Haryana Vet. (June, 2020) **59(1),** 33-37

Research Article

BIOMETRICAL SEXUAL DIFFERENTIATION OF FIRST AND SECOND COCCYGEAL VERTEBRAE OF BLUE BULL (*BOSELAPHUS TRAGOCAMELUS*)

S. SATHAPATHY*, B.S. DHOTE[1], S. TAMILSELVAN[1], I. SINGH[1], M. MRIGESH[1] and S.K. JOSHI[2]
Department of Veterinary Anatomy and Histology, CVSc. and A.H., [2]KVK, Jharsuguda,
Orissa University of Agriculture and Technology, Bhubaneswar–751 003, India
[1]Department of Veterinary Anatomy, College of Veterinary and Animal Sciences,
GB Pant University of Agriculture and Technology, Pantnagar–263 145, India

Received: 03.05.2019; Accepted: 22.06.2019

ABSTRACT

The present biometrical study was carried out on the first (Cy_1) and second (Cy_2) coccygeal vertebrae of six specimens of adult Blue bull of either sex. The first and second coccygeal vertebrae presented body, complete arches and processes. The transverse processes were plates that exceeded beyond the level of the posterior articular surface of the body. There were two intervertebral foramina in the cranial aspect of Cy_1 in Blue bull. The left one was smaller having 0.05±0.001 cm and 0.008±0.001 cm diameter, where as the right one was larger having 0.11±0.002 cm and 0.15±0.001 cm diameter in female and male, respectively. The ventral spine was bifid forming sulcusvasculosus for the passage of the middle coccygeal artery. Ventrally, a foramen was present having 0.11±0.002 cm and 0.13±0.001 cm diameter at the end of the right ventral spine in Cy_1 in female and male, respectively. The biometrical parameters measured showed characteristic sexual dimorphism in Blue bull.

Keywords: Blue bull, Biometrical, Coccygeal vertebrae

The Blue bull 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, Rohlan *et al.*, 2018, Sathapathy *et al.*, 2018a, Sathapathy *et al.*, 2018b, Sathapathy *et al.*, 2018c and Sathapathy *et al.*, 2018d). The Blue bull belongs to the family Bovidae and comes under the genus Boselaphus (Sathapathy *et al.*, 2018e, Sathapathy *et al.*, 2018f, Sathapathy *et al.*, 2018g and Sathapathy *et al.*, 2018h). 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.*, 2018i). The adult male appears like ox and so called as Blue bull. They are usually seen in day times in the meadow pasture, timberland areas and agricultural land area. The Blue bulls are safeguarded beneath the IUCN since 2003 and also under '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.*, 2018j, Sathapathy *et al.*, 2018k and Sathapathy *et al.*, 2018l). The present biometrical study developed a baseline data on the first and second coccygeal vertebrae of adult Blue bull with respect to sex that would immensely help the wild life anatomists and veterinarians in the identification of sex of the animal and solving forensic and veterolegal cases.

*Corresponding author: srinivas.ouat@gmail.com

MATERIALS AND METHODS

The present biometrical study was carried out on the first and second coccygeal vertebrae of six specimens of adult Blue bulls of either sex. The permission for the collection of bones was acquired 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 collected specimens of the blue bull were macerated as per the standard technique (Choudhary *et al.*, 2013, 2015; Choudhary and Singh, 2015 and 2016). The different parameters of first and second coccygeal vertebrae 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 (Cy_1) and second (Cy_2) coccygeal vertebrae were well developed having a body, arch and processes in Blue bull (Fig. 1). They presented complete arches and spinous processes. The transverse processes were large. The cranial non-articular processes were also found. The neural rings were found to be complete in Cy_1 and Cy_2. The present findings were similar to the observations of Getty *et al.* (1930) in ox, Raghavan (1964) in ox, Konig and Liebich (2005) in horse and Choudhary *et al.* (2015) in blackbuck, but dissimilar with the reports of Miller *et al.* (1964) in dog, where the vertebral arch was well developed in Cy_1 after which lumen became progressively smaller. The summits of the supraspinous processes were thick, tuberous and bifid. The extremities of bodies were rounded

