Original Research

Gross Morphological and Morphometrical Studies on the First and Second Coccygeal Vertebrae of Blue Bull (*Boselaphus tragocamelus*)

S. Sathapathy[1*], B. S. Dhote[2], D. Mahanta[2], Tamilselvan, S.[2], M. Mrigesh[2] and S. K. Joshi[3]

[1]Department of Anatomy and Histology, CVSc and Animal Husbandry, OUAT, Bhubaneswar– 751003, Odisha, INDIA
[2]Department of Veterinary Anatomy, CVASc, GBPUA&T, Pantnagar– 263145, Uttarakhand, INDIA
[3]KVK, Jharsuguda, OUAT, Bhubaneswar – 751 003, Odisha, INDIA

***Corresponding author:** srinivas.ouat@gmail.com

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Abstract

The present study was carried out on the first and second coccygeal vertebrae of six specimens of adult Blue bull (Boselaphus tragocamelus). They presented complete arches and spinous processes. The transverse processes were found to be plate like that were directed downward, backward extending 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, whereas the right one was larger having 0.11±0.002 cm and 0.15±0.001 cm diameter. The ventral spine was bifid forming sulcus vasculosus for the passage of the middle coccygeal artery.

Key words: Blue Bull, Coccygeal Vertebrae, Morphology, Morphometry

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Introduction

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; 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 (Sathapathy *et al*., 2018e; Sathapathy *et al*., 2018f and Sathapathy *et al*., 2018g). 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*., 2019). The adult male appears like ox and so called as Blue bull. The Blue bull is protected in various parts of India such as Gir National Park (Gujarat), Kumbhalgarh Santuary

(Rajasthan) and Panchamarahi Biosphere Reserve, India. The coccygeal vertebrae form the skeleton of the tail and play very important role in locomotion of the animals. The present osteo-morphological study was carried out to develop a baseline data on the first and second coccygeal vertebrae of adult Blue bull that would immensely help the wild life anatomists and veterinarians in species identification and solving forensic and vetero-legal cases.

Materials and Methods

Study was carried out on the first and second coccygeal vertebrae of six specimens of adult Blue bulls (*Boselaphus tragocamelus*). The permission for the collection of bones was obtained from the Principal Chief Conservator of Forests (PCCF), Government of Rajasthan. The bones were procured from the Jodhpur zoo, Rajasthan getting permission 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. Afterwards, the specimens were boiled in an aluminium vat for about one hour. They were taken out from the vat and air dried for 3-5 days (Choudhary *et al*., 2013). The gross study was conducted under the supervision of the Zoo Authority, Jodhpur, India. The different morphometrical parameters of body, arch, processes, groove and foramina of first and second coccygeal vertebrae of Blue bull were measured and subjected to routine statistical analysis as per standard technique of 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 or caudal vertebrae were long and well developed in Blue bull that formed the cranial part of skeleton of its tail. They were 15 to 21 in number in Blue bull (Fig. 1). The first and second coccygeal vertebrae included complete neural rings and spinous processes. The transverse processes were large. The cranial non-articular processes were also found. These were similar to the findings of Getty *et al.* (1930) in ox, Raghavan (1964) in ox and Meena (2012) in chital, but contrary to the description 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 (Fig. 2 and Fig. 4).

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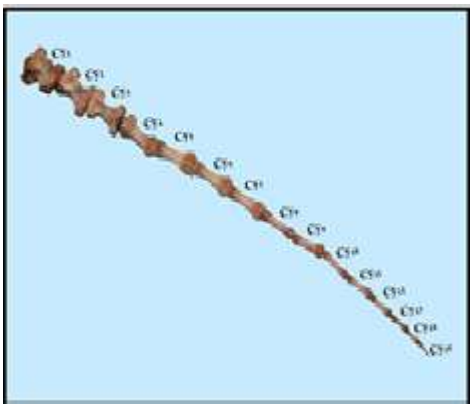

Fig.1: Ventral view of coccygeal vertebrae (Cy_1-Cy_{15}) of adult male Blue bull (*Boselaphus tragocamelus)*

