

MEET THE WORLD'S MOST TOXIC VERTEBRATE

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# THE KISS OF DEATH

Field researcher and passionate conservationist Cesar Barrio Amoròs searches for the deadly Yellow Poison Dart frog *Phyllobates terribilis*





There is no more famous anuran than the golden real poison dart frog. Yellow, bright and bold, it stays quite even close to humans. In 1978, Charles Myers with John Daly and Boris Malkin, described this new striking species of poison frog from Cauca, Colombia, known as Kokoi by the Embera indigenous people.



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The striking bright yellow-orange morph of *Phylllobates terribilis*.

It's early in the morning, the Embera men are already walking through the forest in silence. They are hunting. But not hunting anything to eat. Before that, they need to empower their darts. Emberas do not use bow and arrows to hunt, but blowguns with darts. Many other etnias use blowguns in South America, but no one is as effective as them. One shot, and the prey dies almost immediately. To be so effective, they need a secret component in their darts that assures a quick death and not allowing the prey to escape. And this component is what they are looking for. Still walking barefoot in the jungle, suddenly one says: "kokoi!". He takes a leaf, and proceeds to catch the yellow frog, avoiding touching it directly. Captured by a leg, the frog barely moves and the Embera just rubs his darts on the kokoi skin. He releases the frog, which, hopping, jumps away with not much signs of distress.

**The story of the Kokoi**

In 1973, Chuck Myers and his colleague John Daly were in Colombia doing field research, and came along with the discovery of a distinctive new species of bright yellow frog, which Daly (world's expert at that time about frog toxins) considered the most potent animal toxin discovered to that moment. They, with Boris Malkin, described the new frog as *Phylllobates terribilis* in 1978, honoring

with the dreadful name the possible fate of anyone touching it. And the frog became famous, as the most toxic vertebrate in the world, fame and fact that until now, no other vertebrate surpassed. During the eighties and nineties, and even as recently as 2014, Colombia has suffered a long and tiring war against drugs and guerrillas (armed conflict), and many areas in the country were not possible to visit. Of course biology was one of the abandoned disciplines due to the difficulty to obtain data in the field. The general area of occurrence of *P. terribilis* was one of those dangerous places to go, and so, the species remained for a long time without proper attention. In 2012, a Colombian NGO, Fundacion Proaves, established a 47 ha reserve near Timbiqui, Cauca department, with the specific purpose to protect the species. And this has been surveyed and protected by the ranger Venancio Florez, a real hero of conservation. I had the luck to walk with him and discover many different species around and also, of course he was the one that showed me my first kokoi.

**A dream come true**

But the story started a little before. I received early in 2019 a call by Raul Nieto, old friend and another hero of conservation of the Choco, both in Ecuador and Colombia, inviting me to go

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The bright orange morph of *Phyllobates terribilis* can be encountered in close proximity to other morphs, and they will mate with each other. In the background, a mint (pale bluish or greenish) Kokoi. While I was photographing an orange one, a mint one was very close, and just with a stick, I made him hop a little until both were in my frame.





Left, the other striking dendrobatid we encountered in the area was *Oophaga sylvatica*. One morph, mainly dirty orange, was present at one side of the river. Right, another of the most brightful and astonishing of hylids was this female of *Boana rubracyla*.





Diverse species of anoles, such as this *Dactyloa chocorum*, were present in the area.





The pale yellow morph of *Phyllobates terribilis* is also dominant, and sometimes its color is not uniform; it can present stains in grey or black.





In the deep jungle, among browns and greens, a stoic yellow little figure emerges as the most powerful creature of the rainforest. No other animal will ever touch it. Perhaps except a snake (*Erythrolamprus epinephelus*) known to be the only immune predator to its venom.

to the *terribilis* area to know it directly. This is one of the deepest dreams of any herpetologist, and even naturalist... to go to the Chocan rainforest (one of the last well preserved natural forests in the world, receiving the highest rainfall in the world, over 8.000 mm per year), with the specific purpose of knowing one of the most mythic and mystic of all frogs! How to say no!

So, with my friend Cristian Porrás, we arrived to Cali, and then we flew to Timbiqui with Raul, where the ranger Venancio was the key contact to go around. He knows everybody and is knowledgeable about which parts are dangerous and which ones not. Not everybody is welcomed there, and some people, such as a Russian frog dealer, disappeared mysteriously a couple of years ago...

**Our first find**

Just to be in that mystical area, the Chocan rainforest looking for the most toxic vertebrate on Earth, was enough to be high and hyper excited. Walking through the forest we arrived to a natural clearing, and then, Venancio told me... "Do you see? There...!". And indeed, a bright yellow spot was shining in the middle of the forest floor. He didn't move as we approached... and actually it allowed taking pictures from quite close without moving. That confident it was about its power. I know many other aposematic dendrobatids, and all run away jumping long or short, or just disappear in the vegetation. Not Kokoi!,

he was so powerful... This was actually our best chance to take pictures, we didn't have any permit or even interest in touching one, despite that we always wore gloves just in case.