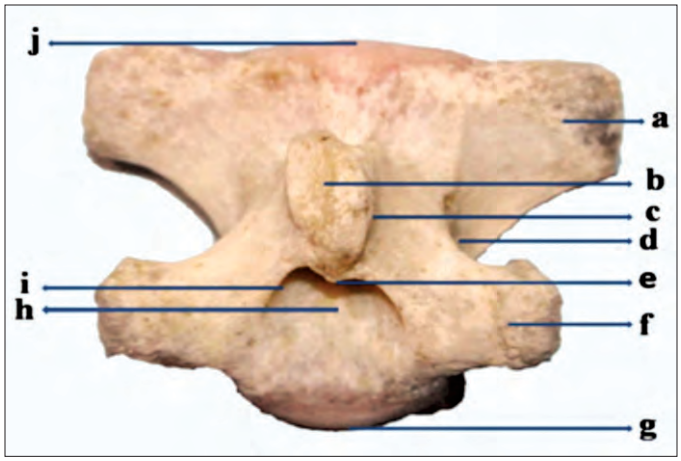

Fig. 1. Dorsal view of first coccygeal vertebra of adult male Blue bull (Boselaphus tragocamelus) showing a) Transverse process, b) Bifid summit of dorsal supraspinous process, c) Dorsal supraspinous process, d) Groove, e) Laminae, f) Anterior non-articular process, g) Anterior surface of body, h) Vertebral foramen, i) Pedicle and j) Posterior surface of body

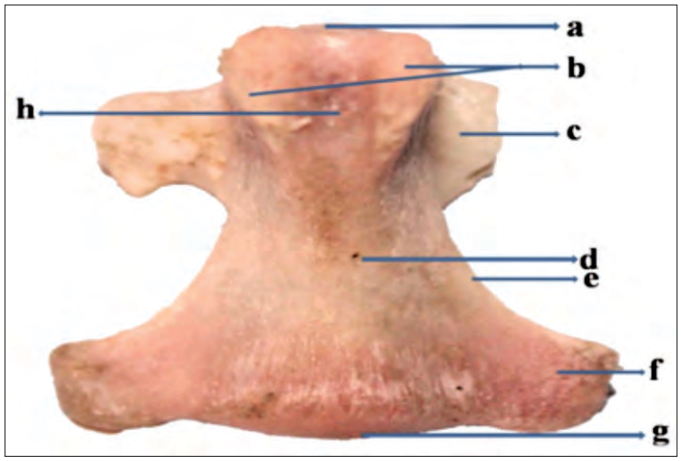

Fig. 1. Ventral view of second coccygeal vertebra of adult male Blue bull (*Boselaphus tragocamelus*) showing a) Anterior surface of body, b) Ventral spines, c) Anterior non-articular process, d) Ventral foramen, e) Groove, f) Transverse process, g) Anterior surface of body and h) Sulcus vasculosus

anteriorly and flattened posteriorly.

There were two intervertebral foramina in the cranial aspect of Cy_1 in Blue bull. The left one was smaller having 0.05±0.001 cm and 0.008±0.001 cm diameter, whereas the right one was larger having 0.11±0.002 cm and 0.15±0.001 cm diameter in female and male, respectively. Further, the left intervertebral foramen was placed 1.5 ± 0.24 cm and 1.3±0.17 cm away from the body of the vertebra in female and male, respectively, while the right one was 1.2±0.14 cm and 1.1±0.28 cm away from the centrum of Cy_1 in female and male, respectively. The left caudal intervertebral foramen was only present in Cy_1 having 0.04±0.001 cm and 0.09±0.001 cm diameter that was situated 0.4±0.002 cm and 0.6±0.001 cm behind the left cranial intervertebral foramen in female and male Blue bull, respectively. The ventral surfaces of the bodies of coccygeal vertebrae were concave in Blue bull. The ventral spine was bifid forming a groove known as sulcusvasculosus (Fig. 2) that provided the passage for the middle coccygeal artery. This artery is usually approached for recording pulse rate in the Blue bull. Ventrally, a foramen was present having 0.11±0.002 cm and 0.13±0.001 cm diameter at the end of the right ventral spine in Cy_1 in female and male, respectively. Another foramen was located ventrally at the cranial aspect of the right transverse process that was 1.74±0.11 cm and 1.64±0.14 cm away from the body of the vertebra in female and male, respectively. Similarly, a foramen having diameter 0.13±0.001 cm and 0.16±0.002 cm was situated 1.01± 0.18 cm and 1.22±0.21 cm away from the end of the right ventral spine in Cy_2 in female and male, respectively, while the other foramen was absent. The biometrical observations revealed characteristic differences between the sexes of the Blue bull.

