



The Cervical Vertebrae of the Sumatran Rhinoceros (*Dicerorhinus sumatrensis sumatrensis*)

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Abstract: The seven cervical vertebrae of a Sumatran rhinoceros (*Dicerorhinus sumatrensis sumatrensis*) are described and compared with that of the horse. The atlas has a short body with wide wings and the alar foramen is not present in the rhinoceros. The width of the axis is greater than its length, the body carries a short round dens and the intervertebral foramen is absent. The 3rd, 4th, 5th, cervical vertebrae are characterized by short bodies, wide transverse processes and long dorsal spines. The sixth cervical vertebra has an 'axe-shaped' ventral branch of the transverse process which carries only two processes on each side. The seventh cervical vertebra has the longest dorsal spine and a foramen transversarium on the left side only. The cervical vertebrae of the rhinoceros were relatively much wider than that of the horse.

INTRODUCTION

A survey of the literature revealed a few publications on the osteology of the Sumatran rhinoceros (*Dicerorhinus sumatrensis sumatrensis*), although the skull of Asian rhinoceros has been described by several workers (Gray, 1867; Flower, 1876; Beddard and Treves, 1889; Groves, 1965; Groves and Kurt, 1972; Groves, 1982; Groves and Chakraborty, 1983). van Strien (1974) compiled a literature on the Sumatran rhinoceros, but makes no reference to the osteology of this species. More recently, Zainal *et al.*, 1990 reported that the skeleton of the Sumatran rhinoceros consisted of 265 bones.

To the best of our knowledge the other information on the osteology of the rhinoceros was diagrams of the skeletons of black rhinoceros (*Diceros bicornis*) and white rhinoceros (*Ceratotherium simum*) (Kingdon, 1989).

This forms part of wider study on the osteology of the Sumatran rhinoceros. The purpose of this paper is to provide a comprehensive description of the cervical vertebrae of a single Sumatran rhinoceros.

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MATERIALS AND METHODS

The study was based on a skeleton of the Sumatran rhinoceros namely, Napanga. Napanga was an adult male captured in Torgamba, Indonesia and brought to Zoo Melaka where it succumbed to severe colic that resulted in shock and death (Zainal *et al.*, 1990).

The skeleton was prepared according to the method of Zainal *et al.*, (1990) where the bones were boiled in a commercial detergent, cleaned, dried and excess fat removed by soaking in the same detergent several times.

Definitions of measurement are given in Table 1.

RESULTS

The Atlas

The atlas of the rhinoceros has a short body carrying long narrow wings the extend latero-ventrally (Fig. 1). The two anterior articular cavities are shallow narrow areas for articulation for the occipital condyles of the skull and are separated by a wide notch dorsally and a narrow notch at the ventral arch. A rough prominent tuberosity is situated on the anterior aspect of the dorsal arch. The ventral tubercle is long and extends caudally (Fig. 1). The posterior articular surfaces conform to the shape of the corresponding articular surfaces of the axis. The wide concave articular surface on the ventral arch provides articulation for the dens of the axis. Centrally, the atlas is perforated by the 'egg-shaped' vertebral foramen. A

Table 1. Definitions of measurements

Atlas	
Length,	the average greatest length between the cranial head and the caudal end of the body.
Height,	the average greatest height between the dorsal tubercle and the body of the atlas.
Width,	the average greatest width across the wings.
Axis	
Length,	the average greatest length between the dens and caudal end of the body.
Height,	the average greatest height between the dorsal spinous process and the body.
Width,	the average greatest width between the transverse processes.
Cervical vertebrae 3rd, 4th, 5th, 6th and 7th	
Length,	the average greatest length between the cranial head and caudal end of the body.
Height,	the average greatest height between the dorsal spinous process and the body.
Width,	the average greatest width between the transverse processes.

wide intervertebral foramen is found on each side of the dorsal arch (Fig. 1).

The height, width and length of the atlas of the rhinoceros are 89 mm, 237 mm and 33 mm (excluding the ventral tubercle), respectively.

