Gross anatomical studies of neurocranium of Emu (Dromaius novaehollandiae)

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Abstract
Neurocranium was composed of the unpaired occipital, sphenoid and paired parietal, frontal and temporal. The occipital bone was composed of three parts, squamous part (Supraoccipital), lateral or exoccipital and basal part (Basioccipital) all of which contributed in the formation of foramen magnum. From the floor of the foramen magnum, the hemispherical single occipital condyle projected ventrally. The supra occipital presented a median external occipital protuberance from which a median occipital crest extended upwards and joined the nuchal crest. Sphenoid formed the major part of the floor of the cranial cavity with basi-phenoid caudally and pre-sphenoid rostrally. The orbital wings of presphenoid also contributed to the formation of the inter-orbital septum. The parietal was located in between the frontal and supra-occipital bones. The frontal bone was the largest of all cranial bones and formed the highest point of skull. The orbital plates of the frontal formed the medial wall of the orbit and were fused medially with each other and formed the inter-orbital septum. The temporal bone formed the lateral wall of the cranial cavity and consisted of two parts, namely squamous temporal and ear capsule (os-oticum). The orbital wings of pre-sphenoid and orbital plates of frontal bones of either sides were connected medially and formed the inter-orbital septum. The caudal part of the perpendicular plate of ethmoid also joined the inter-orbital septum.

Keywords: Gross anatomical, neurocranium, emu, Dromaius novaehollandiae

Introduction
In general the avian skull was composed of neurocranium and splanchnocranium, which were separated by the large orbital cavities. In birds the skull bones were light in weight and were generally fused to provide protection to the brain. Nickel et al., 1977 (5) in domestic birds reported that due to the large sized orbital cavities there was a nasal disposition of the ethmoid which was not a part of the neurocranium. In large birds, the small sized neurocranium and large sized splanchnocranium was related to its feeding habits. The avian skull bones articulate with each other permitting a certain degree of movement. A characteristic feature of the avian skull was the single occipital condyle which made the atlanto-occipital joint a much more mobile articulation than in mammals and allowed considerable rotation of the head, Mc lelland (1990) (3). The present study was undertaken to elucidate the gross morphological features of the bones of neurocranium in the skull of emu.

Materials and Methods
The present study was conducted on three adult emu birds, brought for post mortem to the department of Veterinary Pathology at Rajiv Gandhi Institute of Veterinary Education and Research, Puducherry. Skull was removed after natural maceration and the gross morphological features of the neurocranium was studied.

Results and Discussion
Emu skull had a pyramidal appearance. The apex was narrow and flat while the base appeared large, wide and rounded. The skull was composed of two components neurocranium (Cranial bones) and splanchnocranium (Facial bones). The large orbital cavities separated the neurocranium and splanchnocranium. The Neurocranium was composed of the unpaired occipital, sphenoid and paired parietal, frontal and temporal. The parietal, temporal and sphenoid were pneumatic. Ethmoid due to its nasal disposition was not involved in the formation of neurocranium.
Occipital bone

The occipital bone (Fig 1) was composed of three parts, squamous part (supraoccipital), lateral or exoccipital and basal part (basioccipital), all of which contributed in the formation of foramen magnum, which was slightly transversely oblong in shape. Kumar and Singh, 2014 [2] had observed that the foramen magnum was broader horizontally in emu. The hemispherical single occipital condyle which was convex basally projected ventrally from the floor of the foramen magnum. Similar observations were noticed in ostrich by Moselhy et al., 2018 [4]. A characteristic feature of the avian skull was the single occipital condyle which made the atlanto-occipital joint a much more mobile articulation than in mammals and allowed considerable rotation of the head Mc lelland (1990) [3]. The occipital bone with its foramen magnum was situated basally and horizontally in pigeon, almost vertically and nuchally in duck and goose, whereas in fowl it took up a middle position between these two extremes Nickel et al., 1977 [5]. In contrast, Kumar and Singh, 2014 [2] observed a pear shaped occipital condyle in emu. The squamous occipital formed a part of the posterior thick wall of the neurocranium and was separated from the parietals above by the nuchal crest. Supraoccipital presented a superior lateral U shaped area and a ventro lateral wing shaped area. The intermittent area constituted the median external occipital protuberance from which a median occipital crest extended upwards and joined the nuchal crest (Fig 1). A similar medial occipital protuberance and crest was noticed in ostrich by Moselhy et al., 2018 [4] and in mammals by Dyce et al., 2002 [1]. Just lateral to the median occipital crest on either side, close to the nuchal crest a pneumatic foramen was observed. The basi -occipital was seen as a depressed fossa below, as well as on either sides of the single occipital condyle and was separated from the basi sphenoid behind, by a raised transverse ridge. Paired lateral occipital was in the form of a broad U shaped Para occipital process (Fig 1), which presented on its medial face a concave facet for articulation with mandible. A similar finding was noticed in ostrich by Moselhy et al., 2018 [4]. The external acoustic meatus was observed between the zygomatic process of squamous temporal and para occipital process. At the junction between basi and lateral occipital, 3 to 4 foramina was observed. Hypoglossal foramen was observed between the para occipital process and basisphenoid. A fontanelle was observed between supraoccipital and parietal bones. Nickel et al., 1977 [5] had also observed a fontanelle in duck and goose on either side between supraoccipital and parietal bones.

