Corella, 2022, 46: 92-93

Progress Report for 2021 FAR Grant

Growing up in the tropics: assessing heat stress in nestling Purple-crowned Fairy-wrens

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INTRODUCTION

The environmental conditions experienced during the early-life stage can have strong effects on morphology, physiology and behaviour which can last into adulthood. Nestling birds, in particular, are vulnerable to the effects of high temperature due to their small size, the high energy costs associated with rapid growth and development, undeveloped thermoregulatory systems, and restricted movement. Despite this, studies on nestlings' responses to high temperature have produced complex and often conflicting results. My project examined nestlings' responses to high temperatures in two different species of fairy-wren, the Superb *Malurus cyaneus* and Purple-crowned *M. coro*natus. Superb Fairy-wrens are found in relatively dry and temperate climates with short heat waves, whilst Purple-crowned Fairy-wrens inhabit a hot, tropical climate. These differences in habitat may lead to differences in the thermal tolerance of the species and have interesting implications for their vulnerability to increases in ambient temperature. Very few studies have investigated nestling metabolic rate and behavioural responses to heat, and no studies have been conducted in Australia or on small, non-cavity nesters. Thus, it is unknown at what temperatures nestlings in tropical climates start to experience heat stress and how this may differ from the situation in nestlings of temperate species.

METHODS

I determined the temperatures at which nestling Purple-crowned and Superb Fairy-wrens experience heat stress by exposing them to a range of temperatures while measuring their metabolic rate (measuring the rate of CO_2 production as a proxy). Simultaneously I recorded their heat dissipation behaviours, including wing-drooping and panting. This information will help us to understand the effects of temperature on nestlings and how climatic zone and nest type may influence the thermal tolerances of nestlings. The FAR grant that I received in 2021 funded the travel and shipping of equipment necessary to make the Purple-crowned Fairy-wren data collection possible. Purple-crowned Fairy-wrens are found in northern Australia and I studied the population at the Mornington Wildlife Sanctuary, WA. Here individuals are banded with coloured leg-bands and a numbered metal band (Fig. 1) to allow individual identification and for individuals to be tracked throughout the breeding season (January- May). Nests were found by observation and monitored for egg laying, hatching and fledging, with typically 3-4 eggs being laid in each nest. The chicks' metabolic rate and heat dissipation behaviours were then measured 7 days after hatching (Fig. 2). This is the age of pin break (when the primary feathers start to emerge from the feather pin) and the day on which the female ceases brooding, indicating the attainment of thermoregulatory capacity by nestlings. In the 2021 season I successfully measured 40 Purple-crowned Fairy-wren nestlings.

Figure 1. *Purple-crowned Fairy-wren nestlings in the nest after being measured.*

Figure 2. *Purple-crowned Fairy-wren nestling after banding with coloured metal bands.*

Figure 3. *Author with a brood of four Superb Fairy-wren nestlings after measurement.*

I also studied a population of Superb Fairy-wrens at Lysterfield Park, Victoria during the preceding breeding season of 2020 (September – February). Individuals in this population are also individually colour-banded and were tracked to find and monitor nests. As with Purple-crowned Fairy-wrens, nestlings' metabolic rate and heat dissipation behaviours were measured 7 days after hatching (Fig. 3). I measured 62 nestlings during the breeding season. I can compare these data with those for Purple-crowned Fairy-wren nestlings to examine differences between the species.

RESULTS

The thermoneutral zone is the range of temperatures at which metabolic rate, or energy expenditure, is minimal. Above this zone, nestlings start becoming heat stressed and energy expenditure increases to promote heat dissipation; below this zone, energy expenditure increases to promote heat production. For both fairy-wren species, the lower temperature of the thermoneutral zone, the lower critical limit, is at 36°C

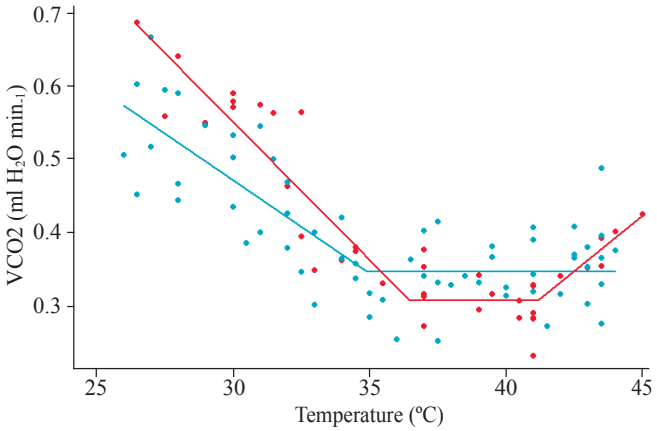

Figure 4. *Metabolic rate (VCO_2 – rate of CO_2 production) of day 7 Superb (blue) and Purple-crowned (red) nestlings. Purple-crowned Fairy-wren nestlings show a lower critical limit at 36°C and an upper critical limit at 41°C. Superb Fairy-wrens have a lower critical limit at 36°C too, but the upper limit still needs to be confirmed.*

