Morphological identification of pectoral limb bones of Indian Muntjac (*Muntiacus muntjak*) from domestic ruminants

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**ABSTRACT**

Indian Muntjac is a short deer variety of Nilgiri-Wayand biosphere. Salient distinguishing features for morphological identification of bones of different species in vetero-legal cases is very important. Morphology of pectoral limb bones from adult Indian Muntjac (n=3), goat (n=6), sheep (n=3) and cross bred cattle (n=6) were carried out. Scapula presented a cranially-placed spine, prominent supraglenoid tubercle and extensive subscapular fossa in Indian Muntjac. Breadth to length ratio of scapula in Indian Muntjac is 0.56:1 whereas in small ruminants the values ranged from 0.41:1 to 0.44:1. Width ratio of supraspinatous to infraspinatous fossae ratio in Indian Muntjac, goat, sheep and cross bred cattle were 1:4.1, 1:2.8, 1:2.9 and 1:2.5 respectively. Angle created by acromian, junction of caudal end of scapular spine to lateral surface of scapula and long axis of scapula passing through spine was a major criterion of distinction and this angle in Indian Muntjac, goat, sheep and cross bred cattle were 52°, 140°, 130°and 110° respectively. Though crest of the humerus was ill-defined, deltoid tuberosity was prominent in Indian Muntjac. Blunt summit of cranial part of lateral tuberosity of humerus projected above head and markedly curved over the intertuberal groove. Radial tuberosity was more distinct in cattle and sheep than in Indian Muntjac and goat. The grooves for extensor tendons on distal extremity of radius were well profiled in Indian Muntjac compared to cattle, goat and sheep. Olecranon of ulna was grooved in Indian Muntjac which was lacking in other animals. Distinct dorsal longitudinal groove on entire shaft and prominent medial and lateral borders were characteristic features in Indian Muntjac. Small metacarpal bone of Indian Muntjac and sheep had the form of a very thin rod. The morphological features revealed more resemblance to that of goat, sheep and spotted deer.

**Key words:** Crossbred cattle, Goat, Indian Muntjac, Morphology, Pectoral limb, Sheep.

**INTRODUCTION**

Indian Muntjac belongs to short deer variety grouped under the family Cervidae of order Ungulata. Animals of this group are popularly known as “barking deer” and are wide spread in the Nilgiri-Wayand biosphere of south India (Santra, 2008). Distinct facial ridges, which extend from nasal bones to pedicels of antlers are prominent morphological attributes (Rajani et al., 2014) to distinguish this species. Specific identification of bones of Indian Muntjac from domestic ruminants especially small ruminants is a challenge faced by wild life researchers and Veterinary anatomists. Detailed investigations on morphological characteristics of pectoral limb bones in Indian Muntjac are scarce. Therefore, the present study was conducted to elucidate the anatomical peculiarities of pectoral limb bones in Indian Muntjac. The findings of the present study will form a data repository for the species and has forensic perspective.

**MATERIALS AND METHODS**

The pectoral limb of adult Indian Muntjac (n=3), goat (n=6), sheep (n=3) and cross bred cattle (n=6) were collected when these animals were brought for post-mortem examination to the College of Veterinary and Animal Sciences, Pookode. The limb was macerated and cleaned (Young, 1980) to procure the bones. The comparative morphological and morphometrical characteristics of various bones of pectoral limb in the above mentioned four species of animals were studied.

**RESULTS AND DISCUSSION**

**Scapula:** The scapula was flat and triangular in shape in all the four species of the animals. The breadth to length ratio was 0.56:1, 0.41:1, 0.44:1 and 0.49:1 in Indian Muntjac, goat, sheep and cross bred cattle respectively. The reported values for this parameter in cattle (Getty, 1975), camel (Jain and Singh, 2010) and spotted deer (Rajaniet al., 2013) are 0.6:1, 0.5:1 and 0.6:1 respectively. The vertebral border of scapula was straight or slightly convex in cross bred cattle and sheep whereas in Indian Muntjac and goat it was concavo convex antero posteriorly (Fig. 1). Indian Muntjac had comparatively broader scapula than in other domestic animals and the width ratio between suprapinuous and

