



Bd CHYTRIDIOMYCOSIS (Bd)

Mountain yellow-legged frogs (*Rana muscosa*) killed by chytrid fungus in 2008.
Image source: AmphibiaWeb; Photo by Vance Vredenburg (2008).

CAUSE

Chytridiomycosis is an infectious disease of amphibians caused by the fungi *Batrachochytrium dendrobatidis* (*Bd*) and *B. salamandrivorans* (*Bsal*). *Bd* was first discovered in 1993 in Australia after a massive mortality event involving several frog species. A study points to East Asia (Korea) as the point source for *Bd* and dates the origin of expansion to the early 20th century, which also coincides with the global expansion of the commercial trade in amphibians.

Phylogenetic studies of *Bd* have revealed extensive genetic diversity. One strain, considered to be hypervirulent, is globally dispersed (*Bd*-GPL) and thought to be the primary lineage responsible for population declines and extinctions. Numerous lineages of *Bd* have been discovered, and it is hypothesized that the hybridization of different strains may lead to the emergence of more virulent, pathogenic strains of *Bd*.

SIGNIFICANCE

Bd chytridiomycosis is considered an emerging disease that significantly impacts amphibian populations across the globe. Over 700 species have been affected by *Bd*, and in the past few decades the disease has contributed to the decline of over 500 amphibian species, including 90 possible extinctions. *Bd* chytrid fungus is believed to be responsible for one of the most significant disease-associated losses of biodiversity in recorded history.

Bd chytridiomycosis is a reportable disease: any detection of the disease should be reported to the appropriate wildlife authorities. Reports can be made through the Partners in Amphibian and Reptile Conservation's Disease Task Team's Herpetofaunal Disease Alert System (HDAS), herp_disease_alert@parcplace.org.

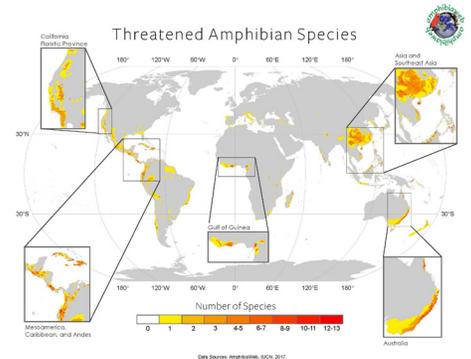


Image source: AmphibiaWeb; Cartography by Christina Lew and Michelle Koo, 2017. Map showing hotspots of species considered most vulnerable to *Bd* across the globe.

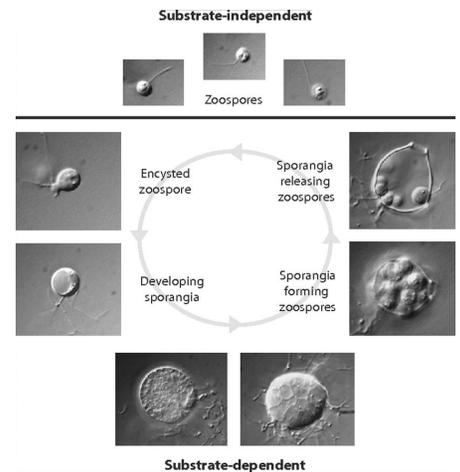


Image Source: Rosenblum et al., 2008 (Figure 1)
Flagellated zoospores are free-living and motile in the substrate-independent aspect of the life cycle. This life stage initiates colonization of host (amphibian) skin cells. In the substrate-dependent portion of the life cycle, the fungus encysts (or embeds) into host cells and can develop into and release new zoospores. The released zoospores can either reinfect the host or enter the water column and become motile.

continued ▶

SPECIES AFFECTED

Currently, *Bd* chytridiomycosis is known to affect over 700 species of amphibians. It appears to impact amphibian species associated with permanent water (i.e., streams, moist bogs, ponds) but can also affect amphibian species with intermittent or ephemeral water and in terrestrial habitats. The disease impact may be strongly mitigated by high, or extreme temperatures. However, the disease does not affect all amphibians equally. For example, the American bullfrog and the African clawed frog appear to be resistant to the disease and may act as carriers of the fungus. The fungus is not known to infect humans.

