Histomorphologic and Radiologic Study of Southern Cassowary Casque (*Casuarius casuarius*)

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Abstract

Cassowaries are large, black-plumaged ratite birds, endemic to the rainforest habitats of New Guinea, Queensland (Australia) and various of the Aru Islands (Indonesia). The bird is characterized by the presence of large process above its head called casque. The casque possesses brownish color and measures 13 cm high and 13.5 cm width at the casque base and 5 cm thick (in the cross section). The rostral border is thick, rounded and curved backward to meet the caudal border, which is also rounded and nearly straight. X-ray image shows that the inner structure of the casque is formed of irregularly arranged, sparse thin trabeculae, looks like a sponge with the naked eye. Trabeculae are densely packed and adheres to the outer layer of the casque except in its most upper caudal part, which is less densely packed. The spaces between the bony trabeculae were not occupied by any liquid or solidified material and contains only those visible filaments. Surrounding the internal mass of trabecular fibers is a bony shell composed of denser bone, the external surface of which is marked with foramina and shallow, dorsoventrally aligned, divaricating canals for the reception of blood vessels and nerves. Histological examination confirmed the X-ray image findings.

Keywords: Cassowary, casque, histology, radiology.

Introduction

Cassowaries (Casuarius) are large, black-plumaged ratite birds, endemic to the rainforest habitats of New Guinea, Queensland (Australia) and various of the Aru Islands (Indonesia) (Rothschild 1900; Folch1992; Davies 2002).It is the third-tallest and second-heaviest living bird, smaller only than the ostrich and emu. The cassowary has often been labeled "the world's most dangerous bird".

Naish (2015) mentioned three cassowary species which are currently recognized: The Double-wattled or Southern cassowary *Casuarius casuarius* (the only one that occurs on mainland Australia), the Single-wattled cassowary *C. unappen-diculatus*, and the Dwarf or Bennett's cassowary *C. bennetti*. A case has also been made that a fourth species (previously included within the synonymy of *C. bennetti*) should be recognized. This is the Papuan or Westermann's cassowary, the correct name for which is *C. westermanni* (Perron, 2011), not *C. papuanus* as has been described by Davies (2002).

All three species have a keratinous skin-covered *casque* on their heads that grows with age. The casque's shape and size, up to 18 cm, is species dependent. *Casuarius casuarius* has the largest and *Casuarius bennetti* the smallest (tricorn shape), with *Casuarius unappendiculatus* having variations in between.
There are meager details on the structure of the casque in the available literature. The present study aims to describe the histomorphology and radiology of this casque, which will help in the understanding of its physiological role.

Material and Methods

1)Samples collection

A cadaver of a cassowary bird, died in one of the wildlife sanctuaries near Townsville, Australia, was presented in 2013 to the Discipline of Anatomy and Pathology, JCU for postmortem examination. The wings and feet of the bird were studied and the results were published by Saber and Hassanin (2014). The kept air-dried casque is used in this study.

2)Radiology

An x-ray image was done to study the interior of the casque, with the parameters: 53 kV and at 5 mAs.

3)Histological analysis

Pieces of the dry preserved casque were decalcified using EDETA (10 % for 30 days). Then they were cut at 1x1x.05 cm and were immediately fixed in Bouin's fluid for 22 hours. The fixed materials were dehydrated in an ascending series of ethanol, cleared in methyl benzoate and then embedded in paraffin. Serial longitudinal and transverse paraffin sections at 3-5 µm thick were cut and stained with Harris hematoxylin and Eosin, Crossman's trichrome, and Sirius Red (Bancroft and Steven, 1996).

Results and Discussion

Several authors have described cassowary casques previously (Mayer, 2018; Naish & Perron, 2016; Parker, 1866; Pycraft, 1900; Richardson, 1991).Green and Gignac (2020) mentioned that the southern cassowary casques are comprised of three paired elements (Ossa nasals, lacrimals and frontals) and two unpaired elements (mesethmoid, median casque

elements). In the early work of Parker (1866), he identified the mesethmoid (ethmoid bone) as the main bone forming the casque. While, Mayer (2018) suggested that the nasal bones contribute to the formation of the lateral portions of the casque.

The casque studied is 13 cm in height and 13.5 cm in width at the casque base and 5 cm thick (in the cross section). It was brownish in colour, having different tints. The rostral border is thick, rounded and curved backward to meet the caudal border which is also rounded and nearly straight (fig1). Naish and Perron (2014) described the casque as variously subtriangular, rounded or trapezoidal, being tallest at a point dorsal to anywhere between the orbit and quadrate. Richardson (1991) gave the casque dimensions as 17 cm high and 15 cm long. He described the outer layer of the casque as resembles the hoof material or the tortoise shell as found in epidermal scales of marine turtles.

