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Gross Morphological Study on Pelvic Limb Bones of Greater Coucal (*Centropus sinensis*)

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ABSTRACT

The present study was conducted during the period from February, 2021 to April, 2024 at Department of Veterinary Anatomy, Veterinary College and Research Institute, Theni, Tamil Nadu, India to document the gross morphological features of the pelvic limb bones (femur, patella, tibiotarsus, fibula, tarsometatarsus and digits) of greater coucal *(Centropus sinensis)*. The bones were collected and processed from four numbers of greater coucal. The femur was a long bone with somewhat curved shaft with four surfaces and two borders. The proximal extremity presented with a distinct hemi spherical head and trochanter major. The distal extremity showed a trochlea anteriorly and condyles posteriorly. The tibiotarsus was the longest bone , made up of a shaft and two extremities. The proximal extremity contained two condyles, among which medial being the larger. The distal extremity was consisted of medial small condyle and lateral larger condyles with intercondyloid fossa. The fibula was a reduced long bone with distinct head and rudimentary shaft. The tarsometatarsus in greater coucal was presented with a shaft and two extremities. The proximal extremity of tarsometatarsus was made up of two concave articular facets with sharp margin for articulation with the distal condyles present in the distal extremity of the tibiotarsus. The distal extremity consisted of three trochlea (medial, middle and lateral) and they were separated by two intertrochlear clefts (medial and lateral) representing the fused second, third and fourth metatarsal bone. The number of phalanges in each digit was one more than the number of digits.

KEYWORDS: Greater coucal, morphology, femur, tibiotarsus, tarso-metatarsus, digit

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1. INTRODUCTION

Greater coucal (*Centropus sinensis*) also known as Crow pheasant is a common wild bird belongs to cuckoo family, native to India and other southeast Asian countries. The greater coucal is a large type cuckoo bird with a long tail and coppery brown wings. They found in a wide range of territories from forest to agricultural land, urban gardens and open plain areas. They are weak fliers, frequently seen clambering in shrubbery or walking on the ground as they forage for insects, eggs and nestlings of other birds. The femur, patella, tibiotarsus, fibula, tarso-metatarsus and digits are major bony components of the pelvic limb in birds, which is more important because of their bipedal standing and walking when compared with mammals. The femur presumes a pivotal role in providing static support akin to a cantilever rather than a pillar, as observed in humans. It also plays a crucial part in trunk motion during ambulation and aids in maintaining the trajectory of the centre of mass, underscoring its multifaceted role in avian locomotion (Provini et al., 2012). The length of tibia is an indicator of a bird's perching habit. The shape of the tarsometatarsus varied according to species locomotion habits, with an elongated metatarsus providing extra leverage for running or take-off during flight (Malley, 2005). Short tarsometatarsus structures facilitated adept climbing and food manipulation, albeit resulting in a characteristic waddling or rolling gait, particularly notable in species like Macaws, which utilize the caudal tarsometatarsus as well as the foot during ambulation (Brown, 2023). The arrangement and morphology of digits in birds is predominantly depends on its locomotion, which in turn helps for their handling of food materials. The digit I and IV of cuckoo family directed backward, while digits II and III directed forward, known as zygodactyly. Sreeranjini et al. (2020) stated that the zygodactyl arrangement of the digits was an adaptive for climbing trees and grasping the food in one foot and bring it to its beak and can move around tree branches. Since the greater coucals are weak flyer, their pelvic limb must be the alternate supporting structure for the clambing and walking. The literature is available on the gross anatomy of femur of domestic fowl, guinea fowl, turkey and ostrich (Venkatesan et al., 2006); Crested serpent eagle and Brown wood owl (Choudhary et al., 2021); Turkey (Yousuf et al., 2021), Tibiotarsus and fibula of peahen (Sreeranjini et al., 2013); Indian eagle owl (Sarma et al., 2018); Male turkey and local cock (Sadi, 2012), Tibiotarsus and Tarsometatarsus of emu (Kumar and Singh, 2014); Cattle egret (Rezk, 2015); Indian eagle owl (Sarma et al., 2018; Saini and Bansal, 2023), Digits of white cockatoo (Sreeranjini et al., 2020), whole pelvic limb bones of Nigerian barn owl (Usende et al., 2017); Pigeon (Jannat et al., 2023); Quail (Kundu et al., 2023); Helmeted Guinea fowl (Onwuama et al., 2023); Duck and fowl (Chaurasia et al., 2018); Ostrich (Kassem et al., 2023); Ostrich, emu, fowl and duck (Rajani et al., 2019); Green winged macaw (Beaulah et al., 2024) there is no previously reported information on morphological characteristic of pelvic limb bones of Greater coucal. So, the present study was executed with an aim to document the morphological characteristics of pelvic limb bones in Greater coucal, so that it could be used as reference finding by the academicians and wildlife veterinarians in treating surgical and other clinical conditions and rendition of radiographs and species identifications.

