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Adult and larval fruit flies cope with cold differently

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

Being cold can get uncomfortable, but when cold-blooded animals (ectotherms) become chilly, their entire pace of life is at risk as the metabolic processes essential for survival become increasingly sluggish. How resilient an individual is as temperatures fall can even depend on their stage of life. Animals that undergo complex life cycles and change form entirely – think tadpoles versus frogs, or larvae versus flies – often tolerate low temperatures very differently. Fly larvae and adults tend to take different approaches when dealing with the cold. But what is driving these differences? Are the insects depending on entirely different mechanisms for protection as they respond to cold at different life stages? Or do they depend on mechanisms that are largely conserved across life stages but with a few fine-tuned tweaks that bring in additional life-saving mechanisms at specific points of life? To find out, Philip Freda from Kansas State University, USA, with Jantina Toxopeus and Gregory Ragland from the University of Colorado Denver, USA, and colleagues from both universities, set out to find how fruit fly larvae and adults deal with a blast of cold.

After nurturing fruit flies and collecting their larvae, Freda, Zainab Ali and Nicholas Heter (Kansas State University) placed 5-day-old adults in a series of vials before plunging the tubes into an ice bath at –5°C for an hour, collecting some of the adults just before their chilly dip, halfway through, right before they emerged from the bath and half an hour later during their recovery. After the trio repeated the same procedure with fruit fly larvae, Rebekah Lambert-Collier (Kansas State University) and Edwina Dowle (University of Colorado Denver) collected the insects' mRNA to find out which genes the youngsters and their elders activated when cold and during their recovery to determine which strategy the insects' different incarnations resort to for survival.

Analysing the expression patterns of almost 11,000 genes from both the adult flies and larvae, it was clear that both stages were using dramatically different strategies to cope with a chilly dip. Although the adult flies mobilised genes that helped them to deal with stress during the recovery phase, they only activated genes from the immune system early during their cold exposure and then again during their recovery. In contrast, during the cold snap, the larvae activated genes involved in clearing up damage in cells and genes that controlled their development, while switching off the genes responsible for producing and metabolising fats. In addition, the larvae activated their immune response and maintained it throughout the hour-long cold immersion. In short, the larvae and adult flies were using completely different physiological strategies to survive a chill.

Toxopeus, Joseph Tucker and Isaiah Sower (University of Colorado Denver) then used a technique to switch off nine genes involved in combating stress, which were also known to respond when the insects get chilly, to find out how their loss affected the adult and larvae's ability to withstand a –5°C dip. Two of the genes were essential for the adults' survival, yet played little role in the larvae's ability to cope with the cold, while another gene was crucial for the larvae's survival, but made virtually no difference to the adults. 'Baseline physiology affecting cold performance is distinct between life stages', says Freda.

The team also points out that the hardy adults' gene expression patterns barely alter when they get cold. In contrast, chilly larvae experience significant gene expression changes, which probably have more to do with the turbulent transformations they are experiencing as they prepare to metamorphose.

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