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GREAT HORNBILL CASQUE FUNCTIONS AS A THERMOREGULATORY RADIATOR

Stephen K. Slaughter¹ and Pilai Poonswad²

¹Department of Biology, Faculty of Science, Mahidol University, Rama 6 Rd., Bangkok 10400, Thailand [sksgh5@mst.edu]

²Hornbill Research Foundation, c/o Department of Microbiology, Faculty of Science, Mahidol University, Rama 6 Rd., Bangkok 10400, Thailand

ABSTRACT

Hornbills (*Bucerotidae*) are defined by their casques, structures that are extensions of the beak. The purpose of these structures, which take diverse forms, has been subject to speculation. In this study, it is asserted that a primary function of the casque is thermoregulation, its large vascularised surface area functioning as a structure to facilitate heat exchange. Infrared thermography on a Great Hornbill (*Buceros bicornis*) revealed that the bird's casque exhibited significant percentage of heat loss in relation to the body's resting heat production along a temperature gradient of 19.2 to 34.2°C. The results indicate that the casque is capable of dissipating a disproportionate amount of heat in relation to the rest of its body and even comparable to major thermal windows in other animals.

Keywords: Great Hornbill, casque, hornbill, thermoregulation, physiology, functional morphology



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Abstract

Hornbills (Bucerotidae) are defined by their casques, structures that are extensions of the beak. The purpose of these structures, which take diverse forms, has been subject to speculation. In this study, it is asserted that a primary function of the casque is thermoregulation, its large vascularised surface area functioning as a structure to facilitate heat exchange. Infrared thermography on a Great Hornbill (*Buceros bicornis*) revealed that the bird's casque exhibited significant percentage of heat loss in relation to the body's resting heat production along a temperature gradient of 19.2 to 34.2°C. The results indicate that the casque is capable of dissipating a disproportionate amount of heat in relation to the rest of its body and even comparable to major thermal windows in other animals.

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INTRODUCTION

The casque is an extension of the beak found in all species of hornbills (Poonswad *et al.* 2013). Despite the casque being a prominent structure that takes many forms and sizes, little is known about its purpose (Kinnaird & O'Brien 2007). While sexual selection and species recognition has likely played a role in the divergence of casque types among hornbill species, there is little sexual dimorphism in terms of difference in proportional shape and size of the casques between males and females.

One concept is that the casque is an organ for amplification of sound frequencies, though dominant frequencies have not been observed to be amplified by the internal structure (Alexander *et al.* 1994). Another possibility is thermoregulation. Large endotherms risk overheating in high-temperature

environments, especially tropical climes, and many species cope by maximising exposed surface area to dissipate heat through convection and radiation. A bare surface that is exposed to air flow functions as a thermal window, an area that allow for heat transfer from the bird to ambient surroundings, capable of losing heat relative to the rest of the body, akin to a radiator. The higher the surface area the greater the heats transfer. This was demonstrated in toucans (Ramphastidae), a New World family somewhat convergent to hornbills in morphology and habits, in which the high surface area and vascularisation of their bills allows for the controlled dissipation of heat (Tattersall *et al.* 2009). In smaller hornbill species (e.g. *Tockus leucomelas*), a similarly high surface area and vascularisation is present in their bills, which have been observed to exhibit heat flux corresponding to changes in ambient temperature (van de Van *et al.* 2016). A casque could allow for more effective and efficient heat dissipation through increasing the exposed surface area.

The Great Hornbill (*Buceros bicornis*) is found in tropical evergreen and moist deciduous forests throughout mainland Southeast Asia, Sumatra, southern Himalayas, and South Western India. Besides being the heaviest Asian hornbill species, it bears a large flared casque with a high surface area (Poonswad *et al.* 2013). In this study, we measured and analysed surface temperatures of the casque and other body parts in a captive Great Hornbill's casque in order to determine the effectiveness of the casque as a thermal window.

MATERIALS AND METHODS

To observe heat loss, the study was reliant on infrared thermography, which allows for measurements of surface temperatures (T_s) in a minimally invasive manner. The focus of this study was a male Great Hornbill at the Dusit Zoo, Bangkok, Zoological Park Organization, under the Royal Patronage of H.M. the King. The studied individual was adopted by the zoo after previously residing in private captivity for an unknown period. It had thus been acclimatised to human presence, resulting in a lower amount of stress compared to non-acclimatised birds during close interactions. During the period of time when the measurements were made, the hornbill resided in a shaded enclosure off-limits from the general public.

The tool used for T_s measurements was a Craftsman model 34-50466 infrared thermometer. Each measurement was taken by pointing the thermometer on a body part for a period of 3 seconds with the distance between thermometer