Rica). This formerly common species has not been recorded since 1986, and extensive searches in the appropriate habitat, during the appropriate season and within the known range, have failed to locate this species. Its disappearance has been attributed, at least in part, to chytridiomycosis-related declines. Climate change or the synergistic effects of multiple factors cannot be ruled out as playing a role.

Craugastor myllomyllon (no common name), changed from DD to EX. (Guatemala). This species is known from only a single female specimen collected in 1978. Numerous surveys between 1998 and 2019 have been unsuccessful in finding any other individuals, whereas other related species have been observed. The cause of its disappearance is unknown but we know that the habitat at the only known site has been destroyed by agriculture. Chytrid may have played a role, as it has affected many other robber frogs, but we just don't know for sure.

Genuine improvements (Possible recovery from *Batrachochytrium dendrobatidis* (Bd)-related declines and/or habitat protection):

Oaxaca Treefrog (*Sarcohyla celata*), changed from Critically Endangered to Near Threatened. (Mexico). This species is apparently recovering from a severe population decline and has recently been recorded at several sites. Its continued survival is entirely dependent on the protection and rigorous management provided by local communities. The municipality of Santiago Comaltepec has assigned a conservation area for La Esperanza where an area of cloud forest is protected and no agriculture or logging activities can take place. Without this level of protection, it is very likely that the species' habitat would be degraded and fragmented resulting in major population declines and would likely warrant an immediate uplisting.

American Cinchona Plantation Treefrog (*Isthmohyla rivularis*). This Mesoamerican tree frog species seemingly disappeared from most of its range in the 1980s probably as a result of infection with the chytrid fungus. In 2007, a population was rediscovered and as of 2019, the species has been recently recorded in five localities in Costa Rica, which suggests that it is beginning to rebound from the edge of extinction. However, this species remains rare and the surviving population is considered to be relatively small, so even though it may be recovering it's still facing all sorts of pressures including habitat loss and disease.

Adler's Mottled Treefrog (*Sarcohyla thorectes*). This Mexican tree frog species experienced a dramatic decline in the 1980s, probably due to chytridiomycosis, and had not been seen for around 30 years until a surviving population was found in 2007. From 2012-2019, it continued to be common within its small range and it seems that it avoided extinction (at least for now)!

Ancient Sedentary Frogs Move Over 350kms in a Day!

By Phil Bishop

Its been a long time coming, but finally, Orana Wildlife Park in Christchurch (New Zealand) have their *Leiopelma* captive breeding centre up and running. During the launch of the Year of Frog campaign in New Zealand I presented a talk on the global Amphibian Extinction Crisis to an eager audience in June 2008 at the annual Zoo and Aquarium Association (ZAA, Australasia) conference in Kerikeri, New Zealand (see www.nzfrogs.org/Resources/Frog+Week/Year+of+the+Frog.html). During the conference I was approached by Lynn Anderson (Chief Executive, Orana Wildlife Trust) and she expressed her desire to help prevent New Zealand's endemic frog species from being further threatened or going extinct. Orana Wildlife Park (run by the Trust, www.oranawildlifepark.co.nz) is internationally renowned for its involvement in zoo-based breeding programmes for endangered exotic and native species. It is set within an 80 hectare park within a short drive of Christchurch Airport and is home to New Zealand's only gorillas. During the latter half of 2008 Lynn and I discussed various ways that Orana Wildlife Park could assist with amphibian conservation, and it was decided that the best way for them to help was to create a purpose-built amphibian facility that doubled as a native frog breeding centre as well as an attractive display of all amphibian species in New Zealand. And so the planning began. The first foundations of the facility were thrown late in 2010 and then unfortunately on 22 February 2011, a major earthquake hit Christchurch killing 185 people and the major focus for all construction workers was diverted to rebuilding the city. Just as Orana were beginning to restart construction on the amphibian facility in 2013 they were struck by a massive gale force storm, the most damaging event in their entire history. The plans were mothballed once again and news that they had to build a gorilla facility to accept the gorillas from Taronga Zoo in 2015 further delayed its development.

While this was all going on, the frogs (*Leiopelma hamiltoni*, Vulnerable on IUCN Red List) were patiently sitting in my lab at the University of Otago (Dunedin), occasionally being disturbed for behavioural studies, or to take swabs for microbiome research, and more recently radio-transmitter trials. Some of these frogs were collected as adults on Maud Island in 2001 and most are likely to be at least 25 years old.

Once the gorillas had settled in it was time to concentrate on the amphibian facility once again, and this was perhaps the most technically challenging project ever undertaken at Orana Wildlife Park. Finally, the environmental controls had been fully installed and tested and the custom-made terraria were fully fitted with substrate, plants, sufficient UV lighting and simulated rainfall. We were ready to go, and the 18 frogs were put into their travel containers ready for the 350 km drive from Dunedin to Christchurch scheduled for 24 March 2020,

Photo: Debbie Bishop

almost 12 years after the initial discussions! What could possibly go wrong?

COVID19! New Zealand went into COVID19 Level 4 Lockdown at midnight on 25 March 2020, so while it was technically possible to get the frogs to Orana Wildlife Park before Lockdown, I might not be able to return to my home town and it would be likely that Orana Wildlife Park would be on 'skeleton' staff during the Lockdown period, which would be unfair on the staff, and on the frogs, so it was again post-poned. But we had waited 12 years, so what difference would another few months make?

Photo: Debbie Bishop

Once New Zealand entered Level 2 of Lockdown the frogs were packaged up and finally made the move to Orana Wildlife Park on 26 May 2020. During Lockdown one of the frogs developed a small abdominal lesion and did not make the journey as it was placed in a quarantine hospital terrarium to recover and will be joining its 17 companions at a later date. The frogs are all enjoying exploring their new homes and we wait with anticipation to see if Orana Wildlife Park staff can successfully breed these unusual frogs in captivity and we look forward to the official opening of New Zealand's one and only amazing amphibian facility once the country settles into the new post-COVID19 normal.

Good things take time; Better things take more time!

Almost 10 Years After the Development of the Conservation Strategy for the Titicaca Frog: What has Been Achieved?

By Roberto Elias[1,2,3,4], Matt Herbert[1], James Garcia[1], Tom Weaver[1], Jorge Rodriguez[3] & Yolanda Matamoros[3]

On July 9, 2020, the International Union for Conservation of Nature (IUCN) published the new categorization of the Titicaca Frog (*Telmatobius culeus*), going from being Critically Endangered (CR) to Endangered (EN). This is based on the assumption that the 80% decrease which was made in the 2004 evaluation was probably too high an estimate. Also taking into account the information available on the species, it is believed that it is highly probable that its population has experienced a decrease of at least 50% (but probably less than 80%) over three generations. Due to the uncertainty in the data, this re-evaluation takes a precautionary approach in the list and decides to lower it to EN under the A4acde criterion with what they believe is a more defensible and reasonable estimate (*1*).

The new categorization of the species served as a prompt for us to provide this progress update since the workshop to establish a conservation strategy for the species was carried out in 2010 in the city of Puno, Peru. The workshop included the participation of the Titicaca National Reserve (RNT), the Technical Forest and Wildlife Administration -(SERFOR) of Puno, the National University of the Altiplano, the Binational Special Project of Lake Titicaca, the Provincial Municipality of Puno, schools, community members, artisans, and others. The workshop was facilitated by the IUCN SSC Conservation Planning Specialist Group and Denver Zoological Foundation (DZF).

In this workshop the main threats to the survival of the species were identified: the illegal collection and trade for consumption as extract, the pollution of the lake, invasive exotic species such as trout and kingfish (Argentinian silverside), and the possible presence of one of the emerging infectious diseases that has infected and caused the extinction of many amphibian species around the world- chytridiomycosis (*2*). In the report published as an outcome of the workshop, it is mentioned that DZF made a commitment to initiate a conservation program for the species. Up until 2010, DZF had led only a captive breeding project that included two strategic partners: the Cayetano Heredia Peruvian University (UPCH), since 2007, and the Huachipa Zoological Park (PZH), since 2010. In addition to continuing the efforts of captive breeding it was suggested to add two more components to the project: in situ work and environmental education.

For this reason, in 2011 an alliance with the RNT began, with which the first efforts began to establish a monitoring methodology in the lake that would provide a population estimate, which was later published (*3*). At the same time educational activities began to be developed with the schools in the communities that live within RNT's protected natural area. These activities emphasized the conservation targets of the reserve, including the Titicaca Frog.

In Lima, the work of captive breeding paid off. In 2011 the first frogs were born at the PZH. Individuals have served as ambassadors of the species and some of their descendants are now exhibited in well-known zoos in the USA and Europe, including Denver Zoo which was the first zoo in North America to reproduce them. The PZH has also been the institution that has led educational activities for the conservation program in Lima in addition to collaborating with the RNT in Puno.

In 2012 DZF, with the help of the organization RARE, carried out a mini campaign in some localities of the Chucuito Peninsula on Lake Titicaca to promote alternative activities that allow additional economic income for a group of women artisans, decreasing their need to collect and sell frogs and in turn promote the species with their handmade products such as scarves, hats and woolen gloves using the frog's image. This initiative then gave rise to the Ccori Ampara Artisans Association, which is still active in trying to reach more people with their products.

These have not been the only achievements resulting from this workshop. In 2014, the Regional Government of Puno approved an ordinance declaring the frog as a species of regional importance (*4*) and has among its plans to create regional conservation areas in the lake as part of the species habitat.

The workshop also made it possible to increase the information on health issues, such as the study which reports the presence of potentially zoonotic bacteria on the skin of frogs confiscated by SERFOR (*5*), and those who recorded the presence of *Batrachochytrium dendrobatidis*, a fungus that causes the disease known as chytridiomycosis, in specimens in the lake and in confiscated individuals (*6, 7*).

Finally, to this we must add other accomplishments that although not a direct result of the workshop, have included the participation of the members of some of the key institutions (DZF and UPCH) that participate in the conservation program, such as in the incorporation of the species to CITES (*8*), an active participation in the creation of the bi-national (Peru-Bolivia) plan for the conservation of the frog and collaboration with the Ministry of the Environment with the content and photographs used to create a coin (legal Peruvian currency, frequently encountered in circulation) as part of a threatened wildlife of Peru coin series (*9*).

[1] Denver Zoological Foundation. [2] Universidad Peruana Cayetano Heredia. [3] IUCN SSC Conservation Planning Specialist Group. [4] IUCN SSC Amphibian Specialist Group.

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Recovering the Habitat of the Green Dotted Treefrog (*Dendropsophus molitor*) in the Bogota Savannah

By Yerson Cruz-Mendivelso, Estefania Gomez-Betancurt, Darwin Ortega-Chamorro, Catalina Rodríguez, Ecoparque Sabana Nature Reserve, Foundation Parque Jaime Duque, Cundinamarca, Colombia

The Andean region in Colombia has lost over 73% of its original vegetation covers, causing severe fragmentation (*1*). This situation has pushed many Andean species to reduced habitats without the chance to migrate, creating isolated populations as in the case of the Green Dotted Treefrog (*Dendropsophus molitor*). Even if it is very common, because of its distribution, it is facing several threats that might affect their population and the populations of other anuran species in the Andean region. Likewise, the wetlands this species inhabits are facing a rapid rate of loss, due to anthropogenic activities related to demographic growth and its consequences like urban expansion and industrial development. Many wetlands in the Bogota Savannah are polluted, reduced or dry, making it difficult for this frog to survive.

Wetlands in Tocancipá, an industrial municipality of Cundinamarca, present similar conditions. For that reason, in 2017 the Foundation Parque Jaime Duque declared two wetlands inside its property as nature reserves. To make this happen, the foundation ceased the farming production carried out in the zone where over 200 cows were present. This is how the Ecoparque Sabana Nature Reserve was created.

Considering all the consequences caused by the farming systems and the environmental problems in our region, the Foundation developed a restoration process that includes the protection of 60 ha of native Andean forest and the recovery of two wetlands (*Fig. 1*). The aim of the project is to provide habitat for native, resident and migratory species, helping to reduce negative impacts generated by industries and others, and to promote community participation. At that moment, it was possible to listen to some Green Dotted Tree Frogs singing in small temporal puddles of water that remained in the area in rainy seasons. However, in the dry season, it was very usual to find dead or dehydrated individuals trying to head from one puddle to another.

The Green Dotted Treefrog is an endemic species of Colombia, only found in Cundinamarca and Boyacá from 1600 to 3600 m asl. The species presents different color patterns (*Fig. 2*) depending on temperature and hormones levels (*2*). It is very common in wetlands, high-altitude scrublands and little ponds surrounded by vegetation as well as in disturbed areas such as grasslands, roadsides and human settlements.

With that in mind, the removal of livestock was crucial, and the first restoration action included the hydrogeomorphological reconfiguration of the wetlands, modifying its size, shape, depth, and the reduction of slopes. We also recovered the open water habitat of the wetlands, since aquatic vegetation totally covered them. The domi-

Fig. 1: A, Arrieros Wetland before the interventions. B, wetland slope and beach after the intervention. C, aquatic vegetation reintroduced in the wetlands. D, Trees planted in the border of the wetland. Photo: Darwin Ortega-Chamorro

Figure 2. Coloration patterns found in Ecoparque Sabana of the Green Dotted Treefrog. Photo: Fernando Castro-Vargas.

nant species were Kikuyo (*Cenchrus clandestinus*) and Common water hyacinth (*Eichornia crassipes*). As we controlled the invasive species, we reintroduced other typical aquatic species of wetlands of the Bogota Savannah like Broadleaf Cattail (*Typha latifolia*), Lamp Rush (Juncus effusus), California Bulrush (*Schoenoplectus californicus*), Dotted Smartweed (*Persicaria punctata*), Water Primrose (*Ludwigia hexapetala*) and Smooth Beggarticks (*Bidens laevis*). Other restoration actions included: creation of islands in the bodies of water, and plantation of over 70,000 native plants. These actions have provided habitat to several species of invertebrates and vertebrates, including *D. molitor*.

The role of the Green Dotted Treefrog in the Bogota Savannah ecosystems is essential to achieve our goals of restoration. The species contributes to the ecosystem structure and function. It supports decomposition and nutrient cycling and also controls annoying and dangerous pests. In other wetlands, where this species is absent, it is full of pest species as mosquitoes and other insects (*3*), changing the perception of the communities about wetlands, who can consider them just as dirty waters. We chose this frog as our conservation value object because of its endemism, the threats it is facing, and the investigation possibilities that could help other amphibian species in the region regarding the chytrid fungus (*4*). Besides, because it is our only amphibian species and the assessment of its population can give us an idea about the impact of the restoration process in the ecosystem's state. The selection process was arranged with the local community and the nature reserve team. To monitor its population, we have developed monthly surveys. In the Arrieros wetland, we have implemented a 1km transect across the border of the water body. While we go through the transect, we count all the individuals we can see and hear obtaining a measure of relative abundance. After increasing the open water area, an outstanding number of frogs appeared in the Arrieros wetland. Our counts rose from 7 to 10 individuals per month at the end of 2017 to over 30 individuals in 2019. At the beginning of the samples, most of the frogs concentrated in the aquatic vegetation inside the wetlands, making it harder to count them. Nevertheless, in the last samples we executed, the Green Dotted Treefrog has begun to use the trees we planted, as its name indicates (*Fig. 3*). We have also noted that more males vocalize before nightfall, a behavior that was not common before. Other important features, like the increase in the recording of tadpoles and amplexus, and the decrease of dead and dehydrated records, show us we are in the right way in the restoration process.

Fig. 3: A, an individual perching on *Oreopanax floribundum* planted in Arrieros wetland. Photo: Yerson Cruz-Mendivelso. B, Amplexus recorded in the Arrieros wetland. Photo: Fernando Castro-Vargas.

We have several questions about the natural life history of the species that have not been resolved. In the short-term, our goal is to mark the individuals found to estimate the size of the population.

In the eastern hills of Bogotá and in wetlands similar to those found in Ecoparque Sabana, up to eight species of amphibian have been reported. The richness of these sites, in comparison with our reserves, allows us to think that in the future, the richness and abundance of amphibians should tend to increase. This will be only possible if the restoration processes advance and if we improve the connectivity of the natural reserves of the Parque Jaime Duque with other natural spaces. Additionally, the establishment of the understory and the growth of the layer of leaf litter could trigger the arrival of other amphibians from the region which, in certain cases, require soils that conserve humidity and leaf litter to hide.

