



Gross Morphological and Biometrical Sexual Dimorphic Studies on the First, Second and Third Pairs of Ribs of Blue Bull (*Boselaphus tragocamelus*)

S. Sathapathy^{1*}, B.S. Dhote², D. Mahanta², Tamilselvan S², I. Singh², M. Mrigesh² and S.K. Joshi³

¹Department of Veterinary Anatomy and Histology, CVSc. and A.H., OUAT, Bhubaneswar, INDIA

²Department of Veterinary Anatomy, CVASc., GBPUAT, Pantnagar, Uttarakhand, INDIA

³Scientist (Animal Science), KVK, Jharsuguda, OUAT, Bhubaneswar, INDIA

*Corresponding Author: S. Sathapathy; Email: srinivas.ouat@gmail.com

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ABSTRACT

The present study was carried out on the first, second and third pairs of ribs of six specimens of adult Blue bull (*Boselaphus tragocamelus*) of either sex. These ribs had a head, neck and a tubercle at the proximal end, shaft or body and a costal cartilage at the distal end. An accessory tubercle was located below the main tubercle of the ribs at their caudal border of the shaft. The accessory tubercle was located 4.1 ± 0.08 cm and 4.2 ± 0.11 cm below the proximal tubercle at the caudal border in females and males respectively. The costal groove was prominent at the proximal aspect of the caudal border of the second rib. The accessory tubercle was absent in the second rib. The accessory tubercle was located 3.3 ± 0.13 cm and 3.5 ± 0.10 cm below the proximal tubercle at the caudal border in females and males respectively. The curviness of the shaft increased up to the 3rd rib. The ribs of both the sides had similar structures and sex wise gross variations were not found. The Biometrical observations on different parameters of first, second and third pairs of ribs of Blue bull reflected significance ($P < 0.05$) differences between the sexes of this species. The present study would be helpful in identification of the first three pairs of ribs of Blue bull and solving vetero-legal cases related with this species.

Keywords: Blue bull, morphology, morphometry, ribs

The Blue bull (*Boselaphus tragocamelus*) is known to be one of the biggest antelopes in Asia and is widely found in both the forests and adjoining villages with enough green grass (Sathapathy *et al.*, 2017). The Blue bull belongs to the family Bovidae and comes under the genus *Boselaphus* (Sathapathy *et al.*, 2018a). It is quite prevalent in northern and central parts of India especially in the foothills of Himalayas, eastern part of Pakistan and southern part of Nepal, but has vanished from Bangladesh (Sathapathy *et al.*, 2018b and Sathapathy *et al.*, 2018c). The adult male appears like ox and so called as Blue bull. The Blue bulls are safeguarded beneath the IUCN since 2003 and also under safeguard of 'Schedule III' of the Indian Wildlife Protection Act, 1972 (Bagchi *et al.*, 2004). The massive body of the Blue bull can be attributed to the large skeleton of the antelope. Further, the skeleton comprises of large and massive bones of axial and appendicular

skeleton that not only protects the viscera, but also provides shape and support to the heavy musculature of the Blue bull (Sathapathy *et al.*, 2018d). The present osteo-morphological study developed a baseline data on the first, second and third pairs of ribs of adult Blue bull that would immensely help the wild life anatomists and Veterinarians in species identification and solving forensic and vetero-legal cases as no previous work has been done in this field on the Blue bull.

MATERIALS AND METHODS

The present study was carried out on the first, second and third pairs of ribs of six specimens of adult Blue bulls (*Boselaphus tragocamelus*) consisting of three male and three female animals. The permission for the collection of bones was acquired from the Principal Chief Conservator

of Forests (PCCF), Government of Rajasthan. The bones were possessed from the Jodhpur zoo, Rajasthan getting authentic confirmation from the Principal Chief Conservator of Forests (PCCF), Government of Rajasthan. The skeletons were taken out from the burial ground that was located in the premises of the office of the Deputy Conservator of Forest Wildlife (WL), Jodhpur. The gross study was conducted under the supervision of the Zoo Authority, Jodhpur, India. The different parameters of first, second and third pairs of ribs of Blue bull were measured and subjected to routine statistical analysis as per standard technique given by Snedecor and Cochran (1994) and independent samples t-Test with Systat Software Inc, USA and SPSS 16.0 version software.

RESULTS AND DISCUSSION

The first, second and third pairs of ribs of Blue bull ribs consisted of a head, neck and a tubercle at the proximal end, shaft or body and a costal cartilage at the distal end (Fig. 1).

