Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

Journal of Entomology and Zoology Studies

E-ISSN: 2320-7078
P-ISSN: 2349-6800
www.entomoljournal.com
JEZS 2020; 8(3): 630-634

Received: 19-03-2020
Accepted: 21-04-2020

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Morphological studies of the atlas in ox and its comparison with the atlas of horse, dog, goat and sheep

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Abstract
Morphological studies were performed on the six each atlas bone in ox (*Bos indicus*) and its comparison with another four different species of animals viz. horse (*Equus ferus*), dog (*Canidae canis*), goat (*Capra hircus*) and sheep (*Ovies aries*). The first cervical atypical vertebra was observed without body and spine. Anteriorly the atlas formed an atlanto-occipetal joint with skull that allows head nod up and down the vertebral column resulting nodding and rotational movements of the head. The cranial and caudal radius of neural ring of atlas was measured and thereafter calculated the area, circumference, ellipticity and linear eccentricity. The morphological characters of atlas were discovered in ox and also the differential features of the same bone were studied in other animal species as to Horse, Dog, Goat and Sheep. The dimensions which could be achieved in present study sufficiently determined the conical shaped neural ring at atlas. However, the remarkable finding in horses and goat doesn't show much more ellipticity in comparison with others species attributing towards the difference of their feeding habits.

Keywords: Morphology, atlas, Ox, horse, dog, goat and sheep

Introduction
The first cervical vertebra i.e. atlas supports the head at its anterior. After the Greek mythology Atlas, means the weight bearing entity. It forms the articulation with occipital condyle of skull at its anterior and with second cervical vertebra, the axis at its posterior. Peculiarly, a vertebra must have a structure as to body and spine which doesn't observe in the presently studied first cervical vertebra, reasoning this atlas vertebra is known as the atypical vertebrae[1]. The atlas is specialized vertebrae while allowing a greater range of movement rather than other typical vertebrae. In accordance to the Rommel and Reynoldslll[2] this vertebra is responsible for the nodding and rotational movements of the head. Present paper is the observance revealing document which is being brought after undertaken thorough studies of six each atlas bone on ox (*Bos indicus*) and also compared the same with four different animal species viz. horse (*Equus ferus*), dog (*Canidae canis*), goat (*Capra hircus*) and sheep (*Ovies aries*).

Materials and Methods
Six numbers of first cervical vertebrae were collected from each of adult animals' cadaver after proper maceration, cleaning and drying. The first cervical vertebrae, atlas of different species of animals include ox (*Bos indicus*), horse (*Equus ferus*), dog (*Canidae canis*), goat (*Capra hircus*) and sheep (*Ovies aries*) were selected for present undertaken study. The morphology of atlas of ox was studied in comparison with others. This study was the part of revolving fund project for articulation of bones after preparation of skeletons of different animal species while providing the same as the study material to other educational institutions.

In each of the species, the average horizontal and vertical diameters of neural ring at cranial and caudal aspects of respective atlases were noted. After calculating the respective radius, the data was filled up in the online calculator supplied by https://keisan.casio.com/exec/system/1223289167 and calculated an area, circumference, ellipticity and linear eccentricity of the neural ring of those atlases of different species which collected for present studies (Table 1 and 2).

Results and Discussion

The atlas of Ox

The atlas has presented in a butterfly look with large rough tuberosity on its dorsal surface. The either side located blade typed wings of atlas were originated from the dense bony masses, engaged in covering the neural ring. The wings were observed as the replacement of transverse processes of other typical vertebrae. These wings provide the attachments of dorsal and ventral musculature which works for up and down movement of head and also form connectivity between spine and nuchal aspect viz. posterior of neck i.e. occipital bone**.** The anteriorly formed joint with skull known after atlanto-occipetal joint that allows head nod up and down the vertebral column (Fig. 3). The observations were very much similar to the observance of the Konig and Liebich [3].