Acknowledgements:

This project is possible thanks to funds provided by the Foundation Parque Jaime Duque and the participation of Fernando Castro and Jonathan Candil from the monitoring and research team, the revegetation and management team led by Leydi Cabrera and her team of ecological restorers that are part of the local community, Juan Carlos Guaquetá, and his team in the plant nursery, Edwin Pérez and his team from the social management and education team, and all the people who have visited the reserve and contributed in the restoration process.

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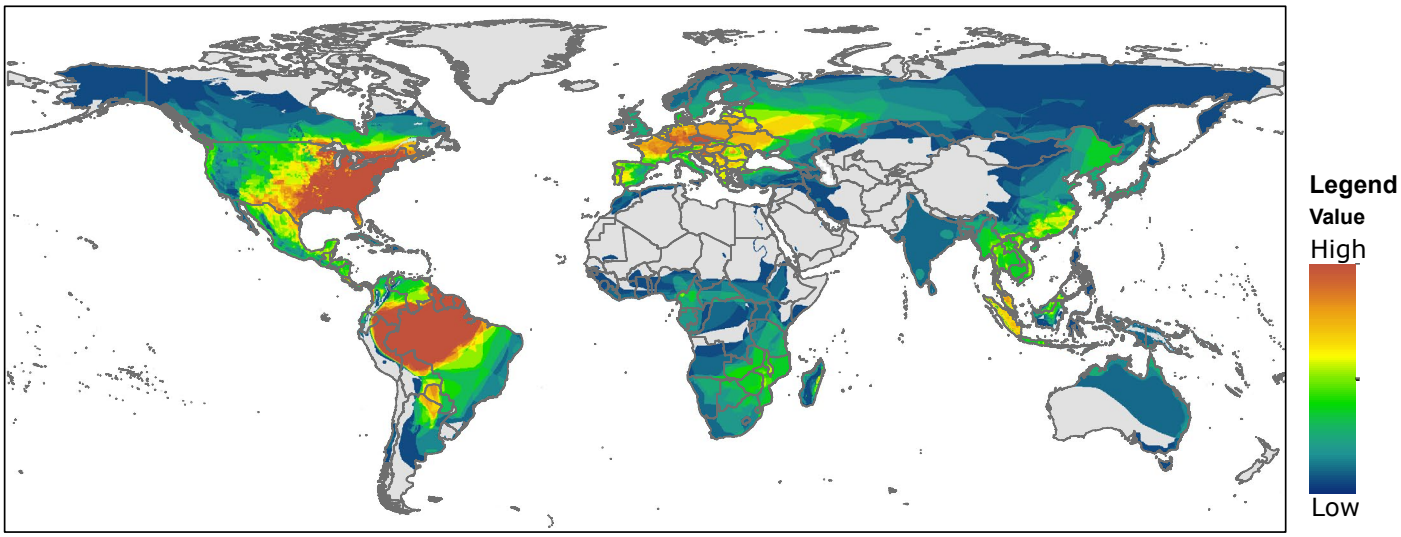
Distribution Patterns of Threatened Amphibians in the Zoo and Aquarium Community: A Call to Action

By Ariel Jacken[1], Dr. Dennis Rödder[2] & Prof. Dr. Thomas Ziegler[3]



Distribution of amphibian species in European and North American Zoos (maximum richness: 41 species).

A scientific paper recently published in the International Zoo Yearbook, zoo databases were investigated for threatened amphibian holdings. A decade after the Amphibian Ark and European Association of Zoos and Aquaria launched the campaign 'Year of the Frog', the study's results suggest a need for a stronger response from zoos to the global amphibian crisis so as to fulfill their self-imposed goal: to be key players in *in situ* and *ex situ* conservation.

In this study, emphasis was laid on *ex situ* conservation and the amphibian species selection in public zoological collections on a global scale. Anurans (76%) made up the largest taxon in collections, followed by caudates (22%) and caecilians (2%). In total, only about 7% of amphibians in general (540 species) were represented in zoos. The order Caudata was best represented, with 121 of 695 species kept in zoological collections (17.4%), and with Salamandridae the most common family found in zoos. Out of 6758 anurans, 411 species were kept in zoos (6.1%). In contrast, caecilians appeared to be grossly under-represented: only eight of the 205 species were to be found in zoos (3.9%). Given the global species richness of amphibians, with currently over 8,000 known species, this result indicates a rather poor representation. Over 10 % of kept species were represented by a single specimen, and only 10.4% were kept in sufficient numbers and in several collections.

Thus, although amphibians are the most threatened vertebrate class, with 41% being threatened with extinction, globally threatened amphibians still play a subordinate role in zoos and their appearance is often restricted to a single collection (44.3%). Just about 4.3% of amphibian species which are recommended by the Amphibian Ark for *ex situ* conservation made their way into global zoo collections. Despite the overall perception that the global zoo community, with few exceptions, has failed to establish and maintain breeding populations of threatened amphibians, it is essential to note that the underlying analysis was a broad and global approach to investigate the overall response to the amphibian crisis. Undoubtedly, some zoological institutions have gained experience on research, husbandry expertise, reproduction and *in situ* and *ex situ* conservation, and public education. However, to date, the overall response to establish conservation breeding programs for threatened amphibian species by the zoo and aquarium community has been weak and slow. Almost three-quarters of amphibian species in zoos and aquariums were not threatened in the wild and, thus, had no direct *ex situ* conservation impact.

To gain further understanding of focal areas of amphibian species richness in zoos a species richness analysis was performed for all species kept in zoos, revealing strong regional differences in coverage and foci. Large numbers of zoos in North America and Europe appeared to be of great importance for a number of species, with many of them from tropical regions. This result offers a strong argument against the formulated claim that zoos in general should restrict their population planning and species selection to native species only. Cooperation between European and North American zoos with partners in the tropics has helped improve *in situ* research as well as developing *ex situ* measures. Phasing out exotic species in a regional collection plan and focusing exclusively on native species helps to boost native biodiversity, and might work in a region such as Australia; however, such a policy might have disastrous consequences if applied in regions such as Europe and North America. The highest number of species facing extinction occurs in the tropics, where there is a comparatively low density of zoos and aquariums that are equipped to respond to the amphibian crisis. Thus, the role of North American and European zoos in maintaining amphibian collections of global importance was highlighted, as they have the holding space and the knowledge in husbandry and breeding amphibians from different taxa and zoogeographic realms, thus providing an important keeping and breeding network for tropical species.

However, the distribution of these institutions does not match the distribution of most amphibian species in need of *ex situ* rescue. A stronger shift of zoos towards managed conservation breeding of threatened amphibians and expansion of the cooperation with local

[1]Leipzig Zoo, Germany. [2]Zoologisches Forschungsmuseum Alexander Koenig, Bonn, Germany. [3]Cologne Zoo, Germany

Vietnamese Crocodile Newt, *Tylototriton vietnamensis* (IUCN Red List Status Endangered), Cologne Zoo. Photo: T. Ziegler.

partners in the countries of origin will help to enforce the response of zoos to the amphibian crisis. Further, a shift from keeping common to managing threatened taxa is recommended in a coordinated framework. A better representation and higher number of threatened taxa in human care, and a growing number of conservation breeding programs and more cooperation with local partners (breeding centers and universities), should be utilized to invest in targeted threatened taxa and extend breeding groups/offspring in zoos. A closer cooperation of zoos, research institutes and private breeders within the frame of Citizen Conservation programs within specialist groups focusing on certain taxa was recommended and assumed to be beneficial for all contributing parties. Existing foci in amphibian collections of zoos and cooperation with specialized breeding centers in the country of origin should be utilized.

We should note that only zoo databases were investigated, thus the focus was on amphibians in zoos. There are also successful *ex situ* amphibian conservation programs in organizations other than zoos such as universities, museums, privately-managed conservation organizations, etc. (*e.g.*, https://progress.amphibianark.org/progress-of-programs). This is particularly true in in Central and South America, where these programs partly counterbalance the low representation of amphibians in local zoos. These include many species which have been recommended for *ex situ* rescue via Conservation Needs Assessments and are being maintained, bred, and in some cases reintroduced back to the wild. The aim of the recently published study was to encourage zoos to reconsider the application of their facilities, time and commitment beyond show exhibits and environmental education. Zoos certainly can play a key role in amphibian conservation by providing their expertise, capacity and specialized facilities for the research and conservation breeding of threatened amphibians, using the One Plan Approach to Conservation supported by IUCN, as some zoos are already doing. But this is a great opportunity for more zoos to join in, because with the global amphibian crisis the time to act is now.

Staurois parvus **(IUCN Red List Status Vulnerable), Cologne Zoo. Photo: T. Ziegler.**

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Photo: Steven Allain

Special Issue on Emerging Diseases and Infections in Herpetofauna

By Steven Allain & Amanda Duffus

As many of you will be aware, we are experiencing unprecedented declines in biodiversity globally in an event that biologists have named the sixth mass extinction. The two biggest obstacles facing the natural world are habitat loss and anthropogenic environment change, particularly for amphibians and even some species of reptiles. However, emerging infectious diseases are also partially responsible for large scale declines and the extinction of species, such as in the case with the amphibian chytrid fungus *Batrachochytrium dendrobatidis* (Bd) which was described formally in 1998 but has been identified to drive declines before this. In 2013, another pathogenic fungus in the genus was identified after causing an unprecedented decline in fire salamanders in the Netherlands: *B. salamandrivorans* (Bsal). Bsal threatens salamander species around the world, although for now it appears to be confined to Europe and Asia.

In reptiles, other species of pathogenic fungi have recently emerged such as *Emydomyces testavorans* (formally identified in 2009) and *Ophidiomyces ophiodiicola* (case definition described in 2019), affecting freshwater turtles and snakes respectively. Ranaviruses are emerging pathogens of both amphibians and reptiles, with a global distribution.

During this time of drastic biodiversity loss, the level of international trade of captive and wild animals has never been higher. It is through these pathways that such diseases are more likely to emerge, finding new hosts or being transported to different continents, leading to the spread of potential pathogens to new species with sometimes devastating consequences.

There are a large number of bacterial, fungal, protozoan, and viral infectious agents that affect amphibians (and reptiles) that we know relatively little about. Therefore we have started a new research topic in Frontiers in Veterinary Science titled '*Emerging Infections and Diseases of Herpetofauna*'. In this issue we seek submissions that examine all aspects of emerging infections and diseases in amphibians and reptiles, including field studies, modelling approaches to understand infection dynamics, treatment methods, pathological investigations, and new diagnostic techniques. The deadline for abstract submissions was 3rd August 2020 however completed manuscripts can still be submitted until the 30th June 2021. You can find more information here.

The Journey of the Mapping Malabar Tree Toad Program Logo

By Kaushik Kannan[1] & Srushti Chiddarwar[2]

A well made logo, especially for a conservation project on lesser known species like amphibians, draws necessary attention from the public as well as clearly communicates the crux of the project. The ideation behind this logo was a long and time consuming process. We faced a bunch of challenges along the way and it was imperative that all designing minds were on deck to overcome them.

The design team consisted of Kaushik Kannan, K.V. Gururaja and Srushti Chiddarwar. Harikrishnan and Ravi Chellam were a crucial part of overseeing the meetings and giving direction when conversations seemed lost. The brief was direct. The logo needed to convey the crux of the project, that is mapping the Malabar tree toad (*Pedostibes tuberculosus*) (MTT). A collaborative project is a venture which when done right results in really fruitful, sustainable work. Here, collaboration itself was being challenged by the unavoidable limitations on social interactions in person. Improvising via video calls was the only option available. Every meeting on video call resulted in moving slightly closer to bring the project to life. All ideas that were pitched were being challenged, justified and cultivated to bring the logo to where it stands today. Amidst the chaos of the pandemic, the five of us put our ideas on the table with hope for the future which transcended boundaries of isolation to come forth as a beautiful graphic. This is its journey.

Fig. 1.1 *Fig 1.2* *Fig 1.3* *Fig 1.4*

Fig 1.5 *Fig 1.6*

Fig. 1: The design process.

Fig. 2: Final logo design

Initial ideations involved deciding the various elements of the logo followed by visually balancing them to fit the aesthetics, scalability and retaining value in its grayscale version. The challenging part about this logo was the fact that there wasn't enough information about the toad online. In a world where people rely on the internet almost entirely, we had to take the approach of going through academic papers based on the little field work done to find out about the toad. We were clear about what was not needed for the logo. It's complex texture and pattern were given the least priority as a logo is about simplicity and scalability. That left us with other unique features of its anatomy. For example, its bulgy eyes, wedge shaped toes, and its very prominent snout. Using this information we ideated and sketched our very first bunch of logo iterations centered around the frog itself (*Fig. 1*).

Our challenges truly began when the individual elements of the logo seemed to be lost in translation, there was hardly any balance between them for the logo to be wholesome. As the complexities began to intensify, we took a step back to inform ourselves of the crux of the project. It was about mapping and locating the toads. Here, Guru's insight of incorporating a location symbol proved extremely helpful.

We had a few directions to explore and as we got to the creation part some interesting ideas began to emerge. Some of them were loosely based on these ideas:

- Elements to show the searching process for the toad.
- Need to show human elements to establish connection between manpower and the mapping process
- Indicating the terrain where the Malabar tree toad resides.

After a few iterations the logo began to take a shape that conveyed the narrative of the project. Soon it was about placing elements together harmoniously. Then it was about testing a refining to see the various options of the logo that were put together. Here is how it went.

Once the elements worked together the technicalities behind the anatomical features had to be resolved.

For example: The snout needed to have nostrils, the feet needed to be triangular in shape along with slight changes to the iris of the toad. The final version of the logo (*Fig. 2*)has 4 main components to it.

- The location symbol that shows the task behind the initiative that is pin pointing the location of the toad
- The negative space inside the location symbol shows the magnifying glass which also the crux of the task at had
- Enclosed within the magnifying glass is the toad itself. It is symbolic of the MTT, the species that needs to be mapped.
- The mountains are used to show the terrain to which the MTT is endemic to. The mountains are cut again with the frog legs to further indicate the dependency of the frog with the terrain.

Acknowledgements

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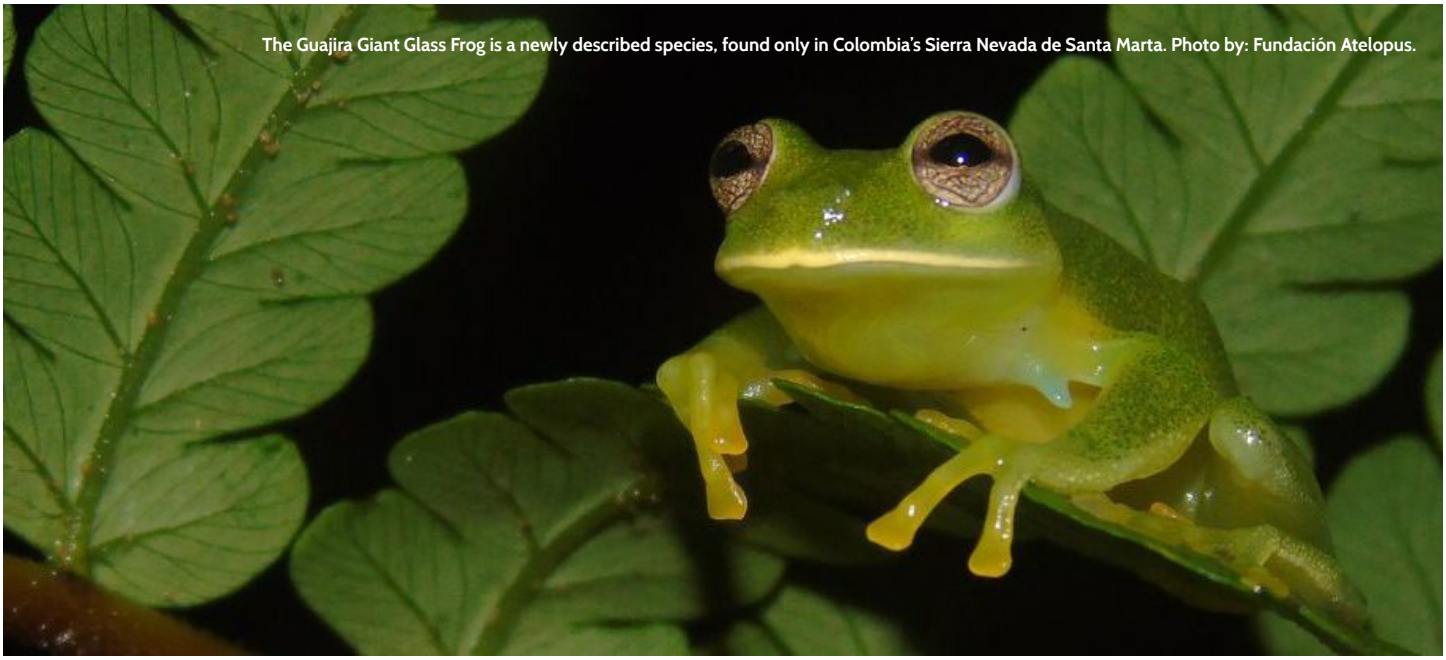

The Guajira Giant Glass Frog is a newly described species, found only in Colombia's Sierra Nevada de Santa Marta. Photo by: Fundación Atelopus.

