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Gross anatomical studies on the sternum of blue and yellow macaw (*Ara ararauna*)

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Abstract

The sternum of blue and yellow macaw was comprised of a manubrium sterni or sternal spine, a body and a sternal crest. The manubrium sterni was thick upwardly bent spine-like process arose only from the ventral edge of the cranial border. At the base of the sternal spine on left side, a large pneumatic foramina was noticed. The body of the sternum was rectangular in shape. In the cranial half presented numerous small pneumatic foramina. Two large oval foramina, the foramen ovale were located near the caudal border. The cranial border of the sternum was convex, thick and semicircular in shape. The craniolateral process was very short, roughly quadrilateral in shape and dorsolaterally directed. The lateral borders presented five transversely placed thin and short articular cylinders. The caudolateral process was short, broad and thin. It extended up to the caudal border of the sternum and fused with it and formed caudal border of the sternum. The sternal crest was well developed, triangular in shape, and projected from below the sternal spine. The cranial border of the sternal crest was the cranial most structure of the sternum. It formed a steep backward curve and extended up to the caudal border of the sternum. The processus thoracicus was absent.

Keywords: Sternal crest, sternal spine, craniolateral process, caudolateral process

Introduction

The sternum is large unsegmented bone, which with its processes forms a considerable part of the ventral body wall. It gives attachment to the large flight muscles (Dyce *et al.*, 2010) [1]. The blue and yellow macaw is blue, with a green crown and a yellow underside, a white face, gray eyes and black feet and bill. They are found in the tropical rain forests from Brazil to Mexico. They belong to the class-Aves, order - *Psittaciformes*, family - *Psittacidae*, genus - *Ara* and species - *Ararauna* (Steiner and Davis, 1981) [2]. The present study was undertaken to evaluate the morphological and morphometric features of the sternum of blue and yellow macaw because the information available is scanty.

Materials and methods

The carcass of three blue and yellow macaws from M/s. Cavin Solai Avian Breeding and Research Centre (ABRC), Injambakkam, Chennai, India brought to Department of Poultry Science, Madras Veterinary College, Chennai, India were utilised for the present study. After the post-mortem examination the carcasses were allowed for biological maceration. The soft tissues were eaten by maggots. The disintegrated skeleton was cleaned with fresh water and soaked in 10-15% NaHCO₃ solution for whitening. The skeleton is then dried and morphological and morphometric studies were performed. Vernier caliper and ruler were used for morphometry.

Results and discussion

The sternum of blue and yellow macaw was comprised of a rostrum or manubrium sterni or sternal spine, a body or corpus sterni and a keel or sternal crest (Fig.1) as observed by John *et al.* (2014) [3] in pigeon hawk.

The body of the sternum was rectangular in shape. The cranial border was 4.3 cm wide, in the centre it was constricted and 3.6cm wide and the caudal border was 5.0cm wide. The length was 8.1cm from middle of the cranial border to the caudal border (Fig.2). It is in agreement with the findings of Nickel *et al.* (1977) [4] in duck and goose, John *et al.* (2014) [3] in pigeon hawk and Sreeranjini *et al.* (2015) [5] in green-winged macaw. But the sternum is relatively long and narrow in chicken (Dyce *et al.*, 2010) [1], large and bowl shaped in emu (Jagapathi *et al.*, 2007) [6].

The dorsal surface was deeply concave in the cranial half but in the caudal half it was wide and shallow (Fig.2) and the ventral surface was convex (Fig.3). Similarly, John *et al.* (2014) ^[7] observed that in pigeon the dorsal surface was concave in the anterior two - third portion only, whereas the remaining surface was almost flat.

The dorsal surface of the body presented a shallow median groove in the centre. In the cranial half presented numerous small pneumatic foramina in the midline, as well as in the cranial and craniolateral borders. A large foramina was noticed behind the cranial border in the centre (Fig.2) as observed by Sathyamoorthy *et al.* (2012) ^[8] in spot-billed pelican, John *et al.* (2014) ^[3] in pigeon hawk and Sreeranjini *et al.* (2015) ^[5] in green-winged macaw. Nickel *et al.* (1977) ^[4] observed that apart from numerous smaller air holes there is strikingly large pneumatic foramen behind the thickened cranial border of the sternum in chicken.

