# GROSS MORPHOLOGICAL AND SEX WISE MORPHOMETRICAL STUDIES ON THE ELEVENTH, TWELFTH AND THIRTEENTH PAIRS OF RIBS OF BLUE BULL (*BOSELAPHUS TRAGOCAMELUS*)

S. SATHAPATHY<sup>1</sup>\*, B.S. DHOTE<sup>2</sup>, D. MAHANTA<sup>2</sup>, S. TAMILSELVAN<sup>2</sup>, I. SINGH<sup>2</sup>, M. MRIGESH<sup>2</sup> and S.K. JOSHI<sup>3</sup>

<sup>1</sup>Department of Veterinary Anatomy and Histology, CVSc. and A.H., <sup>3</sup>KVK, Jharsuguda, OUAT, Bhubaneswar, <sup>2</sup>Department of Veterinary Anatomy, CVASc., GBPUAT, Pantnagar-263 145, India

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## ABSTRACT

The present study was carried out on the eleventh, twelfth and thirteenth pairs of ribs of six specimens of adult Blue bull (*Boselaphus tragocamelus*) of either sex. These ribs 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 11th pair of rib at the caudal border of the shaft. The ribs of both the sides had similar structures and sex wise gross variations were not found. The facet on the tubercle of 11th rib was considered to be more concave among other ribs. The groove of the neck was  $0.17\pm0.002$  cm and  $0.2\pm0.004$  cm deep in females and males, respectively. The facets of the head were separated by a  $0.5\pm0.003$  cm and  $0.45\pm0.008$  cm wide groove in females and males, respectively. The groove of the neck was  $0.18\pm0.001$  cm and  $0.14\pm0.003$  cm and  $0.45\pm0.003$  cm deep in females and males, respectively. The groove of the neck was  $0.18\pm0.001$  cm and  $0.14\pm0.003$  cm deep in females and males, respectively. The groove of the neck was  $0.18\pm0.001$  cm and  $0.14\pm0.003$  cm deep in females and males, respectively. The costal groove was prominent. The facet on the tubercle of the rib was very extensive and concave. The groove of the neck was  $0.18\pm0.001$  cm and  $0.14\pm0.003$  cm deep in females and males, respectively. The costal groove was present that ended at about distal 1/3rd of the shaft of the rib. The accessory tubercle was absent in the 12th and 13th pairs of ribs. The head and tubercle of the 13th rib were fused with each other. The Biometrical observations on different parameters of eleventh, twelfth and thirteenth pairs of ribs of Blue bull reflected significant (P<0.05) differences between the sexes of this species.

Key words: 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). 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., 2018a; Sathapathy et al., 2018b). 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., 2018c; Sathapathy et al., 2018d). The present osteomorphological study developed a baseline data on the eleventh, twelfth and thirteenth 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 meagre literature is available in this field on the Blue bull.

## **MATERIALS AND METHODS**

The present study was carried out on the eleventh, twelfth and thirteenth pairs of ribs of six specimens of adult Blue bulls (*Boselaphus tragocamelus*) of either sex. The bones were possessed from the Jodhpur zoo, Rajasthan after getting authentic confirmation from the Principal Chief Conservator of Forests (PCCF), Government of

\*Corresponding Author: srinivas.ouat@gmail.com

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. They were subsequently boiled in water and air dried. The residual dirts present on the bones were removed manually. The gross study was conducted under the supervision of the Zoo Authority, Jodhpur, India. The different parameters of eleventh, twelfth and thirteenth pairs of ribs of Blue bull were measured and subjected to routine statistical analysis as per the standard method given by Snedecor and Cochran (1994) and independent samples t-Test with Systat Software Inc, USA and SPSS 16.0 version software.

#### **RESULT AND DISCUSSION**

The eleventh, twelfth and thirteenth 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, 2 & 3) as reported by Getty *et al.* (1930) in ox, Dyce *et al.* (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



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



Fig. 2. Proximal end of left eleventh rib of adult male Blue bull (*Boselaphus tragocamelus*) showing (a) Groove between the facets of rib, (b) Facet of head, (c) Head, (d) Neck, (e) Tubercle, (f) Facet on tubercle and (g) Groove on neck



Fig. 3. Proximal end of left twelfth rib of adult male Blue bull (*Boselaphus tragocamelus*) showing (a) Groove between the facets of head, (b) Head, (c) Neck, (d) Tubercle, (e) Facet on tubercle, (f) Groove on neck and (g) Facet on head

presented two articular facets that were separated by a 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 11th pair of 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 like other species.