This Newly Discovered Frog is a Transparent Twin With a Strange Song

By Lindsay Renick Mayer

The wild musicians of Colombia's Sierra Nevada de Santa Marta put on a concert every night with the setting of the sun—the low grunt-like hoots of the owl monkey's war whoop, the cicada-like call of Walker's Sierra Frog and the cacophonous chirps of real cicadas harmonizing in a symphony of life unique to this place. So when Colombian biologist José Luis Pérez-González heard the call of an unusual amphibious vocalist in the creek beside his campsite, he suspected that he and his team had inadvertently stumbled across a frog species new to science.

"We had gone out on an expedition to survey a population of harlequin toads and on the way back decided to sleep by a creek because we were too far from the city to make it by nightfall," says Pérez-González, the vice president of GWC's partner Colombian NGO Fundación Atelopus. "We got bored and went to explore the creek where we found a glass frog—but the frogs' calls were markedly different from the call of the species we already knew, the endemic Magdalena Giant Glass Frog. It was a beautiful experience to find an entirely new species just because we were being lazy. It was a real stroke of luck."

Although that trip was in 2015, Pérez-González and team weren't able to publish their discovery of the new species, the Guajira Giant Glass Frog (*Ikakogi ispacue*), until 2019 in scientific journal PLOS ONE. The frogs' call was certainly distinct, but physically it appeared to be the same as the Magdalena Giant Glass Frog (*Ikakogi tayrona*), previously the only known species in this group of Ikakogi glass frogs, so they needed more information to be sure.

It was only by going on a number of additional expeditions through torrential downpours and thick jungle underbrush back to the site that the team could determine that this was truly a new species, finding differences in tadpole morphology, confirming the differences in the frogs' vocalizations, and finally and conclusively through DNA analysis. The discovery team included researchers from the University of São Paulo in Brazil and the Colombian universities of the University of Magdalena, University of Quindío, University of the Andesand the National University of Colombia.

"Having the fortune to discover a healthy population of a new frog species gives us hope in the context of extinction, reminding us that there are opportunities to maintain and protect our wonderful biodiversity, and that we need to act soon to secure a future for all of the wildlife around us," says Lina M. Valencia, GWC's Colombia Conservation Officer. "This is especially true in the Sierra Nevada de Santa Marta, which is an untouched and understudied place, a magical place of wonder and natural discovery. It holds the incredible promise of abundant opportunities for discovery and protection."

A TALE OF TWO GLASS FROGS

These two Ikakogi glass frog species are part of the broader Centrolenidae family of glass frogs. Glass frogs are known for having partially or fully transparent underbelly skin, revealing their innards. Their tadpoles live in muck and leaf litter on the bottom of streams and often appear blood red because their blood flows close to the surface of their skin to help them survive the oxygen-poor environment. They also have green bones and the males take care of offspring—though the Magdalena Giant Glass Frog and Guajira Giant Glass Frog appear to be the only glass frog species that have white bones and are among the few glass frog species where the females take care of the offspring (and do so for a notably long time). Biologists aren't yet sure why Ikakogi frogs evolved these differences.

Because the Magdalena Giant Glass Frog and the Guajira Giant Glass Frog are identical in appearance, they are considered "twin" species, a fact that played a key role in the naming of the Guajira Giant Glass Frog. The species' scientific name, *Ikagoi ispacue*, comes from the indigenous Kogui people's words "tshi" and "spákue," meaning "twin of."

Including the indigenous community in the naming of this species—and its conservation—is imperative to the animal's future, Valencia says.

"For many generations, indigenous communities have lived in and

The original expedition team that discovered the Guajira Giant Glass Frog, which was just described in a paper in PLOS ONE. Photo: Fundación Atelopus.

protected these beautiful yet fragile ecosystems," Valencia says. "They are the guardians and the stewards of these territories, this is their home, and what ultimately threatens biodiversity also threatens them. Their traditional knowledge, practices and culture is intrinsically linked with nature. It is therefore critical that we work with indigenous people to successfully achieve conservation objectives."

In addition, the four indigenous communities that live in the Sierra Nevada de Santa Marta—Arhuaco, Kogui, Wiwa and Kankuamos—have a deeply rooted relationship with nature, including a tremendous respect for the role that frogs play in the ecosystems that sustain all life on Earth. For these indigenous groups, frogs are a symbol of fertility and ecosystem health.

"Nature is a living organism that produces life. It has its own history and we as humans were made to live alongside it. To do that, we need to understand nature and its stories," says Lorenzo Gill, an indigenous member of the Wiwa community. "What do we have to do to keep protecting species in La Sierra and newly discovered species like this frog? The most important thing we can do is to identify them and, with our indigenous leaders, create a story around them that helps us understand the role they play in our lives and how we can live alongside these new frogs."

TREASURE TROVE OF BIODIVERSITY

There are 78 species of glass frog species that live in Colombia—more than half of the total number of glass frogs in the world. Sierra Nevada de Santa Marta, which is the tallest coastal mountain on Earth and one of the planet's most biodiverse and irreplaceable places (and a Key Biodiversity Area), is a notable haven for amphibians generally, with 17 amphibian species that live here and nowhere else in the world.

This includes five harlequin toad species, one of GWC's priority groups of species. When Pérez-González and team set out on their trip, they were looking for a reportedly new population of harlequin toads. Sierra Nevada de Santa Marta is home of one of the last-remaining populations of harlequin toads in high-altitude ecosystems.

Unfortunately, even as species are discovered and rediscovered in this area, they're also coming under threat. The peace treaty signed in 2018 with the left-wing FARC guerilla group ended the civil war, giving conservationists the opportunity to get a stronger handle on the country's biodiversity—but also increasing the risk for rapid forest loss through development. In addition, the deadly infectious disease chytridiomycosis, caused by an amphibian chytrid fungus, has wiped out hundreds of frog species worldwide and continues to pose a threat to Colombia's amphibians.

"The discovery of this new glass frog is a call to action," says Pérez-González. "We all know that this is a place of high endemism, but the truth is that few conservation actions are in place. We need management plans at the regional and national levels that allow us to invest resources and take actions to conserve the Sierra Nevada de Santa Marta."

Pérez-González reports that the population of the newly described species seems to be stable, but conservation actions will depend, in large part, on an IUCN Red List assessment of how close the Guajira Giant Glass Frog may be to extinction given the threats in the area.

"The first step toward the conservation of this newly recognized glass frog will be to assess its extinction risk, on both the National and Global Red Lists, by considering aspects of its range, population status, and threats," says Kelsey Neam, GWC's Biodiversity Assessments Coordinator. "Only then can an effective conservation plan be designed and implemented to ensure that this population of unique frogs remains healthy in the Sierra Nevada de Santa Marta for millennia to come."

The Golden Toad (*Incilius periglenes*).

Thirty Years After the Last Golden Toad Sighting, What Have we Learned?

By Ethan Freedman, Rainforest Trust

The story of Costa Rica's Monteverde Cloud Forest is like so many other protected areas. First, biologists noticed incredible species in an ecosystem. In Monteverde's case, the forest contained tropical birds like the Resplendent Quetzal and amphibians like the Golden Toad (*Incilius periglenes*). But then, like so many other protected areas, they also documented threats — in this case, habitat degradation from squatters and hunting. So, at last, they worked to protect the forest.

And thus, the Monteverde Cloud Forest Reserve came into existence in 1973. Soon after opening, it hosted tourists and researchers from around the world. The reserve grew over time, offering more and more protection for its species.

All went according to plan.

Until it didn't.

The Golden Toad was endemic to the Monteverde Cloud Forest — found nowhere else on Earth. The species was a brilliant burnt-yellow, prone to easy spotting in its thick, green rainforest home. That's if you were around during the short time the toad was above ground. The species spent most of its life underground, emerging only for a few days at the end of the dry season to mate.

Spotting the frogs must have been an incredible sight to behold. In 1987, between April and July, researchers noted nearly 1,500 adult toads scattered between a few shallow pools around the forest. Imagine — these bright yellow toads, seen once a year, all converging on puddles to breed before retreating underground.

But in 1988, scientists found only one toad, a male, in the same area. They documented nine more a couple of miles away.

And then in 1989, they spotted one male toad — and nothing else.

In 1990, they found none.

And so it's been ever since. Finally, in 2004, the International Union for Conservation of Nature declared the Golden Toad "Extinct."

From 1,500 to 10 in one year. From 10 to one in the next. That is, respectively, a 99% drop and a 90% drop. Of course, going from one to zero is a 100% decline.

What lead to this precipitative drop?

This question leads into a near thirty-year debate on why, exactly, the Golden Toad went extinct. A paper in 1992 (when researchers still hoped some toads were hiding somewhere) noted that in 1988-1990, rainfall started later after the dry season. What's more, the rain came down heavier at first, instead of slow to start. The pools used for frog breeding filled faster, which may have removed the window of shallowness needed to breed.

They speculated that small changes in climate might lead to catastrophic collapse. With the scientific community now examining the

Another victim of the chytrid fungus, from Panama. Photo: Brian Gratwicke.

effect of global warming on ecosystems, this was significant.

But around the same time, amphibian researchers discovered another, once-hidden threat. Researchers around the world found a striking similarity in precipitous amphibian population declines. It seemed amphibians were on the verge of collapse everywhere — and no one could figure out why.

In 1993, researchers first found a possible culprit. Fungi in the genus *Batrachochytrium*, also known as "chytrid" was causing a fatal disease called chytridiomycosis. After decades of research, we know that at least two chytrid fungal species can lead to the disease. Researchers today cite the chytrid fungus as the likely cause of extinction for the Golden Toad. And, I should add, dozens of other amphibian species. The crisis is still occurring. Amphibians are dying everywhere, with species clinging to existence. It's the most deadly threat to biodiversity you've never heard of.

But we're still uncertain of where chytrid came from, why/how it becomes fatal or how it spreads. Some scientists argue that climate change might alter the fungus's growth pattern, leading to disease. Others note that amphibians have a chytrid-fighting bacteria on their skin. But something in the environment — like chemical pesticides or other pollution — might impede their immune response to the fungus. The spores can spread through soil and water, but they might also spread through rain.

We also don't know how to stop it.

This threat doesn't bode well for the Monteverde Cloud Forest Reserve. In fact, this type of threat doesn't bode well for habitat protection at all. Climate change, fungal diseases — these won't stop at a fence. A forest guard can't stop these threats from passing into a reserve. Why even protect land if indiscriminate threats can still kill wildlife?

But while protected areas aren't catch-alls, they're not useless. As the world's ecosystems face a multifaceted barrage of threats, we need to keep habitats as intact as possible. Much like ecosystems, threats to ecosystems are interconnected.

Climate change can reduce rainfall — leading to wildlife migration outside protected areas in search of water. But protecting more land increases the likelihood they can find drinking water within a reserve.

Poaching targets individual animals for meat. But if habitat degradation causes a decrease in pollinator species, crops may not offer enough food for a family anymore. They might poach to survive.

Habitat is the basis of ecological survival. Land conservation is the first step for any species facing extinction because any conservation program is useless without habitat. Intact ecosystems are their own support systems — the more of an ecosystem remains intact, the more resilience it has against threats. Habitat loss is the leading cause of extinction worldwide, so habitat protection is one of the leading necessities of preventing extinction. Fences may not stop killer fungi, but they do keep species happy otherwise — making them stronger in the face of killer fungi. We've also rediscovered species once thought to be extinct in protected areas — like the "golden wonder" salamander.

In the thirty years since the last Golden Toad sighting, scientists and amateur herpetologists alike have searched in vain for the little, colorful amphibian. They've found zilch, nada, squat — every time. Over time, the Golden Toad has become a symbol of extinction and the amphibian biodiversity crisis. This week, many herpetologists mourn one of the world's most-analyzed and rued amphibian losses.

Thirty years later, amphibians are still on the edge of oblivion. But in those thirty years, we've discovered chytridiomycosis. We've developed more plans to build ecosystem resiliency in the face of climate change. We've expanded protected areas, including the Monteverde Cloud Forest Reserve. Rainforest Trust actually helped secure an additional 100 acres for the reserve in 1993.

The work we've done to prevent other frogs from the Golden Toad's fate hasn't been enough. But it's been a start. And you can't get anywhere without that.

Climate Change Responsible for Severe Infectious Disease in UK Frogs

By Zoological Society of London

Climate change has already increased the spread and severity of a fatal disease caused by *Ranavirus* that infects Common Frogs (*Rana temporaria*) in the UK, according to research led by ZSL's Institute of Zoology, UCL and Queen Mary University of London published in *Global Change Biology* (*1*).

Historic trends in mass-mortality events attributed to the disease were found to match the pattern of increased temperatures recorded over recent decades, with disease outbreaks predicted to become more severe, more widespread and occurring over a greater proportion of the year within the next few decades, if carbon emissions continue at their current rate.

The research conducted by international conservation charity ZSL (Zoological Society of London), UCL, Queen Mary University of London and University of Plymouth used a three-pronged approach involving cell cultures, live models and historic data from the Met Office and Froglife's Frog Mortality Project, with the research demonstrating that warm weather where temperatures reach 16°C, dramatically increases the risk of *Ranavirus* causing a disease outbreak in common frogs.

The findings help explain the seasonality of the disease, with incidence peaking during the hottest months of the summer, showing that climate change could see outbreaks becoming more frequent from April to October. Disease outbreaks in the spring could result in the deaths of large numbers of tadpoles, which could have repercussions for population survival. Up to now, *Ranavirus* disease has been largely restricted to England, but as average monthly temperatures increase to exceed 16°C in more areas over longer periods, as predicted by the IPCC's high carbon-emission model, the disease is likely to spread across most of the UK in the next 50 years.

Dr Stephen Price, lead author from ZSL's Institute of Zoology and UCL said, "Climate change isn't something that's just happening in far-away places – it's something real and present that's already had hard-to-predict impacts on wildlife in our own back gardens here in the UK.

"A number of scientists have already alluded to the fact that climate change could increase the spread of disease, but this is one of the first studies that provides strong evidence of the impact of climate change on wildlife disease, and helps to explain how it may facilitate the spread of *Ranavirus* across the UK."

ZSL scientists suggest that frogs may be better able to cope with infection if they have areas in which they can cool down – adding log piles, vegetation or nearby shady patches as well as keeping ponds deep will help reduce the level of sun exposure frogs receive, and thus reduce the growth rate of the virus.

Dr Reid Harris, Science Advisor from the Amphibian Survival Alliance added, "The authors present convincing evidence that the disease caused by ranavirus is more lethal to amphibians and more likely to spread as temperature increases, which will continue to be of great concern as the planet warms. Lowering temperatures in ponds by increasing shading could help, but unfortunately another disease killing amphibians, chytridiomycosis, seems to be at its most powerful in cooler habitats. This creates a conundrum for amphibian species affected by both diseases. A mitigation method that is largely independent of temperature, such as a vaccination strategy, may be the best solution for these species."