The Axis

The body of the axis is massive. Ventrally, the body forms a prominent ridge (ventral spine) which widens towards the posterior. The body extends anteriorly to form the rounded dens (Figs. 3 & 4). The coarse and massive dorsal spinous process extends dorso-posteriorly (Figs. 3 & 4). The posterior articular processes project caudo-dorsally (Fig. 3) and present triangular articular surfaces on each side. The body projects laterally to form the anterior articular processes and the transverse processes posteriorly which are perforated by the foramen transversarium on each side (Figs. 2 & 3). The vertebral foramen which perforates centrally is oval.

The height, width and length of the axis of the rhinoceros are 130 mm, 131 mm and 92 mm, respectively.

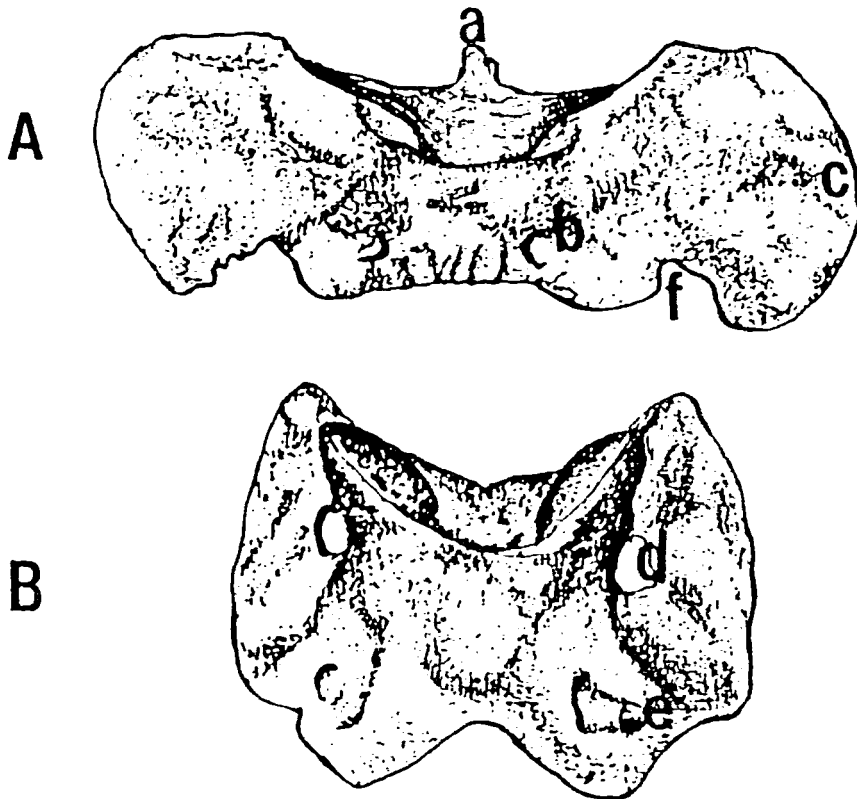


Figure 1. Dorsal view of the atlas of the A. rhinoceros and B, the horse. a, ventral tubercle; b, intervertebral foramen; c, wings; d, foramen transversarium; e, alar foramen; f, alar notch.

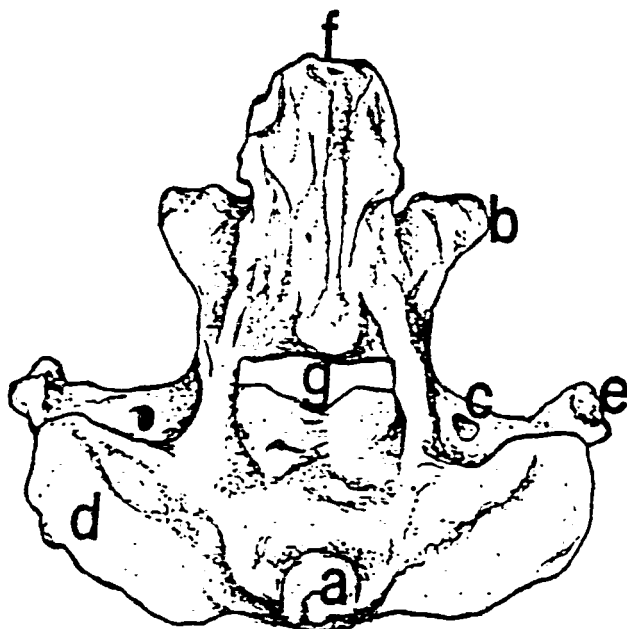


Figure 2. Anterior view of the axis of the rhinoceros. a, dens; b, posterior articular process; c, foramen transversarium; d, anterior articular process; e, transverse process; f, dorsal spinous process; g, vertebral foramen.

