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Morphometrical studies of tibia, fibula and lateral malleolus of the blue bull (*Boselephus tragocamelus*)

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Abstract

The study reports anatomical details of tibia and fibula of Blue bull (*Boselephus tragocamelus*). The tibia was a long prismatic bone, the shaft was distinctly curved, and three sided above. The nutrient foramen was placed in the upper-third, close to the lateral border. The anterior border was very prominent in its upper-third and constituted the tibial crest. The proximal extremity was large and consisted of three tuberosities and two condyles. The rudimentary fibula was attached to the lateral condyle. The lateral malleolus was a four-sided piece of bone compressed from side to side. These studies concluded that the morphology of the tibia and fibula of was almost Blue bull similar to ruminants but differed from horse and dog.

Keywords: Blue bull, Fibula, Lateral malleolus, Tibia

Introduction

The Blue bull (*Boselephus tragocamelus*), sometime called nilgau, is one of the largest Asiatic antelopes founded in the day open forests. The mature male appears ox-like and is also known as blue bull. A blue bull is called nil gai or nilgai in India, from neel meaning blue and a gai meaning bovine animal (literally 'caw') It is also present in parts of southern Nepal and eastern Pakistan. They show marked sexual dimorphism, with only the male having horns. Nilgai are in danger of extinction because people are hunting them for their meat and for skin etc. These animals are protected under International Union for Conservation of Nature and Natural Resources (IUCN) since 2003 and also protected under Schedule III of the Indian Wildlife Protection Act, 1972 (Bagchi *et al.*, 2004) [2]. The Nilgai has become extinct in Bangladesh, it is only member of genus *Baselaphus* and the main threat to this species is the loss of habitat due to deforestation and human population growth. The aim of this study was to investigate the tibia, fibula and lateral malleolus bones of Blue bull, Therefore making a contribution in filling the gap of knowledge in this field.

Materials and Methods

The present study was conducted on head of six adult blue bull of either sex. The permission for the specimen collection was sought from the Principal Chief Conservator of Forest (PCCF), Government of Rajasthan. The skeletons were collected from the Jodhpur zoo after official approvals from the Principal Chief Conservator of Forest vide letter no. F, 3 (04) Tech-II/CCF/2013/2326 dated 12.01.2015 and from The Deputy Conservator of Forest wildlife, Jodhpur s.n./sam/388-90 dated 22.01.2015. The skeletons were dug out from the graveyards located in the premises of Jodhpur zoo. Afterwards, these specimens were processed by the hot water maceration techniques as described by Simoens *et al.* (1994) [13].

Result and Discussion

In the present study, tibia was a long prismatic bone (Fig.1 & 2). The shaft was distinctly curved. The lateral surface was slightly spiral in its direction. The posterior surface was flattened from side to side as reported by Raghavan (1964) [11] in ox, Getty (1975) [5] in horse, Smuts and Bezuidenhout (1987) [14] in dromedary and Choudhary *et al.* (2015) [3] in blackbuck. The posterior surface was marked by a number of rough lines as described by Raghavan (1964) [11] in ox, Miller *et al.* (1964) [10] in dog, Getty (1975) [5] in horse; Choudhary *et al.* (2015) [3] in blackbuck; however, Getty (1975) [5] noted the absence of rough lines in sheep and

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goat. The nutrient foramen was located in the upper-third, close to the lateral border, whereas nutrient foramen was situated on the popliteal line in horse according to Getty (1975) [5]. The medial surface was slightly convex. The anterior border was very prominent in its upper-third and constituted the tibial crest. The lateral border was concave lengthwise as narrated by Raghavan (1964) [11] in ox, Miller *et al.* (1964) [10] in dog, Getty (1975) [5] in horse and Choudhary *et al.* (2015) [3] in blackbuck.

The proximal extremity was large and consisted of three tuberosities and two condyles. The three tuberosities were separated by intertuberal fossa as elucidated by Raghavan (1964) [11] in ox and Konig and Liebich (2006) [6] in dog, Akers and Denbow (2008) [11] in ruminants and Choudhary *et al.* (2015) [3] in blackbuck. The tibial spine was a central articular eminence divided into a medial higher and a lateral lower part as described by Raghavan (1964) [11] in ox and Choudhary *et al.* (2015) [3] in blackbuck. The proximal extremity bears two articular eminences, the medial and lateral condyles as reported by Getty (1975) [5] in horse and Ray and Ray (1994) [12] in leopard but it was in disagreement

with Miller *et al.* (1964) [10] in dog, who revealed that the medial condyle was oval and the lateral condyle was nearly circular and Smuts and Bezuidenhout (1987) [14] in dromedary who revealed that the condylus medialis was larger and more rounded. The tuberosity of the proximal extremity of the tibia showed absence of groove as described in leopard (Ray and Ray, 1994) [11]. In this finding there was presence of a large nutrient foramen just anterior to both tibial spines.