Professor Trenton Garner at ZSL's Institute of Zoology said, "Many studies in amphibian disease cannot do much beyond saying 'we have a problem'. This research offers a number of options for mitigation; however, this is only a short-term solution of course – if we don't eventually slow and reverse human-driven climate change, we unfortunately can only expect things to get worse for our amphibians."

To find out more about ZSL's amphibian health work, please visit: www.zsl.org/science/wildlife-health

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Photo: Lewis Campbell

Joint Amphibian Assessment Workshop in Honduras

By Luis Carrillo[1], Louise Hobin[1], Kevin Johnson[1] Jennifer Luedtke[2] & Kelsey Neam[2]

Amphibians are the most threatened group of vertebrates globally, with 41% of species at risk of extinction. Most of these species are threatened by human activities and can be effectively protected through well-informed strategic conservation. It is therefore of the utmost importance to continue identifying the most highly threatened amphibian species through the IUCN Red List of Threatened Species and prioritizing the conservation actions critical to their survival.

THE AMPHIBIAN RED LIST AUTHORITY

The International Union for Conservation of Nature (IUCN) is the world's oldest and largest global environmental organisation, with more than 1,300 government and NGO members worldwide. The Species Survival Commission (SSC) is the largest of IUCN's commissions with a global membership of over 8,000 voluntary experts. Under the guidance of the IUCN SSC, the Amphibian Specialist Group (ASG) is the world's leading body of scientific and practical management expertise on the status and conservation of all amphibian species. The ASG Amphibian Red List Authority (ARLA) is the group responsible for maintaining the amphibian data on the IUCN Red List.

The overall aim of the ASG is to promote the long-term conservation of these species and their environments worldwide, and the recovery or restoration of populations and ecosystems where feasible. Our mission is to provide the scientific foundation for effective conservation action worldwide.

THE IUCN RED LIST

The IUCN Red List of Threatened Species is the global authority on the conservation status of species and is critical to a wide range of conservation applications. For example, its data are used to identify Key Biodiversity Areas (KBAs) for conservation and to inform policies and international agreements, such as the Convention on International Trade in Endangered Species (CITES). It is also used to guide scientific research priorities and track the impact of conservation action.

The Global Amphibian Assessment (GAA), completed in 2004, was the first comprehensive study of the conservation status of all known amphibian species in the world. The second Global Amphibian Assessment is now underway and the ARLA is working to ensure all 8,000+ species of amphibians have an up-to-date extinction risk assessment on the IUCN Red List.

THE AMPHIBIAN ARK

The Amphibian Ark (AArk) is a joint effort of three principal partners: the World Association of Zoos and Aquariums (WAZA), the IUCN SSC Conservation Planning Specialist Group (CPSG), and the ASG. AArk is a partner in the Amphibian Survival Alliance (ASA), and we were formed to address the captive (*ex situ*) components of the Amphibian Conservation Action Plan.

Our vision is the world's amphibians safe in nature, and our mission is ensuring the survival and diversity of amphibian species focusing on those that cannot currently be safe-guarded in their natural environments.

[1]Amphibian Ark
[2]Amphibian Red List Authority

CONSERVATION NEEDS ASSESSMENTS

With limited conservation resources and thousands of threatened species in need of help, the Conservation Needs Assessment (CNA) process, managed by the Amphibian Ark, seeks to objectively and consistently identify priority species and their immediate conservation needs.

Using a transparent, logical and objective method, the CNA process uses current knowledge of species in the wild to determine those with the most pressing conservation needs and provide a foundation for the development of holistic conservation action plans that combine *in situ* and *ex situ* actions, as appropriate. Conservation Needs Assessments generate national prioritized lists of species recommended for one or more conservation action. These can subsequently be used to assist in the development of species recovery plans and national action plans, or to better inform national conservation priorities.

The subsequent assessments and recommendations for conservation actions can then be used as the basis for the development of a national amphibian action plan. Assessors from a wide variety of backgrounds are identified, and may include ASG members, academics, field biologists and researchers, university students, animal husbandry experts, and members of national, local, or regional wildlife agencies.

JOINT RED LIST AND CONSERVATION NEEDS ASSESSMENTS

Most often, national or regional ASG Chairs help to coordinate both the Red List and Conservation Needs Assessments for all amphibian species in their country, and historically, these two independent assessment processes have been managed separately, and at different times, despite the same expertise generally being required to complete the assessments. Over the past two years, in an effort to reduce the duplication of effort, workshop costs, and the time required by experts to complete the assessments, the ARLA and AArk have joined forces by assembling experts of overlapping priority countries for a single workshop to complete both sets of assessments in parallel. The first joint assessment workshop using this method was held in Malaysia in early 2018, with the recent workshop in Honduras used a similar approach.

HONDURAS

The results of the 2004 Global Amphibian Assessment highlighted that, of all the countries in the Neotropics, the situation facing Honduran amphibians was dire, with approximately half of its species at risk of extinction (Stuart et al. 2004). This realization spawned a number of conservation and research initiatives, which resulted in large amounts of new data and more than fifteen species descriptions, thereby raising the number of known species in Honduras to nearly 150. The extinction risk of the newly described species has never been assessed for the IUCN Red List, and the original GAA data are now more than a decade old and in need of update.

With a relatively high proportion of endemic (39%) and threatened (~50%) amphibian species, Honduras was considered to be a high priority country by Amphibian Ark to complete CNAs.

AMPHIBIAN SYMPOSIUM

Immediately preceding the assessment workshop, a very successful amphibian symposium was held at the Universidad Nacional Autóno-

A very successful amphibian symposium was held at the Universidad Nacional Autónoma de Honduras prior to the assessment workshop, with speakers giving a range of excellent presentations relating to amphibian conservation in Honduras. Photo: Franklin Castañeda.

ma de Honduras (National Autonomous University of Honduras), in Tegucigalpa. The symposium, entitled Conservation of the Amphibians of Honduras: the last decade, attracted a very large audience, and included a range of excellent presentations relating to amphibian conservation in Honduras:

- Assess, plan, act! The role of the IUCN Red List in the conservation cycle. Jennifer Luedtke, IUCN Amphibian Specialist Group / Global Wildlife Conservation
- An overview of the amphibians of Honduras. Mario Solis, Universidad Nacional Autónoma de Honduras
- Informing *ex situ* conservation: Amphibian Ark's Conservation Needs Assessment program. Luis Carrillo and Kevin Johnson, Amphibian Ark
- Rescuing the amphibians of Cusuco National Park. Jonathan Kolby, IUCN Amphibian Specialist Group / Honduras Amphibian Rescue and Conservation Center
- Endemic amphibians receiving protection through Jaguar corridors. Franklin Castañeda, Panthera
- Amphibian diversity and climate change at Sierra Lenca and Cordillera Nombre de Dios. Joe Townsend, Indiana University of Pennsylvania

On the first day of the workshop participants were introduced to the two different assessment processes, and how they would be integrated during the workshop. Photo: Kevin Johnson.

- When the world falls in love: case study of one small frog going global. Chris Jordan, Global Wildlife Conservation

These inspiring presentations provided an excellent background to the issues facing amphibian populations, both in Honduras, and globally, and also informed the audience about what actions are being taken, both inside and outside the country, to save amphibians. Several representatives of the Honduran government were present, some of which shared their perspectives and priorities related to amphibian and habitat conservation.

THE ASSESSMENTS

The primary aim of the workshop was to was to reassess 123 species already on the IUCN Red List and conduct first-time assessments for the 24 species that have been described since the 2004 GAA.

Twelve experts, from a range of institutions both within Honduras and from overseas, contributed to the assessments, along with three facilitators from the ARLA and two facilitators from the AArk. On the first day, participants were introduced to the two different assessment processes, and how they would be integrated during the workshop. Several species were assessed during a plenary session during the first day, then the participants were split into two groups for the subsequent workshop days.

During the workshop, a great amount of unpublished data were readily shared and recorded within the assessments. The level of cooperation and camaraderie between participants was admirable and showed a true and genuine concern for the future of amphibian conservation in Honduras. It was also inspiring to see an excellent representation of local university students, well on their way to becoming the next generation of Honduran herpetologists. Most, if not all, of these experts will play a crucial role in implementing the conservation actions arising from the workshop and helping to protect amphibian habitats throughout the country.

All 147 species occurring in Honduras, including those both previ-

ously assessed and all newly described species to date, were assessed for the IUCN Red List. Preliminary results indicate that Honduras continues to have a high proportion of threatened endemic species, with 90% of species assessed as Vulnerable (VU) (2), Endangered (EN) (17) and Critically Endangered (CR) (34). As for the other 10% of endemics, one species has been assessed as Near Threatened (NT), and two as Data Deficient (DD). Unfortunately, two species (Craugastor anciano and Craugastor omoaensis) were declared Extinct (EX), most likely due to the combined effects of the chytridiomycosis and habitat loss. While these assessments are tragic and alarming, we must commemorate the tireless efforts and dedication of the researchers who exhaustively searched for these species. All non-endemic species still require input from other regional groups before final categories can be assigned, which is set to take place later this year. Finally, several species were removed from the country list, as a result of taxonomic changes, with Honduran records being assigned to other species.

During the workshop, 89 species were assessed using the CNA process. To expedite the assessment process, it is usual not to assess species listed as Least Concern on the Red List, unless those species have been recommended as potential husbandry analog species for more threatened, related species. The summary numbers of recommended conservation actions for the assessments are:

- *In situ* conservation – 71 species
- *In situ* research – 62 species
- *Ex situ* rescue – 18 species
- *Ex situ* research / analog – 15 species
- Conservation education – 28 species
- Supplementation – 1 species
- Biobanking – 18 species
- No conservation actions required – 2 species

It should be noted that each species can be recommended for one or more different conservation actions, hence the total number of actions recommended above is higher than the 89 species assessed. Definitions of the conservation actions above can be found in the help pages on the Conservation Needs Assessment website.

The highest priority species recommended for *ex situ* rescue are *Craugastor anciano, Bolitoglossa cataguana, Nototriton mime, Craugastor chrysozetetes, Duellmanohyla salvavida, Craugastor fecundus* and *Craugastor coffeus*. Of these, three species (N*ototriton mime, Craugastor chrysozetetes* and *Craugastor fecundus*) are probably or possibly extinct, and *Craugastor anciano* was assessed as Extinct. The remainder continue to be threatened by habitat loss due to logging, small-scale agriculture, landslides, small-scale palm oil plantations and human settlements. The experts who contributed to these assessments consider that if these species have not yet become extinct, it is likely that they will face extinction before the threats they face can be mitigated, and that ex situ rescue programs are required to ensure their persistence.

Workshop facilitators, Honduran amphibian experts, and representatives from various government wildlife departments, NGOs and local academics all participated in a five-day assessment and conservation planning workshop in Honduras in March. Photo: Franklin Castañeda.

PLANNING SESSION

On the last day of the assessment workshop, a conservation planning session took place involving the Honduran amphibian experts, representatives from various government wildlife departments, NGOs and local academics, including key organizations, such as Detroit Zoological Society, Global Wildlife Conservation, the Honduras Amphibian Rescue & Conservation Center, Instituto de Conservación Forestal, and Universidad Nacional Autonoma de Honduras. The purpose of this session was to identify and prioritize the research and conservation actions necessary to safeguard Honduran amphibians, and define some critical next steps that the workshop participants and the wider conservation community can take to achieve these actions. This planning exercise was therefore a natural extension of the prior days of the symposium and workshop.

After a summary of both the Red List and Conservation Needs Assessment results, an open discussion forum took place, expertly facilitated by Franklin Castañeda from Panthera - Honduras. The discussion covered topics, such as the development of a national amphibian conservation action plan, including identifying an individual to lead the action planning process; reviewing existing national legislation affecting wildlife and environmental protection; and widespread dissemination of additional scientific publications. All participants were completely engaged with the discussions and eager to participate in future actions.

A timetable of activities over the coming year was developed, with various individuals were identified to lead the development of those activities, including scientific publications, a national action plan, and fundraising for specific conservation and research priorities that emerged during the assessment workshop.

Sponsors

The joint assessment and amphibian conservation planning workshop was made possible by the generous support of the Detroit Zoological Society, Global Wildlife Conservation, Synchronicity Earth, Amphibian Ark, Panthera and Escuela de Biología de la Universidad Nacional Autónoma de Honduras.

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Salamanders are rare in Brazil–only five species are known, all from Amazonia. One of them, *Bolitoglossa paraensis* (Pará's Lungless Salamander) is considered threatened with extinction. Photo: Pedro Peloso / DoTS.

Documenting Threatened Species in Brazil: A Conservation Photography Project

By Pedro L. V. Peloso[1], Ibere Machado[2], Marcelo José Sturaro[3], Leonardo Lanna[4], C. Guilherme Becker[5]

Conservation Photography is a modern discipline that involves the production of images with the main objective of raising public awareness about a specific environmental cause. In addition to documenting and informing the public about biological diversity and the threats posed by the accelerated impacts of human activities, the discipline seeks to expose links between human welfare and a healthy ecosystem. The end goal of *Conservation Photography* is to inspire people to change their behavior or act in favor of any given conservation cause (*1, 2*). Although photography has long been widely used as a powerful conservation tool, it was only recognized as a discipline at the turn of the millennium (*2*).

In its essence, conservation photography unites nature and wildlife photography with scientific information (ecology, evolution, conservation) in an attempt to promote the preservation of species and habitats. With the popularization of photography and the emergence of the internet and social media, the number of images related to global biodiversity has immensely increased in recent years, and so did conservation photography. Despite the high levels of endangerment of amphibians, the number of conservation photography projects focusing on frogs is still small. To fill this gap, we created the *Documenting Threatened Species (DoTS)* project—an ambitious initiative to search and document all species of amphibians threatened with extinction in Brazil; a country with astonishing biodiversity that has been facing accelerated levels of anthropogenic habitat loss.

Brazil is the country with the highest diversity of amphibians globally—with more than 1136 species with reliable records within its territory (*3*). Forty-two species of Brazilian amphibians are currently threatened with extinction (*4*), according to the last assessment by the Brazilian Ministry of Environment (Ministério do Meio Ambiente). For many of these species there is very little biological information available, whereas high quality images are not available for most threatened species. Our project will attempt to fill this important gap, by producing images (photos and videos) of threatened amphibian species in their natural environments. DoTS is essentially a conservation photography project with the goal of documenting and sharing with the world images of endangered and understudied Brazilian species.

