Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
www.entomoljournal.com
JEZS 2020; 8(2): 267-270

Received: 19-01-2020
Accepted: 23-02-2020

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Morphological studies of tarso-metatarsus and digits in emu (*Dromaius novaehollandiae*)

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Abstract
The tarso-metatarsus was long bone and it is almost equal to tibio-tarsal length. The first tarso-metatarsus was absent in Emu. Proximal extremity had two concave articular facets namely the medial and lateral condyles of tibotarsaus. The planter surface had hypotarsus in the form of spine. The distal extremity had three convex articular trochleae, which represented the 2nd, 3rd and 4th digits, respectively. There was totally three digits in the leg and the number of phalanges in each digit were equal to one more than the serial number of the corresponding digits. The third digit was the longest and largest of all, the next longest was the second digit. The proximal articular extremity of all phalanges were divided by a sagittal ridge giving rise to two areas making it saddle shaped with the medial one largest. The last phalanx of all digits were prismatic short bones leading to claw formation which was enclosed in a horny covering.

Keywords: Tarso-metatarsus, trochleae, phalanges, digits, emu

Introduction
In birds, the legs play an important role in determining the degree of mobility apart from their wings. Long legs are generally associated with terrrstial type birds, where acelarated movement in running birds were facilated due their long legs. The maximum stride length in emu was due to their highly specialized musculature of the pelvic limb, enabling them to run at a speed of 40km/hour. In ostrich can make large stride and maintain sustained high speed [10]. Moreover, they can defend, strike and rip with their heavy scaled toes and nails. Underneath its feet are thick cushioned pads. Their feet have three toes and its toes have sharp claws, which acts as a defense mechanism and uses in combat, there by inflicting wounds on its opponents by kicking. The emu was considered under the flightless birds category and to know their anatomy for the purpose of diagnosis of any injures and device the treatment protocol for the hind limb. The present study of gross morphology on foot bones was undertaken owing to the information available on this species related to tarso- metatarsus region was inadequate.

Materials and Methods
The materials for the present study were collected from three adult emu birds belonging to either sex brought for post mortem examination to the Department of Veterinary Pathology, Rajiv Gandhi Institute of Veterinary Education and Research, Puducherry, India. Tarso-metatarsus and digits were removed by maceration method, cleaned, dried and various gross anatomical features were recoreded manually.

Results and Discussion
The foot bone consists of tarso-metatarsus and digits (Fig.1) covered with horny skin and the ventral aspect of the digits was furnished with cushion pads. In ostrich, lesser muscle mass in tibiotarsus and tarso-metatarsus region [12]. The tarso-metatarsus was a 35cm long bone and it is almost equal to tibio-tarsal length. In long-legged birds tarso-metatarsus and tibio-tarsus usually have very similar length [5]. In ostrich and emu long tarso-metatarsus was a marker for ground clearance of bird in standing position [3].

Tarso- metatarsus
The tarso-metatarsus was formed by the fusion of the distal row of the tarsals with 2nd, 3rd and 4th metatarsals and formed into a single solid bone, while the first tarso-metatarsus was absent. In domestic fowl and duck presence of first metatarsal bone was noticed [3].

The dorsal surface and planter surface were proximally broad and triangular in natue with distal extremity semi-cylindrical and slender. The lateral and medial surfaces were smooth and transversely convex. The dorsal surface (Fig.2) presented a deep, large longitudinal groove which was wider proximally and became narrower distally. The groove was quite deep in the midshaft region and became shallow distally.

Fig 1: Lateral surface of leg and digit 1. Tarso metatarsus 2. Digits 3. Claw 4. Scales

Fig 2: Dorsal surface of tarso-metatarsus 1. Longitudinal groove

The proximal extremity (Fig.3) showed two concave articular facets for the medial and lateral condyles of tibotarsaus. Below the proximal articular area, the dorsal surface presented a fossa which had two proximal vascular foramen, a tubercle was presented just above to its medial aspect as observed in ostrich [3]. A bony protuberance found on its cranial border of the articular surface proximally.