Two large oval foramina, the foramen ovale (Fig.2) enclosed by the medial border of the caudolateral process and lateral border of the sternal body were located near the caudal border as in pigeon (Nickel *et al.*, 1977) ^[4], pigeon hawk (John *et al.*, 2014) ^[3] and green -winged macaw (Sreeranjini *et al.*, 2015) ^[5]. But in fowl, duck and goose (Nickel *et al.*, 1977) ^[4] and spot- billed pelican (Sathyamoorthy *et al.*, 2012) ^[8] only incisura ovale (oval notches) are present.

The cranial border of the sternum was convex, thick and semicircular in shape. It's dorsal border was directed upward and slightly backward and gave 'C' or 'U' shaped appearance (Fig.2). However, the cranial border was triangular in pariah kite (Tomar *et al.*, 2011) ^[9] and in peacock and turkey (Pathak *et al.*, 2017) ^[10]. It presented a deep groove on either side to receive the cylindrical distal ends of the coracoid bone as described by Nickel *et al.* (1977) ^[4] in fowl, duck, goose and pigeon and Choudhary *et al.* (2018) ^[11] in crested serpent eagle. The grooves were separated by a faint ridge in the centre. The dorsal edge of the cranial border was thick medially and thin laterally on either side and showed small spiny projections and showed a notch in the centre, whereas the ventral edge was thin and sharp.

The craniolateral process was very short, roughly quadrilateral in shape and dorsolaterally directed (Fig.2) as observed by Sreeranjini *et al.* (2015) ^[5] in green-winged macaw and Choudhary *et al.* (2018) ^[11] in crested serpent eagle. Nickel *et al.* (1977) ^[4] reported that, this process is very large in the fowl, very short in the pigeon and small in duck and goose. In emu, the craniolateral process was short wide and flattened (Jagapathi *et al.*, 2007) ^[6]. In peacock, turkey, duck and white breasted water hen the processes lateralis cranialis was craniolaterally directed (Pathak *et al.*, 2017) ^[10]. This process was short in pigeon hawk (John *et al.*, 2014) ^[3], highly developed in mynah, moderately developed in Himalayan bulbul and least in house sparrow (John *et al.*, 2017) ^[12].

The lateral borders of the sternal body behind the craniolateral processes present five transversely placed thin and short articular cylinders (Fig.1) for the sternocostal bones as observed by sathyamoorthy *et al.* (2012) ^[8] in spot-billed pelicans. But in contrary six articular facets are present in green- winged macaw (Sreeranjini *et al.*, 2015) ^[5] and in pigeon hawk (John *et al.*, 2014) ^[3], and 4 pairs in emu and turkey and 7 pairs in duck Jayachitra *et al.* (2015) ^[13]. Mynah, Himalayan bulbul and house sparrow presented 5,5 and 4 costal facets, respectively (John *et al.*, 2017) ^[12]. Between each pair of articular cylinders, there were numerous

pneumatic foramina present, which lead into the sternum, as in fowl, pigeon, duck and goose (Nickel *et al.*, 1977) ^[4].

In blue and yellow macaw the caudolateral process was short (2.0 cm), broad and thin. It extended up to the caudal border of the sternum and fused with it and formed the convex part of the caudal border of the sternum (Fig.2) as observed by Nickel *et al.* (1977) ^[4] in pigeon. In fowl, this caudolateral process is very long and narrow and widens out at it's caudal extremity. It runs more or less parallel with the middle piece of the sternum, thus forming and elongated incisura ovalis (Nickel *et al.*, 1977) ^[4]. Jagapathi *et al.* (2007) ^[6] observed that the caudolateral processes were absent in emu.

The processus thoracicus was absent in blue and yellow macaw, and also absent in green-winged macaw (Sreeranjini *et al.*, 2015) ^[5], duck and white-breasted water hen (Pathak *et al.*, 2017) ^[10] and crow and owl ^[7] and lapwing ^[14] (John *et al.*, 2014, 2015). Whereas it arises independently in pigeon, but with the caudolateral process in fowl (Nickel *et al.*, 1977) ^[4], and peacock and turkey (Pathak *et al.*, 2017) ^[10].

The caudal border of the sternum was broad (5.0cm), thick, convex in the middle and concave on either side (Fig.2). There were no notches present in the caudal border. John *et al.* (2014) ^[3] noticed that, in pigeon hawk, the caudal border was concave in the middle part and convex on the lateral parts. But in contrary the caudal border present notches in fowl, duck and goose (Nickel *et al.*, 1977) ^[4], crow (John *et al.*, 2014) ^[7], and peacock, turkey, duck and white-breasted water hen (Pathak *et al.*, 2017) ^[10].