While searching for threatened species in their natural environments we have the unique opportunity to document immediate threats to wild populations (*i.e.*, pollution, deforestation, habitat degradation). We will also be collecting skin swabs from threatened species — this will allow us to assess, in many cases for the first time,

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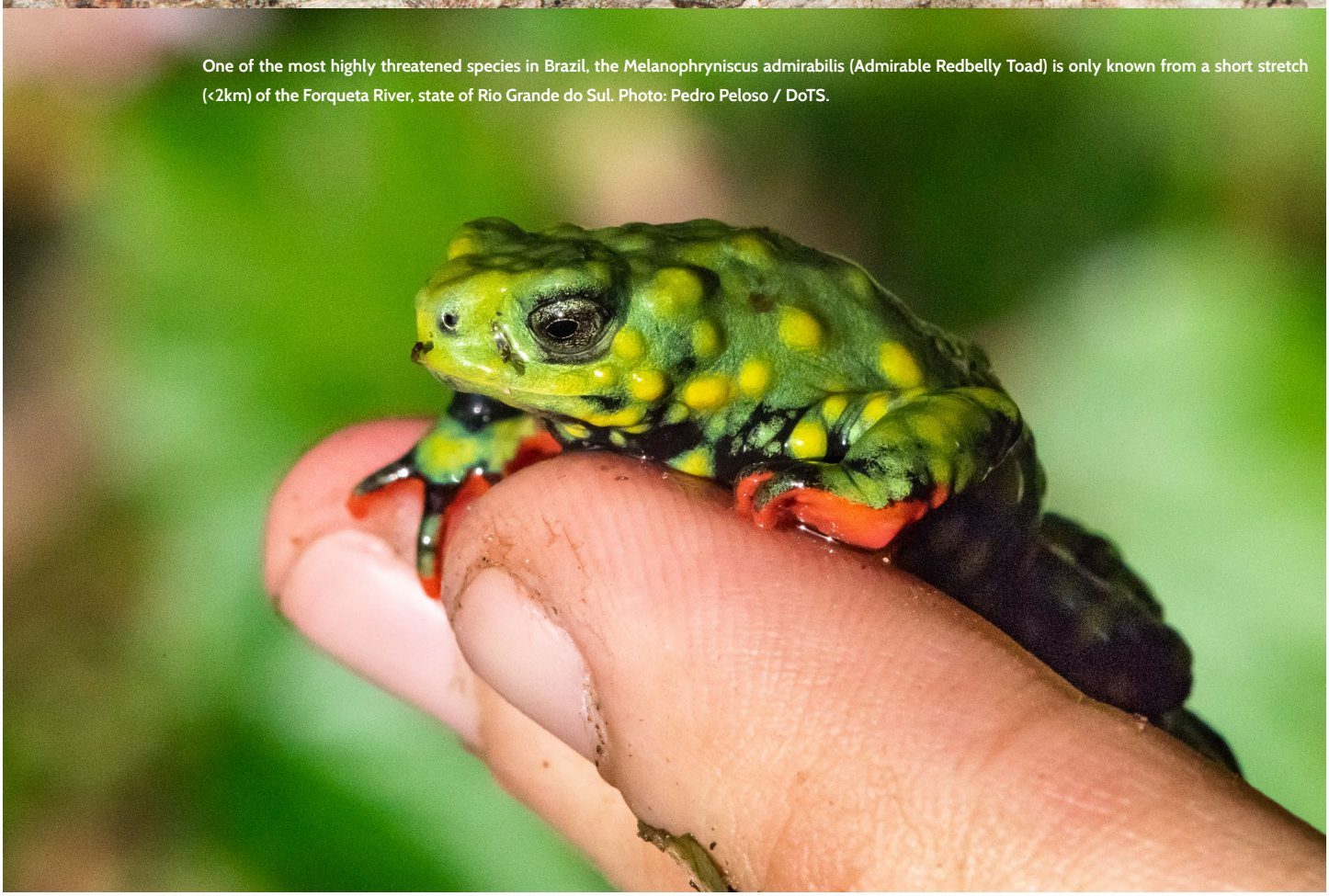
The extremely beautiful *Aparasphenodon pomba* (Pomba's Casque Headed Frog) is only known from a single locality in the state of Minas Gerais, Brazil–a small Atlantic forest fragment inside an unprotected private land. The species is listed as Critically Endangered. Photo: Pedro Peloso / DoTS.



One of the most highly threatened species in Brazil, the Melanophryniscus admirabilis (Admirable Redbelly Toad) is only known from a short stretch (<2km) of the Forqueta River, state of Rio Grande do Sul. Photo: Pedro Peloso / DoTS.

Members of the DoTS and Mantis projects during fieldwork in Massambaba, Rio de Janeiro, Brazil. From left to right: Leo Lanna, Pedro Peloso, Marcelo Sturaro, Ibere Machado, and João Herculano. Photo: Pedro Peloso / DoTS.

whether the deadly chytrid fungus *Batrachochytrium dendrobatidis* (*Bd*) is currently infecting endangered species. *Bd* is a highly infectious pathogen linked to population declines and decimations of multiple species across the globe, including Brazil (*5*).

Thus far, we conducted five expeditions and were able to thoroughly document thirteen of the 42 species that were initially targeted. Over the next few years we will concentrate our efforts to document the remaining species, and we also intend to implement targeted search efforts on species believed to be extinct. Although only a single species in officially considered extinct in Brazil—the Treefrog *Phrynomedusa fimbriata*, others have not been seen in over 40 years, and may also be extinct: *e.g.*, *Holoaden bradei*, *Cycloramphus ohousi*, *Paratelmatobius lutzii*, and *Thoropa petropolitana*.

Ample distribution of images of threatened species in their natural habitats might change people's perception towards amphibian conservation. We hope that our work will inspire people (especially Brazilians) and prompt funding agencies to support the amphibian cause.

DOTS

Documenting Threatened Species

Documenting Threatened Species project logo, designed by Lvcas Fiat from Projeto Mantis. The muiraquitã (red symbol) was chosen as the symbol for the project. Muiraquitãs are old artifacts carved in stone (usually jade) and may have many different forms, the most common is that of a frog - today, they are widely used as pendants and amulets.

Acknowledgments

DoTS is a project supported by Universidade Federal do Espírito Santo, the Fresno Chaffee Wildlife Conservation Fund, Columbus Zoo fund for Conservation and the Becker Lab at The University of Alabama. We thank all who participated in the first DoTS expeditions. We are proud partners of Projeto Mantis (facebook.com/projetomantis/) and Instituto Boitatá (www.institutoboitata.org). For more information, please visit our website (www.projetodots.org) or follow our instagram account (@projeto_dots) for news and updates on the project.

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Fig 1. Photo: Damian Goodall and Deon Gilbert.

Baw Baw Frog Conservation Program Update

By Deon Gilbert. Damian Goodall & Chris Banks

In 2017 we reported on the first six years of the conservation program to recover Australia's Baw Baw Frog *(Philoria frosti*) (Banks & Gilbert, 2017). The species is restricted to a single mountain in south-east Australia and annual surveys are indicating that the wild population is continuing to decline with fewer than 1,000 individuals remaining. Population surveys scheduled for October and November this year will provide new data and allow a more accurate estimation of wild numbers. As such, as the captive program based at Melbourne Zoo is critical to securing a future for the Baw Baw Frog (BBF) in the wild.

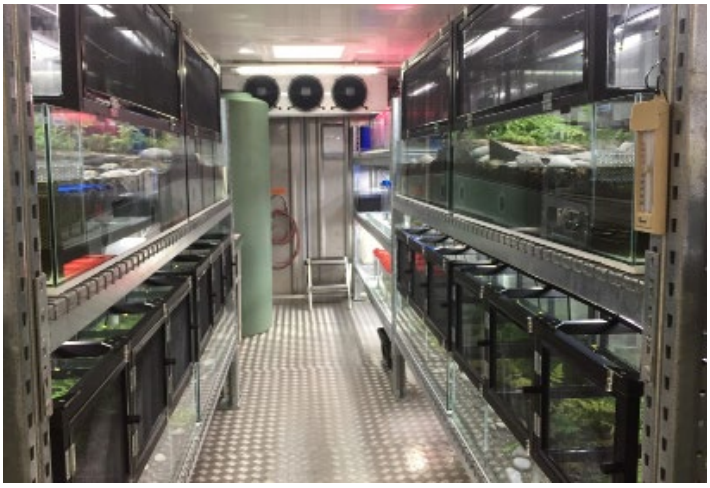

Fig.2. Photo: Damian Goodall and Deon Gilbert

The captive population is demographically stable with recovery objectives well on target. To facilitate increased reproductive output and mitigate genetic loss from an unexpected catastrophic event, funding was allocated to secure a second container. Baw Baw Bunker 2 was fabricated off-site and delivered to Melbourne Zoo earlier this year (Fig.1). The facility is now fully operational and functions independently to the original facility, with its own backup power and life support systems. Importantly, independent temperature and photoperiod schedules will allow us to experiment with optimising growth and development, as well as reproductive output to meet conservation objectives.

The new facility addresses learnings made from the first container, with a redesign of rearing and breeding habitats (Figs. 2 & 3) to allow better filtration and more appropriate space for nest construction and egg laying. Both units are largely automated, with open filtration systems and bioactive substrate, and require very little husbandry

maintenance apart from monitoring life support systems. In total, both facilities house around 300 individuals of all age groups from breeding adults down to one-year old juveniles, with plenty of room for the population to expand.

In addition to the intensive indoor management, we will be experimenting with outdoor habitats at the Zoo. BBF naturally occur at sub-alpine elevations, so providing those conditions outside of their geographic range on-site at Melbourne Zoo has been challenging. The current outdoor habitats draw on learnings gained from exploring a similar approach for another sub-alpine species at the Zoo, Southern Corroboree Frog (*Pseudophryne corroboree*). The outdoor tubs utilise deep (approximately 90cm) thermal buffered substrate, shaded aviaries and chilled water pipes set below the substrate surface (Figs. 4 & 5). This allows refuge sites to maintain temperatures under 20°C during extended summer temperatures of 30˚C or higher experienced in Melbourne, ie. below the critical thermal limit for the species. These outdoor habitats may provide a more efficient way of rearing optimal wild-fit individuals for release.

The plan proposed in our 2017 report to collect adult females in the wild was very successful, with 11 female frogs secured. The method widely used to collect wild small reptiles, drift-fences and buckets dug into the substrate, worked well (Fig. 6), although the many logs and buried rocks meant that it was not possible to install the drift fences in the usual straight lines. The traps were established at two breeding sites where we knew several females were visiting due to egg collections over the previous two seasons. We were reasonably confident of securing a female or two, never expecting to have the success that we did. Securing adult females was a significant breakthrough for the captive program, greatly increasing capability to trial a range of social groupings to boost production of metamorphs.

As spring in Australia is almost here, males will be establishing call sites in the coming weeks in preparation for breeding and we expect choruses in both facilities, unfortunately a phenomenon now rarely heard in nature. Female BBF develop follicles (Fig. 7) pre-winter and typically lay during October and November. Last year (2018) the majority of gravid females deposited eggs in specially designed breeding tanks that replicate natural seep lines. However, fertility and egg survivorship was low and has given us yet another challenge to look forward to in the 2019 season.

Detection of threatened species can be major challenge particularly if the species is rare and spends the majority of its life underground, such as the BBF. There is extensive literature on the use of dogs to detect wildlife and their scats (e.g. Browne, 2005), although very little is published on their use for amphibians. In 2017, Zoos Victoria initiated a project to examine the use of conservation detection dogs to help locate some of our priority native threatened species that are difficult to locate in the field. The BBF is extremely cryptic and given the population decline over the last decade, it is difficult to locate frogs even at sites where they are known to persist. A pilot study was commenced in 2017 to determine the effectiveness of conservation detection dogs at locating BBF under natural conditions. Under controlled settings at Melbourne Zoo, two dogs were first tasked with identifying BBF scent from skin swabs. This was very successful, with both dogs easily able to distinguish the scent across increasingly difficult challenges. The next step in the training process was to assess the dogs on live BBF scent by housing a live frog in a secure opaque ventilated container where the dogs were securely able to smell, but not see or touch the frog. This was again successful, leading on to the challenge of testing the dogs in the field. Following a period of acclimation to field conditions, the dogs were asked to identify BBF at known breeding sites where they had been previously identified by field biologists. Each dog successfully identified three frogs and the trial was considered a success. Moving forward, however, it's likely that we won't utilise detection dogs to assist with surveys, due in large part to the scarcity of remaining BBF, as well as the remoteness and extreme terrain. The focus of the detection dogs with BBF will shift to presence-absence testing following reintroduction.

During the coming field season activities will concentrate on monitoring population transects, collection of unrepresented wild genetics and experimental reintroduction. BBF have a unique life history where almost everything occurs underground - mating, egg laying, egg and larval development and metamorphosis - all in the absence of light. To make matters more complex eggs and larvae rely on an intimate relationship with undergrounded hydrology to complete development, which makes *in situ* observations very difficult. Frogs can

Fig. 3. Photo: Damian Goodall and Deon Gilbert.

Fig. 4. Photo: Damian Goodall and Deon Gilbert.

Fig. 5. Photo: Damian Goodall and Deon Gilbert.

Fig 6. Photo: Damian Goodall and Deon Gilbert.

occur up to 1m below ground and the below-surface environment is a maze of rocks, logs, small cavities seep-lines. If the substrate is disturbed it can change the hydrological flow and dry out the oviposition site, or surrounding material will collapse on the developing eggs or larvae. Transfer of captive-laid eggs back to natural oviposition sites would be almost impossible.

In 2018 we were able to create artificial oviposition sites and begin experimental reintroduction of captive-laid eggs. This was achieved by utilising secure plastic containers with a series of small holes that allowed water to pool and flow through while retaining the developing larvae. The containers were dug into natural seep lines where water flow would be maintained during the approximately 90 days of development through to metamorphosis. A secure lid allowed weekly monitoring without disturbing water flow. As far as we are aware, this novel approach has not been trialed previously with *Philoria frosti.* The methodology appears sound, with eggs able to complete development to metamorphosis. However, the sample size was very small and needs to be more rigorously tested; this will be a major component of this year's fieldwork in November.

Despite chytrid still being a problem in some parts of the BBF's historic range, we are confident there may be large areas of environmental refuge limiting disease transmission. The Baw Baw frog is the only amphibian occupying this montane habitat, as the steepness and complexity of the habitat excludes *Crinia signifera*, the Common Eastern Froglet and a known reservoir host for Bd, from establishing breeding sites. We will focus our reintroduction strategies at these sites.

There is still a long way to go in the recovery journey of the Baw Baw Frog, but it's important to highlight the wins along the way and stay positive when we are focused on such long-term biological time frames. We knew almost nothing about the husbandry of these frogs when we started, but every challenge that has arisen has been faced and overcome. Similarly, organizational commitment and willingness has supported bold and innovative approaches that have greatly increased our knowledge of this little frog in the wild and opened new windows towards securing its future in nature (Zoos Victoria, 2019).

There have been some very exciting developments with this program since this article was submitted. These will be presented in a forthcoming issue of *FrogLog*.

Acknowledgements

Fieldwork is carried out under approved Victorian Government Translocation Plans and ZV Animal Ethics Committee research projects.

Fig. 5. Photo: Damian Goodall and Deon Gilbert

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First individual of *Atelopus tricolor* found after 17 years of effort. Photo: Mauricio Pacheco.

Rediscovery Of The Nearly Extinct Bolivian Stubfoot Toad (*Atelopus tricolor*) In Bolivia

By Mauricio Pacheco[1], Gabriel Archondo[1], Claudia Cortez[2] & Arturo Muñoz[2,3]

In 2003, Andreas John reported what was until this moment the last proof of the existence of *Atelopus tricolor* in Bolivia. This genus of colorful toads, also known as Harlequin Toads, is the group that has suffered population declines from the effect of habitat loss and a highly virulent fungal disease, chytridiomycosis, produced by the fungus *Batrachochytrium dendrobatidis* (hereafter, *Bd*), the infection is responsible for the complete disappearance of a large number of amphibians throughout the world, but with worse consequences within the tropical Andes and Central America (*1,2*). *Atelopus* are among the most threatened amphibians in the world due to Bd and habitat loss among other threats, and most of the 100 described species (*3,4*), have been declining since the second half of the nineties. And it seems the situation has been the same In Bolivia for *A. tricolor* (*5*).

A. tricolor is known from eastern Andes in Peru and Bolivia, between 600 and 2500 meters above sea level, it is the only harlequin toad officially reported for the country. It has been reported from the north of La Paz, to the Chapare region in the center of Bolivia (*6*). The latest records come from Serranía Bella Vista, a very humid area with steep slopes, close to the city of Caranavi. To this mountain range several herpetologists and amateurs including us have been going to look for them many times in recent years, without luck, despite finding a rich herpetofauna.

Then, on the night of January 1st, 2020, we decided to look for a different stream system, also close to Caranavi, but quite far from the known sites for the species. Without much hope (it was not the first time we visited those streams), we assessed three streams that night, and in the third, very close to the site where the creek becomes inaccessible, without believing it, the first *Atelopus tricolor* after 17 years of intensive search. A little bit later we found a second individual.

We returned two nights later and searched in the creeks again. We only found *Atelopus* in the same stream from the first night. This time we found three, but one individual was the same frog form the first occasion (recognizable by the design). All individuals were perching on leaves of ferns and small plants that grow on the rocky walls of the creek.

The creek is one of three, which descend from the nearby summits, it is located at 1150 meters above sea level. The area in general, is strongly affected by agricultural activities, but the streams have a good vegetation cover with abundant waterfalls and very large rocks.

In recent years, findings like this have also occurred in Ecuador, Colombia and Costa Rica, where frogs and toads that have not seen in decades are rediscovered. Small populations that seem have survived to Bd, give us hope and opportunity to do something for its conservation. Now that the presence of the species is confirmed, there is a lot of work to do; It is necessary to determine if there are other places where the species is present, how many they are out there, habitat conditions, confirm the presence of Bd, or other threats or even if it would be necessary to develop an *ex situ* program.