DISTRIBUTION

The fungus, *Bd*, and associated disease, *Bd* chytridiomycosis, is present on every continent where amphibians are found. The disease appears to be having the biggest impact in South and Central America, Australia, and North America. In general, the presence of *Bd* is associated with relatively cool to moderate temperatures (4-28°C) and *Bd* infection increases with cooler conditions, high altitude and mountainous regions. *Bd* morbidity and mortality vary significantly by season.

TRANSMISSION

Bd is a waterborne fungus that disperses zoospores, which have a flagellum used by the fungus for movement, into the environment in order to search for a new host. The fungus travels through water until it finds a new host, entering through the skin. Once the host is infected with *Bd*, *Bd* chytridiomycosis may or may not develop. The disease is also believed to be transmitted through direct contact between diseased amphibians. Research has shown that *Bd* grows best in water that is between 17-25°C (62-77°F) and that in the wild, most disease outbreaks occur seasonally, at higher elevations, and during wet, cooler months.

CLINICAL SIGNS

Clinical signs of *Bd* chytridiomycosis vary by species. The earliest signs of chytridiomycosis include anorexia and lethargy. Most frogs experience excessive shedding of skin, which appears opaque and gray- white or tan in color. Many frogs also experience a thickening of the skin, which may prevent breathing, thermoregulation, nutrient intake, hydration, and/or the release of harmful toxins. Other common clinical signs include red skin, convulsions, lack of the righting reflex (a reflex that corrects the orientation of the body after it has been taken out of its normal upright position), abnormal feeding behavior, and discoloration near the mouth.

DIAGNOSIS

Typically, diagnosis of *Bd* chytridiomycosis requires a combination of molecular, fungal culture, and histopathology. Such tests are used to isolate and/or identify *Bd* from the skin (either direct skin samples or a skin swab) of suspected infected animals. It should be noted that many infected animals may show no clinical signs while sick individuals may be infected with something other than *Bd*. There are no symptoms of *Bd* chytridiomycosis that are considered a definitive characteristic of the disease.

TREATMENT

Captive animals may be treated for chytridiomycosis with antifungal medications and heat therapy. However, it is very difficult to treat amphibians in the wild due to the inability to regulate the temperature of natural bodies of water and the difficulty of dispersing antifungal treatments into the environment. To date, there is no vaccine.

MANAGEMENT

The causative agent (*Bd*) of *Bd* chytridiomycosis can easily be spread during anthropogenic activities, especially during field-work and animal handling. Boots, clothes, and all field equipment should be cleaned with an appropriate cleaner followed by a disinfectant, according to product label(s). Gray *et al.*, (2017) provides an extremely useful overview and table of commonly used, researched disinfectants. Wild amphibians should not be moved between sites, and captive amphibians should not be released into the environment or used as bait. All newly acquired captive amphibians should be initially quarantined from other amphibians until it has been confirmed that they are disease free. Appropriate testing should be done for pathogens of concern (i.e., *Bd*, *Bsal*, and Ranavirus).

SUGGESTED READING

Whittaker, K and Vredenburg, V. 2011. [An Overview of Chytridiomycosis. Amphibiaweb.](#)

The Merck Veterinary Manual. 2013. Infectious Diseases of Amphibians- Fungal Diseases

[The Amphibian Ark. 2014. Chytrid Fungus.](#)

Weldon, C. et al. 2004. Origin of the Amphibian Chytrid Fungus. *Emerging Infectious Diseases*. 10 (12). 2100-2105

O'Hanlon et al. 2018. Recent Asian Origin of Chytrid Fungi Causing Global Amphibian Declines. *Science* 360(6389): 621-627

Miller et al. 2018. Distribution Modeling and Lineage Diversity of the Chytrid Fungus *Batrachochytrium dendrobatidis* (*Bd*) in a central African Amphibian Hotspot. *PLoS ONE* 13(6): e0199288.

Scheele et al. 2019. Amphibian Fungal Panzootic Causes Catastrophic and Ongoing Loss of Biodiversity. *Science* 636(6434): 1459-1463.

Rosenblum et al. 2008. Global gene expression profiles for life stages of the deadly amphibian pathogen *Batrachochytrium dendrobatidis*. *PNAS* 105(44): 17034-17093.

Gray et al., 2017. Pathogen Surveillance in Herpetofaunal Populations: Guidance on Study Design, Sample Collection, Biosecurity, and Intervention Strategies. *Herpetological Review* 48(2): 334-351.