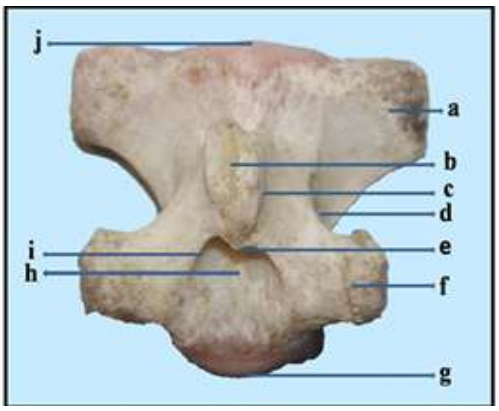

Fig. 2 : Dorsal view of first coccygeal vertebrae of adult male Blue bull (*Boselaphus tragocamelus)* showing- a) Transverse process, b) Bifid summit of dorsal supraspinous process, c) Dorsal supraspinous process, d) Groove, e) Laminae, f) Anterior non-articular process, g) Anterior surface of body, h) Vertebral foramen, i) Pedicle and j) Posterior surface of body

The cranial processes were present, but were non-articular. The caudal ones were absent which was in accordance with the findings of Getty *et al.* (1930) in horse and ox, Raghavan (1964) in ox, Smuts and Bezuidenhout (1987) in camel, Levine *et al.* (2007) in horse and Meena (2012) in chital, but dissimilar with Miller *et al.* (1964) who reported that the posterior articular processes were asymmetrical in dog. The transverse processes were found to be plate like that were directed downward, backward extending beyond the level of the posterior articular surface of the body.

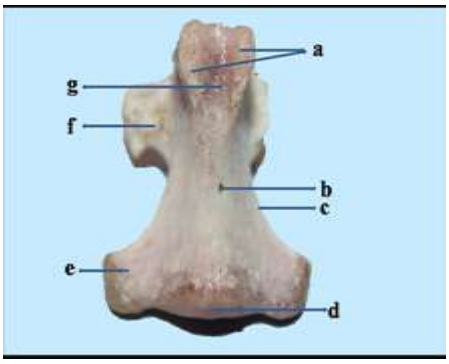

Fig. 3: Ventral view of first coccygeal vertebrae of adult male Blue bull (*Boselaphus tragocamelus*) showing-a) Ventral spines, b) Ventral foramen, c) Groove, d) Posterior surface of body, e) Transverse process, f) Anterior non-articular process and g) Sulcus vasculosus

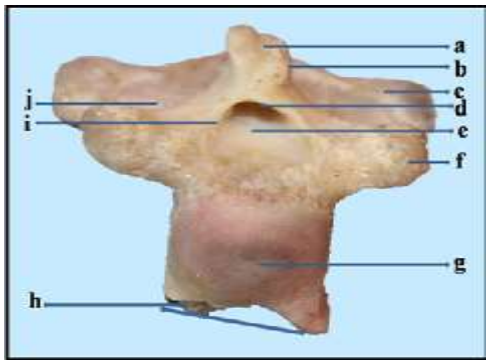

Fig. 4: Cranial view of second coccygeal vertebrae of adult male Blue bull (*Boselaphus tragocamelus*) showing- a) Bifid summit of Dorsal supraspinous process, b) Dorsal supraspinous process, c) Transverse process, d) Laminae, e) Vertebral foramen, f) Anterior non-articular process, g) Anterior surface of body and h) Ventral spines

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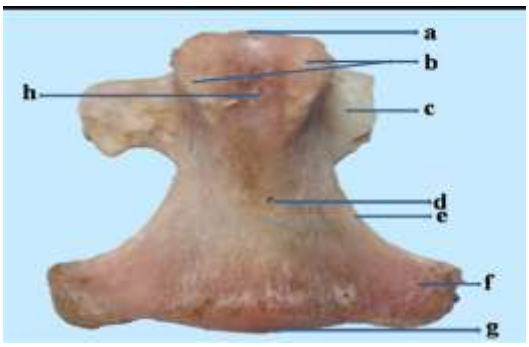