For now, we decided not to reveal the exact place where the frogs were found, in order to protect them from pet trade, people that would like to catch or see the species or even from researchers who

Habitat where *Atelopus tricolor* is present. Photo: Mauricio Pacheco.

[1]Diversidad entre pendientes, La Paz, Bolivia, [2]Amphibian Specialist Group Bolivia, La Paz, Bolivia; [3]Bolivian Amphibian Initiative,Cochabamba, Bolivia

Individuals of *Atelopus tricolor* found in the stream A,B,C; other species present in the streams: D: *Cochranella nola*, E: *Rhinella* cf. *margaritifera*, F: *Pristimantis* cf. *platydactylus*. Photo: Mauricio Pacheco.

Stream where first *Atelopus tricolor* was found. Photo: Mauricio Pacheco.

would like to collect them or could affect them in any way. Even scientific research must guarantee the well-being of what could be the last population of *Atelopus tricolor* in the area or the country. At the moment we are now coordinating efforts with the IUCN SSC Amphibian Specialist Group and the Bolivian Amphibian Initiative to carry out the next steps to try to protect this species. We are now organizing different assessments in the area to try to get more information that will allow us and decision makers to propose the best actions for the conservation of this species. We hope that with this efforts to understand this population and possible others, we can guarantee its survival and that of these miraculous ravines, which protect not only the incredible Bolivian harlequin toad, but also a huge variety of other beings.

To learn more, please visit: https://entrependientes.com/ and http://bolivianamphibian.org/

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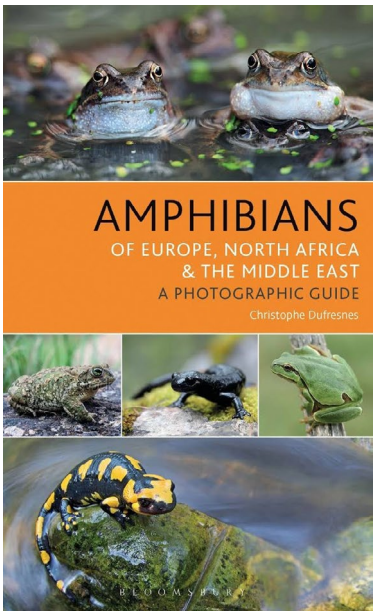
A Comprehensive, Esthetic and Up-to-Date Field Guide for Amphibians of the Western Palearctic

By Christophe Dufresnes

On the verge of Earth's sixth mass extinction, the general concern for biodiversity and nature conservation has never been higher among human societies. Practical, up-to-date, but also visually-pleasing naturalist references are instrumental to raise and ride this wave of awareness, in order to efficiently interest and inform the next-generation of wildlife specialists and enthusiasts. In a globalized world where eco-tourists and invasive species can easily travel across entire biogeographic regions, the necessity to keep field guides transportable but with content extending beyond political boundaries, adds additional challenges. Furthermore, by unravelling biodiversity previously unknown to science, the rapid improvement of molecular methods used in species delimitation is shaking traditional taxonomies, rendering guides obsolete soon after their publication.



These issues are symptomatic of amphibians from the Western Palearctic. While this ecologically-diverse region encompasses a single biogeographic entity, the corresponding literature is essentially divided between political Europe, North-Africa, and scattered Middle-Eastern countries. Moreover, most books rely on outdated species lists, which do not account for the numerous taxonomic advances of the recent years. For instance, 73 native species appears in the 2014 European atlas for amphibians, while more than 90 can now be considered (*1, 2*). Last but not least, much of the available work primarily serves encyclopedic purposes rather than user-friendly travel companions.

To address these limitations, I am proud to present *Amphibians of Europe, North-Africa and the Middle-East*, published by Bloomsbury (*3*), a compact photographic guide accounting for all species/subspecies known from the Western Palearctic at this time. The book first summarizes major concepts on amphibian biology, evolution, and conservation, illustrated by original maps, figures and drawings, meant as a crash course accessible to both professional and amateur biologists alike. The main content then details 139 species (137 native + 2 exotic) across 17 different chapters arranged by taxonomic groups. For each group, the diversity, global distribution, and general characteristics are initially presented, and the corresponding species are listed as a phylogenetic tree, showing their evolutionary relationships. Each species is subsequently treated individually on a single page, designed for efficient identification and accessibility. Instead of literal descriptions, emphasis was given to visual display, i. e. photographs (on which identification criteria are flagged) and distribution maps, complemented by key information on reproductive period, habitats, threats, breeding calls, etc. Eggs and larvae are also documented and illustrated, while the accompanying text briefly reports interesting facts and anecdotes, such as relationships with humans. Finally, the last section is dedicated to the distribution and characteristics of subspecies, so readers can accurately determine their sightings down to the subspecific level. Originally available in English, foreign editions of the book are being released in French, Spanish and Czech, so far. In December 2020, the French edition was distinguished by a prestigious award from the Veterinary Academy of France.

Written by an academic researcher and wildlife photographer, this new resource thus combines up-to-date scientific knowledge with modern design and high-quality pictures that capture the beauty and uniqueness of each Western Palearctic amphibian. It should thus be appealing to a broad community of professional and amateur naturalists seeking for a pocket yet integrative reference, with visually appealing content to inspire local conservation volunteering and herpetological trips. Bringing amphibians under a brighter spotlight, the book will hopefully enlighten the initiated and the uninitiated to these threatened treasures that secretly live in our backyards, and contribute to their preservation.

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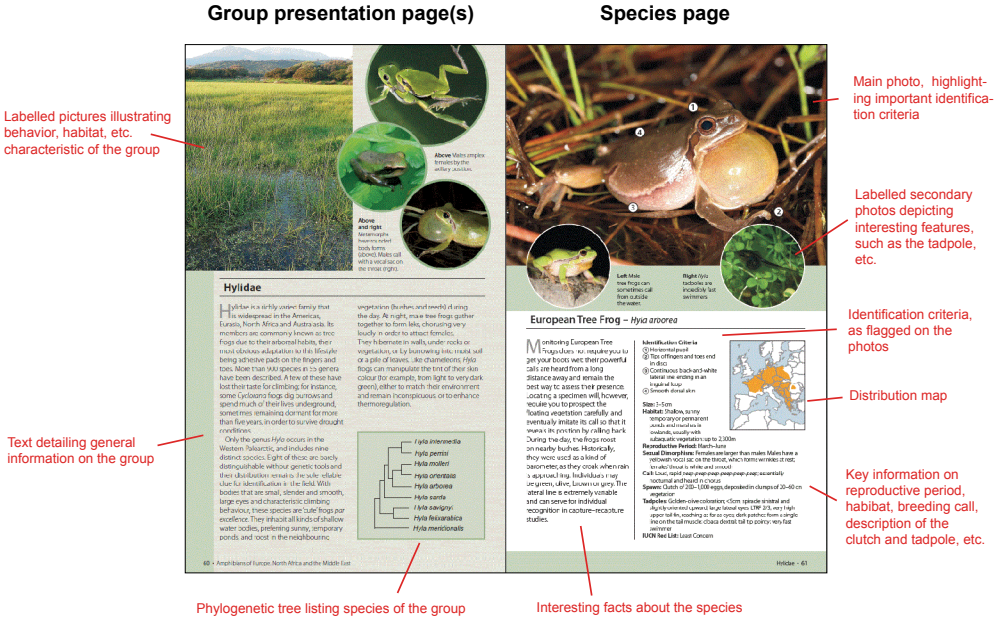


Juvenile stage of the eastern red-spotted newt in Green Mountains National Forest, VT. Photo: R. Bernard, USGS.

Improving Amphibian Conservation: A New Special Issue in the Journal Biological Conservation

By Erin Muths

Amphibian conservation science describes and explains observed declines, but provides little in the way of mitigation strategies. To halt or reverse declines, a shift towards focused research that informs conservation action is necessary. A Special Issue in the journal *Biological Conservation* shows how this goal can be achieved.

The Special Issue ('Amphibians in the Anthropocene') acknowledged the fact that even after decades of research, we have not substantially halted or reversed amphibian declines, but takes a hopeful view, showcasing conservation science that emphasizes mitigation and research applications. Despite much bad news, we know that some local actions are effective and this special issue stresses the importance of targeted research and the field trialing of mitigation measures at meaningful scales. We opened the Issue by describing amphibians as a conservation dilemma and make a case for a more solutions-focused and pragmatic approach to conservation research, a suggestion that is relevant to many of the other creatures facing extinction in the Anthropocene. Authors included scientists from academia and government in Australia, Europe, and North America who were invited because of specific expertise in on-the-ground conservation. Papers were reviewed by scientific experts and by managers, so that not only scientific rigor, but also the feasibility of application was considered for each paper.

The contributions to the special issue covered a wide range of topics. A series of papers discussed approaches to population management, but focused on specifics that are relevant to current challenges, *e.g.*, managing before species decline; incorporating measures of uncertainty; managing translocated populations adaptively; and managing habitats at a broad scale within a metapopulation. Two other papers focused on the impacts of roads on demography and potential mitigation strategies for those impacts. There were papers on new mitigation methods for disease, the application of evidence-based conservation, and the implementation of probability-based dispersal ecology.

In conjunction with the publication of this Special Issue there was, at the 9th World Congress of Herpetology, the sympoisum *Amphibian conservation in the Anthropocene – challenges, priorities and solutions for the human epoch*. This symposium included similarly focused talks. The symposium was novel in that it included a guided discussion with the aim to engage the audience and speakers in developing a list of conservation priorities.

The collaborative editorial team for the special issue was Evan H. Campbell Grant, U.S. Geological Survey – Amphibian Research and Monitoring Initiative, Patuxent Wildlife Research Center, SO Conte Anadromous Fish Research Lab, 1 Migratory Way, Turners Falls, MA 01376, United States of America. ph: 413-863-3823 email: ehgrant@usgs.gov; Benedikt R. Schmidt, Department of Evolutionary Biology and Environmental Studies University of Zurich Winterthurerstrasse 1908057 Zurich, Switzerland and Info Fauna Karch, UniMail, Bâtiment G, Bellevaux 51, 2000 Neuchâtel, Switzerland; Silviu Petrovan, Conservation Science Group, Department of Zoology, University of Cambridge The David Attenborough Building, Cambridge CB2 3QZ, UK and Froglife, 1 Loxley, Werrington, Peterborough, PE4 5BW, UK; and Erin Muths, U.S. Geological Survey – Amphibian Research and Monitoring Initiative, Fort Collins Science Center, 2150 Centre Ave. Bldg C, Fort Collins, CO 80526. Erin Muths and Evan Grant lead the symposium at the World Congress in Dunedin.

Me with long toes. Photo: Diane Kyle.

A Journey With Frogs

By Kirsty Kyle

Ten or so years ago, as an aimless teenager, I flipped a rock in a field on the top of a mountain, and my life changed… there beneath it were a handful of bright green Caco Frogs, and that was it. They're about one cm long, range in colour from brown to grey to vivid green and they absolutely enchanted me with their sparkly little eyes, chunky bodies and cheeky personalities. I was still fairly aimless and useless for a good few years after that, but I had found a direction and a passion: frogs.

Photo: Louis Du Preez

I finished school and clawed my way through a very miserable undergrad with UNISA. After a few bloody and brutal clashes with statistics and economics, I emerged with a BA in Environmental Management and no clue what to do with it. Until the fateful day I received a call from my hero, Prof. Louis Du Preez. He offered me a place in his group at North West University, doing an honours in something related to anurans! I couldn't have been more excited and through a long process of much anticipation and nervous waiting and about five trees worth of paperwork, I was enrolled for a BSc Hons in Biodiversity and Conservation Ecology. And what a ride that was!

I have to be the most un-academic scientist this world has ever seen, and having managed to get into the BSc program with my BA, mostly on the good will of the university and Prof's good standing, there was no ways I was going to let anyone down by flunking. But I found myself, as the aged granny of the group, struggling to understand scientific concepts that these youngsters had just been learning for the last three years, and I had possibly vaguely encountered back in Biology in school many years earlier! Not that I was about to let on that fact to anyone of course! Fortunately stubbornness runs deeply rooted through my family tree and I managed to squeak my way through the modules. But the magical thing about my honours year was the project I was given.

The Oppenheimer family have an enormous cattle farm in the middle of Zimbabwe where they practice holistic beef farming techniques. Along with this they have a keen interest in research and all things environmental. They provided a sum of money which enabled

Leptopelis xenodactylus Photo: Kirsty Kyle.

us to go up to the farm and install passive acoustic monitoring devices for the duration of the entire season. It was then my job to analyse this data to establish the species diversity for the farm. We had four different sites on the farm in order to sample as many different vegetation and habitat types as possible and downloaded them several times over the year.

Ferdi De Lange, Maxwell and I downloading songmeter. date Photo: Louis Du Preez

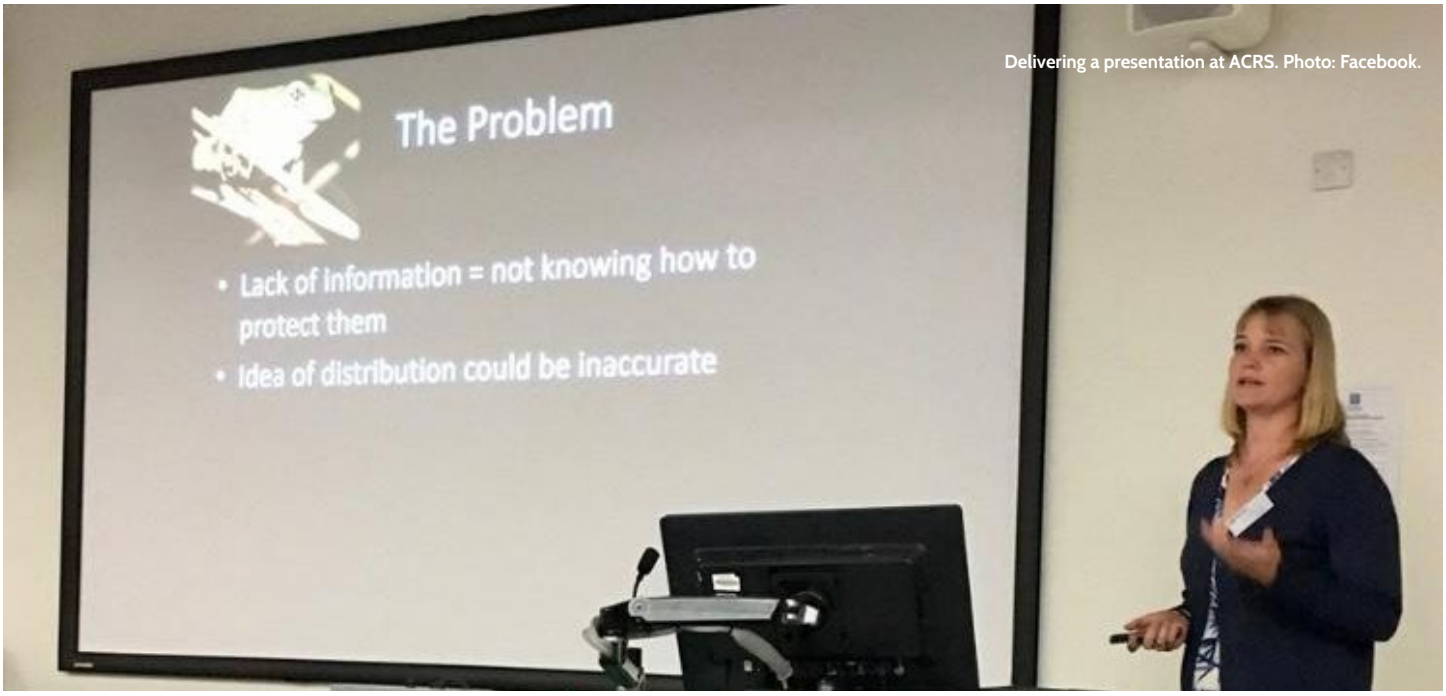
Ferdi De Lange and I netting for tadpoles in Zimbabwe. Photo: Louis Du Preez

As is always the case with field work, things did not necessarily go according to plan. One site's cards were corrupted (possibly by the nests of ants that insist on taking up residence inside the songmeter boxes) and another whole songmeter was stolen by a passing elephant poacher – which obviously presented a snag! Aside from these hiccoughs it went amazingly well considering the potential for disaster. After two awesome field trips, where we got to scratch around a bit up there for herps, I returned home with many, many, many hours of sound data to work through and analyse.

