WHITE NOSE SYNDROME, BATS - NORTH AMERICA (04): SUMMARY
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When Donald McAlpine and his colleagues broke through a snow barricade at the entrance to a cave in New Brunswick this March 2011, bat carcasses covered the floor. The biologists had been conducting winter surveys throughout the Canadian province for 2 years, monitoring the health of hibernating bats. As of early winter, all appeared healthy. But now hosts of corpses lay shrouded in a pale fungus. The dreaded white nose syndrome, a virulent fungal infection, had clearly arrived.

McAlpine's team, from the New Brunswick Museum in St John, estimated that 1200 of the cave's 6000 bats were dead. Within a month after the discovery, the body count mushroomed to more than 5000 among this, the province's largest known collection of hibernating bats.

The researchers immediately alerted the Canadian Cooperative Wildlife Health Centre, which sent out word asking scientists and the public throughout eastern Canada to watch for bats that were dead or acting unusual, such as flying during the day. Hugh Broders of Saint Mary's University in Halifax, Nova Scotia, also found dead bats this spring, sending them to the health center's office on Prince Edward Island. There, a pathologist confirmed that white nose syndrome had officially reached Nova Scotia as well.

This year's [2011] Canadian cases mark the northernmost expansion of the syndrome. In the 5 years since the disease 1st arrived in caves near Albany, New York state (USA), it has spread to more than 190 sites in 16 eastern states, with suspected cases in 2 more, west of the Mississippi, and to 4 Canadian provinces. The disease's toll now exceeds well over one million bats. It's "the most devastating wildlife disease in recorded history," says biologist Thomas Kunz of Boston University.

After 1st being identified in a bat colony near Albany, NY in 2007, a white fungus has since spread to caves across the eastern United States and into Canada. Three cases are suspected in 2

states west of the Mississippi River.

Because species affected by the syndrome are all insect-eaters, their loss could foster the transmission of pestborne diseases in forests, croplands, and among people, Gabriela Chavarria of the United States Fish and Wildlife Service said in testimony on 24 Jun 2011 before a US House of Representatives subcommittee. A million bats can eradicate 3.6 metric tonnes of insects per night, she reported. Others at the hearing cited estimates of bats' annual pest-control benefits to agriculture alone at up to USD 53 billion.

But scientists aren't just documenting the disease's spread and potential devastation. Teams are now testing antifungal therapies and looking for lifestyle habits that might limit vulnerability. Several scientists have begun actively investigating why the fungus is killing bats in North America, while the same infection has left European counterparts virtually unharmed. Such research might help scientists target protection efforts.

The epidemic hit during the winter of 2005 to 2006. "But we didn't know it at the time," says Alan Hicks of the New York State Department of Environmental Conservation in Albany.

A year later, biologists stumbled upon caves harboring thousands of dead and dying bats. Affected animals tended to host a characteristic white dusting of fungal hyphae, extremely friable threadlike growths. As word of the mystery epidemic spread in early 2007, a photographer realized he had loads of pictures that he had taken a year earlier at a now-ravaged site near Albany. One photo from 16 Feb 2006, showed nascent evidence of the fungus.

Hoping to identify this pathogen, Hicks and others immediately began circulating pictures of affected animals among researchers, "people who collectively have probably looked at tens of millions of bats," Hicks says. "And to a person, they all said: 'I've never seen anything like this.'"

Two years later, David Blehert of the US Geological Survey's National Wildlife Health Center in Madison, Wisconsin and colleagues published data confirming that this fungus, a member of the soil-dwelling Geomyces_, was new to science.

For its devastating impact, it was named _Geomyces destructans_. Unlike related fungi, this one doesn't target the dead. Instead, _G. destructans_ latches onto living bats in the dead of winter. Bats living where the weather gets cold either migrate or wait the winter out by hibernating in underground caverns and mines, often at temperatures within 1-10 C of freezing. As body temperatures plummet and immune systems take a winter break, these animals congregate in closely packed masses of hundreds or thousands. Biologists refer to the congregation locales as hibernacula. And it's in these chambers that the cold-loving _G. destructans_ finds its hosts. A

mine that, for ages, served as New York's largest hibernaculum used to host more than 200 000 bats. Once white nose syndrome struck, the resident population plummeted to 2000 within just 3 years. Much of the die-off involved one species, the little brown bat, _Myotis lucifugus._

Many different types of bats can share a hibernaculum, and biologists are now studying whether the little brown's hibernation preferences match the narrow temperature and moisture range most favored by _G. destructans_. The findings might explain why little browns, long the commonest bat in the eastern United States, often suffer 90 per cent or higher mortality within a year or 2 of white nose syndrome arriving at their hibernacula.

