**Batrachochytrium dendrobatidis**

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<td>Chytridiomycota</td>
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<td>Chytridiales</td>
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**Common name**
chytrid frog fungi (English), Chytrid-Pilz (German), chytridiomycosis (English), frog chytrid fungus (English)

**Synonym**

**Similar species**

**Summary**
Batrachochytrium dendrobatidis is a non-hyphal parasitic chytrid fungus that has been associated with population declines in endemic amphibian species in upland montane rain forests in Australia and Panama. It causes cutaneous mycosis (fungal infection of the skin), or more specifically chytridiomycosis, in wild and captive amphibians. First described in 1998, the fungus is the only chytrid known to parasitise vertebrates. *B. dendrobatidis* can remain viable in the environment (especially aquatic environments) for weeks on its own, and may persist in latent infections.

[view this species on IUCN Red List](http://www.iucngisd.org/gisd/species.php?sc=123)
Species Description

Fungal Morphology: *Batrachochytrium dendrobatidis* is a zoosporic chytrid fungus that causes chytridiomycosis (a fungal infection of the skin) in amphibians and grows solely within keratinised cells. Diagnosis is by identification of characteristic intracellular flask-shaped sporangia (spore containing bodies) and septate thalli. The fungus grows in the superficial keratinised layers of the epidermis (known as the stratum corneum and stratum granulosum). The normal thickness of the stratum corneum is between 2µm to 5µm, but a heavy infection by the chytrid parasite may cause it to thicken to up to 60 µm. The fungus also infects the mouthparts of tadpoles (which are keratinised) but does not infect the epidermis of tadpoles (which lacks keratin).

The fungus produces inoperculate, smooth-walled zoosporangia (zoospore containing bodies), which are spherical to subspherical in shape. Each zoosporangium (10µm to 40µm in diameter) produces a single discharge tube, which penetrates (and protrudes out of) the skin. Eventually the plug that blocks the release of immature zoospores is shed and the mature zoospores are released. The zoospores (0.7µm to 6µm in diameter) are elongate to ovoid in shape. Each possesses a single posterior flagellum, rendering it motile in water (Mazzoni et al. 2003; Daszak et al. 1999; Berger, et al. 1998; Berger et al. 1998, Berger, Speare and Hyatt, 2000, in Daszak et al. 1999; Speare et al. 2001; Weldon et al. 2003).

To view a scanning electron micrograph of infected skin of a wild frog (*Litoria lesueuri*) please see: Daszak et al. 1999. Emerging Infectious Diseases and Amphibian Population Declines.

To view histological sections of infected skin of *Bufo haematiticus* and *Atelopus varius* (showing the sporangia and discharge tubes of the fungus) please see: Daszak et al. 1999. Emerging Infectious Diseases and Amphibian Population Declines.

To view a histological section of severely infected skin of a wild frog (*Litoria caerulea*) please see: Berger et al. 1998. Chytridiomycosis causes amphibian mortality.

Pathogenesis of chytridiomycosis: Authors of a recent study, Voyles et al. (2009) have found that *B. dendrobatidis*, causes such severe electrolyte imbalances that the frog’s heart stops. The skin of amphibians maintain proper osmotic balance inside the animal and regulate respiration. The authors found that the skin of infected frogs was less adept at transporting sodium and chloride ions. Sodium and potassium concentrations in the blood of infected frogs dropped, more so as the infection intensified and the animals’hearts began to beat irregularly and ultimately stopped.

Notes

Salamanders can act as host reservoirs of chytrid infection in frogs, and vice versa (Davidson et al. 2003).
Lifecycle Stages