Third, Fourth and Fifth Cervical Vertebrae

The third, fourth and fifth cervical vertebrae have similar features with the exception of the dorsal spine and transverse process. All the anterior articular processes carry tuberosities on their lateral aspects. The larger tuberosities are found from the fifth to seventh cervical vertebrae.

The body of the third cervical vertebra consists of the rectangular bordered head at the anterior and a highly concave posterior cavity. The ventral border forms a prominent ridge (ventral spine) and also carries two small tubercles at each end. The lateral masses of the body form the lateral and ventral branches of the transverse processes. The lateral branches of the transverse processes project latero-posteriorly and form small tubercles at the end while the ventral branches are wider than the lateral branches, project ventrally and cranially and are divided.

The vertebral foramen is relatively large. A short spinous processes is situated dorsally (Fig. 5).

The fourth and fifth cervical vertebrae carry long dorsal spinous processes. The lateral branches of the transverse processes project more caudally while the ventral branches gradually widen towards the subsequent cervical vertebra.

The height, width and length of the third, fourth and fifth cervical vertebrae of the rhinoceros and the horse are given in Table 2.

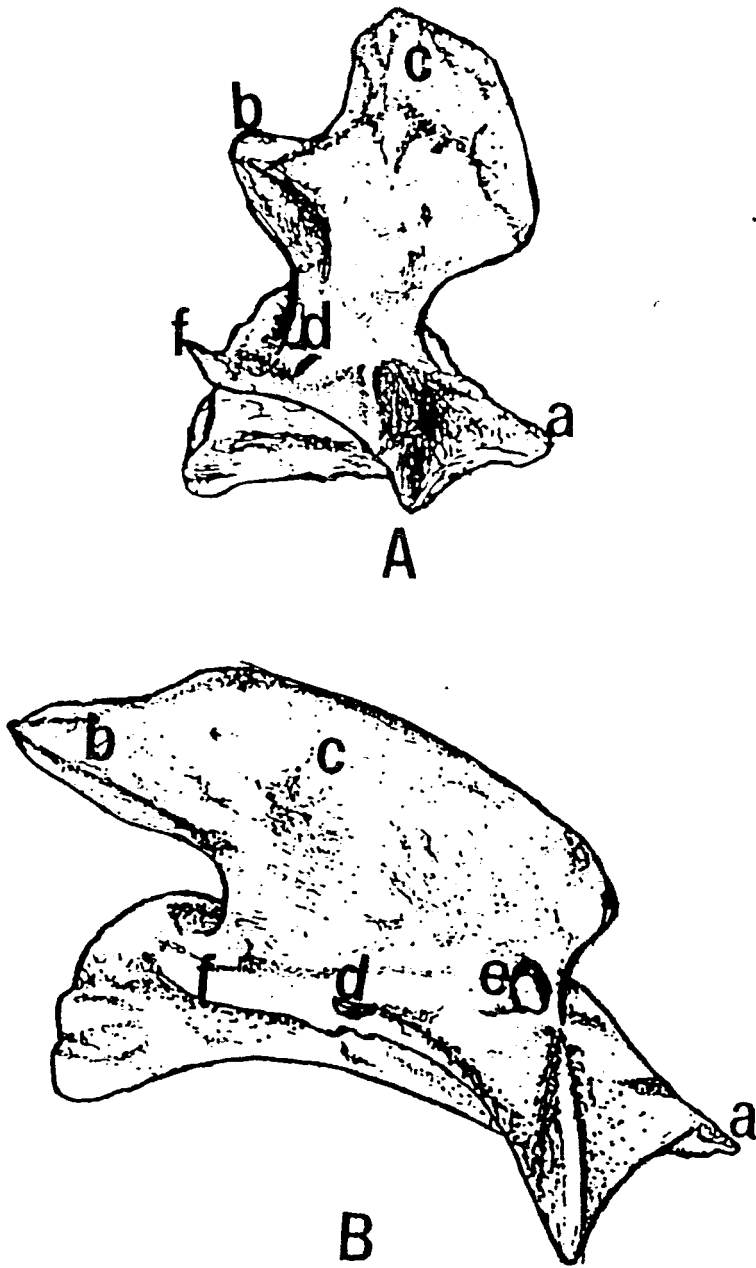
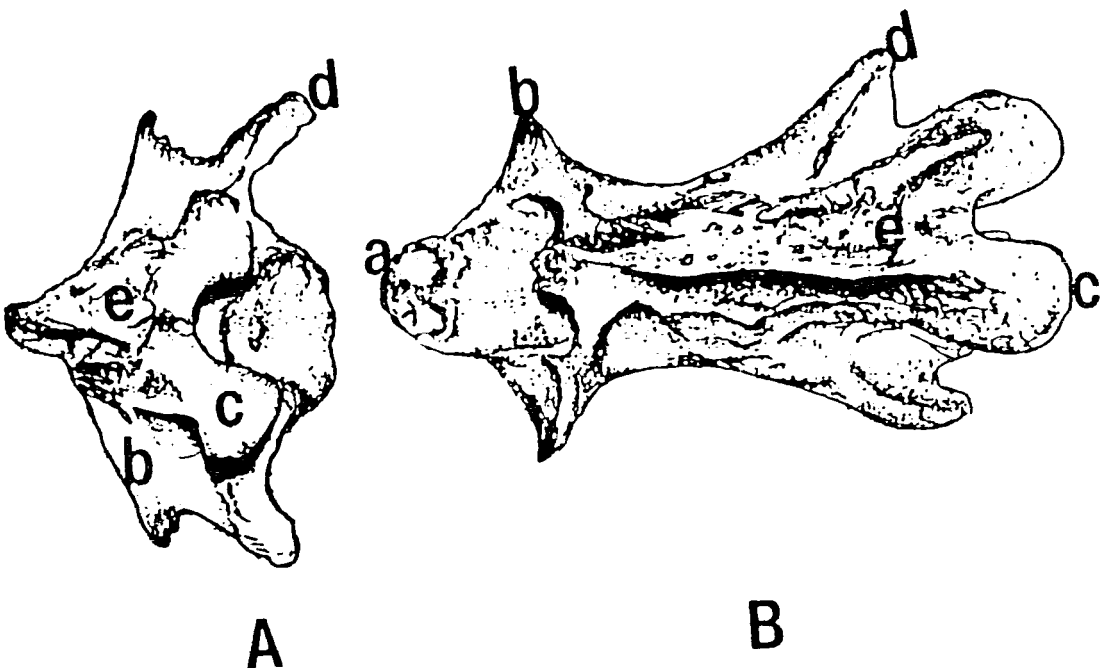


Figure 3. Lateral view of the axis of the A, rhinoceros and B, the horse. a, dens; b, posterior articular process; c, dorsal spinous process; d, foramen transversarium; e, intervertebral foramen (absent in the rhinoceros); f, transverse process.



Sixth Cervical Vertebra

The head of the body of the sixth cervical vertebra is rectangular (Fig. 6, A). The posterior cavity of the sixth cervical vertebra is round and markedly more concave than the seventh cervical vertebra. The ventral spine is less developed and widens posteriorly to form a large tuberosity. The ventral branch of the transverse process widens to form the shape of an 'axe-head' whereas the lateral branch is narrow and tapers to form a pointed end. The dorsal spinous process of the sixth cervical vertebra is long compared to the fourth and fifth cervical vertebrae. The anterior articular processes project cranio-dorsally while the posterior articular processes project caudo-laterally. A large foramen transversarium perforates the transverse process on each side while the dome-shaped vertebral foramen is found centrally (Fig. 6, A). A deep fossa was observed on the left ventral branch of the transverse process only.

The height, width and length of the sixth cervical vertebra of the rhinoceros are 195 mm, 113 mm, 58 mm, respectively.

