

MORPHOLOGICAL STUDIES ON THE THORACIC, LUMBAR, SACRAL AND COCCYGEAL VERTEBRAE IN SPOTTED DEER (*Axis axis*)

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ABSTRACT

Morphology of the thoracic, lumbar, sacral and coccygeal vertebrae of spotted deer was studied using three specimens. The number of vertebrae in thoracic, lumbar, sacral and coccygeal region was thirteen, six, four and twelve respectively. The bodies of the thoracic vertebrae showed a prominent ventral crest from the seventh onwards as in cattle. The articular facets for ribs were concave and quite separate in the first to sixth thoracic vertebrae but were close together in the succeeding vertebrae and even fused on the thirteenth thoracic vertebra. The height of spinous process increased up to the fourth thoracic vertebrae then it decreased to the ninth and the last three had equal height. The caudal slope of spinous process increased up to the tenth vertebra but the twelfth and thirteenth vertebrae had vertical spinous processes and formed the anticlinal vertebrae as in small ruminants. Only eleventh to thirteenth thoracic vertebrae possessed distinct articular processes. The rounded mammillary processes were seen next to the transverse processes except in twelfth and thirteenth vertebrae where they formed mammilioarticular processes. In the lumbar region, the transverse diameter and caliber of the vertebral canal increased from the first to the last. The transverse process of the first vertebra was the shortest; length increased up to the fifth and in the sixth it was shorter as recorded in cattle. Each lumbar vertebra presented two strongly curved cranial articular processes with fused mamillary processes on lateral aspect. The triangular sacrum was formed by fusion of four segments as in sheep and differed from cattle and goat where five segments fused to form sternum. The first two coccygeal vertebrae were typical and haemal processes were absent.

Key words: Thoracic vertebra, Lumbar vertebra, Sacrum, coccygeal vertebra, morphology, spotted deer

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Spotted deer is the most common deer species in Indian forests. The lumbar vertebrae form the vertebrae of the loins and provide a point of fixation for the abdominal wall. The sacrum forms the greater part of the roof of the pelvic cavity. It forms a firm articulation on each side with the pelvic girdle through which the thrust of the hind limb is transmitted to the trunk. Some morphological features of lumbar vertebrae (Rajani *et al.*, 2011) and sacrum and coccygeal vertebrae (Rajani *et al.*, 2012) in leopard were described. But very little information is known on anatomical features of axial skeleton in spotted deer. Therefore the study was undertaken to elucidate the anatomical features of the thoracic, lumbar, sacral and coccygeal vertebrae in spotted deer.

MATERIALS AND METHODS

Thoracic, lumbar, sacral and coccygeal vertebrae column were collected from three spotted deer that were brought for post-mortem examination to the Department of Pathology, College of Veterinary & Animal Sciences, Pookode. Bones were processed (Young, 1980) for studying the morphological features.

RESULTS AND DISCUSSION

Thoracic vertebrae

The thoracic vertebrae were thirteen in number. The vertebrae were typical and possessed a body, neural arch and processes (Fig. 1). The short cylindrical bodies of the

thoracic vertebrae were constricted in the middle. The sixth to ninth thoracic vertebrae were shorter and narrower than the others. The cranial and caudal extremities were more convex and concave respectively in the first seven thoracic vertebrae but those of succeeding vertebrae were almost flat as recorded by Dyce *et al.* (1996) in domestic animals. The length of vertebral bodies decreased up to sixth or seventh then gradually increased in the succeeding vertebrae (Table 1). The bodies of the thoracic vertebrae showed a prominent thin edged ventral crest from the seventh onwards. This was similar to the records in cattle and disagreed in small ruminants where the ventral crest was absent (Nickel *et al.*, 1986). The vertebral canal was wider at the first three thoracic vertebrae for the cervical enlargement of spinal cord, caudally it became narrow and in the last three or four thoracic vertebrae it again enlarged (Table 1).