*Batrachochytrium dendrobatidis* has two life stages: a spherical reproductive sessile zoosporangium and a motile zoospore. The motile zoospore directs itself and attaches to the keratinised outer layers of its host. It then absorbs its tail and buries itself below the surface of the skin. It matures into a zoosporangia with rhizoids within about four days and produces and releases up to 300 zoospores into the external environment (via a discharge tube). The cycle is initiated again once a suitable substrate (in the same or a different host) is found. The presence of the fungus in the keratinised mouthparts of frog tadpoles (without actually killing them) supports the role of larvae as reservoirs for the pathogen. (The larvae of amphibian species may survive for as long as 3 years before metamorphosing.) Syntopic salamanders and frogs may also act as reciprocal pathogen reservoirs for chytrid infections. It has been suggested that *B. dendrobatidis* may not be an obligate amphibian parasite, possibly living in other non-amphibian hosts or even sapropytically (off dead tissue) (Michigan Frog Survey, 2003; Speare *et al.* 2001; Daszak *et al.* 1999; Davidson *et al.* 2003). In

As of yet, no resting structures (either asexual or sexual) have been identified for *B. dendrobatidis*. The fact that sexual reproduction in chytrid fungi has been associated with the production of resistant, thick-walled resting spores has lead to the hypothesis that the production of airborne spores explains the widespread distribution of *B. dendrobatidis* in relatively pristine areas. However recent research has found evidence that shows that the population structure of *B. dendrobatidis* is largely clonal, supporting the hypothesis that the fungus lacks a sexual stage (as is the case for many chytrid fungi). This suggests that dispersal by human (or perhaps other long distance travellers, such as birds), rather than natural causes, are more likely to be the cause of the pathogen's entry into pristine areas (Morehouse *et al.* 2003; Berger *et al.* 1999, Daszak *et al.* 1999, in Morehouse *et al.* 2003).

Habitat Description

Chytridiomycosis has now been reported from 38 amphibian species in 12 families, including ranid and hyliid frogs, bufonid toads, and plethodontid salamanders. Although chytridiomycosis is found in a range of species and habitats (including African frogs in lowland regions in Africa) it has caused population declines of amphibian species confined to montane rain forests (Weldon *et al.* 2004; Daszak *et al.* 1999). The fungus prefers lower temperatures which may explain the high precedence of the fungus in high elevations in the tropics. In culture conditions optimum growth occurred at 23°C, with slower growth occurring at 28°C and (reversible) cessation of growth occurring at 29°C (Longcore, Pessier, Nichols, 1999, in Daszak *et al.* 1999).

Reproduction

*Batrachochytrium dendrobatidis* is diploid and primarily reproduces asexually (and clonally) by producing aquatic uniflagellated zoospores in a zoosporangium (Johnson and Speare, 2003).

Nutrition

Its occurrence solely in keratinised tissues suggests that it uses amphibian keratin as a nutrient. *Batrachochytrium dendrobatidis* will grow for at least one generation on cleaned epidermal keratin or on amphibians that have died of the infection. The fungus may also be cultured *in vitro* on tryptone agar without the addition of keratin or its derivatives (Daszak *et al.* 1999; Longcore, Pessier and Nichols, 1999, Pessier *et al.* 1999, in Daszak *et al.* 1999).
General Impacts

*Batrachochytrium dendrobatidis* has been found to affect at least 93 amphibian species from the orders Anura (frogs and toads) and Caudata (salamanders) in all the continents except Asia. It is thought to be one of the main causes of the global decline in frog populations since the 1960s, and the dramatic population crashes from the 1970s onwards (Parris and Beaudoin, 2004). The chytrid fungus kills frogs within 10 to 18 days (Michigan Frog Survey, 2003), although it is not known how. It may be physical, affecting respiration by altering the frog’s skin, or the fungus may give off a toxin (Michigan Frog Survey, 2003). Tadpoles are not affected, although the fungus may infect the keratinised mouthparts (Berger *et al.* 1999).

For a summary on the impacts of *B. dendrobatidis* please follow this link [impacts].

Key findings of the *The Global Amphibian Assessment* has revealed that one-third (32%) of the world’s amphibian species are threatened, representing 1,896 species. Threats include viral diseases, habitat loss, drought, pollution, and hunting for food. The biggest single threat appears to be *B. dendrobatidis*.

A search on the database using "diseases" as a keyword in "all" habitat types, biogeographic realm and countries results in a list of 547 species impacted by diseases (IUCN, Conservation International, and NatureServe. 2006).