2. MATERIALS AND METHODS

This study was conducted on the entire pelvic limb bones (Femur, Patella, Tibiotarsus, fibula, tarsometatarsus and digits) of greater coucal in the Department of Veterinary Anatomy, Veterinary College and Research Institute, Theni, Tamil Nadu, India. Total four numbers of greater coucal were collected as early decomposed dead carcass from in and around the college campus (Figure 1) over the period from February, 2021 to April, 2024. The parts of carcass and their muscle attachments were separated manually as much as possible and then processed by natural wet maceration technique (Tamilselvan et al., 2024) to separate the bones from their attachments. Then, the disarticulated bones were soaked with 10% bleaching powder solution for overnight to remove the minor tissue debris and make it white (Tamilselvan et al., 2018). The dried bones were immersed in acetone solution for overnight to remove the fat (Tompsett, 1970). Subsequently the bones were photographed and studied for its peculiar gross morphological features.

Figure 1: Showing greater coucal as early decomposed dead carcass on roadside near college campus

3. RESULTS AND DISCUSSION

Like most of the avian species, the greater coucal pelvic limb bones were comprised of femur, patella, tibiotarsus, fibula, tarsometatarsus and digits with talon.

3.1. Femur

The femur of greater coucal was a long cylindrical bone with a shaft and two extremities. The extremities were wider than the shaft (Figure 2) as reported by Tamilselvan et al. (2018) and Sreeranjini et al. (2013) in local hill fowl of Uttarakhand and peahen respectively. The shaft was slightly curved in longitudinal fashion with four surfaces: anterior, posterior, medial, and lateral with two borders were medial and lateral borders as observed by Yousuf et al. (2021) in turkey. The surfaces were well observed in the distal one third, where as in the proximal one third the anterior, medial, and lateral surface are continuous, only posterior surface was observed independently throughout the shaft in greater coucal as opined by Venkatesan et al. (2006) in domestic fowl, turkey and guinea fowl. Both the borders were concave in greater coucal. The shaft was smooth and presented with four rough lines called as linea aspera, among one, located in anterior surface (Figure 2), which extended from trochanter major to medial ridge of distal extremity faintly, remaining three lines located on posterior surface, which extended independently from posterio-medial, posterior, and posterio-lateral aspect of the shaft just below the proximal extremity to respective side of distal extremity in greater coucal. At the level of mid-shaft on posterior surface, a nutrient foramen was observed in the present study as in local hill fowl of Uttarakhand (Tamilselvan et al., 2018) and ostrich, emu, duck, and domestic fowl (Rajani et al., 2019).

The proximal extremity was relatively smaller than the distal extremity in greater coucal. The proximal extremity presented with a distinct hemispherical head and trochanter major. The head was well projected medially at right angle from the depressed neck (Figure 3). In greater coucal, the head showed a deep fovea capitis which covered almost half of the head which was suggestive of a strong articulation with the os coxae, assisting for their walking and clambing behaviour, contrary to the observations in emu, where the fovea capitis was absent (Lakshmi et al., 2007). The trochanter major presented a comparatively large, nearly flat rough area on its lateral aspect with ridges. The trochanter major was at the level of head as resembling that of turkey (Venkatesan et al., 2006) brown wood owl and crested serpent eagle (Choudhary et al., 2021), whereas in domestic fowl, guinea fowl (Venkatesan et al., 2006), it was projected a little above the level of the head. The trochanter major articulates with the anti-trochanter of the acetabulum. In greater coucal the articular surface of the trochanter major was well distinct. The trochanter major was limited with ridge, which extends from anterior to posterior surface. The ridge was sharp at anterior and dorsal aspect, whereas it was blunt ridge at posterior aspect of trochanter major.