Sphenoid formed the major part of the floor of the cranial cavity with basiphenoid caudally and presphenoid rostally (Fig 2) which is in agreement with Nickel et al., 1977 [5] in domestic birds

Basisphenoid had a body and a pair of temporal wings which was observed laterally between it and the parasmphenoid wings of presphenoid. Basiphenoid was separated from body of presphenoid by a traverse ridge and formed the medial boundary of external acoustic meatus and the foramen for the auditory tube was observed craniomedially. Nickel et al., 1977 [5] in duck and goose, observed that the basisphenoid had distinct muscular process and grooves.

Pre sphenoid presented a body with a pneumatic foramen in the midline, a pair of orbital wings and a pair of laterally pointed short thick rod like process (Fig 3), the parasmphenoid wings, which articulated with the pterygoid bone. The orbital wings of presphenoid also contributed to the formation of interorbital septum. These finding concurs with the observations of Moselhy et al., 2018 [4] in ostrich. According to Nickel et al., 1977 [5] in domestic birds the root of pre sphenoid was perforated by eustachian tube.

The parietal was located in between the frontal and supraoccipital bones Nickel et al., 1977 [5] in fowl observed that the parietals were thin bony plates inserted between supra occipital and frontal bones. (Fig 4). The parietals participated in the formation of roof of the cranial cavity. The parietofrontal suture demarcated parietal from the frontal bone. The parietal was compressed laterally by the temporal
fossa in front and zygomatic process of squamous temporal behind. All these finding are in accordance with Moselhy et al., 2018 \(^4\) in ostrich.


The frontal bone was the largest of all cranial bones and formed the highest point of skull (Fig 4). It had three surfaces external, internal and orbital, two borders lateral and medial and three processes frontal, post orbital and nasal. Similar observations were reported by Moselhy et al., 2018 \(^4\) in ostrich but Nickel et al., 1977 \(^5\) in domestic birds and Kumar and Singh 2014 \(^2\) in emu had reported an orbital process. The external surface slopped cranially, caudally and laterally and presented an elevation dorsally. The internal concave surface lodged the cerebrum. The orbital surface was formed by the orbital plate which formed the caudomedial limit of the orbit, where it presented a large optic foramen, behind which was the ophthalmic foramen. The orbital plate was demarcated from the lacrimal by a suture. The orbital plates formed the medial wall of the orbit and were fused medially with each other and formed the interorbital septum. The supraorbital margin formed the lateral border. Interfrontal suture formed the medial border. The supraorbital fissure was found between the postorbital process laterally and the lacrimal bone medially. Postorbital process was short and blunt. The nasal process joined the nasal bone anteriorly. The frontal process which roofed the frontal sinus was leaf shaped and situated medially between the posterior parts of the nasal bone of either side and formed a suture in front with the frontal process of premaxilla.


The temporal bone (Fig 5) formed the lateral wall of the cranial cavity and was situated between parietal and lateral occipital behind, frontal dorsally and sphenoid medially. It consisted of two parts namely squamous temporal and ear capsule (os-oticum). The ear capsule a large irregular pneumatic cavity layed between the lateral part of the occipital above, basisphenoid medially, and squamous temporal laterally. External acoustic meatus wide and was situated below the para occipital process and presented a transverse oro-basal concave articular groove which articulated with the otic process of quadrate bone. The foramen for the auditory tube was observed at junction between the body of basisphenoid and presphenoid. The squamous temporal was located between the parietal, frontal and sphenoid bones and formed the lateral wall of the cranium. It had two processes orbital and zygomatic between which was a large slightly concave temporal fossa. Orbital process was a short pointed process and faced downwards. Moselhy et al., 2018 \(^4\) in ostrich did not observe orbital process. According to Nickel et al., 1977 \(^5\) in domestic birds the orbital process in duck and goose was long and stout, slender in fowl and rudimentary in pigeon. The zygomatic process was in the form of a broad thin concave bony plate behind the temporal fossa and lateral to the otic process of the quadrate bone and was continued below by a long thick rostroventrally directed process, the articular part of which articulated with quadrate bone. Both the processes were separated by the temporal fossa and gave origin to temporalis muscle. Nickel et al., 1977 \(^5\) in fowl observed a zygomatic process which was fused with the orbital process.

The orbital wings of presphenoid and the orbital plates of frontal bones of either sides were connected medially and contributed to the formation of interorbital septum. The caudal part of the perpendicular plate of ethmoid also joined the interorbital septum. The roof of the cranial cavity was formed by frontal and parietal. The floor was formed from before backwards by the presphenoid, basisphenoid and basioccipital. The lateral wall was formed by the temporalis. The posterior wall was formed by supra occipital and lateral occipital. The horizontal plate of ethmoid formed the anterior wall.

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**References**