



Comparative Gross Anatomical Studies on Pelvic Limb Long Bones of Crested Serpent Eagle (*Spilornis cheela*) and Brown Wood Owl (*Strix leptogrammica*)

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ABSTRACT

There is no previously reported information on the morphological characteristics of pelvic limb long bones (femur, tibiotarsus and tarsometatarsus) in crested serpent eagle and brown wood owl. Thus, this study aimed to evaluate morphological and biometrical characteristics of pelvic limb long bones in crested serpent eagle and brown wood owl. The femur consisted of a curved shaft and two extremities. The shaft was wider proximally and distally and presented medial, lateral, anterior and lateral surfaces. The anterior, medial and lateral surfaces were smooth and continuous in both the species. An intermuscular line called *linea aspera* was present on the anterior and posterior surfaces in both the species. The proximal and distal extremities of the femur were almost of equal size. The proximal extremity presented a distinct, hemispherical head which was located in the level of the trochanter major in both the species. The distal extremity furnished a trochlea anteriorly for patella and medial, lateral condyles posteriorly for tibiotarsus bone. The patella was small and triangular and consisted of two surfaces, two borders, a base and an apex in both the species. Tibiotarsus was the longest bone in both the species which was formed by the fusion of distal extremity of the tibia with the proximal row of the tarsal bones. The proximal and distal extremity of the tibiotarsus consisted of medial and lateral condyles. In both the species, the fibula was a rod-shaped bone and reached up to distal third of the lateral border of the tibiotarsus. The tarsometatarsus was a long bone but smaller than tibiotarsus in both the species. Various biometrical parameters of the pelvic limb long bones were more in the crested serpent eagle as compared to the brown wood owl due to species differences.

Key words: Brown wood owl, Crested serpent eagle, Femur, Pelvic limb, Tarsometatarsus, Tibiotarsus.

INTRODUCTION

The crested serpent eagle is a medium-sized bird of prey that is found in forested habitats across the tropical Asia and; brown wood owl is a resident breeder in south Asia and is found in from India, Bangladesh, Sri Lanka, Indonesia, Taiwan and South China (Choudhary *et al.*, 2018, 2019b; Keneisenuo *et al.*, 2019a, b, c).

The literature is available on the gross anatomy of femur of domestic fowl, guinea fowl and ostrich (Venkatesan *et al.*, 2006), tibiotarsus and fibula of peahen, Indian eagle-owl (Sreeranjini *et al.*, 2013; Sarma *et al.*, 2018), tibiotarsus and tarsometatarsus of emu, cattle egret and Indian eagle-owl (Kumar and Singh 2014; Rezk 2015; Sarma *et al.*, 2018), there is no previously reported information on morphological characteristic of pelvic limb long bones in crested serpent eagle and brown wood owl. So the present study was planned with an aim to evaluate morphological and biometrical characteristics of pelvic limb long bones (femur, tibiotarsus and tarsometatarsus) in crested serpent eagle and brown wood owl. The baseline data generated on gross morphological and biometrical aspects on pelvic limb long bones in these species can be used by clinicians in treating surgical and other clinical disorders.

MATERIALS AND METHODS

The specimens were procured from four crested serpent

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eagle and four brown wood owls, brought from Zoological Park, Aizawl for post mortem examination to the Department of Veterinary Pathology, College of Veterinary Sciences and Animal Husbandry, Aizawl, Mizoram. After post-mortem

examination, the collected specimens were macerated by boiling maceration technique for 1-2 hours (Choudhary *et al.*, 2015, 2016, 2017, 2019a and Choudhary and Singh, 2015, 2016). The macerated bone samples were kept in 3% hydrogen peroxide for one day to make bones whitish in colour. These processed samples were utilized for gross anatomical studies and were compared with those of other flying birds. The length and width of bones at different sites were measured by thread, scale and digital Vernier caliper and have been summarized in Table 1. The data obtained were subjected to routine statistical analysis (Snedecor and Cochran, 1994).