First coccygeal vertebra: Biometrical studies revealed that the average weight was measured as 34.57±0.38 gm in females that was significantly lesser ($P<0.05$) than that of males, where it was found to be 37.17±0.60 gm. The average length of the body was found to be 4.53±0.15 cm and 4.83±0.07 cm in females and males, respectively. The average length of the body of coccygeal vertebrae showed a decreasing trend from Cy_1 to Cy_4 in the Blue bull, which was similar to the observations of Rajani and Chungath (2012) in Indian Muntjac. The average width of the body at the middle was measured as 1.44±0.05 cm in females that was significantly lesser ($P<0.05$) than that of males, where it was found to be 1.65±0.03 cm.

The average cranial diameter of vertebral canal was measured as 0.33±0.01 cm in females that was significantly lesser ($P<0.05$) than that of males, where it was found to be 0.38±0.01 cm. Similarly, the average caudal diameter of vertebral canal was found to be 0.10±0.01 cm in females that was significantly lesser ($P<0.05$) than that of males, where it was found to be 0.15±0.01 cm. The average length of vertebral canal was measured as 2.31±0.04 cm in females that was significantly lesser ($P<0.05$) than that of males, where it was found to be 2.46±0.03 cm.

The average length of dorsal spine was found to be 1.05±0.08 cm and 1.18±0.08 cm in females and males, respectively. The average height of dorsal spine at the cranial aspect was measured as 0.39±0.02 cm in females that was significantly lesser ($P<0.05$) than that of males, where it was found to be 0.47±0.02 cm. Similarly, the average height of dorsal spine at the middle was found to be 0.54±0.04 cm in females that was significantly lesser ($P<0.05$) than that of males, where it was found to be 0.75±0.06 cm. The average height of dorsal spine at the caudal aspect was measured as 0.55±0.02 cm in females

that was significantly lesser (P<0.05) than that of males, where it was found to be 0.64±0.01 cm.

The average thickness of dorsal spine at the cranial aspect was measured as 0.15±0.02 cm in females that was significantly lesser (P<0.05) than that of males, where it was found to be 0.28±0.03 cm. Similarly, the average thickness of dorsal spine at the middle was measured as 0.18±0.01 cm in females that was significantly lesser (P<0.05) than that of males, where it was found to be 0.25±0.01 cm. The average thickness of dorsal spine at the caudal aspect was measured as 0.21±0.02 cm and 0.25±0.02 cm in females and males, respectively.

The average distance between the two parts of dorsal spine at the cranial aspect was measured as 0.18±0.01 cm and 0.21±0.02 cm in females and males, respectively. The average distance between the two parts of dorsal spine at the middle was measured as 0.18±0.01 cm in females that was significantly lesser (P<0.05) than that of males, where it was found to be 0.22±0.01 cm. Similarly, the average distance between the two parts of dorsal spine at the caudal aspect was measured as 0.10±0.01 cm in females that was significantly lesser (P<0.05) than that of males, where it was found to be 0.13±0.01 cm. The average length of transverse process was measured as 1.66±0.05 cm and 1.76±0.05 cm in females and males, respectively. The average width of transverse process at the cranial aspect was measured as 0.75±0.03 cm and 0.82±0.04 cm in females and males, respectively. Similarly, the average width of transverse process at the middle was measured as 1.01±0.03 cm and 1.07±0.04 cm in females and males, respectively. The average width of transverse process at the caudal aspect was measured as 0.88±0.04 cm and 0.97±0.04 cm in females and males, respectively. The average distance between the transverse processes of Cy_1 and Cy_2 was found to be 3.39±0.08 cm and 3.55±0.06 cm in females and males, respectively. The average length of cranial non-articular process was found to be 1.19±0.08 cm and 1.26±0.09 cm in females and males, respectively. The average width of cranial non-articular process at the cranial aspect was measured as 0.43±0.02 cm and 0.50±0.03 cm in females and males, respectively. Similarly, the average width of cranial non-articular process at the middle was measured as 0.56±0.03 cm and 0.62±0.03 cm in females and males, respectively. The average width of cranial non-articular process at the caudal aspect was found to be 0.34±0.03 cm in females that was significantly lesser (P<0.05) than that of males, where it was found to be 0.45±0.03 cm.

