



# Amphibian Ark

20 Years Rescuing Amphibians in Crisis



*Pelophylax lessonae* tadpoles © Nordens Ark  
Story on page 28

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20 Years Rescuing Amphibians in Crisis

This year, we celebrate 20 years of amphibian rescue.

In 2004, the first IUCN Global Amphibian Assessment revealed that one-third of all amphibians were already threatened with extinction. As the scale of the crisis became clear, so did the urgent need for *ex situ* conservation breeding—but at the time, most institutions were not equipped to respond.

As a result, the IUCN SSC Amphibian Specialist Group (ASG), the IUCN SSC Conservation Planning Specialist Group (CPSG), and the World Association of Zoos and Aquariums **established Amphibian Ark in 2007 to help coordinate the *ex situ* component of the first Amphibian Conservation Action Plan.**

Twenty years on, we continue working with partners around the world to safeguard amphibians through *ex situ* conservation: buying species time while threats in the wild are addressed, and supporting their return to their natural habitats when conditions allow. In these two decades, significant progress has been made, yet many species still face critical threats and depend on timely conservation action.

**41%**

of all amphibians are now designated as Threatened by the IUCN

**3500+**

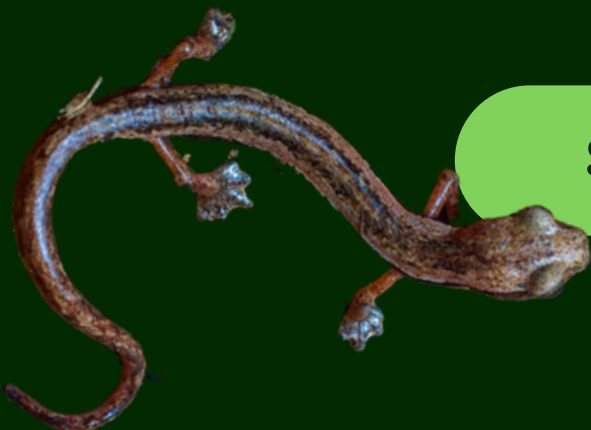
species assessed by the AArk Conservation Needs Assessments

**75**

species in rescue programs

As we mark this milestone, we move forward with greater experience, strong partnerships, and a clearer path to protecting amphibians at risk. With your support, we can continue to secure a future for these extraordinary species.

**Support AArk**



Left: *Bolitoglossa helmrichi* © José Renato Morales  
Right: *Hyperolius pickersgilli* © Keir Lynch



# Amphibian Ark

## 20 Years Rescuing Amphibians in Crisis

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#### A quick guide to our frequently used acronyms:

AArk	Amphibian Ark
ARLA	Amphibian Red List Authority
ASG	Amphibian Specialist Group
CNA	Conservation Needs Assessments
CPSG	Conservation Planning Specialist Group
IUCN	International Union for the Conservation of Nature
SSC	Species Survival Commission
WAZA	World Association of Zoos and Aquariums



# Amphibian Ark News

Welcome to Issue No. 73 of the Amphibian Ark Newsletter!

Here's what's been keeping us busy this quarter:

## Amphibian Husbandry Training in Guatemala

María José Chang | Amphibian Ark National Coordinator, Guatemala

Luis Carrillo | Amphibian Ark Program Director for the Americas & The Caribbean

Training is a core part of Amphibian Ark's response to the amphibian extinction crisis. By strengthening technical capacity in places where *ex situ* programs are beginning (or expanding), we help ensure that rescue efforts are effective, sustainable, and successful in the long term.

Guatemala is one of the most amphibian-diverse countries in the region, with 167 known species (Acevedo 2012). Of these, 58.7% are classified within threatened categories on the IUCN's Red List (Vásquez Almazán 2023). These species face severe and ongoing threats, underscoring the

need for urgent, coordinated, and integral conservation actions.

According to the [AArk CNA conducted in 2024](#), 22 species in Guatemala urgently require *ex situ* rescue. In response, Amphibian Ark launched its Guatemala program in February 2025, with the goals of identifying institutions with both the interest and potential capacity to develop *ex situ* conservation initiatives, as well as assessing the support needed to ensure their long-term success. For this, we sent virtual surveys which highlighted a gap in technical capacity in

Photo: Amphibian husbandry training course at La Aurora Zoo, Guatemala City, in January 2026.





amphibian husbandry required to implement and manage such projects effectively.

Given this context, a training course was developed to address this gap. The course was open to national institutions previously identified through the assessment process.

From 19-21 January 2026, Amphibian Ark delivered an “Amphibian husbandry for *ex situ* conservation” course at the La Aurora Zoo in Guatemala City. The training brought together 18 participants from eight institutions from Guatemala and Mexico. Its primary objectives were to strengthen institutional capacity, provide practical and theoretical knowledge, and foster collaboration among conservation practitioners to support the development of future *ex situ* programs in the region.

This course was organized and sponsored by Amphibian Ark, Saint Louis Zoo, Parque Zoológico La Aurora, Zoo Atlanta, and Indoor Ecosystems. We extend our sincere thanks to the instructors: Robert Hill, Tim Herman, Carlos Vásquez, and Luis Carrillo, and all participants for their engagement and commitment.

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Photo: Course participants at La Aurora Zoo, Guatemala City, in January 2026.





# Effectiveness and implementation of Amphibian Ark training programs—a research survey

Phil Attwood | University Centre Sparsholt

Amphibians are the most threatened class of vertebrates with over 40% of assessed species listed as vulnerable, endangered or critically endangered on the International Union for Conservation of Nature (IUCN) Red List of Threatened Species, underlining the global scale of the amphibian extinction crisis (Luedtke et al., 2023). Current amphibian population declines are determined by multiple converging causes, including native habitat loss, habitat degradation, land-use change, pollution, disease, and climate change (Blaustein et al., 2011; Bolochio et al., 2020). Amphibians are particularly sensitive to habitat modification (Nowakowski et al., 2017), highlighting the need to maintain *ex situ* populations of the most threatened species whose natural habitats can no longer support viable wild populations, using the most current knowledge, techniques, and best-practice husbandry to optimise breeding success and welfare in institutions with amphibians under their care.

In response to these threats, *ex situ* conservation initiatives have increased significantly, however, the effectiveness of these programs depends considerably on the quality of husbandry, management of environmental parameters, and biosecurity practices implemented by trained personnel (Browne et al., 2011). Captive assurance colonies and conservation breeding programs are essential tools in global amphibian conservation as they can rescue critically threatened species from extinction while encouraging long-term recovery efforts through correctly managed reproduction and husbandry improvements (Griffiths & Pavajeau, 2008).

**Evidence-based training has the capacity to greatly improve amphibian conservation outcomes** (Sutherland et al., 2004). One of the

main AArk pillars is capacity building on topics such as amphibian husbandry, veterinary medicine, and small population management, amongst others. Measuring training impact is important, so conducting a survey of workshop participants provides an insight into what has worked or hasn't worked, if any improvements or adjustments need to be made, and can inform future training opportunities by using this evidence-based approach.

**The current survey is the basis of a BSc (Hons) Zoo Biology dissertation project. It has been created using Microsoft Forms and has been sent out to 436 people working in different institutions with amphibian populations under their care such as zoos, aquariums, universities, research institutions, museums and conservation centres who have received some form of amphibian training from Amphibian Ark.** The training types include amphibian husbandry, salamander husbandry, amphibian veterinary medicine, small populations management, artificial reproductive technology (ART) and nutrition training. The dissertation investigates two questions: (1) is there a significant relationship between the amount of time passed since completing the training and the reported impact on amphibian care practices, and (2) is there a significant difference in the reported effectiveness of the training between different training types?

The survey explores these hypotheses by including different questions such as what type of institution they work at, what year they received the training, a Likert scale prompting recipients to report the effectiveness and impact of the training they received, how they implemented it into their daily care routines, which species under



their care received these changes, what challenges they still face regarding amphibian husbandry and what training initiatives they would benefit from in the future.