Management Info

**Preventative measures:** Knowledge of the infectiveness and spread of *Batrachochytrium dendrobatidis* is relevant to all control strategies, particularly in the development of preventative measures. The infective unit of the fungus is the zoospore. Infection by the fungus (and thus spread of the disease) requires water because the zoospore does not tolerate dehydration. *B. dendrobatidis* remains viable for up to 3 weeks in tap water, up to 4 weeks in deionised water and even longer in lake water. Infection by an extremely small inoculum (100 zoospores) is sufficient to cause a fatal infection (Berger *et al.* in Speare *et al.* 2001; Johnson and Speare, 2003; Berger, Speare and Hyatt, 2000, in Daszak *et al.* 1999).

Please see [main preventative management strategies] for a summary under the following headings: improving diagnostics and knowledge of epidemiology, developing trade and quarantine regulations, raising awareness and control options.

*The Amphibian Conservation Action Plan (ACAP)* is designed to provide guidance for implementing amphibian conservation and research initiatives at all scales from global down to local. Chapter 4 outlines action steps relating to the detection and control of chytridiomycosis.

**Principal source:** Berger *et al.* 1999. Chytrid fungi and amphibian declines: Overview, Implications and Future Directions.


Daszak *et al.* 1999. *Emerging Infectious Diseases and Amphibian Population Declines*

**Compiler:** National Biological Information Infrastructure (NBII) & IUCN/SSC Invasive Species Specialist Group (ISSG) with support from the Terrestrial and Freshwater Biodiversity Information System (TFBIS) Programme [Copyright statement]
Review: Matthew J. Parris Assistant Professor, Department of Biology University of Memphis USA

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ALIEN RANGE


Red List assessed species 512: EX = 8; CR = 196; EN = 126; VU = 63; NT = 29; DD = 36; LC = 54:

Adelotus brevis NT
Agalychnis moreletii CR
Alytes cisternasi NT
Aplastodiscus callipygius LC
Aromobates alboguttatus EN
Aromobates nocturnus CR
Atelopus angelito CR
Atelopus arthuri CR
Atelopus bomolochos CR
Atelopus carauta CR
Atelopus carrikeri CR
Atelopus chiriquiensis CR
Atelopus chrysocorallus CR
Atelopus cruciger CR
Atelopus ebeboides CR
Atelopus episkeithos CR
Atelopus eusebianus CR
Atelopus famelicus CR
Atelopus flavescens VU
Atelopus galactogaster CR
Atelopus guanjui CR
Atelopus halhelos CR
Atelopus laetissimus CR
Atelopus longibrachius EN
Atelopus lozanoi CR
Atelopus mandingues CR
Atelopus minutulus CR
Atelopus monohernandezii CR

Agalychnis annae EN
Allobates olfersioides VU
Anaxyrus canorus EN
Aplastodiscus flumineus DD
Aromobates leopoldialis CR
Atelopus andinus CR
Atelopus arsyeucu CR
Atelopus balios CR
Atelopus boulengeri CR
Atelopus carbonerenses CR
Atelopus certus EN
Atelopus chocoensis CR
Atelopus coynei CR
Atelopus dimorphus EN
Atelopus elegans CR
Atelopus erythropus CR
Atelopus exiguus CR
Atelopus farci CR
Atelopus franciscus VU
Atelopus glyphus CR
Atelopus guitarraensis CR
Atelopus ignescens EX
Atelopus limosus EN
Atelopus longirostris EX
Atelopus lynchí CR
Atelopus mindoensis CR
Atelopus mittermeieri EN
Atelopus mucubajensis CR
GLOBAL INVASIVE SPECIES DATABASE