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infraspinous fossae was 1:4:1. This ratio in goat, sheep and cross bred cattle of the present study was 1:2.8, 1:2.9 and 1:2.5 respectively. Recorded values for this parameter in both domestic cattle (Peters, 1986) and spotted deer (Rajani et al., 2013) were 1:3. The scapular spine extended upto the neck in an almost straight line in goat and Indian Muntjac as described in black Bengal goat (Siddiqui et al., 2008; Abdullah-Al-Mahmud and Mussa, 2016). However, the spine created a helicoidal shape on longitudinal axis with a caudal bent in the middle third and a rostral curve at distal end in cross bred cattle and sheep. Similar wavy pattern of spine was also recorded in ox (Nickel et al., 1986), Indian gazelle (Mathur, 2010), spotted deer (Rajani et al., 2013) and bluebull (Rohlan et al., 2017). Tuberosity of spine was more distinct in Indian Muntjac and cross bred cattle—whereas it was ill-defined in goat and sheep. Angle created by acromion process, junction of caudal end of scapular spine to lateral surface of scapula and long axis of scapula passing through spine was amajor criterion of distinction. The measured values of this angle in Indian Muntjac, goat, sheep and cross bred cattle were 52°, 140°, 130° and 110° respectively. Our findings partially concur with Gudea and Stan (2011) who reported a sharp angle in roe deer, whereas it is almost straight line in goat and curved in sheep.

Subscapular fossa was deep extensive and clearly demarcated by two longitudinal ridges in Indian Muntjac, goat and sheep in comparison to the shallow and indistinct one in cross bred cattle. A deep subscapular fossa was also reported in sheep (Getty, 1975), Indian gazelle (Mathur, 2010) and spotted deer (Rajani et al., 2013). Neck of the scapula was very short and clearly demarcated in Indian Muntjac. The coracoid process was well distinct in Indian Muntjac than in sheep, goat and cross bred cattle. These features were also recorded in black Bengal goat (Siddiqui et al., 2008), Indian gazelle (Mathur, 2010) and spotted deer (Rajani et al., 2013).

**Humerus:** The bone presented a thin appearance in Indian Muntjac and small ruminants and its twisted, cylindrical shaft presented a shallow musculospiral groove as described by Dyce et al. (2009). Humerus had a length of 12.8±0.2 cm and its circumference at proximal, middle and distal ends were 8.2±0.2 cm, 5.0±0.1 cm and 4.4±0.1 cm respectively in Indian Muntjac. Other salient features in Indian Muntjac included distinct deltoid tuberosity and teres major tuberosity along with indistinct humeral crest and teres minor tubercle. Though those features were poorly developed in goat and sheep, they were better developed in cross bred cattle. On the contrary, an indistinct deltoid tuberosity was reported in roe deer (Gudea and Stan, 2011). A nutrient foramen was noticed in the distal third at the junction between medial and caudal surfaces in all specimens as described previously in cattle (Getty, 1975) and spotted deer (Rajani et al., 2013.). Conversely, Getty (1975) in sheep and Siddiqui et al. (2008) in black Bengal goat reported nutrient foramen as being more proximally located near the middle of caudal surface.

Proximal extremity of humerus comprised of a medially projected head and two tuberosities. Though two divisions were noticed for both medial and lateral tuberosities, the caudal division of lateral tuberosity was much smaller than the cranial part in Indian Muntjac, goat and sheep. But in cross bred cattle both divisions were well developed. Large and blunt cranial part of lateral tuberosity was kept about 0.8 cm above head (Fig. 2) in Indian Muntjac. Cranial parts of both lateral and medial tuberosities markedly arched over intertuberal groove in Indian Muntjac. This finding was in par with the reports in spotted deer (Rajani et al., 2013) and partially concurs with cross bred cattle wherein the summit of cranial part of lateral tuberosity is pointed. But in sheep and goat the blunt cranial part of tuberosities showed only slight incurving. Medial tuberosity in Indian Muntjac was well defined as recorded in roe deer (Gudea and Stan, 2011). However, in goat and sheep medial tuberosity is less prominent.

Well developed and divided lateral condyle and undivided medial condyle at the distal extremity of the humerus were significant characteristics. There was a wide and deep olecranon fossa separated from radial fossa by a thin plate of bone in Indian Muntjac. Fairly developed laterale picondylor crest was noticed in Indian Muntjac which was ill-defined in other animals. Though other features in general concur with the recorded observations in spotted deer (Rajani et al., 2013), Indian Muntjac deer possessed a
prominent lateral epicondylar crest. Goat and sheep had only shallow radial and olecranon fossae as described in black Bengal goat (Siddiqui et al., 2008).

