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Gross anatomical studies on the pectoral girdle and wings of Emu (*Dromaius novaehollandiae*)

Rajalakshmi K, Sridevi P and Siva Kumar M

Abstract
In the present study, pectoral limb was formed by scapulo- coracoid and clavicle. The scapula and coracoid fused at the junction of the glenoid cavity to form a single bone called scapulo coracoid. The clavicles were short, flat to rounded rod like bone. The glenoid cavity was a concave articular cavity formed by both scapula and coracoid. The clavicles did not participate in formation of glenoid cavity. Humerus was a strong cylindrical and the Proximal extremity consisted of an indistinct head, neck and two tuberosities lateral and medial. Distal extremity presented a sulcus on the anterior surface. The radius was slender and rod like were almost equal in length but shorter than the humerus. The radius and ulna enclosed a wide interosseous space. There were two carpals in the proximal row radial and ulnar. The radial carpal was partially fused with the radius and also articulated with the ulna while its distal end was fused with the carpometacarpus.

Keywords: Gross anatomical studies, pectoral girdle and wings, *Dromaius novaehollandiae*

Introduction
The pectoral girdle in birds is one of the important components of skeletal system associated with flight mechanism and consists of the scapula, coracoid and clavicle. The relatively immobile blade -like scapula is attached firmly to the ribs by muscle and ligament which anteriorly articulates with the clavicle, coracoid and humerus. The clavicle unite to form formula which furnishes attachment to the breast muscle and along with the coracoid act as struts which resists the pressure due to stroke of wing produced during flight. The large coracoid lies between the shoulder joint and sternum during flight and together with the ribs aids in preventing the collapse of thorax in the wing down stroke. The avian wing has a highly modified arm bone, the humerus is the largest, strong bone in the wing. The radius and ulna which is the longest in the wing and the modified carpometacarpals is highly fused provide strength and support of feathers. Emu is a flightless bird with vestigial wings and they flap their wings during running as a means of stabilizing themselves in fast movement. Literatures available on the gross anatomy of the pelvic limb in emu is scanty. Hence the present study was conducted to investigate in detail structure of thoracic limb of emu

Materials and Methods
The materials for the study were collected from three adult emu birds of either sex brought for post mortem examination to the Department of Veterinary Pathology, Rajiv Gandhi Institute of Veterinary Education and Research, Puducherry, India. The Pectoral limb was collected by the regular process of maceration, cleaned, dried and the various gross anatomical features were recorded.

Results and Discussion
Pectoral limb
The pectoral limb was formed by scapulo- coracoid and clavicle whereas in fowl, pigeon and kite it was composed of three bones, scapula, clavicle and coracoid as reported by (King and McLelland, 1975: Getty, 1975: Bradely and Grahame, 1960 Parvez *et al.*, 2016 and Tomar *et al.*, 2010) [3, 2, 1, 7, 9] respectively. The scapula and coracoid fused at the junction of the glenoid cavity to form a single bone called scapulo coracoid (Fig 1). It was directed upward and backward. This findings agreement with we Kumar and Singh (2014) [4] in emu. The scapulo coracoid had two surfaces and two borders. The lateral surface (Fig 1) was convex and on the scapulo-coracoid, close to the caudal border, cranial and caudal to glenoid cavity it presented a tubercle.

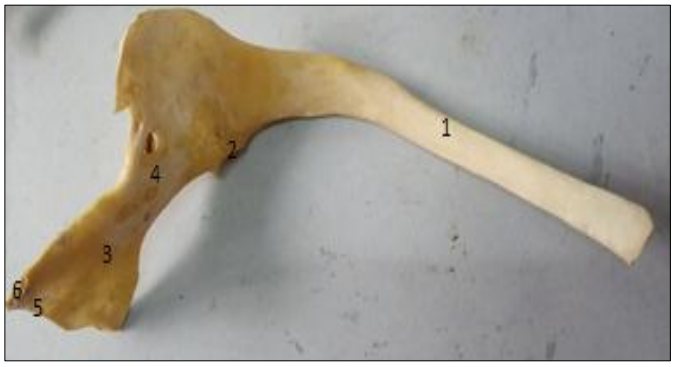
Similar observations were made by Kumar and Singh (2014) [4]. While the medial surface was concave. The cranial border was convex and caudal border concave.

1. Scapulothoracic 2. Glenoid cavity 3. Coracoid 4. Pneumatic foramen 5. Facet for the sternum 6. Lateral angular

Fig 1: Medial view of scapula coracoid

The scapula resembled a rib shape, Parvez *et al.,* (2016) [7] in pigeon scapula was sword shaped (Fig 1) with much reduced acromion. It became wider anteriorly towards its junction with coracoid and narrowed and became thin and flat towards its posterior end. Parvez *et al.,* (2016) [7] in pigeon and Getty (1975) [2] in fowl observed that caudally, the blade ended in the form of thin flat. According to Tomar *et al.,* 2010 [9] in pariah kite reported that scapula blade was projecting pointed which was directed downwards and curved inwards while in the present study scapula blade was not much distinct due to fusion of scapulo coracoid bone.

