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Comparative gross anatomical studies on femur, tibiotarsus, fibula and tarsometatarsus of great Indian horned owl, flamingo and crow

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Abstract

The present study was conducted on the comparative gross anatomical studies on femur, tibiotarsus, fibula and tarsometatarsus of great Indian horned owl, flamingo and crow. The proximal extremity of femur had a distinct hemispherical head in the three species. *Fovea capitis* was deeper in owl compared to that of crow and absent in flamingo. The trochanter major projected a little above the level of the head in flamingo followed by crow and great Indian horned owl. In great Indian horned owl and crow, the distal extremity of lateral condyle were divided into two ridges. The tibiotarsus was the largest of the leg bones in owl and crow, whereas in flamingo tibiotarsus and tarso metatarsus were almost equal in length. The cranial cnemial crest was large, thick, sharp and prominent in flamingo and crow, while in great Indian horned owl it was short and stumpy. Another cnemial crest was observed on caudolateral aspect in all species. The fibula extended upto to the middle in flamingo and crow, while in great Indian horned owl it was extended up to the distal till the shaft. The proximal extremity of the tarsometatarsus presented hypotarsus. The hypotarsus showed variation among the different species under present study.

Keywords: Femur, tibiotarsus, fibula, tarsometatarsus

Introduction

The hind limb is the sole structures for support and walking in birds. The upper leg is composed of a fairly standard femur, but the lower leg and foot are highly variable with modified by fusion. Femur functions more like a forward extension of the hip bones and contributes little to the length of the birds stride. In bird tibial length was associated with their habit, with the longer tibial length in wading birds followed by runners shortest in swimming birds [14]. Distal to the tibiotarsus and the fibula is the tarsometatarsus, an extended fusion of the foot bones. This lengthening adds extra leverage for running, landing and during flight take-off. Flamingos (Phoenicopteridae) often stand and sleep on one leg for long periods [3]. The present study was conducted to record the morphological variations of the femur, tibiotarsus, fibula and tarsometatarsus of an adult great Indian horned owl, common crow and flamingo.

Materials and methods

The materials for the study was collected from flamingo and great Indian horned owl brought for post-mortem examination to the Department of Veterinary Pathology, Rajiv Gandhi Institute of Veterinary Education and Research, Puducherry and crow was obtained death within the campus. Bone samples were collected and removed after post-mortem examination through regular process of maceration, cleaned, dried and followed by the various gross anatomical features were recorded.

Results and Discussion

Femur

The femur of great Indian horned owl, crow and flamingo was long tubular bone with a cylindrical shaft and two extremities. The shaft was straight in great Indian horned owl followed by in crow. In all three species, the shaft has four surfaces namely medial, lateral, anterior and posterior and two borders medial and lateral. The medial surface of the shaft was smooth highly curved in the flamingo. In all three species, the lateral surface of the shaft was smooth, while the proximal end was rough for muscular attachment which continued on the

trochanter major. In great Indian horned owl, on the anterior surface had a distinct muscular line (Fig.1) followed by crow while in flamingo this line was not observed. In the peahen reported that the muscular line on the cranial surface was indistinct [13]. In great Indian horned and crow the medial and lateral borders were nearly straight. In Flamingo, the lateral border was straight while the medial border was slightly concave.

In all three species, proximal extremity (Fig.1) presented a distinct hemispherical head and trochanter major. In great Indian horned owl and crow, the head projected medially at right angles from the well-developed neck. While in flamingo the neck was not that much prominent. In domestic fowl and duck, the long axis of the neck were placed at a right angle to the long axis of the shaft [10]. In great Indian horned owl, the head showed a deep fovea capites which covered almost half of the head and shallow in crow, in great Indian horned owl more deep which was suggestive of a strong articulation with the os-coxal, assisting to grab their prey and in flamingo, the *fovea capitis* was absent. In peahen observed a shallow *fovea capitis* [12].

The trochanter major presented a large, nearly flat area on its lateral aspect in flamingo followed by great Indian horned owl and crow. The trochanter major projected a little above the level of the head in flamingo followed by crow and great Indian horned owl which was also reported in peahen [13]. The trochanter major articulates with the antitrochanter of the acetabulum in all three species. In great Indian horned owl and crow the articular surface of the trochanter major was well distinct. In passer domesticus, parus major and sitta europaea lack the femoral trochanter [2]. In crow between head and trochanter major had a small numerous pneumatic foramen. The distal extremity (Fig.1) showed trochlear anteriorly and condyles posteriorly. The distal extremity furnished medial and lateral trochlear ridges were separated by a groove. Which was narrow in great Indian horned owl and crow, wide in the flamingo.