In blue and yellow macaw, the manubrium sterni or sternal spine was thick, upwardly bent spine-like process arose only from the ventral edge of the cranial border (Fig.1). It's dorsal surface was continuous with the caracoid groove. Ventrally it was continuous with the sternal crest. At the base of the sternal spine on left side, a large pneumatic foramina (Fig.3) was noticed. Sreeranjani *et al.* (2015) ^[5] observed that in green-winged macaw the sternal spine was hook-like, stronger, taller and wider than in fowl. They opined that a stronger rostrum in macaw is indicative of better developed sternoclavicular membrane. In spot-billed pelicans the sternal spine was thick, triangular process with sharp edges and extended form the ventral edge of the groove of the cranial border. It had openings on either side near the ventral border (Sathyamoorthy *et al.*, 2012) ^[8]. The sternal spine was smaller and located just below the cranial border in crested serpent eagle (Choudhary *et al.*, 2018) ^[11], and it was in the form of pointed process in pigeon hawk (John *et al.*, 2014) ^[3]. The sternal spine was 'Y' shaped in common mynah, Himalayan bulbul and house sparrow (John *et al.*, 2017) ^[12] and crow, whereas it was pointed in pigeon and highly reduced in owl (John *et al.*, 2014) ^[7]. A noteworthy feature of the sternum in bulbul was the presence of pneumatic foramen at the base of rostrum.

In fowl (Nickel *et al.*, 1977) ^[4] and in turkey and peacock (Pathak *et al.*, 2017) ^[10] two processes arise from the dorsal and ventral edges of the groove which fuse into a medium vertical bony plate, leaving an opening between them. In the pigeon they remain separate, while in the duck and goose (Nickel *et al.*, 1977) ^[4] and white breasted water hen (Pathak *et al.*, 2017) only the ventral process was present and it formed a single pointed projection. In contrary in pariah kite the rostrum is absent (Tomar *et al.*, 2011) ^[9].

In blue and yellow macaw, the sternal crest or keel was well developed, triangular in shape, and it projected from below the sternal spine. It formed a steep backward curve and

extended up to the caudal border of the sternum. The height of the sternal crest reduced gradually from the cranial to caudal end (Fig.3). It is in accordance with the observations of Nickel *et al.* (1977) ^[4] in pigeon. In blue and yellow macaw the cranial border of the sternal crest was concave and thin above and convex and thick below as observed by Sreeranjini *et al.* (2015) ^[5] in green - winged macaw. The cranial border of the sternal crest was the cranial most structure of the sternum. In spot - billed pelicans the sternal crest was triangular, small and extended only up to the cranial half. It's cranial border was straight, sharp and extended beyond the cranial border of the sternum. The clavicle was fused to the cranial border of the sternal crest permanently (Sathyamoorthy *et al.*, 2012) ^[8]. In common moorhen (Wani *et al.*, 2017) ^[15] and in peacock, turkey and white-breasted water hen (Pathak *et al.*, 2017) ^[10] the sharp cranial end of the crest was concave and did not reach to the cranial border of the sternum.

In common myna, Himalayam bulbul and house sparrow the keel was highly developed triangular structure. In mynah and sparrow the tip of the base is in level with the rostrum, whereas in bulbul it was just in front of the cranial end of the sternal body (John *et al.*, 2017) ^[12]. In pigeon hawk, the sternal crest was triangular, the base of the crest was straight, thick and in line with the cranial border, but terminated well before the caudal border (John *et al.*, 2014) ^[3]. Nickel *et al.* (1977) ^[4] observed that, the sharp cranial end of the crest is

concave in fowls and pigeons but straight in duck and goose. It does not extend to the cranial border of the sternum in the fowl. It's slightly thickened ventral border is somewhat concave in the fowl, duck and goose.

In the present study it was also observed that the sternal crest presented a thickening extending from the base of the sternal spine up to the middle on either side (Fig.3). The lateral surfaces of the sternal crest and the convex ventral surface of the sternal body presented a sharp ridge extending from the cranial border to the caudal border (Fig.3). Above the ridge the sternal crest was thin and rough, below the ridge it was smooth and thick. These ridges and roughened surfaces give better anchorage to the flight muscles.

Summary

The body of the sternum was rectangular, concave dorsally and convex ventrally. The foramen ovale were located near the caudal border. The cranial border of the sternum was convex, thick and semicircular in shape. The craniolateral process was very short. Five articular cylinders for the sternocostal bones were present. The caudolateral process was short, broad and thin. The processus thoracicus was absent. The caudal border of the sternum was convex in the middle and concave on either side. The sternal spine was thick upwardly bent spine-like process. The sternal crest or keel was triangular and well developed.