The glenoid cavity (Fig 2) was a concave articular cavity formed by both scapula and coracoid. The clavicles did not participate in formation of glenoid cavity while in domestic bird scapula coracoid and clavicle contributed in formation of glenoid cavity as reported by Nickel *et al*, 1975: Getty, 1975; King and Mc Lelland, 1975) [2, 3].



1. Scapulothoracic 2. Glenoid cavity 3. Coracoid 4. Pneumatic foramen 5. Facet for the sternum 6. Lateral angular

Fig 2: Medial view of scapula coracoid

The coracoid was roughly quadrilateral in shape fused anteriorly with scapula and became constricted in its middle. The distal sternal end was slightly concave, triangular in shape, presented a facet and medial and lateral angular process and articulated with the sternum. Along the cranial border just above the constriction it presented a triangular pro coracoid process (Fig 3). Just cranial to the constricted part of the coracoid, both surfaces had a well developed large pneumatic foramen.

1. Coraciod 2. Pro Coraciod process

Fig 3: Lateral view of Scapulothoracic

Clavicles were short, flat to rounded rod like bone (Fig 4) and had two surface, two borders with an elongated facet on its medial surface for articulation with the scapulo- coracoid (Fig 5). Parvez *et al.,* (2016) [7] in pigeon reported that clavicle was in the form of thin slender rod-like. According to Kumar and Singh (2014) [4] in emu reported that clavicle was variable from flattened to round because of clavicular articular facet present on coracoid. The cranial and caudal borders were nearly straight. The proximal extremity was slightly curved and had a facet for coracoid similar findings are in accordance with the reports of Parvez *et al.,* (2016) [7] in pigeon. While in emu the distal extremity was tapered to a narrow point and hypocleideum was not observed. Where as in pigeon Parvez *et al.,* (2016) [7] observed that the distal extremity was thicker and larger than proximal extremity and fused with the bone of opposite side to form a rudimentary hypocleideum. According to Patki *et al*., 2010 [8] in crow reported that the hypocleideum was in the form of flattened 'S' shaped sagittal plate and Getty, (1975) [2] in fowl it is in form of an oval thin plate. According to Tomar *et al.,* 2010 [9] in pariah kite reported that two clavicles did not unite to form furculum formed by two clavicle bones was broadly 'U' shaped. Nickel *et al.,* 1975 observed that the bones of pectoral girdle formed a foramen triosseum which allowed passage of the ligament of supracoracoideus muscle to get insert on humerus and thus played role in flight mechanism. The foramen triosseum was not observed in the present study where as in pigeon reported by Parvez *et al.,* 2016 [7] and in domestic birds described earlier by different authors (Getty, 1975; King and McLelland, 1975) [2, 3] presence of foramen triosseum

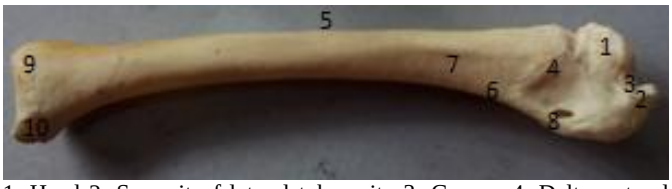
1. Clavicle 2. Proximal end 3. Distal end

Fig 4: Lateral view of clavicle

1. Scapulocoracoid 2. Clavicle 3. Facer for coracoid 4. Facet for sternum 5. Sternum

Fig 5: Medial surface of thoracic girdle

Humerus was a strong cylindrical long bone directed parallel to the thoracic vertebrae when the wing is at rest and placed obliquely downward and backward between the scapula above and radius and ulna below and had a shaft and two extremities. The length of humerus was 10cm and width was 1.9cm in proximal end, 0.8 cm in the mid shaft and 1.9 cm in the distal end The shaft had four surfaces. The anterior surface was rough and had a delto-pectoral crest above (Fig 6). Similar findings are in accordance with Kumar and Singh (2014) [4] in emu. The posterior surface presented an intermuscular line. The medial surface was nearly straight in its length. The lateral surface was slightly curved. The Proximal extremity consisted of an indistinct head, neck and two tuberosities lateral and medial. The head of the humerus was rough and irregular in outline (Fig 7) and had an ill developed neck whereas domestic fowl had a distinct ovoid head and well-developed neck as observed by Nickel *et al.*, 1977 [6]. The head articulated with the glenoid cavity formed by the sacpulocoracoid. The medial tuberosity was close to the head, small and very faint and was separated from the head by a shallow depression. According to Nickel *et al.*, 1977 [6] in domestic birds a distinct groove separated the distinct head and medial tuberosity, the latter continued as a distinct medial crest which was not observed in the present study. The lateral tuberosity had a summit which over-hang the head and arched medially and continued down as a faint lateral crest. A small pneumatic foramen was observed distal to the lateral tuberosity. While in domestic fowl Nickel *et al.*, 1977 [6] observed a large pneumatic foramen ventral to the medial tuberosity. Between the head and lateral tuberosity there was a distinct groove. Above the intermuscular line was a ridge which continued to the medial surface and ended in a tubercle below the medial tuberosity. Distal extremity presented a sulcus on the anterior surface Similar observations were noticed in emu by kumar and Singh (2014) [4]. Just above the articular area and just medial to the sulcus it had a tubercle. A slightly concave articular area was separated by two condyles lateral and medial. Nickel *et al.*, 1977 [6] observed hemispherical lateral condyle in domestic fowl. The lateral condyle articulated with the ulna which extended further distally than the medial one. The medial condyle articulated with radius. Similar observations noticed by Mc lelland (1990) [5] in domestic fowl.