The distal extremity showed a trochlea anteriorly and condyles posteriorly (Figure 2). The trochlea was deep, bounded by lateral and medial ridges anteriorly. The medial

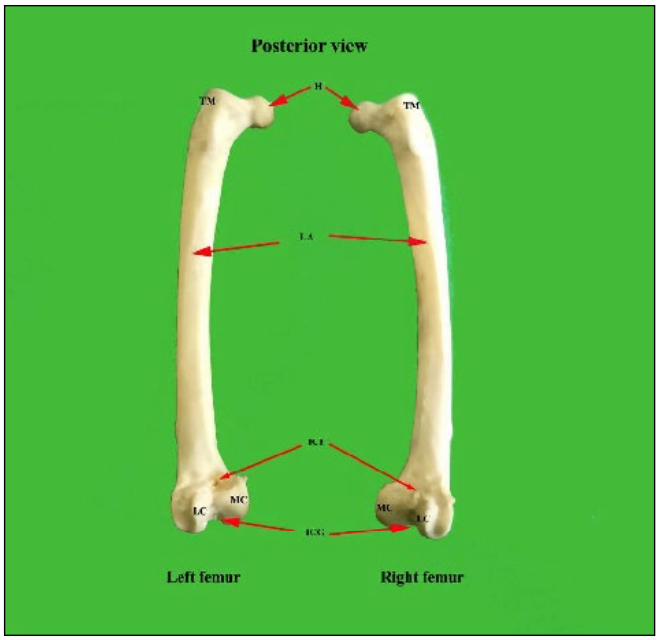

Figure 2: Showing Posterior view of left and right femur of Greater coucal. H: Head; TM: Trochanter Major; LA: Linea aspara; ICF: Inter condyloid fossa; ICG: Inter condyloid grove; MC: Medial condyle; LC: Lateral condyle

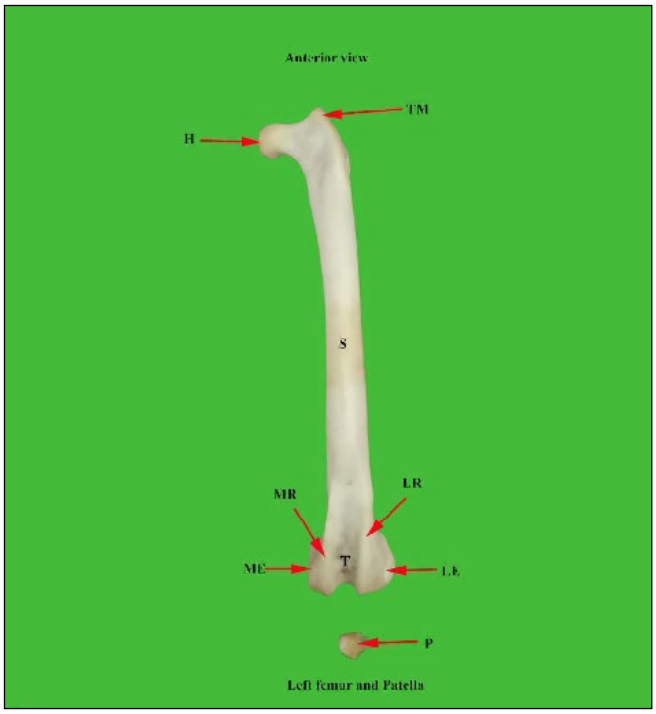

Figure 3: Showing Anterior view of left femur and patella. H:Head; TM: Trochanter major; S: Shaft; MR: Medial ridge; LR:Lateral ridge; ME: Medial epicondyle; LE: Lateral epicondyle; T: Trochlea; P: Patella

ridge was more prominent and placed little higher than lateral ridge, which enclosed a deep trochlear groove (Figure 3). The lateral condyle was larger with prominent epicondyle than medial condyle. The posterior surface of the lateral condyle showed a distinct groove and lateral to it, a distinct facet for the fibula as described in domestic birds (Nickel et al., 1977). Between the condyles, is the intercondyloid groove and above the condyles there is intercondyloid fossa where small pneumatic foramen (Figure 2) was observed as recorded by (Choudhary et al., 2021) in crested serpent eagle, but it was absent in brown wood owl.

3.2. Patella

Patella was a small pea sized sesamoid bone (Figure 3) with articular facet for tibia ventrally and femur caudally, as reported by Sreeranjini et al. (2020) in white cockatoo, which glides over the trochlea of femur like in other domestic birds (Nickel et al., 1977).