We saw at last around 7 individuals in different localities, and on one, we saw the three recognized morphs in just few meters away of each other. While I was photographing an orange one... a mint (bluish or greenish) one was very close, and just with a stick, I made him hop a little until both were in my frame. Another time, while filming an interview to Venancio, a juvenile *terribilis* just was hopping around our equipment. Not all individuals were as bold; some of them were shy and hopped away quickly.

In the same area we also listened a consistent call that was determined to be of *Oophaga sylvatica*, and we could see two different morphs of it. Two more aposematic dendrobatids inhabit the area, the diminutive *Andinobates minutus*, one of the smallest poison frogs, and a relative of *sylvatica*, *Oophaga occultator*, that honored its name and remained hidden.

**A disturbing situation**

We were so focused on knowing and obtaining very good quality videos and photos of the Kokoi, that barely had time to dedicate searching for other herps. But we really noted something disturbing. In several night walks, we didn't see the expected amount of reptiles and amphibians we are used to see, for example in Chocan Ecuador, or in

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Males call in rainy days making their long trills audible in a distance. Some times they just wait for the female and in a few moments they will mate (without known amplexus) and lay eggs in the leaf litter.





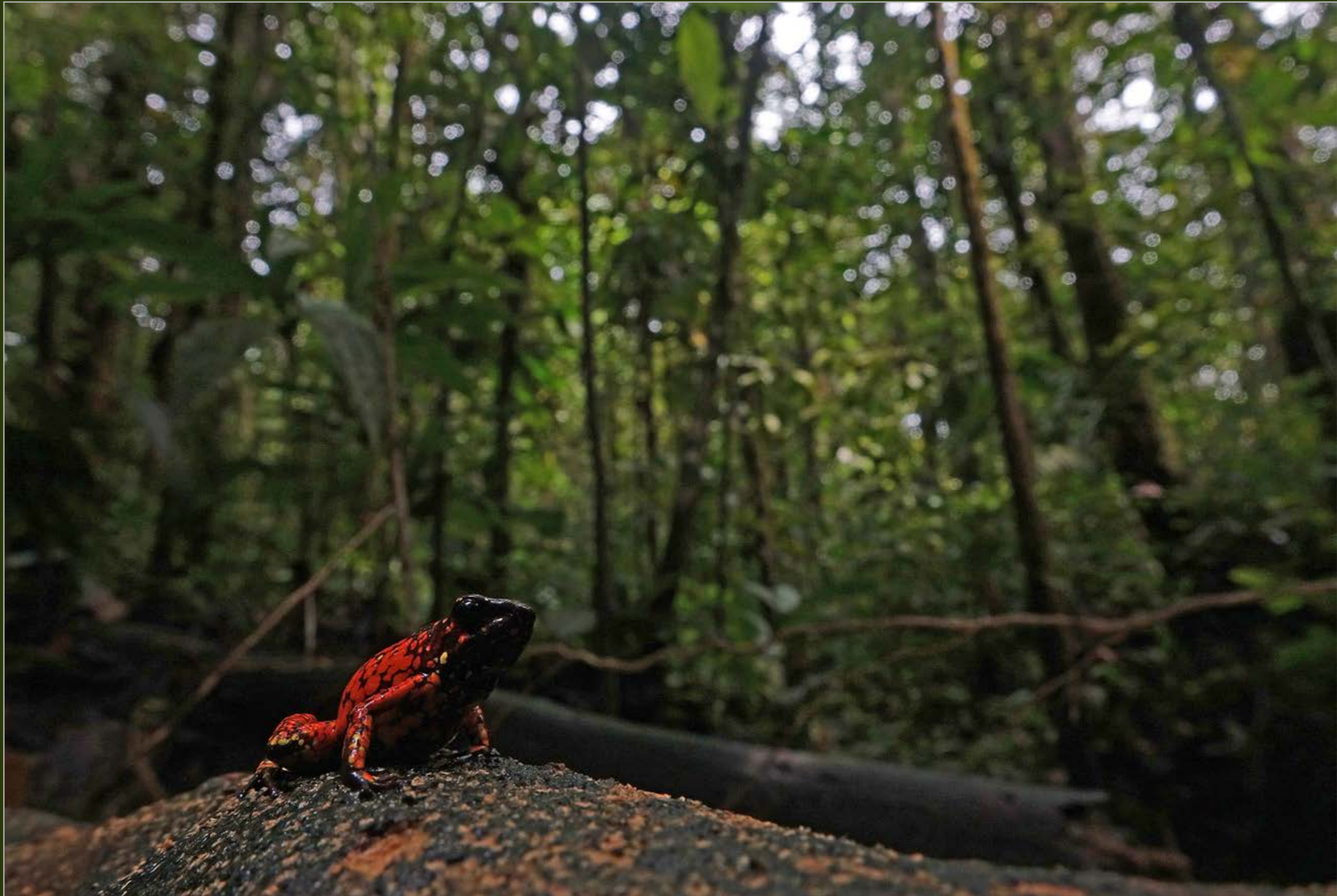
A large *Dactyloa princeps* was seen chasing and consuming a forest cockroach in the canopy.