Alongside the dissertation objectives, the main goal of this project is to improve the effectiveness of amphibian training and inform future programs provided by Amphibian Ark by using survey data to evaluate past training, support adaptive management approaches, refine techniques and strengthen current practices, ensuring that conservation initiatives can more effectively translate into practical, real-world outcomes for species reliant on *ex situ* management (McGowan, 2017; Williams & Brown, 2013).

**If you have received training from Amphibian Ark, I would like to invite you to complete this survey by scanning the QR code below:**



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## Amphibian Rescue - the Amphibian Ark podcast is here!

To celebrate our first 20 years rescuing amphibians in crisis, we launched [Amphibian Rescue](#), a new monthly podcast that highlights the global *ex situ* response to the amphibian extinction crisis.

The series begins by revisiting how the crisis was first discovered and how the conservation community mobilized in response. For these initial episodes, we were honored to feature Dr. Joe Mendelson, one of the early responders to the amphibian crisis, alongside Dr. Onnie Byers and Dr. Bob Lacy, former Chairs of the IUCN SSC Conservation Planning Specialist Group (CPSG), who played key roles in shaping the *ex situ* response that led to the creation of Amphibian Ark back in 2007.

As highlighted in Episode 3, we now have a clearer understanding of what needs to be done—and how to do it. These are the stories we'll

highlight in the future monthly episodes: species on the brink being brought to temporary sanctuaries under human care; species that would otherwise be extinct are already returning to their natural habitats; and species that have developed immunity to chytrid and the work being done to use this knowledge for their conservation.

Don't forget to subscribe on your favorite podcast platform to get notified when the next episode drops: [Spotify](#), [Apple Podcasts](#), [YouTube](#), [other major podcast platforms](#).

**Amphibian  
Rescue**  
The Amphibian Ark Podcast

Original music by **B|OTA**  
BEATS BY BEASTS

You can find Amphibian Rescue in all [podcast platforms](#) and [YouTube](#)—you can also make use of YouTube's tools to listen to it in your language or adapt the subtitles to your language!



## *A note from the producer*

María Braeuner | Amphibian Ark & CPSG Communications Officer

In 2025, Jonathan—Amphibian Ark’s Executive Director—and I were looking at Google Trends and noticed something quite peculiar. While interest in “biodiversity conservation” has grown over the past two decades (which is encouraging), searches for “amphibian conservation” peaked around 2008-2010 and have since declined. Now, you and I know that the amphibian crisis is far from over, but, to paraphrase Jonathan, it seems the world has forgotten.

I then suggested the idea of a podcast—half expecting it to be politely acknowledged or maybe get a chuckle. But I was wrong. Pretty soon, I had the green light from the AArk team to go for it.

I wasn’t always “a podcast person”. In fact, before 2018, I didn’t quite “get it”—I’d rather just listen to music. But once I found the podcast that got me hooked (a quick, unpaid nod to *Ologies* by Allie Ward), I began to understand the power of audio. It might sound like an overstatement, but I dare say that podcasts changed my life. They quickly became a source of inspiration and a different way to learn and engage with ideas.

There is something uniquely intimate about audio and inviting these *strangers* into your daily routines. There’s actually quite a bit of research on the intimacy of podcasts, even more on the power of storytelling. So why not use this to bring amphibian conservation back to the forefront?

A podcast, of course, is not the hands-on conservation work we so urgently need in the labs and in the field. But I do believe in their ability to move us—as listeners, as human beings—to act. Whether that means supporting conservation efforts, strengthening our connection to nature, or even inspiring someone

to pursue a path in herpetology: stories shape what we care about and what we do next.

And what has happened in just the first few weeks since launching Amphibian Rescue has been truly motivating. Thanks to you, within three days the podcast reached the **Top 10 most downloaded Science podcasts (in Apple) in New Zealand**. Since then, it has ranked among the Top 50, Top 100 and Top 200 Science podcasts in countries including Sweden, Mexico, the United States, the United Kingdom, and Australia. There are over 60,000 Science podcasts out there: Top 200 is *a pretty big deal!* **In the last week of March alone, it reached #5 on the Science podcasts chart in Peru, and #1 in the Nature category!**

But these numbers are not only for our delight: they help position the podcast within those platforms, bringing amphibian conservation stories to the eyes and ears of more people: maybe those who have forgotten, or maybe those who have never heard of the amphibian crisis before. So I want to thank you so much for listening and for making this happen! If you’re wondering how else you can support us, don’t forget to rate the podcast and subscribe on your favorite podcast platform.

And, talking about the power of audio, did you know the music in the podcast is made entirely out of animal sounds? The piece is called Crystal Frog’s Melodic Quest, and you can read more about how it is produced on the next page.

*This is such a great telling of the terrible history of decline of amphibians.*

— Jim

(Spotify comment Episode 01)



## *A note from the artist behind Crystal Frog's Melodic Quest*

Dr. Pablo Bolaños | Biota Specimens, Ecotest, & National Museum of Natural History Paris

Biota Specimens is a music project that explores how the sounds of animals can become the building blocks of musical compositions. Instead of adding instruments on top of nature recordings, **the music is created directly from wildlife vocalizations recorded in the field.** These sounds are then edited using music production software, adjusting timing and frequencies, and sometimes cutting them into very small fragments, so they can interact rhythmically and melodically. No additional instruments are used; every musical element comes from animal sounds.

The piece Crystal Frog's Melodic Quest, featured in the Amphibian Ark podcast, is based on recordings made in the Caribbean rainforest region of Izabal, Guatemala. The composition is built entirely from the calls of animals, especially amphibians that inhabit these tropical forests.

Several species appear in the piece. The toad *Incilius valliceps* provides low rhythmic pulses that function almost like a bassline, while the glass frog *Hyalinobatrachium viridissimum* contributes lighter, higher sounds. Other voices include *Dendropsophus microcephalus*, with its high-pitched trills, and *Ptychohyala hypomykter*, whose call resembles the rasping sound of a güiro. The nocturnal mammal *Bassariscus sumichrasti* (the cacomistle) also appears with a long undulating call, accompanied by insects such as cicadas that add broad rhythmic textures.

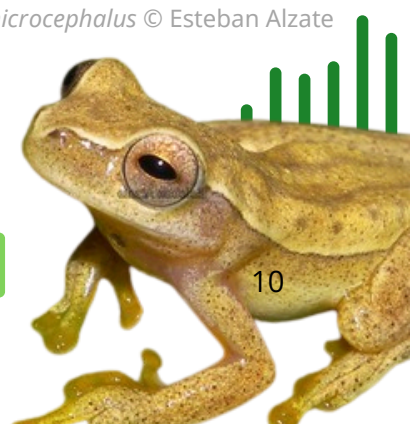


**BIOTA**  
BEATS BY BEASTS

Visit [Biota Specimens](#) to learn more about Pablo's work and listen to more of his music.



Photos left to right:  
*Incilius valliceps* © Todd Pierson  
*Hyalinobatrachium viridissimum* © M. Braeuner  
*Dendropsophus microcephalus* © Esteban Alzate





Success Stories

# The Journey So Far

Since 2007, Amphibian Ark has helped launch and support amphibian *ex situ* programs across the globe. In this section, we explore the *then & now* of these programs: how did it all began? And where are they today?

In this issue: Mitsinjo, Madagascar, and AArk's first-ever grant.



Only two years after the Conservation Needs Assessment (CNA) tool was developed, Amphibian Ark conducted a CNA workshop for Madagascar (2008). Part of the results included recommending the golden mantella (*Mantella aurantiaca*) for *ex situ* rescue.

One year later, in **2009**, Association Mitsinjo received **Amphibian Ark's first-ever seed grant**. This was at a time when no *ex situ* capacity existed in Madagascar.

Where are they now?



# 18 years protecting the golden mantella (*Mantella aurantiaca*)



Although the golden mantella (*Mantella aurantiaca*) has been maintained at zoological institutions outside Madagascar for decades, these captive populations have been sourced from the pet trade from unknown localities. Consequently, they are not suitable for reintroduction.

