

Exploring the Intricacies of Skull Anatomy of Common Crow (*Corvus splendens*)

Hemavathi Nagarajan*, Abinaya Sengodan, Jayachitra Sengottuvel, Thandavan Arthanari Kannan

ABSTRACT

The present study was conducted on skull bone of common crow (*Corvus splendens*) to understand the gross morphological anatomy of the bones and its articulations in depth. The Common crow's carcasses were brought to the department of Veterinary Anatomy of the Institute, and bones were collected after maceration. The skull of common crow was composed of 11 paired and 6 unpaired bones. Occipital, sphenoid, ethmoid, mandible, vomer and hyoid bones were unpaired. Temporal, parietal, frontal, lacrimal, nasal, premaxilla, maxilla, zygomatic, palatine, quadrate and pterygoid bones were paired. The skull of common crow lacked interparietal bone. The bones were divided as neurocranial and viscerocranial groups. Skull length, skull width, height of cranium, viscera-cranial length, upper beak width, lower beak length and lower beak width were measured and skull index, cranial index, facial index and foramen magnum index were calculated. The findings of this study would be a reference material for the upcoming researches on Corvidae family.

Keywords: Common crow, Corvidae, Neurocranium, Viscerocranium, Skull anatomy.

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INTRODUCTION

Birds are the sole survivors of a group of feathered dinosaurs and also, they are closely related to contemporary Crocodylidae family such as crocodiles, alligators and gavials. However, birds have unique distinct skeletal structures that resembles to young stage of their ancestors. This evolutionary phenomenon is known as 'Paedomorphism' (Singers, 2015). Birds' skeleton has wide dome-shaped cranial bones and large eye ball sockets to accommodate proportionately larger brains and eyes.

Crows are common birds, which are distributed to the entire world, except south pole. There are two kinds of crows observed in India namely Common crow (*Corvus splendens protegatus*) and Jungle crow (*Corvus macrohynchosculminatus*). Both are scavengers and omnivores and good predators (Nyari *et al.*, 2006). The bones of avian skull are grouped as neurocranium and splanchnocranium (Elshaer, 2019). Common crow skull was made up of 28 bones articulating with each other to form three cavities namely cranial, orbital and nasal. The gross morphometric analysis on common crow skull will be a better tool for ornithologist and veterinarians to do further research on Corvidae family and to treat the wild birds, respectively. Hence, the study was conducted on skull of common crow which was available at southern part of India.

MATERIALS AND METHODS

The Common crow's carcasses were brought to the Department of Veterinary Anatomy, Veterinary College and Research Institute, Orathanadu, Thanjavur, TamilNadu, (India). after the death of the birds. The bones were removed and collected after maceration. Macerated bones were cleaned, dried and various gross features were observed and recorded. After the gross anatomical study of skeleton, the detailed

Department of Veterinary Anatomy, Veterinary College and Research Institute, Orathanadu-614 625, TANUVAS, Tamil Nadu, India

***Corresponding author:** Dr. Hemavathi Nagarajan, Department of Veterinary Anatomy, Veterinary College and Research Institute, Orathanadu-614 625, TANUVAS, Tamil Nadu, India. E-mail: hemaanu1994@gmail.com

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study of skull bones was engaged. Gross morphometrical parameters were measured and recorded (John *et al.*, 2016). Average height and width of foramen magnum, diameter of orbit and nostrils were also recorded.

The following indexes were also calculated based on Choudhary *et al.* (2020). Skull length (SKL): Length between prominent point of occipital to apex of rostral part of premaxilla, Skull width (SKW): Width of orobasal articular grooves on either side of temporal bone, Height of cranium (SKH): Height between the basi-occipital to highest point of frontal bone, Upper beak length/ Viscero-cranial length (UBL): Length between frontal-nasal hinge to tip of the rostrum, Upper beak width/ (UBW): Width calculated at three different regions like anterior to lacrimal bone, at the level of anterior nares and at the level of palatine process, Lower beak length (LBL): Length between the anterior tip of mandible to the center point at the level of posterior articulations of mandible, Lower beak width (LBW): Maximum width of mandible, Skull index: Skull width/length x 100, Cranial



length: Length between highest point of occipital to center of frontonasal hinge, Cranial width: Width between root of post orbital process of frontal bone, Cranial index (CRI): Width of the neurocranium/ Cranial length x 100, Facial index (FAI): Zygomatic width/ Viscerocranial length x 100 (Zygomatic width- width between projections of the lateral frontonasal sutures on jugal bar), and Foramen magnum index (FMI): Height/Width of foramen magnum x 100.