The average minimum distance between the two cranial non-articular processes was found to be 2.03±0.03 cm in females that was significantly lesser (P<0.05) than that of males, where it was found to be 2.12±0.02 cm. Similarly, the average distance between the cranial non-articular process and transverse process was measured as 0.79±0.02 cm in females that was significantly lesser (P<0.05) than that of males, where it was found to be 0.92±0.03 cm. The average distance between the cranial non-articular processes of Cy_1 and Cy_2 was measured as 3.31±0.04 cm and 3.41±0.04 cm in females and males respectively. The average length of ventral spine was found to be 1.59±0.03 cm and 1.68±0.03 cm in females and males, respectively. The average height of ventral spine at the cranial aspect was measured as 0.58±0.03 cm in females that was significantly lesser (P<0.05) than that of males, where it was found to be 0.73±0.02 cm. The average height of ventral spine at the middle was measured as 0.97±0.04 cm and 1.08±0.04 cm in females and males, respectively. Similarly, the average height of ventral spine at the caudal aspect was measured as 0.68±0.03 cm and 0.78±0.03 cm in females and males, respectively. The average distance between the ventral spines of Cy_1 and Cy_2 was found to be 2.24±0.06 cm and 2.30±0.05 cm in females and males, respectively. The average length of sulcusvasculosus was measured as 1.73 ± 0.04 cm and 1.86 ± 0.03 cm in females and males, respectively. The average width of sulcusvasculosus at the cranial aspect was measured as 0.67±0.07 cm and 0.85±0.03 cm in females and males, respectively. The average width of sulcusvasculosus at the middle was measured as 0.43±0.02 cm in females that was significantly lesser (P<0.05) than that of males, where it was found to be 0.52±0.01 cm. The average width of sulcusvasculosus at the caudal aspect was found to be 0.20±0.03 cm and 0.22±0.01 cm in females and males, respectively. The average distance between the sulcusvasculosus of Cy_1 and Cy_2 was measured as 2.37±0.09 cm and 2.53±0.03 cm in females and males, respectively.

Second coccygeal vertebra: Biometrical studies revealed that the average weight measured as 29.42±0.36 gm in females that was significantly lesser (P<0.05) than that of males, where it was found to be 31.83±0.73 gm. The average length of the body was measured as 4.00±0.06 cm in females that was significantly lesser (P<0.05) than that of males, where it was found to be 4.27±0.03 cm. The average width of the body at the middle was measured as 1.44±0.04 cm and 1.57±0.03 cm in females and males, respectively. The average cranial diameter of vertebral canal was found to be 0.22±0.01 cm in females that was significantly lesser (P<0.05) than that of males, where it was found to be 0.27±0.01 cm. The average caudal diameter of vertebral canal was measured as 0.11±0.01 cm and 0.14±0.00 cm in females and males, respectively. The

average length of vertebral canal was measured as 2.02±0.03 cm in females that was significantly lesser (P<0.05) than that of males, where it was found to be 2.15±0.03 cm. The average distance between the vertebral canal of Cy_2 and Cy_3 was measured as 1.87±0.07 cm in females that was significantly lesser (P<0.05) than that of males, where it was found to be 2.23±0.09 cm. The average length of dorsal spine was found to be 0.86±0.04 cm in females that was significantly lesser (P<0.05) than that of males, where it was measured 0.97±0.03 cm.

