Flying dry

How mosquitoes survive the rain

David Sang

Go out in the rain and you get wet. It's unpleasant, but you survive. Individual raindrops are small compared to a human being so they can do little damage.

But imagine that you are a small, flying insect such as a mosquito. A raindrop is much bigger than you. How can you avoid being flattened? Some clever photography shows how it's done.

Physics for flies

Picture a mosquito. Its **mass** is only 2 or 3 µg (micrograms). It likes living in damp places so it's likely to be out in the rain.

Now picture a raindrop. Its mass may be as much as 100 µg, 50 times that of the mosquito. It may be falling at 9 m/s. When a raindrop hits a mosquito, it's like a double-decker bus hitting a human at top speed.

If the mosquito is sitting on the ground, it's likely to be crushed as the raindrop breaks up. But, if the mosquito is flying, the result is different.

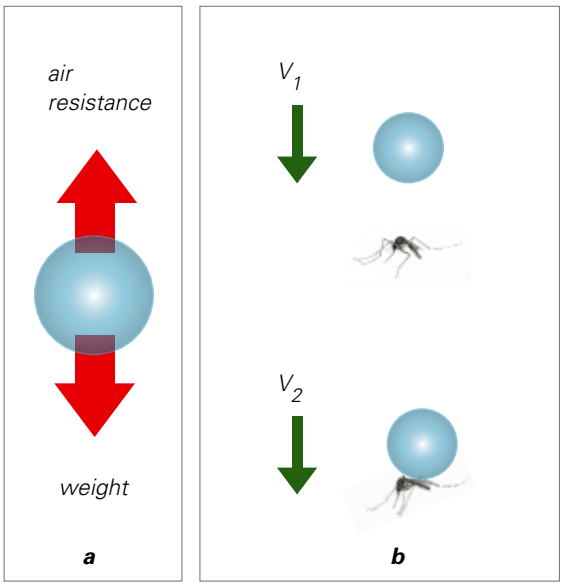


Figure 1 a *As it falls, a raindrop soon reaches terminal velocity, a bit less than 10 m/s. This is when its weight is balanced by the force of air resistance.* ***b*** *When a large mass collides with a smaller, stationary mass, the large mass will slow very slightly. Some of its momentum has been transferred to the smaller mass.*

Photographing flies

To find out how mosquitoes survive impacts with raindrops, a group of engineers from Georgia Institute of Technology (USA) developed a system which allowed them to photograph collisions between water droplets and flying mosquitoes. Initially, they experimented with fake flies described as 'mimics'.

Figure 2 shows the apparatus. Water from jet A passes through an infra-red beam (a light gate) B. This triggers the controller C and power supply D which operates the solenoid E which pulls downwards, releasing the insect mimic F (the green ball) made of expanded polystyrene (Styrofoam).

A high-speed camera films the impact. The photographs on pages 10-11 show what happens when the apparatus was adapted so that a water drop hit a flying mosquito.

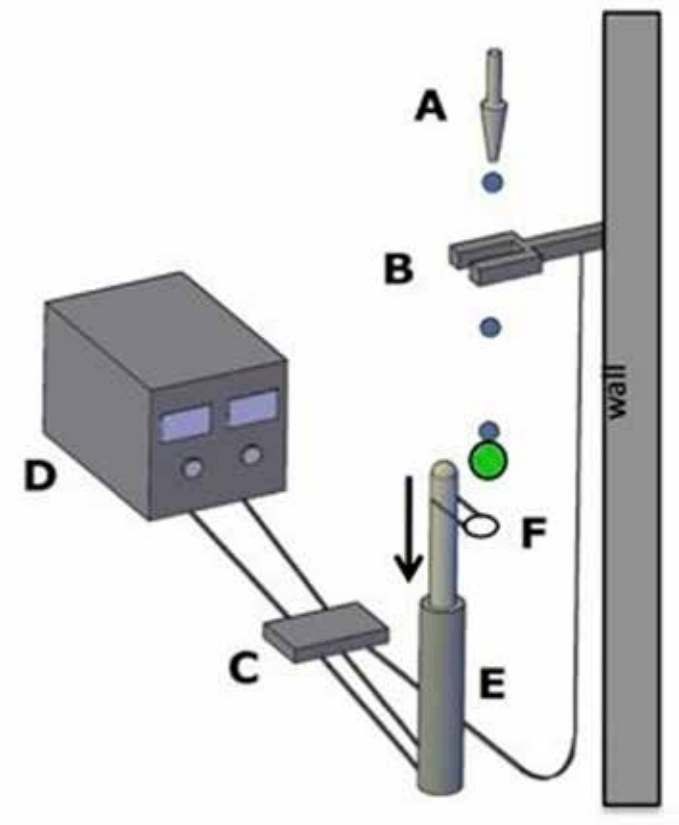
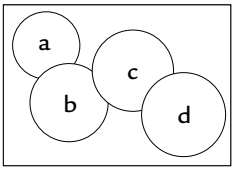


