Mortality among birds and bats during an extreme heat event in eastern South Africa

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Abstract

Heat-related mortality events involving birds and bats are projected to occur more frequently as a result of anthropogenic global heating. Reports of mass mortalities associated with extreme heat have, over the last decade, mostly involved Australian birds and pteropodid flying-foxes. Here, we report a mortality event involving ~110 birds and fruit bats in eastern South Africa in early November 2020 when maximum air temperatures (T_{max}) reached 43–45°C and relative humidities were 21–23%. The mortalities included 47 birds of 14 species, all but three of which were passerines, and ~60 Wahlberg's epauletted fruit bats (*Epomophorus wahlbergi*). This mortality event occurred on a single very hot day preceded by several cooler days (T_{max} = 37–39°C at one location) and involved weather conditions similar to those associated with at least one recent flying-fox die-off in Australia. The disproportionately high representation of passerines among the avian mortalities supports recent predictions that songbirds are more vulnerable to lethal hyperthermia on account of the relative inefficiency of panting as an avenue of evaporative heat dissipation. As far as we are aware, this is the first documented heat-related mortality event involving wild birds and bats in southern Africa.

Keywords: climate change; deaths; heat wave; hyperthermia; Pteropodidae

Extreme heat events sometimes result in large-scale mortality among animals. Avian mortality events are best known in Australia (reviewed by McKechnie *et al*. 2012), and in at least one instance had serious negative consequences for a threatened species (Saunders *et al*. 2011). Among pteropodid bats, catastrophic die-offs involving tens of thousands of flying-foxes have become regular occurrences on the Australian east coast (Welbergen *et al*. 2008; Ratnayake *et al*. 2019), sometimes decimating populations (e.g. Kim & Stephan 2018).

When environmental temperature exceeds body temperature (T_b), evaporative cooling becomes the only avenue available for heat loss. Mortality can occur if animals are unable to evaporatively dissipate heat fast enough to defend T_b below lethal limits, or if cumulative evaporative water losses exceed dehydration tolerance limits. The frequency of hyperthermia-or dehydration-associated avian mortality events is projected to increase substantially in arid regions during the 21st century (McKechnie & Wolf 2010; Albright *et al*. 2017; Conradie *et al*. 2020). Similarly, increasingly frequent mortality events are anticipated among flying-foxes, for which air temperature (T_{air}) exceeding 42°C has emerged as a strong predictor of mortality (Ratnayake *et al*. 2019).

We are not aware of any prior accounts of major heat-related mortality among birds and bats in southern Africa. Here, we report heat-related mortality among wild birds and bats on an extremely hot day in northern KwaZulu-Natal province, South Africa, on 8 November 2020. To the best of our knowledge, this is the first such event documented for the region.

We compiled reports of bird carcasses found by staff of Phongolo Nature Reserve (PNR) on 8 November 2020, when T_{air} measured using a mercury-in-glass minimum/maximum thermometer in a shaded location reached 40°C by 10:00 and 45°C by mid-afternoon. Heat dissipation behaviour (panting, seeking of shade on south side of buildings, drinking/bathing) and subsequently dead and dying birds were first noted in the vicinity of the PNR office complex (S 27.337° E 31.845°, elevation = 215 m a.s.l.). The following day, field rangers walked a distance of 11.23 km searching for further casualties. Assuming carcasses were visible for 20 m either side of the track, the search area is ~45 ha, equivalent to 1.1% of the surface area of PNR. We also subsequently collated records of avian and fruit bat mortalities from other sites in northern KwaZulu-Natal on the same day. To evaluate the prevailing weather conditions, we obtained hourly T_{air} and relative humidity (%) data from three weather stations within 50 km of PNR (Fig. 1).