Cranial surface had a large neural ring with either side placed wings. Either side of neural ring located articular surfaces for articulating two rounded knobs, called occipital condyles at the base of the skull**.**

Dorsal surface of the vertebra had a rough and striking tubercle in the middle, which known after the dorsal tubercle. At the either side of dorsal tubercle there were two foramens. Medial one was the intervertebral foramen and the lateral one was the alar foramen. It had a common opening for intervertebral and alar foramens, hence might be recognized as the intervertebro-alar foramen (Fig.1 and 2). Konig and Liebich identified the intervertebral foramen as an individual hence notified it as the lateral foramen [3]. Contrary, it was located median to alar foramen and both were opening into single foramen, therefore with their disagreement in the present studies collectively it is being recognized as the intervertebro-alar foramen**.**

The broad ventral arch was observed with less curving thick wings, which were appeared close to horizontal in appearance [4]. The cranial articular cavities were located for occipital condyles and caudal articular surface for attachment of axis. There were the presence of cranio-internal intervertebral foramen and cranio- external alar foramen which were connected by a short furrow. A deep atlantal fossa was present in the ventral aspect of wings [5]. On the ventral surface there was a tubercle which is known after ventral tubercle. The atlas possessed a canal connecting the atlantal fossa with the vertebral foramen which is known as the Canalis vertebroalaris [6] (Fig. 4 and 5). Caudal to this common opening there were another two small foramens in a linear groove. Caudal end had saddle shaped articular facets for the axis. The floor of the neural ring had depression called as fovea dentis for articulating odontoid process of axis (Fig.6). The analogous findings were reported by Raghwan[7] and Ghosh [4].

Ventrally the atlas was looking like the facial shape of owl. In the mid of face there was a tubercle known as ventral tubercle. Either side of ventral tubercle there were two masses known as the lateral masses. At the either sides of ventral tubercle, the vertebral canal opening foramens were there which are identified in the name of fossa atlantis [4, 7]. At the anterior of tubercle there were wing perforation and alar foramen connecting small passage after the ventral primary branch of first spinal nerve and branches of vertebral vessels. The caudal border of ventral surface was wavy in appearance. The wavy cranio-ventral surface had the lower down folded borders in comparison with dorsal face. It facilitated the holding of occipital condyles while befitting the increasing lower down movement of neck to have comfortable feeding at ground level (Fig. 4 and 5).

Atlas of Horse

The wings were sloping downwards and outwards. Besides the alar and intervertebral foramina there was a foramen transversarium at the posterior part of the wings. The posterior edge of the dorsal arch have not present with the notches, as was observed in the ox. Dorsal and ventral tubercles were also smaller than that of ox. The saddle shaped posterior articular surfaces were there (Fig. 7 and 8). These observations were very much of the same kind from those of Getty *et al* [8].

Atlas of Dog

The arch shaped dorsal surface was observed as the convex, strong and rough at middle. Wings were horizontal. An alar notch had a presence there on the anterior border replacing the alar foramen. Foramen transversarium were present at either side of small dens. The arch shaped ventral surface was narrower than dorsal that bears a small posterior tubercle (Fig. 9 and 10). The findings in present studies were corroborative with the outcome submitted by Miller *et al* [9].

Atlas of Goat

The atlas was differing chiefly in that of the prominence on the dorsal arch which was much less developed. The openings after an alar and the intervertebral foramen were comprehensibly separated. The ventral tubercle was not well developed (Fig. 11 and 12). The outcomes of present studies were very much comparable with those of Clarence [10].

Atlas of Sheep

The smaller atlas of sheep had no transverse foramens. Dorsal and ventral tubercles were less prominent. At the caudal border of dorsal surface a notch was there on the mid part of the border. The wings were not much broader. No regular shaped common opening was observed for intervertebral and alar foramens (Fig. 13 and 14). The mentioning of present undertaking work were somewhat near to the assertions stated by May Neil [11] and shalini *et al* [12].

In general the spinal cord in domestic animals started with the initiation of atlas at base of skull and has direct relation with the functional ability and their feeding habits [13, 14]. They also observed the cylindrical and well-organized structure of spinal cord in human beings which begin at the foramen magnum as a continuation of the medulla oblongata at the base of the skull. The spinal nerves which contain motor, sensory, and autonomic fibers have exit through the intervertebral foramen. In the present studies, almost all species have shown lower cranial diameter of neural ring than that of caudal diameter. These findings were very much concurring with them as to indicating the conical neural ring at atlas, only the remarkable findings in horses and goat doesn't show much more ellipticity in comparison with others, which might be attributed with the difference of their feeding habits.

