HOW low CAN YOU GO?

BLAIR WOLF

Cooling off period for hummingbirds

Andrew McKechnie, professor of zoology at the University of Pretoria, was part of a team that recently published a study in the journal *Biology Letters* in which it is revealed that tiny hummingbirds living in the Andes Mountains in Peru drop their body temperature from around 40 °C to 3.3 °C, near freezing point, to survive bitterly cold nights. 'It is the lowest body temperature reported so far in any bird or non-hibernating mammal,' says McKechnie.

He explains that these tiny nectar-feeders go into torpor to save energy on bitterly cold nights. 'Torpor is the most effective means of energy conservation used by mammals and birds. It is a state of inactivity devoid of movement and with the purpose of reducing energy requirements, either in the cold or in a very dry climate. The energy savings occur because the animal reduces its body temperature and metabolic rate far below normal levels.'

The hummingbirds studied in the region live at an elevation of about 4000 metres. To survive the nights, they drop their body temperature, which is usually 40 °C, to extremely low values. Six species were studied, from the Bronze-tailed Comet (4.9 grams) to the Giant Hummingbird (weighing in at 24 grams). Most hummingbirds weigh between 3 and 7 grams.

While all the species lowered their body temperatures to different degrees, all dropped below 10 °C at some point, according to McKechnie. The Black Metaltail's temperature dropped to 3.3 °C, close to freezing point. The previous record for birds was 4.3 °C, recorded in the Common Poorwill, a North American nightjar.

Torpor is critical for the survival of these hummingbirds because they are often unable to store enough energy during the day to last through the night. They feed on the nectar of flowers that grow in abundance even at such high elevations. But, McKechnie adds, the nectar is sometimes not very rich in energy and some hummingbirds have to drink up to three or four times their own body mass each day to obtain sufficient energy. They also have very limited fat reserves.

Some of the birds remained in torpor for just three hours, while others remained in that state for up to 13 hours. To heat up again in the morning, or sometimes during the night, they start to shiver. 'While shivering they generate a lot of heat internally,' McKechnie says. 'Their muscles contract rapidly. One sees them shivering, then suddenly their eyes open and they fly away.' To get out of torpor, the hummingbird raises its temperature by 1.5 °C a minute; the process can take as little as half an hour.

Hummingbirds also have extremely high heart rates of up to 1200 beats a minute, but during torpor the rate can be as low as 50 to 80 beats a minute. While in torpor, they are potentially vulnerable to predators, because they can't move at all. Many hummingbirds of the high Andes roost in caves, clinging to the walls in suspended animation, surviving in the most extraordinary way. Caves are just one of the known places they go to at night; there is even evidence that some hummingbirds enter torpor while in their nests incubating eggs.

To measure the body temperatures of these tiny birds at night, the team caught 26 hummingbirds representing the six species with mist nets and kept them in tents that were adapted to serve as aviaries. Each bird was kept for one or two nights at most. An extremely fine Teflon-coated thermocouple wire was inserted into the cloaca of each bird.

'About 30 minutes before dark, food was withheld and the birds were transferred into individual roosting enclosures so their temperatures could be measured,' explains McKechnie. Another novel finding to emerge from the study is that the six species varied substantially in terms of torpor depth and duration, despite experiencing the same weather conditions. These differences suggest evolved differences among these species, rather than torpor patterns being determined wholly by environmental conditions.

above *A Sparkling Violetear, one of six hummingbird species involved in the study.*

hot stuff

ALBERT FRONEMAN

Red-billed Queleas rewrite the record books

Birds have higher body temperatures than most mammals, a phenomenon thought to reflect the power requirements for flight and the increase in power output associated with warmer muscles. Evidence supporting this notion includes the observation that the lowest avian body temperatures typically occur in flightless birds. For many taxa, including passerines, resting body temperature is around 41 °C, compared to 37 °C in humans. Avian body temperature may, however, increase far above these baseline levels for short periods.

During very hot weather, a bird's body temperature sometimes increases to 44–45 °C without any obvious adverse effects. The available evidence suggests that during summer in the Kalahari the temperatures of many species routinely reach this range for short periods. The intense activity and high work rates associated with breeding, even in cooler conditions, also seem to regularly push body temperature to very high levels. For instance, in southern Sweden, temperatures of breeding Marsh Tits provisioning nests approach and occasionally slightly exceed 45 °C.

If body temperature strays too far above the physiologically tolerable range, however, decreases in the delivery of oxygen to cells combined with the breakdown of proteins responsible for cellular functioning lead to rapid death through lethal hyperthermia. These fundamental biochemical constraints mean that body temperatures exceeding 46 °C are almost always fatal for birds. But new findings reveal that one species, the Red-billed Quelea *Quelea quelea*, has evolved a way to bend these rules of biochemistry so effectively that it can tolerate body temperatures that would be fatal for any other species.

University of Pretoria PhD student Marc Freeman and postdoctoral fellow Zenon Czenze recently investigated the thermal physiology of grassland species near Harrismith in the eastern Free State. Along with data for the larks, chats and other grassland taxa that were their priority groups, Marc and Zen collected information about the queleas. They quickly realised that body temperature regulation in the queleas was fundamentally different to that of any other species investigated so far. At environmental temperatures similar to those they would experience foraging in the sun on a hot summer's day, the queleas allowed their body temperatures to increase to about 48 °C, with one individual reaching a staggering 49.1 °C.

Body temperatures of 48–49 °C are unprecedented among birds and these unexpected findings raise a host of questions. Why has no other species investigated to date evolved similarly extreme hyperthermia tolerance? What aspects of the Red-billed Quelea's natural history have driven the evolution of such unusually high thermal limits? One possibility is that individual queleas occasionally need to tolerate severe dehydration before a flock visits water to drink. Allowing body temperature to increase far above normal levels is a very effective way to conserve water and perhaps the queleas' extreme hyperthermia tolerance is functionally linked to them living in these massive flocks.

ANDREW McKECHNIE

Reference

Freeman MT, Czenze ZJ, Schoeman K and McKechnie AE. 2020. 'Extreme hyperthermia tolerance in the world's most abundant wild bird.' *Scientific Reports* 10: 13098.