Figure 2 *The apparatus used to film insect mimics as they are hit by water drops.*

Key to pages 10-11



a A mosquito tips its wings to escape from under a raindrop.
b A direct hit spells danger.
c The raindrop breaks over the mosquito.
d A wet mosquito.

Tim Nowack/TimNowackPhotography.com

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A mosquito struck by a raindrop must avoid breaking the drop.

A mosquito flies among artificial raindrops.

Under impact

The experimenters found two possible outcomes.

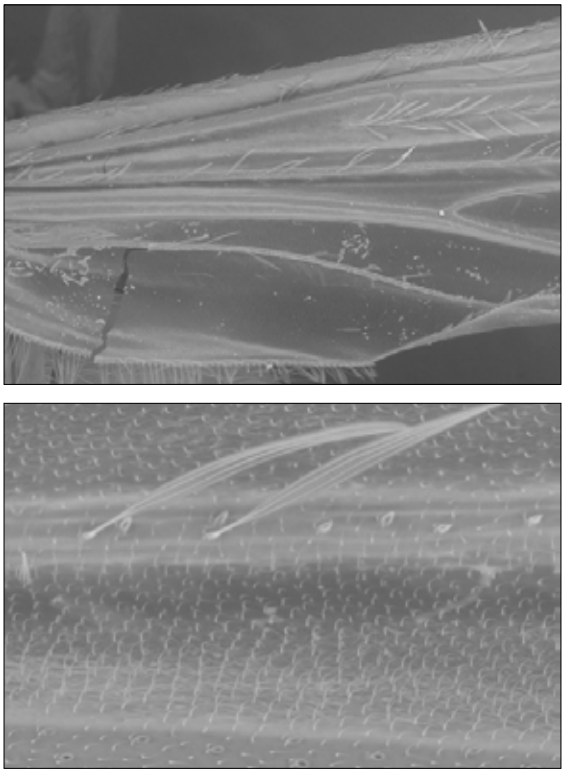
- A fly hit off-centre is tipped sideways but manages to shake off the drop. It does this within about one-hundredth of a second, before recovering its flight.
- A direct hit causes the fly to fall with the drop, which remains intact. It may fall about 20 cm, so it is not advisable for flies to stay close to the ground.

Staying dry

If a raindrop hits a solid object, it usually splatters. What prevents this when it hits a mosquito?

- Firstly, a mosquito's mass is very small compared to that of a raindrop. The force of the raindrop on the mosquito is small, about the weight of a small feather. The mosquito is pushed so that it moves with the raindrop.
- Secondly, a raindrop is held together by the force of surface tension. This is a result of the attractive forces which act between water molecules and which pull the drop into a roughly spherical shape. The force of the impact is not enough to break the drop.
- Thirdly, a mosquito is covered in water-repellent hairs. These probably help it to pull itself free of a raindrop as they fall together.
- A mosquito's body is flexible with a tough exoskeleton. This allows it to survive the impact and cope with the sudden acceleration it experiences – up to 300 times the acceleration due to gravity.

So, provided a mosquito can avoid breaking the surface of a raindrop and thereby getting wet, it can survive an impact. It must twist its body and wings so that it slips out from under the drop.



Scanning electron microscope images of water-repellent hairs on the wing of a mosquito.

David Sang is Physics editor of CATALYST

Look here!

This work was done by Andrew K. Dickerson, Peter G. Shankles, Nihar M. Madhavan and David L. Hu. Follow the link to see their films of mosquitoes in the rain and read their published paper: http://dickerson.gatech.edu/file/Mosquitoes_in_Rain.html