GROSS ANATOMY OF THE SPLANCHNOCRANIUM IN GREEN-WINGED MACAW

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ABSTRACT

A study was conducted on the gross features of the splanchnocranium of eight year old male Green-winged macaw and their morphological peculiarities were correlated with its possible functions. The horizontal plate of ethmoid was well developed and broad. The lacrimal was very large and the orbit was completely ringed with bone. The steeply down curved premaxilla with its hooked tip gave the distinctive character to the broad-based bill. The external nares were small and circular. The maxilla formed movable articulation with both the palatine and zygomaticus. The zygomaticus was rod like and formed a movable articulation with the maxilla cranially and quadrate caudally. The paired palatines were vertical in position and formed a strong bone of the upper jaw. The pterygoid was a rod like bone which articulated with only the palatine cranially and quadrate caudally. The quadrate was semicircular. The mandible was horse-shoe shaped with wide vertical thickened rami. The dentine presented a toothed-cutting edge to which the horny beak was attached. The fronto-nasal synovial hinge joint was highly mobile and supported the well developed prokinesis seen in this bird.

Keywords: *Green-winged macaw, splanchnocranium, gross anatomy*

INTRODUCTION

The size of splanchnocranium is largely dependent on the diet and feeding habits of the bird (Nickel *et al*., 1986). The Green-winged macaw is an intelligent bird with diverse feeding habits. Information on the anatomical peculiarities of this bird is scanty. Hence, an effort has been made to record the morphological variations in the splanchnocranium and to correlate it with their possible functions.

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MATERIALS AND METHODS

The bones of splanchnocranium were collected from eight year old male Green-winged macaw died of natural causes and brought to the Department of Pathology for postmortem examination. After natural maceration the bones were cleaned and observed for gross anatomical features.

RESULTS AND DISCUSSION

The bones of splanchnocranium enclosed the orbital, nasal and oral cavities. They were lacrimal, nasal, premaxilla, maxilla, zygomatic, palatine, pterygoid, vomer, quadrate and mandible. The ethmoid was shared by both neurocranium and splanchnocranium. The boundaries of the individual bones were difficult to identify because the sutures between many of them were lost (Nickel *et al*., 1986).

The ethmoid consisted of two parts *viz.*, a horizontal plate which separated the orbital and nasal cavities and a perpendicular plate. The horizontal plate was present craniodorsally and formed the cranial wall of orbit. It was well developed and broad and was filled with spongy bone. The paired olfactory foramen located in it, were large and widely separated and served for the passage of the olfactory nerves into the nasal cavity. The perpendicular plate was thick and formed the interorbital septum and continued rostrally into the nasal cavity as the nasal septum. Contrarily in domestic fowl and Japanese quails, the ethmoid was thin and small and formed the cranio-dorsal wall of the orbit and the olfactory foramen was present in the dorsomedial part of the perpendicular plate (Fitzgerald, 1969; Nickel *et al*., 1986). The wide horizontal plate of ethmoid seen in Green-winged macaw might be an adaptation to accommodate the well developed nasal, lacrimal and premaxilla. It also formed the strong posterior base of the cranio-facial hinge.

The lacrimal was very large unlike the observations made in Japanese quail (Fitzgerald, 1969) and domestic fowl (Nickel *et al*., 1986). It fused with the frontal behind and formed a movable joint with the nasal called as cranio-facial hinge (Fig.1). The caudo-ventrally directed lacrimal process was very well developed and fused with the orbital process of temporal to form a small nearly circular complete lower orbital ring (Fig.2). Internally it united with the horizontal plate of ethmoid and olfactory foramen could be seen in it. Externally the cranioventral arc of the orbital ring was marked by a longitudinal concave notch (Fig.2). On the contrary, the bony orbit in chicken was exceptionally large as reported by Mc Lelland (1990). Moreover in duck, fowl and Japanese quail the lacrimal process was absent and ventral wall of the orbit was incomplete (Fitzgerald, 1969; Nickel *et al*., 1986).

