

SCIENCE

The World's Most Valuable Parasite Is in Trouble

And so are the livelihoods of the people who depend on it.

ED YONG OCTOBER 22, 2018



A handful of caterpillar fungus (KELLY HOPPING)

Ten years ago, Kelly Hopping was driving through a Tibetan mountain pass when her Chinese colleague stopped the car, hopped out, walked to a roadside stall, and returned with what looked like a bag of Cheetos on sticks. Each orange lump was, in fact, a dead caterpillar whose body had been overrun by a fungus (the stick). Hopping's colleague, whose mother had cancer, had bought them for their medicinal value—and he had parted with an astonishing \$1,000 for about 250 pieces. “My mind was blown,” says Hopping, an ecologist at Boise State University.

The caterpillar fungus, *Ophiocordyceps sinensis*, is the world's most valuable parasite. It's a relative of the tropical fungus that turns ants into zombies, but unlike its infamous cousin, it is found only on the Tibetan plateau, where it infects the larvae of ghost moths. It has long been part of traditional Chinese medicine, and demand for it has risen so sharply in recent decades that in Beijing it is now worth three times its weight in gold. In Bhutan, one of the countries where the fungus is harvested, it accounts for a significant slice of the gross domestic product.

[Read: How the zombie fungus takes over ants' bodies to control their minds]

That's good news for the people of the Tibetan plateau, hundreds of thousands of whom harvest the fungus as their main source of income. It pays for food, clothes, medical bills, and education. It allows them to eke out a living on the roof of the world, where a living is increasingly hard to eke out.

But tough times lie ahead. By interviewing hundreds of collectors, and analyzing the local climate, Hopping has conclusively shown what others have suspected: The precious fungus is disappearing, as a result of a double whammy of overharvesting and warming weather. The caterpillar-fungus bubble is ready to burst, and an entire way of life could vanish with it. “I asked them, ‘Would you do something different if you could?’”

Hopping says. “A lot of people said, ‘Yes, if there was another way to make money. But I don’t have any other options.’”

The fungus first infects caterpillars in the summer, while they are buried underground and feeding on plant roots. It grows through their bodies in the fall and winter, slowly consuming them. Once the overlying snow melts in the spring, the fungus forces its almost-dead hosts toward the surface, before sending a dark-brown, spore-filled stalk through their heads. For that reason, the fungus is known locally as *yartsa gunbu*, from the Tibetan words for “winter worm, summer grass.”

Spotting the dark stalks that the fungus extrudes is tricky, since they closely resemble the sedges that flourish in Tibet’s alpine meadows. Digging them out is even harder. “If the fungus breaks off the caterpillar, it loses value, so during the harvest, it’s really important to keep the two parts connected,” says Hopping. “And the turf in these areas is so thick that when I was taking soil samples, I’d have to cut it with a knife.” It’s laborious work, but for the collectors, it’s also a social activity—a chance to hang out with friends on a summery mountainside.





A caterpillar fungus stalk, sticking out from the ground (Kelly Hopping)

The collectors work in May and June. Once they've unearthed their prizes, they sell to visiting traders using a complicated haggling system, in which their hands secretly exchange offers and counteroffers while hidden by the long sleeves of their robes. Once sold, the caterpillars slowly work their way through a chain of middlemen and toward the bustling metropolises of Hong Kong and mainland China.

Though the fungus has been prized as medicine for centuries, demand for it was long restricted to elites. That started changing in September 1993, when a team of Chinese athletes unexpectedly smashed several world records in track-and-field events—a feat that their coach partly attributed to their consumption of caterpillar fungus. Whether or not that was true (and there have long been suspicions about doping), the claims helped to turn the fungus into a valuable commodity, as did subsequent rumors in 2003 that it

could help ward off SARS. Demand surged, and collecting and selling the weird parasite became truly profitable.