Seventh Cervical Vertebra

The dorsal aspect of the body is short and narrow compared to the ventral aspect. The head of the vertebra is rectangular in shape. The posterior cavity is shallow and broad. A less prominent ventral spine extends from the ventral border of the head to the ventral border of the posterior cavity. On either side of the ventral spine a prominent tubercle is found (Fig. 6, B).

Table 2. The measurements of the cervical vertebrae of the rhinoceros and horse.

Vertebra	Rhinoceros*		Horse**	
Atlas				
Length	50	(33) ++	72	
Height	89		95	
Width	237	(1:5.93) +	168	(1:2.33) +
Axis				
Length	92		170	
Height	130		132	
Width	131	(1:1.42) +	105	(1:0.62) +
Third Cervical				
Length	65		132	
Height	118		110	
Width	152	(1:2.34) +	120	(1:0.01) +
Fourth Cervical				
Length	57		132	
Height	132		110	
Width	138	(1:2.42) +	135	(1:1.02) +
Fifth Cervical				
Length	62		125	
Height	160		100	
Width	120	(1:1.94) +	145	(1:1.16) +
Sixth Cervical				
Length	58		114	
Height	195		100	
Width	113	(1:1.95) +	140	(1:1.23) +
Seventh Cervical				
Length	58		105	
Height	205		100	
Width	115	(1:1.98) +	130	(1:1.24) +

* adult sumatran male rhinoceros (650 kg).

** stallion.

+ the ratio of length to width of the vertebra.

++ excluding the ventral tubercle.

All measurements are in mm.

There is a facet for the head of the rib excavated on the lateral border on each side of the posterior cavity. The dorsal spine is extremely long. The transverse process has a single branch and is perforated by the foramen transversarium only on the left side (Fig. 6, B).

The height, width and length of the seventh cervical vertebra of the rhinoceros are 205 mm, 115 mm, 58 mm, respectively.

DISCUSSION

Like most mammals there are seven vertebrae in the cervical region, of

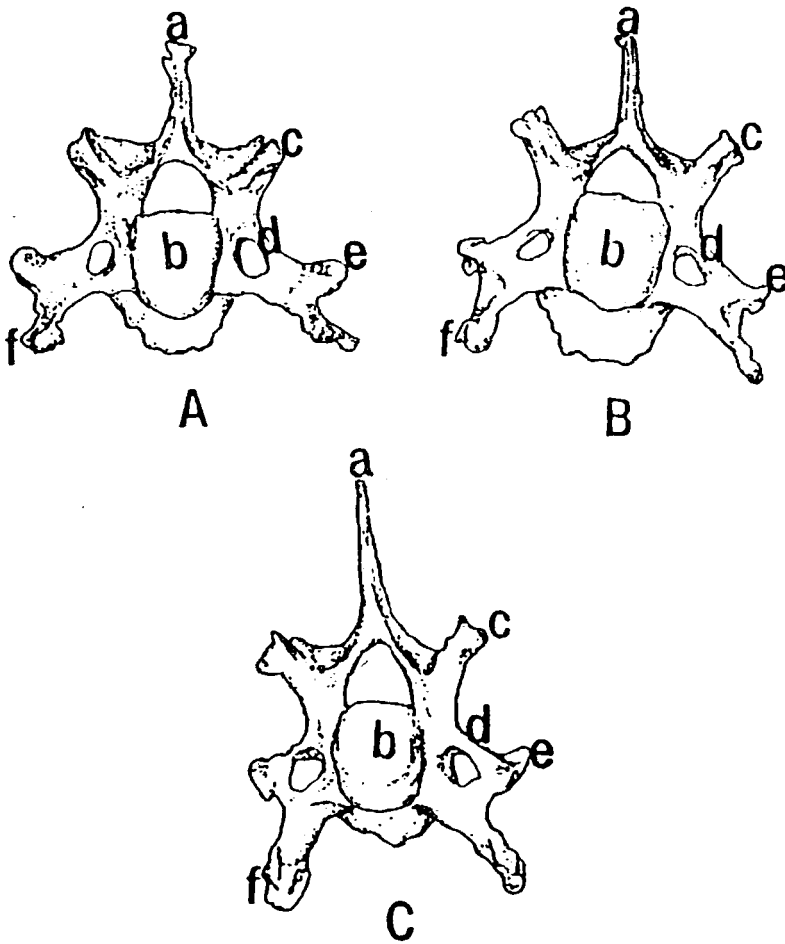


Figure 5. Anterior view of the A, third; B, fourth and C, fifth cervical vertebrae of the rhinoceros. a, dorsal spinous process; b, rectangular head; c, anterior articular process; d, foramen transversarium; e, lateral and f, ventral branches of the transverse process.