Nasal bones formed part of the skeleton of upper beak and greater part of the roof of nasal cavity. It consisted of three well developed processes viz. frontal, intermaxillary and maxillary as described by Nickel *et al*. (1986) in domestic fowl, but they were comparatively well developed in Green-winged macaw. The maxillary and intermaxillary process formed the cranial border of the small external nares (Fig.1).

The paired premaxilla constituted the largest part of the upper jaw and was covered by the horny beak as reported by King and Mc Lelland (1975) in aves. It was composed of a body and three pairs of well developed processes *viz.*, frontal, palatine and maxillary (Fig.1). The maxillary process supported part of the beak and were joined to the maxillary bones. The palatine process was large and spongy and united with one another and with the ossified nasal septum and filled the whole base of the beak (Fig.3). These findings are contrary to the observations made by Nickel *et al*. (1986) in fowl, who reported that the palatine processes were very narrow with a broad cleft in between them. The frontal process were fused medially and reached up to the frontal bones. The body was encased in the upper beak to which it confirmed in shape as reported in parrots by Dyce *et al*. (2002). It was highly arched in the middle and hooked at the tip and was located in the arc of a circle extending from the craniofacial axis to the tip of the beak. The conical, curved beak of Green-winged macaw made it ideal for cracking shells. The maxillary and intermaxillary process of nasal fused with the frontal and maxillary process of premaxilla to form the small circular external nares (Fig.1). Contrarily in fowl, turkey, guinea fowl and crow, Patki *et al*. (2009) reported that the external opening to nasal cavity was elliptical and large. The small external nares in Green-winged macaw might be an adaptation to strengthen the oversized beak which aided in prehension of food and locomotion.

The maxilla formed the caudal rim of upper beak and formed part of the caudal extremity of the bony palate. It was fused with the nasal and premaxilla. It presented the palatine and zygomatic processes to form a movable articulation with the respective bones. However, Getty (1975) reported that in domestic fowl, the maxilla was fused with the palatine and zygomatic.

The zygomatic was rod like and formed a movable articulation with the maxilla cranially and quadrate caudally (Fig.4). The maxillary portion of the zygomatic was flattened and inserted to the posterior edge of beak on a higher plane than the insertion of palatines. This was contradictory to the reports made by Patki *et al*. (2009) in fowl, turkey, guinea fowl and crow, that the zygomatic bones were thin, rod-like elongation of the rim of upper beak and articulated with hemispherical fossa of quadrate bones.

The extraordinarily fashioned paired palatines were vertical in position and formed a strong bone of the upper jaw (Fig.4). However, Dyce *et al*. (2002) reported that in fowl, pigeon and Japanese quail the palatine was caudally directed rod connecting the premaxilla with pterygoid. In contrast Patki *et al*. (2009) stated that in crows it was rod shaped cranially and plate-like caudally. In the present study it was observed that the palatines were horizontally flattened cranially and inserted above the caudal part of the maxilla to meet the lower part of the nasal septum. Proceeding backwards from this horizontal extremity, the palatine was seen to contract and a broad, spindle shaped cavity existed between them (Fig.3). Thereafter it formed a broad and oblong vertical plate with a divergent angle which formed the lateral osseous borders of caudal nares (Fig.4). The vertical plates presented a dorsal and ventral margin. The dorsal margin was rounded and caudally articulated with the sphenoid. The anterior one third of the ventral margin of this vertical plate was flattened plate like and met the corresponding edge of the bone of the opposite side (Fig.3). The corresponding pterygoids articulated at its caudal part. The posterior part of the ventral margin of this plate was deeply notched and anterior two-thirds of the corresponding pterygoids rested on it (Fig.4).

Both the medial and lateral surfaces of the palatine plates showed ridges for the insertion of the strong jaw muscles. These features could be an adaptation towards the diverse feeding habits of this bird.