From 1997 to 2012, prices rose by 20 percent every year, and the global market for caterpillar fungus is now worth \$5 billion to \$11 billion. The high end of that market was driven by the parasite's newly symbolic value as a bribe: The biggest and most attractive pieces are used as business gifts and sell for about \$140,000 per kilogram. But there's also a huge demand for smaller and cheaper pieces, thanks to China's booming middle class. The fungus is no longer just a treat for emperors and businessmen; it's coveted by ordinary people, who are now taking it prophylactically to ward off all kinds of possible ills.

The fungus is often described as "Himalayan Viagra" by Western media, but Hopping says she never heard it described that way in Tibet. People mostly take it as a generic immune booster, or to treat a growing list of conditions, including cancer. Its antitumor properties have never been tested in a clinical trial, but researchers have isolated pharmacological compounds from the organism. "It's not medically worthless, like rhino horn," says Hopping. "Whether the price is commensurate with its medicinal value is another thing."

"Its role in contemporary Tibetan lives and livelihoods is really very difficult to overstate," says Emily Yeh of the University of Colorado at Boulder. "In many rural areas, it is the single most important source of cash income." People have rearranged their lives around the harvest. Some have fought violently over access to fungus zones. Certain schools schedule vacations so that students can go collecting.

Despite its importance, the fungus might be in trouble. "A lot of people remembered that they would find it everywhere when they were children," says Hopping, who

interviewed dozens of collectors. Decades ago, it was so unremarkable that they'd trade it for cookies, and so abundant that its stalks would redden the meadows. That's no longer the case. By comparing her interviews with hundreds from prior studies, Hopping showed that over the past decade, more and more collectors have said that the harvest is thinning. "They used to say it's fluctuating, and now they're unequivocally saying it's decreasing," she says.

The frenetic harvesting is almost certainly involved. By extracting the fungus before it has a chance to lace the soil with spores, the collectors are preventing the next rounds of infection. And as Hopping's interviews show, many of them recognize the problem. "They're aware they're contributing to this, but they don't have an alternative," she says.

A small number of respondents also said that changing climate was involved—and Hopping found that they are right to think that. By comparing the abundance of the fungus with features of the local climate, Hopping showed that it grows best in areas that are 3,000 to 5,000 meters above sea level, where there's plenty of bare ground and where winters are dry and cold. The fungus, and the caterpillars it parasitizes, are adapted for life in extreme cold. They do best at temperatures of 5 to 20 degrees Fahrenheit (-15 to -5 Celsius). And "in the Himalayas, there's been a staggering amount of winter warming," Hopping says.

Other studies have speculated about the causes of the decline, but Hopping's careful work "establishes a clear link between winter temperature and fungus production, which was previously lacking," says Uttam Babu Shrestha of the University of Southern Queensland.

Alpine regions are warming worldwide, and several species have responded by slowly shifting to higher and colder ranges. But the caterpillar fungus is so dependent on its

host moths (and the plants they feed from) that it might be hard for the entire web of partners to relocate. Besides, in the Tibetan plateau, there's not a lot of extra mountain to move toward. "There's a real mismatch between the rate at which the climate is changing and the rate at which the ecosystems can keep up," says Hopping.

Throughout humanity's history, we have repeatedly pulled the trigger on species that were already weakened by warming climates. The caterpillar fungus might be the next casualty of a trend that has claimed more charismatic species, such as the woolly mammoth and ground sloths.

[Read: How climate change unleashed humans upon South America's megabeasts.]

To avert catastrophe, countries such as Bhutan have set national limits on the caterpillar-fungus harvest, and some communities have implemented their own regulations. But the fungus attracts poachers who are not beholden to those rules, "and there's a mentality that if I don't collect it, someone else will," says Hopping. It's a classic tragedy of the commons, and one exacerbated by the lack of other opportunities.

Ultimately, Hopping says, this is an economic issue. The collectors are often very poor, and come from different ethnic groups than those in power. They don't get an education that would make them qualified for other jobs. And other traditional occupations, such as herding, are also becoming more difficult because of the changing climates that are working against the fungus. "They need choices," says Hopping. "That would be the main way to take the pressure off. Just saying that they need to collect less of it ... I think they know that."

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