RESULTS AND DISCUSSION

The skull of common crow appeared roughly triangle in shape with elevated base or cranial part and extended apex. It was composed of 11 paired and 6 unpaired bones. The bones were divided into neurocranial bones and viscerocranial bones which made cavity for brain and visceral organs, respectively. They were separated by two large orbital cavities. The skull length and width were measured as 8.21 ± 0.03 cm and 2.87 ± 0.03 cm, respectively. As per Choudhary *et al.* (2020) skull index was calculated as 34.94, while in crested serpent Eagle and Brown wood owl it was observed as 52.63 and 68.56 individually. The skull index of common crow was lower than these birds that indicate the flying ability of common crow would be comparatively higher (Choudhary *et al.*, 2020).

Neurocranium of Common Crow

The neurocranium of common crow skull was made up of 6 bones. Occipital, sphenoid and ethmoid bones were unpaired. Temporal, parietal and frontal were paired. The skull of common crow lacked interparietal bone. Together these bones built a cranial cavity at postero-dorsal aspect of the skull. The cranial length, width and height were measured as 3.63 ± 0.03 cm, 3.14 ± 0.02 cm and 2.12 ± 0.04 cm, respectively. The cranial index and facial index were calculated as 86.59 and 39.02, respectively. Most of the skull region was occupied by cranial bones to make large brain cavity compared to mammals as cited in Nickel *et al.* (1977).

Occipital bone: The occipital bone situated caudo-ventral aspect of skull was divided into three regions (ex-occipital, supra-occipital and basi-occipital) as observed in ostrich (Moselhy *et al.*, 2018). The three regions of occipital bone united and formed irregularly triangular shaped foramen magnum located at the base of the skull (Plate 3). The position of foramen magnum in common crow was characterized by more horizontal head posture, it was associated with reduced drag in flight (Winkler *et al.*, 2004). Supra-occipital or squamous part of occipital extended from dorsal part of foramen magnum to parietal bone superiorly. At the junction of supra-occipital and parietal bone elevated suture called nuchal crest was noticed. A similar pattern was obtained in Ostrich (Moselhy *et al.*, 2018). External occipital protuberance was noticed at the mid region. Ex-occipital bone consists of a fossa medially and a paraoccipital process laterally. A fossa was noted on the lateral aspect of foramen magnum and continued laterally underneath the paraoccipital process.

Below the paraoccipital process external acoustic meatus was placed. In the lateral aspect of fossa medial to external acoustic meatus hypoglossal foramen was noticed. The paraoccipital process was 'U' shaped structure in the crow, while it was V shaped in Indian Eagle owl and Horse shoe shaped in Flamingo (Sridevi *et al.*, 2020). Basi-occipital was located on the ventral aspect of foramen magnum and reached sphenoid bone cranially. A sharp elevated transverse crest was observed at basi-occipital sphenoid suture. An oval hemisphere shaped single occipital condyle was present at the ventral aspect of neurocranium, which helps in high degree of head rotation in birds. However, the shape of occipital condyle was round in crested serpent Eagle and Brown wood owl (Choudhary *et al.*, 2020), pear shaped in Emu (Kumar and Singh, 2014) and hemispherical in Ostrich (Moselhy *et al.*, 2018). The height and width of foramen magnum was measured as 0.60 ± 0.01 cm and 0.71 ± 0.02 cm, respectively. The foramen magnum index was calculated as 85.44 that indicates common crow might have well developed central nervous system like other predatory birds.

Parietal bone: In our study a distinct demarcation between frontal, parietal and occipital bones was observed by sutures (Plate 2). Both side of parietal bones were sutured at the central axis of the cranium. In line with previous study of Evans and Noden (2006), frontal and parietal bones were separated by curved fronto-parietal suture. Interparietal bone was absent like any other birds.

Sphenoid bone: Sphenoid bone was located at ventral aspect of the skull rostral to basi-occipital. It consisted of presphenoid and postsphenoid with their body and wings. A sharp crest demarcated the boundaries of two parts. Body of postsphenoid was triangular in shape and laterally attached with pair of temporal wings. The temporal wings extended laterally and joined with paraoccipital process of ex-occipital bone. There were no distinct muscular processes and grooves as observed in duck and goose (Nickel *et al.*, 1977). Presphenoid body was rod like structure, the orbital wings spread dorsally and laterally connected to frontal and temporal bones. The two sides of the orbital wings were connected at the central axis to form interorbital septum. The septum was perforated by a large inter orbital septal notch which extends from ethmoid to caudal aspect of the wings (Plate 3). Two optic foramina were observed on either side of the notch caudally. The body of the presphenoid had a tubercle at its posterior region in Indian eagle owl (John *et al.*, 2016), which was not seen in common crow.

