VERTEBRAL COLUMN OF MITHUN *(Bos frontalis)* - ITS BIOMECHANICS IN REFERENCE TO HABITAT ADAPTATION

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Received : 15.10.2017
Accepted : 17.10.2017

Abstract

Vertebral columns of six adult healthy mithun, four male and two female were prepared by simple natural maceration process in water, and then they were cleaned with bleaching powder solution and sun dried. It was observed that mithun had 7 cervical, 13/14 thoracic, lumbar 5/6, sacrum 5 and coccygeal verterbrae 15-20 in number. The posterior border of atlas being notched for a pair of small tubercles. Foramen transversarium continued in the lateral processes of axis as a short and narrow canal. The dorsal spine of third to seventh cervical vertebrae inclined anteriorly and was most wide in the 7th cervical vertebra. Generally caudal articular facets of thoracic vertebrae were flat directed ventrolaterally demarcated by a line. The dorsal spines of all the thoracic vertebrae were massive and were wider towards their summit. The transverse processes of lumbar vertebrae were extensive and arched anteriorly. The bodies of sacrum were transversely oval and fused to form a concave ventral surface. The sacrum became narrower caudally so that the apex part was least wider. In the present study the notched lateral border of occipital articular cavities, the paired tubercles on the mid caudal dorsal arch and the typical "bow" shaped caudo-dorsal arch of atlas in mithun specified it from other ruminants. The well developed dorsal spines broad at their summits in thoracic vertebrae of mithun provided extensive anchoring of neuchal ligaments. The continuous and progressive ventral curvature of vertebral column in mithun was unlike the other ruminants. The general vertebral curvature of the body axis in mithun made this animal more adaptive to its hilly habitat.

Key words : *Anat vertebral column, mithun*.

Introduction

Mithun, the living wealth of tribals, is mainly distributed in hilly areas of Northeast states in Sub-himalayan hills of continent. It is kept as a semi-domesticated, managed in fenced tracts of forests rather than being kept in or farm or barn. The skeletal framework which has to support the massive body is suitably modified and many peculiarities can

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be visualised on a critical study. Since this animal is managed in free range hilly forest the locomotor system and the body axis warrents detailed study which may reflect its survival in the habitat. The characteristic form of skull, jaws, teeth and vertebral column of mithun are all parts of the adaptive complex associated with its locomotion and thus the survival in sub-himalayan hilly terrain. In this paper we attempt to record our observations and interpretations in reference to the vertebral columns of six adult healthy mithun, four male and two female.

Materials and Methods

The two vertebral columns one from apparently healthy adult male and from an adult female were collected from NRC- Mithun, Nagaland and the other four were collected from the local slaughter house. The specimens were prepared by simple natural maceration process in water, and then they were cleaned with bleaching powder solution and sun dried.

Results and Discussion

The present study revealed the vertebral formula in mithun as C7T13-14L5-6S5Cy15-20 as against the same in ox as C7T13L6S5Cy18-20 (Getty, 2012), C7T14L6S5Cy15 in yak (Bhattacharya *et al,* 1998), C7T12L7S5Cy15-21 in camel (Grossman, 1960), C7T13L6/7S4Cy19 in sheep and C7T13L6S5Cy16-19 in goat (Getty, 2012) and C7T19-20L3-4S4Cy24-30 in elephant (Chungath *et al,* 1989). The vertebral column of mithun measured a length of 224 centimetres along the bodies while the animal stood 135 centimetres at withers. The vertebral column curvature in mithun could be observed as dorsal convex between head and neck, dorsal concave between neck and thorax, dorsal convex between thorax and lumbar and this dorsal convexity continued along the whole lumbar as well as in the sacral regions to bend down to the caudal vertebrae (Figure 1).