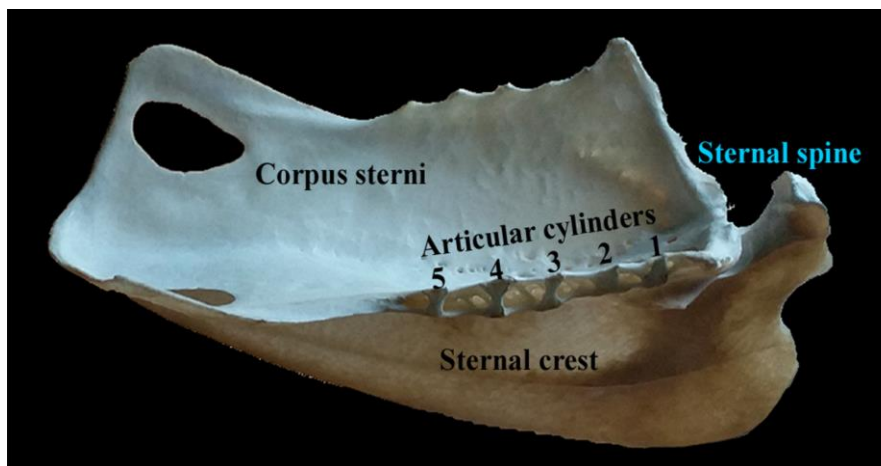


Fig 1: Photograph showing dorsolateral view of the sternum of blue and yellow macaw