which, the first two vertebrae (atlas and axis) are atypical and highly modified. The function of the atlas and axis is to support and assist the movement of the head.

In the discussion that follows the cervical vertebrae of the rhinoceros are compared with that of the horse.

There are marked differences in the shape of the atlas of the rhinoceros and horse. The distinguishing points are the short body (approximately one half that of the horse), the wide wings, and shallow anterior articular cavities and narrow widely spaced posterior articular cavities. These anatomical differences in the rhinoceros are adaptations to support the massive head and favours lowering the head for charging. The alar foramen and the transverse foramina are characteristically absent in the rhinoceros.

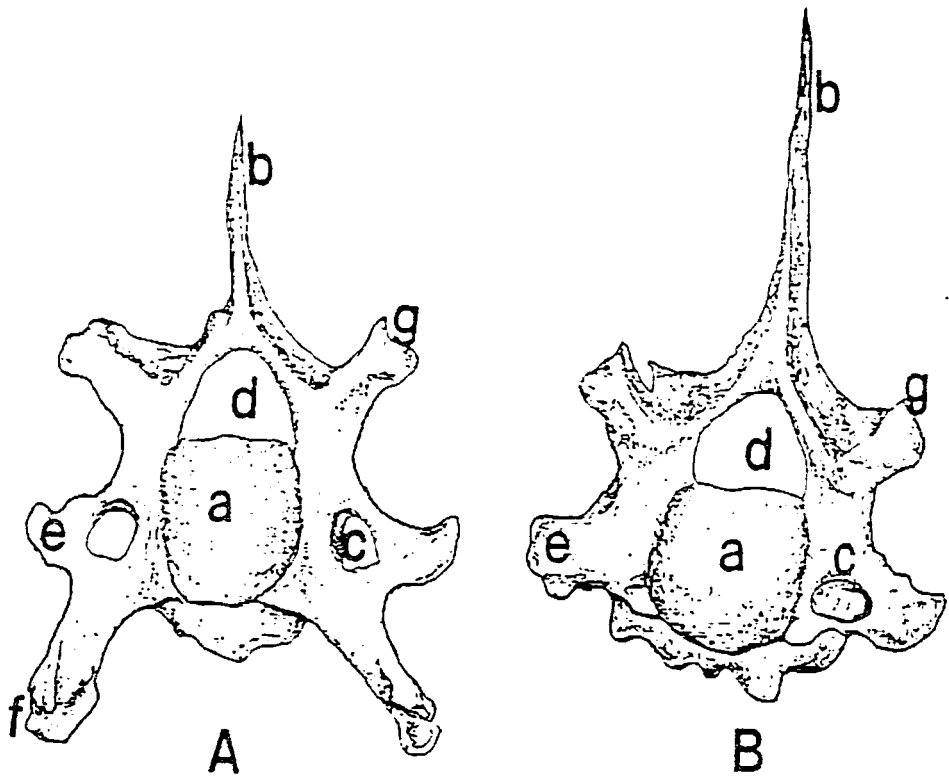


Figure 6. Anterior view of the A, sixth and B, seventh cervical vertebrae of the rhinoceros. a, rectangular head; b, dorsal spinous process; c, foramen transversarium; d, vertebral foramen; e, lateral and f, ventral branches of the transverse process; g, anterior articular process.

The axis is characterised by the dens which articulates with the ventral arch of the atlas. A prominent feature of the axis of rhinoceros is that its body is shorter than its width whereas in the horse it is reverse. Other features are that the height of the axis of the rhinoceros is comparable to that of the horse, the short rounded and tuberosus dens and the absence of the intervertebral foramen in the rhinoceros.