At the time of the AArk Conservation Needs Assessment of 2008, no *ex situ* capacity existed in Madagascar. **In 2009, the local community-based conservation organization Mitsinjo**

**received the first AArk grant**, covering training and capacity-building in *ex situ* amphibian management. This involved in-person training in biosecurity, enclosure construction, and live food culturing, setting Mitsinjo up to secure further support for the construction of Madagascar's first amphibian breeding center.



Initial funding to renovate the facility came from the AZA Conservation Endowment Fund.

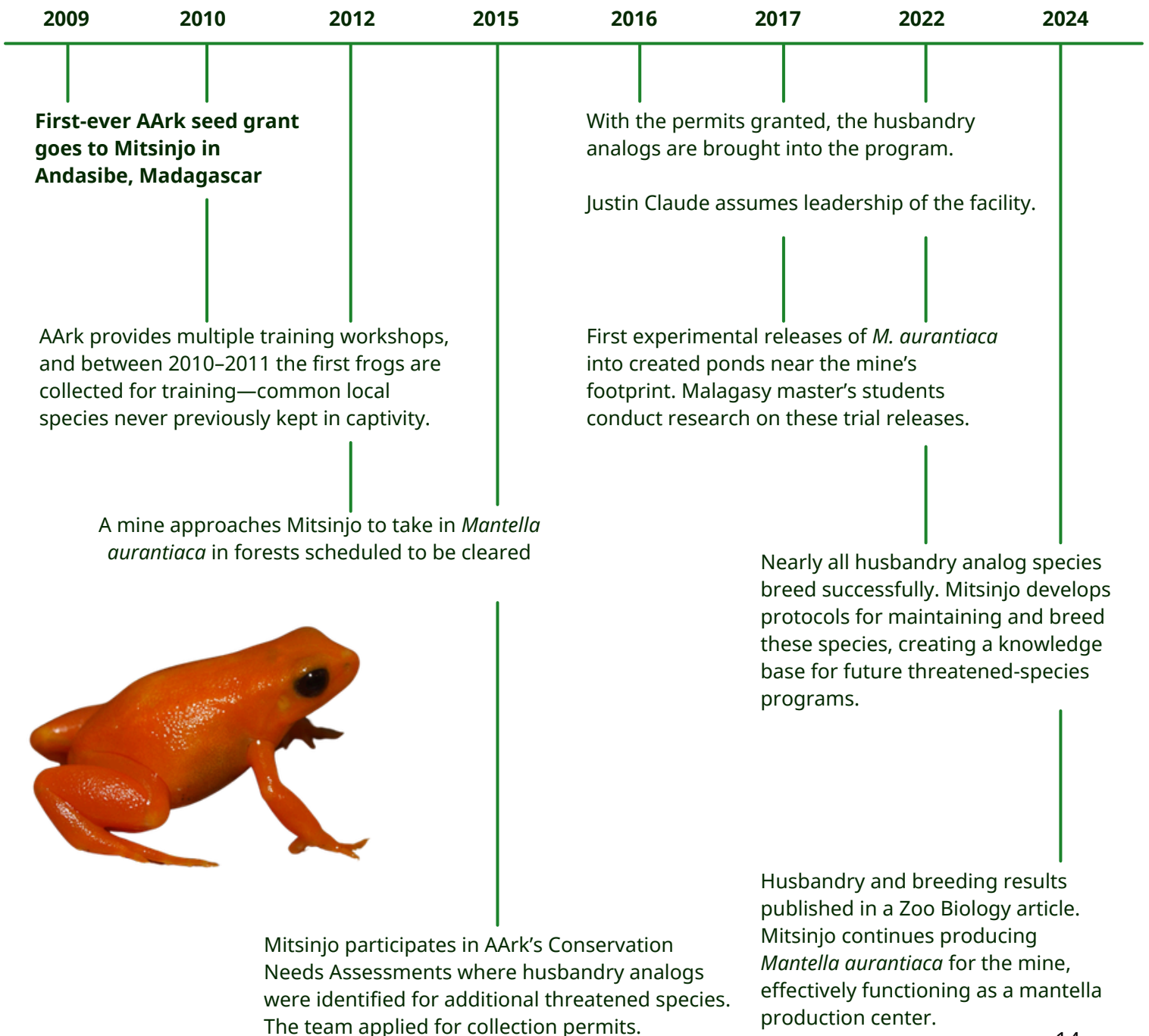


AArk has provided multiple training workshops since 2009





An *ex situ* conservation breeding program for the Golden Mantella began in 2012 with individuals collected from within the footprint of a planned nickel and cobalt mine. Reliable breeding was established, and **trial reintroductions into the created habitat began in 2017.**



*Remembering*  
**Justin Claude Rakotoarisoa**  
1981 – 2026



Amphibian Ark is deeply saddened by the passing of Justin Claude Rakotoarisoa, a founding member of Association Mitsinjo and one of Madagascar's most respected amphibian conservation practitioners. For more than two decades, Justin Claude—known affectionately as JC—was a steady, confident, and reassuring presence within Association Mitsinjo, the Andasibe community, and the wider conservation world.

As the lead running Mitsinjo's amphibian conservation programs, JC carried himself with quiet confidence, offering guidance that was honest, kind, and grounded in personal experience. He brought people together and led by example, earning the respect of colleagues, visiting researchers, and the many technicians, students, and interns he worked alongside over the years. He was thoughtful, dedicated, and someone you could always count on.

JC grew up in Ankaizinina, a small village in Analamazaotra Forest Station near Andasibe. His connection to the forest began early. His father patrolled the forest station, and JC spent much of his youth interacting with Madagascar's unique biodiversity. As a child, he caught chameleons and stood by the road to Andasibe displaying the largest Parson's chameleon he could find to passing buses of tourists. He later became one of Mitsinjo's top guides, specializing in amphibians and reptiles, and later contributed to the Malagasy translation of the 2007 Glaw and Vences Field Guide to the Amphibians and Reptiles of Madagascar.

In 2009, JC was selected as one of six Mitsinjo members to establish the organization's amphibian breeding facility, which was supported by AArk's first Seed Grant. From 2010 onward, he served as the lead technician, and in 2013, he traveled to the United States to participate in AArk's amphibian husbandry training workshop at Toledo Zoo. He played central roles in AArk programs, including the 2015 Conservation Needs Assessments for Madagascar.

He was generous with his expertise, hosting and training staff from other institutions at Mitsinjo's facility and traveling to share his knowledge elsewhere. He worked with the Madagascar Fauna and Flora Group at Parc Ivoloina to strengthen their amphibian conservation program and husbandry practices. After having received Durrell's Endangered Species Management certificate in Jersey, he supported a staff member from the Durrell Wildlife Conservation Trust in captive husbandry protocols for their ploughshare tortoises. He also coordinated amphibian disease screening initiatives for Andasibe.

In recent years, JC oversaw Mitsinjo's captive assurance colony of the IUCN Red List Endangered Golden Mantella Frog (*Mantella aurantiaca*), producing tadpoles and juveniles for release into restored habitat. His work strengthened amphibian conservation in Andasibe and built capacity that will endure far beyond his lifetime. We honor Justin Claude for his leadership, kindness, and commitment to Madagascar's amphibians. He will be deeply missed.





*Pristimantis latidiscus* © Tristan Vratil



# Conservation breeding around the world



## Advances in husbandry and *ex situ* breeding protocols for *Physalaemus signifer*: a model species supporting the conservation of the threatened *Physalaemus soaresi* at BioParque do Rio, Brazil

Marcela Rosa Tavares | BioParque do Rio

Renata Ibelli Vaz | AArk National Co-Coordinator Brazil; IUCN SSC Amphibian Specialist Regional Group Brazil

Cybele Sabino Lisboa | AArk National Co-Coordinator Brazil; IUCN SSC Amphibian Specialist Regional Group Brazil

Samuel Villanova Vieira | BioParque do Rio

Since 2024, BioParque do Rio has been implementing the *ex situ* conservation project for *Physalaemus soaresi*, a critically endangered species endemic to a single forest fragment in the state of Rio de Janeiro, Brazil (Caram et al., 2016; Johnson et al., 2022). This project is being developed at the Prof. Dr. Sergio Potsch Herpetofauna Laboratory, which was built to serve as a permanent center dedicated to research and conservation initiatives for threatened herpetofauna species.