Fig 3: Proximal extremity of tarsometatarsus 1. Articular facet for medial tibial condole 2.Articular facet for lateral tibial condole 3. Fossa 4. Tubercle S. Summit

The groove on the plantar surface (Fig.4) was shallow and had two nutrient foramen in its proximal part and presented hypotarsus was formed by a distal tarsal bone had a longitudinal spine as observed in ostrich [3]. The hypotarsus in the form of spine (Fig.5) it was tuberous, raised above the articular area and formed the summit of the bone and disappeared a short distance below the articular area. On either side of hypotarsus medial and lateral faint longitudinal ridges were observed. The lateral longitudinal ridge and medial longitudinal ridge continued distally.

Fig 4: Planter surface of tarso-metatarsus

Fig 5: Planter surface of proximal extremity

1. Lateral longitudinal ridge 2. Hypotarsus 3: Medial longitudinal ridge 4. Groove S. Summit

The distal extremity had (Fig.6) three articular trochlea medial, middle and lateral trochlea and each articulated with the corresponding digits *via* 2nd, 3rd and 4th digit. Each part of trochlea was separated by two sagittal cleft, which was in agreement with similar findings in emu [4, 6]. Middle and lateral trochlea had a well distinct sagittal cleft observed compared to that of medial trochlea. Whereas in ostrich that the distal extremity was represented by two trochlea for articulation with the toes and the third and fourth were separated by a deep intertrochlear groove [1].

The distal extremity on its plantar surface (Fig.7) above the trochlea was concave but that of the dorsal surface was convex transversely. The middle trochlea was stronger, broader and longer with wide distinct groove and extended far distally. The medial and lateral trochlea was placed more proximally, the lateral was larger than the medial, both medial and lateral showed a distinct plantar orientation. The middle trochlea was wedge shaped with apex in front and medial trochlea was convex. The three trochleae were separated by two intertrochlear notches. A extensor canal was observed between the middle and lateral trochlea. This observation was concurrence with the findings in domestic fowl [8].

Fig 6: Dorsal surface of distal extremity

Fig 7: Plantar surface of distal extremity

1. Trothlea 2. Inter trochlear groove 3 Medial trochlea 4. Middle trochlea S. Lateral trochlea 6. Inter trochlear notch 7. Bony canal

Digits

Emu had three digits first and fifth digits were absent. First digit was absent in agreement with the similar findings in emu [4]. In ostrich there was a reduction in the number of digits, first and second digit were absent [1]. In emu [2] and cassowaries [11] reported that having three toes. The presence of three digits in emu, two digits in ostrich, four digits in domestic fowl and duck [3]. In domestic birds first digit which consisted of two phalanges [8].

Phalanges

In the present study the second, third and fourth digits the number of phalanges were in each digit was one more than the serial number of the digit i.e. three, four and five numbers of phalanges, respectively (Fig.6). This observation was in concurrence with the findings in emu [3, 4]. In ostrich third and fourth digit showed the presence of four phalanges [1].

All had a shaft and two extremities except the last phalanx and fourth phalanx of the fourth digit. The proximal extremity were saddle shaped articular surface divided by a sagittal ridge into two areas of which medial was larger and articulated with the trochlea of the tarso-metatarsus. The distal extremity was divided by a sagittal groove into two condyles. On either side above the condyle, there was a deep fossa for ligament attachment. The shaft was cylindrical in shape had two surface dorsal and planter and two borders lateral and medial. The dorsal surface is smooth, broad in the proximal part and narrow in its distal part and the planter surface oblong and rough in the proximal and middle had a groove on the distal extremity.

The third digit was longest and largest which was in concurrence with findings in ostrich [1]. The first phalanx were largest and longest in third digits in comparison with second and fourth digits.