Frontal bone: Frontal bone was the largest cranial bone located dorsally and formed roof of the cranial cavity. It was narrow at frontonasal hinge and broad more convex posteriorly near to parietal suture. A suture line was observed in-between the two sides of frontal bone. Frontal bone of common crow had three parts namely frontal part, nasal part and orbital part. There was no supraorbital process as reported in mammals. A frontal bone possessed postorbital process caudolateral aspect of orbit continued with lateral

border. There was no distinct supraorbital foramen (Plate 1). The orbital part extended caudomedially and formed interorbital septum which was notched. A large foramen was found on the caudodorsal aspect of orbital wing of frontal bone. The nasal part of the frontal bone was located in between the two orbits and connected to maxilla, nasal and lacrimal bones.

Ethmoid bone: The ethmoid bone was located anterior to the neurocranium and attached to nasal, frontal and sphenoid to make anterior boundary to the orbit and interorbital septum cranially.

Temporal bone: It was guarded by parietal bone dorsally, exoccipital laterally, postsphenoid bone medially. Temporal bone consisted ear capsule and squamous temporal bone. Ear capsule or osoticum was present between zygomatic process of squamous temporal and paraoccipital process of ex-occipital bone. The capsule was perforated ventrally by external acoustic meatus. Above the meatus a flat articular cavity was observed for otic process of quadrate bone. Squamous temporal part had two processes and fossa ventrally. A long pointed zygomatic process directed rostrally from the body. Orbital process was blunt and short (Plate 2, 3), while it was long in duck and goose, slender in Indian eagle owl, rudimentary in pigeon (Moselhy *et al.*, 2018). A temporal fossa was accommodated between two processes of squamous temporal bone. It was shallow in Common crow but deep and wide in Flamingo and Barn owl (Kumar *et al.*, 2017).

Viscerocranium of Common Crow

The viscerocranium of common crow composed of 11 bones to make the facial region. Mandible, vomer and hyoid bones were unpaired. Lacrimal, nasal, premaxilla, maxilla, zygomatic, palatine, quadrate and pterygoid bones were paired.

Lacrimal bone: Lacrimal bone of common crow was irregularly triangular in shape. The base directed upward and joined with frontal bone (Plate 2). Apex or lacrimal process pointed downward and continued by curved plate which was similar to the findings of John *et al.* (2016).

Nasal bone: Nasal bone consisted of body and 3 processes (intermaxillary, frontal and lateral). Intermaxillary process was attached with premaxilla anteriorly to construct an upper beak. Lateral process was extended laterally to form roof and lateral wall of nasal cavity. Frontal process travelled posteriorly and met the frontal bone to form frontonasal hinge (Plate 1, 2).

Premaxilla: The anterior most presented bone of the viscerocranium was premaxilla. It consisted of three processes namely nasal, palatine and maxillary processes (Plate 1, 2). The nasal process extended caudally, overlapped the nasal bone, reached frontonasal hinge to make a synovial joint which gives a characteristic feature of cranial kinesis of avian skull (Gussekkloo *et al.*, 2001). Maxillary process fused with maxilla to form lower boundary of anterior nares. Palatine process and palatine bone together formed hard palate. The

maximum of upper beak was made by premaxilla since the size of maxilla bone was reduced.

Maxilla: Maxilla bone was a small, delicate constituted of four processes and body. Premaxillary process runs rostrally to reach maxillary process of premaxilla to form ventral border of anterior nares. Palatine process runs medially to the palatine bone at the roof of oral cavity to form bony palate (Plate 1, 2). At the ventral region of maxilla two processes emerged passed towards the central axis to attach with pterygoid bone and progressed posteriorly to meet jugal bone as pterygoid process and jugal process, respectively.

Zygomatic or jugal bone: A slender extension from maxilla to quadrate bone was observed as jugal bone. The caudal end of jugal bone consisted of a tubercle for quadrato-jugal synovial articulation (Plate 3). The jugal bone of common crow was a straight in its course, however curved jugal bone was observed in crested serpent Eagle and Brown wood owl (Choudhary *et al.*, 2020).

Palatine: Palatine bone was a plate-like structure joined with premaxilla, maxilla and vomer rostrally to form roof of oral cavity. The caudal end reached upto pterygoid bone (Plate 3).

Pterygoid bone: Pterygoid bone was located at ventral aspect of the skull on either side of vomer bone. It formed a suture with palatine and maxilla rostrally and quadrate bone caudally.

Vomer: A long well-developed tubelike bone was inserted between two sides of pterygoid and presphenoid at the median plane of floor of nasal cavity (Plate 3). Nickel *et al.* (1977) reported rudimentary vomer bone in fowl and pigeon.

