



# LAZARUS

**Amphibians are under attack. Climate change, habitat loss and the effects of the deadly skin disease caused by the chytrid fungus have wiped out many frog and toad populations worldwide. Some entire species are missing, presumed dead. But in a few spots in the forests of Central America, a fightback has begun. Meet the Lazarus toads**

Photographs by Clay Bolt and Twan Leenders.  
Words by Catherine Brahic

In March 2013, Twan Leenders and a student were hiking in the Cocobolo reserve in central Panama when they spotted a precious jewel: a delicate string of white pearls floating at the bottom of a rocky puddle at a stream's edge. "That was absolutely tremendous," says Leenders. "Everything fit for *Atelopus*, there was nothing else it could be."

Leenders, a herpetologist at the Roger Tory Peterson Institute of Natural History in Jamestown, New York, has spent his career studying tropical frogs and toads. That had mostly meant documenting their astonishing decline. Climate change and human encroachment on the amphibians' favoured habitats were a major part of the problem – as was the advance of the deadly chytrid fungus.

Since the chytrid strain *Batrachochytrium dendrobatidis* was identified in 1999, it has been seen in amphibian populations across Europe, Africa, Australia and Central and South America. The fungus accumulates in the outer skin layers of amphibians, overstimulating production of the protein keratin and hardening the skin. That prevents >



## *Atelopus limosus*

Panama

Discovery of spawn from this toad species – known as "harlequin frogs" – (pictured in the main photo, left) in the streams of the Cocobolo reserve indicated the revival of a species thought almost gone. The toad's colourful skin harbours bacteria that produce a neurotoxin also found in blue-ringed octopuses and the notorious "fugu" pufferfish. Until the advent of chytrid, this was sufficient protection against most enemies.



## *Atelopus varius*

Costa Rica

Before the arrival of the chytrid fungus, more than 100 populations of this harlequin species were once known in the mountains of Costa Rica and adjoining Panama. One population is now known to have survived and thrived in a single stream valley on an isolated mountain in Costa Rica's Pacific coastal plain. What conferred it with resistance to chytrid is a mystery.



the uptake of water and essential minerals - and is normally lethal.

The tiny, colourful toads of the *Atelopus* genus - known colloquially as harlequin frogs - suffered badly. "Harlequin frogs were particularly hard hit by the fungus, and dozens of species disappeared rapidly in the 1980s and 90s," says Robin Moore of Global Wildlife Conservation and the Amphibian Survival Alliance, both based in Austin, Texas.

Hence the reaction of Leenders and his crew to that pearl-string of spawn. It came from a species, *Atelopus limosus*, thought to have been wiped out in Panama. Here was a population that hadn't just survived, but was reproducing in the wild. A few days later, the team spotted juveniles further upstream. In the following years, more and more sightings were made around Cocobolo.

*A. limosus* is one of a small number of "Lazarus" amphibian species. In Costa Rica, Moore and Leenders are watching the recovery of *Atelopus varius*, a species thought extinct until one was found sitting on a rock a few years ago.

We still can't fully explain the comebacks. One theory is that long-term exposure to non-lethal levels of the fungus may confer individuals with resistance to the fungus. The Cocobolo reserve may also have been unsuitable for chytrid when it first took hold in Central America 10 to 20 years ago. At the time, it was pasture - too hot and dry for the fungus, which thrives on the cool surfaces of riverside rocks, just like the toads. *A. varius*, meanwhile, lives in a valley surrounded by a belt of agricultural land and plantations, which perhaps formed a protective barrier against the fungus.

The fact that the threatened amphibians have

## "This species hadn't just survived - it was reproducing"

prospered in habitats that are far from pristine may point to new ways to protect them - for example, by managing farmed landscapes to create new habitats. "I would like to work with local farmers to help them restore some of the stream corridors," says Leenders.

The amphibians aren't out of danger yet. "A few frogs have reappeared after massive declines and seem to be hanging on in relictual populations," says Ariadne Angulo, who co-chairs the International Union for Conservation of Nature's Amphibian Specialist Group. "They are not the norm, but there are some remarkable cases." As if to underline the point, Leenders's team is now getting reports of amphibian declines in areas just outside the Cocobolo reserve.