Fig. 5: Ventral view of first coccygeal vertebrae of adult male Blue bull (*Boselaphus tragocamelus*) showing- a) Anterior surface of body, b) Ventral spines, c) Anterior non-articular process, d) Ventral foramen, e) Groove, f) Transverse process, g) Anterior surface of body and h) Sulcus vasculosus

The extremities of bodies were rounded anteriorly and flattened posteriorly, which corroborated the findings of Getty *et al.* (1930) in horse and ox, Raghavan (1964) in ox, Smuts and Bezuidenhout (1987) in camel and Konig and Liebich (2005) in horse. The ventral surfaces of the bodies of coccygeal vertebrae were concave in Blue bull. The ventral spine was bifid forming a groove known as sulcus vasculosus for the passage of the middle coccygeal artery (Fig. 3 and Fig. 5).

Biometrical Observation

The biometrical observations were represented in Table 1 and Table 2.

Table 1: Measurements of first coccygeal vertebra of Blue bull in cm

Parameters			Range	Mean±SE
Body	Length		4.3-4.9	4.68±0.09
	Width at the middle		1.38-1.71	1.55±0.05
Dorsal spine	Length		0.82-1.39	1.11±0.06
	Height	Cranial	0.32-0.52	0.43±0.02
		Middle	0.43-0.91	0.64±0.04
		Caudal	0.49-0.69	0.59±0.02
Transverse process	Length		1.48-1.92	1.71±0.04
	Width		0.65-0.90	0.79±0.03
Cranial non-articular process	Length		0.99-1.48	1.23±0.06
	Width		0.24-0.53	0.40±0.03
Ventral spine	Length		1.50-1.78	1.64±0.02
	Height	Cranial	0.48-0.81	0.65±0.03
		Middle	0.83-1.18	1.02±0.03
		Caudal	0.59-0.91	0.73±0.03
Sulcus vasculosus	Length		1.66-1.91	1.79±0.04
	Width		0.39-0.55	0.48±0.02
Diameter of vertebral canal		Cranial	0.32-0.39	0.36±0.01
		Caudal	0.08-0.18	0.13±0.01
Length of vertebral canal			2.24-2.51	2.38±0.04

Values bearing superscript (*) differ significantly in column P< 0.05

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Table 2: Measurements of second coccygeal vertebra of Blue bull in cm

Parameters			Range	Mean±SE
Body	Length		3.9-4.3	4.13±0.07
	Width at the middle		1.37-1.63	1.51±0.04
Dorsal spine	Length		0.74-1.05	0.91±0.03
	Height	Cranial	0.22-0.39	0.29±0.02
		Middle	0.43-0.75	0.58±0.03
		Caudal	0.43-0.71	0.57±0.02
Transverse process	Length		0.9-1.3	1.17±0.04
	Width		0.94-1.11	1.03±0.01
Cranial non-articular process	Length		0.9-1.9	1.35±0.09
	Width		0.30-0.51	0.41±0.02
Ventral spine	Length		1.55-1.99	1.77±0.05
	Height	Cranial	0.38-0.50	0.45±0.01
		Middle	0.51-0.67	0.60±0.01
		Caudal	0.40-0.51	0.44±0.01
Sulcus vasculosus	Length		1.97-2.10	2.02±0.02
	Width		0.11-0.24	0.18±0.02
Diameter of vertebral canal		Cranial	0.21-0.29	0.25±0.01
		Caudal	0.08-0.15	0.13±0.01
Length of vertebral canal			1.98-2.20	2.09±0.03

Values bearing superscript (*) differ significantly in column P< 0.05

Conclusion

The first and second coccygeal vertebrae of Blue bull consisted of a well-developed body, plate like backwardly and downwardly directed transverse process, cranial non-articular process, bifid dorsal spine and bifid ventral spine forming sulcus vasculosus in Blue bull. Further, various morphometrical parameters of the first and second coccygeal vertebrae like average length and width of body, average length, height and thickness of dorsal spine, average length and width of transverse process, cranial non-articular process and sulcus vasculosus, average length and height of ventral spine, average length of vertebral canal, average cranial and caudal diameters of vertebral canal were of importance for identification of this animal.

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