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INSIDE JEB

Brains, not biochemistry, speed up hot flies

A small male *Drosophila melanogaster* fly. By André Karwath aka Aka (own work) [CC BY-SA 2.5], via Wikimedia Commons.

It's a predicament to which warm-blooded (endothermic) animals cannot relate: the sun nips out from behind a cloud and suddenly your entire metabolism bursts into action as the warmth seeps in. 'If it is hotter, more energy gets input into a system and hence the system goes faster', says Andrea Soto-Padilla from the University of Groningen, The Netherlands. And the same holds true for cold-blooded (ectothermic) animals: 'If you look at a graph of flies moving at different temperatures, it confirms that they move faster at hotter temperatures and that they slow down at colder temperatures', says Soto-Padilla. However, she and her advisor Jean-Christophe Billeter wondered whether there might by more to the flies' variable tempo as the mercury fluctuates; might they be processing sensory information in their brains about the temperature to alter their speed, instead of depending passively on the effect of temperature on their metabolism?

'Fruit flies (*Drosophila*) are an excellent research model for uncovering the mechanisms underlying biological traits', says Soto-Padilla, explaining how the tiny insect is associated with an arsenal of molecular techniques which has allowed scientists to generate thousands of mutant flies that can be used to ask questions about the roles of specific genes. Wondering whether the speed at which a fly moves is determined by its temperature or is regulated by the insect's brain, Soto-Padilla, Billeter and Ody Sibon, also from the University of Groningen, selected flies that lacked key temperature-sensing genes to investigate how their movements altered as the temperature changed. However, building a temperature-controlled arena where Soto-Padilla could be sure that the tiny insects experienced temperature fluctuations in real time was technically challenging. Based on an idea by Hedderik van Rijn (University of Groningen), Rick Ruijsink from Ruijsink Dynamic Engineering custom built an arena that could produce temperature changes of 2°C in as little as 100 ms that would allow Soto-Padilla to film wild-type and mutant insects' movements as they sauntered across temperature-controlled tiles.

Warming the normal flies from 16 to 46°C over a 16 min period, Soto-Padilla recorded how the insects began speeding up gradually from a starting speed of 0.5 cm s^{-1} at 20°C until they hit a top speed of 2 cm s^{-1} at 34°C. However, by the time the temperature reached 42°C, the hot flies were incapable of moving and the team realised that the pattern of the speed changes matched the pattern that they would expect if the insect's speed was simply regulated by the temperature of the environment. 'This correlation implies that flies may just use their metabolic reaction to deal with temperature changes', says Soto-Padilla.

But how would the mutant flies that lacked the central thermal receptor and the ability to sense temperature respond to the temperature fluctuations? Surprisingly, the insects did not speed up at all; they were no longer able to respond to the rising temperature, even though their metabolism was speeding up. 'This result was unexpected', says Soto-Padilla, explaining that she had presumed that the flies' temperature response would be controlled by a combination of passive heating and their perception of the temperature.

So, flies move faster in response to rising temperatures because they sense the temperature change, although Soto-Padilla emphasises that the direct effects of heat on speed are still an important factor in the insects' ability to move. She adds that the flies' ability to control their reactions to temperature 'gives them more behavioural flexibility', allowing them to flee, feed and woo on their own terms, rather than at the thermometer's behest.

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