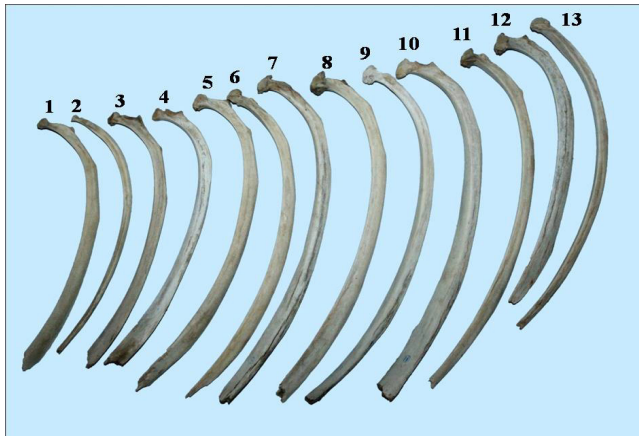


Fig. 1: Lateral view of ribs (13 numbers) of left side of adult female Blue bull (*Boselaphus tragocamelus*)

Similar findings were also reported by Getty *et al.* (1930) in ox, Dyce (2006) in ruminants and Frandson and Spurgeon (1992) in cattle. The shaft or body was curved and presented two surfaces and two borders. The curvature at the upper part was more and the distal part was inclined inward. The lateral surface was found to be convex and had a wide groove at its upper part. The medial surface was smooth and concave. The anterior border was thick and concave, whereas the posterior border was convex

that lodged the costal groove for the intercostals vessels. This groove was prominent at the upper part. Further, the head presented two articular facets that were separated by a costal groove. These facets articulated with the facets of the body of the corresponding vertebrae to form the costo-central articulation. The tubercle was situated behind the head and the two structures were found to be separated by a constricted portion known as neck. The length of the neck was found to be variable. The neck presented a groove all along its length. The neck was long and formed a smaller angle with the shaft or body except in the caudal part of the series. An accessory tubercle was located below the main tubercle of the rib at the caudal border of the shaft (Fig. 2). The distance between the two tubercles also varied in the ribs. The main tubercle of the rib presented articular facet that was usually concave in shape. However, variations were recorded with respect to the shape and size of the facets of the tubercle. This facet articulated with the corresponding facet present on the transverse process of thoracic vertebra to form the costo-transverse articulation.

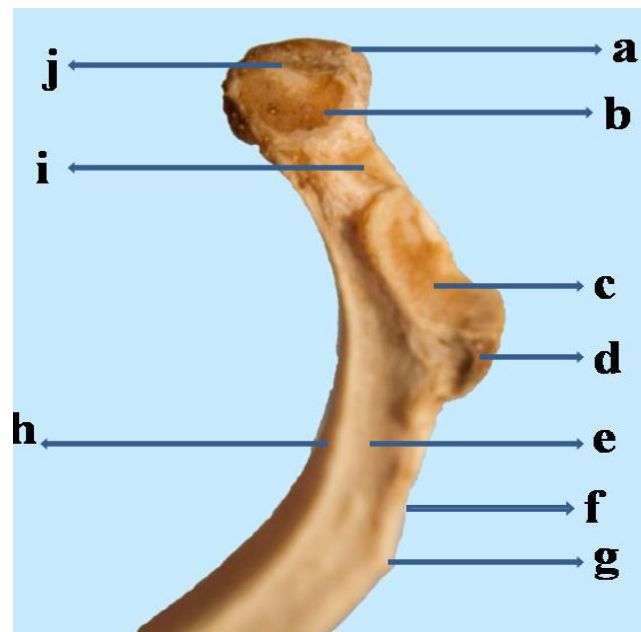


Fig. 2: Medial view of proximal end of left first rib of adult female Blue bull (*Boselaphus tragocamelus*) showing (a) Head, (b) Facet on head, (c) Facet on tubercle, (d) Tubercle, (e) Costal groove, (f) Posterior border of shaft, (g) Accessory tubercle, (h) Anterior border of shaft, (i) Groove on neck and (j) Groove between the facets of head

The distal end of the ribs was little expanded that articulated with the costal cartilages. The cartilages were found to be cylindrical and little compressed from side to side. Similar findings were also reported by Getty *et al.* (1930) in ox, Dyce (2006) in ruminants and Frandson and Spurgeon (1992) in cattle.