The inner structure of the casque is formed of irregularly arranged, sparse thin bone trabeculae, looks like a sponge with the naked eye. These are densely packed and adheres to the outer layer of the casque except in its most upper caudal part which is relatively looser than the rest of the casque, as seen on the X-ray image (Fig 2). The entire external sheath of the casque is stiff along its rostral and dorsal edges but soft and pliable elsewhere: it is not a hard 'helmet', but flexible and able to deform when subjected to load (Crome and Moore, 1988 and Richardson, 1991).

Histologically, the casque is composed of loosely knit web of irregularly arranged, sparse, extremely thin trabeculae of spongy bone that are most densely packed in the rostral half of the casque (Fig 3). Naish and Perron (2014) mentioned that the trabeculae are most densely packed in the anterior (rostral) half of the casque but are absent (caudally) where a cavity is present. Surrounding the internal mass of the trabeculae is a bony shell composed of denser bone, the external surface of which is marked with foramina and shallow, dorsoventrally aligned, divaricating canals for the reception of blood vessels and nerves (Fig 4, 5). The shell-like outer layer of the casque is approximately 2 – 3 mm thick and is formed of many tiny fibroblasts, formed by fine strut-like trabeculae arranged in a semi-regular, honeycomb-like arrangement. It is also characterized by deposition of collagen substance (Fig. 6, 7), all enclosed within inner and outer bone layers, the overall effect being that of a 'sandwich' of bone cells. In places, the cells are arranged in rows that are approximately parallel to the inner and outer layers. Similar 'sandwich' layers formed of parallel rows of cells have been figured for other birds where the rows may be double, four-deep or more randomly arranged (Bühler, 1988). This arrangement is best known

for the braincase bones of passerines but occurs widely, including in the palate, sternum and the ends of long bones (Bühler,1988). The dermis and epidermis are in tight contact with the bony core of the casque, the soft tissues together forming a keratinous sheath over the skeletal component.

Richardson (1991) described these as up to 1 mm deep and nothing appears unusual about their number, density or arrangement compared with the similar bony canals present on the keratin-covered cranial bones (premaxillae especially) seen in other birds.

Naish and Perron (2014) denied the presence of spongy bone structure in the posterior (caudal) part of the casque and affirmed the presence of a cavity instead. This dissimilarity in the findings may be interpreted to the age of the bird, health, diet, the status or way of preservation of the casque.

The spaces between the bony trabeculae were not occupied by any liquid or solidified material as reported by Jones et al. (2003) who noted that the casque seemingly contains liquid of some kind. Crome and Moore (1988) referred to the presence of 'a core of firm, cellular foam-like material that looks like some hi-tech plastic'. However, Richardson (1991) described the presence of 'large amounts of darkly pigmented sludge [that came] from the deeper regions of the casque', indicating the presence of 'an extensive vascular network and possibly other structures deep within the casque'. Richardson (1991) presumed that the method of preparing the skull was somehow responsible for the 'sludge'. Naish and Perron (2014) agreed with the results of this study that the casque is not occupied internally by liquid and contains only those visible filaments. Moreover, they argued the liquid or sludge to blood that has hemorrhaged from vessels associated with the dermis assist is extremely easy to damage the outer layer of the bony casque due to its fragility.

The Southern Cassowary (*Casuarius casuarius*) is variously described as having a hard bony (MacDonald, 1973; Simpson & Day, 1984; Beehler et al., 1986) or a horny (North, 1913; Pizzey, 1980; Coates, 1985) casque. Chrome and Moore (1988), after dissecting an adult male Cassowary found that the casque is neither horny nor bony. They added that the skull does not have a protuberance as might be expected and the casque itself consists of a keratinous skin over a core of firm.

Descriptions have differed in their interpretation of casque contents. Jones et al. (2003) noted that the casque seemingly contains liquid of some kind; Crome and Moore (1988) referred to the presence of 'a core of firm, cellular foam-like material that looks like some hi-tech plastic'; while Richardson (1991) referred to the

presence of 'large amounts of darkly pigmented sludge [that came] from the deeper regions of the casque', indicating the presence of 'an extensive vascular network and possibly other structures deep within the casque'. Richardson (1991) presumed that the method of preparing the skull was somehow responsible for the 'sludge'.