It was my first time dealing with acoustic data in any formal way and I really enjoyed the experience. I would put my earphones on and shut my eyes and it felt like such a secret privilege to eavesdrop on the goings on of the bush. The songmeters record everything for a set period of time every night and so I literally got to listen to the natural, undisturbed noises of a very wild piece of Africa. I became very familiar with the crickets–there were a great many of them–as well as the little francolin bird who clearly had a sunrise ritual of greeting the dawn from a rock somewhere very close to my one songmeter. It really was a treat. I also heard elephants on one occasion as well as people talking another time, but the sad fact is that these would quite likely have been poachers hunting down elephants. That aspect was quite sobering.

The frogs themselves delighted me. According to a desktop survey, 34 species were supposed to occur there using available past data. Through our work there, we were able to confirm 12 species through tadpole identification. This was a fascinating experience for me. I had to learn to identify down to family and most often species level based on parameters like the number of labial tooth rows and the internarial distances (distance between the nostrils) of these minute little tadpoles.

We also managed to find 18 different species during active searches while we were there for the fieldwork. This may not sound all that impressive but what I haven't yet mentioned is the fact that my project year coincided perfectly with a severe drought that crippled much of southern Africa for several years and apparently is still continuing on the farm to this day. As such, it was quite an achievement to get our 18 species and we were proud of them.

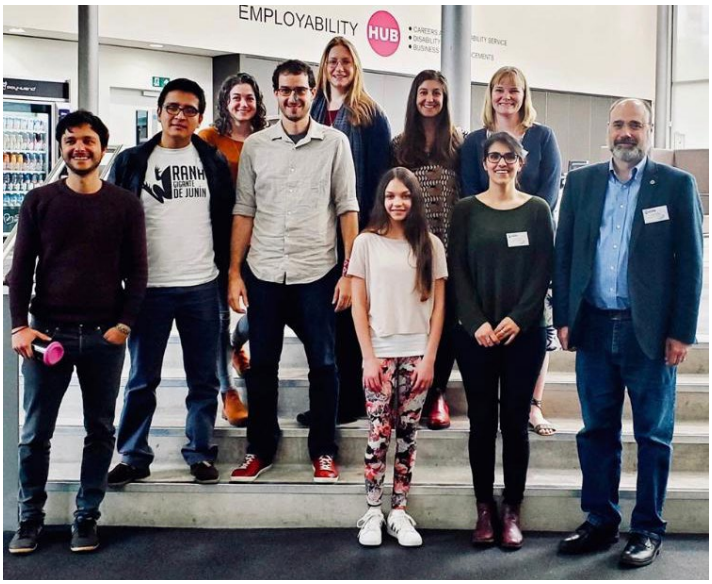


Delivering a presentation at ACRS. Photo: Facebook.

Finally, the acoustic monitoring resulted in 19 species. And I'm not ashamed to admit I was really chuffed with that. It took many hours of listening and re-listening. I'd frequently think I'd lost the plot, and all too often find I had! I'd send recordings away to Prof thinking I had a new species for the area only to be told it was a cricket with a nasal drip.

By the end of it all, I was able to report back to the Oppenheimers that they had a healthy amphibian population on their farm and that we had confirmed 24 of the possible 34 species using the various techniques. What an amazing experience the whole project turned out to be. I learned so very much from it and it only cemented the fact that I was finally, doing exactly what I wanted to do. Working with incredible animals and with an amazing group of people.

Having now got a taste for the academic world of amphibian research, I wanted more and this presented a problem having come to the end of my honours project. However, my long suffering prof, bribed with some nice bits of wood (he makes wooden pens), offered me the opportunity to continue with them in the form of a masters, and that is what I am busy with now. I can't believe how blessed I have been with the team around me and the projects and opportunities I've been given. My masters project is focused on an endangered species here in the KZN Midlands called the Long-toed Tree Frog (*Leptopelis xenodactylus*). It is a large, bright green, charismatic tree frog with huge eyes and such a deliberate and ponderous style of movement.



The future leaders from ACRS. Photo: Facebook.

I now face a few years of lurking around bogs at all hours of the night trying to sneak a peek into their private lives, figuring out what major threats they face and what secrets are tied up in their breeding behaviour and migrations. I have such great supervisors and colleagues and have found the amphibian community to be amazingly welcoming and helpful which has been a breath of fresh air. I got a chance to experience this first hand when an incredible opportunity was given to me by the Amphibian Survival Alliance to attend the 2019 Amphibian Conservation and Research Symposium in Manchester, as a future leader and present on my project. It was such an inspiring experience and I was blown away by how welcoming the international amphibian community was and how generous they were with their information and trade secrets. It was also deeply inspiring and even moving to see how much amazing work is being done around the world by such clever, dedicated and passionate people to make a difference for amphibians. The years ahead are going to be so interesting as we watch all the new technologies, combined with old school hard work and experience, being applied to the extreme situations caused by the massive threats facing the amphibian population worldwide.

As for me and my little project here with the Long toes, watch this space as I shall definitely be writing again as my journey with these secretive and stunning frogs continues.

The Third Consecutive Year of Save The Frogs Day in the Brazilian Amazon and the Experience of Working With Environmental Education

By Lucas Ferrante[1], Luciana Frazão[2], Sylker Teles[3], Amanda Picelli[4], Camila Noronha[4], Cathele Felix[5], Celina M. Pinagé[4], Felipe Atem[4], Gabriel S. Masseli[1], Izabela S. Campos[4], Mahima Hemnani[4], Milla Dutra-Nunes[4], Thainá Najar[5] & Igor L. Kaefer[4]

Fig. 1: Team of Third Save The Frogs Day Amazonia. Photo: Igor Kaefer.

The Amazon Forest is the largest continuous forest in the world, with most of its territory located in Brazil (*1*). Brazil, for its part, is the country with the largest number of amphibian species in the world (*2*). This last large tropical rainforest in the world has been threatened by deforestation, mining, agriculture and livestock on a large scale (*1*) and although it is the Brazilian region with the lowest proportion of human occupation by territorial extension, Amazonia concentrates a large metropolis in his heart, the city of Manaus with 2.1 million inhabitants (*3*). For Amazonia, there are no consistent surveys of how many species of amphibians occur in the biome, but for the municipality of Manaus, more than 50 species have been recorded (*4*). Environmental education is perhaps the most important initiative for the conservation of amphibians in the world (*5*), becoming indispensable in the largest city in the midst of the largest forest where many people see amphibians as disgusting, poisonous and dangerous animals (*6*).

As an initiative to promote ecological importance and demystify people's clouded view of amphibians, students and researchers from the National Institute of Amazonian Research (INPA), the University of the State of Amazonas (UEA) and the Federal University of Amazonas (UFAM) held the third Save the Frogs Day Manaus (*Fig. 1*). Proposed by the international organization "Save the Frogs!", this activity is the world's largest day of amphibian education and conservation action.

The first Amazon Save the Frogs Day occurred in the Amazon Museum of the Adolpho Ducke Reserve, where we received students and teachers from schools near the reserve (*6*). The second event was held at the Federal University of Amazonas, opening the day of conservation of the frogs not only for biology students but for students and teachers of other courses and visitors to the university, including young people and children (8). For the third edition of Save The Frogs Day Amazon, the event was held at the Fair of Fuá on 06 May 2018, a cultural event with wide circulation (approximately three thousand in a day) that takes place monthly in Mindú park in the city of Manaus.

We performed various activities to cover all age groups of the population that circled the event. The Save The Frogs booth had live animals exhibited in terrariums (*Fig. 2*) of five species belonging to four families–*Adenomera hylaedactyla, Boana lanciformis, Phyllomedusa bicolor, Osteocephalus taurinus* and *Rhinella marina*–as well as tadpoles at different stages of development. There was also an exhibition of photos of Amazonian amphibians (*Fig. 3*) and activities of painting and drawing on paper some species (*Fig. 4, 5*). In this way, the participants of the activity could know some species that occur in the forest fragments of Manaus.

Additionally, there was A presentation of the virtual reality game Amazon Frogs created by the edutech startup Flying Saci (*Fig. 5*) which provides an active search of anurans in nature; and the Singing Frogs game, a mobile application in which the player has to guess which frog is singing by listening to three frogs (*Fig. 6*). The experience has shown itself mutually enriching as narrated by many of the monitors:

Fig. 2: Exhibition of frogs in terraria. Photo: Luciana Frazão.

Fig. 3: Exhibition of photos of Amazonian amphibians. Photo: Luciana Frazão.

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Fig. 4: Activities of painting and drawing on paper by children's. Photo: Luciana Frazão.

Fig. 5: Activities of painting and drawing on paper by children's. Photo: Luciana Frazão.

Fig 6: Virtual reality game of Amazon Frogs. Photo: Luciana Frazão.

"The 3rd Save The Frogs Day was my first experience with biology events, and it taught me a lot. Among them, the importance of directing and sensitizing the children, who were the biggest audience of the stand and had the most interesting doubts. Listening to small children who now wanted to be biologists was worth all the effort put into the project. - C. Noronha."

"The children are the real scientists, by far the most curious, some even went so far as to call the parents and explain to them what we were talking about. - F. Atem"

"Save The Frogs brought a very satisfying experience as we had a hugely positive response from the audience that honored the project. We have had the opportunity to see people of all age groups interested in becoming aware of the importance of anuran amphibians in the world and especially in our region. Community support was the most enjoyable part of talking about a subject as important as conservation. We saw children very committed to saving nature and even more the animals we were presenting. In addition, I have the honor to hear from children and other adolescents that we encourage them to pursue a career as a biologist, a fact of great importance for any student or professional in this area. In general, the participation of Save The Frogs has brought us more experience with the public, to understand how they think and, even more, to try to change these thoughts to something even more positive. - C. M. Pinagé ."

"This was the first time I attended the organization of the event. In 2017 I participated only on the day of the action to help with the animals and explain about them to the people. Even with limited resources, we were able to produce many activities. Our team worked well both in the preparations and on the day of project implementation. One of the things that caught my attention was the phrase of a boy of about eight years who was painting a poster frog Phyllomedusa tomopterna: "But the frogs are not only green?". And I said, "Not every one. Look, this frog you're drawing is here on the clothesline pictures. Does he have orange sides, do you see? " After that, the child was very excited seeing the photo and trying to reproduce in his painting. I think this is the central message of "Save the frogs": to demystify erroneous information that has been engraved in our heads since we were children, like this child's phrase. Virtual activities, without a doubt, were also a differential, since they attracted both children and adults, especially the virtual reality. I'm particularly looking forward to the rest of the game is released! The "what's the frog?" Is a game that looks silly at first glance but is very educational, not only for people outside academia but for the herpetologists themselves. For example, with this application, I learned how to distinguish more species than I already knew, which will be very useful for my life when I'm in the field. - M.R. M. D. Nunes ."

Save the Frogs Day can be a way beyond just raising awareness about the biodiversity and importance of frogs, but our experiences have been able to bring children and young people into the world of biological sciences, ecology, zoology, and conservation, stimulating greater contact of urban youths with nature and awakening future savers of frogs.

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Adult Titicaca water frog at Isla de la Luna. Photo: Arturo Munoz, Bolivian Amphibian Initiative.

Work With Local Communities and Conservation of the Titicaca Water Frog by the Creation of its Sanctuary

By Arturo Muñoz[1,2], Dan Lay[1], Patricia Mendoza[1], Gabriel Callapa[1] & Jaime Salamanca[1]

The Titicaca Water Frog (*Telmatobius culeus*) is a truly iconic species endemic to Lake Titicaca and surrounding smaller lakes. It is one of the largest fully aquatic frogs in the world and has unique adaptations to living in the world's highest navigable lake, at 3,810 metres. Sadly, this wonderful species is listed as Endangered by the International Union for Conservation of Nature (IUCN).

There have been multiple efforts to understand this species: taxonomic studies, natural history research and conservation status assessments. Based on all this gathered information it is known that the species population has been drastically declining during the last decades. Additionally, it is important to note and recognize that different methods have been used to try to understand the conservation status of this species and big differences have been observed throughout its range, making accurate long term monitoring difficult.

At Lake Titicaca, which straddles both Bolivia and Peru, isolated conservation efforts have been carried out in both countries, but no complete understanding of the real conservation situation of the frog is known. *T. culeus* has been exposed to *Batrachochytrium dendrobatidis* (*Bd*) for more than 100 years and it is known that there is some ongoing existence with *Bd*. In Bolivia, dead individuals are commonly found, and on some occasions massive mortalities have been recorded, notably in 2009, 2011 and most recently in 2015, where thousands of frogs were found dead spanning large areas. Most sadly, in these large areas the species is now completely absent.

The situation of the species in the lake can change drastically due to massive mortalities, diseases or over-harvesting and a close monitoring program is needed, in addition to a strategy where a rapid rescue response can be implemented. The Bolivian Amphibian Initiative is establishing a real time monitoring system that provides up-to-date knowledge of the species and allows us to be in a strong position to undertake further conservation measures in the case that it would be needed. This project, in close collaboration with local communities and other Bolivian institutions, will provide an up-to-date and ongoing picture of the conservation status of *T. culeus* in this area.

Working together closely with a local community from Isla de la Luna, a small island on the Bolivian side of the lake, we are commencing a collaborative project to monitor this species in the wild. By training community members in the methods to obtain data, together we

[1]Bolivian Amphibian Initiative. [2]Laboratory of Animal Nutrition, Ghent University, Belgium

Meeting with the local community at Isla de la Luna. Photo: Arturo Munoz, Bolivian Amphibian Initiative.

can monitor the species almost in real time. This collaboration has been developed from the desire of the local community, who have a special relationship with *T. culeus*, called in Aymara the Ispi Ahuatiri or the shepherd of the Ispi (an important native fish species of the genus Orestias). In the waters surrounding Isla de la Luna, the frog population is healthy, with densities comparable to those found in the 1970s by Jaques Cousteau, and with individuals of nearly the same large size reported by him.

Monitoring population of Titicaca Water Frog at Isla de la Luna. Photo: Arturo Munoz, Bolivian Amphibian Initiative.

Working together with this small community and other organizations, we aim to provide the island with a socioeconomic alternative and sustainable way to live in harmony with their environment, established and managed by the local community. When this sanctuary has been established, it will be the first protected area on the Bolivian side of Lake Titicaca, the first area designated for this species, and will enact the Titicaca Water Frog as an "umbrella species", protecting other key ecological species, and the lake environment as a whole.

For more information about the Bolivian Amphibian Initiative and its work, please visit www.bolivianamphibian.org

Ethnoherpetological notes regarding the paha frogs and conservation implication in Manaslu Conservation Area, Gorkha District, Nepal

Biraj Shrestha & Min B. Gurung

Mountains by their very nature as isolated structures of sloped terrain and unique environmental attributes have always spurred biodiversity and human civilization that gets adapted to these local conditions. Such adaptations enable communities to forge a greater relationship with nature's bounty, often reflected in social norms. One such cultural representation comes from the mountain communities of Nepal, where hunting mountain freshwater frogs, locally called Paha is a commonplace activity. The collection is primarily for food as a reliable source of protein followed by a deep-rooted belief that some of these amphibians possess healing benefits although no such scientific explanation exists. Paha is a generic term popularized by the ethnic minority, Tamangs of Nepal, to a special group of frogs from the genus Amolops, Nanorana, and Ombrana. Other indigenous nationalities like Magar, Rai, Gurung, Jirel, etc. cleave to similar credence. In our study from 2016/17, we tried understanding an undocumented relationship from the remote communities of Manaslu Conservation Area (MCA) at the foothills of Mount Manaslu in Nepal.