The potent component of the Kokoi's venom, the batrachotoxin, is the most potent toxin among vertebrates. Its toxicity was exaggerated and it is heard many times in documentaries and popular articles that the toxins of a single frog could kill 100 men or 10 elephants. This is not true of course, but still the venom is powerful enough to kill around 6 to 10 men and maybe, one elephant. A single frog can have around 1100 micrograms of batrachotoxin. 170 Mg are enough to kill an average person of 68 Kg.





The territory of a male *O. sylvatica* can be quite large, as we never heard two close males. Mostly they were about 50 m from each other.





*Boana rubracyla* is a creek inhabitant that awakes at dusk and starts calling. Females will search for nice voice males to mate.

Costa Rica. Just a few frogs and lizards appeared and only two snakes, in 5 nights! To me this is a reminder that something ominous is happening in the area. Probably the fumigation with glyphosate that occurred from 2005 to 2014 to end the coca fields, was too prominent and the chemical travelled through the air to distant areas, affecting most vertebrates. Venancio and others remember on those years seeing monkeys, sloths and birds just falling down and dying. Of course amphibians are among the most sensitive creatures in the forest, and their absence could affect predators as snakes. Some years passed, and probably now some species are recovering but the damage was so important that many creatures were probably locally extinct and many others will need a lot of time to recover well.

### What about the venom?

Few years before Myers, Daly and Malkin described the species, its potent component, the batrachotoxin, was presented by Daly and collaborators as the most potent toxin among vertebrates. Its toxicity was exaggerated and I heard many times in documentaries and popular articles that the toxins of a single frog could kill 100 men or 10 elephants. This is not true of course, but still the venom is powerful enough to kill around 6 to 10 men and maybe, one elephant. A single frog can have around 1100 micrograms ( $\mu\text{g}$ ) of batrachotoxin. 170  $\mu\text{g}$  are enough to kill an average person of 68 Kg.

How a little frog can be so toxic? It is known that colorful dendrobatids are poisonous, and that they sequester alkaloids from its prey, basically ants and mites. But why *terribilis* is so much more toxic than other dendrobatids? What is in its diet that differs from other species? Even the two closest relatives, *Phyllobates bicolor* and *P. aurotaenia*, occurring in the same general area to the north (but not sympatric) are significantly less toxic than *terribilis*. It is not yet known, and analysis of diets of different dendrobatids will decipher the riddle. In New Guinea, a small beetle (*Melyridae*) is known to contain batrachotoxin, and perhaps the "secret" component of the kokoi's venom is not mites or ants, but some little beetles. Those highly poisonous species, after a while in captivity, eating fruit flies and small crickets (with no toxins), lessen and even lose their toxicity. And even if it is so clear for herpetologists, maybe it is not so clear to the rest of the world, and must be worthy to explain that no frog is capable to transmit their toxins by biting, spitting, peeing or so. Their defense is passive, and only if a predator tries to bite them (this applies also to bufonids –common toads- and phyllomedusids –leaf frogs-) will release the venom from dermal glands.

It is also surprising to know that the batrachotoxin is also present in at least two genera of birds from Papua-New Guinea: *Pitohui* and *Ifrita*, and on a melyrid beetle also from New Guinea. While *Pitohui* is orange and black (apparently aposematic) resembling an American Icterid, *Ifrita* is a small



passerine very similar to the European common firecrest *Regulus ignicapillus*. How the birds use the toxic plumage or how toxic it is remains a mystery.

### Is the Kokoi frog endangered?

As bright and mystic as it is, the kokoi has called the attention of many collectors since its discovery. All anuran terrarists want to have it in their collections, like zoos and private collections. This is meaning that the species is endangered by overcollection? Well, no. Fortunately, they breed very well in captivity, and are sold legally across US and Europe for around 50 US dollars a frog, or even less. With the bonus that they have no venom! So, why risking to go to one of the most dangerous areas in Colombia to collect one of the most toxic animals in the world (just some accidental touching could be fatal!), and then travel with them to Europe, for not much money? In any case, there is the mysterious incident of the Russian who apparently was there trying to collect poison frogs in the general area. No one wants to talk there... Guerrilla? Common crime? An accident? The truth is that he disappeared and left no clue. Apart some anecdotal collection, which should not affect the general population, the real threat is the continuous destruction of the area to cultivate illicit crops. We saw from the air how much forest is being cut down. And to me, the most preoccupant is how the glyphosate fumigation could affect them (and other forest species). On the other hand, and as a positive epilog, all the time there are more new sightings in other departments, and the distribution of the kokoi appears to be wider than expected. Long life to the Kokoi!

#### Acknowledgements

I am deeply thankful to Raul Nieto for his invitation, and very especially to Venancio Florez for his enthusiastic guidance and empiric knowledge. Cristian Porras was the best field companion.

Right, top: one the few snakes we saw in the area was a large *Chironius grandisquamis*, a fast and aggressive hunter that lives beside creeks. Right, bottom: while making a filmed interview to Venancio, a juvenile Kokoi arrived and hopped around our equipment, totally oblivious of our presence.