The average height of dorsal spine at the cranial aspect was measured as 0.26±0.01 cm and 0.32±0.02 cm in females and males, respectively. The average height of dorsal spine at the middle was measured as 0.51±0.03 cm in females that was significantly lesser (P<0.05) than that of males, where it was found to be 0.66±0.03 cm. The average height of dorsal spine at the caudal aspect was measured as 0.52±0.02 cm and 0.62±0.02 cm in females and males, respectively. The average thickness of dorsal spine at the cranial aspect was found to be 0.20±0.02 cm in females that was significantly lesser (P<0.05) than that of males, where it was recorded 0.26±0.02 cm. Similarly, the average thickness of dorsal spine at the middle was measured as 0.31±0.01 cm in females that was significantly lesser (P<0.05) than that of males, where it was found to be 0.39±0.02 cm. The average thickness of dorsal spine at the caudal aspect was measured as 0.28±0.02 cm and 0.31±0.01 cm in females and males, respectively. The average distance between the two parts of dorsal spine at the cranial aspect was measured as 0.06±0.01 cm in females that was significantly lesser (P<0.05) than that of males, where it was found to be 0.10±0.01 cm. The average distance between the two parts of dorsal spine at the middle was measured as 0.13±0.01 cm and 0.18±0.02 cm in females and males, respectively. The average distance between the two parts of dorsal spine at the caudal aspect was measured as 0.10±0.01 cm in females that was significantly lesser (P<0.05) than that of males, where it was found to be 0.14±0.01 cm.

The average length of transverse process was found to be 1.08±0.05 cm in females that was significantly lesser (P<0.05) than that of males, where it was recorded 1.25±0.04 cm. The average width of transverse process at the cranial aspect was measured as 0.99±0.01 cm in females that was significantly lesser (P<0.05) than that of males, where it was found to be 1.06±0.01 cm. The average width of transverse process at the middle was measured as 1.11±0.05 cm and 1.18±0.04 cm in females and males, respectively. The average width of transverse process at the caudal aspect was measured as 0.68±0.03 cm and 0.74±0.03 cm in females and males, respectively. The average distance between the transverse processes of Cy_2 and Cy_3 was found to be 3.14±0.02 cm and 3.20±0.03 cm in females and males, respectively.

The average length of cranial non-articular process was measured as 1.23±0.11 cm and 1.47±0.13 cm in females and males, respectively. The average width of cranial non-articular process at the cranial aspect was measured as 0.36±0.02 cm in females that was significantly lesser (P<0.05) than that of males, where it was found to be 0.46±0.01 cm. The average width of cranial non-articular process at the middle was found to be 0.47±0.02 cm and 0.52±0.02 cm in females and males, respectively. Similarly, the average width of cranial non-articular process at the caudal aspect was found to be 0.37±0.02 cm and 0.43±0.03 cm in females and males, respectively.

The average minimum distance between the two cranial non-articular processes was measured as 2.10±0.02 cm and 2.17±0.02 cm in females and males, respectively. Similarly, the average distance between the cranial non-articular process and transverse process was found to be 1.21±0.02 cm and 1.26±0.01 cm in females and males, respectively. The average distance between the cranial non-articular processes of Cy_2 and Cy_3 was measured as 3.25±0.02 cm in females that was significantly lesser (P<0.05) than that of males, where it was found to be 3.33±0.02 cm.

The average length of ventral spine was measured as 1.72±0.06 cm and 1.82±0.07 cm in females and males, respectively. The average height of ventral spine at the cranial aspect was found to be 0.42±0.01 cm in females that was significantly lesser (P<0.05) than that of males, where it was found to be 0.48±0.01 cm. The average height of ventral spine at the middle was measured as 0.58±0.02 cm and 0.62±0.01 cm in females and males, respectively. Similarly, the average height of ventral spine at the caudal aspect was found to 0.43±0.01 cm and 0.46±0.01 cm in females and males, respectively. The average distance between the ventral spines of Cy_2 and Cy_3 was found to be 2.82±0.13 cm and 2.90±0.14 cm in females and males, respectively.

The average length of sulcusvasculosus was measured as 1.99±0.01 cm and 2.05±0.02 cm in females and males, respectively. The average width of sulcusvasculosus at the cranial aspect was found to be 0.20±0.01 cm and 0.23±0.02 cm in females and males respectively. Similarly, the average width of sulcusvasculosus at the middle was measured as 0.14±0.02 cm and 0.22±0.01 cm in females and males, respectively. The average width of sulcusvasculosus at the caudal aspect was found to be 0.12±0.02 cm and 0.16±0.01 cm in females and males, respectively. The average distance between the sulcusvasculosus of Cy_2 and

Cy_3 was measured as 2.67±0.03 cm and 2.77±0.03 cm in females and males, respectively.

