facing THE furnace

How heat affects behaviour in birds

TEXT **ANDREW McKECHNIE & SUSIE CUNNINGHAM**

'Will this be the end of the rain and the birds?
Who can send an emissary to speak to the seasons?
For the ravens and the crows already soak up the skies...'
Johnny Clegg and Juluka, 'Digging for some words', *Scatterlings* (1982)

On a hot, cloudless summer's day, the Koa Valley in the Northern Cape is a harsh place. The intense, unremitting solar radiation heats the red sand dunes until their surface temperature can exceed 70 degrees Celsius. Vegetation is sparse and seldom taller than waist height; there is no succour anywhere from the blazing sun. Field work under these conditions is not for the faint of heart. Stand in one spot for more than a minute or so and your feet become uncomfortable as heat from the sand is transferred through your boots' soles. Descend from a dune crest into a valley and there is not so much as a hint of air movement to relieve the stifling heat.

The small subset of humans foolish enough to voluntarily tramp around the Koa dunes at midday in summer includes ornithologists studying the Red Lark. Observations of the larks during extremely hot weather provide some striking insights into how some birds eke out a living in this most inhospitable environment. As the mercury soars, a Red Lark retreats into the deepest shade available, usually to be found under a scraggly three thorn (*driedoring*) *Rhigozum trichotomum* shrub. There the lark rests with its belly pressed against the comparatively cool sand. >

PATRICK CARDWELL/AVIAN LEISURE

above *Red Larks survive and reproduce in some of the most inhospitable conditions imaginable, yet are not known to drink water.*

left *Sand dunes in the Koa Valley. Red Larks rely on the scattered shrubs for shade.*

PETER CHADWICK

ALBERT FRONEMAN

NICHOLAS PATTINSON (2)

above *Southern Pied Babblers doing what they can to beat the heat: seeking shade, panting and wing-drooping.*

top *A Kalahari Southern Fiscal early on a sunny morning. As temperatures climb, it will sacrifice foraging and retreat to the shade.*

cannot afford inefficiency or unnecessary activity and evolution has shaped their physiology and behaviour to maximise their chances of being able to survive and breed, despite scarce, unpredictable food and water resources. But climate change is severely threatening the ability of desert-adapted birds to persist in these harsh environments and influencing their behaviour. Research by the Hot Birds Research Project, involving the Fitztitute, University of Pretoria and National Zoological Garden, is revealing the extent to which global warming is affecting the ability of arid-zone birds to endure and reproduce.

Trade-offs between thermoregulation and foraging

The Red Lark taking shelter under a *driedoring* exemplifies a bird doing all it can to keep cool. It has identified the shadiest location available in the landscape and retreated there to minimise heat gain from the environment. It has ceased activity, reducing the heat produced by its body. Finally, by gaping to enable evaporation from the moist surfaces of its respiratory tract, the bird trades precious water for the dissipation of heat and avoidance of lethal hyperthermia. This trio of behaviours is used by all desert birds when the going gets hot, although different species engage more readily in some than in others. Most species use all three behaviours simultaneously only when conditions are particularly tough, because each carries subtle but important costs.

Perhaps the most salient cost of keeping cool is that thermoregulatory behaviours curtail birds' ability to forage. Reducing activity means decreasing food intake, even for a sit-and-wait predator such as the Fork-tailed Drongo. Research student Ryan Olinger showed that drongos in the Kalahari begin to ignore even the easiest of prey (mealworms thrown in their direction by a researcher) once temperatures climb above 35 degrees. During extremely hot weather, when the air temperature is higher than the birds' body temperature (approximately 42 degrees), drongos are more likely to simply remain perched than to sally to catch a food item in mid-air.

Seeking shade also carries costs, even if birds continue to forage actively. Common Fiscals shift to shaded perches when it becomes too hot to sit out in the sun, but they nevertheless keep hunting. Southern Yellow-billed Hornbills forage on the ground under bushes and glean insects from the bark of sheltered trees when air temperatures are high. But our data show that both species pay a heavy price for this seemingly innocuous shade-seeking behaviour: prey is harder to find in shady sites and consequently returns on foraging effort are diminished. This is perhaps because predators rapidly deplete prey patches in the cooler locations or simply because pickings are naturally richer out in the open for the types of prey targeted by the fiscals and hornbills. But the very act of gaping or panting to evaporate water can also severely restrict a bird's ability to acquire food; an actively foraging hornbill or Southern Pied Babbler is likely to see its food intake rate halved as soon as it opens its beak to pant, probably because of the fundamental mechanical difficulty of digging up and handling prey while panting.

Fork-tailed Drongos reduce foraging effort when the going gets hot: sallying out to catch prey increases body heat production.

Body condition

The catch-22 faced by desert birds on hot days – whether to keep foraging or keep cool – has important consequences for their physical condition. The small size of most species means that, on a gram-for-gram basis, they metabolise fat stores much faster than larger animals do. As a result, birds may lose substantial amounts of body mass overnight; in Southern Pied Babblers and Southern Yellow-billed Hornbills overnight losses during summer are typically equivalent to about four per cent of their total mass. If mass gains achieved through foraging during the day do not compensate for these overnight losses, a bird's condition will progressively decline over each 24-hour cycle.

Ornithologists can assess these short-term changes in body mass by studying wild birds accustomed to the presence of human observers. If sufficiently habituated, birds can be weighed regularly by being taught to perch on a scale in return for a small food reward or by a researcher positioning a modified electronic scale in lieu of a natural perch at a nest box. Studies making use of these techniques have revealed that hot weather has a distinctly negative effect on daytime mass gain because of the precipitous decline in food intake when birds engage in their trio >

SUSIE CUNNINGHAM

Studying birds in aviaries in situ *helps us learn how behavioural and physiological costs are balanced in an effort to keep cool.*

of heat-defence behaviours. In the babblers, for instance, mass gain between sunrise and sunset plummets from five or six per cent on days when the maximum air temperature is about 34 degrees to zero or even a slight daytime mass loss on days of 40 degrees. Babblers can thus easily maintain body condition on cooler days, but during hot weather their body mass decreases and their physical condition progressively deteriorates.