Before working with *Physalaemus soaresi*, it was necessary first to gain knowledge and experience, and to properly establish husbandry and breeding protocols with a congeneric species with similar ecological habits. The model species was *P. signifer*, a species classified as Least Concern, and identified as a surrogate species during the latest Conservation Needs Assessment workshop in Brazil. Here, we describe what has been achieved since the collection of the first individuals in January 2025, and how working with the surrogate species *P. signifer* has been important to gain valuable knowledge and practical experience that will significantly contribute to the development of protocols for the target species.

In early 2025, we collected nine adult individuals of *P. signifer* (previously identified as five males and four females) along with an egg clutch (from which the tadpoles hatched and completed their metamorphosis in the laboratory). The initial

stages in developing the husbandry protocol involved identifying the species' habits and behaviors by observing the adult individuals. This would then guide the proper design and structure of the maintenance terrariums. Within the first few days, we observed the species exhibit fossorial behavior, consistently burrowing into the substrate. This behavior limited daily visual monitoring of individuals and required a reconfiguration of the enclosures to better accommodate for burrowing activity while maintaining appropriate husbandry conditions. Therefore, the initial configuration of the permanent maintenance terrariums consisted of a substrate layer composed of topsoil and coconut fiber, a layer of dry leaves covering the surface, and a water container. Over time, the optimal substrate mixture, temperature, and humidity conditions for maintaining the animals were determined. The egg clutch provided valuable experience in rearing tadpoles in the laboratory, allowing us to understand their feeding requirements and track their developmental progression.

*Physalaemus soaresi* © Pedro Peloso



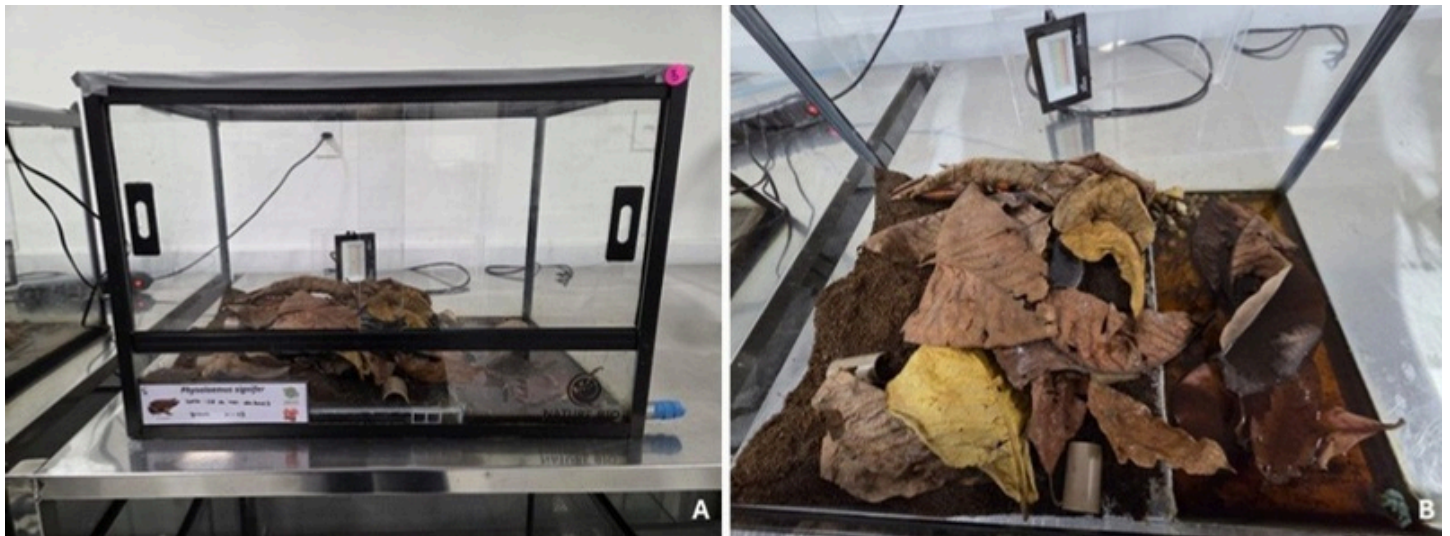


Figure 1. Permanent terrariums modified to include a liquid-introduction point, allowing the formation of a pool of almond-leaf tea. A – Front view; B – Top view from inside the terrarium.

All collected adults were tested for *Batrachochytrium dendrobatidis* (Bd). Individuals who tested positive were treated with compounded itraconazole, administered topically through immersion baths. Following mortality events during the initial treatment phase, the institutional treatment protocol was revised. After some adjustments, all remaining individuals tested negative for Bd.

In October 2025, we initiated breeding attempts using both wild-caught adults and laboratory-reared individuals that had already reached sexual maturity. Initially, the animals were stimulated with playbacks of vocalizations recorded in their natural habitat. A more complex terrarium was set up, featuring a large water pool with almond tree leaves and an elevated platform covered with substrate. Pairs were observed in amplexus, both in the complex terrarium and in the terrarium without the pool. Therefore, we adopted the more complex setup as the new configuration for the permanent maintenance terrariums, as it supports both the maintenance and reproduction of the animals by allowing the formation of foam nests in the pool area (Fig. 1).

Following the stimuli, at least seven pairs were observed in amplexus (Fig. 2A), along with spontaneous vocalizations. At the beginning of January 2026, two foam nests were formed by animals kept in the same terrarium (Fig. 2B).

The first nest remained in its original terrarium and developed under the prevailing water conditions of that microcosm, resulting in the successful hatching of 115 tadpoles, which metamorphosed into 90 juveniles. The second nest was removed and transferred to an aquarium containing clean, filtered water to facilitate tadpole handling and enable closer monitoring of individuals. This resulted in the successful hatching of 55 tadpoles, of which 35 reached metamorphosis.

Currently, we are caring for two adults collected from the wild, 18 adults that originated from the egg clutch collected in the natural environment and completed metamorphosis in the laboratory, as well as 125 juveniles from the two foam nests observed in early January 2026 in the laboratory.

Based on the knowledge consolidated



Figure 2. Reproductive behaviors of *Physalaemus signifer*. A – Male and female in amplexus; B – Foam nest.

throughout the management process and the positive outcomes achieved with the analogous species, **the next step will be to initiate the collection of the target species, *Physalaemus soaresi***. With the experience gained in managing and monitoring all developmental stages of *P. signifer*, the team is now prepared to ensure high standards of husbandry, welfare, and reproduction of the threatened species in an *ex situ* conservation context.

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## Conservation efforts for the Mexican axolotl (*Ambystoma mexicanum*), a perspective with an *ex situ* and *in situ* approach, by the Commission of Natural Resources and Rural Development (CORENADR) of Mexico City

Claudia Viridiana Saldaña Durán | CORENADR

Erika Servín Zamora | CORENADR

Rosa Isela Quintero Pérez | CORENADR

Aldo Eric Fuentes Barradas | CORENADR

Miguel Levy Domínguez | CORENADR

Alma Mirella Domínguez López | CORENADR

Aldair Rubí Méndez | CORENADR

Roció Penélope Montiel Bustos | CORENADR

Humberto Adán Peña Fuentes | CORENADR

Mexico ranks as one of the megadiverse countries in the world due to the large number of ecosystems it hosts, derived from the interaction of the Nearctic and Neotropical biogeographic regions. This great diversity is the result of its historical, topographical, and geological background, endemisms, and socio-ecosystem interactions (Luna Plascencia et al., 2011).

Mexico City has undergone a drastic ecological transformation, where what is now urban land was once a lacustrine system (Herrera-Juárez et al., 2024). This area supported the development of the *chinampa* (artificial island) agricultural system, which, due to its cultural and biological richness, is recognized as a UNESCO World Heritage Site and a Wetland of International

Importance (RAMSAR Site), located in the boroughs of Xochimilco and Tláhuac.

