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DIGITALVISION

EPIDEMIOLOGY

It's not easy being green

Chytridiomycosis, a disease caused by the fungal pathogen *Batrachochytrium dendrobatidis*, has been directly linked to the decline and extinction of hundreds of amphibian species worldwide. Now, two long-term monitoring studies published in the *Proceedings of the National Academy of Sciences USA* describe the dynamics of disease spread and persistence in Californian frog populations.

B. dendrobatidis infects adult and larval amphibians as a zoospore and encysts in the skin, where it develops into a zoosporangium. The zoosporangium then produces and releases zoospores, which start a new infection cycle at a different site on the skin. The outcome of infection varies between species and even among populations in a species. In most frogs, infection of the tadpole is not lethal, whereas infection of adults can lead to death within weeks.

B. dendrobatidis infection has had a devastating effect on California's mountain yellow-legged frog population (a species complex consisting of *Rana muscosa* and *Rana sierrae*), which has disappeared from 93% of its Sierra Nevada mountain lake habitat. In the first of the two studies, Vredenburg *et al.* used quantitative PCR to monitor the spread of *B. dendrobatidis* into previously uninfected frog populations in three lake basins. After the fungus was first detected, the infection spread to almost all of the frog populations in each basin in 1–5 years, and frog numbers rapidly declined, with extinction occurring in most populations. The decline in frog numbers was not evident until a threshold value of 10,000 zoospore equivalents per swab had been reached, indicating that infection intensity probably has a primary role in driving population extinction.

In the second study, Briggs *et al.* used a mark-and-recapture approach to investigate three sites in which persistent *B. dendrobatidis* infection had decreased the frog population without causing extinction. They observed that frogs at these sites frequently lost and gained *B. dendrobatidis* infections and that the average infection intensity (220 zoospore equivalents per swab) was much lower than that observed by Vredenburg *et al.* in the rapidly declining populations. Such loss and gain of infection suggests that there is a fine balance between infected and uninfected states, such that the rate of infection by zoospores must equal the rate of zoosporangia loss to maintain the pathogen population and must exceed the rate of zoosporangia loss to allow the pathogen population to grow. The authors developed a model that suggests that long-term persistence of the pathogen is probably achieved by the presence of a reservoir of zoospores that can maintain pathogen levels when the frog population declines. Curiously, it may be the infected tadpoles that provide the source of zoospores which prevent the normal boom-and-bust cycle, allowing the pathogen to persist in these sites.

Taken together, these papers suggest that the intensity of *B. dendrobatidis* infection may be the key difference between frog populations heading for extinction and those that survive, a fact that might be exploited in strategies aiming to halt the spread of this devastating disease.

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> "intensity of *B. dendrobatidis* infection may be the key difference between frog populations heading for extinction and those that survive"

ORIGINAL RESEARCH PAPER Vredenburg, V. T., Knapp, R. A., Tunstall, T. S. & Briggs, C. J. Dynamics of an emerging disease drive large-scale amphibian population extinctions. *Proc. Natl Acad. Sci. USA*, 10 May 2010 (doi:10.1073/pnas.0914111107) | Briggs, C. J., Knapp, R. A. & Vredenburg, V. T. Enzootic and epizootic dynamics of the chytrid fungal pathogen of amphibians. *Proc. Natl Acad. Sci. USA*, 10 May 2010 (doi:10.1073/pnas.0912886107)