Fig 1: Photograph showing anterior view of the Femur the great Indian horned owl (A), crow (B), flamingo(C) 1. Head 2. Neck 3. Trochanter major 4. Pneumatic foramen 5. Anterior intermuscular line 6. Trochlea groove 7. Trochlear ridges 8. Epicondyle

In great Indian horned owl, on the posterior surface (Fig.2) had a distinct muscular line while in crow this line was not observed. In flamingo, a faint line descended from the neck, which became prominent at about the middle of the posterior surface and then reached the lateral condyle. In the peahen reported that the muscular line on the caudal surface was distinct and extended distally up to the medial condyle. In chicken and duck the linea aspera was distinct [10]. In the

flamingo on the 2/3rd of posterior surface was a small pneumatic foramen [9]. The distal extremity (Fig.2) of lateral and medial condyles on the posterior surface of the distal extremity were separated by an inter condyloid fossa which was narrow in great Indian horned owl and crow, while in flamingo it was deeper and broader. In great Indian horned owl and crow, the medial condyle was smaller than the lateral condyle and was placed at a lower level and divided by a distinct groove into two ridges. Whereas, in flamingo both the condyles were of equal width were placed at the same level and lateral condyle was undivided. In domestic fowl [10] and in peahen [13] mentioned that the lateral condyle was placed at a lower level. The caudo lateral part of the lateral condyle showed a distinct facet for the fibula in great Indian horned owl and crow species. In crow above the both the condyles had numerous small pneumatic foramen. In peahen a large number of pneumatic foramina which contributed to the light weight of the bone. In all the three species patella was observed



Fig 2: Photograph showing Posterior view of the Femur the great Indian horned owl (A), crow (B), flamingo(C) 1. Head 2. Posterior Line 3. Lateral Condyle 4. Medial Condyle 5. Inter Condylar Fossa 6. Pneumatic Foramen

Tibiotarsus

Tibiotarsus in all there species was long bone formed by the fusion of the distal extremity of the tibia with the proximal row of the tarsal bones as reported Indian eagle owl [12]. The tibiotarsus was the longest of the leg bones. In flamingo, great Indian horned owl, crow was 38 cm, 12.5 cm, 7.2cm respectively. In great Indian horned owl and crow the tibiotarsus the length was twice longer than femur and in flamingo it was thrice longer than the femur. In duck and goose the tibiotarsus was twice longer and in fowl and pigeon it was one third longer than the femur [10]. The total limb length increases, avian femora became relatively shorter [5]. In all three species, tibiotarsus presented a long shaft and two extremities namely proximal and distal. In flamingo the proximal extremity was semi cylindrical, below which was fully cylindrical, while in great Indian horned owl the entire length of the shaft was semi cylindrical followed by crow. In great Indian horned owl about the middle of the lateral surface there was a nutrient foramen. However, in the peahen proximal to the extensor canal nutrient foramen which might be due to species variations [13]

The proximal extremity was larger than the distal extremity in all the three species and a similar finding was noticed in fowl [9] and in courtnix quail [4]. The proximal extremity showed lateral and medial condyles of which medial condyle was larger than lateral in all the three species which was in

agreement with the findings made in Indian eagle owl ^[12] and in Peahen ^[13]. Both the condyles were separated by a prominent ridge in great Indian horned owl followed by crow while in flamingo it was noticed as a groove.

The condyles of the tibiotarsus articulated with the menisci and condyles of the femur. The lateral border of the lateral condyle showed a facet for articulation with the head of the fibula. The lateral surface of the shaft presented a fibular crest for fibula. The crest was more prominent in great Indian horned owl followed by crow and flamingo. In coturnix quail, the convexities of the condyles along with the menisci provided an extensive undulated area that permits some amount of rotation in addition to flexion and extension of the stifle.

In all three species, the cranial border of the articular surface presented two oblique ridge which was connected with each other and formed a patellar crest. Similar observations were reported in Indian eagle owl ^[12] and in cattle egret ^[11]. The crest was very prominent in flamingo, while it was blunt in great Indian horned owl and crow. Whereas in peahen, a transverse ridge on the cranial border of the articular surfaces ^[13]. In coturnix quail observed a transverse ridge for the attachment of the broad patellar ligament ^[4]. In crow and great Indian horned owl the medial and lateral condyles were separated posteriorly by a notch. From the center of the patellar crest, extended a cranial cnemial crest which projected downward in crow and in great Indian horned owl and flamingo was located on the medial aspect. In all three species, the cranial cnemial crest (Fig.3) faced laterally. This was in concurs with the findings in Peahen ^[12] and in India eagle owl ^[11]. The cranial cnemial crest was large, thick sharp and prominent in flamingo and crow while in great Indian horned owl it was short and stumpy. The cnemial crest provided, attach to the main extensor muscle of the knee joint. In all the species, the cranial cnemial crest ended abruptly in the proximal extremity as reported in peahen ^[12] and in fowl ^[9]. The cnemial crest faded on the shaft. Another cnemial crest (Fig.3) was also observed on caudolateral aspect all species. In crow had a long pointed apex followed by flamingo however in great Indian horned owl it was tuberosus and in all the three species it faced downwards. In turkey ^[1] and cattle egret ^[11] observed the presence of two cnemial crests. Between the two cnemial crest a wide inter-cnemial sulcus in all three species, which was deeper in flamingo. The caudal surface of the proximal extremity had the flexor fossa was more prominent in flamingo, followed by crow and great Indian horned owl.