In 2021, the Wildlife Conservation Management Unit (UMA) “Vivero de San Luis Tlaxialtemalco” was established for the conservation, management, and reproduction of priority wild flora and fauna species listed in NOM-059 SEMARNAT-2010 within the



Figure 1. Mexican axolotl (*Ambystoma mexicanum*), specimen from the Anemilkalli Laboratory.



conservation land of Mexico City. Subsequently, in September 2024, a laboratory called “Anemitilkalli,” a Nahuatl term meaning “Enclosure of aquatic animals” (Figure 1), was established to prioritize and work on the conservation of native aquatic species of the wetlands of Mexico City's conservation land.

The project is led by the Directorate of Preservation, Protection, and Restoration of Natural Resources of the Commission of Natural Resources and Rural Development (CORENADR) of the Government of Mexico City. The main objective of the Anemitilkalli Laboratory is the recovery and establishment of populations of priority native aquatic species for their reintroduction into the wild, through strategies of environmental diagnosis, research, and community participation to ensure their long-term success. Currently, there are three priority species:

the Mexican axolotl (*Ambystoma mexicanum*), the mexclapique (*Girardinichthys viviparus*), and the Moctezuma crayfish (*Cambarellus montezumae*). This laboratory combines *in situ* and *ex situ* strategies for the conservation of the Mexican axolotl, with four lines of action:

**Native species conservation:** Promotes the reproduction and care of endangered endemic aquatic species, contributing to their survival. This includes the management and care of aquatic species and strategies for their sustainable use.

**Ecosystem restoration:** Through its artificial wetland and projects such as the demonstration *chinampa*, this seeks to improve water quality and promote the recovery of key ecosystems, aiming to establish thermal refuges for species such as the Mexican axolotl. This includes the monitoring of physicochemical and biological parameters of wetlands (Fig. 2).

**Socio-environmental strategies:** Through community participation and outreach activities, this promotes the conservation of biodiversity and natural habitats, environmental communication and culture, and socio-environmental diagnostics (Fig. 3). Through a territorial work model, it fosters comprehensive and sustainable development that allows the continuation of agriculture and conservation of wetland ecosystems in Mexico City.

**Scientific research:** This seeks to generate practical knowledge and innovative solutions to address environmental problems such as climate change, pollution, and the presence of invasive species, with three research lines: reproduction, genetics, and ecology.

The conservation of the Mexican axolotl is a key pillar for the restoration of wetlands and the *chinampa* system, which has been maintained for centuries



Figure 2. CORENADR artificial wetland.

despite serious challenges such as pollution, the introduction of invasive exotic species, urban expansion, and land-use change. Therefore, CORENADR, through the “Anemitilkalli” Laboratory, proposes the development of a strategy that ensures the persistence of wildlife and the sustainable and environmentally friendly development of productive activities.

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Figure 3. The artificial wetland of CORENADR provides the space for environmental education.



# Hatching plasticity confirmed in Pickersgill's reed frogs in the Johannesburg Zoo: understanding this evolutionary change is a step forward for amphibian conservation efforts

Ayrelia Sherené Randerá | The Johannesburg Zoo Aquarium  
Erica Catherine Marais | The Johannesburg Zoo Aquarium  
Peter Baloi | The Johannesburg Zoo Aquarium

## The Johannesburg Zoo and its fight to save the *Hyperolius pickersgilli* frog:

According to the IUCN Red List of Threatened Species, the Pickersgill's reed frog (*Hyperolius pickersgilli*) is a small, brightly coloured amphibian found only in the KwaZulu-Natal province of South Africa and is currently classified as endangered, mainly because of habitat loss and degradation of breeding sites due to water pollution, urbanization, and invasive vegetation. The greatest threat to amphibians in general isn't a single habitat event but a combination of gradual environmental pressures.

To address this, the Johannesburg Zoo, together with Ezemvelo in Kwa-Zulu Natal, established the Amphibian Research Project (ARP), a bio-secure *ex situ* conservation breeding program designed to maintain an insurance population and produce individuals for release into restored habitats. With the success of our breeding program, over 700 specimens

have been released to date. A comprehensive husbandry manual—Pickersgill's Reed Frog Husbandry Manual (2022)—published by JCPZ ARP was also created, as well as various scientific publications.

### What is hatching plasticity?

For many years, biologists assumed that the timing of hatching in amphibians was relatively fixed (Poo and Bickford, 2014). Hatching plasticity, also known as environmentally cued hatching, occurs when embryos accelerate or delay their emergence in response to environmental stimuli such as predators, flooding, oxygen availability, parasites, and/or parental care (Delia et al, 2014, Warkentin, 2011; Seymour et al, 2000; Sinai et al, 2022). This then allows developing animals to reduce mortality risks during this vulnerable early life stage. Hatching early to escape an unfavorable environmental cue comes with trade-offs (Delia et al, 2018): escaping danger quickly versus being physiologically prepared for survival.

The life cycle of *H. pickersgilli* has not been studied in the wild. Therefore, what we know about this species has been derived from observations of the species *ex situ* (Randerá et al., 2025). *Ex situ* conservation programs often reveal aspects of species biology that are impossible to observe in natural environments. One such discovery at the Johannesburg Zoo was unexpected: frog embryos appeared to hatch much earlier than previously documented.

A scientific study was then conducted between 2019 and 2021, which led to the first confirmed documentation of hatching plasticity in *H. pickersgilli* (Randerá et al., 2025). In captivity, *H. pickersgilli* frogs lay approximately 100-200 eggs in a gelatinous mass on vegetation above water bodies. Tadpoles emerge after approximately 6-8 days of developing in the egg capsule (du Plessis et al 2022b, Raw 1982). However, a clutch observed in 2019 hatched on day four. This prompted biologists at the Johannesburg



Zoo to test whether a disturbance could trigger earlier hatching.

Twelve clutches (1606 eggs) across two breeding seasons were monitored in a bio-secure facility, at optimum *H. pickersgilli* required conditions, as outlined in du Plessis et al. (2022b). A disturbance in the form of direct misting on the egg clutches was introduced to simulate vibrations that could alert the developing tadpoles of potential danger. Clutches were divided into two groups: undisturbed clutches, which were misted indirectly to maintain humidity, and disturbed clutches, which were directly mist-sprayed on day four after oviposition. Day four was chosen to introduce the disturbance because embryos showed movement at this stage (Gosner stage 21, Gosner 1960; see also Cohen et al, 2016). Researchers then recorded the time of first hatching, hatching success, and a 30-day tadpole survival rate (Randera et al, 2025).

The results clearly demonstrated hatching plasticity. Disturbed clutches hatched significantly earlier, at approximately 4.7 days, compared with 7 days in undisturbed clutches (Randera et al, 2025). **Remarkably, once disturbed, the first tadpole emergence was in an average of 10 seconds.** Embryos visibly moved inside the egg capsule before hatching, suggesting that disturbance triggered a rapid

Female Pickersgill's reed frog laying eggs that contributed to the hatching plasticity study.  
© Ayrelia Randera



Disturbed clutch of tadpoles emerging from their egg capsule after being directly misted.  
© Ayrelia Randera





escape response. Similar behaviour in other frogs, like in *A. callidryas*, is associated with predator avoidance or flooding events (Warkentin et al., 2007).

Although early hatching allows embryos to escape immediate danger, it can come at a cost. Tadpoles from undisturbed clutches had significantly higher survival rates, with approximately 84% surviving 30 days. Early-hatching tadpoles have only a 45% survival (Randera et al, 2025). The reason for this is developmental readiness. Later-hatching tadpoles had absorbed their yolk sacs, they began feeding within three days and developed lungs sooner, while early-hatched tadpoles still possessed yolk sacs, began feeding later, and took longer to develop lungs (Randera et al, 2025). These early hatched tadpoles were smaller and remained vulnerable for longer periods. In nature, they would face predators and environmental challenges for a longer time before reaching a more developed stage (Cope, 1874). This study demonstrated a fundamental principle in evolutionary ecology: escaping danger can reduce later survival probability (Randera et al, 2025).