The distal extremity was smaller than the proximal. The surface was compounded of two deep antero-posterior grooves separated by an articular ridge as described by Raghavan (1964) [11] in ox and Choudhary *et al.* (2015) [3] in blackbuck. The medial groove was bounded by the medial malleolus, while the lateral groove was separated by a sharp border, which articulated with the lateral malleolus as revealed by Raghavan (1964) [12] in ox and Choudhary *et al.* (2015) [3] in blackbuck, it was in disagreement with Getty (1975) [5] in horse who revealed that the distal extremity was much smaller than the proximal and it was quadrangular in form and Smuts and Bezuidenhout (1987) [13] found the cochlea consisted of two sagittal grooves in dromedary.

Table 1: Measurements of the tibia and fibula of Blue bull in cm

Specimen no.	Description		Tibia				Fibula
			Greatest length (Lg)	Maximum breadth of shaft (Bs)	Maximum breadth of proximal extremity (Bp)	Maximum breadth of distal extremity (Bd)	Greatest length (Lgf)
1.	female-1	Left	38.32	4.07	8.83	5.61	4.34
		Right	38.34	4.05	8.82	5.62	4.36
2.	female-2	Left	38.31	4.06	8.84	5.60	4.34
		Right	38.30	4.04	8.83	5.63	4.37
3.	female-3	Left	38.34	4.05	8.81	5.65	4.45
		Right	38.45	4.03	8.80	5.65	4.43
4.	male-1	Left	38.42	4.09	8.85	5.68	4.46
		Right	38.50	4.11	8.87	5.67	4.50
5.	male-2	Left	38.41	4.09	8.86	5.68	4.49
		Right	38.42	4.08	8.85	5.69	4.48
6.	male-3	Left	38.46	4.07	8.87	5.68	4.43
		Right	38.49	4.11	8.86	5.67	4.44
Range			38.30-38.50	4.03-4.11	8.80-8.87	5.60-5.69	4.34-4.50
Mean			38.40	4.04	8.84	5.65	4.42
SD			0.07	0.03	0.02	0.03	0.06
SE			0.02	0.02	0.01	0.01	0.02
Female Mean ± SE			38.34±0.02	4.05±0.01	8.82±0.01	5.63±0.01	4.38±0.02
Male Mean ± SE			38.45±0.02	4.09±0.01	8.86±0.01	5.68±0.01	4.47±0.01

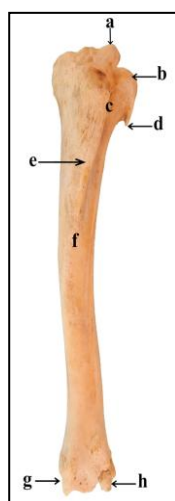


Fig. 1: Cranial view of the tibia-fibula showing tibial spine (a); condyle of femur (b); tibial tuberosity (c); fibula (d); tibial crest (e); cranial surface (f); medial malleolus (g); lateral malleolus (h).

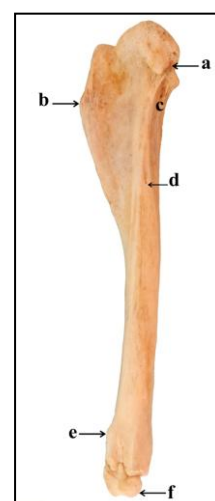


Fig. 2: Caudal view of the tibia fibula articular facet for lateral showing fibula (a); tibial crest (b); triangular area and popliteal line (c); nutrient foramen (d); medial lateral malleolus (f).

The average greatest length of the tibia of blue bull was 38.40 ± 0.02 cm. The average maximum breadth of proximal extremity, shaft and distal extremity was 8.84 ± 0.01 cm, 4.07 ± 0.02 cm and 5.65 ± 0.01 cm, respectively (Table. 1), However as per documented by Choudhary *et al.* (2015) in blackbuck 21.36 ± 0.01 cm, 3.94 ± 0.006 cm, 2.07 ± 0.007 cm and 2.65 ± 0.009 cm, respectively.