The ribs of both the sides had similar structures and sex wise gross variations were not found. The facet on the tubercle of the first rib was bicycle seat like. The costal groove was prominent at the proximal aspect of the caudal border of the first rib. The accessory tubercle was located 4.1 ± 0.08 cm and 4.2 ± 0.11 cm below the proximal tubercle at the caudal border in females and males respectively. The costal groove was prominent at the proximal aspect of the caudal border of the second rib. The accessory tubercle was absent in the second rib. The tubercle of the third rib was more concave in shape. The accessory tubercle was located 3.3 ± 0.13 cm and 3.5 ± 0.10 cm below the proximal tubercle at the caudal border in females and males respectively. The curviness of the shaft increased up to the 3rd rib.

Biometrical Observation

The biometrical observations revealed characteristic differences between the sexes of the Blue bull.

First rib

The biometrical observation showed that the average diameter of the head of the first rib was found to be 2.43 ± 0.06 cm in adult Blue bull. Further, it was measured as 2.30 ± 0.07 cm in females that was significantly less ($P<0.05$) than that of males, where it was found to be 2.57 ± 0.06 cm. The average diameter of the tubercle at the dorso-ventral aspect was found to be 1.50 ± 0.03 cm in adult Blue bull. Further, it was measured as 1.44 ± 0.03 cm in females that was significantly less ($P<0.05$) than that of males, where it was found to be 1.57 ± 0.01 cm.

The average minimum length of the neck at the cranial aspect was found to be 0.96 ± 0.02 cm in adult Blue bull. Further, it was measured as 0.92 ± 0.04 cm in females that was significantly less ($P<0.05$) than that of males, where it was found to be 1.01 ± 0.02 cm. Similarly, the average maximum length of the neck at the caudal aspect was found to be 1.45 ± 0.01 cm in adult Blue bull. Further,

it was measured as 1.42 ± 0.02 cm in females that was significantly less ($P<0.05$) than that of males, where it was found to be 1.49 ± 0.01 cm. The average length of the shaft was found to be 29.71 ± 0.15 cm in adult Blue bull. Further, it was measured as 29.40 ± 0.19 cm in females that was significantly less ($P<0.05$) than that of males, where it was found to be 30.02 ± 0.14 cm. The average width of the shaft at the proximal aspect of the rib was found to be 1.45 ± 0.06 cm in adult Blue bull. Further, it was measured as 1.30 ± 0.04 cm in females that was significantly less ($P<0.05$) than that of males, where it was found to be 1.60 ± 0.07 cm. Similarly, the average width of the shaft at the middle was found to be 1.41 ± 0.04 cm in adult Blue bull. Further, it was measured as 1.33 ± 0.04 cm in females that was significantly less ($P<0.05$) than that of males, where it was found to be 1.48 ± 0.05 cm. The average width of the shaft at the distal end of the rib was found to be 2.05 ± 0.05 cm in adult Blue bull. Further, it was measured as 1.93 ± 0.06 cm in females that was significantly less ($P<0.05$) than that of males, where it was found to be 2.17 ± 0.06 cm.

The average cranio-caudal diameter of the cranial articular facet of the head was found to be 0.76 ± 0.01 cm in adult Blue bull. Further, it was measured as 0.72 ± 0.01 cm in females that was significantly less ($P<0.05$) than that of males, where it was found to be 0.79 ± 0.01 cm. Similarly, the average dorso-ventral diameter of the cranial articular facet of the head was found to be 1.53 ± 0.04 cm in adult Blue bull. Further, it was measured as 1.42 ± 0.03 cm in females that was significantly less ($P<0.05$) than that of males, where it was found to be 1.65 ± 0.04 cm. The average cranio-caudal diameter of the caudal articular facet of the head was found to be 0.74 ± 0.02 cm in adult Blue bull. Further, it was measured as 0.70 ± 0.02 cm in females that was significantly less ($P<0.05$) than that of males, where it was found to be 0.79 ± 0.01 cm. Similarly, the average dorso-ventral diameter of the caudal articular facet of the head was found to be 1.34 ± 0.01 cm in adult Blue bull. Further, it was measured as 1.30 ± 0.01 cm in females that was significantly less ($P<0.05$) than that of males, where it was found to be 1.37 ± 0.01 cm.

The average diameter of vascular groove at the proximal aspect was found to be 0.45 ± 0.01 cm in adult Blue bull. Further, it was measured as 0.41 ± 0.01 cm in females that was significantly less ($P<0.05$) than that of males, where it was found to be 0.49 ± 0.01 cm. The average diameter



of vascular groove at the distal aspect was found to be 0.38 ± 0.01 cm in adult Blue bull. Further, it was measured as 0.34 ± 0.01 cm in females that was significantly less ($P < 0.05$) than that of males, where it was found to be 0.41 ± 0.01 cm.