### **What does this mean for the future of conservation?**

This discovery has immediate relevance to captive breeding programs. Routine husbandry practices- such as mist spraying

to maintain humidity can trigger premature hatching and lead to a decrease in tadpole survival.

Egg care is one of the most critical stages in amphibian breeding. More broadly, the research shows that captive environments can inadvertently create artificial environmental signals that developing tadpoles interpret as danger. Understanding environmentally cued hatching allows conservationists to align captive-bred conditions with natural developmental needs rather than unintentionally working against them.

Studies like these shed light on the need to have a stress-minimized captive facility and careful handling procedures. Knowing embryos respond to disturbances helps predict how climate change events- storms, flooding, drought- may affect reproduction in the wild. We now know that hatching plasticity occurs across at least 12 Anuran families (Warkentin, 2011). Therefore, this knowledge can be applied to endangered frogs in conservation programs worldwide.

### **Conclusion**

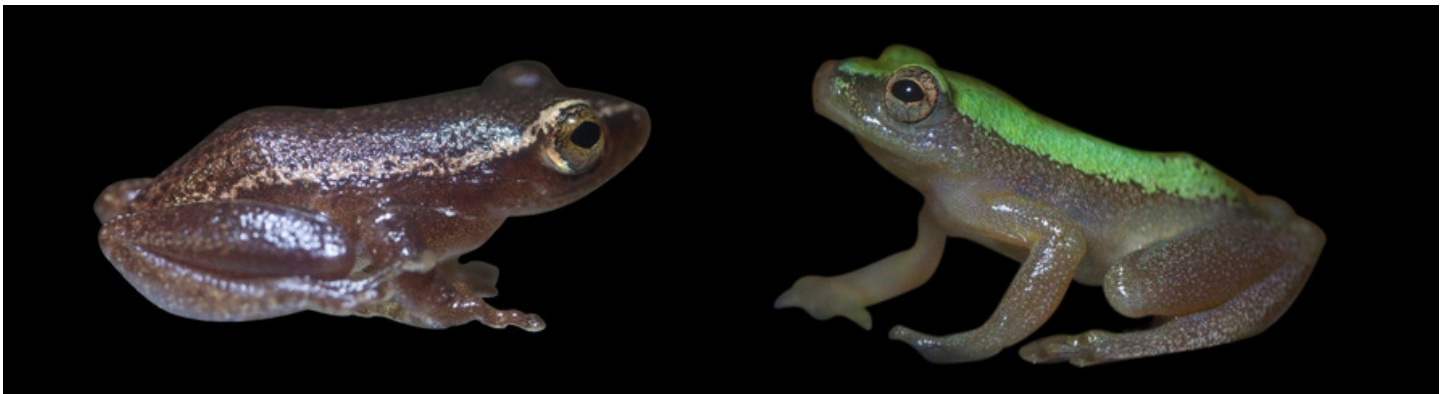
The confirmation of hatching plasticity in the Pickersgill reed frog is more than just a behavioural observation, it is a conservation tool! By recognizing environmentally cued hatching, conservationists can increase tadpole survival,

improve captive breeding success, enhance reintroduction outcomes, and better predict species responses to environmental changes. In a time when amphibians are among the most threatened vertebrates on Earth, conservation success can come down to understanding biology at its most delicate of stages: the embryo.

The Johannesburg Zoo's work shows that conservation breakthroughs sometimes begin with a simple observation: a frog hatching a few days too early!



Pickersgill's tadpole at 30 day survival day. © Donovan Marais



Left: Breeding male Pickersgill's frog that contributed to the hatching plasticity study. Right: adult female Pickersgill's reed frog that contributed eggs for the hatching plasticity study. © Donovan Marais

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## Head-starting hope: *ex situ* conservation of five federally protected amphibians in California's Sierra Nevada

**Rochelle Stiles** | Field Conservation Team, San Francisco Zoo & Gardens  
**Tiffany May** | Field Conservation Team, San Francisco Zoo & Gardens  
**Ben Witzke** | Field Conservation Team, San Francisco Zoo & Gardens  
**Jamie McNellis** | Field Conservation Team, San Francisco Zoo & Gardens  
**Matthew Weeks** | Field Conservation Team, San Francisco Zoo & Gardens  
**Mikaela Wiley** | Field Conservation Team, San Francisco Zoo & Gardens  
**Rosalie Tang** | Field Conservation Team, San Francisco Zoo & Gardens  
**Jae Rendall** | Field Conservation Team, San Francisco Zoo & Gardens  
**Maclen Sheehy** | Field Conservation Team, San Francisco Zoo & Gardens  
**Jarrold Willis** | Field Conservation Team, San Francisco Zoo & Gardens  
**Jessie Bushell** | Field Conservation Team, San Francisco Zoo & Gardens

The Sierra Nevada, part of the globally recognized California Floristic Province biodiversity hotspot, contains some of the most ecologically significant montane wetland systems in North America. High-elevation lakes, streams, ponds, and ephemeral pools have historically supported extensive amphibian metapopulations distributed across elevational gradients. Early-twentieth-century surveys by Joseph Grinnell and colleagues systematically documented these distributions, establishing a historical baseline for amphibian occupancy throughout the mountain range. More recent surveys detected steep and widespread amphibian declines, beginning in the 1970s, and many species now persist as small, fragmented populations occupying a fraction of their former range. Contemporary threats include habitat

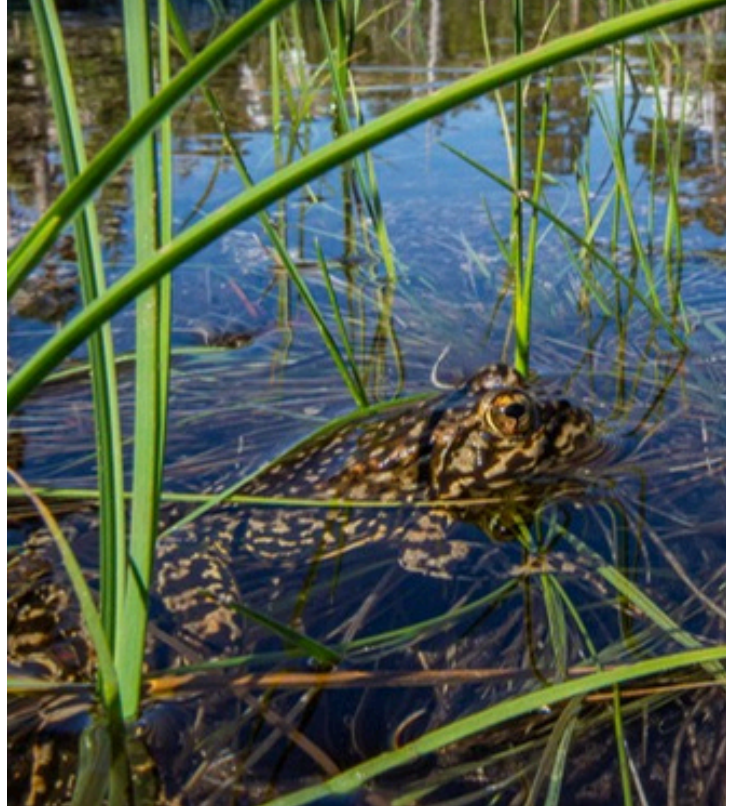
alteration, introduced predatory fishes and American bullfrogs, prolonged drought, and the pathogenic chytrid fungus *Batrachochytrium dendrobatidis* (Bd).

In response to population declines, biologists and resource managers collaborated with San Francisco Zoo & Gardens (SF Zoo) to develop head-starting programs for Sierran amphibians to increase larval and post-metamorphic survival to accelerate population recovery in restored habitats.