Table 1: Observations on neural ring at cranial aspect

S. No.	Species	The Average Radius of Neural Ring at Cranial Aspect		Area S=abπ ; b≤a a-Horizontal radius b-Vertical Radius	Circumference $L = 4aE(k), \quad k = \sqrt{1-(\frac{b}{a})^2}$ $E(k)$: 2nd complete elliptic integral	Ellipticity c=b/a	Linear eccentricity $f = \sqrt{a^2 - b^2}$
		Vertical (cm)	Horizontal (cm)				
1.	Ox	1.35	2.15	9.02	11.06	0.64	1.65
2.	Horse	2.00	2.30	14.77	13.69	0.86	1.24
3.	Dog	0.90	0.50	1.42	4.49	0.56	0.75
4.	Goat	1.05	1.60	5.28	8.42	0.66	1.21
5.	Sheep	0.70	1.00	2.20	5.39	0.70	0.72

Table 2: Observations on neural ring at caudal aspect

S. No.	Species	The Average Radius of Neural Ring at Caudal Aspect		Area S=abπ ; b≤a a-Horizontal radius b-Vertical Radius	Circumference $L = 4aE(k), \quad k = \sqrt{1-(\frac{b}{a})^2}$ $E(k)$: 2nd complete elliptic integral	Ellipticity c=b/a	Linear eccentricity $f = \sqrt{a^2 - b^2}$
		Vertical (cm)	Horizontal (cm)				
1.	Ox	2.55	2.50	20.03	15.87	0.99	0.51
2.	Horse	2.45	2.05	15.78	14.17	0.84	1.35
3.	Dog	1.10	1.85	6.34	9.42	0.60	1.49
4.	Goat	1.25	1.45	5.70	8.50	0.87	0.74
5.	Sheep	1.10	1.05	3.63	6.76	0.96	0.33