RESULTS AND DISCUSSION

Femur

The femur (Fig 1, 2) consisted of a curved shaft and two extremities. The shaft was wider proximally and distally and presented medial, lateral, anterior and lateral surfaces. The anterior, medial and lateral surfaces were smooth and continuous in both the species as mentioned in domestic fowl (Kind and McLelland, 1975). The lateral surface was rough on the proximal end for muscular attachment and continued to trochanter major in both species as reported in peahen (Sreeranjini *et al.*, 2013). An intermuscular line called *linea aspera* was present on the anterior and posterior surfaces in both the species as reported in domestic fowl and guinea fowl (Venkatesan *et al.*, 2006). The intermuscular line was well marked on the posterior surface and extended distally up to medial condyle in both the species similar to peahen (Sreeranjini *et al.*, 2013). The intermuscular line was bifurcated in two lines at the distal third of tibiotarsus and extended up to medial and lateral trochlear ridges in brown

wood owl; however, the bifurcation was not reported in crested serpent eagle.

The proximal and distal extremities were almost of equal size. The proximal extremity presented a distinct, hemispherical head which was located in the level of the trochanter major in both the species. The head contained a deep fovea capitis in brown wood owl as compared to that of crested serpent eagle however the fovea capitis was absent in emu (Lakshmi *et al.*, 2007). The head was separated from the shaft by a distinct neck in both the species as reported in peahen (Sreeranjini *et al.*, 2013). The lesser trochanter was indistinct in both the species as in peahen (Sreeranjini *et al.*, 2013); however, the lesser trochanter was in the form of tubercle in emu (Lakshmi *et al.*, 2007). The trochanter major furnished a facet for articulation with the antitrochanter of the ilium bone in both the species as mentioned in peahen (Sreeranjini *et al.*, 2013). One pneumatic foramen was present on the anterior surface below the trochanter major in crested serpent eagle however the same pneumatic foramen was absent in the brown wood owl. Venkatesan *et al.* (2006) also reported large pneumatic foramen on the posterior surface immediately below the head in ostrich. It can be concluded that the crested serpent eagle had more flying ability as compared to that of brown wood owl due to the presence of the pneumatic foramen on the femur bone.

The distal extremity furnished a trochlea anteriorly for patella and medial, lateral condyles posteriorly for tibiotarsus bone as also reported in domestic fowl and guinea fowl (Venkatesan *et al.*, 2006) and peahen (Sreeranjini *et al.*, 2013). The trochlea was bounded by the two ridges separated by the deep trochlear groove in both the species as also mentioned in domestic fowl, guinea fowl and ostrich (Venkatesan *et al.*, 2006). The trochlear ridges were almost

Table 1: Different parameters of pelvic limb long bones in crested serpent eagle and brown wood owl in centimeters.

Bones	Parameters	Mean±SD	
		Crested serpent eagle	Brown wood owl
Femur	Length of femur	7.69±0.01	7.29±0.03
	Height of the head	0.71±0.02	0.62±0.02
	Width of the head	0.72±0.01	0.64±0.01
	Width of the proximal extremity including head	1.91±0.04	1.47±0.02
	Width of the shaft	0.90±0.02	5.99±0.01
	Width of the distal extremity	1.84±0.05	1.45±0.04
Patella	Height of the patella	0.64±0.01	0.53±0.05
	Width of the patella	1.01±0.01	0.83±0.01
Tibiotarsus	Length of tibiotarsus	12.61±0.03	11.46±0.04
	Width of the proximal extremity	1.37±0.01	1.16±0.01
	Width of the shaft	0.79±0.05	0.61±0.01
	Width of the distal extremity	1.51±0.01	1.21±0.02
Fibula	Length of the fibula	9.37±0.02	8.99±0.01
Tarsometatarsus	Length of the tarsometatarsus	9.02±0.01	6.14±0.04
	Width of the proximal extremity	1.59±0.02	1.31±0.02
	Width of the shaft	0.82±0.01	0.78±0.01
	Width of the distal extremity	1.59±0.01	1.69±0.01