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 et al. (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 11th rib was considered to be more concave among other ribs. The groove of the neck was  $0.17\pm0.002$  cm and  $0.2\pm0.004$  cm deep in females and males, respectively. The facets of the head were separated by a  $0.5\pm0.003$  cm and  $0.45\pm0.008$  cm wide groove in females and males, respectively. The groove of the head had more width in the 11th rib than others. The costal groove was prominent. The facet on the tubercle of the rib was very extensive and concave. The groove of the neck was  $0.18\pm0.001$  cm and  $0.14\pm0.003$  cm deep in females and males respectively. The accessory tubercle was placed  $3.0\pm0.41$  cm and  $2.8\pm0.34$  cm below the proximal tubercle at the caudal border in females and males respectively. The costal groove was present that ended at about distal 1/3rd of the shaft of the rib. The accessory tubercle was absent in the 12th rib in the Blue bull. The head and tubercle of the 13th rib were fused with each other. So, the neck was found to be absent. The accessory tubercle was absent. The costal groove was prominent which was extended up to the distal 1/3rd of the shaft of the rib like the previous one.

## **BIOMETRICAL OBSERVATION**

**Eleventh Rib:** The biometrical observation showed that the average weight of the eleventh rib was  $131.85 \pm 0.24$ gm in adult Blue bull. Further, it was measured as  $131.28 \pm$ 0.17 gm in females that was significantly less (P<0.05) than that of males, where it was found to be  $132.41 \pm 0.31$ gm (Table 1). All the measurement differed significantly between male and female animals except length of the neck at caudal aspect, width of the shaft at distal end and diameter of vascular groove at distal aspect.

**Twelth Rib:** The biometrical observation showed that the average weight of the twelfth rib was  $87.87\pm0.10$  gm in adult Blue bull. Further, it was measured as  $87.79\pm0.17$  gm and  $87.95\pm0.11$  gm in females and males, respectively (Table 2). All the measurement differed significantly between male and female animal except diameter of tubercle at the dorso-ventral aspect, length of the shaft, cranio-caudal diameter of the caudal articular facet of the

head, Diameter of vascular groove at proximal and distal aspect.

**Thirteenth Rib:** The biometrical observation showed that the average weight of the thirteenth rib was  $84.07\pm0.25$  gm in adult Blue bull. Further, it was measured as  $83.38\pm0.14$ gm in females that was significantly less (P<0.05) than that of males, where it was found to be  $84.75\pm0.24$  gm. There was significant difference between male and female animals for many observations except a few including length of the neck at the cranial aspect, length of the shaft, width of the shaft at the middle and cranio-caudal diameter

Parameters			Range	Mean	SD	SE	Female (Mean±SE)	Male (Mean±SE)
Diameter of head			3.27-3.41	3.33	0.05	0.01	3.30*±0.01	3.37*±0.02
Diameter of tubercle	Dorso-ventral Cranio-caudal		1.72-1.84 1.17-1.31	1.78 1.25	0.03 0.04	0.01 0.01	1.76*±0.01 1.22*±0.02	1.81*±0.01 1.27*±0.01
Length of neck	Cranial (Minimum) Caudal (Maximum)		0.51-0.66 0.80-0.96	0.60 0.89	0.05 0.05	0.01 0.01	$0.56*{\pm}0.01$ $0.86{\pm}0.02$	0.63*±0.01 0.91±0.02
Length of shaft			43.0-44.0	43.46	0.29	0.08	43.25*±0.09	$43.67 \pm 0.08$
Width of shaft	Proximal Middle Distal		1.54-1.71 2.30-2.40 2.57-2.73	1.63 2.34 2.65	0.05 0.04 0.05	0.01 0.01 0.01	1.59*±0.01 2.31*±0.01 2.63±0.02	1.67*±0.01 2.37*±0.01 2.68±0.02
Diameter of articular facets of head	Cranial	Cranio-caudal Dorso-ventral	1.11-1.25 1.61-1.77	1.18 1.70	0.04 0.05	0.01 0.01	1.16*±0.01 1.66*±0.02	1.21*±0.01 1.73*±0.01
	Caudal	Cranio-caudal Dorso-ventral	1.17-1.30 1.51-1.69	1.23 1.59	0.04 0.05	0.01 0.01	1.20*±0.01 1.56*±0.01	$1.25*\pm0.01$ $1.62*\pm0.02$
Diameter of vascular groove	Proximal Middle Distal	0.43-0.60 0.67-0.81 0.43-0.56	0.51 0.72 0.48	0.05 0.04 0.04	0.01 0.01 0.01	$0.47^{\pm}0.01$ $0.70^{\pm}0.01$ $0.46^{\pm}0.01$	$\begin{array}{c} 0.54^{*}{\pm}0.01\\ 0.75^{*}{\pm}0.02\\ 0.50{\pm}0.02 \end{array}$	

 Table 1

 Measurements of eleventh rib of Blue bull (cm)

\*Values bearing common superscript within column differ significantly (p<0.05)

Table 2Measurements of twelfth rib of Blue bull (cm)