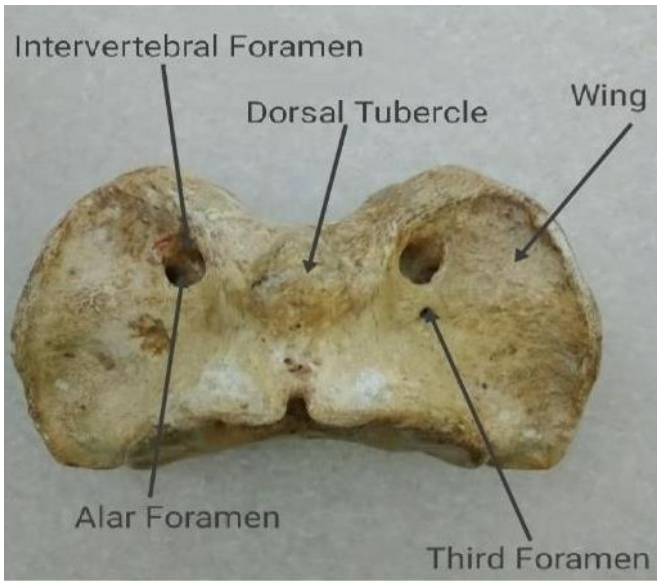

Fig 1: Dorsal View of Atlas of Ox

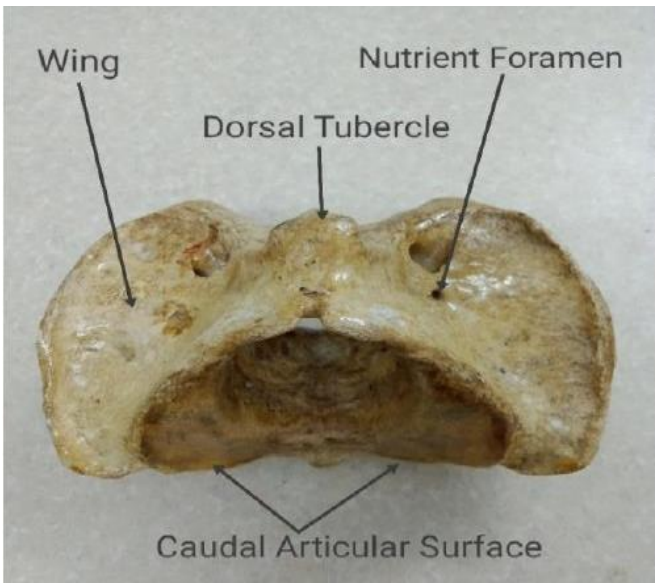

Fig 2: Caudo-Dorsal View of Atlas of Ox

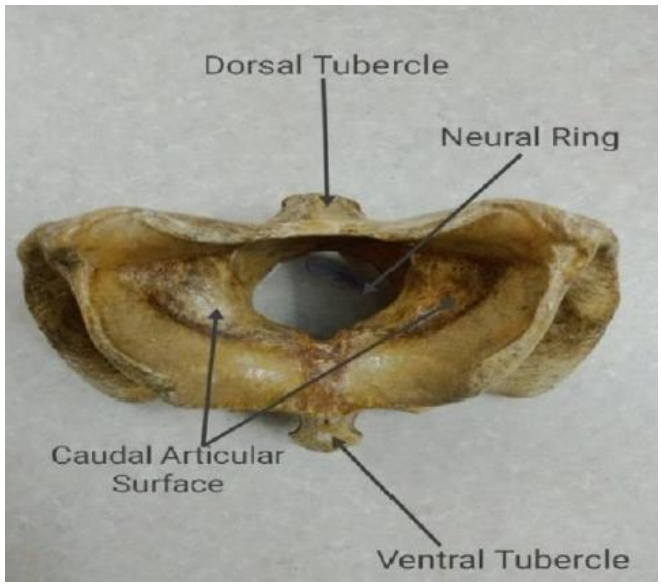

Fig 3: Cranial View of Atlas of Ox

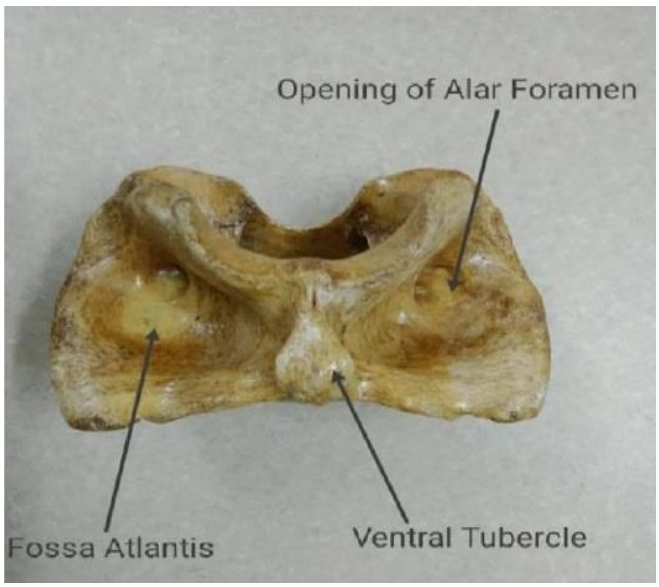

