Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
www.entomoljournal.com
JEZS 2020; 8(2): 51-54

Received: 04-01-2020
Accepted: 06-02-2020

Sridevi P
Department of Veterinary Anatomy and Histology Rajiv Gandhi Institute of Veterinary Education and Research, Puducherry, India

Rajalakshmi K
Department of Veterinary Anatomy and Histology Rajiv Gandhi Institute of Veterinary Education and Research, Puducherry, India

SivaKumar M
Department of Veterinary Anatomy and Histology Rajiv Gandhi Institute of Veterinary Education and Research, Puducherry, India

Corresponding Author:
Sridevi P
Department of Veterinary Anatomy and Histology Rajiv Gandhi Institute of Veterinary Education and Research, Puducherry, India

Comparative gross anatomical studies on the shoulder girdle of great Indian horned owl, pigeon and crow

Sridevi P, Rajalakshmi K and SivaKumar M

Abstract
The shoulder girdle of owl, pigeon and the crow was composed of three bones namely scapula, coracoid and clavicle. In all three species the scapula was sword like and slight curved in a craniocaudal direction and its proximal extremity consisted of an acromion process and a coracoid process. The crow had an additional intermediate process and its acromion process had a pneumatic foramen. The coracoid was the strongest bone of the shoulder girdle and its proximal extremity had a hook like appearance and presented a procoracoid, acrocoracoid in all the three species and scapular process prominent in owl and crow. The medial face of the acrocoracoid process had a well-developed pneumatic foramen in crow, about four foramina were seen in owl, while it was absent in pigeon. In owl a well-developed semi-circular procoracoid process and notch with a piercing foramen. The right and left clavicle fused distally to form a single bony component the furcula which was 'U' shaped in crow and 'V' shaped in owl and pigeon. The hypocleidium was noticed only in crow while the pigeon showed a thoracic process.

Keywords: Scapula, coracoid, clavicle, hypocleidium

Introduction
The shoulder girdle is one of the vital constituent of the skeletal system associated with the flight mechanism of birds. It is formed by thee bones namely the scapula, coracoid and clavicle. These three bones enclose the foramen trioseum which allows the passage of tendon of flight muscles [2]. The coracoid is the strongest bone of the shoulder girdle which serves as a bridge between the shoulder joint and the sternum. The right and left clavicle fuses to form a single bony component namely the furcula. The furcula acts as a bony frame to maintain the distance between the two shoulders. The furcula connects the shoulder joint to the axial skeleton. The present study was undertaken to compare the gross morphological features of the bones of the shoulder girdle in pigeon, crow and owl.

Materials and Methods
The materials for the study were collected from pigeon and owl brought for post mortem examination to the Department of Veterinary Pathology and crow were obtained after death in and around campus, Rajiv Gandhi Institute of Veterinary Education and Research, Puducherry. The shoulder girdle was removed and collected by the regular process of maceration, cleaned, dried and the various gross anatomical features were recorded

Results and Discussion
The shoulder girdle was composed of three bony components, namely, the scapula, coracoid and clavicle (Fig.1) seen in all three species as reported by in homing pigeon and common pigeon [1]. The bones in the shoulder girdle of great Indian horned owl were larger stronger than pigeon and crow.

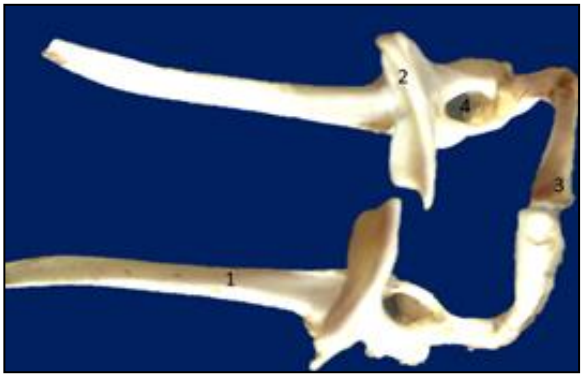

Fig 1: Photograph showing Pectoral Girdle of the Great Indian Horned Owl. 1. Scapula 2. Coracoid 3. Clavicle 4. Foramen Triosseum

The scapula (Fig.2/1) was in the form of a sword like and directed backwards and upwards and ran parallel to the vertebral column in all the three species. The scapula presented two surfaces, namely costal and dorsal lateral surface, two borders dorsal and ventral and a proximal extremity and a blade. The costal surface was convex and the dorsal lateral surface was concave which was more prominent in great Indian horned owl compared to that of crow and pigeon. In all three species the dorsal border presented a sharp downward bend posteriorly. The ventral border was concave in great Indian horned owl and crow and almost straight in pigeon

