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## RESEARCH ARTICLE

### GROSS ANATOMICAL STUDIES ON VERTEBRAL COLUMN IN WHITE SPOTTED DEER (*Axis axis*)

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#### ABSTRACT

The present study was conducted at department of veterinary anatomy and histology utilizing a 2.5 year old white spotted deer by wet method of maceration. The vertebral formula observed was  $C_7 T_{13} L_6 S_5 Cy_4$  and the atlas was atypical, in the form of a ring with laterally projected wings and enclosed by large vertebral canal. At its anterior margin, the dorsal arch was perforated by intervertebral foramen on either side and was connected to the alar foramen. The body of the axis was longer and a wide dens was seen in its anterior aspect. The bodies of the thoracic vertebra were short with anterior convexity and posterior concavity which carried demifacets except in 13<sup>th</sup> and the dorsal spinous processes were long, thin, plate like and inclined backwards. The bodies of lumbar were constricted and comparatively longer with less convexity in the anterior and less concavity in the posterior. Anterior articular processes were strongly curved with concave facet on its medial aspect. The posterior articular processes were less curved and presented a flat facet ventrally to articulate with the succeeding lumbar vertebra. The sacrum was formed by fusion of five segments with three dorsal sacral foramina and four large ventral sacral foramina. In coccygeal vertebra, first three had neural ring, dorsal spine and articular process.

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#### INTRODUCTION

The vertebral column consists of a flexible chain of median irregular unpaired bones extending along the dorsal median line and is the fundamental part of the axial skeleton (Shalini et al., 2012). It extends from head to tail and the vertebral column is divided into five regions viz. cervical, thoracic, lumbar, sacral and coccygeal. The number of bones present in each region varies with different species. The present study was undertaken to describe the vertebral column anatomy of white spotted deer in detail and was compared with the other domestic ruminant species.

#### MATERIALS AND METHODS

A 2.5 year old white spotted deer brought to the department of veterinary pathology for postmortem examination was utilised for the present study. The animal was macerated by wet maceration and the disarticulated bones were cleaned and the bones were arranged in order for various vertebral regions. Then the osteological characteristics of different vertebra were recorded and compared with other domestic ruminants. The cervical, thoracic and lumbar, sacral, coccygeal regions were showed in the Fig. 1, Fig 2 and Fig 3 respectively.

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#### RESULTS AND DISCUSSION

In the present study, the vertebral formula observed was  $C_7 T_{13} L_6 S_5 Cy_4$  which is similar to the observation of Shalini et al., 2012 in barking deer. In the cervical region, the first cervical vertebrae, the atlas was atypical and was in the form of a ring with laterally projected wings and enclosed by large vertebral canal. Dorsal and ventral spines were absent and only dorsal tuberosity was noticed as in ox (Sisson and Grossman, 1953). The dorsal arch was roughly deep triangular, its anterior border was notched and posterior border showed central and two lateral notches. At its anterior margin, the dorsal arch was perforated by intervertebral foramen on either side and was connected to the alar foramen on the wing by a alar groove as in sheep and goat (Shalini et al., 2004).

But Shalini et al., 2012 mentioned that the two foramina were not connected by a groove in barking deer. The ventral arch presented a central and two lateral notches anteriorly and had transversely flat articular surface for dens of axis posteriorly. In front of it a rough transverse area was noticed as in ox for ligamentous attachment. Anterior articular cavities of atlas were deep and received the occipital condyles and was clearly divided into two parts by a 'U' shaped notch and posterior articular surface was flattened and continued into the vertebral canal as reported in barking deer by Shalini et al., 2012. Unlike those of domestic animals, mentioned by Sisson and



**Fig. 1. Photograph showing cervical region viz. atlas, axis and 3<sup>rd</sup> to 7<sup>th</sup> cervical vertebra in white spotted deer**



**Fig. 2. Photograph showing thoracic region with supraspinous processes inclination in white spotted deer**



**Fig. 3. Photograph showing lumbar, sacral and coccygeal regions in white spotted deer**

Grossman (1953), the wings were sloping downwards and free edges were thin in white spotted deer. A common opening for intervertebral and alar foramen was noticed on the dorsal aspect of wing. Ventrally the wing presented fossa atlantis whose deeper part contain ventral opening of alar foramen. Contrast to our results Shalini *et al.*, 2012 reported four unnamed foramina in the fossa atlantis of barking deer. The body of the axis (2<sup>nd</sup> cervical) was longer and a wide spout like process called dens was seen in its anterior aspect and rim of the dens was faintly notched dorsally. But Shalini *et al.*, 2012 observed deep notch on the dens. Dorsal face of the dens was concave, rough which continued into the vertebral canal whereas the ventral face of the dens was convex. On either side of the process, a flat ventrally sloping articular surface which were separated by faint notch in the center which continued in the ventral face of the dens was noticed as in

sheep and goat (Sisson and Grossman, 1953). Anterior articular process was absent. Pair of flat posterior articular process directed backwards was noticed. The Pointed transverse process was undivided and directed backwards. It is not in accordance with the Shalini *et al.*, 2004 who noticed laterally directed transverse process in sambar deer. Its root presented anterior and posterior openings of foramen transversarium communicated by osseous canal. As reported by Shalini *et al.*, 2012, the two ridges from the transverse process converged upto ventral process forming a V shaped structure in barking deer was not seen in the present study. Anteriorly, a large oval intervertebral foramen was noticed which communicated with the anterior opening of the foramen transversarium and formed a common opening. But in ox, there was no communication between the intervertebral foramen and anterior opening of foramen transversarium (Getty, 1965). Posteriorly, the intervertebral foramen was represented by a shallow notch. Dorsal spine was thin flat, anteriorly flanked over the neural ring (dorsal arch) and posteriorly it was bifid but there was no bifurcation mentioned by Shalini *et al.*, 2004 in sambar deer. Ventral spine was ridge like and it showed small tubercle posteriorly.