1. Head 2. Summit of lateral tuberosity 3. Groove 4. Deltopectoral crest 5. Medial surface 6. Lateral surface 7. Anterior surface 8. Pneumatic foramen 9. Medial condyle Lateral condyle

Fig 6: Anterior view of humerus

1. Head 2. Medial tuberosity 3. Lateral tuberosity 4. Groove

Fig 7: Proximal extremity of humerus

The radius was slender and rod like (Fig 8), similar findings were noticed in emu by Kumar and Singh (2014) [4]. The length of radius and ulna was 7.5cm and both the bones were almost equal in length but shorter than the humerus. According to Nickel *et al.*, 1977 [6] in domestic birds forearm consisted of the thick ulna and the slender radius which were of about equal length and shorter than the humerus while in pigeon these bones were longer to a little extent than the humerus. The radius had four surfaces. The proximal extremity had a slightly concave small articular area for the medial condyle of the humerus and just below it on the lateral surface it had a facet for the ulna. The distal end also had a similar facet for the ulna. The distal end articulated with radial carpal, whose distal end was fused with carpometacarpus. The ulna was thicker, almost straight with four surfaces but Nickel *et al.*, 1977 [6] reported that the cylindrical shaft of ulna was distinctly curved in fowl and pigeon. The olecranon was poorly developed similar to that o**f** Nickel *et al.*, 1977 [6] in domestic birds**.** The proximal extremity had a concave articular facet for lateral condyle of humerus and below it on its medial surface was a facet for the radius and same at the distal too. In the distal third, both the bones were flattened. The radius and ulna enclosed a wide interosseous space which is in agreement with finding made by Kumar and Singh (2014) [4] in emu and Nickel *et al.*, 1977 [6] in domestic birds.

There were two carpals in the proximal row radial and ulnar. The radial carpal was partially fused with the radius and also articulated with the ulna while its distal end was fused with the carpometacarpus. The ulnar carpal was fused with the

distal row of carpals which were in turn fused with metacarpus. Similar observations were reported in emu by Pawn kumar and Gurdial Singh (2014) [4]. According to Nickel *et al.*, 1977 [6] in domestic birds, radial carpal articulated with radius and ulna. The ulnar carpal articulated only with the ulna.

The distal row of carpals were fused with the metacarpus and formed the carpometacarpus (Fig 8) which concurs with the findings of Nickel *et al.*, 1977 [6] in domestic birds. The carpometacarpus was curved, 7cm in length, its width in the proximal end was 1cm, in midshaft 0.5cm and 0.3 cm at its distal end. The proximal two third of its length was flatter and distal one third was rod like. The proximal extremity was wider and was fused with ulnar carpal and distal row of carpals. The narrow distal end articulated with first phalanges. The first carpometacarpus was observed as a small nodule along the medial border of the chief carpometacarpus towards its proximal end. The second carpometacarpus was the chief component and had three phalanges. The proximal phalanx was fused with the distal end of second carpometacarpus. The narrow distal end of first phalanx articulated with the corresponding concave articular facet on the proximal end of second phalanx. The distal end of second phalanx also narrowed and had two condyles separated by a groove. The shape of the third phalanx corresponded to the claw and its proximal end presented two concave facets for the condyles of second phalanx. The third phalanx was curved and presented a groove on its medial and lateral surfaces. The third carpometacarpus was represented by a thin bony spindle which was fused with the lateral aspect of the chief 2nd carpometacarpus. According to Nickel *et al.*, 1977 [6] in domestic birds reported that first and second digits had two phalanges while third digit had only one phalanx.

1. Radius 2. Ulna 3. Interosseous space 4. Radial carpal 5. Chiefcaro point campus 6. First carpometacarpus 7. Third carpometacarpus 8. Phalanx

Fig 8: Medial surface of the wing

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