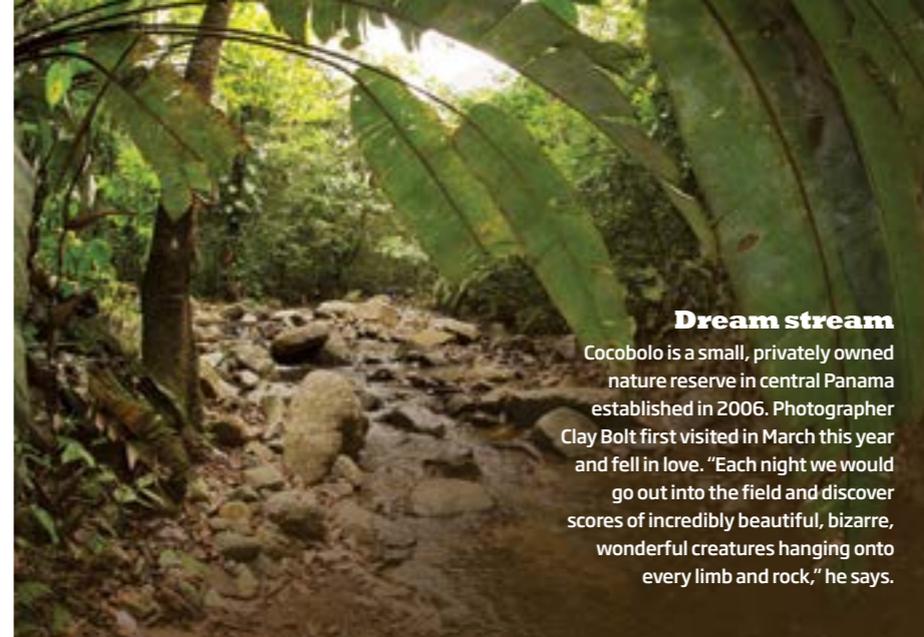
But Lazarus species give room for hope. "The fact that some of these species are reappearing years or even decades after they were last seen is enormously encouraging," says Moore - and an opportunity to understand what sets these populations apart. "After decades of witnessing rampant declines, these glimmers of hope are much-needed morale boosters." ■

An estimated  
**42%**  
of amphibian species have decreasing populations

**6424**  
amphibian species have had their extinction risk assessed

**1961**  
species are currently listed as "threatened"

SOURCE: ARIADNE ANGULO/IUCN



### Dream stream

Cocobolo is a small, privately owned nature reserve in central Panama established in 2006. Photographer Clay Bolt first visited in March this year and fell in love. "Each night we would go out into the field and discover scores of incredibly beautiful, bizarre, wonderful creatures hanging onto every limb and rock," he says.

### Fungal menace

Many tropical amphibians had hardly been studied before the chytrid fungus kicked in, and population declines were initially put down to natural cycles. The Lazarus toads give a much-needed chance to see what factors influence survival in the wild. "This is where Cocobolo becomes a pivotal point in the research and conservation of these most at-risk species," says Leenders.



### Desirable residence

Leenders and his students monitor temperature, humidity, water chemistry, sun exposure and other environmental parameters in two 1-kilometre-long sections of stream in Cocobolo, one that houses *Atelopus limosus* and one that doesn't. By superimposing that data on a biological and physical habitat map they hope to pinpoint the qualities of an ideal toad home.

### Tiny survivor

Harlequin species such as this *Atelopus varius*, pictured in Costa Rica, have unique dorsal patterns that allow individuals to be "fingerprinted" and tracked throughout their lives. Skin swabs are used to test for chytrid fungus, allowing the researchers to assess how factors such as age and habitat use affect susceptibility to the fungus - and so how best to protect these species.



## Toads in a hole

Faced with a worldwide collapse in frog and toad numbers, researchers around the world have begun to collect vulnerable species and try to get them to reproduce in captivity. Given the upbeat title of "reassurance colonies", these safe houses provide an environment to study the species' biology and perhaps understand why they are susceptible to chytrid fungus.

But they are a counsel of desperation as long as the captive populations have nowhere to go. "The longer we wait, the more generations have passed of frogs that have lived entirely in captivity," says herpetologist Twan Leenders. "To some extent [the projects] are a desperate measure to try and keep the last survivors of several species around."

Conservationist Robin Moore agrees, but points out that collecting species ahead of a wave of chytrid in Panama probably prevented their extinction there, and in general conservation activities help to educate the public about the amphibians' fate. And he sees room for optimism in stories of amphibian species rendered vulnerable to extinction through habitat loss that have bounced back.

The Mallorcan midwife toad, a "living fossil" thought to have been extinct for 2000 years before it was rediscovered in 1977, was revised from critically endangered to vulnerable by the International Union for Conservation of Nature in 2004, thanks to a programme that integrated breeding, reintroduction and habitat management. And Tanzania's Kihansi spray toad, driven to extinction in the wild around 2004 following the construction of a dam, has bred well in colonies. Preliminary reintroductions are promising.

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