The dorsal spine was like a crest in third and fourth cervical and the height of the spine increased gradually and directed upwards and forwards up to sixth and it was plate like and slightly inclined backwards in seventh. It is not in agreement with the Shalini *et al.*, 2004 in sambar deer who reported tuberosus summit in the seventh. In contrast to Shalini *et al.*, 2012, the bodies were convex anteriorly and concave posteriorly, longer from 3<sup>rd</sup> to 5<sup>th</sup>, shorter and wider in 6<sup>th</sup> and 7<sup>th</sup>. The ventral surface had medial ventral spinous processes which were tuberculate at its posterior end from third to fifth and ventral spines were absent in 6<sup>th</sup> and 7<sup>th</sup> cervical as in barking deer (Shalini *et al.*, 2012). Anterior articular process faced upwards and posterior articular process faced downwards and joined by a thin plate of bone as in ox (Raghavan, 1964). The tubercle on the outer margin of bony plate in 4<sup>th</sup>, 5<sup>th</sup>, 6<sup>th</sup> and 7<sup>th</sup> vertebra of barking deer (Shalini *et al.*, 2012) was not seen in the present study. As in other domestic species, transverse process had two divisions from third to sixth vertebra and the lower division of transverse process was better developed, plate like and extended below and behind the level of the body in 6<sup>th</sup> and the root of the process had foramen transversarium from 3<sup>rd</sup> to 6<sup>th</sup> (Getty, 1965).

The transverse process of 7<sup>th</sup> was undivided, lacked foramen transversarium and large concave demifacets for head of the first rib were present on the posterior aspect of body as noted in the barking deer (Shalini *et al.*, 2012). In white spotted deer, the thoracic vertebra was 13 in number and the bodies were short with anterior convexity and posterior concavity which carried demifacets except in 13<sup>th</sup> as in ox (Nickel *et al.*, 1986). The transverse processes were plate like with tubercular facet for tubercle of ribs, gradually decreased in length up to 11<sup>th</sup> and were pointed in 12<sup>th</sup> and 13<sup>th</sup>. Mammillary processes were noticed up to 11<sup>th</sup> thoracic vertebra but it was absent in barking deer and sambar deer (Shalini *et al.*, 2004 and Shalini *et al.*, 2012). Anterior pedicles were shallow and posterior pedicles formed intervertebral foramen with adjacent vertebra. The anterior and posterior articular processes were in the form of oval facets as in sheep and goat (Sisson and Grossman, 1953).

The dorsal spinous processes were long, thin and plate like with anterior and posterior borders and two lateral surfaces and were inclined backwards. Its height gradually increased up to seventh, then gradually decreased and it was straight in 13<sup>th</sup> thoracic vertebra as first lumbar. So that the greatest length of spine was noticed at 6<sup>th</sup> and 7<sup>th</sup> dorsal whereas Maala *et al.*, 1992 and Shalini *et al.*, 2012 found highest spine at 4<sup>th</sup> and 5<sup>th</sup> dorsal in calamian deer and barking deer respectively. The dorsal spinous tubercle were seen in the 6<sup>th</sup> dorsal on its posterior border and it gradually increased in size upto 10<sup>th</sup> and were absent in 11, 12 and 13<sup>th</sup> thoracic vertebra. But Shalini *et al.*, 2012 mentioned spinous tubercle in all thoracic vertebra except the last one in barking deer. The lumbar vertebra were six in number and bodies were constricted and comparatively longer with less convexity in the anterior and less concavity in the posterior. In contrast, Maala *et al.*, 1992 observed triangular body in calamian deer. As mentioned by Sisson and Grossman, 1953 in domestic ruminants, the anterior notches were shallow whereas posterior notches were deep and formed intervertebral foramen with adjacent vertebra.

Anterior articular processes were strongly curved with concave facet on its medial aspect. The posterior articular processes were less curved and presented a flat facet ventrally to articulate with the succeeding anterior articular processes. The transverse processes were elongated and plate like and were flattened dorso-ventrally, projected downward and forward. They were shortest in the first and the length gradually increased upto 5<sup>th</sup> and the 6<sup>th</sup> were shorter than 5<sup>th</sup> with more forward inclination and pointed ends. The adjacent transverse processes were widely separated and large intertransverse spaces were formed. The dorsal spines were plate like, straight with concave anterior and posterior borders and their dorsal margins were thick (Shalini *et al.*, 2012 and Raghavan, 1964). The sacrum was formed by fusion of five segments. Median and two lateral sacral crest were noticed as like ox (Nickel *et al.*, 1986). Three dorsal sacral foramina and four large ventral sacral foramina were noticed whereas Shalini *et al.*, 2012 reported two dorsal sacral foramina. The first dorsal sacral foramina were medial to the lateral sacral

crest and the second and third dorsal sacral foramina were noticed lateral to the lateral sacral crest as in ox. As in sheep and goat (Sisson and Grossman, 1953), the anterior articular process of first sacral was strongly curved and supraspinous process was straight and a large gap was formed between last lumbar and first sacral vertebra. Wings were compressed plate like and directed downward and forward. But laterally directed wings were noticed in the barking deer (Shalini *et al.*, 2012). Posterior extremity of sacrum was the posterior end of 5<sup>th</sup> sacral segment and a small triangular neural canal was noticed and the body of last sacral was flat. In coccygeal vertebra, first three had neural ring, dorsal spine and articular process. Remaining vertebra had only body as noticed by Shalini *et al.*, 2012.

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