Heat tolerance in African Penguins in the face of climate change

Masters project to be held at the FitzPatrick Institute of African Ornithology (University of Cape Town).

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Penguins evolved from an ancestral species in the Subantarctic regions of Australia-New Zealand and the Antarctic Peninsula (Bertelli and Giannini 2005). Due to critically cold temperatures in water and on land, penguins adapted efficient morphological and physiological mechanisms to reduce heat loss (Williams 1995, Luna-Jorquera et al. 1997, Dawson and Whittow 2000). However, although for low-latitude *Spheniscus* penguins, adaptations for tolerating cold conditions can be disadvantageous when breeding in hot terrestrial habitats (Luna-Jorquera et al. 1997).

The African Penguin (S*pheniscus demersus*) has been classified as 'Endangered' by the IUCN since 2010, due to the loss of >50% of its global population since 2004 (Crawford et al. 2011). While the major threats occur at sea, from oil spills and low prey availability, habitat loss on land due to former guano scraping (Crawford et al. 1995), can be a major issue for African Penguins, as it exacerbates heat stress on land. Historically, most African Penguins bred in burrows in guano that provided protection from aerial predators as well as providing a buffered microclimate, with high relative humidity and little exposure to the wind (Frost et al. 1976). These factors are important as penguins are generally sensitive to heat stress and, during extremely high temperatures, leave their nests unattended to go into the sea to cool down (Frost et al. 1976). This is mostly fatal for the broods of penguins nesting in exposed surface nests, which are subject to predation and/or over-heating (Yorio & Boesrma 1994). In addition, small chicks raised in surface nests have higher mortality rates in severe rains (Randall 1983, Frere et al. 1992, Renner and Davis 2001, Demongin et al. 2010). Since climate change increases the frequency of extreme weather events such as heat waves or storms (Parmesan et al. 2000), the situation is worsening for an already stressed species. Previous studies (e.g. Pichegru 2012,

Sherley et al. 2012) and our pilot data indicate that these effects can be ameliorated to some extent by the use of artificial nests or nest-covers. But whether these structures can fully replace natural burrows and/or whether any type of burrow will provide sufficient protection in the face of climate change remains to be tested.

In order to understand potential consequences of ongoing climate changes on penguins, it is crucial to understand their physiological and behavioural capacities and the limitations to their abilities to thermoregulate. Due to the African Penguin's adaptations to a cold aquatic environment, it is mostly through their behaviour that they dissipate heat to reduce thermal stress without excessive water loss (Lustick 1984, Davenport 1992, Dawson and Whittow 2000). In this project, we seek to (1) establish the thermoneutral zone and upper critical temperature of adult African Penguins and their chicks, (2) understand the behavioural responses of penguins to increased temperatures according to their breeding status, (3) estimate inter -colony and nest type differences to temperature exposure, (4) determine how extreme weather events of different types (heat waves, storms) can affect African Penguin breeding success and (5) evaluate the effectiveness of mitigation solutions such as artificial nests. The results of this study will help to predict how African Penguin populations may be affected by future climate changes, as well as informing management actions to limit such impacts.

Methods

Thermoneutral Zone (TNZ) and Upper Critical Temperature (UCT)

The Thermoneutral Zone (TNZ) and Upper Critical Temperature (UCT) of African Penguins will be established using an experimental approach on captive penguins. Birds will be exposed to a range of temperatures in a constant temperature chamber and the onset of heat stress will be established by measuring body temperature using a thermocouple placed in the cloaca. By using captive birds we will reduce the effects of stress on the results.

Behavioural thermoregulation of nesting and non-nesting birds

Behavioural observations following Simeone et al. (2004) will be conducted on breeders and non-breeders, during summer and winter, on Bird and St Croix Islands. These observations will

be related to temperatures experienced by penguins, using a mounted penguin adult and chick (small dawnie and large blue) skins. The skins are mounted on a foil-covered chicken wire frame, with i-button temperature recorders on the inside to record temperature. This allows the 'effective temperature' experienced by the penguins to be recorded then related back to UCT established in the laboratory and temperatures recorded inside burrows and nests.

Breeding success

From January to August, breeding success of summer breeders versus winter breeders in surface nests will be collected forthnightly from two colonies of contrasting shape and substrate (some data are available since 2009). Breeding success in two types of artificial nests will also be assessed on Bird Island.

Weather

Weather stations will collect daily maximum and minimum temperatures on Bird Island and 5 km from St Croix Island, as well as rainfall, wind speed and direction.

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