Naish & Perron (2014) hypothesized that a visual, sexual display role is most likely and that it co-evolved with the use of the casque as a resonating device. While, Starck (1995) said that the possibility that cavernous subdermal blood sinuses might play a role in amplifying the booming calls that cassowaries make has also been suggested, though this doesn't discount the possibility that the casque also has an acoustic role. Eastick et al. (2019) provided evidence that the casque acts as a thermal radiator, offloading heat at high temperatures and restricting heat loss at low temperatures.

Conclusions

- Our observations of cassowary dissections lead us to conclude that reports of liquid or sludge present between the bony core and the keratinous casque in fact refer to blood that has bleed from the vessels associated with the dermis. It is extremely easy to damage the outer layer of the bony casque due to its fragility.
- The casque is not occupied internally by liquid and contains only those visible filaments.
- The part not occupied by bony trabeculae in the casque and its size is differently described by different authors, which needs further studies for its importance.
- This finding allows us to examine the list of potential purposes in a new light.

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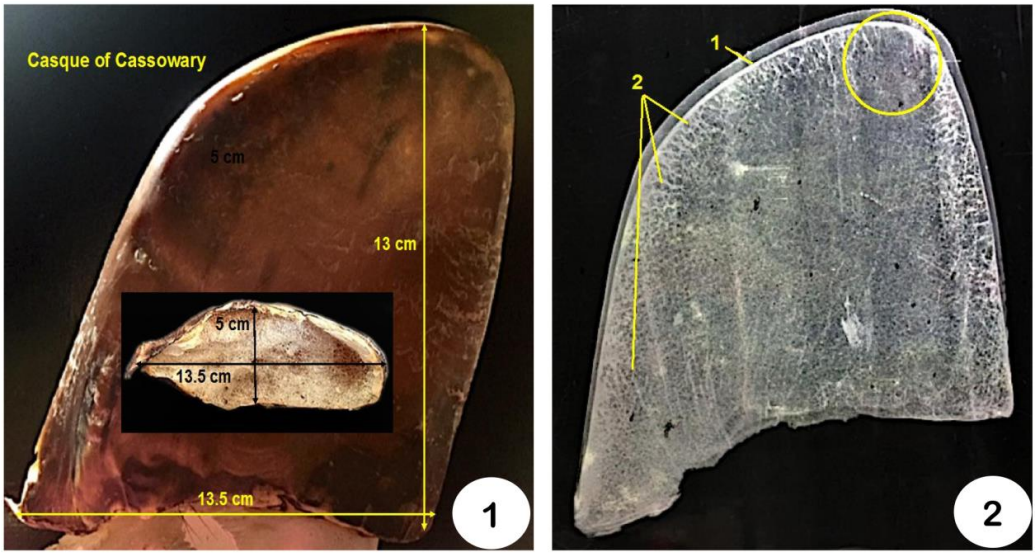


Fig (1): Cassowary casque dimensions. The box in the middle is the ventral aspect of the casque after removing from the skull dorsum.

Fig (2): X-ray image for the casque showing in the upper yellow circle the less dense spongy bone structure of the casque.1 outer bony shell of the casque, 2 trabeculae forming the bulk of the casque.

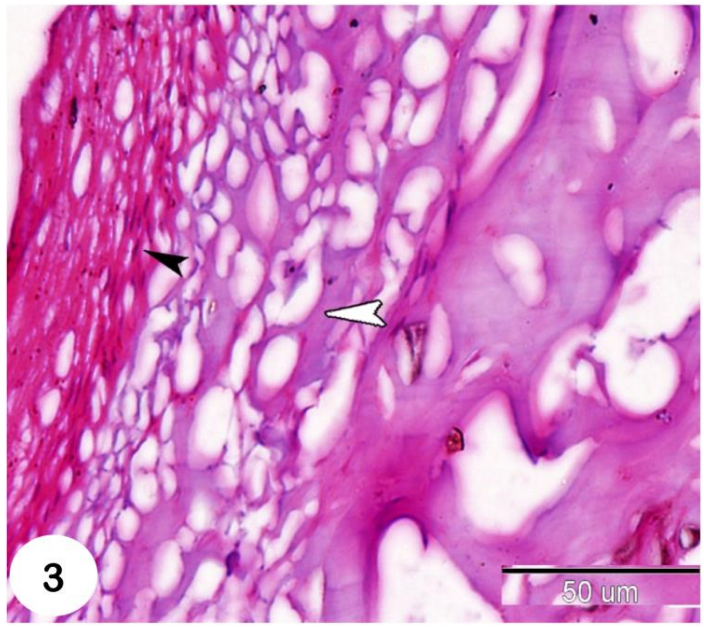
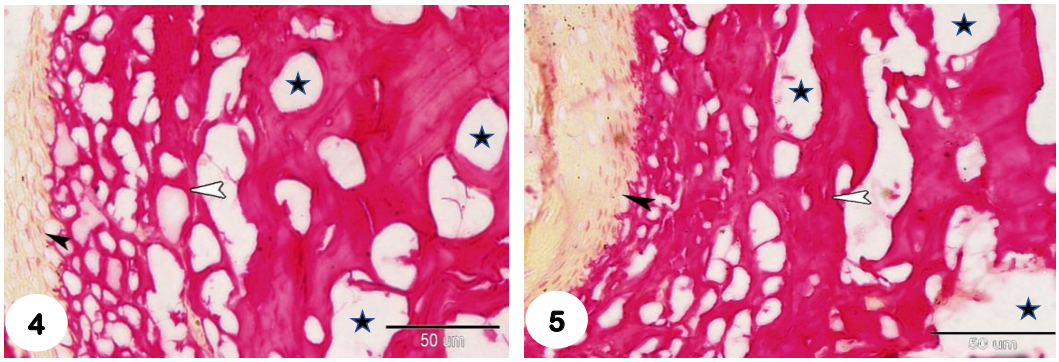