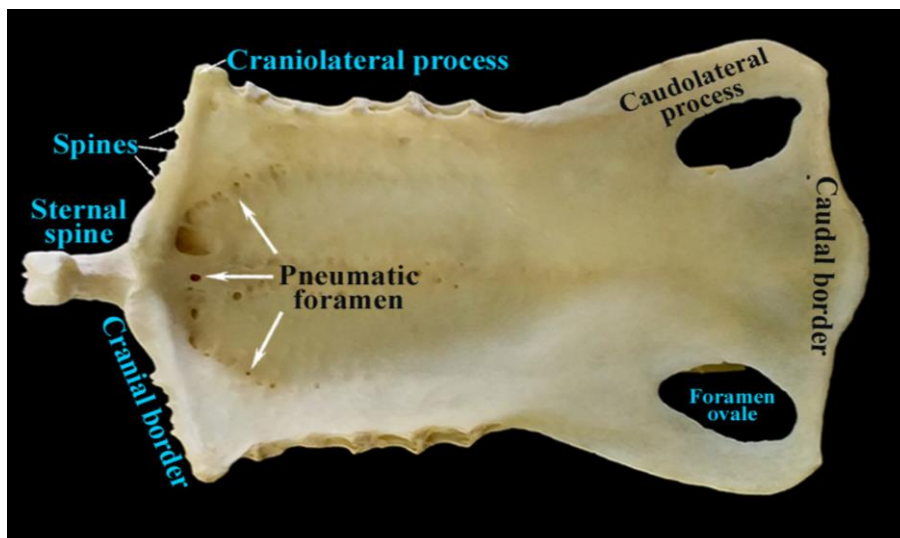


Fig 2: Photograph showing dorsal view of the sternum of blue and yellow macaw

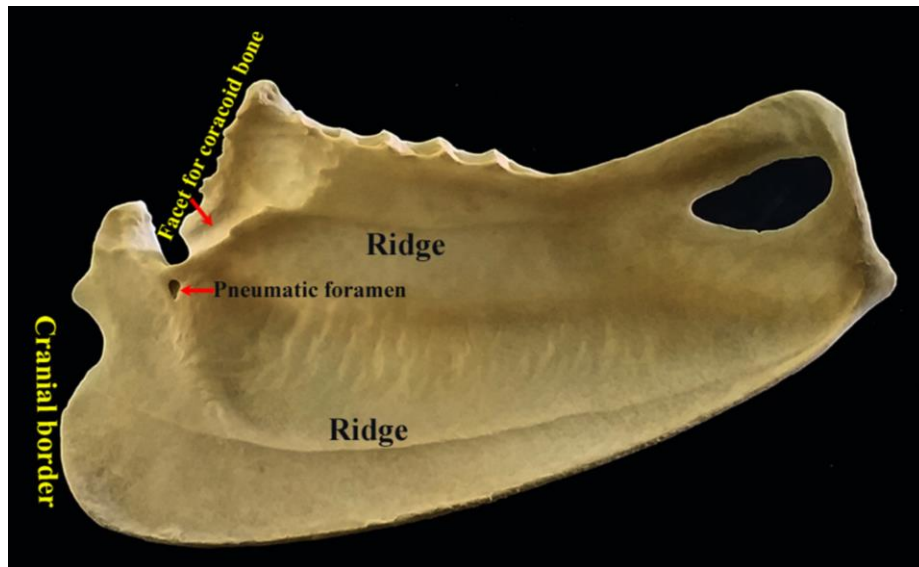


Fig 3: Photograph showing ventrolateral view of the sternum of blue and yellow macaw

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References

1. Dyce KM, WO Sack, Wensing CJG. Text book of Veterinary Anatomy. Edition 4 edition, Saunders Elsevier, St. Louis, Missouri, 2010, 784-813.
2. Steiner CV, Davis RB. Caged bird medicine. Edn 1, Iowa state university press, Ames, Iowa. 1981; I:9.
3. John MA, Mamde CS, Baba OK, Rohankar RU. Anatomical studies on sternum of pigeon hawk (*Falco columbarius*). Indian J. of Poult. Sci. 2014; 49(2):231-233.
4. Nickel R, Schummer A, Seiferle E. Anatomy of the Domestic Birds. Edn 1, Verlag Paul Parey, Berlin, Hamburg. 1977; 1:10-12.
5. Sreeranjini AR, Ashok N, Indu VR, Lucy KM, Maya S, Chungath JJ. Gross anatomical features of the sternum of green-winged macaw (*Ara chloroptera*). Indian J. Anim. Res., 2015; 49(6):860-862.
6. Jagapathi RP, Chandrasekhara Rao TS, Shanti LM, Ravindra Reddy Y. Gross anatomical studies on the sternum and ribs of emu (*Dromaius novaehollandiae*). Indian J. Poult. Sci. 2007; 42:112-114.
7. John MA, Sasan JS, Ahmed K, Tomar MPS, Ahmad A, Singh AD. Morphometry of sternum of pigeon, crow and owl. Indian Vet. J. 2014; 91(03):40-41.
8. Sathyamoorthy OR, Thirumurugan R, Senthilkumar K, Jayathangaraj MG. Gross anatomical studies on the sternum and clavicle of spot-billed pelican (*Pelecanus philippensis*). Tamil Nadu J. Veterinary & Animal Sciences. 2012; 8(3):166-170.
9. Tomar MPS, Vsish R, Parmar ML, Shrivastav AB, Tiwari Y. Gross morphometrical studies of sternum of pariah kite (*Milvus migrans*). Vet. Wld. 2011; 4:171-172.
10. Pathak A, Gupta SK, Verma A, Farooqui MM, Prakash A, Kumar P. Comparative gross anatomy of the sternum in peacock (*Pavo cristatus*), turkey (*Meleagris gallopavo*), duck (*Anas platyrhynchos*) and white-breasted water hen (*Amaurornis phoenicurus*). Journal of Animal Research. 2017; 7(3):501-505.
11. Choudhary OP, Kalita PC, Rajkhowa TK, arya RS, Kalita A, Doley PJ. Gross morphological studies on the sternum of crested serpent eagle (*Spilornis cheela*). Indian J. Anim. Res. 2018, 0367-6722.
12. John MA, Khan M, Quadir A, Choudhary AR, Baba MA, Dar FA *et al.* Sternal morphometry of common myna (*Acridotheres tristis*), Himalayan bulbul (*Pycnonotus leucogenys*) and house sparrow (*Passer domesticus*). Applied biological research. 2017; 19(1):237-240.
13. Jayachitra S, Balasundaram K, Paramasivan S. Comparative gross anatomical studies on the sternum of emu, turkey and duck. J Animal Research. 2015; 5(2):385-387.
14. John MA, Baba MA, Khan M, Dar FA, Sheikh AR. Gross morphological studies on sternum and shoulder girdle of red wattled lapwing (*Vanellus indicus*). Indian J Vet. Anatomy. 2015; 27(2):18-20.
15. Wani SUA, Pathak SK, John MA, Ahmad K, Sheikh FA, Ishaque S. Gross morphological studies on sternum of common moorhen (*Gallinula chloropus*). Int. J Curr. Microbiol. App. Sci. 2017; 6(6):1489-1492.