In all the species, the distal extremity presented cranially a large lateral and a small medial condyle separated by the intercondyloid fossa. In great Indian horned owl the medial and lateral condyles were separated by an intercondylar notch and lateral condyle was at the higher level whereas in crow and flamingo both condyles was almost equal level. On the cranial surface proximal to distal condyles a deep passage observed called extensor canal in all the three species which was also reported in peahen ^[13]. The extensor canal were prominent in the flamingo and crow compared to that great Indian horned owl. This canal was covered by a supratendinal bridge which appeared as a bony bridge in all species. The bony bridge was distinct in flamingo and crow. Extensor sulcus is the longitudinal groove leading to the extensor canal and seen above the condyles in all the species. In all species, the condyles continued caudally to form trochlea. In flamingo it was a wide grooved followed by crow and great Indian

horned owl above the trochlea it had posterior sulcus was prominent in great Indian horned owl. On either side of the found shallow depression of medial and lateral epicondyle. The depression for the attachment of collateral ligaments as noticed in great Indian horned owl as also observed in birds ^[6]. The extensive articular surface provided by the condyles and trochlea permits a great deal of movement of the hock joint in coturnix quail ^[4].



Fig 3: Photograph showing dorsal view of the tibiotarsus the great Indian horned owl (A), crow (B), flamingo (C) 1. Cranial Cnemial Crest 2. Lateral Cnemial Crest 3. Extensor Canal 4. Bony Bridge 5. Lateral Condyle 6. Medial Condyle 7. Inter-Condylod Fossa 8. Intercondylar Notch

Fibula

The fibula (Fig.4) in three species under study was a reduced long bone with a distinct head and a rudimentary shaft. The head articulated with the lateral condyle of the tibia and femur. The shaft distally tapered and was thin and needle like. The shaft extended up to the middle of the lateral border of the tibiotarsus in flamingo and crow while in great Indian horned owl it extended up to the distal to the shaft as described in the *Bubo virginianus* ^[8]. Fibula till proximal one third very prominent beyond that, it continued as an oblique faint line which coincided with the findings in Indian eagle owl ^[12]. In all the species, the slender shaft had a smooth lateral surface while its medial surface was rough. The dorsal surface of the shaft articulated with the tibiotarsus and the articular area was interrupted by the interosseous foramen were present proximal and distal between the head of the fibula and tibiotarsus in all the three species.

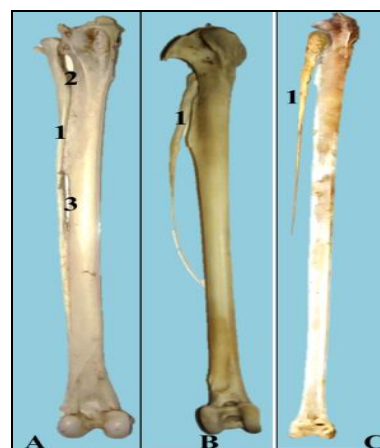


Fig 4: Photograph showing dorsal view of the fibula the great Indian horned owl (A), crow (B), flamingo (C) 1. Fibula (F), 2. Proximal Interosseous Space. 3. Distal Interosseous Space.

Tarsometatarsus

In all three species the tarsometatarsus was formed by II, III and IV metatarsal bones which were fused with each other as well as with the distal row of tarsal bones. This finding was in corroboration in chicken ^[14] and Indian eagle owl ^[12]. Metatarsal (I) is a rudimentary, small bone, which has a ligamentous attachment ventromedially with tarsometatarsus in all the species. The length of bone in flamingo, great Indian horned owl, crow about 35.5 cm, 7 cm and 4.4cm, respectively. The great Indian horned owl and crow tarsometatarsus was smaller than the tibiotarsus while in flamingo it is almost equal. In very long-legged birds the tarsometatarsus and tibiotarsus usually have very similar lengths ^[7]. In all the species, tarsometatarsus presented a shaft and two extremities. The proximal extremity showed two concave articular facets for the condyles of tibiotarsus. In great Indian horned owl and crow, the lateral facet were separated from the medial facet by a distinct bony protuberance (Fig.5) which was also observed in Indian eagle owl ^[12]. In flamingo, the bony protuberance was noticed on the cranial border.