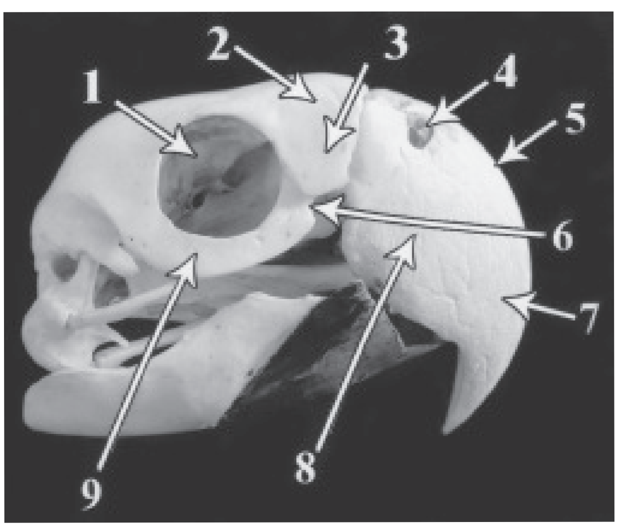
The pterygoid was seen as a rod like bone which articulated with the palatine in front and quadrate behind (Fig.4). This is in contradiction to the observations of Nickel *et al.*(1986) in fowl that it was short and flattened bone which articulated with the palatine and sphenoid cranially and quadrate caudally. The vomer was unpaired thin bony plate which articulated rostrally with the fused maxilla and caudally with the rostrum of sphenoid bones as in fowl (Getty, 1975).

The quadrate formed a link between the skull and lower jaw and formed the basis of the mechanism of kinesis as stated by Nickel *et al.* (1986) in domestic fowl. It was semicircular in shape and presented three processes viz. otic, articular and orbital (Fig.4). Angle between the otic and orbital processes was observed to be obtuse. However, Patki *et al.* (2009) described that in fowl, turkey, guineafowl and crow the quadrate was quadrilateral in shape. The angle between the otic and orbital processes was observed to be obtuse in crow and guinea fowl but in fowl it formed a right angle. The otic process formed a movable joint with the articular groove of the squamous temporal (Fig.4). It was stout and sub cylindrical rod like structure with convex articular facets at its summit. These were divided by a notch into a smaller inner and larger outer facet. Pneumatic foramen was seen near it. The articular process was strong and semicircular and presented a well developed condyle caudo-ventrally to articulate with the mandible (Fig.4). Cranio-ventrally it articulated with the pterygoid bones. Middle of the lateral surface of articular process presented a conical projection with a pit at its apex for articulation with the caudal end of zygomatic bone (Fig.4). The orbital process was directed towards the orbit. But these features differed in domestic fowl as reported by Nickel *et al.* (1986) who stated that the articular process presented a facet medially for articulation with pterygoid. Further Patki *et al.* (2009) observed that in crow caudoventral part of the lateral surface of articular process had a hemispherical fossa articulating with zygomatic and in fowl, turkey and guinea fowl a corresponding notch was present. The well developed strong quadrate formed the pivotal bone of the kinetic jaw mechanism and also served in jaw suspension.

The mandible was horse-shoe shaped. Each half of the mandibular rami was made up of five parts viz., angular, articular, supraangular, splenial and dental bones which were fused into a single structure as observed by Getty (1975) in domestic fowl (Fig.5). The lingual surface was deeply concave and wider than in fowl. The mental surface was convex transversely and concave longitudinally. The two rami formed wide vertical thickened deep plates which were smooth laterally and irregular medially. But in domestic fowl Dyce *et al.* (2002) reported that the rami were thin long plates fused rostrally and contributed only marginally to the height of the head. While in the present study it was observed that the well developed mandible contributed to about forty percent of the height of the head (Fig.1). The rami diverged from the body to form a mandibular space (Fig.5). The angular part of the mandible was L-shaped with an internal medial condyloid process and the posterior or angular process which curved upward and outward. To the inner side of the articular part a protrusion was present to support the concave longitudinal glenoid cavity for articulation with the quadrate bone (Fig.5). Behind the glenoid cavity a pit was present with several pneumatic foramina. A coracoid process, thick and wide was found in front of the articular area and formed the widest part of the ramus called the supraangular part. The largest and most rostral of the bones of lower jaw was the dentine which presented a toothed-cutting edge to which the horny beak was attached (Fig.5). Contrarily in Japanese quail (Fitzgerald, 1969) and domestic fowl (Nickel *et al*., 1986) the mandible was reported to be V–shaped and the dentine narrowed in front to a round flat point.