Fig 4: Ventral View of Atlas of Ox

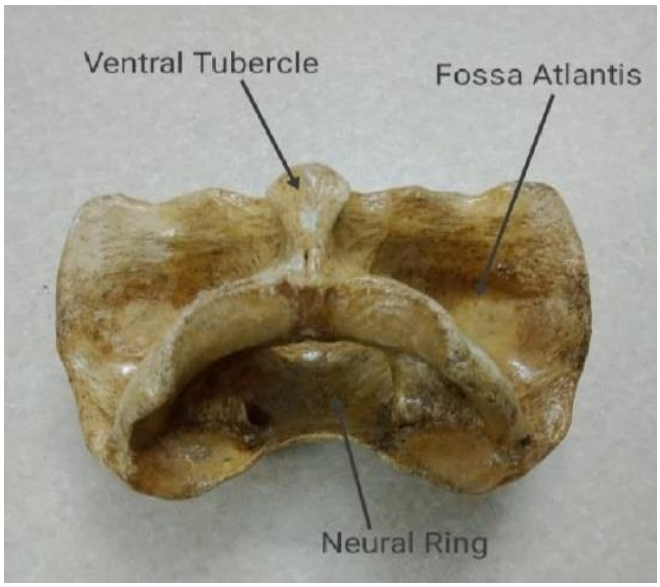

Fig 5: Crania-Ventral View of Atlas of Ox

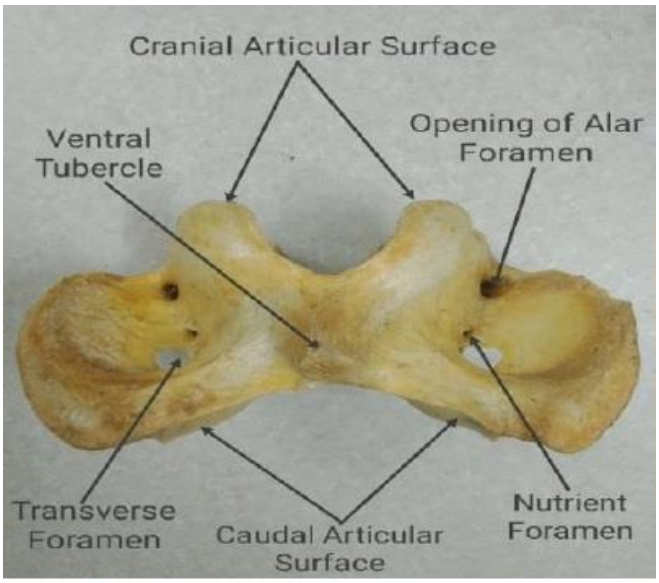

Fig 8: Ventral View of Atlas of Horse

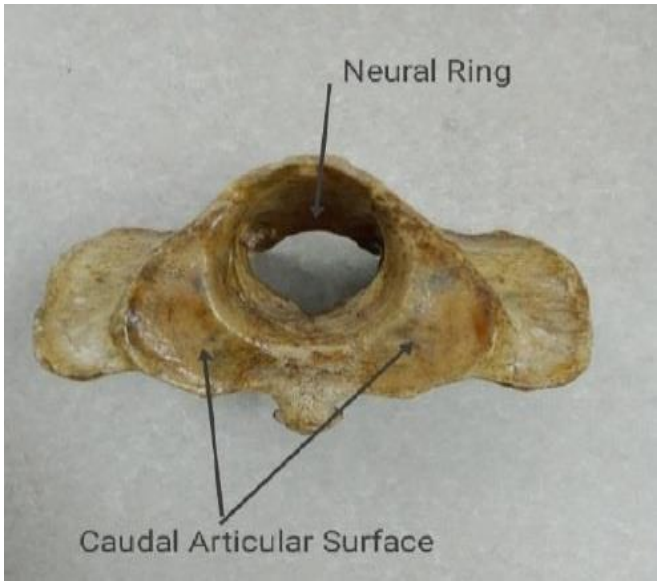

Fig 6: Caudal View of Atlas of Ox

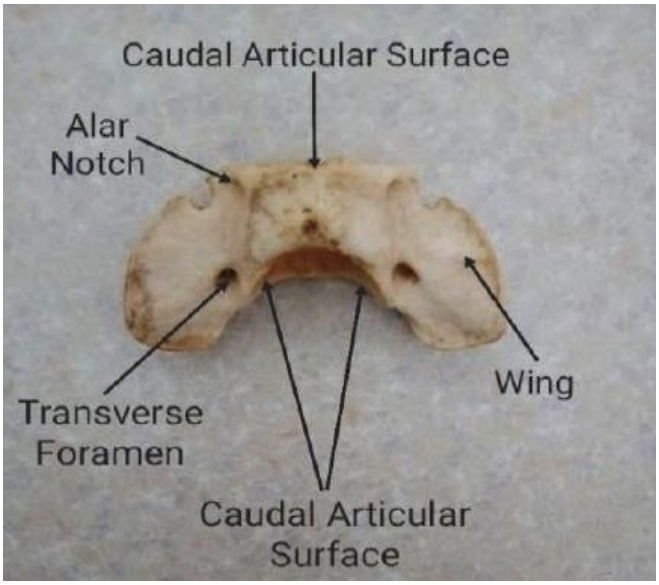

