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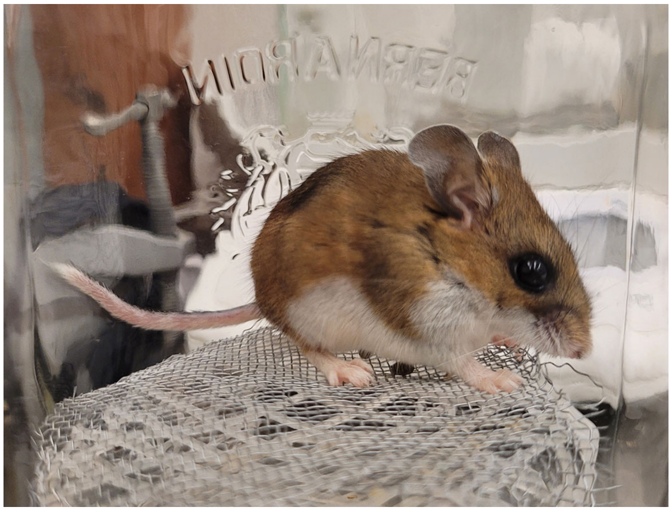
High-altitude deer mice depend on blood fuel supply for warmth



A deer mouse (*Peromyscus maniculatus*) in a respirometry chamber. Photo credit: Sulayman Lyons.

They may not look like it, but high-altitude deer mice are metaphorically on fire. With an astronomically fast metabolism evolved to combat the twin challenges of living at high altitude – maintaining their warm body temperature while living in chilly thin air – the tiny mammals are well prepared for their mountain existence. To stoke their heating, the deer mice fuel their internal inferno with fat: 'Highland deer mice burn fats faster for maximum heat production than when they are exercising', says Sulayman Lyons from McMaster University, Canada. But it wasn't clear exactly how they managed to mobilise enough fatty fuel to meet their extraordinary heat production demands. So, Lyons and Grant McClelland (McMaster University) collected deer mice from the summit of Mount Evans, CO, USA (4350 m) and low altitude Nine-mile Prairie, NE, USA (320 m), to find out how the animals manage their fuel supplies in warm low altitude conditions and in a chilly mountain top simulation.

'We simulate high altitude conditions by keeping mice in special chambers, which lower the air pressure, in a cold room', says Lyons, who kept deer mice originating from both the mountain and prairie at 5°C in the air pressure experienced at ~4300 m for 6 weeks, while other deer mice basked in warm (~23°C) lab air. He then measured the metabolic rates of some of the animals at the temperature and air pressure at which they had been living in the lab, while also measuring the metabolic rates of the animals as he chilled them to extreme mountain temperatures (–10°C) in thin air. Then he collected blood samples, fat and muscle from all of the deer mice, to find out how they managed and mobilised their fat reserves.

Comparing the deer mice that originated from the lowland prairies with the highland deer mice as they adjusted to life on the simulated mountain top, both groups of animals increased the amount of fat they released from their white fat stores into their blood to fuel their higher metabolisms in the thin cold air. In addition, the deer mice that had originally lived at high altitude in Colorado carried more triglyceride fats in their blood, which could be used as fuel by their muscles and brown fat to produce warmth.

Lyons also measured the quantities of two different types of fat (non-esterified fatty acids and triglycerides) in the blood of resting deer mice and when the animals had to work harder because they were breathing high-altitude thin cold air. The deer mice that had been born at high altitude were able to boost the amount of fat in their blood enormously, increasing the non-esterified fatty acids 3.1-fold and triglycerides by a massive 7.1-fold, when their bodies needed the fuel to keep warm in the chilly mountain conditions.

However, when he checked for evidence of the proteins that are responsible for transporting fuel fats into the muscle cells and brown fat that generate heat, the low- and high-altitude deer mice had essentially the same quantities of fat-transporting proteins within the tissues. The differences in the animals' metabolisms were entirely down to their abilities to transport fats in their blood, with deer mice that make their homes amongst the mountain peaks supplying more fuel through the blood to their muscle and brown fat furnaces.

Lyons also suspects that the mini mountaineers devote more muscle to shivering than they use when moving, which could account for the deer mouse's extraordinarily high rates of fuel consumption when keeping warm at altitude.

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