Drought may drive deadly amphibian disease, researchers find

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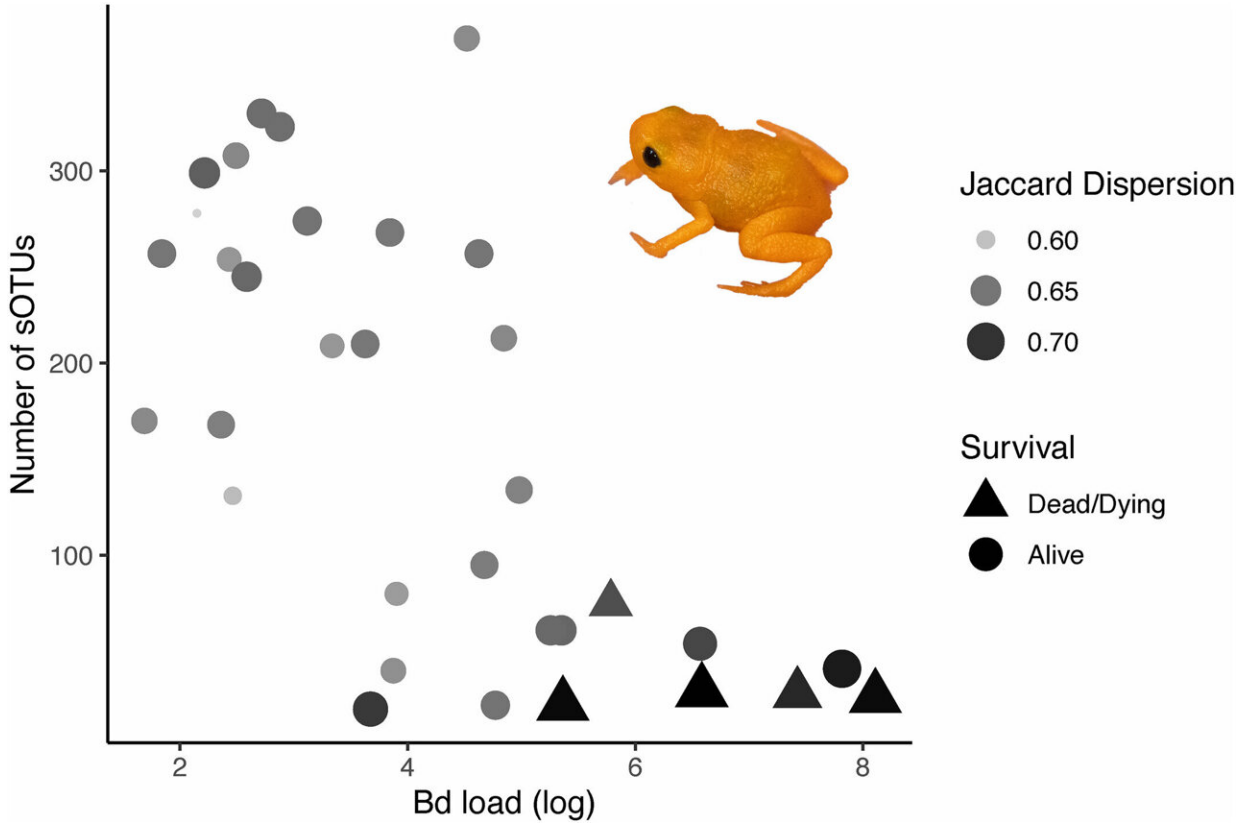

The richness of skin bacteria is negatively correlated with Bd loads. Color and size correspond with Jaccard dispersion values. Shape indicates frog survival. Bd-negative samples have been excluded. Credit: *Ecology Letters* (2024). DOI: 10.1111/ele.14372

Pumpkin toadlets are in trouble. Progressively severe droughts are

disrupting the microbiomes of the thumbnail-sized orange frogs, potentially leaving them vulnerable to a deadly fungal disease, according to a new study by an international research team. The finding suggests that abnormal rainfall patterns, which are expected to worsen due to climate change and deforestation, may upset mutually beneficial relationships between wildlife and microorganisms, leading to biodiversity decline.

The researchers, led by Penn State doctoral candidate Shannon Buttimer and Professor of Biology Guilherme Becker, published their findings in *Ecology Letters*. The work was featured on the cover of the journal's January issue.

During a campaign to sample the skin bacteria of the pumpkin toadlets for his master's thesis, co-author Diego Moura-Campos found nine dead or dying frogs. It was later confirmed that they had died of chytridiomycosis, a fungal disease caused by Batrachochytrium dendrobatidis (Bd), which is a threat to amphibian populations worldwide. Pumpkin toadlets, like many other amphibians, boast natural Bd-inhibiting bacteria on their skin. These microbes should help protect against the fungus, so why did these frogs die, and why all at once?

"It is super rare to witness amphibian die-offs in the wild, let alone have collected samples from before and throughout an outbreak," said Buttimer, who is pursuing her doctorate in the Huck Institutes of the Life Sciences' Intercollege Graduate Degree Program in Ecology.

Buttimer explained that deforestation of this region and in the Amazon rainforest has resulted in greater rainfall variability—increased duration of drought and, conversely, heavier periods of rainfall. "The outbreak coincided with some of the lowest rainfall in the area in the past 60 years, so we set out to investigate whether there might be a connection between the drought, the skin microbiome, and the die-off."

Using 237 skin swab samples gathered over the course of a year, the researchers genetically sequenced the toadlets' skin microbiomes and compared that information against a reference database of skin microbes identified as Bd-inhibitors—bacteria that exert a protective effect against the amphibian chytrid fungus. The AmphiBac database, organized by Doug Woodhams, assistant professor of biology at the University of Massachusetts, Boston and 25 co-authors, contains a growing list of DNA sequences of microbes whose inhibitory properties have been tested against Bd in controlled lab experiments.

The researchers found that toadlet microbiomes sampled following periods of higher-than-average rainfall were more abundant in known Bd-inhibitors. In contrast, one month after the drought, the toadlet microbiomes had fewer known Bd-inhibiting bacteria. The finding, researchers said, indicates that drought may reduce the abundance of some Bd-inhibiting bacteria, leaving the toadlets vulnerable to the fungal disease.

The researchers also investigated microbiome diversity metrics like species richness and composition. Overall, the researchers found that higher levels of species richness were associated with lower infection severity. Microbiome composition also became more variable following periods of low rainfall, indicating that the toadlets' microbiomes may have transitioned to a state known as dysbiosis, where they become less stable and less functional. According to researchers, this higher variability and the loss of key protective microbes may both contribute to the increase in chytridiomycosis infections.

While further experimentation is required to understand the causal mechanisms that influence the skin microbiome and Bd dynamics, the researchers said this study underscores the importance of considering microbiome health when assessing populations that are threatened by climate change, habitat loss and disease.

"I hope our results will encourage people to consider how deforestation and climate change are breaking down invisible symbioses and leading to population-scale consequences," Buttimer said.

Co-authors on the study include Diego Moura-Campos, The Australian National University; Sasha E. Greenspan, Wesley J. Neely, University of Alabama; Lucas Ferrante, Universidade Federal do Amazonas; Luís Felipe Toledo, Universidade Estadual de Campinas.

More information: Shannon Buttimer et al, Skin microbiome disturbance linked to drought-associated amphibian disease, *Ecology Letters* (2024). DOI: 10.1111/ele.14372

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