INSIDE JEB

Fat-fuelled brown adipose radiators keep mountain deer mice warm

A deer mouse (*Peromyscus maniculatus*) in the lab. Photo credit: Lauren Dessureault.

Even on a sunny day, it never gets too hot at the top of Colorado's Mount Blue Sky, perched on the eastern edge of the mighty Rocky Mountains in the USA. With the warmest days nudging above 13°C and oxygen levels around 50% of those at sea level, life can be a struggle, especially for the smallest mammals that have to keep their tiny bodies warm in the chilly mountain conditions. But no one seems to have told the robust deer mice (*Peromyscus maniculatus*) that make their homes at these inhospitable heights. They seem perfectly prepared for the travails of high-altitude life. Sulayman Lyons from McMaster University, Canada, explains that the hardy mountain dwellers fuel their high-octane metabolism with fats carried in their blood. However, it wasn't clear which heat-generating tissues the fats were destined for. Would the miniature mountaineers depend on their shivering muscles to maintain their body temperature in the cold thin air, or would they redirect fuel to specialised heat-generating fat stores, known as brown adipose tissue, located between their shoulder blades to remain warm?

Lyons and Grant McClelland, also from McMaster University, injected some of the hardy mountain mice, which were used to living at 5°C in thin air, with a tiny dose of a special radioactive fat, ^{14}C-bromopalmitate, which the body cannot burn, to find out where the fat lodged when the mountain mice were generating the huge amounts of heat required when pushed to their limits at –10°C. After 12 mins in the thin super-chilly air, Lyons collected samples of several of the mice's muscles, in addition to some of their white fat, liver, heart and their heat-generating brown fat. Then, Lyons measured the radioactivity that had accumulated in the different tissues, and it was clear that the mice were directing the fat that fuels their heat-generating metabolism to the brown adipose tissue. So, when faced with extreme cold at high altitude, the mountain deer mice fuel their brown adipose tissue with fats, rather than shivering, to generate warmth.

Lyons and McClelland then checked where fuel fats ended up when mountain mice that had been kept warm (30°C) in well oxygenated air – as if living at sea level – for several months were transferred suddenly to the chilly mountain conditions. This time, the mice directed the metabolism-fuelling fats to their muscles, as they shivered to remain warm. And when Lyons checked how the different tissues were consuming various fuels, he confirmed that the heat produced by the rodents' brown fat was largely powered by the fats carried in the blood.

So, mountain deer mice that are used to the cold thin air at altitude adjust their bodies to fuel heat production by burning fat in brown adipose tissue, while high-altitude deer mice that have adjusted to a warmer lifestyle at sea-level switch to fat-fuelled shivering to generate warmth when plunged suddenly into chilly high-altitude conditions. However, when the team checked how low altitude deer mice, which usually reside at 650 m, cope with perishing high-altitude conditions, those mice were unable to switch to burning fat to maintain their body temperature as they shivered to keep warm, 'which may suggest that highland deer mice have evolved a mechanism to better regulate fat metabolism associated with heat production in cold, low oxygen environments', says Lyons.

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Kathryn Knight
kathryn.knight@biologists.com

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