Fig 9: Dorsal View of Atlas of Dog

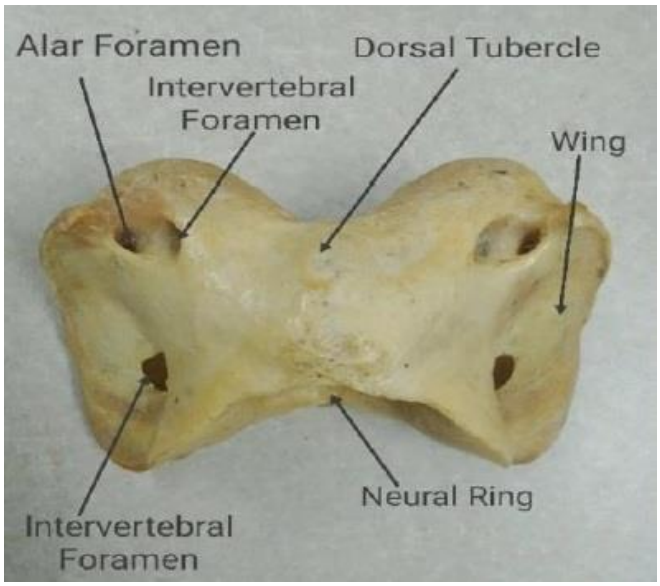

Fig 7: Dorsal View of Atlas of Horse

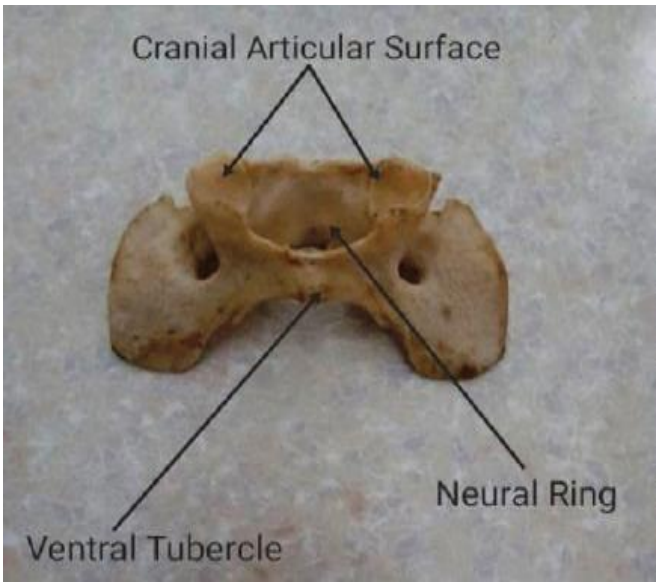

Fig 10: Cranio-Ventral View of Atlas of Dog

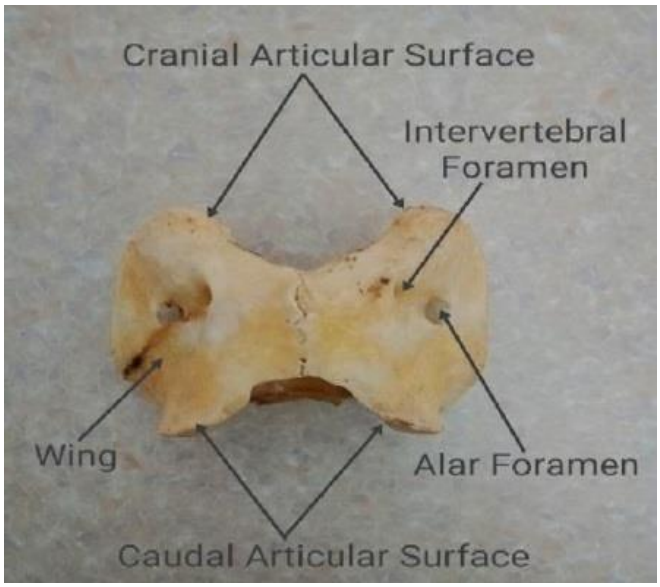

Fig 11: Dorsal View of Atlas of Goat