Fig (3): Histological structure of the casque stained with H&E shows that it is composed of irregularly arranged trabeculae of spongy bone (white arrowhead). Surrounding the trabeculae is a bony shell (black arrowhead).



Figs (4, 5): Positive reaction (collagen in red) of the trabecular tissue (white arrow head) to Sirius Red. Note the surrounding bone mass (black arrowheads). Stars indicate the hollow spaces between the boney trabeculae.

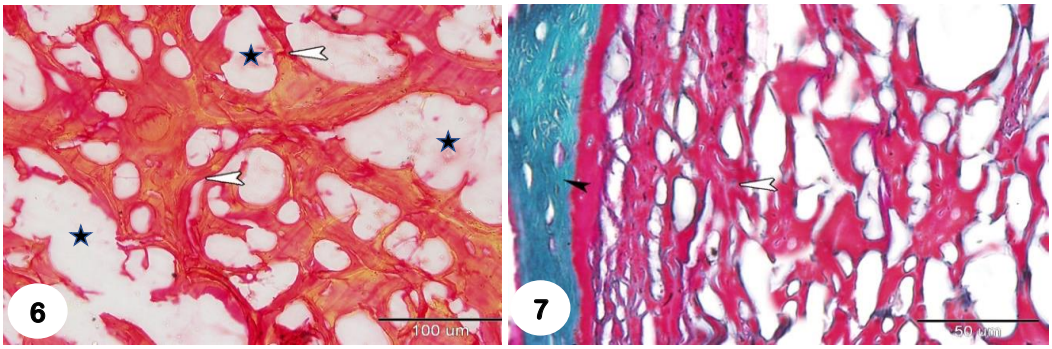


Fig (6): Higher magnification of Fig. 5 showing a positive reaction of the trabecular tissue (white arrowheads) to Sirius Red. Red colour indicates collagen fibers deposition. Stars indicate the hollow spaces between the boney trabeculae

Fig (7): The shell-like outer layer (black arrowheads) of the casque is formed of tiny cells formed by fine strut-like trabeculae (white arrowhead) arranged in a semi-regular, honeycomb-like arrangement (Crossman's trichrome).
N.B. green/blue coloration of the outer shell layer indicates the presence of collagen.

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Animal species in this Issue

southern cassowary (*Casuarius casuarius*)

Kingdom: Animalia & Phylum: Chordata & Class: Aves & Order: Casuariformes & Family: Casuaridae & Genus: *Casuarius* & Species: *C. casuarius*

Casuarius is a genus of birds in the order Casuariiformes, whose members are the **cassowaries**. It is classified as a ratite (flightless bird without a keel on its sternum bone) and is native to the tropical forests of New Guinea (Papua NewGuinea and Indonesia), Aru Islands (Indonesia), and northeastern Australia.

Cassowaries feed mainly on fruit, although all species are truly omnivorous and take a range of other plant foods, including shoots and grass seeds, in addition to fungi, invertebrates, and small vertebrates. Cassowaries are very wary of humans, but if provoked, they are capable of inflicting serious, even fatal, injuries to both dogs and people. The cassowary has often been labeled "the world's most dangerous bird"

Source: Wikipedia, the free encyclopaedia