In all three species proximal or articular extremity (Fig.2/2) was thicker and presented an acromion or clavicular process medially and a coracoid process on the laterally which had a facet. The acromion process at its cranial end was attached to the clavicle bone while its lateral part was attached with coracoid. The acromion process which formed a syndesmotic union with clavicle in all three species. The shape of acromion process (Fig.2/3) was blunt in owl and pigeon whereas it was pointed in crow. The acromion process was single in great Indian horned owl and pigeon, but in crow an additional process, namely the intermediate process was blunt noticed which was separated from acromion process by a wide groove and just below the acromion process had a pneumatic foramen this foramen can be termed as sub-acromial pneumatic foramen which was not noticed in great Indian horned owl and pigeon. It is in agreement with the earlier observations in pigeon, crow and owl [7] and in ramphastidae, indicatoridae and woodpecker [4], in crested serpent eagle [9].

The coracoid process (Fig.2/4) was situated on the medial aspect and was noticed as a convex protuberance in all the three species which was in agreement with findings made in domestic fowl [10] and in peahen [6]. The coracoid process presented on the lateral aspect a facet which articulated with the coracoid and formed an articular socket which received the head of the humerus and aided in the formation of the shoulder joint as reported by in pariah kite [14]. In the present study, the lateral facet had an oval appearance in great Indian horned owl and pigeon while it was circular in crow. In contrary, the facet was concave in owl and crow while in pigeon it was flat [7]. In all the three species of the present study, the blade of the scapula resembled the shape of a twin Ninja sword and showed a slightly curved in a craniocaudal direction. The tip of the blade (Fig.2/5) was pointed and faced downwards in all the three species which was more characteristic in the crow.

Fig 2: Photograph showing **scapula** of the great Indian horned owl (A), pigeon (B), crow (C) 1. Scapula 2. Proximal extremity 3. Acromion process 4.Coracoid process 5. Blade

Coracoid

The coracoid was the strongest bone of the shoulder girdle in all the three species of the present study. It articulated with the sternum at sternocoracoid articulation by its spatula clavicle and humerus, this articulation, it raised in an oblique cranio dorsal direction to form shoulder joint.

The coracoid was a long in crow and short and stronger in great Indian horned owl and pigeon. It had a shaft and two extremities, the shaft of the bone was cylindrical in crow, but oval in great Indian horned owl and pigeon and their extremity was compressed it was marked by muscular line narrow and wider in the proximal and distal extremity. In all the three species of the present study, the proximal extremity had a hook-like appearance and presented two processes namely the procoracoid and acrocoracoid which articulated with the scapula and clavicles enclosed the foramen triosseum (Fig.1/4) for the passage of the tendon of supracoracoideus muscle as reported in Ramphastidae [4]. In domestic birds that, tendon which inserted on the dorsal aspect of the humerus, to elevate the wing and thus played a vital role in the flight mechanism [3].

The presence of hook like the proximal extremity of coracoid facilitates the supracoracoideus muscle for better support and thus aids in flight. In crow the acrocoracoid process was in the form a tubercle. The medial surface of the acrocoracoid process showed a well developed two pneumatic foramen which were absent in the pigeon. In pigeon a wide tuberosity acrocoracoid process, but in great Indian horned owl the acrocoracoid process was more prominent, very broad and tuberosity was placed at a higher level and the medial face of the acrocoracoid presented about numerous pneumatic foramina. In peahen mentioned that the coracoid presented a tuberous furcular tuberosity in green wing macaw it was hooked- shaped [6]. In all the three species the acrocoracoid process (Fig.3/3).towards lateral it was more convex in pigeon and followed by crow, but it is almost straight and below to that had a major part formed by glenoid fossa (Fig.3/1) it had a facet for articulation with the head of the humerus below to glenoid fossa had a small oval facet for the articulation with scapula

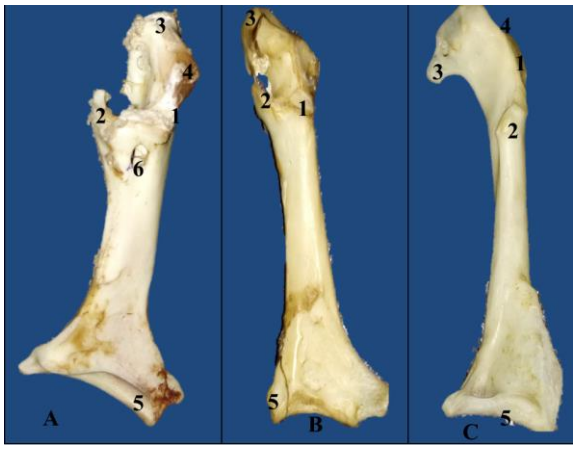

Fig 3: Photograph showing medial aspect of the coracoid of great Indian horned owl (A), pigeon (B), crow (C) 1. Glenoid Fossa, 2. Procoracoid Process, 3. Acrocoracoid Process, 4. Scapular Process, 5. Articular Facet for Sternum, 6. Foramen.

