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INSIDE JEB

Central nervous system shutdown causes cold flies to keel over

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

If you're not a fan of insects, then you may prefer chilly days. 'Most insects go into a coma when they are cooled', says Mads Andersen from Aarhus University, Denmark, explaining that they usually begin to lose the ability to move a few degrees before the full coma takes hold. However, it was not clear why cold insects keel over. 'It was obviously caused by some sort of shutdown of neuromuscular function', says Andersen, but whether it was a failure of the muscle or an inability to sense the environment and respond was not clear. More recently, studies had suggested that muscle may not be the culprit, so Andersen and his colleagues Johannes Overgaard (also from Aarhus) and Meldrum Roberts from Queen's University, Canada, decided to compare how the nervous systems of fruit flies that hale from different climates cope as the temperature falls.

Equipped with five species of *Drosophila* – ranging from tropical *Drosophila birchii* to temperate *Drosophila montana* – from Overgaard's lab stocks, Andersen travelled to Canada to find out how well they tolerate the cold.

'The techniques that we wanted to use to investigate central nervous system function had recently been established in Meldrum's lab', says Andersen, who had to learn how to carefully insert a minute electrode into the fly's micro-dot sized brain to measure the electrical activity of the neurons that control movement as the fly was cooled. 'This was very difficult', recalls Andersen, adding, 'The only way we have to test if we're in the right spot is to cool the fly; it's hit or miss', he laughs. After gently cooling the insects, it was clear that the tropical flies (*D. birchii*) were much more vulnerable, losing the use of their central nervous systems as charge drained out of the neurons and they descended into a coma at 10.3°C, while the more robust temperate flies (*D. montana*) held out until 1.1°C. Andersen then painstakingly inserted a second electrode to measure potassium concentrations in the brain and it was clear that potassium flooded out of the neurons at the temperature where the fly slipped into a coma, with the tropical species suffering larger potassium losses than the temperate species. 'The central nervous system shutdown is likely caused by a mismatch between passive and active ion transport', says Andersen.

After Andersen's return to Denmark, he and Overgaard wondered how the nervous systems of one of the species, *Drosophila melanogaster*, would cope when the insects were chilled if they had previously been acclimated to different temperatures. 'I had to build a new system capable of making the same measurements [in Aarhus]', says Andersen, who teamed up with undergraduate Nikolaj Jensen to acclimate the insects to temperatures ranging from 15 to 25°C and measure when their nervous systems failed. This time, the warmest acclimated insects slipped into a coma at 5.6°C, while insects that had acclimated to a cool 15°C held out until 1.8°C. And when Andersen and Jensen compared how long it took for the different species and temperature-adapted flies to fall into a coma when oxygen was withdrawn, again the tougher cold-adapted species (*D. montana*) held out the longest (19.8 s), while the tropical species (*D. birchii*) succumbed within 10.5 s.

Having shown that flies become incapacitated at low temperature because their nervous system ceases to function, Andersen adds that this partially explains the global distributions of different insect populations and says: 'Comatose insects are "ecologically dead" (they cannot move or reproduce), meaning that the temperature where central nervous function is lost limits where insects can establish a population'.

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