equal in both the species as reported in turkey (Venkatesan *et al.*, 2006), however, the lateral trochlear ridge was prominent in ostrich (Venkatesan *et al.*, 2006). The condyles were separated by an intercondyloid groove that contained pneumatic foramen in crested serpent eagle; however the same foramen was absent in the brown wood owl. The larger lateral condyle was placed at a lower level as mentioned in fowl (Nickel *et al.*, 1977) and peahen (Sreeranjini *et al.*, 2013). The lateral condyle presented a distinct groove, which consisted of an articular area on the posterolateral aspect for the head of the fibula as stated in domestic birds (Nickel *et al.*, 1977).

The patella (Fig 4) was small and triangular in both the species. The patella consisted of two surfaces, two borders, a base and an apex in both the species. The base was broader and apex was concave in the present study. Lakshmi *et al.* (2007) reported the absence of patella in emu.

Tibiotarsus

The tibiotarsus (Fig 3, 4) was the longest bone in both the species which was formed by the fusion of distal extremity of the tibia with the proximal row of the tarsal bones as reported in cattle egret (Rezk, 2015) and Indian eagle-owl (Sarma *et al.*, 2018).

The tibiotarsus consisted of a shaft and two extremities. The shaft was straight and consisted of three surfaces i.e. medial, lateral and posterior in both species. The shaft presented a distinct fibular crest just below the lateral condyle in both the species for the attachment of the shaft of the fibula as reported in Indian eagle-owl (Sarma *et al.*, 2018). The nutrient foramen was present in the middle of the lateral surface as mentioned in emu (Kumar and Singh, 2014). However, the nutrient foramen was observed proximal to the extensor canal in peahen (Sreeranjini *et al.*, 2013). A distinct bony ridge was seen on the distal third of the medial border in brown wood owl as mentioned in Indian eagle-owl (Sarma *et al.*, 2018); however, the bony ridge was absent in the crested serpent eagle.

The proximal extremity presented medial and lateral condyles. The medial condyle was larger than the lateral condyle in both species as reported in peahen (Sreeranjini *et al.*, 2013) and Indian eagle-owl (Sarma *et al.*, 2018). The medial and lateral condyles were separated by a ridge in both the species. These condyles articulated with the condyles of femur to form femorotibial articulation. The lateral border of lateral condyle presented a facet for articulation with the head of the fibula in both the species. A sharp cranial cnemial crest was present at the proximal end of tibiotarsus in both the species as also observed in peahen (Sreeranjini *et al.*, 2013), cattle egret (Rezk, 2015) and Indian eagle-owl (Sarma *et al.*, 2018). The crest was more prominent in the crested serpent eagle as compared to that of brown wood owl in the present study. This crest provided an attachment site for the extensor muscles of the knee joint (McLelland 1990). Another cnemial crest was also observed caudolateral to the cranial cnemial crest in both the species and was longer in the brown wood owl. Al-Sadi

(2012), Rezk (2015) and Sarma *et al.* (2018) also reported the presence of two cnemial crests in turkey, cattle egret and Indian eagle owl, respectively. An intercnemial sulcus was present in between these two crests in both the species as also reported in Indian eagle-owl (Sarma *et al.*, 2018).

