Biology: uniformity and diversity

Ballooning Spiders

Narrator
Biophysicist Bob Suter is off on a spider hunt.

Bob Suter, Vassar College, New York State
If we're going to catch any spiders out here that are ballooning, they're going to be falling past us downward, because we're sitting still in the air, and the spiders are falling down.

Narrator
All they need to get airborne is an upward flow of air and a single strand of silk.

Spiders are denser than air, but they can gain height if the air column is rising faster than gravity is pulling them down.

Human balloonists need lots of hot air to keep them aloft.

Bob Suter
We're actually neutrally buoyant. Which means we're at the same density as the air that's around us. This whole system that we're in is of the same density. So, we're sitting still, with respect to the air column. A spider is always falling through it.

Let's see if we've got anything on here. Have we got him? Yes. I got him.

Narrator
Size is an important factor in determining a spider's chance of getting airborne.

Bob Suter
The forces important in spider ballooning really are gravity. Because that acts on all objects no matter where they are, and the drag force created by air flowing past the spider.

Narrator
The hot wire anemometer measures the speed of the air currents. The stream of smoke gives an indication of the direction of the airflow.

Bob Suter
A spider that stands on the tip of a twig with silk in the air above it, and is trying to balloon is going to become airborne only when the velocity of the air is high enough in an upward direction, so that the drag the spider experiences exceeds the pull of gravity.

Narrator
Because air currents are unpredictable, and the next puff of wind could carry it up or down, the spider has to choose the right moment for take off.

Bob Suter
These graphs show velocity of the wind here, the angle of the wind. And the probability that a spider can get airborne under those conditions. And so the angle of the wind is what I got from the smoke. The velocity of the wind came from that anemometer that I was using. And what basically this shows is that for all the variety of angles, and all the variety of winds, there is a very small proportion of the time when the spider can actually get itself airborne.

If you look at this in more detail, you can see how this works out for very small spiders, medium sized spiders and larger spiders. And what you see of course is that for the very large spider, this is 1.6 milligrams, becoming airborne is very difficult, and only happens in a very small fraction of the time when conditions might be right for a medium spider. And of course for a very small spider a tenth of a milligram conditions are much more frequently ideal for getting airborne.

Narrator
After take off, the direction they go depends entirely on the wind. But balloonists of all sizes have some control over the duration of their flight.

Bob Suter
The way we're controlling out height right now is by burning propane into the air above us, which makes us less dense. So we go up and we can vent some air, or we could just let it cool down, and we'd go down. Adjusting how dense we are relative to the air around us.

Narrator
Spiders can't adjust their density. What they can do is vary their surface area to increase or decrease the viscus drag.

Bob Suter
Some of the work that I've been doing has shown that as they spread their legs out, they substantially increase the drag that they experience, so they fall more slowly. And if they pull their legs in, that is crunch them up against their body, they can fall more rapidly.

Narrator
And falling spiders makes subtle use of ballooning silk.

Bob Suter:
The length of silk that they let out, or reeling up the silk, which they can do with their legs, can of course decrease or increase the amount of silk that's out there. And therefore decrease or increase the amount of drag that they're experiencing. But they're always falling.

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