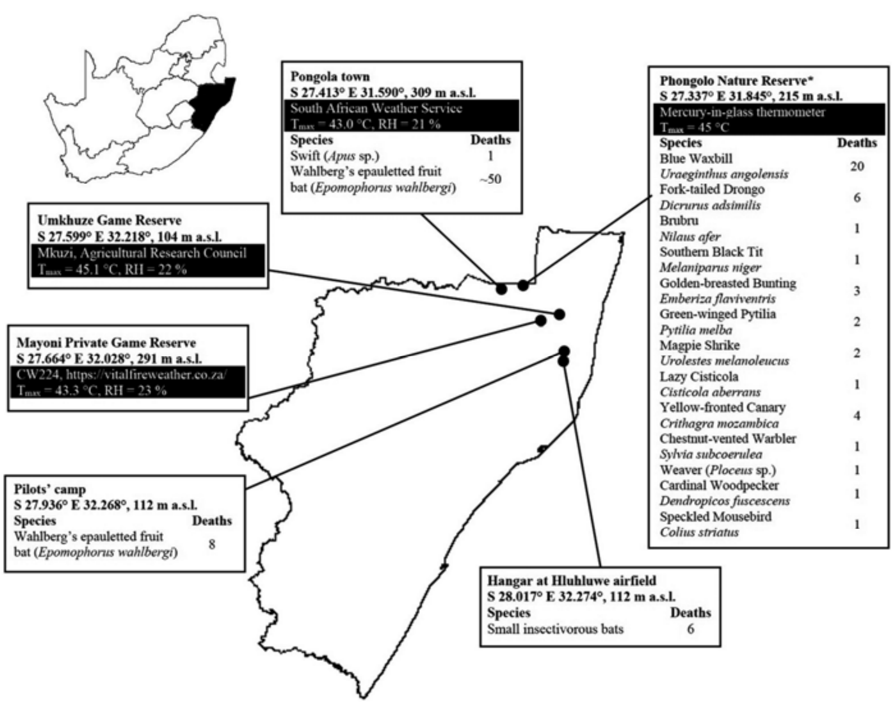

Fig. 1. Summary of weather conditions and bird and bat deaths on 8 November 2020 in northern KwaZulu-Natal province, South Africa. For each location, elevation is provided together with weather conditions (maximum air temperature (T_{max}) and associated relative humidity (RH)) and/or reported deaths of birds and bats. *Three records for Pongola Game Reserve have been included with the data for Phongolo Nature Reserve, as these are immediately adjacent to each other. Casualities included two unidentified passerines not listed in the table.

Weather conditions

Hourly data from three weather stations reveal that maximum air temperatures (T_{max}) on 8 November 2020 in the area surrounding PNR varied between 43.0 and 45.1°C (Fig. 1), with T_{air} remaining >40°C for >5 h at all three sites (Fig. 2 – Pongola). Furthermore, the Pongola weather data reveal T_{max} on 8 November 2020 was 4.5°C higher than on any of the preceding six days or during the subsequent week (Fig. 2). Relative humidity associated with T_{max} on the day of the event varied between 21% and 23% (Fig. 1).