Across North America, little browns have taken the biggest hit in terms of overall numbers, but at least 5 other species on the continent have also been devastated by white nose syndrome. European bats appear resistant to white nose syndrome, a clue that may help fight the spread of the fungus that causes it. A European bat with signs of the fungus was able, with a little grooming, to clear the infection in 9 days.

The syndrome gets its name from the observation that infected bats often develop a thin mask of pale fungal fibers on their faces. "If you touch it, the fungus falls apart," Hicks says. Any disturbance will make it visually disappear. But it's not truly gone.

Smooth white patches may also form on the ears, tail, feet or wings, which recent work shows are most vulnerable. Researchers are now coming to realize that a more apt name for this epidemic might be wing-digesting syndrome.

This fungus doesn't invade blood vessels and spread the way other fungal species do, explains wildlife pathologist Carol Meteyer, also of the USGS health center in Madison. _G. destructans_ initially starts multiplying on the skin of wings, then shoots hyphae, essentially the body of the fungus, out in all directions, she, Blehert, and colleagues reported last year [2010] in BMC Biology.

"My assumption is these hyphae are releasing biologically active enzymes because they digest the skin," Meteyer says. Instead of creating open, oozing sores, the fungi fill in behind the eroding skin. What's left is a wing with fungal cells increasingly substituting for bat cells.

With a bat's immunity depressed during hibernation, white nose syndrome doesn't elicit redness, swelling or irritation. Only when an animal wakes and its body temperature increases can it begin to fight the fungus. By then it's usually too late. Scientists documenting white nose syndrome's spread often have to climb through caves and abandoned mines over piles of dead bats.

Though most bats wake periodically throughout the winter, bats infected with white nose syndrome may rouse more often and for a longer time than non-infected bats. Researchers at USGS's Madison center note that frequent and somewhat prolonged arousals by infected bats also tend to coincide with emaciation and attempts by the animals to slake their thirst. The team now suspects that fungal digestion of wing tissue underlies both symptoms.

Wings make up about 85 per cent of the total skin surface of a bat's body, Blehert notes. Skin on the wing not only plays a role in blood pressure regulation and gas exchange, he says, but also water balance. As wing infections progress, a developing thirst is likely to rouse bats. Waking pushes body temperature up to normal and puts a big drain on a bat's stores of energy, fat.

Not surprisingly, awake, infected bats tend to be weak and hungry. McAlpine says some bats at the infected cave he visited were so famished that they left in search of food. But because it was still March, there were no insects to eat. "These bats were essentially dead on the wing," he says. He encountered several that traveled too far in their fruitless search for food; they froze to death.

To evaluate white nose syndrome's effects on rousing under controlled conditions, Craig Willis of the University of Winnipeg in Manitoba and his colleagues have monitored a colony of several dozen infected little brown bats in the lab. His team installed sensors to keep track of the animals' body temperatures and video cameras to record when animals rouse, and whether they show signs of excessive thirst. The team is now analyzing the video footage to get a better sense of the devastating chain of events that the fungus appears to trigger.

Despite the damaging effect in American bat colonies, _G. destructans_-infected European bats aren't dying, an international team of scientists reported on 27 Apr 2011 in PLoS ONE. Jeff Foster of Northern Arizona University in Flagstaff and others are now investigating why.

Foster is sequencing the genome of _G. destructans_ from 7 sites in the United States and Canada and 4 in Europe. Although fungi from the 2 continents are relatively closely related, preliminary findings show that there is far less variation in genes within the North American samples. That find is precisely what he would expect if the American samples derive from a common immigrant that had been established elsewhere for a long time, such as in Europe.

Last year [2010], researchers at the Broad Institute in Cambridge, Massachusetts completed a more thorough analysis of the US variant's genome. This July [2011], they finished cataloging the individual genes contained in the fungal DNA and predicted what proteins the genes make, says team leader Christina Cuomo. Over the coming year, her group will compare these proteins with those produced by different fungal species (her team has already sequenced genomes for more than 50 fungi, none of which affect bats). Any proteins unique to _G. destructans_ could shed light on how the pathogen kills, Cuomo says, and how it might be killed.

But Willis isn't waiting. This past winter [2010-11], his group began directly investigating the relative toxicity of _G. destructans_ from each continent in Canadian bats collected from a syndrome-free cave. The researchers infected 18 bats with the American strain, 18 more with its European cousin and left a 3rd batch untreated. If each fungal variant causes comparable disease, then some special vulnerability of North American bats would explain the continent's pandemic, Willis says. His team expects to publish its findings soon.

In the meantime, scientists are anxious to find a treatment. Plenty of medicines for fungal infections in people can kill _G. destructans_, at least in the test tube, notes Alison Robbins of the Cummings School of Veterinary Medicine at Tufts University in North Grafton, Massachusetts. That knowledge has led her and others to investigate the potential of terbinafine, an active ingredient in many athlete's foot medicines, to treat white-nose syndrome. This drug has been used safely in children around the world, she notes.

