Batrachochytrium dendrobatidis

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<td>Fungi</td>
<td>Chytridiomycota</td>
<td>Chytridiomycetes</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
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 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](http://www.iucngisd.org/gisd/species.php?sc=123).

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**.

Click here to see information about Symptoms of the disease caused by *Batrachochytrium dendrobatidis*.

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).

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 hylid 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 amphibians 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).

[Accessed 05 June 2021]
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. dendrobatis* 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. dendrobatis*.

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.


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](#)
GLOBAL INVASIVE SPECIES DATABASE
FULL ACCOUNT FOR: *Batrachochytrium dendrobatidis*

**Review:** Matthew J. Parris Assistant Professor, Department of Biology University of Memphis USA

**Publication date:** 2006-08-14

**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 cisternasii* **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 eberoi* **CR**
- *Atelopus epikeistho* **CR**
- *Atelopus eusebianus* **CR**
- *Atelopus famelicus* **CR**
- *Atelopus flavescens* **VU**
- *Atelopus galactogaster* **CR**
- *Atelopus guanujo* **CR**
- *Atelopus halihelos* **CR**
- *Atelopus laetissimus* **CR**
- *Atelopus longibrachius* **EN**
- *Atelopus lozanoi* **CR**
- *Atelopus mandingues* **CR**
- *Atelopus minutulus* **CR**
- *Atelopus monohernandezii* **CR**
- *Agalychnis annae* **EN**
- *Allobates offersioides* **VU**
- *Anaxyrus canorus* **EN**
- *Aplastodiscus flumineus* **DD**
- *Aromobates leptopelis* **CR**
- *Atelopus andinus* **CR**
- *Atelopus arsyeucie* **CR**
- *Atelopus balius* **CR**
- *Atelopus boulengeri* **CR**
- *Atelopus carbonerensis* **CR**
- *Atelopus certus* **EN**
- *Atelopus chocoensis* **CR**
- *Atelopus coynei* **CR**
- *Atelopus dimorphus* **EN**
- *Atelopus elegans* **CR**
- *Atelopus erythrops* **CR**
- *Atelopus exiguus* **CR**
- *Atelopus farci* **CR**
- *Atelopus franciscus* **VU**
- *Atelopus glyphus* **CR**
- *Atelopus guitarraensis* **CR**
- *Atelopus ignescens* **EX**
- *Atelopus limous* **EN**
- *Atelopus longirostris* **EX**
- *Atelopus lynchii* **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 peruensis CR
Atelopus petiruizi CR
Atelopus pinangoi CR
Atelopus pulcher CR
Atelopus reticulatus CR
Atelopus seminiferus CR
Atelopus sermai CR
Atelopus siranus DD
Atelopus soriano CR
Atelopus spurrelli VU
Atelopus tamaense CR
Atelopus varius CR
Atelopus zeteki CR
Bokermannohyla claresignata DD
Bolitoglossa conanti EN
Bolitoglossa dolfini NT
Bolitoglossa pesrubra VU
Bolitoglossa sooyorum EN
Bombina pachypus EN
Bromeliophyla dendroscarta CR
Centrolene audax EN
Centrolene buckleyi VU
Centrolene gemmaturum CR
Centrolene Lynchi EN
Centrolene persisticum 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 daryi EN
Craugastor emleni CR
Craugastor escoces EX
Craugastor fleischmanni CR
Craugastor guerreiroensis CR
Craugastor laevissimus EN
Craugastor lineatus CR
Craugastor merendonensis CR
Atelopus nahumae CR
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Atelopus onorei CR
Atelopus oxyrhynchos CR
Atelopus palmaus DD
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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 magnifica EN
Bolitoglossa sombra VU
Bolitoglossa subpalmata EN
Bromeliophyla bromeliacia 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 azueroensis EN
Craugastor brocchi VU
Craugastor charadra 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
FULL ACCOUNT FOR: *Batrachochytrium dendrobatidis*

- **Craugastor milesi** CR
- **Craugastor olanchano** CR
- **Craugastor pechorum** EN
- **Craugastor podiciferus** NT
- **Craugastor punctariolus** EN
- **Craugastor rhycobatrachus** EN
- **Craugastor rugulosus** LC
- **Craugastor sabrinus** EN
- **Craugastor sandersoni** EN
- **Craugastor tabasarae** CR
- **Craugastor trachydermus** CR
- **Crinia pseudinsignifera** LC
- **Crinia georgiana** LC
- **Crinia ranoides** CR
- **Cycloramphus boraceiensis** LC
- **Cycloramphus ohausi** DD
- **Duellmanohyla chamulae** EN
- **Duellmanohyla lythrodectes** EN
- **Duellmanohyla schmidtorum** VU
- **Ecnomiohyla echinata** CR
- **Ecnomiohyla rabborum** CR
- **Eleutherodactylus barlagnei** EN
- **Eleutherodactylus cooki** VU
- **Eleutherodactylus jasperi** CR
- **Eleutherodactylus longipes** VU
- **Eleutherodactylus orcutti** CR
- **Eleutherodactylus patriciae** EN
- **Eleutherodactylus richmondi** CR
- **Eleutherodactylus semipalmatus** CR
- **Eleutherodactylus unicolor** VU
- **Epipedobates tricolor** EN
- **Exerodonta juanitae** VU
- **Exerodonta melanomma** VU
- **Gastrotheca cornuta** EN
- **Gastrotheca guentheri** VU
- **Gastrotheca orophylax** EN
- **Gastrotheca piperata** LC
- **Gastrotheca pseustes** EN
- **Gastrotheca splendens** EN
- **Gastrotheca gaucho** LC
- **Heleioporus aurantius** LC
- **Hyalinobatrachium guaiampanense** EN
- **Hylarana chalconota** LC
- **Hylodes magalhaesi** DD
- **Hylodes perplicatus** LC
- **Hyloxalus anthracinus** CR
- **Hyloxalus phylloides** LC
- **Hyloscirtus armatus** LC
- **Hyloscirtus colymba** CR
- **Hyloscirtus dactylocheirus** EN
- **Hyloscirtus platydactylus** VU
- **Hyloscirtus staudtii** EN