Breeding

Many Kalahari bird species breed during summer when rain falls and the invertebrates they need to feed their chicks become abundant. However, breeding in the heat means breeding under pressure because when it's too hot to forage, abundant prey does not translate into readily available prey. During hot weather, hornbill, fiscal, babbler and drongo parents all keep more of their diminished catches for themselves; panting requires water and the only way to replenish this resource in a waterless landscape is to obtain it from your food. A reduction in food intake combined with increasing parental 'selfishness' on hot days means that nestlings are provisioned less. The impacts on breeding success in hornbills, fiscals and babblers are consequential, with their chicks fledging smaller, lighter and later during hot periods, and many failing to fledge altogether. These impacts can be shockingly dramatic: work by Fitztitute PhD graduate Dr Tanja van de Ven revealed that the probability of a hornbill breeding pair managing to raise any chicks at all drops below 50 per cent when maximum temperatures during the nesting attempt average above 35 degrees.

Social networks

A feature of the avifauna of arid zones globally (but especially in the southern hemisphere) is that the birds are often remarkably sociable. Cooperative breeding, in which the mated pair is assisted by several other non-breeding individuals in their efforts to raise chicks, is common. Several of the Kalahari's iconic birds, including White-browed Sparrow-weavers, Scaly-feathered Finches and Southern Pied Babblers, all breed in this manner. But Sociable Weavers really take this approach to the extreme, with multiple breeding pairs and all their helpers living together in enormous thatched nests and barrelling over the dunes in flocks of several hundred individuals.

For social species, the strength of the bonds between individuals is hugely important. Social bonds dictate the rapidity with which information flows through a group, for instance about where to find food and how to avoid predators. The benefits of being well connected within a social group are considerable. But social networks too come under pressure when the mercury rises: Dr Margaux Rat, a postdoctoral researcher in our team, showed that 'friendship' networks between individual Sociable Weavers in a colony collapse during very hot weather. Formerly highly social colonies fragment into 'cliques', with more peripheral individuals becoming increasingly isolated and vulnerable.

One surprising interaction between sociality and climate emerged from a recent study during which we temporarily kept birds in large outdoor aviaries in the Kalahari during midsummer. Individuals occupying more dominant positions in social hierarchies maintained consistently lower and more stable body temperatures compared to subordinate individuals of the same species. This unexpected observation reflected, in part, the control of shady spots by dominant birds; subordinates were excluded from the coolest spots in the aviaries and consequently had to work harder to lose heat. In Sociable Weavers, however, subordinate birds struggled with high, unstable body temperatures even when dominant birds were willing to share shade. It remains to be seen whether similar patterns occur in free-ranging populations, but this finding certainly suggests we have only begun to scratch the surface of the ways in which warming will affect avian societies.

The future: deserted deserts?

Because temperature affects so many aspects of avian behaviour and consequently body condition and reproductive success, arid-zone birds are extremely vulnerable to climate change. The world's deserts are warming rapidly. Parts of the southern Kalahari, where we conduct most of our research, have warmed by nearly three degrees since the mid-1990s. On the other side of the planet, July 2018 saw several new maximum temperature records, with North America's Death Valley experiencing four consecutive days of 53 degrees; for most of us, an unimaginably high temperature.

The effects of warming on birds are already becoming evident. The nesting success of a long-term study population of Southern Yellow-billed Hornbills near Vanzylsrus in the Northern Cape has

ALBERT FRONEMAN

'FRIENDSHIP' NETWORKS BETWEEN INDIVIDUAL SOCIABLE WEAVERS IN A COLONY COLLAPSE DURING VERY HOT WEATHER. **FORMERLY HIGHLY SOCIAL COLONIES FRAGMENT INTO 'CLIQUES',** WITH MORE PERIPHERAL INDIVIDUALS BECOMING INCREASINGLY ISOLATED AND VULNERABLE

dwindled over the past decade and a half, with the available data suggesting that this population will be in real trouble as soon as the 2030s. An analysis recently completed by MSc student Shannon Conradie submits that by the end of this century, the hornbills, babblers and fiscals that we study will be unable to maintain body condition or breed during summer and will most probably disappear in their entirety from the Kalahari. By 2100, the number of bird species inhabiting the Kalahari is likely to be a fraction of what it is today.

This gloomy prediction is supported by large-scale declines in desert bird communities already documented in other regions. Researchers from the University of California, Berkeley, recently repeated ornithological surveys that took place in the first half of the 20th century in the Mojave Desert. Their findings are depressing: the resurveyed sites have, on average, lost 43 per cent of their species over the past century and reporting rates have declined substantially for about 30 per cent of breeding species. These concerning results confirm that desert birds are in real trouble and we stand to lose much of our arid-zone avian diversity in the coming decades.

There are, however, a select few species benefiting from climate change. In South Africa, dramatic recent increases in Pied Crow numbers in the arid Karoo appear to be related to warming in that region. And the Mojave study revealed that the only native North American species to have substantially increased in abundance over the past century is the Common Raven. Soaking up the skies, indeed. ◆

TANJA VAN DE VEN

above *A Southern Yellow-billed Hornbill panting in the sun. Both panting and seeking shade reduce its ability to find food.*

top *Sociable Weavers' social networks are affected by the heat: high and variable temperatures weaken relationships between birds.*