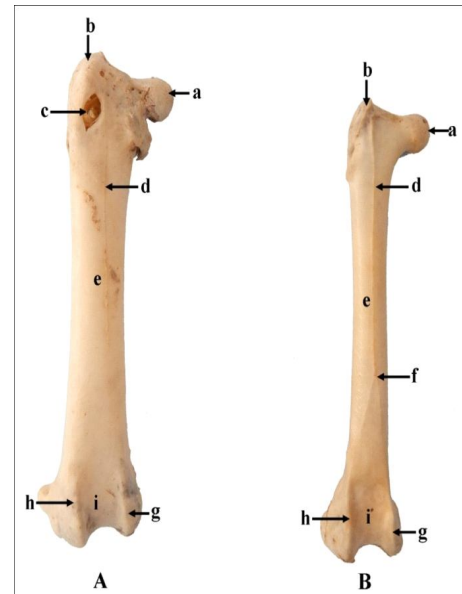


Fig 1: Anterior view of the femur of the crested serpent eagle (A) and brown wood owl (B) showing head (a), trochanter major (b), pneumatic foramen (c), anterior intermuscular line (d), shaft of the femur (e), bifurcation of the intermuscular line (f), medial trochlear ridge (g), lateral trochlear ridge (h) and intertrochlear groove (i).

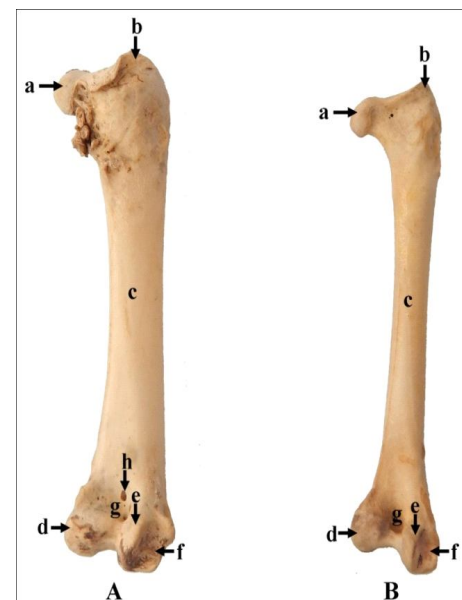


Fig 2: Posterior view of the femur of the crested serpent eagle (A) and brown wood owl (B) showing head (a), trochanter major (b), posterior surface of femur (c), medial condyle (d), lateral condyle (e), lateral condylar groove (f), intercondylar fossa (g) and pneumatic foramen (h).

The sulcus was deeper in brown wood owl as compared to that of crested serpent eagle. Proximally both crests were connected by an oblique patellar crest as reported in cattle egret (Rezk, 2015) and Indian eagle-owl (Sarma *et al.*, 2018). The medial and lateral condyles at proximal extremity were separated by a notch as mentioned in cattle egret (Rezk, 2015) and Indian eagle-owl (Sarma *et al.*, 2018).

The distal extremity presented small medial and large lateral condyles anteriorly separated by the intercondyloid fossa as also mentioned in Indian eagle-owl (Sarma *et al.*, 2018). The lateral condyle was at a slightly higher level than the medial condyle. Extensor canal (Fig 1) was seen immediately proximal to the condyles in both the species as observed in peahen (Sreeranjini *et al.*, 2013) and Indian eagle-owl (Sarma *et al.*, 2018), however, the extensor canal was absent in brown wood owl in the present study. The condyles extended caudally to constitute wide grooved trochlea with medial and lateral trochlear ridges in both the species. There were depressions on either side of the condyles for the attachment of collateral ligaments of hock joint in both the species as seen in fowl (Getty 1975). The extensive articular surface provided by the condyles and trochlea permits a great deal of movement of the hock joint (Fitzgerald, 1969).

In both the species, the fibula (Fig 3, 4) was a rod-shaped bone and reached up to distal third of the lateral border of the tibiotarsus and remain fused with it as also reported in Indian eagle-owl (Sarma *et al.*, 2018). It presented a distinct head and rudimentary shaft (Fig 1). The head was for the articulation with the lateral condyle of the tibiotarsus. The shaft of the fibula was needle-like and body had a rough area for attachment with the fibular crest of the tibiotarsus and thus enclosed proximal and distal interosseous spaces in both the species as mentioned in Indian eagle-owl (Sarma *et al.*, 2018).