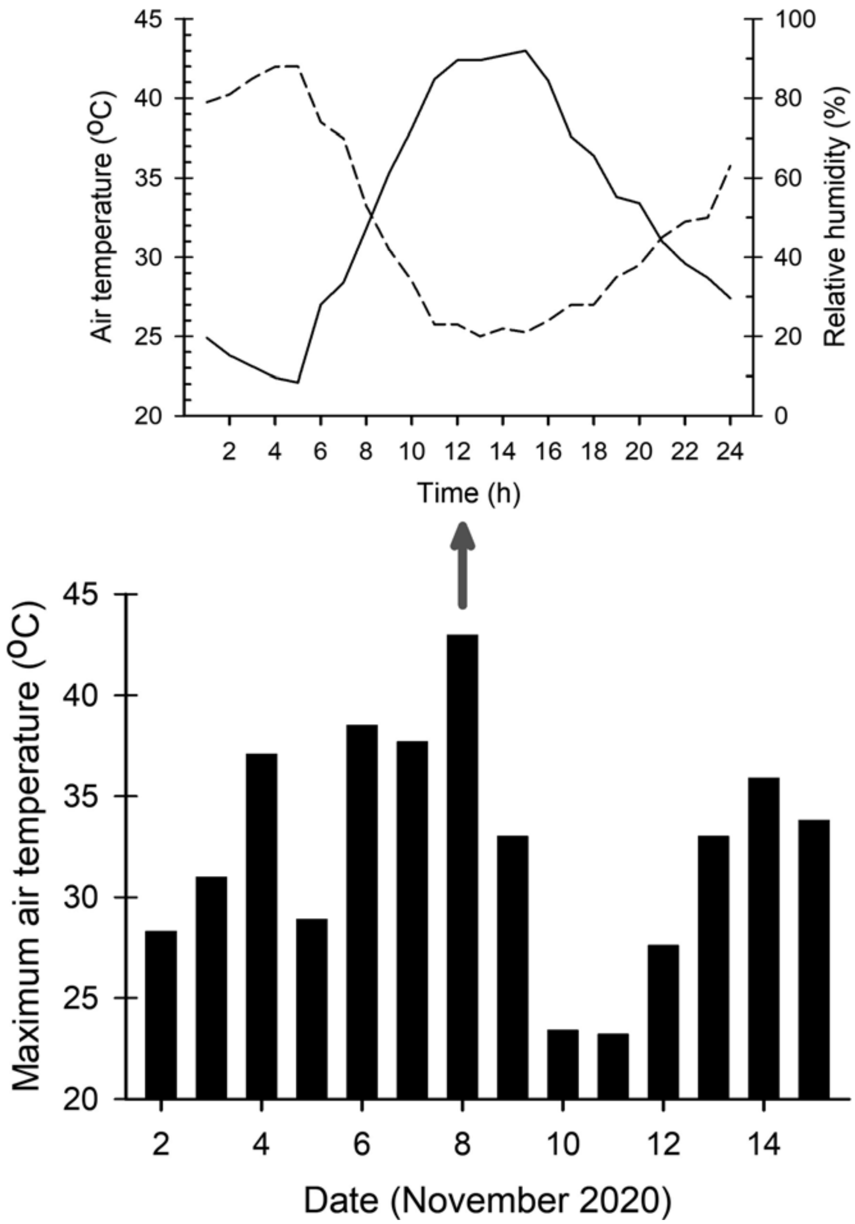

Fig. 2. Maximum air temperature from 2 to 15 November 2020 in the town of Pongola, South Africa (lower panel), where ~50 Wahlberg's epauletted fruit bats (*Epomophorus wahlbergi*) died on 8 November 2020 during extremely hot conditions, as did 46 birds in the nearby Phongolo Nature Reserve and Pongola Game Reserve. The upper panel shows hourly air temperature (solid line) and relative humidity (dashed line) traces for Pongola on the same day.

Mortality

A total of 47 dead birds belonging to 14 species were found (Fig. 1), with the majority of these reports from PNR (Fig. 3). As only 1.1% of the reserve was searched the day after the extreme heat event, the actual number of casualties may have been much greater than reported here. The vast majority (44/47) of bird carcasses were passerines, with only three non-passerine casualties encountered: a mousebird (Coliiformes), a woodpecker (Piciformes) and a swift (Apodifomes). Mortalities among Wahlberg's epauletted fruit bats (*Epomophorus wahlbergi*) occurred in Pongola (H. Kohrs, pers comm., 2019) and at a pilots' camp ~10 km north of Hluhluwe (D. Cooper, pers. comm., 2019; Fig. 1). Small numbers of fruit bat mortalities were also reported from Hluhluwe village and at a lodge within Manyoni Private Game Reserve (MPGR; A.S. Riley, pers. comm., 2019). In addition, the carcasses of six small insectivorous bats were found in a hangar at Hluhluwe airstrip.

Fig. 3. Some of the birds found dead following an extreme heat event at Phongolo Nature Reserve (PNR), South Africa, on 8 November 2020. Photographs by Ferdi Myburgh and PNR field rangers.

Multiple reports were received of atypical avian drinking behaviour on the same day. At Zebra Hills Lodge within MPGR, for instance, unprecedented numbers of birds were observed drinking and bathing at a small pool of water in a shaded location (A.S. Riley, pers. comm., 2019). The species involved included several small insectivores that do not usually drink, such as Grey Tit-flycatcher (*Myioparus plumbeus*) and Willow Warbler (*Phylloscopus trochilus*) (A.S. Riley, pers. comm., 2019).