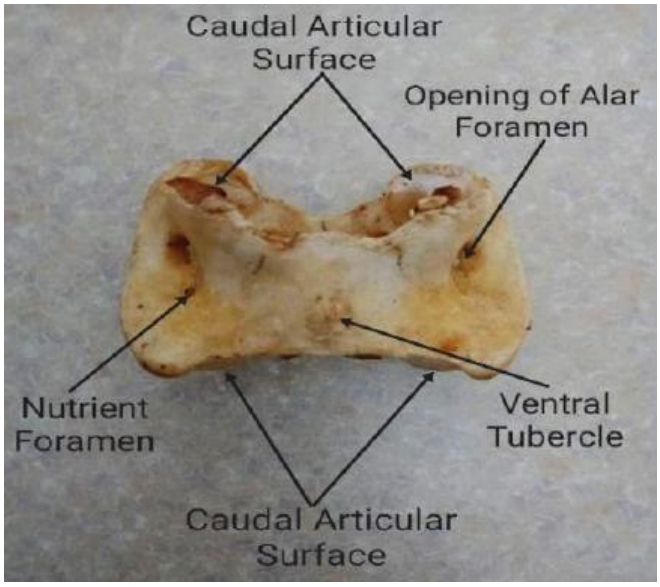

Fig 12: Ventral View of Atlas of Goat

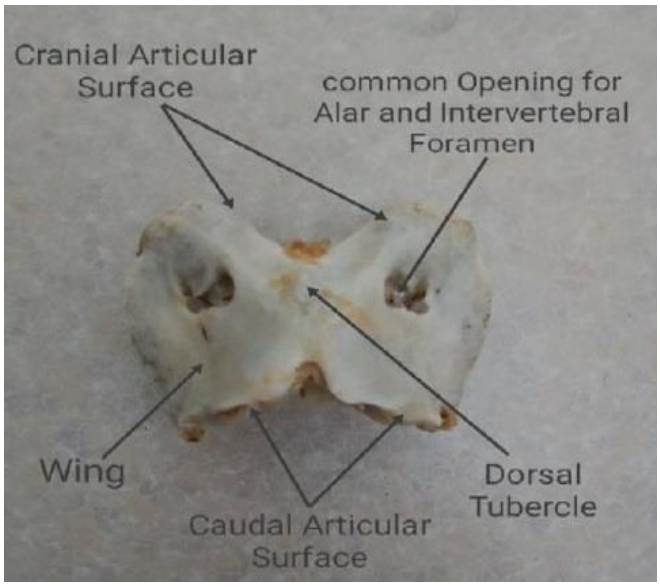

Fig 13: Dorsal View of Atlas of Sheep

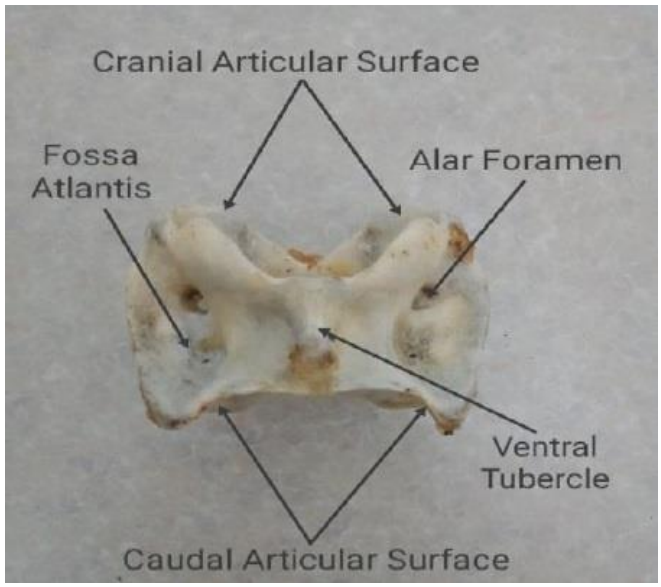

Fig 14: Ventral View of Atlas of Sheep

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