In all three species dorsal surface below the proximal articular facets had a deep wider infracotylar fossa with in fossa had a large proximal vascular foramina in flamingo while in crow had two to three small foramina. In great Indian horned owl just below the proximal articular facet close to the lateral crest had a pneumatic foramen and towards the medial crest had a bony bridge curved inwards and roofed the fossa which contained several pneumatic foramina and curved bony bridge appeared like arched ring like which was also observed in *bubo virginianus* ^[7]. In great Indian horned owl medial and lateral crest were more prominent in the proximal half and absence of crest in crow and flamingo.



Fig 5: Photograph showing dorsal view of the tarsometatarsus the great Indian horned owl (A), crow (B), flamingo(C) 1. Medial Condyle 2. Lateral Condyle 3. Bony Protuberance 4. Deep Fossa 5. Bony Bridge 6. Pneumatic Foramina 7. Bony Canal 8. Articular Trochlea for Second Digit 9. Articular Trochlea for Third Digit 10. Articular Trochlea for Fourth Digit 11. Inter-Trochlear Cleft

The proximal extremity of the plantar surface in great Indian horned owl presented with a pronounced hypotarsus (Fig.6) in the form of calcaneal ridge which was also observed in *Bubo virginianus* ^[8] while in crow they were three in number which were in the form of three longitudinal directed crests, lateral, medial and intermediate as also reported in cattle egret ^[11]. Whereas in flamingo had two in number medial and lateral were separated by a wide groove which showed numerous pneumatic foramina. In crow, the tendinal canals (Fig.6) were

noticed to be enclosed between the lateral and intermediate hypotarsus and medial and intermediate hypotarsus. On either sides of the hypotarsus had a small pneumatic foramen in flamingo and great Indian horned while in crow below the lateral and medial hypotarsus had a small pneumatic foramen. In great Indian horned owl well a developed deep longitudinal groove called flexor sulcus as mentioned in cattle egret ^[11]. In great Indian horned owl both medial and lateral crests were more distinct. In flamingo the medial crests and in crow lateral crest were prominent.

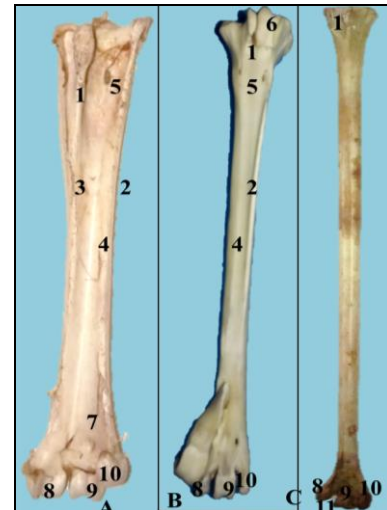


Fig 6: Photograph showing dorsal view and plantar view of the tarsometatarsus the great Indian horned owl (A), crow (B), flamingo(C) 1.Hypotarsus 2. Lateral Crest (L), 3. Medial Crest 4. Flexor Sulcus 5. Pneumatic Foramina 6. Tendinal Canals 7. Tubercle 8. Articular trochlea for second digit 9. Articular trochlea for third Digit 10. Articular Trochlea for fourth Digit 11. Inter-Trochlear Cleft.

The distal extremity in three species presented three trochlea which were separated by two inter trochlear clefts. The third trochlea had a distinct groove. The second articular trochlea was placed at higher level than the third and fourth trochlea in flamingo and crow. In all three species the third trochlea was stronger, broader and longer with wide distinct groove. In crow and flamingo the third trochlea were extended distally. The third inter trochlear cleft was wider in flamingo compared to that of crow and great Indian horned owl. The fourth articular trochlea was larger than second articular trochlea in crow and flamingo. Whereas in great Indian horned owl fourth articular trochlea was placed at a higher level and the third and second articular trochlea were at the same level.

Conclusion

The present study was conducted on the comparative gross anatomical studies on femur, tibiotarsus, fibula and tarsometatarsus of great Indian horned owl, flamingo and crow. *Fovea capitis* was deeper in owl which was suggestive of a strong articulation with the os-coxal, assisting to grab their prey. The tibiotarsus was the largest of the leg bones in great Indian horned owl and crow, whereas in flamingo it was long and strong tibiotarsus and tarso metatarsus were equal in length indicated adaptive features to combat the stresses involved in landing and taking off, running and wading. The highly reduced fibula in flamingo and crow, while in great Indian horned owl it was extended up to the distal till the shaft. These comparative study may aid in devising treatment

regimes and in forensic analysis based on this comparative bone morphological and morphometrical studies on hind limb bones.

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