Heat as the cause of mortality

No carcasses were collected for post-mortem investigations. We therefore cannot completely rule out potential causes of mortality such as disease, poisoning or contaminated drinking water. However, several factors point to a direct link between weather conditions and the observed mortality. First, deaths of birds and mammals at multiple locations up to 90 km apart on the same day make it highly unlikely that poisoning or contaminated water sources were involved, as do the accounts of atypical drinking behaviour and visible signs of heat stress observed among birds at PNR and MPGR.

Second, although several preceding days at Pongola saw T_{max} = 37–39°C (Fig. 1), 8 November was the only day on which T_{max} exceeded the normothermic T_b of most birds (McKechnie *et al*. 2021; Prinzinger *et al*. 1991). Among bats, hyperthermia tolerance among large frugivorous species generally appears to be lower than that of small insectivorous species (reviewed by McKechnie & Wolf 2019) and the likelihood of mortality events among Australian flying-foxes increases significantly at $T_{air} \geq 42$°C (Ratnayake *et al*. 2019). The mortality documented at T_{max} = 43–45°C on the day on which this study focuses suggests that a similar threshold may also apply to *E. wahlbergi*. This notion is supported by physiological (Minnaar *et al*. 2014) and behavioural data for *E. wahlbergi*: individuals commencing saliva-spreading, panting and wing-spreading at $T_{air} > 34$°C (Downs *et al*. 2015). The six small insectivorous bat deaths at Hluhluwe airfield reflect, we suspect, very high roost temperatures in roosts under building roofs (e.g. Maloney *et al*. 1999).

Third, the disproportionately high representation of passerines among the avian casualties is consistent with recent predictions regarding the greater vulnerability of songbirds to lethal effects of extreme heat (Conradie *et al*. 2020; McKechnie *et al*. 2021). Passerines rely on panting as their primary avenue of evaporative heat dissipation, a less efficient evaporative cooling pathway compared to the gular flutter used by many non-passerine orders (reviewed by McKechnie *et al*. 2021). Even among passerines in which tolerance of exceptionally high T_b has been recorded (>48°C: (Freeman *et al*. 2020), heat tolerance limits in terms of maximum T_{air} remain within the typical passerine range (reviewed by McKechnie *et al*. 2021). In the context of ruling out contaminated drinking water as a source of mortality at PNR, the absence of dead columbids is noteworthy. Pigeons and doves are highly water-dependent but possess a cutaneous evaporation pathway that provides the basis for tolerance of extremely high T_{air} (Marder & Arieli 1988; Smith *et al*. 2015; McKechnie *et al*. 2016).

In addition to high T_{air}, humidity may have played a role. Humidity levels at Pongola on 8 November were equivalent to 12.4 g H_2O m^{-3} and a saturation deficit of 6.9 kPa (Campbell & Norman 1998). Moreover, humidity levels at PNR may well have been higher on account of its location adjacent to the 13 000-ha Pongolapoort Dam. The interaction between T_{air} and humidity emerged as a significant predictor of evaporative cooling efficiency in an arid-zone passerine, with the ratio of evaporative heat loss/metabolic heat production decreasing with increasing humidity when $T_{air} > 38$°C (van Dyk *et al*. 2019). These data suggest that the humidity levels on 8 November may well have been high enough to significantly reduce the efficiency of avian evaporative cooling. The relative humidity associated with T_{max} = 42.4°C during a flying-fox mortality event on 4 January 2014 in southeast Queensland, Australia, was 23.8% (Ratnayake *et al*. 2019), conditions very similar to those in northern KwaZulu-Natal on 8 November 2020.

Conclusions

The recorded deaths of approximately 110 birds and bats on 8 November 2020 are likely only a small fraction of the total number of individuals involved, as only carcasses close to human habitation and within the ~45-ha search area in PNR were recorded. That a significant heat-related mortality event has now been documented in southern Africa is cause for concern, supporting recent predictions that climate change is leading to a substantially greater risk of lethal effects of extreme weather events among small endotherms globally.

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Conflict of interest

The authors declare no conflict of interest.

Author contributions

Andrew McKechnie: Conceptualization (equal); Data curation (equal); Writing-original draft (equal). **Ian Rushworth:** Investigation (equal); Methodology (equal); Writing-review & editing (equal). **Ferdi Myburgh:** Data curation (equal); Investigation (equal). **Susan Cunningham:** Conceptualization (equal); Data curation (equal); Writing-review & editing (equal).

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