At the origin of the arches the bodies showed cranial and caudal costal foveae. The short and stubby transverse process carried transverse costal fovea for the ribs as in domestic animals (Dyce *et al.*, 1996). The rib articular facets were concave on the first six thoracic vertebrae but further caudally became more flat. Further these articular facets for ribs were quite separate in the first to sixth thoracic vertebrae but were close together in the succeeding vertebrae and even fused on the thirteenth thoracic vertebrae. The dorsal spinous process was thin, sharp, long and well-developed. The height of spinous process increased up to fourth; then height decreased

by about 0.6 cm from fifth to ninth thoracic vertebrae and last three vertebrae had equal height (Fig.1). This partially agreed with Nickel *et al.* (1986) in ruminants where the height of spinous processes increased up to fifth; then it decreased gradually up to the twelfth. The free ends of the spinous processes were expanded to form tuberosities. The caudal slope of spinous process increased up to the tenth (Fig. 1) and the twelfth and thirteenth vertebrae had vertical spinous processes forming the anticlinal vertebrae. The spinous process in the last vertebra was broader than the others. These features were in concurrence with the reports of Nickel *et al.* (1986) in small ruminants. However it disagreed with the cattle (Getty, 1975) wherein the thirteenth thoracic vertebra was the anticlinal vertebra and the spinous processes of the first seven and the last thoracic vertebrae were broader than the others.

The first to eleventh thoracic vertebrae had cranial articular facets situated dorsally on either side of the vertebral arch. The caudal articular facets were at the root of the spinous process. The strongly curved cranial articular processes of the twelfth and thirteenth vertebrae had sagittal placed dorsomedial deep concave facets. Two well-developed caudal articular processes with ventrolaterally cylindrical condyle like articular area projected on either side of the dorsal spine in the eleventh to thirteenth vertebrae. The mammillary processes were located next to the transverse processes in the cranial series but in succeeding vertebrae but caudally they become nearer to the cranial articular processes and on twelfth

and thirteenth vertebrae they were fused to form mammilioarticular processes. The cranial vertebral notches were shallow but caudal notches were deep as in small ruminants. Nevertheless, these caudal notches were not converted to foramina as recorded in cattle Nickel *et al.* (1986).

Lumbar vertebrae

The lumbar vertebrae were six in number as stated in cattle and sheep (Getty, 1975). The vertebrae were typical and possessed a body, neural arch and processes (Fig.2). The vertebral bodies were constricted in the middle and expanded at their ends. The cranial extremities of the bodies were convex while the caudal ones were concave transversely. The length of vertebral body increased from first to fifth. The ventral spine was pronounced in the last four vertebrae as reported in cattle by Nickel *et al.* (1986).

The neural arches were well-developed and enclosed a vertebral canal. The caliber of the vertebral canal increased from the first to the last lumbar vertebrae (Table 2) for the lumbar swelling of the spinal cord. Interarcuate spaces between successive vertebrae were more marked in the caudal series with a well developed space at lumbosacral junction (Fig.2). The cranial vertebral notches at the junction were shallow whereas the caudal ones were deep. The caudal vertebral notches were not converted into foramina as reported in cattle by Nickel *et al.* (1986). Inter vertebral foramina were larger in the caudally placed vertebrae.

The dorsal spinous process was low, broad almost vertical except in the last two vertebrae where they were inclined forwards. The spine of the last one was the smallest. The free extremity of the spine expanded to form a ridge that projected both cranially and caudally as in cattle. The broad transverse process projected laterally had sharp free borders with expanded extremities. These processes curve forward as stated in sheep Nickel *et al.* (1986). The transverse process of the first vertebra was the shortest and its length increased up to the fifth and in the sixth it was shorter (Fig.2). These features concur with the findings of cattle (Getty, 1975).

The cranial articular processes were strongly curved and presented sagittally placed dorsomedial deep concave facets as in sheep (Getty, 1975). Two well developed caudal articular processes showed ventrolaterally condyle like articular area and were overlapped by the cranial articular processes. These sagittal articular facets prevent lateral flexion of the lumbar region. The cranial articular processes of all lumbar vertebrae carried the fused tuberous mamillary processes on lateral aspect and formed the mamilloarticular processes as recorded in cattle (Nickel *et al.*, 1986). The accessory processes were absent.

Sacrum

The triangular sacrum was formed of four fused sacral vertebrae. This partially concurs with the reports in sheep where the

sacrum is formed of four sacral vertebrae that fused partially. It also differs from cattle and goat where the sacrum was formed by the fusion of five sacral vertebrae (Getty, 1975). The sacrum consisted of two surfaces- dorsal and ventral, two lateral borders, a base and an apex (Fig.3). The longitudinally curved bone narrowed from its cranial extremity to the caudal extremity. The smooth ventral surface was concave craniocaudally; ventral crest and the vascular groove on this surface was absent as in sheep (Nickel *et al.*, 1986). But the surface showed three transverse lines, and three large ventral sacral foraminae.