3.3. Tibiotarsus

The tibiotarsus was the longest bone among the pelvic limb bones in greater coucal with in average length of 7 cm, which was formed by the fusion of distal extremity of the tibia with the proximal row of the tarsal bones (Figure 4) as reported in cattle egret (Rezk, 2015), Indian eagle-owl (Sarma et al., 2018) and crested serpent eagle and brown wood owl (Choudhary et al., 2021). The tibiotarsus was

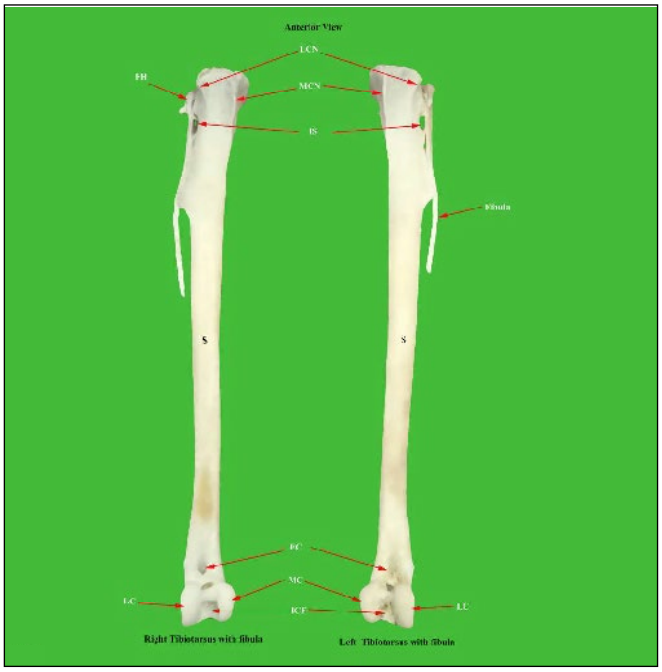

Figure 4: Showing anterior view of right and left tibiotarsus and Fibula. FH: Fibular head; LCN: Lateral cnemial crest; MCN: Medial cnemial crest; IS: Interosseus space; S: Shaft; EC: Extensor canal; MC: Medial Condyle; LC: Lateral Condyle and ICF: Inter condyloid fossa

one third time longer than the femur like in local hill fowl of Uttarakhand (Tamilselvan et al., 2018), but twice the length of femur in peacock, goose and duck Sreeranjini et al. (2013). The tibiotarsus consisted of a long shaft and two extremities. The proximal half of the shaft was curved anteriorly, and showed four surfaces i.e. anterior, posterior, medial and lateral, in which the last three surfaces were blended and indistinct. In crested serpent eagle and brown wood owl, the shaft was straight and consisted of three surfaces (Choudhary et al., 2021). On the lateral aspect of the shaft around 1.5 cm prominent fibular crest (Figure 5) was observed for the fusion of fibula. A faint linea aspera extends from the distal end of fibular crest towards distal extremity of tibiotarsus in greater coucal. Dorsal surface of the shaft near its distal extremity furnished a very narrow extensor canal (Figure 4) for the passage of the tendon of extensor muscles of the toes.

The proximal extremity contained two condyles, i.e. medial and lateral, among which medial was larger as like that of fowl. There were two cnemial crest, medial and lateral was observed in anterior surface of the proximal extremity. The medial cnemial crest was the larger located on cranio-medial aspect with sharp edge. The lateral cnemial crest was half length of the medial cnemial crest (Figure 4). These are in accordance with Sadi (2012) who reported the presence of two cnemial crests in turkey, but they were in cranial and caudal fashion. The lateral crest was short and stump compared to that of the fowl and it ends abruptly in the proximal extremity as reported by Sreeranjini et al. (2013) in peahen and Sreeranjini et al. (2020) in white cuckoo.

The distal extremity contained small medial condyle and large lateral condyle with intercondyloid fossa (Figure 4). These were akin to the observations of Sreeranjini et al. (2013) in peahen, but in local hill fowl of Uttarakhand medial condyle was larger than lateral one (Tamilselvan et al., 2018). The extensor canal was seen immediately above the condyles on its anterior surface. The condyles continued caudally to constitute a shallow wide grooved trochlea (Figure 5). On both sides of the distal extremity, deep depressions were observed for the attachments of collateral ligaments conforming to fowl (Getty,1975). The extensive articular surfaces provided by condyles anteriorly and trochlea posteriorly helps the hock joint to execute wide range of movement during its walking and clambing behaviour.

3.4. Fibula

The fibula was a reduced long bone with a distinct head and a rudimentary shaft (Figure 4). The head articulated with the posterior-lateral aspect of lateral condyle of tibiotarsus and femur proximally. The average length of the fibula was 2.5 cm, it had a comparatively broad proximal extremity

with a shaft continued distally as tapering end till above the mid shaft of tibiotarsus (Figure 5) as in coturnix quail and peahen (Sreeranjini et al., 2013). But in local hill fowl of Uttarakhand (Tamilselvan et al., 2018), crested serpent eagle and brown wood owl (Choudhary et al., 2021), the shaft of fibula extends up to the distal third of the shaft of tibiotarsus. A very narrow interosseous space was observed between the fibula and tibiotarsus (Figure 4) in greater coucal. The long tibiotarsus of greater coucal showed adaptive structures for bipedalism and running whereas the highly reduced fibula and fusion of tibia with proximal row of tarsals to form tibiotarsus were suggestive of adaptations for flight.