Fig 8: Dorsal view of the digits of emu 1. Second digit 2. Third digit 3. Fourth digit 4. First phalanx 5. Second phalanx 6. Third phalanx. 7. Fourth phalanx S. Fifth phalanx

In the second digit, first phalanx was a four sided slender, long bone with large proximal and small narrow distal extremity. Second one was three sided short bone.

In the third digit, first phalanx was a four sided and longest bone. Its planter surface presented with two tubercles along its volar articular margin, below which a rough tuberous 'V' shaped fossa for ligamentous attachment was noticed. Second phalanx was a also four sided long bone and the third was a short bone.

Fig 9: Dorsal view of first Phalanx of third digit of emu

Fig 10: Volar view first phalanx of third digit of emu

1. Proximal extremity 2. Distal extremity 3. Fossa 4. 1" shaped S. Tubercle.

In the fourth digit the first phalanx was a four sided long bone and slightly smaller than the first the phalanx of the second digit. The sagittal groove in proximal articular area divided it

into two articular areas and the medial was larger. Second phalanx was a short bone, slightly longer and reduced in thickness than that of the second phalanx of the second digit. The third phalanx was a short bone reduced in size compared to second phalanx and fourth phalanx was semicircular shape and it is the smallest one it had a concave surface to articulate with the third phalanx.

The last phalanx of all digits was conical shaped had a base, apex, shaft. It presented three surfaces the medial, lateral, plantar and three angles medial, dorsal and lateral. Base which articulated with the preceding phalanges. The apex was slightly curved, and pointed. The medial and lateral angles formed the base and dorsal angle was projected to correspond to the groove seen in the distal extremity of the third phalanx. Medial and lateral surfaces were confluent on the dorsal aspect which were convex and presented grooves which extended from the base to the anterior third of the apex and presented a foramen at the anterior end. The plantar surface was concave and smooth. The proximal articular area was divided by a sagittal ridge into two areas of which the medial was larger. The rim of the articular surface presented a prominence about its middle anteriorly.

The last phalanx of all digits was completely enclosed inside a horny pointed claw and had a base, shaft and tapered end. In ostrich fourth digit was devoid of claw and fourth phalanx was conical in shape located entirely inside the keratinised pointed claw [1]. All the distal phalanges were sheathed completely inside keratinous nails [9, 7]. In cassowaries had a large pointed claw on the tip of the main digit [13]. The claw of all digits had a planter curvature In ostrich claw was a rough cone hollow and pen shaped with a tapered end extremity [1]. The claw is smooth externally and internally. The colour of the claw is gray internally while black externally, except on the planter surface at the tapered end which was white in colour.

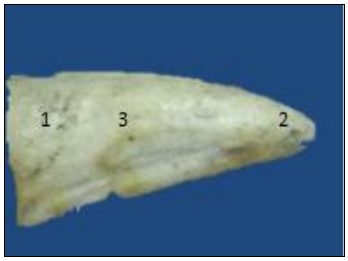

Fig 11: Lateral view of last phalanx

Fig 12: Dorsal iev. Of clay

1. Base 2.Apex 3.Shaft 4. Tipered end

Conclusion

Present study on tarso-metatarsus and digits were covered by a horny skin with less muscle mass. Fusion of 2nd, 3rd and 4th metatarsals to form single long bone almost equal length to that of tibiotarsal bone. Tarso-metatarsus were relatively long and plays vital role in locomotion, skeletal support, and defense mechanism. Absence of first tarso-metatarsus and first digit and fifth digit reduction in number of digits. It cursorial adaptation for high-speed locomotion and endurance. This documentation may aid in furture studies pertaining to tarso-metatarsus and digits regions in other heavy terrestrial birds for comparative analsyis.

Acknowledgement

Authors are thankful to the Dean Rajiv Gandhi Institute of Veterinary Education and Research, Puducherry for providing the basic infrastructure for carrying out this research work.

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