

# Fungal spores travel farther by surfing their own wind (w/ Video)

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The spore cups, or apothecia, of the fungus *Sclerotinia sclerotiorum* are about a half-centimeter across and produce thousands of spores throughout the spring and summer. The fungus is often hidden in fields, where they infect crops ranging from peanuts and cabbage to sunflowers. Credit: Helene Dillard/Cornell University

Long before geese started flying in chevron formation or cyclists learned the value of drafting, fungi discovered an aerodynamic way to reduce drag on their spores so as to spread them as high and as far as possible.

One fungus, the destructive *Sclerotinia sclerotiorum*, spews thousands of spores nearly simultaneously to form a plume that reduces drag to nearly zero and even creates a wind that carries many of the spores 20 times farther than a single spore could travel alone, according to a new study by mathematicians and biologists from the University of California,

Berkeley, Harvard University and Cornell University.

"In the Tour de France, riders form a peloton that can reduce air drag by 40 percent," said co-lead author Marcus Roper, a postdoctoral researcher in the Department of Mathematics at UC Berkeley and at Lawrence Berkeley National Laboratory. "The ascospores of *Sclerotinia* do the peloton perfectly, reducing air drag to zero and sculpting a flow of air that carries them even farther."

Presumably, this strategy helps the fungi get their spores off the ground into the foliage of their host plants, or into airstreams that can carry them to host plants, the scientists say.

Co-lead author Agnese Seminara, a postdoctoral researcher and theoretical physicist in Harvard's School of Engineering and Applied Sciences, added: "I realized that the spores behaved much like cloud droplets. To follow their paths, I adapted algorithms I had developed to describe cloud formation."

Roper, Seminara, and colleagues report the findings this week in the early online edition of the journal [Proceedings of the National Academy of Sciences](#) (*PNAS*).

"These findings could have implications for methods of controlling the spread of fungal pathogens," said senior author Anne Pringle, associate professor of organismic and evolutionary biology at Harvard.

"*Sclerotinia* alone costs U.S. farmers on the order of \$1 billion annually, including costs of controlling the fungus and crop losses. Research directed at understanding how to disrupt the cooperative ejection of spores may provide novel tools for the control of these fungal pathogens."

Researchers in the field of bioballistics - how plants, fungi and animals

accelerate seeds, spores or even parts of their body to high speed - have found an amazing variety of techniques to overcome friction with the air, the main limitation for small spores and seeds.

"Understanding how *Sclerotinia* is discharging its spores and getting them onto the plants will eventually lead us to new ways of looking at plant architecture," said co-author Helene Dillard, a plant pathologist who heads Cornell University's Cooperative Extension and is associate dean of the College of Agriculture and Life Sciences. "When plant breeders are developing new varieties of crops - such as beans, cabbage or sunflowers - they can keep in mind how *Sclerotinia* gets the spores to reach their targets, which is usually the flowers."

Scientists have recognized for more than 100 years that many spore-producing fungi - the ascomycetes - release their spores in plumes that carry them long distances. More than 50 years ago, scientists noted that these spore plumes create a wind of their own, but the physics of the plumes was not understood, Roper said. In addition, little work has been done on how seeds or spores cooperate to improve dispersal to new environments.

With training in the mathematics and physics of fluid flow, Roper and Seminara decided to investigate in collaboration with Pringle, a Harvard mycologist.

For the current *PNAS* paper, the researchers used high-speed video to clock the speed of spores ejected by *Sclerotinia*, finding that they are expelled at a speed of about 8.4 meters per second (19 miles per hour). However, because the spores are so small - 10 microns long - [air drag](#) brings them to a stop in a mere 3 millimeters. When thousands of spores are ejected at the same time, however, some can travel more than 100 millimeters, or 4 inches.

These high-speed video images enabled Roper and Seminara to model spore plume movement precisely with standard equations of hydrodynamics. They showed that the thousands of spores ejected at the same time quickly eliminate all drag and allow the spores to travel about a centimeter, by which time the wind generated by the spores captures and whisks them to a speed of 60 centimeters per second. Their upward motion is stopped only by gravity, Roper said.

The added range from "hydrodynamic cooperation" allows fungi on the ground to shoot their spores into flowers or plant wounds, whence they can quickly spread throughout the plant and kill it.

Often called white mold, Sclerotinia rot, or wilt, the fungus attacks more than 400 species of plants, Dillard said, including beans, sunflowers, soybeans, canola and peanuts, and can wipe out entire fields. In spring and summer, the fungus produces cups (apothecia) about one-half centimeter across that spew spores into the air to infect plants. The fungus produces overwintering seed-like bodies called sclerotia on the infected plant tissues.

"It grows across a cabbage head and produces these small sclerotia that look like mouse droppings," Dillard says. "The sclerotia fall on the ground, and are then in position to initiate the infection process the following year."

The researchers were also curious how fungi manage to eject their spores simultaneously. To investigate this, they grew another mold, a coprophilic fungus from the genus *Ascobolus*, on horse dung and focused their high-speed video camera on the two-millimeter, cup-shaped fruiting body containing tens of thousands of spore sacs (asci), each containing eight spores. They found that, while the spore sac that ejects first seems to be random, after the first one or two go off, a wave of ejection travels outward as successive rings of spore sacs rupture in

sequence. Because this happens in one-tenth of a second, the ejection seems simultaneous.

"What looks like a plume is actually a series of sheets going off," Roper said.

By tweaking their mathematical model to take account of this, Roper and Seminara discovered that cooperative ejection in sheets is a highly effective method for shooting spores long distances. The scientists continue to investigate how spore ejection is initiated, and whether and how [spores](#) can cheat to make sure that they get ejected farther than their companions.

Provided by University of California -- Berkeley

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