FULL ACCOUNT FOR: Batrachochytrium dendrobatidis

Atelopus muisca CR
Atelopus nanay CR
Atelopus nicefori CR
Atelopus oxapampae EN
Atelopus pachydermus CR
Atelopus patazensis CR
Atelopus perlensis CR
Atelopus petiririuii CR
Atelopus pinangoi CR
Atelopus pulcher CR
Atelopus reticulatus CR
Atelopus seminiferus CR
Atelopus sernaii CR
Atelopus siranus DD
Atelopus sorianoi CR
Atelopus sputrelli VU
Atelopus tamaense CR
Atelopus varius CR
Atelopus zetekii CR
Bokermannohyla claresignata DD
Bolitoglossa conanti EN
Bolitoglossa dolefinai NT
Bolitoglossa pesrubra VU
Bolitoglossa sooyorum EN
Bombina pachypus EN
Bromeliohyla dendoascarta CR
Centrolene audax EN
Centrolene buckleyi VU
Centrolene gemmata CR
Centrolene lynchii EN
Centrolene persistium VU
Centrolene scirtetes DD
Charadrahyla nephila VU
Chiropterotriton cracens EN
Craugastor anciano CR
Craugastor angelicus CR
Craugastor berkenbuschii NT
Craugastor catalinae CR
Craugastor chrysozetetes EX
Craugastor darii EN
Craugastor emleni CR
Craugastor escoces EX
Craugastor fleischmanni CR
Craugastor guerrerensis CR
Craugastor laevissimus EN
Craugastor lineatus CR
Craugastor merendonensis CR
Atelopus nahumae CR
Atelopus nepiozomus CR
Atelopus onorei CR
Atelopus oxyrhynchus CR
Atelopus palmatus DD
Atelopus pedimormoratus CR
Atelopus petersi CR
Atelopus pictiventris CR
Atelopus planispina CR
Atelopus quimbaya CR
Atelopus sanjosei DD
Atelopus senex CR
Atelopus simulatus CR
Atelopus sonsonensis CR
Atelopus spumarius VU
Atelopus subornatus CR
Atelopus tricolor VU
Atelopus walkeri CR
Bokermannohyla circumdata LC
Bokermannohyla hylax LC
Bolitoglossa copia DD
Bolitoglossa magna EN
Bolitoglossa sombra VU
Bolitoglossa subpalmata EN
Bromeliohyla bromeliai EN
Bufo bufo LC
Centrolene ballux CR
Centrolene geckoideum VU
Centrolene heloderma CR
Centrolene medemi DD
Centrolene pipilatum EN
Charadrahyla altipotens CR
Charadrahyla trux CR
Chiropterotriton multidentatus EN
Craugastor andi CR
Craugastor azuroensis EN
Craugastor brocchi VU
Craugastor charandra EN
Craugastor cruzi CR
Craugastor emcelae CR
Craugastor epochthidius CR
Craugastor fecundus CR
Craugastor greggi CR
Craugastor inachus EN
Craugastor laticeps NT
Craugastor melanostictus LC
Craugastor mexicanus LC

Hylochabrus bocagei LC
Hylochabrus chocoensis DD
Hylochabrus elachyhistus EN
Hylochabrus pulchellus VU
Hylochabrus dolops VU
Incilius cycladen VU
Incilius holdridgei EX
Incilius periglenes EX
Incilius porteri DD
Incilius tutelarius EN
Isthmohyla calypsa CR
Isthmohyla graceae CR
Isthmohyla tica CR
Leiopelma archeyi CR
Leiopelma hochstetteri VU
Leptodactylus fallax CR
Lithobates chiricaheuensis VU
Lithobates sierramadrensis VU
Lithobates tarahumarae VU
Lithobates vabicarius CR
Lithobates yavapaiensis LC
Litoria aurea VU
Litoria caerulea LC
Litoria chloris LC
Litoria ewingii LC
Litoria lesueuri LC
Litoria moorei LC
Litoria nanotis EN
Litoria nyakalensis CR
Litoria phylochroa LC
Litoria raniformis EN
Litoria spenceri CR
Mannophryne caquetio CR
Mannophryne herminae NT
Mannophryne neblina CR
Mannophryne olmonae CR
Megaeteria massarti DD
Mesotriton alpestris LC
Mixophyes fasciolatus LC
Nymphargus griffithi VU
Oedipina EN
Osteopilus pulchirlineatus EN
Paratelmatobius lutzii DD
Pelobates fuscus LC
Phrynomedusa appendiculata NT
Phyllomedusa ecuatoriana EN
Physalaemus moreirae DD

