# IS WHITE-NOSE SYNDROME A THREAT FOR BATS IN EUROPEAN CAVES?

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**Abstract:** White-nose syndrome is an emerging infectious disease that caused drastic die-offs in North American hibernating bats. It is associated with a fungal skin infection. The fungus, *Geomyces destructans*, grows in cold temperatures, and the body temperature of bats drops during hibernation to that ideal for *G. destructans* growth. In Europe, the fungus was first found in Germany in 2008. Since then it was also reported from France, Switzerland, the Czech Republic, Slovakia and Hungary. Affected bats sometimes have skin lesions, but no massive mortality has yet been observed. The fungus was probably present in Europe for an extended time period, as white growth similar to that of *G. destructans* was found on photographs and reported in literature. The occurrence of geomycosis increased in 2010 in the Czech Republic and Slovakia both in direct observation and on photographs of hibernating bats. Future research should aim to establish if geomycosis in Europe occurs also with the white-nose syndrome, and what effects it has on hibernating bat populations. In the meantime, cave visitors should try to reduce chances of accidental transmission over long distances by using new equipment for expeditions to other continents and thorough decontamination in known infected areas.

**Keywords:** white-nose syndrome, bats, *Geomyces destructans*, geomycosis, Europe, fungal disease

White-nose syndrome (WNS) is an infectious disease that affects hibernating bats (Blehert *et al.* 2009). In underground hibernacula, including caves, mines, cellars and other structures, infected bats have white fungal growth around their muzzles, on ears and wings. The fungal growth is most prominent towards the end of the hibernation period, and it consists of hyphae and spores of species *Geomyces destructans* (Gargas *et al.* 2009). In North America, the field signs of the WNS include the fungal infection, the geomycosis, aberrant behavior and high mortality (for term definitions, see Table 1; Meteyer *et al.* 2009, Martínková *et al.* 2010, Chaturvedi & Chaturvedi 2011). Winter mortality is often severe at affected sites, and population dynamics predictions show that even widespread species might become locally extinct within two decades (Frick *et al.* 2010).

## WNS IN NORTH AMERICA

The spreading of WNS in North America shows signs typical of an emerging disease. The WNS was first identified in 2006 in the north-eastern United States, near Albany, New York (Blehert *et al.* 2009). Since then, the range affected by the disease increased yearly and nowadays includes also show caves. The predominant direction of the front movement is south-west, along the Appalachian Mountains, but it is also found with increasing frequency distant from the mountain range (see Foley *et al.* 2011 for a current map).

The bat species with high mortality associated with WNS include *Myotis lucifugus*, *M.*

*Table 1. Definition of white-nose syndrome and geomycosis.*

| Term | Definition |
|---|---|
| White-nose syndrome | Specific histopathologic criteria for the disease, including confirmation of the geomycosis |
| Geomycosis | Fungal infection of *Geomyces destructans* without skin pathology indicative of the WNS |

*septentrionalis*, *Eptesicus fuscus* and *Perimyotis sufblavus* (Blehert *et al.* 2009). *M. lucifugus* is the most affected species in North America. It hibernates in large clusters, amounting up to hundreds of thousands individuals in some hibernacula (Fenton & Barclay 1980), and seasonally the majority of animals in each site might die (Frick *et al.* 2010). In the north-eastern United Stated, *M. lucifugus* might become extinct in less than two decades as the direct consequence of the WNS (Frick *et al.* 2010).

*Table 2. Bat species with the Geomyces destructans infection, the geomycosis, in Europe.*

| Species | Country | Year | Reference |
|---|---|---|---|
| *Myotis myotis* | France | 2009 | Puechmaille *et al.* 2010 |
| | Germany | 2009 | Wibbelt *et al.* 2010 |
| | Switzerland | 2009 | Wibbelt *et al.* 2010 |
| | Czech Republic | 2010 | Martínková *et al.* 2010 |
| | Slovakia | 2010 | Martínková *et al.* 2010 |
| | Hungary | 2009 | Wibbelt *et al.* 2010 |
| *M. bechsteinii* | Czech Republic | 2010 | Martínková *et al.* 2010 |
| *M. brandtii* | Germany | 2009 | Wibbelt *et al.* 2010 |
| *M. dasycneme* | Germany | 2008, 2009 | Wibbelt *et al.* 2010 |
| *M. daubentonii* | Germany | 2009 | Wibbelt *et al.* 2010 |
| *M. mystacinus* | Czech Republic | 2010 | Martínková *et al.* 2010 |
| *M. nattereri* | Czech Republic | 2010 | Martínková *et al.* 2010 |
| *M. oxygnathus* | Hungary | 2009 | Wibbelt *et al.* 2010 |

## GEOMYCOSIS IN EUROPE

Shortly after the outbreak of the WNS in North America and identification of the fungus, *G. destructans* was found in France on a *Myotis myotis* individual (Table 2; Puechmaille *et al.* 2010). The bat had the white fungal growth on its muzzle that was identified genetically and in culture as *G. destructans*. Other than the fungal infection, the geomycosis, the bat appeared to be healthy (Puechmaille *et al.* 2010).

