

Toxic frogs with weak defenses persist in the gene pool alongside stronger competitors

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The Dyeing Poison Frog (*Dendrobates tinctorius*) of French Guiana has yellow stripes to keep predators away, but some have white stripes instead. Credit: University of Jyvaskyla

Diversity is a hallmark of life and it shows up in unexpected places. A multi-national team of evolutionary biologists investigated how two types

of poison frog co-exist when only one might be expected. Their innovative study uncovers conditions where diversity flourishes against the odds, and offers new perspectives on chemical defense. The findings were published in the *Proceedings of the National Academy of Sciences (PNAS)* on September 2nd 2019.

Many creatures carry warning colors that signal toxicity, such as wasps with yellow bands. The dyeing poison [frog](#) (*Dendrobates tinctorius*) of French Guyana also has yellow stripes to keep predators away, but some have white stripes instead. This is an anomaly of evolution, because predators learn to avoid warning colors through bad experience, and rare warning colors are harder to learn.

The team headed by Dr. Bibiana Rojas from University of Jyväskylä and Dr. J.P Lawrence from the University of California, Irvine, propose evolutionary explanations for how nature allows rare warnings to persist.

Firstly, rare or weak signals can persist under the protection of stronger signals. The researchers show that predators learn to avoid more distasteful yellow frogs and generalize this avoidance to white frogs. Although the stronger defenses of yellow frogs should allow them to out-compete the whites over time, genomic analysis revealed that the population of white frogs is genetically separate from the yellows. Thus, diversity can exist within a single population (due to generalized learning) and between different populations (due to genetic isolation).



The research team is headed by Doctors Bibiana Rojas (in picture) from University of Jyväskylä and J.P Lawrence from the University of California Irvine. Credit: University of Jyväskylä

New methods to measure chemical defence

The initial experiments were modest in scope, but strange results inspired the researchers to develop new methods.

"We faced the difficulty of not having an established method to quantify predator reaction to the chemical defenses. However, that difficulty turned into one of the biggest assets of our study, as we eventually succeeded at developing a method," says Dr. Bibiana Rojas from University of Jyväskylä.

New Research!

Weak warning signals can persist in the absence of gene flow

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Weak warning signals can persist in the absence of gene flow. Credit: JP Lawrence/University of Irvine California, USA

The new method improves the ecological relevance and precision of measuring [predator](#)-prey interactions. Past studies have assumed that toxicity is everything, and measure it by injecting mice with defensive

chemicals. But prey survival and evolution depends on whether they are eaten or spat out, not the blood chemistry of their predators. Thus, the researchers used skin extracts mixed with oats to get a separate measure of distastefulness. They show that toxicity and distastefulness are better considered independently.

"The biggest surprise came from the fact that the frogs [with] a higher amount of toxins in their skin are not necessarily the ones that birds find most distasteful. This finding challenges previous assumptions that most toxic equals most unpalatable," says Rojas.

More information: J. P. Lawrence et al., "Weak warning signals can persist in the absence of gene flow," *PNAS* (2019).

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Provided by University of Jyväskylä

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