



Biologists Struggle To Solve Bat Deaths

An epidemic has stricken the northeastern United States for 3 years. As it spreads, researchers wonder whether a white fungus is the real killer

CHALKHILL, PENNSYLVANIA—Leaning back against a grimy rock wall, wildlife biologist Greg Turner of the Pennsylvania Game Commission focuses his headlamp on a brown, furry clump of bats hanging in a cramped underground passageway. After a few seconds, he spies what he's looking for: the gleam of a tiny temperature sensor glued to the back of a bat. Gingerly, Turner plucks the hibernating bat with his gloved hands and stashes it in a cloth sample bag.

Turner and two colleagues have spent the past 3 hours scouring this cave for instrumented bats that may provide clues to a pressing mystery. An unknown killer has been wiping out populations of six species of hibernating bats in the northeastern United States in what appears to be the biggest die-off on record. "We're stabbing in the dark in a lot of ways, just trying to understand what's going on," Turner says.

Scrambling out of the cave in the late afternoon, Turner is feeling upbeat. There

were no dead or dying bats, and no sign of the telltale white fungus that may or may not be involved in the trouble. Moreover, he and his colleagues retrieved 17 bats with data loggers to reveal more about the hibernation patterns of healthy bats, which could shed light on what's going wrong elsewhere. Euthanized bats and soil samples will be shipped to researchers in other states for analysis.

All told, the crew gathered data for six experiments involving dozens of scientists. Similar missions are under way throughout the eastern United States, as bat researchers on the East Coast have shifted gears from routine bat research in the past 2 years to investigate the malady. So far, there are more questions than answers. Efforts are ramping up farther west as well: Scientists are forming a Midwest Bat Working Group, which met for the first time earlier this month in Indiana to plan and coordi-

◀ **Ominous sign.** Little brown bats are one of six species in trouble.

nate future bat-research strategies.

The task is urgent. The disappearance of these northeastern hibernating bats could have larger impacts on ecosystems, as these night flyers hunt insects that annoy humans and damage crops. And last October, a group of more than 100 participants from a science strategy meeting concluded that if the problem continues to expand at its current rate, entire species—including the endangered big-eared bat in Virginia and Indiana—could be in jeopardy.

Bleak midwinter

The first sign of trouble came in February 2006, while researchers in New York state were conducting a routine census of bats in four caves some 80 kilometers west of Albany. To their horror, they discovered either a precipitous drop in population or many dead bats in the four caves, located less than 13 kilometers from each other. At Hailes Cave, for example, the number had dropped by 43%, from 15,584 the year before to 6735.

Many bats—both dead and alive—had a whitish fungus ringing their muzzles and dotting their ears and wings. Although fungi on bats are not unusual, there was far more than normal. The dead bats had no obvious diseases, toxins, or parasites. Instead, they lacked enough body fat to get through the winter. Apparently, they had come out of hibernation early and exited caves during daylight, perhaps to search for insects. With nothing to eat, they starved to death.

The situation worsened over the next winter. Bat populations in these four caves fell by 50% to 100%. Even more alarming, researchers were finding emaciated or dead bats in other caves and mines in a widening area. Because the white fungus was seen in all these locations, the researchers dubbed the problem white-nose syndrome.

Last winter, the syndrome continued to spread. By April, it had reached 10 caves and mines in eastern and central Pennsylvania. Several caves in Virginia and West Virginia also showed signs.

Many caves visited by bat biologists in these newly affected areas remain free of white-nose, but the syndrome is clearly advancing across an ever-wider front.

Early clues

The same fungus, a new species of the cold-loving genus *Geomyces*, is turning up everywhere. David Blehert of the U.S. Geological

Online

sciencemag.org

S Podcast interview about this article.

Survey's National Wildlife Health Center in Madison, Wisconsin, identified the fungus in affected bats from multiple sites (*Science*, 9 January, p. 227). He and a dozen co-authors concluded that the fungus is "consistent with properties predicted for a causative agent." But the central question remains: Is the white-nose fungus the primary cause of the deaths or simply an opportunistic infection?

Further tests by Blehert's group may settle the issue. Since last fall, researchers and recreational cavers have been collecting soil samples from more than 200 sites in almost 30 states. If *Geomyces* spp. turns out to be present in unaffected sites distant from the syndrome's epicenter, the fungus may not be the primary pathogen. Blehert expects results by the fall.

Blehert has also conducted trials to see if *Geomyces* spp.—and clinical signs of white-nose syndrome—can be spread among hibernating bats. Using little brown bats (*Myotis lucifugus*) in the lab, the researchers brushed spores onto bats, allowed infected bats to touch unaffected ones, and housed unaffected bats in mesh enclosures near separate enclosures containing infected bats. These experiments wrapped up last month, and it appears that bats can spread the fungus among themselves.

Still, many researchers doubt that the fungus itself is to blame. "Fungal infections don't typically kill animals," explains DeeAnn Reeder of Bucknell University in Lewisburg, Pennsylvania. Instead, she says, fungi tend to be secondary infections that attack an animal already compromised by some other pathogen, such as a virus or bacteria.

