New fluid fats fuel frozen flies

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When goldenrod gall flies embark on their winter hibernation, they freeze solid and have only the fats that they carry on board to sustain them. However, scientists from Western University, Canada, have discovered that the insects produce a new and extremely novel low calorie fat that remains fluid at the super cold temperatures experienced by the larvae to sustain them through to spring.

North American winters can be harsh, so anything that wants to make it to summer has to be pragmatic about surviving the coldest months; and insects are no exception. Katie Marshall from The University of British Columbia, Canada, explains that as the days draw in, the larvae of the goldenrod gall fly (*Eurosta solidaginis*) shut down their metabolism and development and begin producing cryoprotectants ready to freeze solid to survive the winter months. Intrigued by how the larvae manage their energy reserves as they repeatedly freeze and thaw, Marshall decided to investigate the energy-rich lipids (fats) stored by the overwintering insects. But when she began analysing the insect's lipid content, she stumbled upon an unexpected mystery. In addition to all of the regular lipids that occur routinely in all other terrestrial organisms, there was a new class of lipids that didn't match any of the standard molecules that always crop up. What were they and what was their purpose? Marshall and her PhD supervisor, Brent Sinclair from Western University, Canada, publish their discovery that goldenrod gall fly larvae full their winter slumber with a new low calorie fat that remains fluid at low temperatures in *The Journal of Experimental Biology*.

However, Sinclair recalls that he was initially dubious when Marshall told him about the unexpected lipid. 'First, Katie needed to prove to me that she wasn't screwing up', chuckles Sinclair. But Marshall's fiancé and pharmaceutical scientist Áron Roxin was more confident that there was something novel going on. Marshall recalls that he was sceptical that she and Sinclair could be so certain of the identities of the lipids that they had identified so far. He suggested that Marshall try some analytical chemistry to find out exactly what the novel lipids were, so she began searching for chemists who could help her. 'Katie was literally wandering the halls of the chemistry department reading posters to see if anybody was using methods that might be useful', recalls Sinclair.

Teaming up with local chemists Raymond Thomas, Eric Chen and Elizabeth Gillies to analyse the mystery lipids with techniques including mass spectrometry and NMR, Marshall and Sinclair were eventually convinced that the molecules were acetylated triacylglycerols. These lipids are less energy dense than the long chain triacylglycerols that are found in all other organisms, so the duo began searching for an explanation for their presence.

Measuring the ratio of the acetylated triacylglycerols to other lipids in the overwintering insects, Marshall and Sinclair found that novel lipid levels rocked to 37% of the insect's lipid pool during the winter, compared with the normal triacylglycerols, which only comprised 17% of the total lipids. And when Marshall monitored how the acetylated triacylglycerol levels varied across the seasons, she found that the insect accumulated the lipids in winter and when frozen repeatedly. She also found that the lipids might even have some antifreeze characteristics. Then, Marshall tested the tissue of the goldenrod to see whether the plant was the source of the acetylated triacylglycerols, eventually concluding that the larvae must synthesise the lipids from their own resources by converting the normal long-chain triacylglycerols into the acetylated lipids. Next, Marshall contacted Jason Brown, who showed that instead of occurring in the insect's cell membrane, the acetylated triacylglycerols were mainly located in the insect's energy-storing fat body. And when she measured the lipid's melting point, she found that it was significantly lower than that of other lipids, providing a ready supply of energy for the frozen insect.

Having discovered an exciting new class of lipids that remain fluid at low temperatures to provide energy for frozen animals, Marshall and Sinclair are keen to find out how the fly larvae produce it and whether we might be able to use these new low calorie fats to tackle the human obesity crisis.

More information: Marshall, K. E., Thomas, R. H., Roxin, Á., Chen, E. K. Y., Brown, J. C. L., Gillies, E. R. and Sinclair, B. J. (2014). Seasonal accumulation of acetylated triacylglycerols by a freeze-tolerant insect. *J. Exp. Biol*. 217, 1580-1597. jeb.biologists.org/content/217/9/1580.abstract

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