CONCLUSION

Various parameters of the first and second coccygeal vertebrae showed characteristic sexual variations in the Blue bull. There is no previous information on these parameters in the first and second coccygeal vertebrae of Blue bull. We therefore believe that the data presented above would form a baseline for further work.

ACKNOWLEDGEMENT

The authors are grateful to the Dean, CVASc., GBPUA&T, Pantnagar, Uttarakhand, Principle Chief Conservator of Forests, Government of Rajasthan and Jodhpur Zoo, Rajasthan for providing facilities and support for carrying out research on the bones of Blue bull. Funding was provided by Department of Science and Technology, New Delhi and Indian Council of Agricultural Research, New Delhi, India as Ph.D. grant (DST-INSPIRE Fellowship and ICAR-SRF (PGS)) to the first author.

REFERENCES

Bagchi, S., Goyal, S.P. and Shankar, K. (2004). Herbivore density and biomass in a semi-arid tropical dry deciduous forest of western India. *J. Trop. Ecol.* **20(4)**: 475-478.

Choudhary, O.P., Mathur, R., Joshi, S., Beniwal, G. and Dangi, A. (2013). Gross and Biometrical studies on carpals of chital (*Axis axis*). *Vet. Prac.* **14(1)**: 36-39.

Choudhary, O.P., Singh, I., Bharti, S.K., Mohd, K.I., Dhote, B.S. and Mrigesh, M. (2015). Gross Studies on Lumbar, Sacrum and Coccygeal Vertebrae of Blackbuck (*Antelope cervicapra*). *Indian Vet. J.* **92(3)**: 75-78.

Choudhary, O.P. and Singh, I. (2015). Morphometrical Studies on the Skull of Indian Blackbuck (*Antelope cervicapra*). *Int. J. Morphol.* **33(3)**: 868-876.

Choudhary, O.P. and Singh, I. (2016). Morphological and Radiographic Studies on the Skull of Indian Blackbuck (*Antilope cervicapra*). *Int. J. Morphol.* **34(2)**: 788-796.

Getty, R., Sisson, S. and Grossman, J.D. (1930). The Anatomy of the Domestic Animals. W.B. Saunders Company., Philadelphia, USA.

Konig, H.E. and Liebich, H.G. (2005). Veterinary Anatomy of Domestic Animals (3rd Edn.), Schattauer, Stuttgart, Germany.

Miller, M.E., Christensen, G.C. and Evans, H.E. (1964). Anatomy of the Dog. WB Saunders Company, Philadelphia, USA.

Raghavan, D. (1964). Anatomy of Ox. Indian Council of Agricultural Research, New Delhi.

Rajani, C.V. and Chungath, J.J. (2012). Studies on the Lumbar, Sacral and Coccygeal Vertebrae of Indian Muntjac (*Muntia cusmuntjak*). *Indian J. Vet. Anat.* **24(2)**: 78-79.

Rohlan, K., Mathur, R., Dangi, A., Shringi, N., Ganguly, S. and Kumar, V. (2018). Morphometrical studies on humerus of Blue Bull (*Boselaphustra gocamelus*). *Int. J. Liv. Res.* **8(6)**: 177-184.

Sathapathy, S., Dhote, B.S., Singh, I., Mahanta, D. and Tamil selvan, S. (2017). Gross and morphometrical studies on the sacrum of Blue bull (*Boselaphustra gocamelus*). *JEZS.* **5(6)**: 1591-1597.

Sathapathy, S., B.S. Dhote, M. Mrigesh, D. Mahanta and Tamil Selvan, S. (2018a). Gross and Morphometrical Studies on the Sternum of Blue Bull (*Boselaphustra gocamelus*). *Int. J. Curr. Microbiol. App. Sci.* **7(01)**: 136-145.