Second rib

The biometrical observation showed that the average diameter of the head of the second rib was found to be 1.97 ± 0.04 cm in adult Blue bull. Further, it was measured as 1.88 ± 0.03 cm in females that was significantly less ($P < 0.05$) than that of males, where it was found to be 2.05 ± 0.04 cm. The average diameter of the tubercle at the cranio-caudal aspect was found to be 0.42 ± 0.01 cm in adult Blue bull. Further, it was measured as 0.40 ± 0.01 cm in females that was significantly less ($P < 0.05$) than that of males, where it was found to be 0.44 ± 0.01 cm.

The average minimum length of the neck at the cranial aspect was found to be 0.76 ± 0.01 cm in adult Blue bull. Further, it was measured as 0.73 ± 0.02 cm in females that was significantly less ($P < 0.05$) than that of males, where it was found to be 0.79 ± 0.01 cm. Similarly, the average maximum length of the neck at the caudal aspect was found to be 1.17 ± 0.05 cm in adult Blue bull. Further, it was measured as 1.07 ± 0.06 cm in females that was significantly less ($P < 0.05$) than that of males, where it was found to be 1.27 ± 0.06 cm. The average length of the shaft was found to be 31.36 ± 0.10 cm in adult Blue bull. Further, it was measured as 31.13 ± 0.13 cm in females that was significantly less ($P < 0.05$) than that of males, where it was found to be 31.58 ± 0.08 cm. The average width of the shaft at the proximal aspect of the rib was found to be 0.79 ± 0.01 cm in adult Blue bull. Further, it was measured as 0.75 ± 0.02 cm in females that was significantly less ($P < 0.05$) than that of males, where it was found to be 0.82 ± 0.01 cm. Similarly, the average width of the shaft at the middle was found to be 1.42 ± 0.01 cm in adult Blue bull. Further, it was measured as 1.40 ± 0.01 cm in females that was significantly less ($P < 0.05$) than that of males, where it was found to be 1.45 ± 0.01 cm. The average width of the shaft at the distal end of the rib was found to be 1.43 ± 0.01 cm in adult Blue bull. Further, it was measured as 1.39 ± 0.01 cm in females that was significantly less ($P < 0.05$) than that of males, where it was found to be 1.47 ± 0.01 cm.

The average cranio-caudal diameter of the cranial articular facet of the head was found to be 0.83 ± 0.01 cm in adult Blue bull. Further, it was measured as 0.81 ± 0.01 cm in females that was significantly less ($P < 0.05$) than that of males, where it was found to be 0.85 ± 0.01 cm. Similarly, the average dorso-ventral diameter of the cranial articular facet of the head was found to be 1.01 ± 0.01 cm in adult Blue bull. Further, it was measured as 0.99 ± 0.01 cm in females that was significantly less ($P < 0.05$) than that of males, where it was found to be 1.03 ± 0.01 cm. The average cranio-caudal diameter of the caudal articular facet of the head was found to be 0.71 ± 0.01 cm in adult Blue bull. Further, it was measured as 0.69 ± 0.01 cm in females that was significantly less ($P < 0.05$) than that of males, where it was found to be 0.73 ± 0.01 cm. Similarly, the average dorso-ventral diameter of the caudal articular facet of the head was found to be 0.95 ± 0.01 cm in adult Blue bull. Further, it was measured as 0.92 ± 0.01 cm in females that was significantly less ($P < 0.05$) than that of males, where it was found to be 0.97 ± 0.01 cm. The average diameter of vascular groove at the proximal aspect was found to be 0.45 ± 0.01 cm in adult Blue bull. Further, it was measured as 0.41 ± 0.0 cm in females that was significantly less ($P < 0.05$) than that of males, where it was found to be 0.48 ± 0.01 cm. The average diameter of vascular groove at the distal aspect was found to be 0.19 ± 0.01 cm in adult Blue bull. Further, it was measured as 0.17 ± 0.01 cm in females that was significantly less ($P < 0.05$) than that of males, where it was found to be 0.21 ± 0.01 cm.