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<td>Mixophyes balbus</td>
<td>VU</td>
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<tr>
<td>Mixophyes fleayi</td>
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</tr>
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<td>Nymphargus megacheirus</td>
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<td>Oophaga arborea</td>
<td>EN</td>
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<tr>
<td>Osteopilus vastus</td>
<td>EN</td>
</tr>
<tr>
<td>Paratelmatobius mantiqueira</td>
<td>DD</td>
</tr>
<tr>
<td>Phyllophorus frosti</td>
<td>CR</td>
</tr>
<tr>
<td>Phyllobates bicolor</td>
<td>NT</td>
</tr>
<tr>
<td>Physalaemus barrioi</td>
<td>DD</td>
</tr>
<tr>
<td>Plectrohyla acaenathodes</td>
<td>CR</td>
</tr>
</tbody>
</table>
GLOBAL INVASIVE SPECIES DATABASE
FULL ACCOUNT FOR: Batrachochytrium dendrobatidis

Plectrohyla ameibothalame DD
Plectrohyla avia CR
Plectrohyla caltha CR
Plectrohyla charlota CR
Plectrohyla chrysoleura CR
Plectrohyla cyanomma CR
Plectrohyla dasyus CR
Plectrohyla exquisita CR
Plectrohyla guatemalensis CR
Plectrohyla hazelae CR
Plectrohyla lacertosa EN
Plectrohyla mykter EN
Plectrohyla penithec EN
Plectrohyla psiloderma EN
Plectrohyla quechi CR
Plectrohyla sabrina CR
Plectrohyla siopela CR
Plectrohyla teuchestes CR
Pleurodema marmoratum LC
Pristimantis anolus DD
Pristimantis calcaratus VU
Pristimantis caryophyllaceus NT
Pristimantis cremnobates EN
Pristimantis crucifer VU
Pristimantis diogenes EN
Pristimantis fallax EN
Pristimantis ginesi EN
Pristimantis ignicolor EN
Pristimantis jorgevelosai EN
Pristimantis lancini EN
Pristimantis lymani LC
Pristimantis nigroterminatus VU
Pristimantis prolatus EN
Pristimantis ruedai VU
Pristimantis sanguineus NT
Pristimantis scolobopharusa CR
Pristimantis signifer VU
Pristimantis tamsitii NT
Pristimantis urichi EN
Pristimantis vicarius NT
Prostherapis dunni CR
Pseudoeurycea unguidentis CR
Pseudophryne pengilleyi EN
Psychodya acrochorda DD
Psychodya erythromma EN
Psychodya legleri EN
Psychodya arborescens EN
Psychodya bistincta LC
Psychodya calvicollina CR
Psychodya cembra CR
Psychodya chryses CR
Psychodya crassa CR
Psychodya cyclada EN
Psychodya ephemera CR
Psychodya glandulosa EN
Psychodya hartwegi CR
Psychodya ixil CR
Psychodya matudai VU
Psychodya pachyderma CR
Psychodya pokomchii CR
Psychodya pycnochila CR
Psychodya robertsoni EN
Psychodya sagorum EN
Psychodya tecunumani CR
Psychodya thorectes CR
Pristimantis alberi CR
Pristimantis bicolor VU
Pristimantis caprifer LC
Pristimantis chalceus LC
Pristimantis crenquini EN
Pristimantis diaphorus VU
Pristimantis duellmani VU
Pristimants fetosus EN
Pristimants gracilis VU
Pristimants incanus EN
Pristimantis labiosus LC
Pristimantis lichenoides CR
Pristimantis molybrius NT
Pristimantis penelopus DU
Pristimantis quinquagesimus VU
Pristimantis sanctaemartae NT
Pristimantis savagei NT
Pristimantis scolodiscus EN
Pristimantis sulcus EN
Pristimantis uranobates LC
Pristimantis verecundus VU
Pristimantis zophus EN
Pseudacris triseriata LC
Pseudophryne coronopide CR
Psychodya CR
Psychodya dendrophasma CR
Psychodya euthysanota NT
Psychodya leonhardshultz GE