The acrocoracoid process towards medially presented a well defined facet for articulation with the clavicle which was very much more extensive in the owl and the pigeon as reported in birds [12]. In crow the procoracoid process (Fig.3/2) was short, triangular in form and was projected downwards. In the great Indian horned owl the procoracoid process was semi-circular and curved towards the antero lateral aspect of the coracoid. It was an elongate flattened with a broad base and blunt apex. At the junction of the base to the shaft of the coracoid was noticed a round piercing foramen (Fig.3/6). Which was also reported in pariah kite [14] and owl [7] and in crested serpent eagle and brown wood owl [9]. In great Indian horned owl below the procoracoid process (Fig.3/2) had a sharp procoracoid notch (Fig.4/7) which was absent in owl and crow. In pigeon the procoracoid process (Fig.3/2) which was a thin, short, elongate, flat bony structure which was slightly curved and pointed upwards, but was restricted only to the medial surface of the coracoid. A groove intervened between these two processes which was wide and little deep in great Indian horned owl and while in pigeon it was shallower. The coracoid presented on its medial surface the scapular process (Fig.3/4) in great Indian horned owl and crow. It was well developed in the great Indian horned owl followed by the crow. The scapular process for the ligamentous attachment in crow together with the scapula formed the articular socket for the head of the humerus. The shape of the scapular process was like horizontal tubercle but in crow it is a raised ridge this ridge continues middle of the shaft. A well-developed scapular process in green winged macaw and observed its absence in peahen [6]. In domestic fowl the absence of scapular process [10].

The distal extremity was wide and roughly triangular in shape in all the three species. It presented a transversely concave elongated articular facet for sternum (Fig.3/5), a medial angle and a lateral process. The medial angle was highly concave in great Indian horned owl followed by pigeon and crow. The lateral process was sharp and pointed well developed in great Indian horned owl followed by pigeon while in crow it was observed to be rudimentary. In peahen and green winged macaw a well marked lateral process [6]. In crow two third of shaft lateral had a tubercle which was absent in great Indian horned owl and pigeon. In all three species, it presented a sternocoracoid fossa which is more prominent in crow and pigeon. The distal extremity of the coracoids articulated with the cranial end of the sternum through the transverse elongated concave facet which agreed with the findings in pigeon hawk and kite [8] and in crested serpent eagle and brown wood owl [9]. The sternal facet was very large more prominent in great Indian horned owl followed by crow and pigeon.

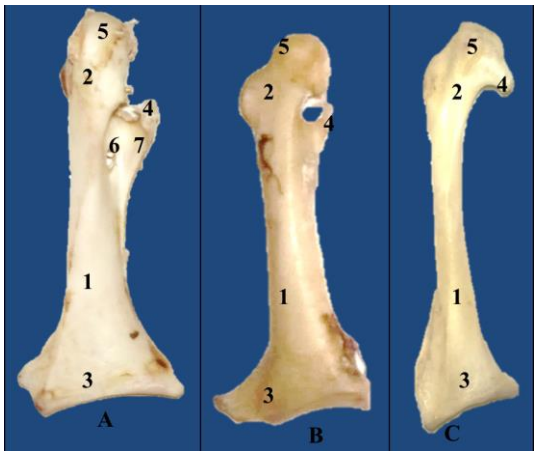

Fig 4: Photograph showing lateral aspect of coracoid - great Indian horned owl (a), pigeon (b), crow (c) 1. Coracoid 2. Proximal 3. Distal 4. Procoracoid Process 5. Acrocorcoid Process 6. Foramen 7. Procoracoidnotch

The clavicles in all the three species were two in number the right and left, which were fused distally to form a single bony component namely the furcula. The clavicle was well developed in crow, followed by in pigeon and was least developed in the great Indian horned owl. In pariah kite clavicle had a two extremity, two surfaces, two borders and ramus [14]. In all the three species, the proximal extremity was directed cranially and was wider and thicker much larger than the distal extremity. In crow and great Indian horned owl the dorsal border was curved, concave and ventral border was strongly convex, but in pigeon both borders almost straight. In all the three species the proximal extremity was laterally compressed than distal extremity.