(Fig. 4). The upper critical temperature for the Purple-crowns is clearly at 41°C and for Superb nestlings will probably be the same (more data collection is needed to finish this part of the investigation). Nestlings of both species thus probably have very similar upper and lower limits to the thermoneutral zone (36°C to 41°C), despite living in such different climates. This suggests that at 7 days of age nestlings may still be developing where their limits are and that the nest climate at this stage may not yet affect a species' thermal tolerance. Additionally, the heat dissipation behaviours of both species were not significantly different and closely tracked the thermal limits (Fig. 5). Wing-drooping behavior, a passive way to dissipate heat, occurred at temperatures at and above the lower limit, whereas panting, a more active heat dissipation method, occurred at temperatures at and above the upper limit. Collecting heat dissipation behaviour data may therefore be a noninvasive way to determine thermal limits for nestlings.

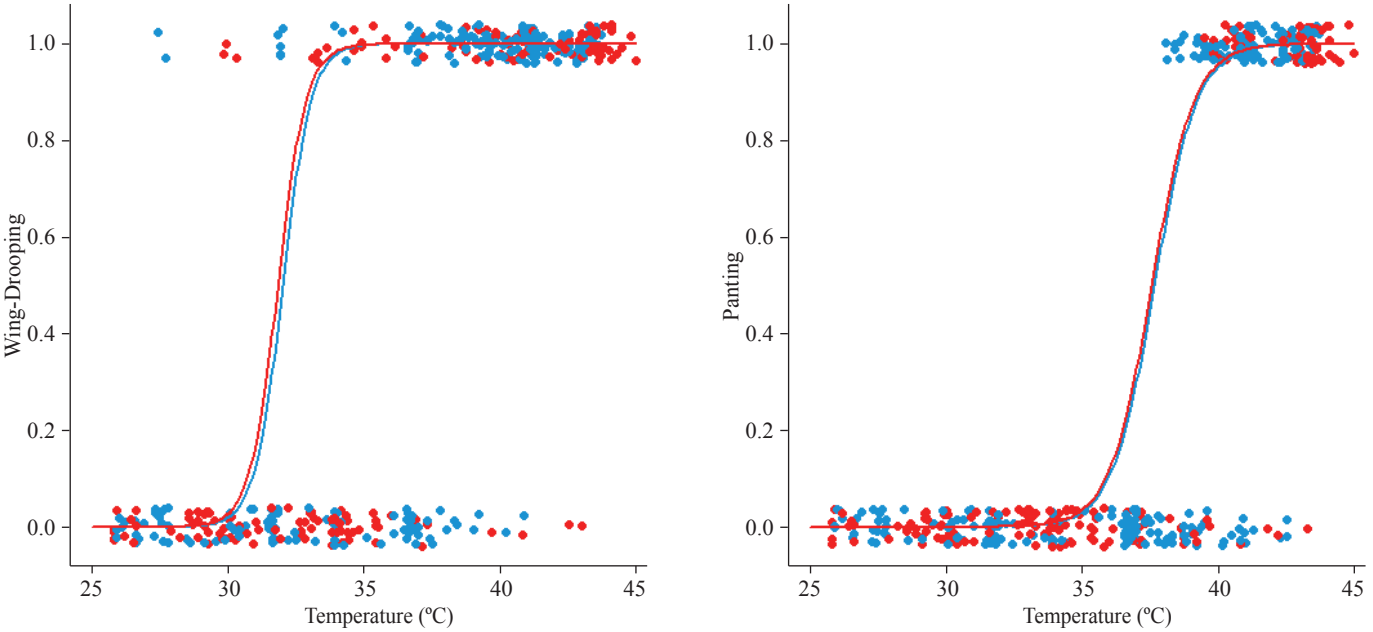

Figure 5. *Heat dissipation behaviour, wing-drooping (left) and panting (right), at temperatures 25-45ºC for both species (Superb = blue, Purple-crowned = red)*