Mandible: Mandible of common crow was narrow and V shaped structure that built a lower beak. The two side horizontal rami joined rostrally to form mandibular symphysis. The superior border of the mandible had several small foramina on both medial and lateral aspect. Caudal region of rami had one large foramen called mandibular foramen. Articular part of the bone was located dorsocaudally with two facets for medial and lateral divisions of mandibular process of quadrate bone. Quadrato-mandibular joint was a movable joint. From the medial articular facet, a process runs upward medially (Plate 4). The length and width of the mandible bone was measured as 6.06 ± 0.45 cm and 1.96 ± 0.02 cm, respectively, while these were reported as 6.96 ± 0.02 cm and 3.89 ± 0.02 cm in crested serpent Eagle and 5.95 ± 0.02 cm and 4.88 ± 0.01 cm in Brown wood owl (Choudhary *et al.*, 2020). This indicates the oral cavity of common crow was narrow and pointed than other predatory birds.

Quadrate bone: A specialized quadrilateral bone which is present in avian skull had a body and three processes in common crow (mandibular, otic and orbital) (Plate 5). The mandibular process extended ventrally and possessed medial and lateral condyles. However, in hooded crow the mandibular process was divided into three condyles as medial, lateral and caudal (Hassan and El-Sayed, 2018)



Sulcus intercondylaris separated the condyles. Wide, flat medial and dorsal extension was called as orbital process that would reach the orbital cavity. Otic process directed backward and upward and embedding with in ear capsule at temporal region. Small tubercle was found between orbital and mandibular processes as described by Choudhary *et al.* (2020). The quadrato jugal bone connect the upper and lower part of skull bone and enable the kinesis.

Orbital cavity was formed by frontal dorsally, sphenoid, ethmoid and orbital plate of frontal bones medially. The anterior and posterior boundaries were marked by lacrimal and frontal, respectively. Pterygoid process of palatine and pterygoid reached some extent of medial aspect of orbit. Interorbital septum was formed by postsphenoid, presphenoid and ethmoid bone with interorbital septal notch. Maxilla, premaxilla and nasal bones guarded the elongated oval shaped anterior nares.



Plate 1: Photograph showing dorsal view of skull of Common crow (PM- Premaxilla; NP- Nasal process of premaxilla; IMP-Intermaxillary process of Nasal; N-Nasal; M- Maxilla; F- Frontal; J- Jugal; P Parietal and dotted line- Frontonasal hinge)

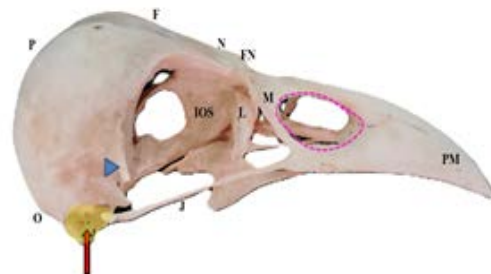


Plate 2: Photograph showing lateral view of skull of Common crow (PM-Premaxilla;FN- Frontonasal hinge; N-Nasal; L- Lacrimal; IOS- Inter Orbital Septum;O- Occipital; M- Maxilla; F- Frontal; J- Jugal; P Parietal and dotted line-Anterior nares; Arrow- External acoustic meatus and yellow coloured area shows ear capsule)

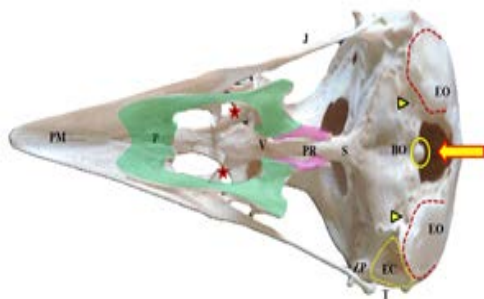


Plate 3: Photograph showing ventral view of skull of Common crow (PM- Premaxilla; P-Palatine (Green); V- Vomer; PR- Presphenoid; S- Post sphenoid;BO- Basi occipital; EO-Ex occipital;T- Temporal; EC- Ear capsule (yellow dotted line); ZP- Zygomatic process of temporal; J- Jugal; Arrow- Foramen magnum; Red dotted lines- Para occipital process; Arrowheads- Hypoglossal foramen; Star- Palatine process of maxilla and pink coloured area showed pterygoid bones)



Plate 4: Photograph showing dorsal view of Mandible and Quadrate bones of common crow (MS- Mandibular Symphysis; Arrows- Mandibular foramen; Circle- Facets for Quadrate bone)



Plate 5: B- Photograph showing Quadrate bone of common crow (Body; MM- Medial Mandibular Process; ML- Lateral Mandibular Process; S- Sulcus intercondylaris; O- Orbital process; OT- Otic process and T- Tubercle)

CONCLUSION

The results of this study indicate that the common crow's skull has neurocranium and viscerocranium bones, but no interparietal bone. The shape and components of the skull differed from those of other flying birds, both domestic and predatory.

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