Cervical vertebrae

They were 7 in number. Atlas the first cervical vertebra supported the globe of the massive skull in mithun. Anteriorly, the dorsal arch had a tubercle above and was perforated by lateral vertebral foramen that is opening into neural canal (Figure 2). The anterior border was thicker than the posterior and the latter being notched for a pair of small tubercles. The ventral arch was much thicker than the dorsal and ventrally tuberculated towards posterior border. The upper face of ventral arch presented the fovea dentis for dens of axis. The lateral masses presented cranial articular cavities for occipital condyle and they were partially divided by a non articular area and a lateral notch on the anterior

Figure 1. Vertebral column of mithun *(Bos frontalis).* The dorsal convexity between thorax and lumbar continued along the whole lumbar as well as in the sacral regions to bend down to the candal vertebrae.

Figure 2. Atlas of mithun *(Bos frontalis)*, caudo-dorsal view showing ★ -caudo-dorsal notch and ⟶ tubercles.

border. The posterior articular surfaces were somewhat flat and continous with ventral arch of atlas for articulation with antero-ventral facets of axis. The wings of atlas were deeply concave ventrally and presented the alar foramen which dorsally channelled to lateral vertebral foramen. Atlas has the largest neural canal.

As in other animals axis has the longest body which was transversely elongated while that in other cervical vertebrae presented circular body. Foramen transversarium continued in the lateral processes of axis as a short and narrow canal. These foramina in other cervical vertebrae were circular anteriorly but vertically oval behind. The dens pivoted the atlas in position. The lateral vertebral foramen is circular and not close to cranial border of the arch. The caudal pediculate notches are not so deep. The other features resembled to that of ox.

The third cervical vertebra presented a transverse process that divided into anterior and posterior parts rather than the dorsal and ventral ones in other cervical vertebrae. The third cervical vertebra had the longest transverse canal.

The ventral divisions of the transverse process in the fourth and fifth cervical vertebrae of mithun arrowed anteriorly under the body of preceding vertebra where as this of sixth was most wide and presented ventrally downwards.

The seventh cervical vertebra caudally presented a pair of facets for costal articulation on its body. The transverse process presented a very narrow transverse foramen or canal probably for branches of vertebral artery. The dorsal spine of third to seventh cervical vertebrae inclined anteriorly and was most wide in the 7th cervical vertebra.

Thoracic vertebrae

They were 13-14 in number. The bodies were almost circular in cross section in all of them. The body length increased in caudal series and presented anteriorly caudal facets for rib heads. The caudal articular facets of 12th and 13th thoracic vertebrae were dorsolaterally flattened. Generally caudal articular facets were flat directed ventrolaterally demarcated by a line. The bodies of thoracic vertebrae distinctly constricted in the middle and presented a thin edged ventral crest.

The dorsal spines of all the thoracic vertebrae were massive and that of all the thoracic vertebrae but of the last inclined caudally. The dorsal spine of last thoracic vertebra was vertically upwards. The dorsal spines were wider towards their summit. It was widest in the first thoracic but longest in the second or third vertebra (30-32cm). From the fourth thoracic vertebra the height and width decreased gradually towards the lumbar vertebrae. The caudal border of the dorsal

spines thickened gradually towards the lumbar vertebrae. The summit of the dorsal spines were pointed and inclined caudally.

The transverse processes were thick and strong and presented mammillary processes except in the caudal series. The mammillary processes were thin or less tuberous. The transverse processes presented the facets for costal tubercles. Neural canal appeared transversely triangular from the first thoracic vertebrae onwards caudally all along the vertebral column.

Lumbar vertebrae

They were 5-6 in number. The bodies were transversely oval in cross section and they were much constricted in the middle. The transverse processes were extensive and arched anteriorly. These processes presented thin anterior and caudal borders and increased the length from the first to fifth. The dorsal spines were relatively low and wide but upright above. The articular processes were large and strongly curved. The fourth or fifth were longest among the lumbar vertebrae. The neural canal being transversely oval in these vertebrae.

Sacrum

Sacrum was a fused structure of five vertebrae where the dorsal spines fused together to form dorsal median sacral crest. The transverse process of sacral vertebrae fused to form a pair of ridges, lateral sacral crest, on either side of fused dorsal spine. The bodies of these vertebrae were transversely oval and fused to form a concave ventral surface. The lateral borders are more compact and concave. The sacrum of mithun became narrower caudally so that the apex part was least wider. The sacral neural canal was transversely triangular tapering to the coccygeal neural canal.