The dorsal surface showed in the middle a caudally directed median sacral crest and on either side low but prominent lateral sacral crest which faded in the last sacral segment. The caudal end of the median sacral crest formed a pointed projection over the exit of the sacral canal. This feature corroborated with that of Getty (1975) in cattle but differed from sheep where the spines were separate. The caudal articular process of the last sacral segment was rudimentary. Of the three small dorsal sacral foraminae the last two were divided by the lateral sacral crest. The dorsoventrally flattened sacral canal at the apex was almost the half the size of the canal at the base as in other animals (Table 3).

The plate like thin lateral borders with irregular margin curved ventrolaterally. The broad sacral wings at the base curve ventrally and cranially and were quadrangular. The caudal surface of the wings showed articular facet for the ilium facing caudodorsally. The

transverse process of last sacral segment was well developed, thin and projected caudally.

The broad base presented centrally dorsoventrally flattened wide body of the first sacral segment (Fig.3). Its anterior extremity was convex and the promontorium on its cranioventral border was less distinct as in other domestic animals. On either side the body a smooth notch and well developed cranial articular processes with medial deeply concave facets were present. The caudally facing apex was smaller and contained the triangular exit of the sacral canal. These features concur with the reports of Nickel *et al.* (1986) in cattle.

Coccygeal vertebrae

The coccygeal vertebrae were 12 in number. Nickel *et al.* (1986) reported the number of coccygeal vertebrae in cattle, sheep and goat as 18-20, 12-16, 16-24 respectively. So, the present study concurs with the findings of sheep. The first two coccygeal vertebrae were typical with a complete vertebral arch and processes (Fig.3). In the third to the fifth vertebrae the vertebral arches formed only partially. The spinal canal was open dorsally on the sixth; in the seventh coccygeal vertebrae it was represented only by a dorsal groove. From the seventh vertebrae onwards, the spinal canal totally disappeared and consisted of only a body that too gradually became smaller towards the tip of the tail. The first coccygeal vertebra had the shortest body. Caudally, the length increased gradually up to the seventh then shortened gradually up to tenth vertebra. Later on the length diminished rapidly and the

last vertebrae was only 1.3cm in length (Table 3).

The transverse processes sprang more caudally from the body of the vertebrae (Fig.3). The transverse processes were large plate-like and quadrilateral in first coccygeal vertebra. In second to fifth vertebrae, the processes were smaller and narrower; from the sixth vertebrae onwards they were faint or absent. The second to sixth vertebrae had well developed cranial articular processes. Haemal processes were absent as recorded in sheep by Nickel *et al.* (1986) and Getty (1975). But these processes were described in cattle from the first coccygeal vertebrae onwards Nickel *et al.* (1986).

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Morphological studies on the vertebrae in spotted deer

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Table 1 Morphometrical parameters of thoracic vertebrae in spotted deer

Parameters (cm)	Thoracic vertebrae							
	I	II& III	IV	V	VI & VII	VIII & IX	X	XI - XIII
Length of vertebral body	3.1	3.0	3.0	2.9	2.7	2.8	2.9	3.2±0.2
Breadth of vertebral body	3.3	3.2	3.0	3.0	2.9	2.9	2.9	3.2
Height of vertebral body	2.0	2.0	2.0	1.9	1.9	1.8	1.8	1.9
Vertebral canal width	2.4	2.1	1.8	1.7	1.6	1.4	1.5	1.8
Vertebral canal height	1.6	1.4	1.2	1.2	1.2	1.2	1.1	1.2
Height of spinous process	7.8	9.5	9.8	8.9	7.9±0.2	6.9±0.3	5.7	3.8

Table 2 Morphometrical parameters of lumbar vertebrae in spotted deer

Parameters (cm)	Lumbar vertebrae					
	I	II	III	IV	V	VI
Length of vertebral body	3.3	3.3	3.4	3.6	3.8	3.3
Breadth of vertebral body	2.4	2.5	2.7	2.9	3.1	3.4
Height of vertebral body	1.6	1.7	1.7	1.8	1.7	1.6
Vertebral canal width	2.1	2.2	2.5	2.5	3.1	3.2
Vertebral canal height	1.6	1.6	1.6	1.6	1.7	1.7
Height of spinous process	3.5	3.6	3.7	3.7	3.4	3.2
Transverse process length	3.6	4.7	5.7	6.3	6.7	5.9

Table 3 Morphometrical parameters of sacrum and coccygeal vertebrae in spotted deer

