

# Rudolph the red-nosed reindeer's cooling strategy revealed

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Insulated in a luxuriously thick winter coat, reindeer are perfectly prepared for the gripping cold of an Arctic winter. But the pelt doesn't just keep the cold out, it keeps the warmth in too: which is fine when the animals are resting, but what happens when they are active and generating heat? Usain Bolt would never sprint in a fur coat so how do exercising reindeer avoid overheating?

Arnoldus Blix from the University of Tromsø, Norway, explains that the [animals](#) have three tactics: panting with their mouths closed to evaporate water from the nose; panting with the mouth open to evaporate water from the tongue; and activating a [cooling system](#) that selectively cools the [blood](#) supply to the brain. But how do they coordinate these different strategies for protection? Intrigued, Blix and his colleagues Lars Walløe from the University of Oslo, Norway, and Lars Folkow, also from Tromsø, decided to monitor [reindeer](#) brain temperatures, breathing rates and the blood flow through several major blood vessels in the head, to find out how active reindeer keep cool in winter. The team publish their discovery that reindeer use three strategies to keep cool and only resort cooling their brains with a heat exchanger when their temperature becomes dangerously high in *The Journal of Experimental Biology*.

'Reindeer are the best animals to work with; once they trust the trainer they will do anything for you,' explains Blix. So, the team trained reindeer to trot at 9km/h on a treadmill in temperatures from 10 to 30°C to get the animals warmed up while they recorded the animals' physiological responses. In the early stages of the run their breath rate

rocketed from 7 breaths/min to an impressive 260 breaths/min. Blix explains that the animals were inhaling chilly air through their noses and evaporating water from the mucous membranes to cool blood in the nasal sinuses before sending it back to the rest of the body through the jugular vein to keep their temperature down.

However, as the animals continued exercising and generating more heat, they switched to panting, throwing their mouths wide open and flopping their tongues out like dogs. 'The tongue is large, vascularised and well circulated,' explains Blix, and adds, 'They moisturise the tongue so you have evaporation which also takes heat away from the blood'.

Monitoring the temperature of the reindeer's brain, the team noticed that the blood flow through the animal's cooling [tongue](#) peaked when the brain's temperature reached a critically high 39°C, at which point the reindeer switched to their third tactic. They began selectively cooling the brain by diverting cooled venous blood – which came from the nose – away from the body and up into the head, where it entered a network of heat exchanging blood vessels to cool the hot arterial blood destined for the brain to protect it from overheating.

Blix admits that initially he had not thought that this strategy would work. 'Only 2% of the respiratory volume went through the nose when they resorted to open mouth panting,' he says. However, when he calculated the colossal amounts of air inhaled by the exercising animals – coupled with the low air temperatures – it was clear that the reindeers were able to inhale sufficient cold air through their noses to keep their brains cool, but only as a last resort once the other cooling tactics were no longer sufficient.

So Blix and his colleagues have discovered how heavily insulated reindeer prevent themselves from overheating and how Rudolph keeps cool every Christmas Eve.

**More information:** Blix, A. S., Walløe, L. and Folkow, L. P. (2011) Regulation of brain temperature in winter-acclimatized reindeer under heat stress. *J. Exp. Biol.* 214, 3850-3856. [jeb.biologists.org](http://jeb.biologists.org)

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