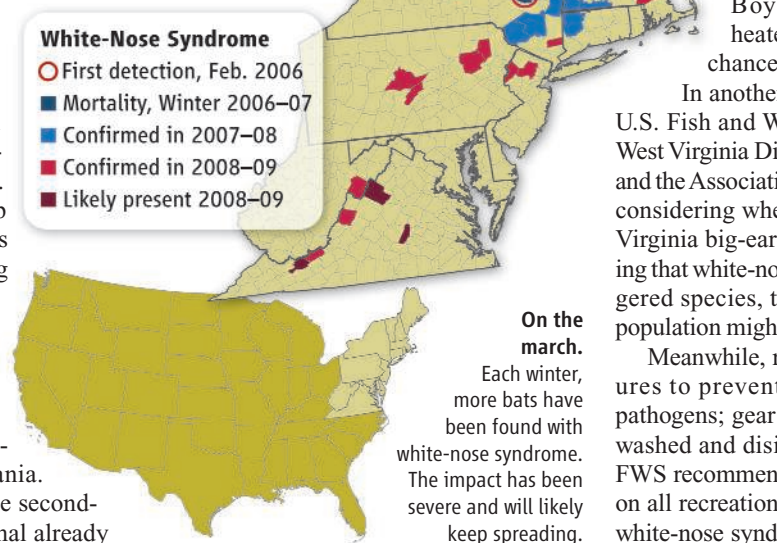
To find out more about what could be going wrong, researchers are probing the basics of bat biology. Reeder and her colleagues have put more than 300 temperature data loggers and transmitters on bats in six states. Hibernating bats will arouse and triple their body temperature for a few hours every 12 to 15 days. In bats with white-nose syndrome, however, the arousals seem to be more frequent. One hypothesis is that the bats do this to groom the fungus away or to reactivate their immune systems to fight off an unknown pathogen.

A team led by Marianne Moore of Boston University is testing the latter idea. She and colleagues have been measuring the strength of the immune system in bats at various times

during hibernation season, both in torpor and when aroused. They hope to find out if the immune systems of bats with white-nose syndrome have been compromised.

Another question is whether the sick bats lose most of their body fat during hibernation or start out the winter already in trouble. Jonathan Reichard of Boston University measured the body fat of bats during the fall, when they fatten up, and followed them during hibernation. "We're hoping to narrow down when bats are being most affected," he says. Preliminary results suggest that regardless of when white-nose initially attacks the bats, it worsens over time. Even if bats survive hibernation, many either die prematurely in the spring or enter the next hibernation scrawny.

Intriguing clues are also emerging from the digestive system, according to microbiologist H. Kathleen Dannelly of Indiana State



University in Terre Haute. Bats eat a lot of chitin, the hard exoskeleton of insects, and in summer they don't digest it. But they seem to do so in winter. Inside the digestive tract are bacteria that produce chitinase, an enzyme that breaks down chitin, and the bats might be extracting energy from the chitin, according to Dannelly.

Bats with white-nose syndrome seem different. Compared with healthy hibernating bats, 18 affected bats from New York state had far fewer chitinase-producing bacteria. "In fact, in the majority of white-nosed bats, we couldn't isolate any chitinase producers," Dannelly says. Her team has found "several predominant organisms" in the digestive systems of all 18, but she declines to elaborate, as the data are still

preliminary. Still, she suspects a pathogen might be compromising the bats' ability to digest chitin, which is possibly their only winter fuel other than fat. This could explain their starvation.

Stopgap measures

As researchers struggle to identify the culprit behind white-nose syndrome, an even larger question looms. What, if anything, can be done to help the bats?

One idea, proposed by Justin Boyles of Indiana State University and Craig Willis of the University of Winnipeg in Canada, is to put heated refuges in caves. They have found that when bats arouse during hibernation, they naturally go to the cave's warm spots in order to conserve energy. Because white-nose syndrome forces them to arouse more frequently, Boyles and Willis hope that heated areas could increase their chances of survival.

In another effort, a partnership of the U.S. Fish and Wildlife Service (FWS), the West Virginia Division of Natural Resources, and the Association of Zoos and Aquariums is considering whether to place several dozen Virginia big-eared bats in captivity. Assuming that white-nose eventually hits this endangered species, the hope is that this captive population might prevent its extinction.

Meanwhile, researchers are taking measures to prevent the accidental spread of pathogens; gear is either new or thoroughly washed and disinfected. And on 26 March, FWS recommended a voluntary moratorium on all recreational caving in any state where white-nose syndrome has been found within or adjacent to its borders. Then, on 24 April, the U.S. Forest Service closed all caves and mines for 1 year in all national forests in the northeastern United States. A similar closure for the southeastern United States is expected before the end of May.

Because bats migrate, experts expect that the syndrome will keep moving west and south in the coming years. As the pathogen moves south, it might not be as damaging, because hibernation is shorter and the bats might make it through the milder winter. As for the prospects of bats in the Northeast, most bat specialists seem pessimistic. "The future does not look good," says Craig Stihler of the West Virginia Division of Natural Resources.

—ROBERT ZIMMERMAN

Robert Zimmerman is a writer in Greenbelt, Maryland.