**Radius and ulna**: In Indian Muntjac the radius was 11.3±0.3 cm long and the ulna was longer than radius with a length of 14.0±0.4 cm. Shaft of radius was cranio-caudally flattened and longitudinally curved (Fig. 3). Circumference of shaft in Indian Muntjac was 4.5±0.2 cm, 4.0±0.1 cm and 4.2±0.1 cm at proximal, middle and distal ends respectively. The radial and medial tuberosities were well profiled in cattle; better developed in sheep than in Indian Muntjac and goat. The non-articular synovial fossa separating the concave articular facets at the proximal extremity of radius was well-defined in cattle but was in distinct in other species. Salient differences in the radius for specific identification were the features of the grooves for the extensor tendons and distal articular surfaces. The grooves for extensor tendons and intervening ridges at distal extremity were well distinct in Indian Muntjac and its prominence revealed a decreasing order in sheep, cattle and goat. Similarly, the articular grooves and ridges on the distal extremity were well-developed in Indian Muntjac than in small ruminant. Lateral articular groove was partially contributed by the fused styloid process of ulna. These characters had been described in barking deer (Sarma et al., 2010) and spotted deer (Rajani et al., 2013) and roe deer (Gudea and Stan, 2011). Further, proximal part of semilunar notch presented a non-articular fossa in cattle which was lacking in other species. Styloid process of ulna constituted the distal extremity and extended below the radius.

The thin curved shaft and distal extremity of ulna was fused to a limited narrow area on the caudal surface of the radius near the lateral border. Circumference of its shaft in Indian Muntjac at proximal, middle and distal ends was 2.8±0.2 cm, 2.1±0.1 cm and 2.0±0.1 cm respectively. Proximal end was extensive and was located well above the radius. It comprised of a large olecranon process and a semilunar notch. The olecranon was grooved transversely and consisted of two prominces; the caudal one was being larger than the cranial one in Indian Muntjac whereas in other species it was a simple tuberous entity. Similar characteristics were also recorded in barking deer (Sarma et al., 2010) and spotted deer (Rajani et al., 2013) and roe deer (Gudea and Stan, 2011). Further, proximal part of semilunar notch presented a non-articular fossa in cattle which was lacking in other species. Styloid process of ulna constituted the distal extremity and extended below the radius.
Carpals: Carpal bones were six in number and were arranged in two rows in all animals studied. Radial, intermediate, ulnar and accessory carpal bones constituted the proximal row while second and third fused carpal and fourth carpal comprised the distal row. Accessory carpal was longer and flattened in Indian Muntjac, goat and sheep whereas in cross bred cattle it was broad and thick. Similar features were reported in small ruminants (Nickel et al., 1986) and in spotted deer (Rajani et al., 2013).

Metacarpals: A large metacarpal bone and a small metacarpal bone were observed in Indian Muntjac, sheep and cross bred cattle. Large metacarpal was 9.1±0.3cm long and its circumference at proximal, middle and distal ends were 4.2±0.2cm, 3.5±0.1cm and 4.3±0.2cm respectively. The breadth to length ratio of large metacarpal bone of Indian Muntjac, goat, sheep and cross bred cattle were 1:8.2, 1:7.1, 1:6.9 and 1:6.2 respectively. This ratio was also a key identifying element which clearly indicates the thinner appearance of large metacarpal of Indian Muntjac. Further, dorsal longitudinal groove was well distinct throughout shaft in Indian Muntjac (Fig. 3) whereas in other species this groove was only faintly marked in the proximal and distal third of shaft. Another distinctive feature in Indian Muntjac on the palmar surface was the medial and lateral borders which fashioned the entire palmar surface of shaft to a transversely concave area. The palmar surface was transversely flattened in its distal half and in the proximal part, only slight concavity was observed in other species. The two concave articular areas of proximal extremity were well defined in Indian Muntjac and sheep than in goat. These prominent ridges were also described in roe deer (Gudea and Stan, 2011). The distal end was marked by two condyles separated by intertrochlear incisura. The small metacarpal was lacking in goat and has been reported in black Bengal goat (Siddiqui et al., 2008). The small metacarpal of Indian Muntjac and sheep was in the form of a thin cylinder with a pointed distal end, a feature observed in spotted deer (Rajani et al., 2013).

Digits: Two chief digits (III) and (IV) were noticed in the present study in all the species. Each digit was made up of three phalanges and three sesamoids. Flexor tubercles of proximal phalanx was positioned more proximally in Indian Muntjac, goat and sheep than in cross bred cattle. Other salient features of the phalanges in Indian Muntjac, goat and sheep were sharp dorsal border of middle phalanx and prominent extensor process of distal phalanx. These peculiarities are in accordance with the records of Nickel et al. (1986) in small ruminants and Rajani et al. (2013) in spotted deer.

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