Midge swarms show mechanical properties, behave as a viscoelastic material

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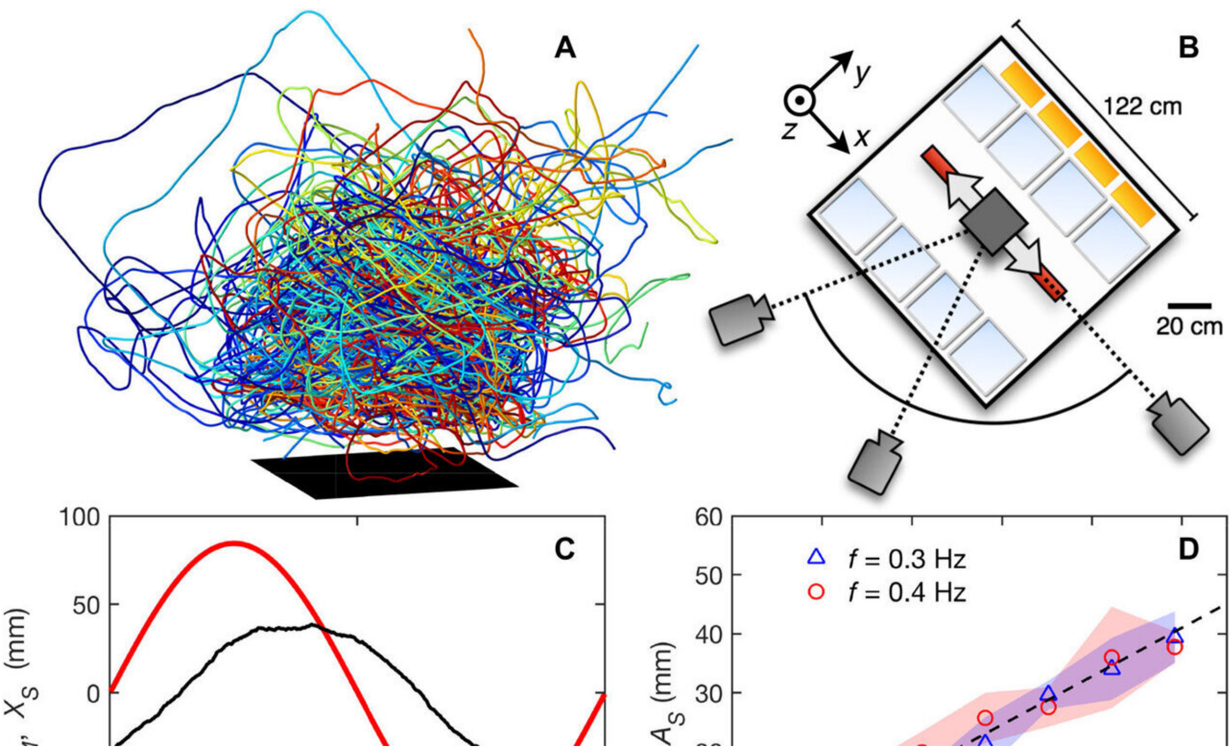

Mean swarm response to an oscillating swarm marker. (A) Trajectories (>40 s long) of individual midges (each color corresponding to a different midge) are individually convoluted but remain localized over the ground-based swarm marker (black square). (B) Sketch of our experimental setup. Swarms form inside a plexiglass cube measuring 122 cm on a side and are imaged using three cameras mounted outside the enclosure. The swarm marker (in dark gray) is mounted on a linear stage (in red) that can be oscillated over a range of controlled frequencies and amplitudes along the direction indicated by the white arrows, which we label as the x direction. z increases vertically from the swarm marker (antiparallel to gravity), with the marker itself at z = 0. Midge development tanks (light blue) and four infrared light-emitting diode arrays (yellow; additional arrays on top of the enclosure are not shown) are also shown. (C) Phase-averaged position of the center of the swarm marker X_M and the center of mass of the swarm X_S. The swarm center of mass tracks the sinusoidal motion of the marker, although with a reduced amplitude and a phase lag. (D) The amplitude of the swarm center-of-mass motion AS as a function of the amplitude of the marker motion A_M for two different oscillation frequencies, showing a linear relationship between the two. The shaded area shows the SEM.

A team of researchers from Stanford University and Rothamsted Research, has found that midge swarms have some types of mechanical properties and also respond to a stimulus at times as a viscoelastic. In their paper published in the journal *Science Advances*, the group describes their study of swarm behavior in a species of midges and what they found.

Midges are an unofficial classification of two-winged fly. There are many species, most of which are associated with swarms that live near water or marshy areas. In this new effort, the researchers wanted to learn more about the physical properties of swarming behavior from the perspective of an entire swarm, rather than the individuals in it. To that end, they obtained a mass of male *Chironomus riparius*, which are known to swarm over a given object such as a tree stump as part of their mating ritual—the swarm allows the females to find them from a distance. In their lab, the researchers placed a square of black felt on the bottom of a tank for the midges to use as their orienting object. When the piece of felt was moved, the swarm responded to it. To test swarm responses to it, the felt square was attached to a small oscillating device.

The researchers report that they focused specifically on how the swarm responded as an entire unit to the moving object below them. They report that it behaved in a layered manner, with those closest to the moving object responding faster than those in more distant layers. The researchers suggest this was likely due to propagation delays in messaging between individuals. They also observed mechanical properties—and sometimes the swarm behaved elastically, while at other times it behaved more like a viscous liquid—which, in physics terms, meant it was behaving like a viscoelastic material. They also found that sometimes, the viscosity properties were overcome by the elastic properties, which led to an observed dampening effect of the swarm's overall movement. The researchers suggest this made the swarm more stable, making it easier for the females to find it. They also suggest their findings might have some relevance to swarming robotics efforts.

More information: Kasper van der Vaart et al. Mechanical spectroscopy of insect swarms, *Science Advances* (2019). DOI: 10.1126/sciadv.aaw9305