We confirmed the use of three species of paha, namely *Nanorana liebigii* (Man paha in Nepali), *Ombrana sikimensis* (Rato paha), and *Amolops formosus* (Hariyo paha) in major settlements of lower Manaslu. The Gurungs in Sirdibas usually hunt paha at night using flashlights (45.7%) or flipping big rocks underwater (29.6%) in spring and summer. Nanorana liebigii (50%) is inordinately preferred for its high-use value (delicacy and medicine), while Ombrana sikimensis (33.33%) considered solely for food and Amolops formosus (16.67%) for therapeutic purpose. When asked how many paha are usually collected, the majority responded 51-100 individuals at one hunting season. A fraction of the harvest is sold locally between the range of NPR 50-250 (USD 0.45-2.26). People surmised paha populations have diminished over the last decade (76%) and demanded strict hunting regulation (58.5%) combined with enhanced educational campaigns (29.2%). On a different note, we felt a stark contrast in ethnoherpetological relationship between the Gurungs and the Tibetan Lamas of MCA. The Lamas revere paha and have prohibited all forms of killing in the region. A local youth club has sanctioned penalties aimed to deter intentional abuse, including paha frogs. This is one great example of community-based conservation where active community engagement has helped to thrive frogs in a time when amphibians around the world demand urgent conservation action.

B. Shrestha, M. B. Gurung, *Journal of Ethnobiology and Ethnomedicine*. **15**, 23 (2019).

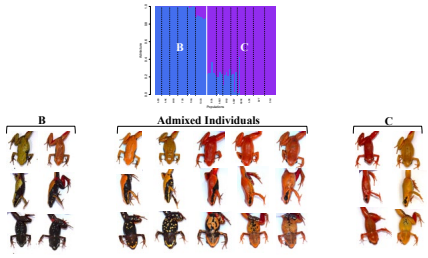
Spring Peeper, one of many amphibian species at risk from emerging infectious disease. Photo: Jeremy Cohen.

Impacts of thermal mismatches on chytrid fungus Batrachochytrium dendrobatidis prevalence are moderated by life stage, body size, elevation and latitude

Jeremy M. Cohen, Taegan A. McMahon, Chloe Ramsay, Elizabeth A. Roznik, Erin L. Sauer, Scott Bessler, David J. Civitello, Bryan K. Delius, Neal Halstead, Sarah A. Knutie, Karena H. Nguyen, Nicole Ortega, Brittany Sears, Matthew D. Venesky, Suzanne Young & Jason R. Rohr

Global climate change is increasing the frequency of unpredictable weather conditions; however, it remains unclear how species-level and geographic factors, including body size and latitude, moderate impacts of unusually warm or cool temperatures on disease. Because larger and lower-latitude hosts generally have slower acclimation times than smaller and higher-latitude hosts, we hypothesized that their disease susceptibility increases under 'thermal mismatches' or differences between baseline climate and the temperature during surveying for disease. Here, we examined how thermal mismatches interact with body size, life stage, habitat, latitude, elevation, phylogeny and International Union for Conservation of Nature (IUCN) conservation status to predict infection prevalence of the chytrid fungus *Batrachochytrium dendrobatidis* (*Bd*) in a global analysis of 32 291 amphibian hosts. As hypothesized, we found that the susceptibility of larger hosts and hosts from lower latitudes to *Bd* was influenced by thermal mismatches. Furthermore, hosts of conservation concern were more susceptible than others following thermal mismatches, suggesting that thermal mismatches might have contributed to recent amphibian declines.

J. Cohen, T. McMahon, C. Ramsay, E. A. Roznik, E. L. Sauer, S. Bessler, D. J. Civitello, B. Delius, N. Halstead, S. A. Knutie, K. Nguyen, N. Ortega, B. Sears, M. D. Venesky, S. Young, J. R. Rohr, *Ecology Letters*, 22(5), 817–825, 2019.



Genetic and phenotypic admixture in Malagasy poison frogs. Photo: Karina Klonoski.

Phenotypic and genetic diversity in aposematic Malagasy poison frogs (genus Mantella)

Karina Klonoski, Ke Bi & Erica Bree Rosenblum

Intraspecific color variation has long fascinated evolutionary biologists. In species with bright warning coloration, phenotypic diversity is particularly compelling because many factors, including natural and sexual selection, contribute to intraspecific variation. To better understand the causes of dramatic phenotypic variation in Malagasy poison frogs, we quantified genetic structure and color and pattern variation across three closely related species, *Mantella aurantiaca*, *Mantella crocea*, and *Mantella milotympanum*. Although our restriction site-associated DNA (RAD) sequencing approach identified clear genetic clusters, they do not align with current species designations, which has important conservation implications for these imperiled frogs. Moreover, our results suggest that levels of intraspecific color variation within this group have been overestimated, while species diversity has been underestimated. Within major genetic clusters, we observed distinct patterns of variation including: populations that are phenotypically similar yet genetically distinct, populations where phenotypic and genetic breaks coincide, and populations that are genetically similar but have high levels of within-population phenotypic variation. We also detected admixture between two of the major genetic clusters. Our study suggests that several mechanisms—including hybridization, selection, and drift—are contributing to phenotypic diversity. Ultimately, our work underscores the need for a reevaluation of how polymorphic and polytypic populations and species are classified, especially in aposematic organisms.

K. Klonoski, K. Bi, and E. B. Rosenblum, *Ecology and Evolution* **9**, 5 (2019).

Warming-induced shifts in amphibian phenology and behavior lead to altered predator-prey dynamics

Long-toed Salamander larvae (*Ambystoma macrodactylum*). Photo: Fabian G. Jara.

Fabian G. Jara, Lindsey L. Thurman, Pierre-Olivier Montiglio, Andrew Sih & Tiffany S. Garcia

Climate change induced phenological variation in amphibians can disrupt time-sensitive processes such as breeding, hatching, and metamorphosis, and can consequently alter size-dependent interactions such as predation. Temperature can further alter size-dependent, predator-prey relationships through changes in species' behavior. We thus hypothesized that phenological shifts due to climate warming would alter the predator-prey dynamic in a larval amphibian community through changes in body size and behavior of both the predator and prey. We utilized an amphibian predator-prey system common to the montane wetlands of the U.S. Pacific Northwest: the Long-toed Salamander (*Ambystoma macrodactylum*) and its anuran prey, the Pacific Chorus Frog (*Pseudacris regilla*). We conducted predation trials to test if changes in predator phenology and environmental temperature influence predation success. We simulated predator phenological shifts by using different size classes of the long-toed salamander representing an earlier onset of breeding, while using spring temperatures corresponding to early- and mid-season larval rearing conditions. Our results indicated that the predator-prey dynamic was highly dependent upon predator phenology and temperature, and both acted synergistically. Increased size asymmetry resulted in higher tadpole predation rates and tadpole tail damage. Both predators and prey altered activity and locomotor performance in warmer treatments. Consequently, behavioral modifications resulted in decreased survival rates of tadpoles in the presence of large salamander larvae. If predators shift to breed disproportionately earlier than prey due to climate warming, this has the potential to negatively impact tadpole populations in high-elevation amphibian assemblages through changes in predation rates mediated by behavior.

F. G. Jara, L. L. Thurman, P.-O. Montiglio, A. Sih & T. S. Garcia, *Oecologia* 189, 3 (2019):803-813. DOI 10.1007/s00442-019-

Panamanian Golden Frog (*Atelopus zeteki*). Photo: Jeremy Cohen.

An interaction between climate change and infectious disease drove widespread amphibian declines.

Jeremy M. Cohen, David J. Civitello, Matthew D. Venesky, Taegan A. McMahon & Jason R. Rohr

Climate change might drive species declines by altering species interactions, such as host–parasite interactions. However, few studies have combined experiments, field data, and historical climate records to provide evidence that an interaction between climate change and disease caused any host declines. A recently proposed hypothesis, the *thermal mismatch hypothesis*, could identify host species that are vulnerable to disease under climate change because it predicts that cool- and warm-adapted hosts should be vulnerable to disease at unusually warm and cool temperatures, respectively. Here, we conduct experiments on *Atelopus zeteki*, a critically endangered, captively bred frog that prefers relatively cool temperatures, and show that frogs have high pathogen loads and high mortality rates only when exposed to a combination of the pathogenic chytrid fungus (*Batrachochytrium dendrobatidis*) and high temperatures, as predicted by the thermal mismatch hypothesis. Further, we tested various hypotheses to explain recent declines experienced by species in the amphibian genus *Atelopus* that are thought to be associated with *B. dendrobatidis* and reveal that these declines are best explained by the thermal mismatch hypothesis. As in our experiments, only the combination of rapid increases in temperature and infectious disease could account for the patterns of declines, especially in species adapted to relatively cool environments. After combining experiments on declining hosts with spatiotemporal patterns in the field, our findings are consistent with the hypothesis that widespread species declines, including possible extinctions, have been driven by an interaction between increasing temperatures and infectious disease. Moreover, our findings suggest that hosts adapted to relatively cool conditions will be most vulnerable to the combination of increases in mean temperature and emerging infectious diseases.

J. Cohen, D. Civitello, M. Venesky, T. McMahon, J. Rohr, *Global Change Biology*, **25**(3), 927-937 (2019).

***Proteus anguinus*. Photo: Domin Dalessi.**

Composition of the cutaneous bacterial community of a cave amphibian, Proteus anguinus

Rok Kostanjšek, Ylenia Prodan, Blaž Stres & Peter Trontelj

The European Cave Salamander Proteus anguinus is a charismatic amphibian endemic to the concealed and inaccessible subterranean waters of the Dinaric Karst. Despite its exceptional conservation importance not much is known about its ecology and interactions with the groundwater microbiome. The cutaneous microbiota of amphibians is an important driver of metabolic capabilities and immunity, and thus a key factor in their wellbeing and survival. We used high-throughput 16S rRNA gene sequencing based on seven variable regions to examine the bacteriome of the skin of five distinct evolutionary lineages of *P. anguinus* and in their groundwater environment. The skin bacteriomes turned out to be strongly filtered subsamples of the environmental microbial community. The resident microbiota of the analyzed individuals was dominated by five bacterial taxa. Despite an indicated functional redundancy, the cutaneous bacteriome of *P. anguinus* presumably provides protection against invading microbes by occupying the niche, and thus could serve as an indicator of health status. Besides conservation implications for *P. anguinus*, our results provide a baseline for future studies on other endangered neotenic salamanders.

R. Kostanjšek, Y. Prodan, B. Stres, P. Trontelj, *FEMS Microbiol. Ecol.* **95**, fiz007 (2019) https://doi.org/10.1093/femsec/fiz007

Mountain lake of Montenegro where a population of paedomorphic newts disappeared following alien fish introductions. Photo: Mathieu Denoël.

Traditionally managed landscapes do not prevent amphibian decline and the extinction of paedomorphosis

Mathieu Denoël, G. Francesco Ficetola, Neftali Sillero, Georg Džukić, Miloš L. Kalezić, Tanja Vukov, Irma Muhovic, Vuk Ikovic, Benjamin Lejeune

Eco-cultural landscapes are assumed to be favourable environments for the persistence of biodiversity, but global change may affect differently their terrestrial and aquatic components. Yet, few long-term studies have examined how multiple, global change stressors may affect wetland biodiversity in such environments. Facultative paedomorphosis is a spectacular example of intra-specific variation, in which biphasic (metamorphosing) amphibians coexist with fully aquatic conspecifics which do not metamorphose (paedomorphs). Paedomorphosis is seriously threatened by global change stressors, but it is unknown to what extent traditional management will allow its long-term persistence. Here, we tested the effects of alien species introductions while taking into account land-use and climate changes on the distribution of two polymorphic newt species (*Ichthyosaura alpestris and Lissotriton graecus*) in Montenegro by using a 68-year data set and Bayesian mixed models integrating complex spatial and temporal structures. We found that, despite the persistence of natural landscapes, metamorphs dramatically declined, and paedomorphs were nearly extirpated, losing 99.9% of their aquatic area of occupancy and all the major populations. Fish introduction was the main determinant of decline for both phenotypes. Climate and the presence of crayfish further contributed to the decline of metamorphs, which started later and was less dramatic than that of paedomorphs. The near extinction of paedomorphosis on a country-wide scale shows how invasive species determine broad scale impacts, which can be even stronger than other global change stressors, and underlines the need for immediate management actions to avoid the extinction of a unique developmental process, paedomorphosis.

Mathieu Denoël, G. Francesco Ficetola, Neftali Sillero, Georg Džukić, Miloš L. Kalezić, Tanja Vukov, Irma Muhovic, Vuk Ikovic, Benjamin Lejeune, Ecol. Monogr. **89**, e01347 (2019). https://doi.org/10.1002/ecm.1347

Multiple environmental gradients influence the distribution and abundance of a key forest-health indicator species in the Southern Appalachian Mountains, USA

Meaghan R. Gade & William E. Peterman

The effects of global climate change are threatening worldwide biodiversity, with particular concern for amphibians, whose survival often depends on specific abiotic conditions. To predict how future climate change will affect populations, it is first necessary to understand how patterns of distribution and abundance are shaped by environmental conditions at both local and regional scales. Plethodontid salamander are a group of particularly vulnerable amphibians because they are lungless ectotherms that require cool and moist habitats to survive. These salamanders are indicators of forest ecosystem condition and as such, understanding their responses and resilience to decline is critical. The Southern Appalachian Mountains host the greatest diversity and endemism of plethodontid salamanders. While broad distribution and abundance patterns are well understood across elevations, other pertinent abiotic gradients exist within montane systems that are likely contributing to fine-scale spatial abundance patterns, which have received less attention. Herein, we assess the spatial distribution and abundance of *Plethodon shermani* across two environmental gradients: temperature and moisture. We found heterogeneous abundance patterns across these two gradients whereby warmer low elevations contain the greatest abundance near stream sides, where conditions are cooler and wetter relative to the regional landscape. At higher elevations, salamanders are distributed more uniformly across the broader landscape, likely as a result of the wetter and cooler regional climate. We found that the fine-scale habitat associations of *P. shermani* are driven by temperature and moisture, and the spatial patterns of suitable microhabitats drive the regional scale spatial patterns. Such information is important for understanding the potential for persistence in the face of climate change, and can help inform conservation and management strategies into the future.

M. R. Gade, W. E. Peterman, *Lands Ecol.* **34**, 569-582 (2019).

***Polypedates otilophus*. Photo: Farinosa**

Instructions to Authors

Background

FrogLog has been one of the leading amphibian conservation community newsletters since the early 1990's. Over the years it has been affiliated with different groups but has always strived to help inform the community. In 2005 *FrogLog* became the official newsletter of the IUCN SSC Amphibian Specialist Group and is produced on a quarterly basis.

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All manuscripts must be written in Standard US English. For example, "color" should be spelled "color."

Title

Titles should ideally be no more than 15 words.

Authors

Authors names should be written in full as follows: By James P. Lewis & Robin D. Moore

Main body of text

Use Georgia 11-point font. Genus and species names should be in italics as should the abbreviation for *Batrachochytrium dendrobatidis, Bd*. Suggested headings include Acknowledgements, Author Details and References and Notes.

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Figures should be numbered and include brief, concise legends. Where photographs or illustrations are used please state whom the image should be credited to, e.g., Photo: James P. Lewis. Graphics should preferably be submitted in tiff or jpeg format in the highest possible quality. Resolution should be at least 300 dpi at the final size.

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Tables may be included within the text file and should be numbered and include brief, precise legends.

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Journals/Periodicals

1. E. Recuero, J. Cruzado-Cortés, G. Parra-Olea, K. R. Zamundio, *Ann. Zool. Fenn.* **47**, 223 (2010).

Books

2. J. Gupta, N. van der Grijp, Eds., Mainstreaming Climate Change in Development Cooperation (Cambridge Univ. Press, Cambridge, UK, 2010).

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Paper presented at a meeting

4. M. Konishi, paper presented at the 14th Annual Meeting of the Society for Neuroscience, Anaheim, CA, 10 October 1984.

Published Online Only

5. N. H. Sleep, Geochem. *Geophys. Geosyst.*, 10, Q11010 (2009): DOI:10.1029/2009GC002702.

Web site

6. National Oceanic and Atmospheric Administration, Beaufort Wind Scale, http://www.spc.noaa.gov/faq/tornado/beaufort.html (2012).

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Leiopelma pakeka. Photo: Phil Bishop