Sacrum	Measurements (cm)
Length of sacrum	10.2
Breadth at base	3.8
Breadth at apex	1.2
Spinal canal height at base	1.5
Spinal canal breadth at base	3.5
Spinal canal height at apex	1.2
Spinal canal breadth at apex	1.1
Coccygeal vertebrae length	
First coccygeal vertebra	2.4
Second to seventh coccygeal vertebra	2.5±0.2
Eighth to tenth coccygeal vertebra	2.3±0.2
Eleventh and twelfth coccygeal vertebra	1.4±0.2

LIST OF FIGURES

1. Thoracic vertebra of spotted deer- Dorso lateral view. 1T- First thoracic vertebra, 4T- Fourth thoracic vertebra, 13T- Thirteenth thoracic vertebra , T- Transverse Process, S- Spinous process, CA- Caudal articular process.
2. Lumbar and sacral vertebra of spotted deer- Dorso lateral view. 1L- First lumbar vertebra, T- Transverse Process, S- Spinous process, 6L- Sixth lumbar vertebra, CR- Cranial articular process, W- Wing, LS- Interarcuate space lumbo sacral junction.
3. Sacrum and coccygeal vertebra of Spotted deer-Dorso lateral view. CR-Cranial articular process, S- Spinous process, B- Base of sacrum, E- Entrance to sacral canal, 1C- First coccygeal vertebra, 7C- Seventh coccygeal vertebra, W- Wing of sacrum, L- lateral sacral crest.

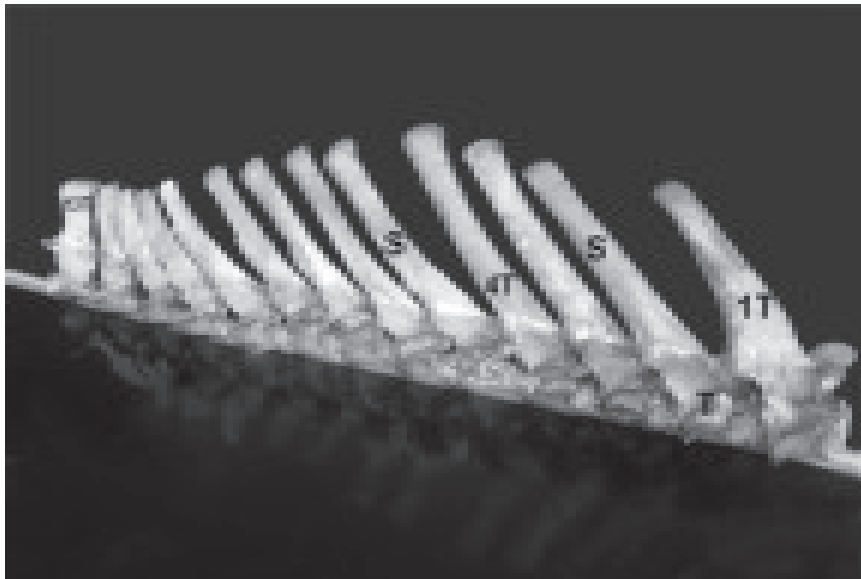


Fig - 1



Fig -2

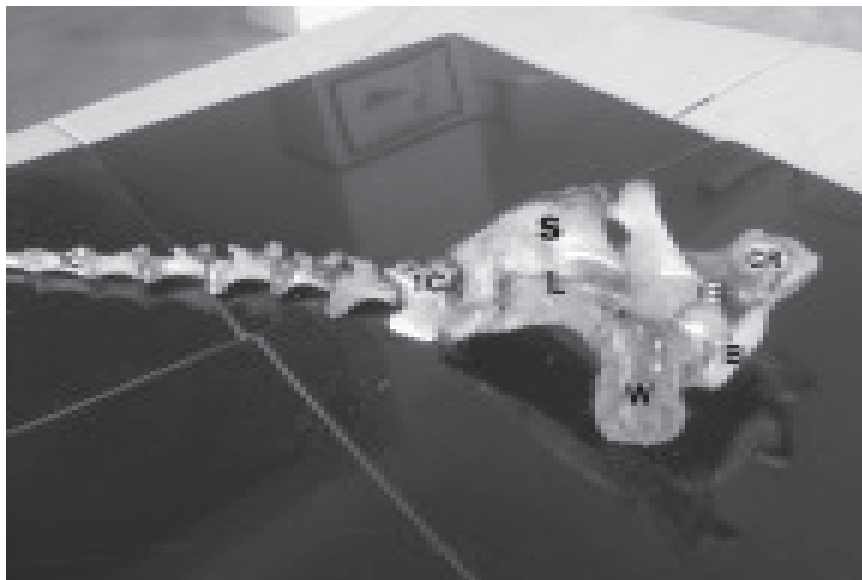


Fig -3