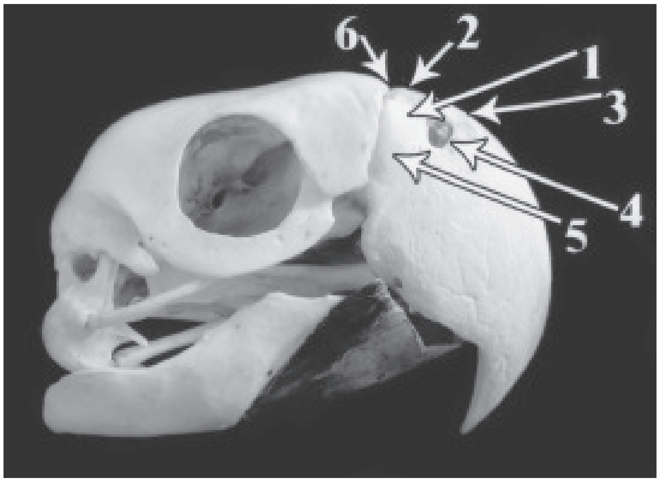
The maxillopalatine apparatus was formed by the articulation of quadrate with squamous temporal, zygomatic, pterygoid and mandible. Other contributions of this apparatus were formed by the articulations of the palatine bones with the sphenoid, pterygoid and maxilla as reported in aves by Nickel *et al*. (1986). The strong and well developed bones of the maxillopalatine apparatus in Green-winged macaw permitted the bird to move its upper jaw vertically. The caudal extremities of nasal formed a synovial hinge joint with the frontal and lacrimal bones called as the fronto-nasal hinge which was highly mobile and supported the well developed prokinesis as reported in psittacine by Dyce *et al*. (2002). However in the domestic fowl and ducks, between the nasal and frontal bones a cranio-facial elastic zone was seen where the bones were thin and flexible in contrast to the synovial hinge joint seen in parrots (Mc Lelland, 1990). Thus the Green-winged macaw has a versatile beak which has great deal of dexterity and is very useful in manipulating and cracking hard seeds and nuts.

Fig.1. Skull of Green-winged macaw (Lacrimal & premaxilla) – Cranio-lateral aspect



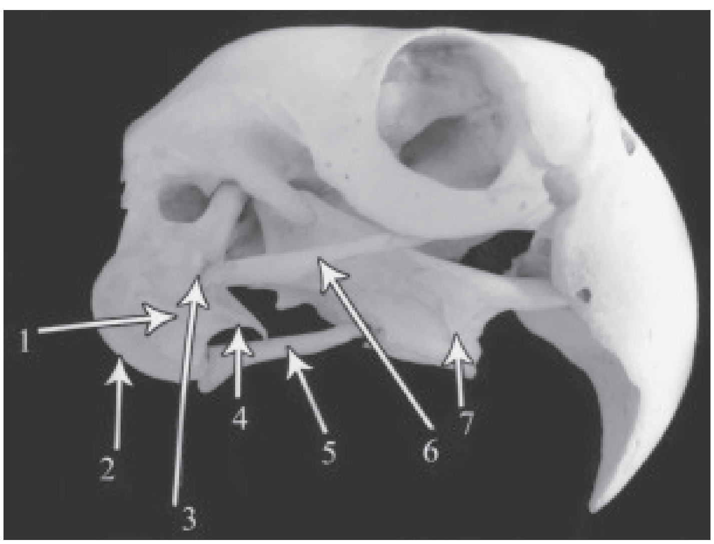
1. Orbit
2. Lacrimal
3. Lacrimal process
4. External nares
5. Frontal process of premaxilla
6. Notch
7. Premaxilla
8. Maxillary process of premaxilla
9. Orbital process of temporal