In the same year, additional infected bats were reported also from Germany, Switzerland and Hungary, and the geomycosis affected, except *M. myotis*, also *M. dasycneme*, *M. daubentonii*, *M. brandti* and *M. oxygnathus* (Table 2; Wibbelt *et al.* 2010), amounting in total to 22 bats infected with geomycosis (Puechmaille *et al.* 2010, Wibbelt *et al.* 2010). Wibbelt *et al.* (2010) were also able to confirm geomycosis in the pond bat from Germany collected the previous year, in 2008 (Table 2).

The third study in Europe summarised data from early spring 2009 and 2010 and it showed that clinical signs of geomycosis increased recently in the Czech Republic and Slovakia (Martínková *et al.* 2010). The trend was visible both on photographs of hibernating bats and in direct observation. The most often infected species was *M. myotis*, and the geomycosis was confirmed also in *M. bechsteinii*, *M. mystacinus* and *M. nattereri*, increasing the number of affected species in Europe to eight (Table 2; Martínková *et al.* 2010). In the Czech Republic, the geomycosis was found in a show cave first in 2010.

None of the European studies reported massive die-offs (Martínková *et al.* 2010, Puechmaille *et al.* 2010, Wibbelt *et al.* 2010). However, if the mortality was not as severe as in North America, it could remain undetected in Europe. The bats hibernate in smaller groups or individually in crevices. A small number of dead bats could remain undetected in such places. Alternatively, many hibernacula are accessible for small predators and those might scavenge the carcasses on some cave floors if carcasses are not too numerous. Mortality would be more readily noticeable in overall survey counts. Martínková *et al.* (2010) analysed long-term population size data for *M. myotis*, and they found that the population fluctuation in recent years is within the predicted trend interval. Therefore, it seems that geomycosis does not adversely affect bat populations in Europe at the moment.

## CLINICAL FIELD SIGNS OF GEOMYCOSIS

While specific diagnostics of the WNS and associated geomycosis based on microscopic examination of tissues, fungal spores and DNA analyses can be proved only in specialized laboratories (Meteyer *et al.* 2010), the common field signs are easily discernible. Bats have white, puffy fungal growth patches on

muzzle, ears or wings. They arouse from hibernation and fly in winter more frequently, and they often relocate close to the entrance to the hibernaculum.

The white growth is the spores and hyphae of the fungus. As *G. destructans* grows slowly (Blehert *et al.* 2009, Gargas *et al.* 2009, Chaturvedi *et al.* 2010, Martínková *et al.* 2010), it is usually observed later in the hibernation season and not on all infected bats. Bats without the visible white fungus on their bodies can still be infected with *G. destructans*, and the signs are subtle (Fig. 1). Infected bats wake up from hibernation due to physiological challenges of the infection (Cryan *et al.* 2010), and they groom the fungus off (I. Horáček, pers. comm.). Microscopic spores remain on and in the skin and they re-grow. Severe geomycosis directly damages skin in hibernating bats. On folded wings, this manifests as lightly colored skin in patches of different size and shape, as an area without sheen and as lesions (Fig. 1a). Infected bats arouse from hibernation and they increase their body temperature. If precipitation condensated on hair tips during hibernation, the water soaks into hair as the body temperature increases and the bat appears wet (Fig. 1b). While wet hair is not always an indication of increased body temperature, it often accompanies the process of arousal and would occur more often in hibernacula where geomycosis is present.

## INFECTION TRANSMISSION AND PREVENTION

Bats can become infected by direct one-to-one transmission (D. Blehert *et al.*, cited in Foley *et al.* 2011), but the fungus was also found in soil in sites with confirmed WNS (Lindner *et al.* 2011). Spores from contaminated soil could adhere to clothing and equipment of cave visitors. Without thorough decontamination between visits, men can relocate the pathogen across distances larger than those accessible for infected bats. The disease front would expand faster. But the greatest danger from human-induced transmission is tourism between continents.

One of the hypotheses explaining the difference in manifestation of geomycosis between bats in Europe and North America is transfer by humans. Geomycosis appears to have been present in Europe prior to its first emergence in North America (Martínková *et al.* 2010, Wibbelt *et al.* 2010), and bats in Europe do not suffer massive die-offs that accompany the WNS across the Atlantic. If *G. destructans* was introduced to naïve bat populations and caused a catastrophe that nears to extinction, prevention of such events in the future is absolutely critical.

The U.S. Fish & Wildlife Service issues decontamination protocols that would make visiting underground safe for bats (http://www.fws.gov/whitenosesyndrome/), but some items cannot be decontaminated perfectly. Therefore, I would like to encourage cavers and cave visitors to invest in their expeditions. If people travel to a different continent and they expect to the visit underground there, a new set of clothing, shoes and gear that will be disposed of after the visit should be preferred. Alternatively, local cavers and cave manag-


*Fig. 1. Hibernating Myotis myotis with Geomyces destructans infection. (A) Skin lesions on wings indicative of geomycosis. (B) Wet hair might accompany arousal in hibernating bats and occurs more often at infected sites.*

ers could allocate necessary equipment to lend to visitors. These measures will increase costs of any underground explorations. But, hopefully, knowing that the costs help to protect the beautiful and interesting habitat will also increase personal satisfaction. The underground is a fragile and complex ecosystem, and bats are an important part of it that is currently in great danger from the white-nose syndrome in North America. And without further information, we have to assume that the danger is potentially worldwide.

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