Last year [2010], she dabbed it on bats that were temporarily taken from roosting in a hibernaculum. "But just the disturbance of doing that killed them," Robbins says. So she and bat physiologist DeeAnn Reeder of Bucknell University in Lewisburg, Pennsylavania, turned to lab studies, applying terbinafine onto wings of infected bats as a cream or spray. It didn't save them.

Robbins also tried injecting terbinafine directly into little brown bats infected with the white nose fungus that she brought back to her lab from a cave in Virginia. All bats that were handled and kept warm following the disruption, whether treated or not, survived longer than those that went straight back into hibernation without any care from Robbins' team. But none survived hibernation more than roughly 100 days, Robbins says. Few made it even that long. The stress, especially from handling, was enough to kill them. Still, she says, she hasn't given up on terbinafine.

The bats' 600-km road trip to Massachusetts probably contributed to their stress. Unfortunately, Robbins says, the Virginia colony was the closest of any significant size. As recently as 2008, some 10 000 bats used to hibernate about 50 km from her facility. By 2009, the syndrome had culled that population to 117. This past fall [2010], just 14 bats returned.

Insect-eating bats simply don't do well in captivity, Robbins says, but scientists may need to keep small numbers alive in the lab until a workable treatment can be found. "We have to try to figure out how to make it work," she says. "At this point, there's nothing to lose."

Kunz has been focusing on another survival strategy: making bats' summer digs more hospitable.

In spring, hibernating females awake and take flight to maternity colonies. These sites can be the

ridgepoles of barns, somebody's attic or a natural site. In contrast to winter, when they hunker down in near-freezing accommodations, females seek ultrawarm homes in summer where they nestle together, conserving their bodies' energy for pregnancy and lactation. But as white-nose has taken its toll, Northeastern maternity populations have plummeted. This June 2011, Kunz visited a trio of summer lodges that used to host between 800 and 1200 bats each. Two were empty, and the last housed just 38.

Concerned that some communities are losing too many bodies to maintain crucial spring warmth, his group designed what it calls roost modules. Outfitted with many baffles, these wooden structures can be inserted into buildings, creating bat incubators. He has installed them at 2 sites. Unlike neighboring populations that continued to dwindle perilously, colonies with roost modules seem to have stabilized at 30 per cent of the original colony size, Kunz says. "I'm now collecting data on genetic variation in the survivors to see if they show signs of genetic resistance."

Because effective treatments for the disease are lacking, some scientists have pinned their hopes on the evolution of such resistance among American bats. Biologist Sebastien Puechmaille of University College Dublin suspects European bats have already evolved such a resistance, explaining their survival. "It appears the fungus has been in Europe for a long time. And when I say a long time, I mean thousands, if not tens of thousands, of years," he says.

But there is growing concern that the initial waves of infection won't leave enough survivors to successfully breed and reproduce, jeopardizing the chance of building a more resistant population, says ecologist Winifred Frick of the University of California, Santa Cruz. Although bats mate in the fall, a female doesn't ovulate and become pregnant until the following spring, and then only if she is fat and healthy enough to support a pup.

With infected bats now emerging from hibernation emaciated, dehydrated and with damaged wings, their bodies are prioritizing allocation of their energy into getting well, Kunz says. That means, even with the help of roost modules for warmth, reproduction could be put on hold at precisely the time more bats with the survivors' genes are needed to begin rebuilding savaged populations. Any recovery of American populations from white-nose syndrome, scientists now suspect, will take many decades if not a century or longer.

For the scientists, that means there is no end in sight for what has turned out to be exhausting, daunting and ultimately disheartening work.

Often, Reeder says, "we have to drag ourselves on hands and knees through small spots in caves, crawling on bat carcasses. It feels like we're working ourselves to the bone, just to document an extinction."

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[Let us hope this is not an extinction. Rather let us hope for a cure or a treatment. We will be far worse off without these diligent consumers of insects. - Mod.TG]

[see also:
White nose syndrome, bats - USA (07): (NC) 20110720.2191
White nose syndrome, bats - USA (06) : official information 20110604.1708
White nose syndrome, bats - USA (05): (ME) 20110526.1606
White nose syndrome, bats - USA: federal plan 20110521.1544
White nose syndrome, bats - Canada (02): (NS) 20110515.1486
White nose syndrome, bats - North America (03) 20110421.1241
White nose syndrome, bats - North America (02): (USA, Canada) 20110420.1229
White nose syndrome, bats - USA (03): (KY) 20110415.1178
White nose syndrome, bats - Canada: (ON) RFI 20110410.1129
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