Figure 5: Showing posterior view of right and left tibiotarsus and Fibula. FH: Fibular head; FC: Fibular crest; T: Trochlea

3.5. Tarsometatarsus

The tarsometatarsus in greater coucal was a long bone presented with a shaft and two extremities (Figure 6). The average length of the tarso-metatarsus was 5 cm in greater coucal and two third length of the tibiotarsus. These agreed with the reports in Indian eagle-owl (Sarma et al., 2018), crested serpent eagle and brown wood owl (Choudhary et al., 2021), who stated that the length of the tarsometatarsus was smaller than the tibiotarsus. The tarso-metatarsus of greater coucal was formed by the fusion of the distal row of carpal bones and the second, third and fourth metatarsal as described by Kaseem et al. (2023) in ostrich and Beaulah et al. (2024) in green winged macaw. Whereas, the rudimentary small first metatarsal was attached with the distal extremity of tarsometatarsus on its medial aspect (Figure 7) as reported

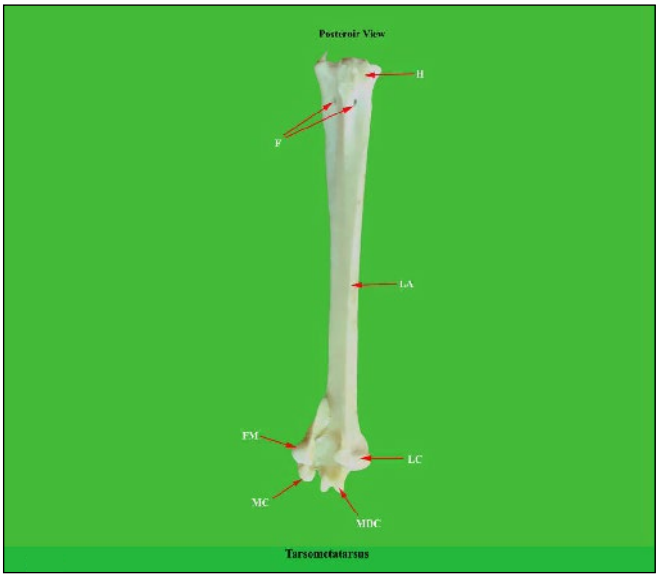

Figure 6: Showing posterior view of tarsometatarsus. H: Hypotarsus, F: Foramens; LA: Linea aspara; FM: First metatarsal; MC: Medial condyle; MDC: Middle condyle; LC: LC: Lateral condyle

in chickens (Tahon et al., 2013). The extremities were wider than the shaft. The shaft of tarsometatarsus comprised of three surfaces and three borders. The surfaces were cranial, medial, and lateral surfaces and the borders were medial, lateral, and posterior borders. The shaft was presented with

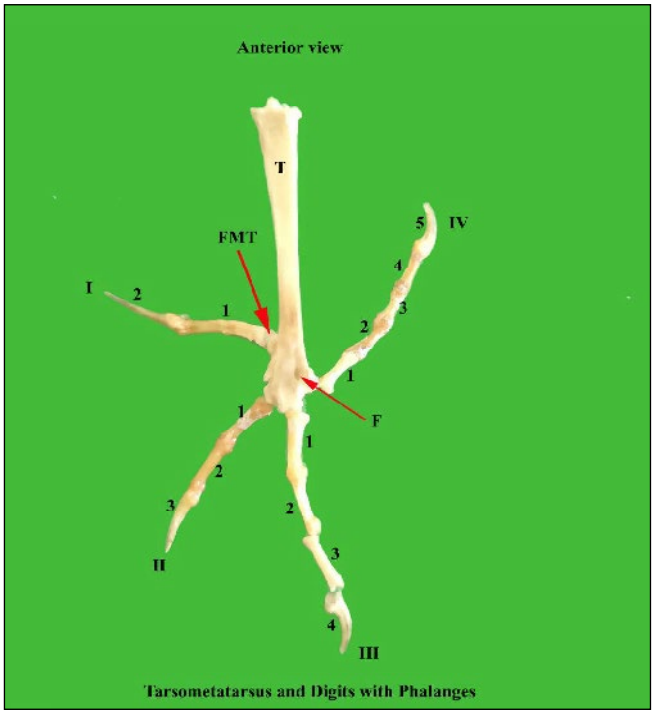

Figure 7: Showing Anterior view of Left tarsometatarsus and digits with phalanges. I to IV indicates respective digits, 1 to 5 indicates phalanges in each digit, T: Tarsometatarsus; FMT: First metatarsal; F: Foramen