The 3rd, 4th and 5th cervical vertebrae in both the rhinoceros and horse are fairly similar. The bodies of the vertebrae appear shorter because of the wide transverse processes in the rhinoceros. The distinguishing features are the long dorsal spine and the relatively wide transverse process which is directed more posteriorly in the rhinoceros. The ventral spine is less prominent and forms two ridges and two tubercles at the posterior end.

The sixth cervical vertebra is large and the ventral spine is reduced and form two small ridges and tubercles at the posterior end. The ventral branch of the transverse process is 'axe-shaped' and carries only two

processes on each side whereas in the horse there are three processes.

The ventral spine of the seventh vertebra of the rhinoceros is less prominent and carries two grooves. Tubercles are absent on the ventral spine in the rhinoceros.

In an earlier study (Zainal *et al.*, 1990) observed that the cervical vertebrae contributed to 18 per cent of the total length of the vertebral column in the rhinoceros while in the horse it was as much as 33.33 per cent. The total length of the cervical vertebrae was 432 mm and 850 mm in the rhinoceros and horse respectively. The study revealed that the atlas and axis contributed to 132 mm in the rhinoceros against 242 mm in the horse. The total length of the 3rd, 4th, 5th, 6th and 7th cervical vertebrae in the rhinoceros was 300 mm and 608 mm in the horse. Interestingly, there has been no marked relative reduction in the length of the atlas and the axis or the remaining cervical vertebrae but the total length of the cervical vertebrae is shorter in the rhinoceros compared to the horse.

The visual assessment of the length and shape of the transverse processes do not give an indication of the relative length of body of the vertebra and its transverse process. Therefore, it was necessary to calculate the ratio of these two measurements to establish relative values for the length of the body or the transverse processes of the vertebra.

Measurements of the various vertebrae of the cervical region revealed some interesting facts. The ratio of the length to the width of the atlas of the rhinoceros and the horse indicated that there has been an extensive widening ($\times 5.93$) of the wing of the atlas in the rhinoceros. A comparison of the measurements of the axis of these two animals showed major differences in the ratio of length to width of the vertebra indicating that the axis is relatively wider in the rhinoceros. The ratio of the length to width measurements of the cervical vertebrae 3rd, 4th, 5th, 6th and 7th indicated relatively shorter bodies in the rhinoceros compared to the horse.

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REFERENCES

- Beddard, F.H. & Treves, F. 1889. On the anatomy of the *Rhinoceros sumatrensis*. *Proceedings of the Zoological Society of London* pp. 7-25.
- Gray, J.E. 1867. Observations on the preserved specimens and skeletons of the Rhinocerotidae in the collection of the British museum and the Royal College of Surgeons, including the description of three new species. *Proceedings of the Zoological Society of London* pp. 1003-1031.
- Groves, C.P. 1965. Description of a new subspecies of rhinoceros from Borneo. *Saugetierkundliche Mitteilungen* 13: 128-131.

- Groves, C.P. 1982. The skull of Asian Rhinoceros: wild and captive. *Zoo Biology* 1: 251-161.
- Groves, C.P. & Kurt, F. 1972. Mammalian species *Dicerorhinus sumatrensis*. *The American Society of Mammalogists* 20: 1-6.
- Groves, C.P. & Chakraborty, S. 1983. The Calcutta collection of Asian Rhinoceros. *Record of the Zoological Survey of India* 80: 251-263.
- Flower, W.H. 1876. On some cranial and dental characters of the existing species of rhinoceros. *Proceedings of the Zoological Society of London* pp. 433-459.
- Kingdon, J. 1989. *East African mammals vol IIIB* (An atlas of evolution in Africa) (Large mammals) pp. 80-119. University of Chicago Press.
- van Strien, N.J. 1974. The Sumatran or two-horned Asiatic rhinoceros. A study of literature. *Mededelingen Landbouwhogeschool Wageningen*.
- Zaimal-Zahari, Z., Vidyadaran, M.K., Mohd-Tajuddin, A., Rozyati, T.H. & Peng, B.Y. 1990. Observations on the skeleton of the Sumatran Rhinoceros. *Jurnal Veterinar Malaysia* 2(1): 59-61.