Tarsometatarsus

The tarsometatarsus (Fig 5, 6) was a long bone but smaller than tibiotarsus in both the species as also reported in Indian eagle-owl (Sarma *et al.*, 2018). It was formed by metatarsal bones II, III and IV, which were fused with each other and with distal tarsal bones as also reported in Indian eagle-owl (Sarma *et al.*, 2018) and chicken (Tully *et al.*, 2003; Tahon *et al.*, 2013). The tarsometatarsus presented a shaft and two extremities (proximal and distal extremity) in both the species.

The shaft presented longitudinal medial and lateral crests on both anterior and posterior surfaces in both the species. The crests were more prominent on the posterior surface in brown wood owl as compare to that of crested serpent eagle. This area bears a deep fossa at proximal end where internal and external foramen opens. The distal vascular foramen was observed on the anterior surface just above the lateral trochlear cleft in both the species as also reported in Indian eagle-owl (Sarma *et al.*, 2018). A longitudinal groove known as flexor sulcus bounded by

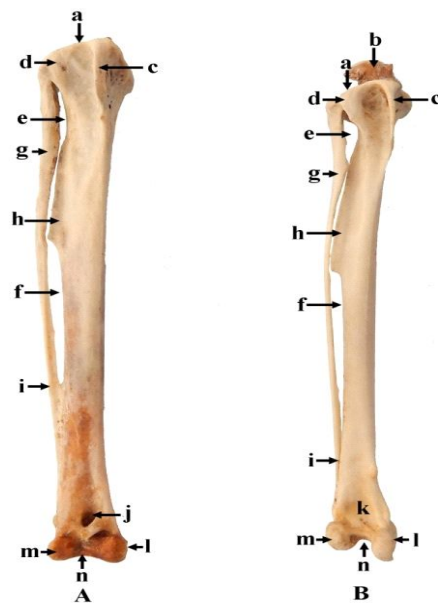


Fig 3: Anterior view of the tibiotarsus and fibula of the crested serpent eagle (A) and brown wood owl (B) showing proximal extremity of tibiotarsus (a), patella (b), anterior cnemial crest (c), lateral cnemial crest (d), proximal interosseous space (e), distal interosseous space (f), shaft of fibula (g), fibular crest (h), distal end of the fibula (i), extensor canal (j), supracondyloid fossa (k), medial condyle (l), lateral condyle (m) and intercondyloid fossa (n).

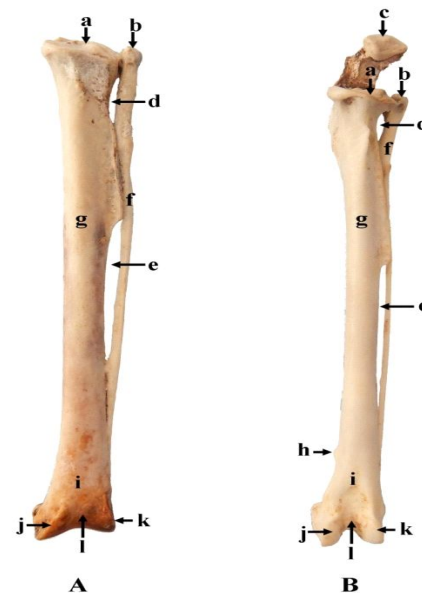


Fig 4: Posterior view of the tibiotarsus of the crested serpent eagle (A) and brown wood owl (B) showing proximal extremity of tibiotarsus (a), proximal extremity of fibula (b), patella (c), proximal interosseous space (d), distal interosseous space (e), shaft of the fibula (f), shaft of the tibiotarsus (g), bony protuberance (h), distal extremity of tibiotarsus (i), medial trochlear ridge (j), lateral trochlear ridge (k) and patellar groove (l).

medial and lateral crest was observed over the posterior surface of the shaft of the tarsometatarsus bone in both the species as also reported in Indian eagle-owl (Sarma *et al.*, 2018). This groove was deeper in brown wood owl as