medial and lateral longitudinal crest on both anterior and posterior aspect, which enclosed a deep fossa on proximal anterior surface in which two vascular foramina were observed like in helmeted guinea fowl (Onwuama et al., 2023). The crest was extended from the respective side of proximal condyles. Proximal dorsal longitudinal groove was observed as reported in duck (Rajani et al., 2019). The vascular foramen passes through anterior fossa to posterior fossa (Figure 6). The articular facet for the first metatarsal and digit was present posterior-medially on the distal end of the shaft just above the distal extremity of tarsometatarsus as reported by crested serpent eagle and brown wood owl (Choudhary et al., 2021) and in fowl and duck (Rajani et al., 2019).

The proximal extremity of tarsometatarsus in greater coucal consisted of two concave articular facets (medial and lateral cotyle) with sharp margin for articulation with the distal condyles present in the distal extremity of the tibiotarsus. The lateral facet was separated from the medial facet by a distinct bony protuberance as in brown wood owl (Choudhary et al., 2021) and Indian eagle-owl (Sarma et al., 2018) and cattle egret (Rezk, 2015). Hypotarsus was observed on the middle of the posterior surface of proximal extremity of tarsometatarsus where two foramens were present on either side of hypotarsus (Figure 6) as stated in Indian eagle-owl (Sarma et al., 2018). In greater coucal, longitudinal ridges with intercalated grooves represented hypotarsus, which also enclosed bony canal for guiding flexor tendons as in domestic fowl and duck, which were lacking in ostrich and emu (Rajani et al., 2019).

The distal extremity consisted of three trochleas (medial, middle and lateral) and they were separated by two intertrochlear clefts (medial and lateral) representing the fused second, third and fourth metatarsal bone. The lateral trochlea was larger and situated at higher level than the remaining two and middle trochlea was positioned quite lower level and presented with distinct sagittal groove over the trochlea and medial trochlea was smaller. The lateral intertrochlear cleft was wider than the medial. But this is in contrary to the observations of Sarma et al. (2018) in Indian owl and Choudhary et al. (2021) in brown wood owl, where the medial (second) trochlea and medial intertrochlear clefts were larger and higher level than the lateral. A distal nutrient foramen was observed in the distal extremity between the third and fourth metatarsal, which can be viewed on both the surfaces (Figure 7). Long tarsometatarsus is a marker for ground clearance of bird in standing position.

3.6. Digits and phalanges

The greater coucal has a zygodactyl foot with four digits i.e. first, second, third and fourth digits like domestic fowl and duck. Whereas only two and three digits are present in ostrich and emu respectively (Rajani et al., 2019). The number of phalanges in each digit was one more than the number of digits. i.e. 1st, 2nd, 3rd and 4th digits contained 2, 3, 4 and 5 numbers of phalanges respectively (Figure 7) as reported by (Sreeranjani et al., 2020) in white cockatoo. But in ostrich only four phalanges were noticed in the fourth digit, since fifth phalanx of fourth digit had been disappeared or degenerated (Zhang et al., 2016). In greater coucal, the first and fourth digits were directed backwards, whereas second and third digits were directed forwards (Figure 8). This arrangement is most common in arboreal species, particularly those that climb trees or clamber through vegetation. The distal phalanx in each digit was a slender talon and was covered by horny skin in life as in fowl (Getty, 1975). These slender and sharp talons are typical of birds which perch and climb. Proximally, the first phalanx of first digit was articulated with distal extremity of first metatarsal, whereas the first phalanx of remaining digits articulated with the respective trochleas of tarso-metatarsus. The last phalanx is called as talon which consists of round bone called collar bone at the base, from which the apex was projected with pointed end and was externally covered by the same shaped keratinized hoof tissue. The structure of first and interphalanges were constant, which consisted of a base with a concave articular surface for tarsometatarsus, a body and a capitulum incorporating a trochlear articular surface for subsequent phalanx as mentioned by (Konig, 2016) in birds. In life, the greater coucal uses its first and fourth digits to grip the rear of the plant branch, whereas the second and third digits are used to grip the front of the plant branch.