Third rib

The biometrical observation showed that the average diameter of the head of the third rib was found to be 2.82 ± 0.01 cm in adult Blue bull. Further, it was measured as 2.80 ± 0.01 cm in females that was significantly less ($P < 0.05$) than that of males, where it was found to be 2.84 ± 0.01 cm. The average diameter of the tubercle at the dorso-ventral aspect was found to be 1.95 ± 0.06 cm in adult Blue bull. Further, it was measured as 1.78 ± 0.03 cm in females that was significantly less ($P < 0.05$) than that of males, where it was found to be 2.12 ± 0.07 cm. The average diameter of the tubercle at the cranio-caudal aspect was found to be 1.06 ± 0.04 cm in adult Blue bull. Further, it was measured as 0.97 ± 0.04 cm in females that was significantly less ($P < 0.05$) than that of males, where it was found to be 1.15 ± 0.05 cm. The average minimum length of the neck at

the cranial aspect was found to be 0.46 ± 0.01 cm in adult Blue bull. Further, it was measured as 0.43 ± 0.01 cm in females that was significantly less ($P<0.05$) than that of males, where it was found to be 0.49 ± 0.01 cm. Similarly, the average maximum length of the neck at the caudal aspect was found to be 0.86 ± 0.02 cm in adult Blue bull. Further, it was measured as 0.82 ± 0.01 cm in females that was significantly less ($P<0.05$) than that of males, where it was found to be 0.90 ± 0.01 cm. The average width of the shaft at the proximal aspect of the rib was found to be 1.02 ± 0.01 cm in adult Blue bull. Further, it was measured as 0.99 ± 0.01 cm in females that was significantly less ($P<0.05$) than that of males, where it was found to be 1.05 ± 0.02 cm. Similarly, the average width of the shaft at the middle was found to be 1.11 ± 0.03 cm in adult Blue bull. Further, it was measured as 1.09 ± 0.01 cm and 1.13 ± 0.01 cm in females and males respectively. The average width of the shaft at the distal end of the rib was found to be 2.35 ± 0.01 cm in adult Blue bull. Further, it was measured as 2.31 ± 0.01 cm in females that was significantly less ($P<0.05$) than that of males, where it was found to be 2.39 ± 0.01 cm.

The average cranio-caudal diameter of the cranial articular facet of the head was found to be 1.02 ± 0.01 cm in adult Blue bull. Further, it was measured as 0.99 ± 0.01 cm in females that was significantly less ($P<0.05$) than that of males, where it was found to be 1.04 ± 0.01 cm. The average cranio-caudal diameter of the caudal articular facet of the head was found to be 0.91 ± 0.01 cm in adult Blue bull. Further, it was measured as 0.88 ± 0.01 cm in females that was significantly less ($P<0.05$) than that of males, where it was found to be 0.93 ± 0.01 cm. Similarly, the average dorso-ventral diameter of the caudal articular facet of the head was found to be 1.37 ± 0.02 cm in adult Blue bull. Further, it was measured as 1.33 ± 0.02 cm in females that was significantly less ($P<0.05$) than that of males, where it was found to be 1.41 ± 0.01 cm.

The average diameter of vascular groove at the proximal aspect was found to be 0.75 ± 0.01 cm in adult Blue bull. Further, it was measured as 0.72 ± 0.01 cm in females that was significantly less ($P<0.05$) than that of males, where it was found to be 0.79 ± 0.01 cm. Similarly, the average diameter of vascular groove at the middle was found to be 1.10 ± 0.01 cm in adult Blue bull. Further, it was measured as 1.08 ± 0.01 cm in females that was significantly less ($P<0.05$) than that of males, where it was found to be

1.12 ± 0.01 cm. The average diameter of vascular groove at the distal aspect was found to be 0.43 ± 0.01 cm in adult Blue bull. Further, it was measured as 0.41 ± 0.01 cm in females that was significantly less ($P<0.05$) than that of males, where it was found to be 0.45 ± 0.01 cm.

CONCLUSION

The first three pairs of ribs of Blue bull consisted of a head, neck and a tubercle at the proximal end, shaft or body and a costal cartilage at the distal end. An accessory tubercle was located below the main tubercle of the ribs at their caudal border of the shaft. The various parameters of ribs like the average diameter of head, average dorso-ventral and cranio-caudal diameters of tubercle, average cranial and caudal lengths of neck, average length of shaft, average proximal, middle and distal widths of shaft, average cranio-caudal and dorso-ventral diameters of cranial and caudal articular facets of head, average proximal, middle and distal diameters of vascular groove showed characteristic sexual variations. There was meager information available on these parameters in the first three pairs of ribs of Blue bull, so the data presented above would form a baseline for further work in this regard.

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