Coccygeal vertebrae

They were 15-20 in number. Caudal vertebrae are relatively longer and the first six have complete arches and spinous processes. The transverse processes are well developed in the cranial series in which there are cranial articular processes and a pair of ventral spines which formed the groove for median caudal artery. The bodies were transversely oval in first, second and third coccygeal vertebrae. They were cylindrical in shape, but constricted in the middle, transverse processes were wide upto 5th coccygeal vertebra. Dorsal articular processes were presentable upto 7th coccygeal vertebra. Haemal processes were present upto 8th or 9th coccygeal vertebra.

The vertebral canal in the present study could be observed as most wide in the atlanto-axial joint (50 mm height & 50 mm width) on an average. It was much wide and almost circular at cervico-thoracic junction i.e. at first thoracic (30 mm height & 28 mm width). The canal became dorso-ventrally flattened further backwards and measured on an average 30 mm height and 34 mm width at first lumbar vertebra. The neural canal in mithun at the level of first sacral was transversely oval measuring a height of 25 mm and width of 52 mm. Further the canal tapered abruptly 18 mm height and 20 mm width on an average at last sacral vertebra. It continued upto the fifth or sixth coccygeal vertebra.

The vertebral curvature in mithun varied from the other ruminants at the dorsal convexity of the thoraco-lumbar region which further continued downward as against somewhat straight in other ruminants. The vertebral canal was maximum wide and cylindrical at atlanto-axial junction and presented the relative widening at the cervico-thoracic and lumbo-sacral junction to accommodate the spinal cord which was similar in other ruminants.

The cervical series of vertebrae in mithun confirmed as seven in number as in other mammals. In the present study the notched lateral border of occipital articular cavities, the paired tubercles on the mid caudal dorsal arch and the typical “bow” shaped caudo-dorsal arch of atlas in mithun specified it from that of ox, horse and buffalo as we compare these features of atlas explained by Getty (2012), Nickel Schummer *et al* (1979). The well depthed occipital pit and large antero-dorsal tubercle of atlas evidenced the well

developed ligamentum nuchae to support the massive skull in mithun as interpreted by Kalita *et al*. (2001) and Bhattacharya *et al.* (1998). The atlas in mithun presented circular and largest neural canal probably enabling the free rotation of massive head of mithun pivoted on the long dens of axis.

The well developed dorsal spines broad at their summits in thoracic vertebrae of mithun provided extensive anchoring of neuchal ligaments for the support of head and neck which are mechanically cantilevered in position and work as an inverted "bow string" facilated by the cervical vertebral curvature as postulated by Badoux (2012) in other ruminants. The piling of these long dorsal spines in mithun probably reduced the lateral movement of this animal to a certain extend but at the same time it strengthened the "dorsal string" of the body axis to support the massive thorax with a well arched thoracic hump which is almost similar in elephant (Chungath *et al*., 1989)

The ventro-laterally directed flat articular facets in the vertebrae of mithun corresponded to the caudal thoracic, lumbar and coccygeal vertebral curvature of this animal where the hind quarters was little bit ill developed, compact and less tall when compared to the massive thorax and fore quarter. The continuous and progressive ventral curvature of vertebral column in mithun unlike the other ruminants (Habel, 1964., Raghavan, 1964) relieve the strain imposed by the massive body in general and shift the centre of gravity close to the sciphoid thereby the braking action of forelimbs are more effective and the propulsive force of hind limbs made more forceful.

Thus the anterior cervical and cervico-thoracic curvature of vertebral column in mithun helped the animal as an inverted "bow string" to support the heavy head and to graze from the high and low pastures. The vertebral curvature further backwards that is at the thoraco-lumbar-sacral facilitated the animal to move up the hill and slowly come down. The general vertebral curvature of the body axis in mithun made this animal more adaptive to its hilly habitat.

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