
A story of a frog, a fungus and some bacteria: Microbiome mediated colonisation resistance via siderophore production

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Résumé

Batrachochytrium dendrobatidis (Bd) is a fungal pathogen responsible for chytridiomycosis, a disease that has caused catastrophic declines in amphibian populations worldwide by infecting amphibians' skin. This infection disrupts skin permeability and electrolyte balance, leading to cardiac arrest and death. One of the host's primary defence strategies is nutritional immunity-limiting access to essential metals like iron, zinc, and manganese-to inhibit pathogen growth and virulence.

In parallel, the amphibian skin microbiome plays a crucial role in chytridiomycosis resistance by producing antifungal metabolites. However, the impact of host-driven metal restriction on these microbial communities remains largely unexplored. Our preliminary data suggest that iron limitation triggers skin bacteria to produce siderophores, specialized iron-chelating molecules with strong antifungal properties. This points to a potentially important synergy whereby host nutritional immunity and skin commensals' siderophore production act together to reduce iron bioavailability, critically limiting *Bd*'s access to this essential micronutrient.

To investigate this interaction, we isolated bacterial strains from the skin of *Alytes obstetricans* and assembled a minimal bacterial community representing the most abundant bacterial phylogroups. Using a high-throughput screening method, we found that most isolates, tested so far, produce siderophores under iron limitation, and that environmental factors such as pH and carbon source significantly influence siderophore production.

Importantly, our functional assays revealed that *Bd*: 1) cannot exploit any of the tested siderophores, 2) lacks competitive iron acquisition systems, and 3) cannot degrade siderophores. This suggests that microbial siderophores effectively reinforce host-imposed iron limitation, creating an environment hostile to *Bd*.

Together, these findings reveal a novel mechanism by which the amphibian skin microbiome complements nutritional immunity, enhancing protection against *Bd*. Understanding this interplay could pave the way for microbiome-based strategies to mitigate chytridiomycosis and aid amphibian conservation.

Mots-Clés: Siderophores, skin microbiome, *Bd*, amphibians, infection, metals, iron

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