Fig. 2. Skull of Green-winged macaw (Nasal) – Cranio-lateral aspect



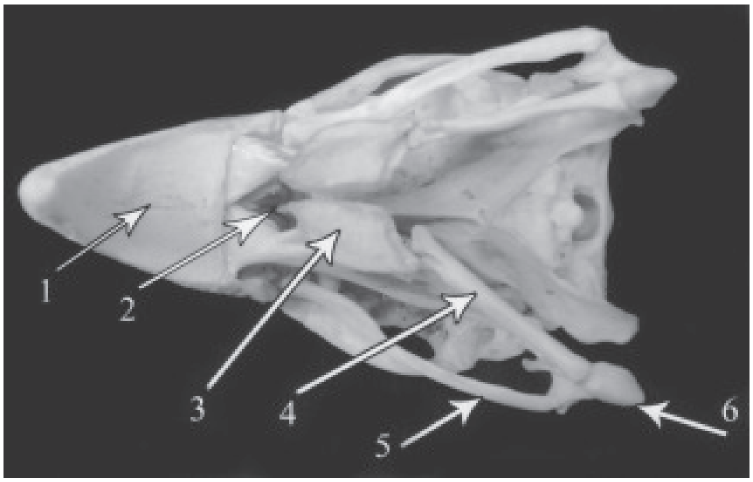
1. Frontal process of nasal
2. Nasal
3. Intermaxillary process of nasal
4. External nares
5. Maxillary process
6. Fronto-nasal hinge

Fig. 3. Skull of Green-winged macaw – Lateral aspect



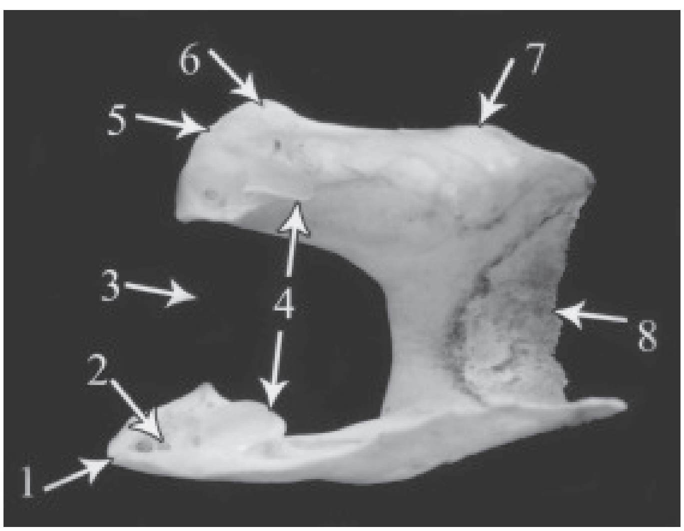
1. Quadrate
2. Articular process (condyle)
3. Articular area for zygomatic
4. Orbital process
5. Pterygoid
6. Zygomatic
7. Palatine

Fig. 4. Skull of Green-winged macaw – Ventral aspect



1. Palatine process of Premaxilla
2. Spindle shaped cavity
3. Ventral margin of vertical plate of palatine
4. Pterygoid
5. Zygomatic
6. Quadrate

Fig. 5. Mandible of Green-winged macaw – Dorsal aspect



1. Angular part
2. Pneumatic foramen
3. Mandibular space
4. Articular facet for Quadrate in Articular part
5. Supraangular part
6. Coracoid process
7. Splenial
8. Dental with toothed-cutting edge

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