At SF Zoo, our Field Conservation Department operates one of the largest amphibian head-start programs in the United States. What began as a single-species effort with the Sierra Nevada yellow-legged frog (*Rana sierrae*) has expanded into a coordinated, multi-partner initiative supporting five federally listed amphibians for

release into the Sierra Nevada: the Sierra Nevada yellow-legged frog, the mountain yellow-legged frog (*R. muscosa*), foothill yellow-legged frog (*R. boylei*), California red-legged frog (*R. draytonii*), and Yosemite toad (*Anaxyrus canorus*).

Over the past decade, **our program has released more than 9,900 juvenile frogs into restored habitats across the Sierra Nevada**, representing sustained, multi-species recovery efforts (Table 1). Releases span elevations, watersheds, and land-management jurisdictions, contributing to both reintroduction and population-augmentation goals.



Top left: California red-legged frog (*Rana draytonii*) reared by the San Francisco Zoo & Gardens recently released into Yosemite National Park. © Rochelle Stiles.

Top right: Foothill yellow-legged frog (*Rana boylei*) in the Sierra Nevada. © Isaac Chellman.

Bottom left: Head-start yosemite toad (*Anaxyrus canorus*) at San Francisco Zoo & Gardens. © Ivan Parr.

Bottom right: Sierra Nevada yellow-legged frog (*Rana sierrae*) in the Sierra Nevada. © Isaac Chellman.



Table 1. Amphibians reared and released by San Francisco Zoo and Gardens and partners.

Species	Federal Status	Project Years	Cumulative released	Release Jurisdictions
Sierra Nevada yellow-legged frog ( <i>Rana sierrae</i> )	Endangered	2013 – present	4,865	Yosemite and Sequoia-Kings Canyon National Parks
Mountain yellow-legged frog ( <i>Rana muscosa</i> )	Endangered	2015 – 2025	508	Sequoia-Kings Canyon National Parks
California red-legged frog ( <i>Rana draytonii</i> )	Threatened	2016 – present	4,430	Yosemite National Park and Solano County
Yosemite toad ( <i>Anaxyrus canorus</i> )	Threatened	2022 – present	188	Yosemite National Park
Foothill yellow-legged frog ( <i>Rana boylei</i> )	Endangered	2025 – present	Over 550 to be released in 2026	Yosemite National Park

While the number of animals released is an important measure of impact, our program prioritizes preparing frogs for survival in the wild, aiming to ensure frogs are physiologically, behaviorally, and immunologically equipped to persist. To this end, SF Zoo has participated in collaborative research with universities, non-profit organizations, federal and state agencies, and other zoological institutions to address multiple facets of amphibian conservation biology, as follows. We partnered with researchers to investigate host immune responses in three program species following exposure to and subsequent treatment of Bd (Adams et al., 2022; Knapp et al., 2024) and also studied skin microbiome dynamics (Jani et al., 2021). As most of our species inhabit high-elevation

environments and remain in brumation for much of the year, we initiated a multi-year study evaluating the physiological effects of brumation on head-started populations. We are continuing to study and monitor reproductive phenology between released individuals and wild populations, including work with California red-legged frogs (Grasso et al., 2023). In collaboration with San Diego Zoo Wildlife Alliance and other partner institutions, we are advancing research on spermiation and cryopreservation techniques for endangered frog populations throughout California. Additionally, we are working to make our extensive long-term datasets available to researchers studying climate change and other environmental stressors affecting amphibians. Some of

our other research included studies of behavioral ecology, thermal and habitat preference in artificial and natural environments, and bioacoustic monitoring of anuran vocalizations (several *in prep* papers).

As our program grows, we continue to refine husbandry practices, expand research collaborations, build new partnerships for outreach and education, and broaden our conservation efforts to include additional threatened amphibian species across the state. Our head-start program operates under federal and state permits and in coordination with agency and institutional partners, including the U.S. Fish & Wildlife Service, National Park Service, U.S. Forest Service, Bureau of Land Management,



California Department of Fish and Wildlife, San Francisco Public Utilities Commission, and the Sierra Nevada Aquatic Research Laboratory (University of California, Santa Barbara), which contribute field expertise, ecological monitoring, and applied research that inform both rearing and release strategies.

The Zoo developed husbandry and rearing protocols for the three yellow-legged frog species in partnership with the California Conservation Society at Oakland Zoo, which contributed essential facility space and institutional expertise. Additional research collaborators include Stillwater Sciences, WRA, the University of Mississippi, Vanderbilt Medical Center, and California State University East Bay, with field logistics supported by the Sequoia-Kings Canyon Helitack and Yosemite Helitack.

Yosemite National Park components of this work are a Zoo–Park Partnership for America’s Keystone Wildlife supported by the Wildlife Restoration Foundation, with implementation and long-term continuity made possible through philanthropic support from Sequoia Parks Conservancy, Yosemite Conservancy, the Dorrance Family Foundation, Ruth Smart Foundation, The Kinnoull Foundation, and the Sylvanus Charitable Trust.

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San Francisco Zoo & Gardens and the Sierra Nevada Aquatic Research Laboratory staff releasing head-started frogs in Yosemite National Park.

© Paulo Vergara





## Securing a future for the pool frog (*Pelophylax lessonae*) in Southern Sweden

**Kristofer Försäter** | Foundation Nordens Ark

**Emma Nygren** | Foundation Nordens Ark

**Josefin Töllborn** | County Administrative Board of Kalmar

In 2025, a new conservation initiative for the pool frog (*Pelophylax lessonae*) was launched in Sweden through a collaboration between Foundation Nordens Ark and the County Administrative Board of Kalmar. The new project focuses on one of the country's most at-risk amphibian populations: the pool frog. This population represents the very last fragments of a once much wider Nordic range.

The pool frog has a highly restricted distribution in Sweden, occurring only at a limited number of sites along the northern coast of Uppland County and in forested landscapes in northern Kalmar County and southeastern Östergötland County. The populations in Kalmar County and Östergötland County are considered relict and nationally unique (Jacob, 2007). They differ from the Uppland population, which represents the "northern clade" of pool frogs (Zeisset & Hoogesteger, 2018) in morphology and most strikingly in color, with individuals from the population in Kalmar County having a strong green color, as opposed to the much darker

brown tones found on the population in Uppland.

In the upcoming national Red List (SLU, unpublished), pool frogs are proposed to be downlisted from Vulnerable (VU) to Least Concern (LC). However, the situation for the populations in Kalmar and Östergötland is considered critical. Yearly

surveys in both counties have revealed a continuing population decline, with little or no annual recruitment due to extremely low reproductive success. The Kalmar population (discovered as recently as 2018) consists of a single small group of fewer than 20 adult individuals. In Östergötland, the population decline has been so



Pool frog (*Pelophylax lessonae*) in situ © Nordens Ark



severe that the species is now likely locally extinct.

The remaining population in Kalmar is therefore highly vulnerable to stochastic events and environmental disturbances, including predation, diseases, fluctuation in pH, and other changes in their habitat. Without urgent conservation actions, this nationally unique lineage risks being lost entirely. The situation is critical and requires coordinated and comprehensive conservation measures implemented without delay.

The County Administrative Board of Kalmar, in collaboration with the landowner, is working to reduce predator pressure, protect the existing habitat, and restore surrounding wetlands to enable the population to expand to additional sites. Additionally, the County Administrative Boards of Kalmar and Östergötland jointly developed a regional reintroduction and release program for the species, forming the foundation for the current conservation efforts. This regional program is an addition to the existing national

action plan for the species (Lindgren et al. 2014).

### **From the wild**

In June 2025, the first frogs were collected from a site in Kalmar County and transported to Nordens Ark. Over the coming 2–3 years, additional founders will be brought into the program to gradually establish a genetically representative captive population. The goal is to create a biosecure assurance colony that will serve as a stable foundation for future reinforcement and reintroduction efforts.

Pool frog habitat in Kalmar County  
© Nordens Ark





Although the species is new to the current conservation program, Nordens Ark is not starting from scratch. For educational reasons, Nordens Ark managed a group of pool frogs between 2008 and 2019. This group, originating from Uppland, was used for developing husbandry and breeding protocols that were later published (Michaels & Försäter, 2017). These experiences have now proven invaluable for the new project.