The fibula (Fig.1 & 2) was long, thin and rudimentary bone. It was reduced to a small, short blunt, pointed prolongation as described by Raghavan (1964)^[12] in ox, Frandson *et al.* (2009)^[4] in dog and pig and Choudhary *et al.* (2015)^[3] in blackbuck; it was in disagreement with Getty (1975)^[5] in horse and Smuts and Bezuidenhout (1987)^[14] in dromedary, who described that the fibula was laterally compressed bone the proximal part of the fibula was represented by a blunt tuberosity on the lateral condyle whereas the head and distal extremity of the fibula was very prominent as reported by Kirberger *et al.* (2005)^[7] in lion and the tibia-fibula were fused almost in the distal half as reported by Ozkan (2002b)^[9] in hedgehog. The tibia and fibula were partially fused at the tips as elucidated by Oliveira *et al.* (2007)^[8] in paca.

The average greatest length of the fibula was 4.42 ± 0.02 cm in blue bull (Table.1). However, it was 2.31 ± 0.007 cm Choudhary *et al.* (2015)^[3] in blackbuck.

Lateral malleolus

It was a four-sided piece of bone compressed from side to side (Fig.3). The dorsal surface has an articular facet, which was in agreement with Raghavan (1964)^[11] in ox and Choudhary *et al.* (2015)^[3] in blackbuck. In this finding dorsal surface has a small pointed projection or protrusion which divides the dorsal surface into anterior and posterior articular surface.

The lateral malleolus bone was characterized by a pointed proximal process and distal surface was saddle-shaped as revealed by Raghavan (1964)^[11] in ox, Smuts and Bezuidenhout (1987)^[14] in dromedary and Choudhary *et al.* (2015)^[3] in blackbuck, it was resembled to the finding with Miller *et al.* (1964)^[10] in dog, he revealed that the distal end of the fibula was known as the lateral malleolus; whereas the distal extremity of fibula was fused with tibia constituting the lateral malleolus in horse (Getty, 1975)^[5]. The fibula in the cow was represented by the separated malleolar bone (Akers and Denbow, 2008)^[11].

The average greatest length and maximum breadth of the lateral malleolus of blue bull was 2.61 ± 0.01 cm and 3.40 ± 0.01 cm, respectively (Table.2). However, it was 1.28 ± 0.006 cm and 1.39 ± 0.05 cm, respectively Choudhary *et al.* (2015)^[3] in blackbuck.

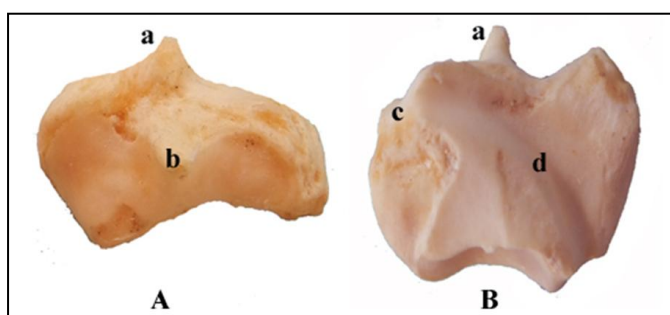


Fig. 3: Lateral (A) and medial (B) view of the lateral malleolus showing pointed proximal process at dorsal surface (a); lateral surface (b); articular facet for tibia (c); medial surface (d).

Table 2: Measurements of lateral malleolus of Blue bull in cm

Specimen no.	Description	Greatest length (Lg)	Maximum breadth (Bm)
1.	female-1 Left	2.58	3.41
	Right	2.57	3.39
2.	female-2 Left	2.64	3.38
	Right	2.67	3.40
3.	female - 3 Left	2.57	3.39
	Right	2.56	3.37
4.	male -1 Left	2.66	3.43
	Right	2.65	3.40
5.	male-2 Left	2.61	3.39
	Right	2.62	3.42
6.	male-3 Left	2.59	3.39
	Right	2.60	3.41
Range		2.56-2.67	3.37-4.43
Mean		2.61	3.40
SD		0.04	0.02
SE		0.01	0.01
Female Mean \pm SE		2.60 \pm 0.01	3.39 \pm 0.01
Male Mean \pm SE		2.62 \pm 0.01	3.41 \pm 0.01

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