There was a facet on the lateral aspect of the proximal extremity, which articulated with the acrocoracoid process (Fig.5/1) of the coracoid bone. This facet was well developed in the great Indian horned owl followed by pigeon and crow. In owl the facet for acrocrocid process was least developed [7]. In the present finding in great Indian horned owl which showed two well developed oval facets for the prominent acrocoracoid process of coracoid. Moreover the clavicle of the great Indian horned owl had another small facet close to its cranial border, which articulated with the procoracoid process (Fig.5/2) of the coracoid bone. In crow, the proximal extremity on its lateral surface beard pneumatic foramina which were absent in great Indian horned owl and pigeon which coincided with the observations in crow [7]. In eagle observed numerous pneumatic foramina on the lateral surface of the proximal extremity of the clavicle which was scanty in brown wood owl [9]. The pneumatic foramina varied in each clavicle of the shoulder girdle as reported in ramphastidae [4] and in crow [7].

The proximal extremity of the clavicle, it was triangular and distinctly truncated at apex in crow, while in pigeon it was elongated and had a terminal pointed apex whereas in great Indian horned owl it was very broad elongated and had a blunt end.

In the present study the right and left clavicles fused ventrally in an acute angle in all three species which was observed to be

more acute in pigeon and crow. In domestic fowl reported that clavicle in birds unites into a single wish bone known as furcula and presents a considerable inter-species variation in shape and strength [10]. In crow the furcula was 'U' shaped as reported in crow [11] and in goose [3]. In soaring birds, the furculae were more 'U' shaped or circular than those of flapping birds [5]. Whereas in owl and pigeon it was 'V' shaped which concurred with similar findings in owl and pigeon [7] and in pariah Kite [14], in green winged macaw [6] and in eagle and brown wood owl noticed a broad 'U' shaped [9]. In peahen had reported that 'V' shaped furcula [6]. The morphological variations in furcula were correlated with the flight requirements of different birds

The crow presented an elongated plate like bony structure at the junction of the two clavicles called as hypocleidium (Fig.5/4). Lateral it was noticed "S" shaped in crow [11]. The hypocleidium was absent in pigeon and great Indian horned owl which was in conformation with the reports in pigeon and owl [7] and in brown wood owl [9]. In Picidae, indicatoridae, galbulidae and coraciiformes the absence of hypocleidium [4].

In the present study in pigeon the two clavicles fused ventrally and continued as a small thoracic process (Fig.5/3) as observed earlier in in the pigeon [10]. Clavicle formed a syndesmotic union with the acrocoracoid tuberosity of the coracoid, which were attached to the acromion process of the scapula by a ligament whereas, in green winged macaw reported that the proximal end of two branches of the furcula carried a caudal process [6]. In domestic birds this ligament acted like springs and the furcula maintained the distance between the shoulder joint during wing movement [10].

The ramus of the clavicle were straight in great Indian horned owl and pigeon whereas in crow it was strongly bent and turned towards the hypocleidium. In pigeon it was a thin rod like while in great Indian horned owl and crow was flattened mediolaterally

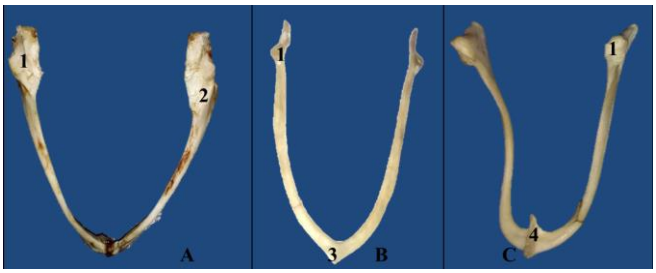

Fig 5: Photograph showing clavicle of great Indian horned owl (A), pigeon (B), Crow (C) 1. Facet for acrocoracoid process 2. Facet for procoracoid process 3. Thoracic process 4. Hypocleidium

Conclusion

The shoulder girdle of owl, pigeon and the crow consists three bones namely scapula, coracoid and clavicle. In all three species the scapula was sword like and consisted of an acromion process and a coracoid process. In crow had an additional intermediate process and its acromion process had a pneumatic foramen which could serve to distinguish the scapula of crow from other species. The coracoid was the strongest bone of the shoulder girdle and presented a procoracoid, acrocoracoid process in all the three species and scapular process prominent in owl and crow. In owl a well developed semi-circular procoracoid process and notch with a piercing foramen was characteristic. The right and left clavicle fused distally to form a single bony component the furcula which was 'U' shaped in crow and 'V' shaped in owl and pigeon. The hypocleidium was noticed only in crow while the pigeon showed a thoracic process.

Acknowledgement

Authors are thankful to the Dean, Rajiv Gandhi Institute of Veterinary Education and Research, Puducherry for providing the basic infrastructure for carrying out this research work.

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