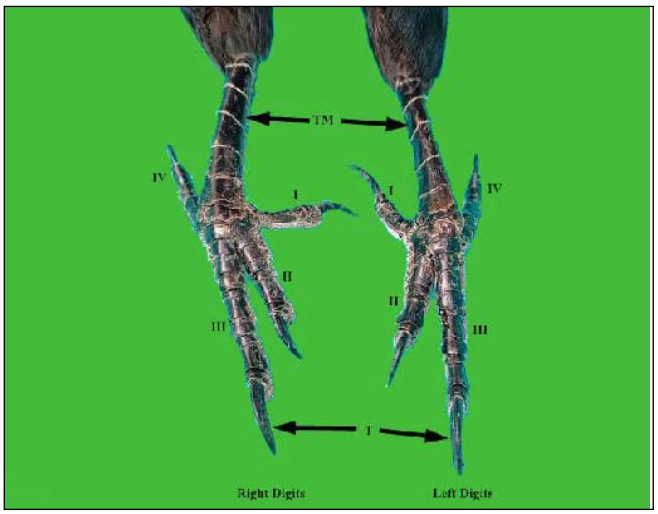

Figure 8: Showing zygodactyl arrangement of digits in Greater coucal. I to IV indicates respective digit. I & IV digits directed backward and II & III digit directed forward, T: Talon; TM: Tarsometatarsus

4. CONCLUSION

The pelvic limb bones of greater coucal consisted of femur, patella, tibiotarsus, fibula, tarsometatarsus and digits with talon. The structures were observed in the pelvic limb bones of greater coucal suggested that, it was peculiar and adaptive morphological features, which in turns help the greater coucal's alternative frequent behaviour like clambing over the trees or walking on vegetation since they were weak fliers.

5. REFERENCES

Beaulah, V.J., Sridevi, P., Ravali, K.S., Dharani, P., Rajathi, S., Kannan, T.A., 2024. Hindlimb skeletal structure of the Green-winged macaw-An anatomical study. Uttar Pradesh Journal of Zoology 45(10), 26–33.

Brown, H.N., 2023. Chapter 2: Anatomy and Physiology of Parrots. Available from https://www.researchgate.net/publication/ 368873502_ Chapter_2_ Anatomy_and_ physiology_ of_parrots. Accessed on 10th September, 2024.

Chaurasia, D., Ingole, S.P., Deshmukh, S.K., Netty, S., Mandavi, S., 2018. Comparative gross morphometrical study on appendicular skeleton of Duck and Fowl. Indian Journal of Veterinary Anatomy 30(2), 95–96.

Choudhary, O.P., Kalita, P.C., Arya, R.S., Rajkhowa, T.K., Doley, P.J., Kalita, A., 2021. Comparative gross anatomical studies on pelvic limb long bones of crested serpent eagle (*Spilornis cheela*) and brown wood owl (*Strix leptogrammica)*. Indian Journal of Animal Research 55(3), 277–282.

Getty, R. 1975. Sisson and Grossman's: Anatomy of the domestic animals. Vol. II, 5th edn., The Macmillan Company of India Limited, New Delhi, India.

Jannat, N., Islam, R., Sultana, N., 2023. Preparing and presenting a pigeon skeleton for gross anatomical study using boiling maceration method: a quick and effective method. American Journal of Life Science and Innovation 2(1), 26–32.

Kassem, M.A.M., Tahon, R.R., Khalil, K.M., El-Ayat, M.A., 2023. Morphometric studies on the appendicular bony skeleton of the ostriches (*Struthio Camelus*). BMC Veterinary Research 19(109), 1–14.

Konig, H.E., Korbel, R., Liebich, H.G., 2016. Avian anatomy: textbook and colour atlas (2nd Edn). 5m Publishing, UK. 68.

Kumar, P., Singh, G., 2014. Gross anatomy of axial skeleton in emu (*Dromaius novaehollandiae*). Indian Journal of Veterinary Anatomy 26(2), 87–91.

Kundu, S.K., Rocky, Z.H., Maruf, M.A.A., Chowdhory, A.T., Sayeed, A., 2023. Preparation of quail (*Coturnix coturnix*) skeleton to promote the teaching facilities of avian anatomy laboratory. International Journal of Veterinary and Animal Research 6(3), 91–95.

Lakshmi, M.S., Rao, T.C.S., Ramayya, P.J., Ravindra Reddy, Y., 2007. Gross anatomical studies on the os coxae and femur of emu (*Dromaius novaehollandiae*). Indian Journal of Poultry Science 42(1), 61–63.

Malley, B.O., 2005. Avian anatomy and physiology in; clinical anatomy and physiology of exotic species. Elsevier Saunders, Germany, 97–161.

Nickel, R., Schummer, A., Seiferle, E., 1977. Anatomy of the domestic birds, Chapter (Skeleton of the head), Verlag Paul Parey, Berlin and Hamburg, Germany.

