

# Bat White-Nose Syndrome: An Emerging Fungal Pathogen?

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The first evidence of bat white-nose syndrome (WNS) was documented in a photograph taken at Howes Cave, 52 km west of Albany, New York, on 16 February 2006. Since emerging in the northeastern United States, WNS has been confirmed by gross and histologic examinations of bats at 33 sites in Connecticut, Massachusetts, New York, and Vermont (fig. S1). Current bat population surveys suggest a 2-year population decline in excess of 75% [see supporting online material (SOM) text for further details].

WNS has been characterized as a condition of hibernating bats and was named for the visually striking white fungal growth on muzzles, ears, and/or wing membranes of affected bats (Fig. 1A). Detailed postmortem evaluations were completed for 97 little brown myotis (*Myotis lucifugus*; Mylu), nine northern long-eared myotis (*M. septentrionalis*; Myse), five big brown bats (*Eptesicus fuscus*; Epfu), three tricolored bats (*Perimyotis subflavus*; Pesu), and three unidentified bats from 18 sites within the WNS-affected region. Distinct cutaneous fungal infection was observed in histologic sections from 105 of the 117 necropsied bats [91 Mylu (94%), eight Myse (89%), zero Epfu (0%), three Pesu (100%), and three unidentified (100%)]. Fungal hyphae replaced hair follicles and associated sebaceous and sweat glands, breaching the

basement membrane and invading regional tissue. Hyphae also eroded the epidermis of ears and wings (Fig. 1B). Additionally, 69 of the 105 bats [62 Mylu (64%), six Myse (67%), zero Epfu (0%), one Pesu (33%), and zero unidentified (0%)] with cutaneous fungal infection had little or no identifiable fat reserves, crucial for successful hibernation [see SOM text for additional mortality investigation details].

A fungus with a previously undescribed morphology was isolated from 10 bats (table S1) with histologic evidence of WNS-associated cutaneous fungal infection. These bats were collected between 1 February and 1 April 2008 from all states within the confirmed WNS-affected region (fig. S1). The distinctive curved conidia (Fig. 1C) of the isolates were identical to conidia scraped directly from the muzzles of WNS-affected little brown myotis collected at Graphite Mine (New York) and to conidia observed histologically on the surface of infected bat skin (Fig. 1B, inset). Isolates were initially cultured at 3°C, grew optimally between 5°C and 10°C, but grew marginally above 15°C. The upper growth limit was about 20°C. Temperatures in WNS-affected hibernacula seasonally range between 2° and 14°C, permitting year-round growth and reservoir maintenance of the psychrophilic fungus.

Phylogenetic analysis of the identical internal transcribed spacer region (fig. S2) and small subunit (fig. S3) ribosomal RNA gene sequences from the 10 psychrophilic fungal isolates placed them within the inoperculate ascomycetes (Order Helotiales) near representatives of the anamorphic genus *Geomyces* (teleomorph *Pseudogymnoascus*) (*1*). In contrast to the genetic data, morphology of the psychrophilic fungal isolates differed from that known for *Geomyces* species. The bat isolates produced single, curved conidia (Fig. 1C) morphologically distinct from clavate and arthroconidia characteristic of *Geomyces* (*2*). Species of *Geomyces* are terrestrial saprophytes that grow at cold temperatures (*3*). Placement of the WNS fungal isolates within *Geomyces*, members of which colonize the skin of animals in cold climates (*4*), is consistent with properties predicted for a causative agent of WNS-associated cutaneous infection.

Worldwide, bats play critical ecological roles in insect control, plant pollination, and seed dissemination (*5*), and the decline of North American bat populations would likely have far-reaching ecological consequences. Parallels can be drawn between the threat posed by WNS and that from chytridiomycosis, a lethal fungal skin infection that has recently caused precipitous global amphibian population declines (*6*). A comprehensive understanding of the etiology, ecology, and epidemiology of WNS is essential to develop a strategy to manage this current devastating threat to bats of the northeastern United States.

## References

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## Supporting Online Material

www.sciencemag.org/cgi/content/full/1163874/DC1  
Materials and Methods

SOM Text

Figs. S1 to S4

Table S1

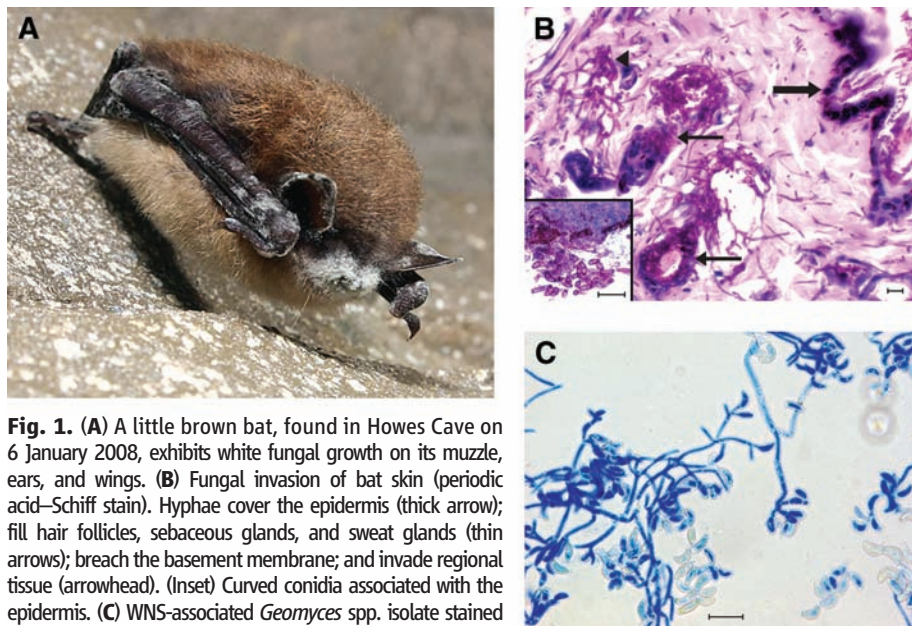
References

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**Fig. 1.** (A) A little brown bat, found in Howes Cave on 6 January 2008, exhibits white fungal growth on its muzzle, ears, and wings. (B) Fungal invasion of bat skin (periodic acid-Schiff stain). Hyphae cover the epidermis (thick arrow); fill hair follicles, sebaceous glands, and sweat glands (thin arrows); breach the basement membrane; and invade regional tissue (arrowhead). (Inset) Curved conidia associated with the epidermis. (C) WNS-associated *Geomyces* spp. isolate stained with lactophenol cotton blue. Scale bars indicate 10  $\mu$ m.

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