#### **A first major milestone**

During our first year, we achieved a major breakthrough as one of the breeding pairs successfully reproduced. At present, over 300 tadpoles are in care at Nordens Ark's dedicated amphibian facility. This marks the first concrete step toward reinforcing the critically small wild population of pool frogs.

The long-term objective is to rear these offspring to adulthood and release them at the site where the founders were collected, thereby reinforcing the remaining wild population. At the same time, a subset of individuals will be retained in the newly established institutional studbook to build a sustainable breeding population to support future conservation actions.

#### **A model for regional amphibian conservation**

The pool frog project is part of a broader national effort to safeguard the species through coordinated *ex situ* and *in situ* conservation. With habitat loss, fragmentation, and population isolation continuing to threaten amphibians across Europe, this initiative demonstrates how targeted breeding programs can provide a vital lifeline for species

on the brink of extinction. Conservation is not only about the largest or the rarest species, but it is also about protecting regional diversity and evolutionary uniqueness.



Pool frog management in Nordens Ark's dedicated amphibian facility  
© Nordens Ark

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Pool frog (*Pelophylax lessonae*) tadapoles © Nordens Ark





## Looking beyond the tropics: *ex situ* conservation and reintroduction of the fire-bellied toad (*Bombina bombina*) in Lithuania

Šarūnas Kulbokas | Lithuania Zoological Gardens Coordinator of Scientific Activity  
Gintarė Stankevičė | Lithuania Zoological Gardens Director

The decline of amphibian species in tropical forests has been the focus of global conservation campaigns in recent years. This focus is necessary because tropical amphibians face severe threats from climate change, deforestation, habitat loss, and emerging diseases. But this attention often obscures other conservation issues, especially in temperate places like Europe.

The difference between national and international conservation assessments is one of the main problems. Although species classified as Least Concern on

the IUCN Red List are frequently thought to be safe, significant regional declines may be obscured by this global status. Conservation attempts might therefore be postponed until local populations have already declined. This is especially challenging because the loss is both genetic and numerical: haplotypes shaped over hundreds of years, local adaptations, and distinctive phenotypes may all be lost without being identified.

This risk is clearly illustrated by the fire-bellied toad (*Bombina bombina*). In Europe, the genus

*Bombina* is represented by two species: *Bombina bombina* and *Bombina variegata*, both of which show strong regional variation in conservation status despite relatively stable global assessments (IUCN 2025). If northern populations of *Bombina bombina* were to disappear, their recovery would be highly uncertain. Individuals from Central Europe are unlikely to adapt to the shorter growing seasons and colder winters typical of northern regions. As a result, the species' ecological role and adaptive potential in the north would be irreversibly lost.

Fire-bellied toad (*Bombina bombina*)  
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### Conservation status and threats in Lithuania

*Bombina bombina* is categorized as Near Threatened in the Lithuanian Red Data Book, while being listed as Least Concern worldwide. The majority of populations in Lithuania occur in the country's north and south, where there are still suitable wetland habitats.

Despite this, wetlands in Lithuania are still extensively managed or drained, mostly because of agriculture. These activities restrict gene flow between populations by reducing breeding habitats and disrupting dispersal corridors. As a result, populations become increasingly fragmented, leading to a decrease in genetic diversity.

Population vulnerability is directly affected by low genetic diversity. Fragmented

populations are much more prone to infectious diseases and have fewer resources for adaptation to their surroundings.

The amphibian pathogens *Batrachochytrium dendrobatidis* (Bd) and *Batrachochytrium salamandrivorans* (Bsal) are alarming concerns. Both diseases have already been detected in Europe and are gradually expanding their range northward (Welfare et al. 2018). Therefore, in tiny, isolated populations of *Bombina bombina*, *ex situ* programs may be able to save more populations from outbreaks.

### Ex situ program

The Lithuanian Zoological Garden initiated an *ex situ* rearing and release initiative for *Bombina bombina* from 2017 to 2022 in response to the national status. The main priority was

protecting local populations that were in decline while preserving their natural developmental and behavioral patterns.

We obtained official permits to collect egg clutches from breeding sites. We transferred the eggs with water from their original ponds to reduce stress and maximize survival. Once the eggs reached the laboratory, they were carefully moved into 60-liter plastic containers that were three-quarters full. After being kept near outside temperatures for five days, the laboratory temperature was gradually raised to 24-25°C, where it remained throughout the larval development.

For temperate amphibian species to develop and adapt successfully, seasonal temperature change is necessary. As a result, overwintering was done in a



Frog eggs are collected from natural wetlands in spring, when the water temperature reaches about 13-14 °C. The eggs, attached to plant stems in shallow water, are carefully gathered together with the plants, placed in buckets filled with water from the same pond (including natural microfauna as a food source), kept outdoors at stable temperatures, and delivered to the zoo within 1-2 days.

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The first tadpoles hatch from the collected eggs and are then carefully reared under controlled conditions at the zoo. © Lithuanian Zoological Gardens

laboratory setting with strict monitoring. To prepare the five-month-old juveniles for wintering, we cut the photoperiod to five hours per day. We gradually reduced the water temperature to 10°C over the course of two weeks.

The collected spawn hatched a total of 229 tadpoles during the period, with 92.9% of individuals successfully completing metamorphosis and completing the next developmental phases.

### **Post-metamorphic rearing and behavioral conditioning**

After metamorphosis, we maintained the juvenile fire-bellied toads in a controlled environment that was enriched with natural elements. We created shelters as well as functional microhabitats that mimicked natural circumstances using substrate, stones, oak leaves, live aquatic plants, and other natural decorations. These characteristics reduced stress and promoted natural hiding behavior.

In addition, we used live prey feeding to promote natural

behavior, including cockroaches, crickets, fruit flies, and chironomid larvae. Hunting live prey encouraged individuals to engage in normal foraging activity. This created competitive relationships amongst frogs, which further supported behavioral development.

Both aquatic and terrestrial microhabitats were available to the toads in adaptation enclosures. Their ability to swim freely, climb on branches, stones, or emergent plants resembled how they would use their native habitat.

### **Reintroduction procedures and habitat management**

We transferred juvenile toads (10-12 months old after rearing) to protected area agencies for release into the wild. To guarantee proper condition before release, individuals who were noticeably smaller than other specimens were raised for a longer period.

Toads were not fed 24 hours before release to reduce risks during reintroduction. On the night before release, they were

moved from adaptation enclosures and kept at temperatures approximately 2°C below normal. These measures reduced physiological stress and potential digestive complications associated with sudden changes in ambient temperature after release.

Before reintroduction, release sites were actively managed to maintain suitable breeding conditions. Woody vegetation was removed around ponds to prevent cooling of the water, as high water temperatures are essential for tadpole development. In addition, excessive leaf input from surrounding vegetation can accelerate eutrophication, leading to oxygen depletion and a reduction in open water areas required by larvae. Other than that, the nearby meadows were either grazed or mown.

Adults of *Bombina bombina* forage frequently on the grasslands around breeding ponds, and the terrestrial part of their life cycle is crucial. Fully covered, overgrown meadows restrict *Bombina bombina*'s



mobility by increasing habitat isolation and decreasing invertebrate diversity (Dolgener et al., 2012). Therefore, ongoing habitat management is crucial.

### Future plans

Long-term success will be evaluated through post-release monitoring, including population surveys, estimation of population size and structure, and assessment of breeding success. The results will guide future management decisions for *Bombina bombina* in Lithuania and neighbouring countries, and assess the effectiveness of *ex situ* breeding.



The first captive-reared fire-bellied toads are released back into their natural wetlands, marking the start of field monitoring and a new chapter in their conservation. © Lithuanian Zoological Gardens

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Fire-bellied toads released by the team in Lithuania can be observed in wetlands during the breeding season, floating at the surface and calling while occupying small patches of vegetation. © Lithuanian Zoological Gardens



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*Picker's reed frog tadpole*  
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