Onwuama, K.T., Ibe, C.S., Omowunmi, L.K., Kirgir, E.S., Jaji, A.Z., Salami, S.O., 2023. Hindlimb skeletal morphology of the Helmeted Guinea fowl (*Numida meleagridis*). Folia Veterinaria 67(1), 24–34.

Provini, P., Goupil, P., Hugel, V., Abourachid, A., 2012. Walking, paddling, waddling: 3D kinematics of Anatidae locomotion (*Callonetta leucophrys*). Journal of Experimental Zoology Part A: Ecology, Genetics and Physiology 317, 275–282.

Rajani, C.V., Patki, H.S., Wilson, H.M., Surjith, K., 2019. Comparative morphological studies of the pelvic limb bones in ostrich (Struthio camelus), emu (*Dromaius novaehollandiae),* domestic fowl (*Gallus gallus domesticus)* and duck (*Anas platyrhynchos domesticus*). Indian Journal of Animal Research 53(11), 1445–1449.

Rezk, H.M., 2015. Anatomical investigation on the appendicular skeleton of the cattle egret (*Bubulcus ibis*). Journal of Experimental and Clinical Anatomy 14(1), 5–12.

Sadi, A.S., 2012. Comparative morphometric study of shank bone in the tom (*Meleagris gallopavo*) and local cock (*Gallus banikaval*). Iraqi Journal of Veterinary Sciences 26, 57–64.

Saini, S., Bansal, S., 2023. Gross anatomical studies on the skeleton of pelvic limb of Indian eagle owl *(Bubo bengalensis)*. International Journal of Veterinary Sciences and Animal Husbandry 8(4), 149-153.

Sarma, K., Sasan, J.S., Suri, S., 2018. Gross anatomy and biometry on tibiotarsus, fibula and tarsometatarsus of Indian eagle owl (*Bubo bengalensis*). Exploratory Animal and Medical Research 8(1), 123–127.

Sreeranjini, A.R., Ashok, N., Indu, V.R., Lucy, K.M., Maya, S., Syam, K.V., 2013. Morphological studies on the femur, tibiotarsus and fibula of peahen (*Pavo cristatus*). Tamil Nadu Journal of Veterinary and Animal Sciences 9(4), 248–252.

Sreeranjini, A.R., Ashok, N., Maya, S., Lucy, K.M., Indu, V.R., Sunilkumar, N.S., Sumena, K.B., 2020. Gross anatomical studies on the pelvic limb bones of white

cockatoo (*Cacatua alba*). Journal of Veterinary and Animal Sciences 51(1), 86–90.

Tahon, R.R., Ragab, S.A., Abdel Hamid, M.A., Rezk, H.M., 2013. Some anatomical studies on the skeleton of chickens. Ph.D. Thesis. Anatomy and Embryology, Faculty of Veterinary Medicine, Cairo University.

Tamilselvan, S., Chemmalar, S., Sivagnanam, S., 2024. Chevron bones and os penis in dog: Structural and Functional Anatomy. Archives of Current Research International 24(8), 169-177.

Tamilselvan, S., Jaiswal, P., Mrigesh, M., Singh, B., Mahanta, D., 2018. Morphology of femur, tibiotarsus and fibula of local hill fowl of Uttarakhand. The Indian Journal of Veterinary Sciences & Biotechnology 13(4), 84–87.

Tompsett, D.H., 1970. Anatomical techniques, 2nd edn. Edinburgh, Livingstone.

Usende, I. L., Oyelowo, F., Abiyere, E., Adikpe, A., Ghaji, A., 2017. Macro-anatomical investigation on the Appendicular skeleton of the Barn Owl (*Tyto alba*) found in Nigeria. Nigerian Veterinary Journal 38(1), 42–51.

Venkatesan, S., Paramasivan, S., Kannan, T.A., Basha, S.H., Ramesh, G., 2006. A comparative anatomical study of the femur of domestic fowl, guinea fowl, turkey and ostrich. Indian Journal of Animal Sciences 76(11), 925–926.

Yousuf, D., Kumar, P., Gedam, P.M., Kumar, A., 2021. Gross anatomical study of femur of turkeys (*Meleagris gallopavo*). Indian Journal of Veterinary Anatomy 33(1), 72–73.

Zhang, R., Wang, H., Zeng, G., Zhou, C., Pan, R., Wang, Q., Li, J., 2016. Anatomical study of the ostrich (*Struthio camelus*) foot locomotor system. Indian Journal of Animal Research 50(4), 476–483.