[Accessed 05 June 2021]
GLOBAL INVASIVE SPECIES DATABASE

FULL ACCOUNT FOR: Batrachochytrium dendrobatidis

Ptychohyla macrotymanum CR
Ptychohyla salvadorensis EN
Ptychohyla spinipollex EN
Rana muscosa EN
Ranitomeya abdita CR
Rhaebo haematiticus LC
Rhinella amabilis CR
Rhinoderma darwini VU
Scinax albicans LC
Silverstoneia nubicola NT
Strabomantis cheiroleptus VU
Strabomantis zygogactylus LC
Taudactylus diurnus EX
Taudactylus liemi NT
Taudactylus rheophilus CR
Telmatobius atacamensis CR
Telmatobius bolivianus NT
Telmatobius brevirostris EN
Telmatobius ceiorum EN
Telmatobius colanensis EN
Telmatobius culeus CR
Telmatobius degener EN
Telmatobius gigas CR
Telmatobius hockingi VU
Telmatobius ignavus EN
Telmatobius jelskii NT
Telmatobius latrostris EN
Telmatobius mayoloi EN
Telmatobius niger CR
Telmatobius peruvianus VU
Telmatobius pinguculius DD
Telmatobius platyccephalus EN
Telmatobius scrochi EN
Telmatobius simonsi NT
Telmatobius thompsoni EN
Telmatobius truebae EN
Telmatobius verrucosus VU
Telmatobius yuracare VU
Thoropa lutzi EN
Thoropa petropolitana VU

Ptychohyla panchoi EN
Ptychohyla sanctaeucrucis CR
Ptychohyla zophodes DD
Rana sierrae EN
Rhacophorus margaritifer LC
Rheobatrachus vitellinus EX
Rhinella chrysophora EN
Rhinoderma rufum CR
Scinax heyderi DD
Smilisca cyanosticta NT
Strabomantis necerus VU
Taudactylus acutirostris CR
Taudactylus eungellenis CR
Taudactylus pleione CR
Telmatobius arequipensis VU
Telmatobius atahualpai DD
Telmatobius brevipes EN
Telmatobius carrillae VU
Telmatobius cirrhacelis CR
Telmatobius contrerasi DD
Telmatobius dankoi DD
Telmatobius edaphonastes EN
Telmatobius hauthali VU
Telmatobius hyphseocephalus EN
Telmatobius intermedius DD
Telmatobius laticeps EN
Telmatobius marmoratus VU
Telmatobius necopinus EN
Telmatobius pefauri CR
Telmatobius philippi DD
Telmatobius pisanoi EN
Telmatobius schreiteri EN
Telmatobius sibiricus EN
Telmatobius stephani EN
Telmatobius timens DD
Telmatobius vellardi CR
Telmatobius vilamensis DD
Telmatobius zapahuirensis CR
Thoropa miliaris LC
Thoropa saxatilis NT

BIBLIOGRAPHY

55 references found for Batrachochytrium dendrobatidis

Management information

[Accessed 05 June 2021]
GLOBAL INVASIVE SPECIES DATABASE
FULL ACCOUNT FOR: *Batrachochytrium dendrobatidis*


**Summary:** Available from: [http://www.cdc.gov/ncidod/EID/vol9no8/03-0145.htm](http://www.cdc.gov/ncidod/EID/vol9no8/03-0145.htm) [Accessed 7 Dec 2004]


Gartswaite, R. Department of Conservation. *Batrachochytrium dendrobatidis, Frog Chytrid Fungus. Department of Conservation: Waikato*


**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.


**Summary:** Available from: [http://www.cdc.gov/ncidod/EID/vol7no4/00-0050.htm](http://www.cdc.gov/ncidod/EID/vol7no4/00-0050.htm) [Accessed 7 Dec 2004]


General information


Summary: Available from: [http://www.pnas.org/cgi/content/full/95/15/9031](http://www.pnas.org/cgi/content/full/95/15/9031) [Accessed 7 Dec 2004]


IUCN, Conservation International, and NatureServe. 2006. Global Amphibian Assessment. Downloaded on 5 May 2006. Summary: The Global Amphibian Assessment (GAA) is the first-ever comprehensive assessment of the conservation status of the world’s 5,918 known species of frogs, toads, salamanders, and caecilians. This website presents results of the assessments, including IUCN Red List threat category, range map, ecology information, and other data for every amphibian species.


Johnson, Pieter T.J., 2006. Amphibian diversity: Decimation by disease. Published online before print February 21, 2006, 10.1073/pnas.1000293103

Summary: Available from: [http://www.pnas.org/cgi/content/full/103/9/3011](http://www.pnas.org/cgi/content/full/103/9/3011) [Accessed 14 August 2006]


Norman, R. Undated. Chytrid fungus disease in New Zealand. Massey University Institute of Veterinary, Animal and Biomedical Sciences.

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 worldwide amphibian declines. However, the mechanism by which Bd causes death has not been determined. We show that Bd infection is associated with pathophysiologica 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: This article gives details about the first case of chytrid fungus in New Zealand, including possible means of introduction and spread.

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