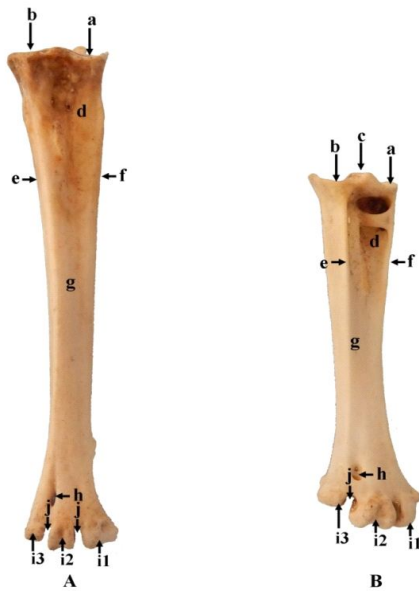


Fig 5: Anterior view of the tarsometatarsus of the crested serpent eagle (A) and brown wood owl (B) showing medial cotyle (a), lateral cotyle (b), bony protuberance (c), fossa (d), lateral crest (e), medial crest (f), shaft of the tarsometatarsus (g), distal vascular foramen (h), medial (i1), middle (i2), lateral trochlea (i3) and intertrochlear cleft (j).

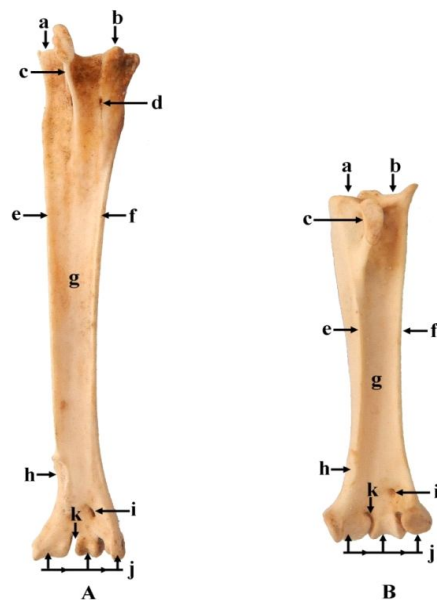


Fig 6: Posterior view of the tarsometatarsus of the crested serpent eagle (A) and brown wood owl (B) showing medial cotyle (a), lateral cotyle (b), hypotarsus (c), nutrient foramen (d), medial crest (e), lateral crest (f), flexor sulcus bounded by medial and lateral crests (g), facet for first digit (h), distal vascular foramen (i), medial, middle, lateral trochlea with intertrochlear cleft (j).

compare to that of crested serpent eagle. The articular facet for the first digit was present posteromedially on the distal third of the shaft of tarsometatarsus in both the species.

The proximal extremity presented two concave articular facets (medial and lateral cotyle) for articulation with the condyles of tibiotarsus bone. The lateral facet (lateral cotyle) was separated from the medial facet (medial cotyle) by a distinct bony protuberance in brown wood owl as also reported in Indian eagle-owl (Sarma *et al.*, 2018) and cattle egret (Rezk 2015), whereas the bony protuberance was not observed in crested serpent eagle in the present study and emu (Kumar and Singh 2014). There was hypotarsus medially on the posterior surface of proximal extremity in both the species. Internal and external proximal foramen was present on either side of the hypotarsus in both the species as also reported in Indian eagle-owl (Sarma *et al.*, 2018). These foramina were more prominent in crested serpent eagle as compared to that of brown wood owl.

The distal extremity consisted of three trochlea (medial, middle and lateral) separated by two intertrochlear clefts (medial and lateral) representing metatarsal bone II, III and IV in both the species. The medial trochlea was larger and middle trochlea presented a distinct groove in both the species as also mentioned in Indian eagle-owl (Sarma *et al.*, 2018). The medial intertrochlear cleft was wider than the lateral intertrochlear cleft in brown wood owl as also reported in Indian eagle-owl (Sarma *et al.*, 2018); however, both clefts were almost equal in crested serpent eagle.

In conclusion, overall results showed that crested serpent eagle and brown wood owl was of a flying group of birds; however, some differences in the morphological features in both species were due to their flying abilities and habitat.

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