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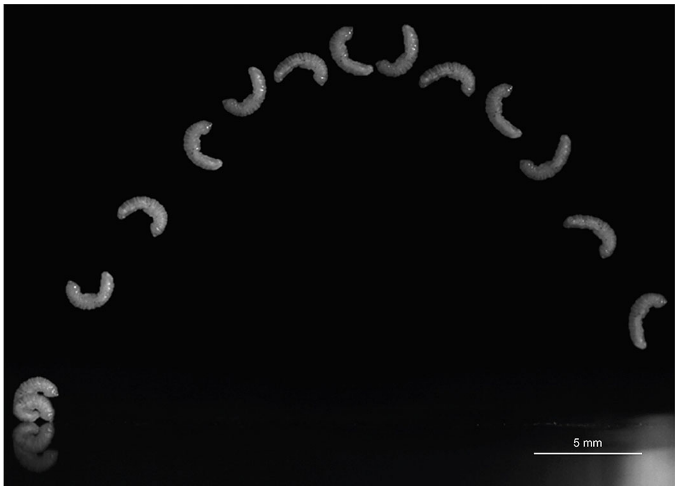
INSIDE JEB

Legless gall midge maggots use improvised limb to leap



A time-lapse image of a gall midge grub (*Asphondylia* sp.) spinning through the air. Photo credit: the Patek lab.

Mike Wise is fascinated by the beasts that infest goldenrods. After gall midge eggs hatch on the plants, the emerging larvae ('maggots') stimulate the plant to produce a gall which the developing insects nibble from within. Over his career, Wise, at Roanoke College, USA, has dissected thousands of galls in search of new species and sometimes, if he opens a fleshy swelling produced by an *Asphondylia* gall midge at the right time of year, a fully developed maggot crawls out. 'If their galls are damaged in nature, they need to scoot to have a chance at survival', he explains. But *Asphondylia* maggots don't simply wriggle away: they catapult themselves to safety, which is quite a feat for an animal with no legs. 'It borders on the fantastical', chuckles Wise, who mentioned the unconventional creatures to his graduate school friend, Sheila Patek. 'I knew Sheila was an expert in cool mechanisms of locomotion, so I wanted her opinion', says Wise. And when he visited Patek's Duke University lab, USA, with freshly gathered galls to show off the maggots' extraordinary take-off, Patek was captivated.

But there was a catch. The 3 mm long *Asphondylia* maggots only perform their power leaps for a brief period each August; 'The team filmed non-stop for the few days they were available', says lab member Jacob Harrison. In addition, only a few of the opened gall chambers provided healthy larvae of the correct age. It also took several years for the team to perfect a technique that allowed them to film the take-offs of leaps ranging from 49 to 121 mm. 'We had to zoom in with the camera lens to see the animal clearly and then we had to operate within a small field of view on our computer screen', says team member Grace Farley, adding, 'We really had to work as a team and communicate'.

Eventually, after 3 years of patience, the team's determination was rewarded when they clearly saw the maggots curl their bodies into a loop in preparation to jump. 'They plant one end of their body on the ground and slide the opposite portion of the body until both ends meet', says Harrison. Next, the upper portion of the maggot compresses the lower portion until a kink forms midway along the body, producing an improvised leg, which swells as the maggot continues pushing. Then, as the temporary leg gives a final push on the ground, the front end of the body detaches to propel the maggot spinning into the air. And when Greg Sutton from the University of Lincoln, UK, calculated the amount of energy that the insects use to leap instead of crawling, he realised that crawling was a massive 28.75 times more costly. In terms of energy saved, leaping out of danger really is a no-brainer for gall midge maggots.

However, when the team took a closer look at the portions of the body that make contact during the launch preparation, they were surprised that instead of locking the head in place with a rigid portion of the maggot's skin – the sternal spatula, which they use for digging – they appeared to use an unanticipated mechanism. Having painstakingly preserved the tiny maggots, Farley scrutinised the delicate surface of the two portions that contacted each other using an electron microscope and was amazed to see that they were both covered in microscopic hairs. The team suspects that the hairs are so minute that they are able to squash up close enough to an opposing surface to latch on with molecular forces, attaching the two ends of the looped maggot together while it applies pressure to the ground in preparation for take-off.

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Farley, G. M., Wise, M. J., Harrison, J. S., Sutton, G. P., Kuo, C. and Patek, S. N. (2019). Adhesive latching and legless leaping in small, worm-like insect larvae. *J. Exp. Biol.* **222**, jeb201129. doi:10.1242/jeb.201129

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