Parameters			Range	Mean	SD	SE	Female (Mean±SE)	Male (Mean±SE)
Diameter of head			3.17-3.25	3.19	0.03	0.01	3.17*±0.01	3.22*±0.01
Diameter of tubercle	Dorso-ventral Cranio-caudal		2.07-2.22 1.18-1.30	2.15 1.24	0.05 0.04	0.01 0.01	2.13±0.02 1.21*±0.01	2.17±0.02 1.26*±0.01
Length of neck	Cranial (Minimum) Caudal (Maximum)		0.51-0.67 0.85-1.01	0.59 0.92	0.05 0.05	0.01 0.01	0.56*±0.01 0.89*±0.01	0.63*±0.01 0.96*±0.02
Length of shaft			41.5-42.6	41.99	0.35	0.10	41.85±0.11	42.13±0.15
Width of shaft	Proximal Middle Distal		1.59-1.74 2.08-2.22 2.87-3.01	1.67 2.14 2.94	0.05 0.05 0.04	0.01 0.01 0.01	1.62*±0.01 2.11*±0.01 2.92*±0.01	1.71*±0.01 2.17*±0.02 2.97*±0.01
Diameter of articular facets of head	Cranial	Cranio-caudal Dorso-ventral	1.20-1.34 1.49-1.70	1.28 1.60	0.05 0.06	0.01 0.02	1.24*±0.01 1.55*±0.02	$1.31*\pm0.01$ $1.65*\pm0.02$
	Caudal	Cranio-caudal Dorso-ventral	1.21-1.35 1.39-1.55	1.28 1.47	0.04 0.05	0.01 0.01	1.27±0.01 1.44*±0.01	1.30±0.02 1.51*±0.01
Diameter of vascular groove	Proximal Middle Distal	0.82-0.95 0.80-0.93 0.63-0.75	0.89 0.86 0.69	0.04 0.04 0.03	0.01 0.01 0.01	0.87±0.01 0.82*±0.01 0.67±0.01	0.91±0.02 0.89*±0.01 0.71±0.01	

\*Values bearing common superscript within column differ significantly (p<0.05)

Table 3	
Measurements of thirteenth rib of Blue bull (c	:m)

Parameters			Range	Mean	SD	SE	Female (Mean±SE)	Male (Mean±SE)
Diameter of head			3.27-3.41	3.33	0.05	0.01	3.30*±0.01	3.37*±0.02
Diameter of head			2.76-2.91	2.85	0.04	0.01	$2.82*\pm0.02$	$2.88* \pm 0.01$
Diameter of tubercle	Dorso-ventral Cranio-caudal		1.60-1.73 0.50-0.65	1.67 0.58	0.04 0.05	0.01 0.01	1.64*±0.01 0.55*±0.01	$1.70^{\pm 0.01}$ $0.62^{\pm 0.01}$
Length of neck	Cranial (Minimum) Caudal (Maximum)		0.08-0.24 0.10-0.24	0.16 0.15	0.05 0.04	0.01 0.01	0.13±0.01 0.13*±0.01	0.18±0.02 0.18*±0.02
Length of shaft			33.8-34.5	34.26	0.25	0.07	34.15±0.09	34.37±0.10
Width of shaft	Proximal Middle Distal		1.18-1.30 1.76-1.91 1.97-2.22	1.24 1.84 2.04	0.03 0.04 0.05	0.01 0.01 0.01	1.22*±0.01 1.82±0.02 2.00*±0.01	1.27*±0.01 1.85±0.01 2.07*±0.01
Diameter of articular facets of head	Cranial	Cranio-caudal Dorso-ventral	1.23-1.39 1.28-1.41	1.31 1.35	0.05 0.04	0.01 0.01	1.28*±0.01 1.32*±0.01	$1.34*\pm0.01$ $1.38*\pm0.01$
	Caudal	Cranio-caudal Dorso-ventral	1.16-1.30 1.30-1.42	1.23 1.37	0.04 0.04	0.01 0.01	1.21±0.01 1.34*±0.01	1.25±0.02 1.40*±0.01
Diameter of vascular groove	Proximal Middle Distal	0.53-0.65 0.59-0.71 0.30-0.45	0.58 0.65 0.39	0.04 0.04 0.04	0.01 0.01 0.01	0.55*±0.01 0.62*±0.01 0.36*±0.01	$0.60*{\pm}0.01$ $0.69*{\pm}0.01$ $0.41*{\pm}0.01$	

\*Values bearing common superscript within column differ significantly (p<0.05)

of the caudal articular facet of the head (Table 3).

## CONCLUSION

The eleventh, twelfth and thirteenth 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 11th pair of rib at the caudal border of the shaft. The different parameters of ribs showed characteristic sexual variations. The data presented above would form a baseline for further work which can be useful in veterolegal cases.

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