Sathapathy, S., Dhote, B.S., Singh, I., Mahanta, D. and Mrigesh, M. and Joshi, S.K. (2018b). Gross Anatomical and Sex wise Biometrical Studies on the Atlas and Axis of Blue bull (*Boselaphustra gocamelus*). *J. Anim. Res.* **8(1)**: 137-147.

Sathapathy, S., Dhote, B.S., Singh, I., Mahanta, D., Tamilselvan, S. and Mrigesh, M. (2018c). Gross morphometrical study on the atypical (6th and 7th) cervical vertebrae of Blue bull (*Boselaphustra gocamelus*) with special reference to sexual dimorphism. *Int. J. Liv. Res.* **8(9)**: 192-201.

Sathapathy, S., Dhote, B.S., Mahanta, D., Tamilselvan S., Singh, I., Mrigesh, M. and Joshi, S.K. (2018d). Gross morphological and sex wise morphometrical studies on the first, second and third thoracic vertebrae of Blue bull (*Boselaphustra gocamelus*). *JEZS.* **6(6)**: 1-6.

Sathapathy, S., Dhote, B.S., Mahanta, D., Tamilselvan, S., Singh, I., Mrigesh, M. and Joshi, S.K. (2018e). Gross morphological and sex wise morphometrical studies on the eighth, ninth and tenth pairs of ribs of Blue bull (*Boselaphustra gocamelus*). *Multilog. Sci.* **VIII (XXVIII)**: 207-212.

Sathapathy, S., Dhote, B.S., Mahanta, D., Tamilselvan, S., Singh, I., Mrigesh, M. and Joshi, S.K. (2018f). Gross Morphological and Biometrical Sexual Dimorphic Studies on the First, Second and Third Pairs of Ribs of Blue Bull (*Boselaphustra gocamelus*). *J. Anim. Res.* **8(6)**: 1041-1046.

Sathapathy, S., Dhote, B.S., Mahanta, D., Tamilselvan, S., Singh, I., Mrigesh, M. and Joshi, S.K. (2018g). Gross Morphological and Sex wise Morphometrical Studies on the Third to Fifteenth Coccygeal Vertebrae of Blue Bull (*Boselaphustra gocamelus*). *Int. J. Curr. Microbiol. App. Sci.* **7(11)**: 411-428.

Sathapathy, S., Dhote, B.S., Mahanta, D., Tamilselvan, S., Mrigesh, M. and Joshi, S.K. (2018h). Gross morphological and biometrical Studies on the typical cervical vertebraeof Blue bull (*Boselaphustra gocamelus*). *Indian J. Anim. Res.* DOI: 10.18805/ijar.B-3572.

Sathapathy, S., Dhote, B.S., Mahanta, D., Tamilselvan, S., Mrigesh, M. and Joshi, S.K. (2018i). Gross and morphometrical studies on the first second and third lumbarvertebrae of Blue bull (*Boselaphustra gocamelus*). *Indian J. Anim. Res.* DOI: 10.18805/ijar.B-3575.

Sathapathy, S., Dhote, B.S., Mahanta, D., Tamilselvan, S., Mrigesh, M. and Joshi, S.K. (2018j). Biometrical sexual differentiation of fourth, fifth and sixth lumbar vertebrae in Blue bull (*Boselaphustra gocamelus*). *Indian J. Anim. Res.* DOI: 10.18805/ijar.B-3598.

Sathapathy, S., Dhote, B.S., Mahanta, D., Tamilselvan, S., Singh, I., Mrigesh, M. and Joshi, S.K. (2018k). Gross morphological and sex wise morphometrical studies on the eleventh, twelfth and thirteenth pairs of ribsBlue bull (*Boselaphustra gocamelus*). *Haryana Vet.* **58(1)**: 104-107.

Sathapathy, S., Dhote, B.S., Mahanta, D., Tamilselvan, S., Mrigesh, M. and Joshi, S.K. (2018l).Gross morphological and morphometrical studies on the first and second coccygeal vertebrae of Blue bull (*Boselaphustra gocamelus*). *Int. J. Liv. Res.* **9(6)**: 49-55. DOI 10.5455/IJLR.20190310063048.

Snedecor, G.W. and Cochran, W.G. (1994). Statistical Methods. (8th Edn.), Iowa State University Press, Ames, Iowa, USA.