Battling white-nose syndrome in bats

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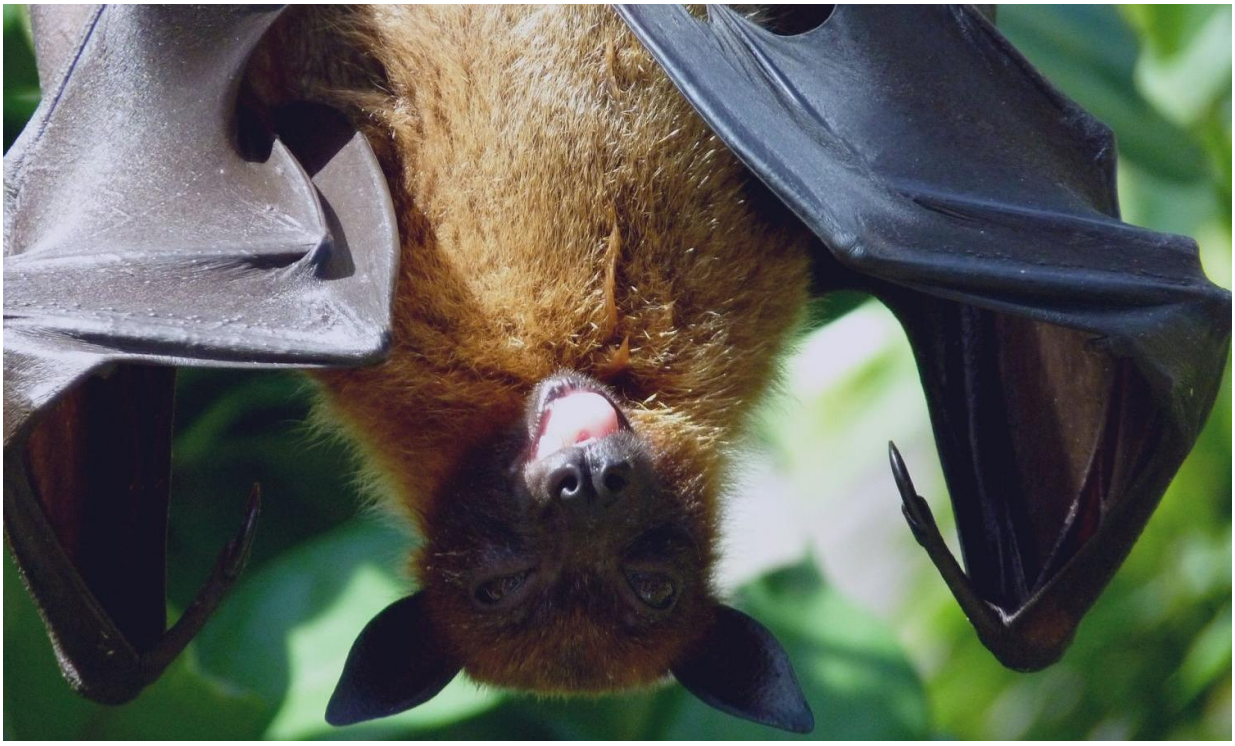

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Millions of bats in North America have been wiped out by the disease white-nose syndrome caused by the fungus *Pseudogymnoascus destructans*, and scientists worry that a catastrophic reduction in the bat population will have pervasive ecological repercussions. Now, a new study in *mBio* shines light on where the fungus came from and how it spreads.

"Our work suggests that the fungus has been throughout Eurasia for a long period of time, at least thousands of years, and that bats there have evolved resistance to it. It has only recently been introduced into North America," said principal study investigator Jeffrey Foster, PhD, associate professor, Pathogen and Microbiome Institute, Northern Arizona University, in Flagstaff. "Our genetic data show that the bats have been really effective dispersers of this fungus once it arrived in North America. If the bats can get there, the fungus likely will, making it exceedingly difficult to control the spread of the fungus."

P. destructans has colonized nearly all surveyed bat caves in the Eastern United States and Canada, in the past decade. Estimates are hard to come by, but the majority of individuals from eastern bat species have been lost. "Millions of bats have died as a result of this disease and several species are threatened with extinction, including the northern long-eared bat, little brown bat, and Indiana bat," said Dr. Foster.

It is extremely unusual for fungi to kill vertebrates, but researchers have found that *P. destructans* is wiping out the bats while they hibernate. "When the bats' immune systems are off or at a low simmer, they are not able to fight off the fungus," said Dr. Foster. The loss of bats has had consequences, since bats provide widespread insect suppression services to natural and agricultural ecosystems and are the primary suppliers of nutrients to unique cave ecosystems through deposition of guano.

In previous studies, *P. destructans* has exhibited few genetic polymorphisms, presenting challenges for epizoological tracking of the spread of the fungus and determining its evolutionary history. In the new study, researchers used single nucleotide polymorphisms from whole genome sequencing and microsatellites to construct high-resolution phylogenies of *P. destructans*. Understanding phylogenies is similar to reading family trees. Scientists performed whole genome sequencing on 26 isolates from throughout the white nose syndrome epizootic zone in

North America that were collected from 2008 to 2014. They also analyzed five isolates from Europe and three isolates from Asia.

"Our collaborators went into hibernation sites in the winter and used a swab to get some of the fungus off of the bat or collect it from the environment of the cave," said Dr. Foster.

Previous studies of *P. destructans* have analyzed only a small portion of the genome. "It is a herculean task to sequence entire fungal genomes," said Dr. Foster. "They are big, time intensive, and cost a lot of money."

Their genetic analysis suggests that the fungus was recently introduced to North America from a source in Europe, rather than Asia. While the study was ongoing, other researchers also found evidence that the fungus is not native to North America. "Our microsatellite data and our genetic data overall show a very complex picture of a single introduction, followed by widespread movement of the bats," said Dr. Foster. "It has spread farther than people thought." The researchers also found that the fungus in Europe and Asia is tremendously diverse, but were unable to find a definitive source for the North American outbreak.

Dr. Foster emphasizes that the study would never have been possible without the support of many scientists. "We have many, many collaborators around the world that have been willing to work with us to collect samples. There has been an outpouring of support from the bat community, in particular," said Dr. Foster. "Hundreds, if not thousands, of people have gotten together to help fight off this disease. It is pretty unusual that people will collaborate at this level for a single cause within science. It is encouraging."

Another reason for optimism, he said, was that researchers have discovered some bats that are seemingly resistant to white-nose syndrome in Vermont and elsewhere in the Northeast. While scientists

are not going to be able to put the genie back in the bottle in terms of controlling the fungus in North America, said Dr. Foster, understanding how fungal invasions happen can potentially prevent the next invasion.

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