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heat & miss

As global heating continues its relentless march, animals everywhere are exposed to temperatures higher than those that typified their recent evolutionary past. Average temperatures are increasing and heatwaves are more frequent and severe. Recently, mass mortality events involving hundreds of individual birds and bats have occurred during severe hot weather events, including one in northern KwaZulu-Natal, as reported in the March/April issue of this magazine.

Although mass mortalities of animals during extreme heatwaves grab the headlines, rising global temperatures also have more insidious sub-lethal impacts. These are often overlooked, but have important implications for individual fitness, population persistence and potentially even ecosystem function.

FitzPatrick Institute researchers recently published a review of these impacts that doubles as a call-to-arms for researchers and conservationists. In their article in *Frontiers in Ecology and the Environment* they describe how the behaviours used by birds and other animals to evade the heat (such as seeking shade and shifting activity in

above *Two Spike-heeled Larks seek shade during hot weather, potentially trading off valuable foraging opportunities. The birds are drooping their wings to aid heat loss from their bodies by exposing their flanks to the air.*

time and space or reducing it altogether) do not come for free.

In short, behavioural responses to high temperatures carry costs in the form of missed opportunities to engage in other vital behaviours. For example, simply by seeking shade, diurnal animals may forgo opportunities to forage in more profitable parts of their habitat. Reduced foraging during hot weather, combined with increased demand for energy and water for thermoregulation, can result in loss of body condition. Reduced foraging success also means parent birds provision their nestlings less frequently during hot weather and this can compromise nestling growth. Nestlings that fledge in poor condition after experiencing hot weather in the nest have a lower probability of long-term survival, as do adult birds leaving the breeding season in poor condition after experiencing repeated heatwaves. Reducing activity in hot weather can also restrict animals' abilities to defend territories and attract mates, with direct impacts on breeding success.

As climate change progresses and animals face thermally challenging conditions more frequently, these chronic, sub-lethal costs of keeping cool may weaken populations, making them more vulnerable to extreme heatwave events and other human impacts on the environment.

Population-level impacts are not the end of the story, however. The research team noted that the behaviour changes animals make to avoid high temperatures are analogous to those they make to avoid predation risk. The non-lethal impacts predators have on prey behaviour have implications for the function of entire ecosystems. The most famous example of this is the ecosystem-level changes that resulted

from the reintroduction of wolves to Yellowstone National Park and subsequent alteration in the behaviour of ungulates in that ecosystem.

We could think of global heating as the ultimate predator: as temperatures rise, animals will increasingly shift the timing and location of their activity to avoid the potentially lethal effects of heat exposure. Thermal tolerances are species-specific, so this is likely to affect species interactions as ecological partners begin to miss each other in space and time and new relationships form. For example, predator-prey relationships may change as species alter their foraging hours or locations and mutualisms may unravel if one partner is no longer available at a time the other remains active.

These potentially profound changes in individual fitness, population persistence and ecosystem function do not require mass mortality events of animals during heatwaves or even broad-scale range shifts in response to climate change. They can occur in situ, insidiously, as temperatures continue to rise. We need to be on our guard as climate change continues to impact the world around us in sometimes totally unexpected ways.

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REFERENCE

Cunningham SJ, Gardner J and Martin RO. 2021. 'Missed-opportunity costs and the response of birds and mammals to climate warming.' *Frontiers in Ecology and the Environment*. <http://doi.org/10.1002/fee.2324>

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