Hylochabrus breviquartus DD
Hylochabrus delatorreae CR
Hylochabrus lehmanni NT
Hylochabrus vertebralis CR
Hypsiboas cymbalum CR
Incilius fastidiosus CR
Incilius melanochlorus LC
Incilius peripatetes CR
Incilius tacanensis EN
Isthmohyla angustilineata CR
Isthmohyla debilis CR
Isthmohyla pictipes EN
Isthmohyla xanthosticta DD
Leiopelma hamiltoni EN
Leptobrachium hasseltii LC
Limnodynastes dumerilii LC
Lithobates omiltemanus CR
Lithobates subaquavocalis CR
Lithobates taylori LC
Lithobates warszewitschii LC
Litoria adelaides NC
Litoria booroolongensis CR
Litoria castanea CR
Litoria dayi EN
Litoria genimaculata LC
Litoria litorica CR
Litoria myola CR
Litoria nudidigita LC
Litoria pearsoniana NT
Litoria piperata CR
Litoria rheocola EN
Litoria verreauxii LC
Mannophryne cordilleriana CR
Mannophryne lamarcai CR
Mannophryne obliterata DD
Mannophryne riveroi EN
Megastomatothyla pellita CR
Mixophyes balbus VU
Mixophyes fleayi EN
Nymphargus megacheirus EN
Oophaga arboarea EN
Osteopilus vastus EN
Paratelmatobius mantiqueira DD
Philoria frosti CR
Phyllobates bicolor NT
Physalaemus barrioi DD
Plethrohyla achatnites CR
FULL ACCOUNT FOR: Batrachochytrium dendrobatidis

BIBLIOGRAPHY
55 references found for Batrachochytrium dendrobatidis

Management information

GLOBAL INVASIVE SPECIES DATABASE
FULL ACCOUNT FOR: Batrachochytrium dendrobatidis


Summary: The Amphibian Conservation Action Plan (ACAP) is designed to provide guidance for implementing amphibian conservation and research initiatives at all scales from global down to local. Available from: http://www.amphibians.org/newsletter/ACAP.pdf [Accessed 9 June 2008]


This article gives details about the first case of chytrid fungus in Spain. Rana.
Summary: Article outlining the first case of chytrid fungus in New Zealand.


Summary: B. dendrobatidis differentially affects genotypes between two species of hybridizing leopard frogs (Rana). Hybrid genotypes are more susceptible to infection, and suffer greater reductions in growth and development from the fungus.


Summary: B. dendrobatidis alters the outcome of natural predator-prey dynamics in a larval amphibian-predator system.


Summary: B. dendrobatidis impacts on Hyla larvae may be somewhat ameliorated in a heavy metal (Cu) aquatic environment. Thus, pathogenic effects may be a result of interactions with other aquatic contaminants.


Summary: This paper documents that B. dendrobatidis induces competitive effects in the larval environment between a toad (Bufo) and treefrog (Hyla) species.


Summary: This paper outlines the role of antimicrobial peptides in deterring chytrid infection.

Speare, R., Berger, L. Chytridiomycosis in amphibians in Australia.


Summary: The pathogen Batrachochytrium dendrobatidis (Bd), which causes the skin disease chytridiomycosis, is one of the few highly virulent fungi in vertebrates and has been implicated in widespread amphibian declines. However, the mechanism by which Bd causes death has not been determined. We show that Bd infection is associated with pathophysiological changes that lead to mortality in green tree frogs (Litoria caerulea). In diseased individuals, electrolyte transport across the epidermis was inhibited by >50%, plasma sodium and potassium concentrations were respectively reduced by ~20% and ~50%, and asystolic cardiac arrest resulted in death. Because the skin is critical in maintaining amphibian homeostasis, disruption to cutaneous function may be the mechanism by which Bd produces morbidity and mortality across a wide range of phylogenetically distant amphibian taxa.


Summary: A discussion of the factors involved in the population declines of amphibians in Latin America.