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Gross morphometrical studies on the Skull, Atlas and Axis of Female Asiatic elephant (*Elephas maximus*): A Case Study

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Abstract: The present investigation was carried out on the dead Asian elephant (*Elephas maximus*) presented to the Centre for Wildlife Health, OUAT, Bhubaneswar whose skeleton remains were attempted for fire burn by the land poachers. After ascertaining the sex, tentative age and height of the animal basing on the morphology of skull, number of lamellae on the table surface of molar tooth and shoulder height respectively, the morphological and biometrical studies were conducted on the skull, atlas and axis vertebra to develop a baseline data for the particular species, sex and age group of the Asiatic elephant. The present biometric study was conducted by using the instruments used for routine biometrical studies of the bones such as graduated tape, scale and digital Vernier's caliper. It was found that the skull contained air cavities that gave the inside of the skull a honeycomb-like appearance and back of the skull was flattened and spread out. The atlas had dorsal and ventral arches, united by the lateral masses of cartilage. The length and width of the body of atlas were comparatively smaller than that of axis. The length of cranial articular facet of left side of atlas was greater than that of the right side, where as a reverse relation was noted for their widths. The foramina transversarium were found to be circular in shape in atlas. Further, the axis was comprised of a body carrying the dens and the neural arch, united by a cartilage. Unlike atlas, the foramen transversarium of left side was larger than that of the right one in axis. It aimed to develop a baseline data for the particular species, sex and age group of the Asiatic elephant, which will help explore new avenues in the forensic wild life science in dealing with the vetero-legal cases particularly for the identification purposes. Further, the gross and biometric studies may be conducted on the whole axial skeleton of the female Asiatic elephant (*Elephas maximus*) along with their biomechanical role.
Keywords: Gross, morphometry, skull, atlas, axis, Asiatic elephant

INTRODUCTION

The elephants are widely accepted as an intelligent and socially complex species according to Bates and Byrne [1].They are primarily threatened by degradation, fragmentation loss of habitat and poaching as described by Choudhary *et al.* [2]. Moreover, they are long-lived, highly-social and large-brained animals [4, 6]. They are distributed in Southeast Asia from India in the west to Borneo in the east. The back of the Asian elephant is convex or level as described by Shosani [5] and it has up to 20 pairs of ribs and 34 caudal vertebrae. Female captive elephants live beyond 60 years when kept in semi-natural surroundings, such as forest camps, but die at a much younger age and are declining due to a low birth and high death rate when kept in the zoos as discussed by Stiles [8]. Due to availability of scanty literature, the present study on the morphometry of skull, atlas and axis vertebra of the Asiatic elephant was conducted to develop a baseline data for the particular species, sex and age group of the animal.

MATERIALS AND METHODS

The present investigation was carried out on the skull, atlas and axis of an Asian elephant (*Elephas maximus*) which was presented to the Centre for Wildlife Health, C.V.Sc. & A.H., Orissa University of Agriculture and Technology, Bhubaneswar by the Dept. of Forest, Govt. of Odisha. The skeleton remains were attempted for fire burn by the poachers. Subsequently, Department of Anatomy and Histology was approached for discriminating sex, tentative age and height of the animal. While this study was in progress for vetero-legal purposes, it was noted that the skull bones, atlas and axis had intact morphology with black to brown discoloration. Therefore attempts were made to record the biometrics of these bones using graduated tape, scale and digital Vernier's caliper. The data are presented in table 1, table 2 and table 3.

RESULTS AND DISCUSSION

During examination of the skull, it was seen that most of the facial bones like anterior part of the frontal bone, Nasal bone, lacrimal bone, malar bone and maxillae were completely burnt. Hence, only the basic

morphometrical studies were carried out on the available skull of the animal. The skull contained air cavities that gave the inside of the skull a honeycomb-like appearance [3]. The back of the skull was flattened and spread out. The lower jaw is solid and heavy. Basing on the morphology of the skull, the female sex of the elephant was confirmed as described by Todd [9]. The convex or rounded shape of the parieto temporal crest, smooth temporal fossa and thin, short and pointed lip bone confirmed the female sex of the animal (Fig 1). The major biometrical observations on the skull are presented in Table 1.

The atlas and axis revealed black to brown discoloration, with intact morphology. They are connected by tight joint, which was in line with the finding of Shosani [7].The atlas revealed two parts, i.e a ventral arch and a dorsal arch, united by the lateral masses of cartilage. The length and width of the body were comparatively smaller than that of axis (Table 2 and Table 3). The ventral tubercle was not well developed (Fig 2). The posterior part of the dorsal face of the ventral arch revealed an articular area for the dens. The lateral masses presented large vertical concave facets meant for articulation with the occipital condyles. These two facets were separated by a small notch ventrally and a wider notch dorsally. The length of cranial articular facet of left side was greater than that of the right side. A reverse relation was noted for their widths. The transverse process was long and drawn anteriorly as a pointed projection, and consisted of two elements united laterally by cartilage enclosing the foramen transversarium. The foramina transversarium were found to be circular in shape. Further, the foramen transversarium of left side was smaller than that of the right one. The intervertebral foramina were oval in shape and right one was found to be larger than the left one (Table 2). The cranial face of the dorsal arch was grooved for the first cervical spinal nerve. The dorsal arch had two tubercles above. The posterior articular facet appeared below the intervertebral notch and articulated with the anterior facet of the axis. The major biometrical observations pertaining to the atlas are presented in Table 2.

The axis was comprised of two pieces i.e body carrying the dens and the neural arch. Both the parts were united by a cartilage. The length and width of the body were comparatively larger than that of the atlas (Table 2 and Table 3). The dens was found to be large and conical. Dorsally, it was grooved for the transverse ligament, and ventrally it was smooth and articular. The anterior articular facet was large, being formed by the body and the arch. The transverse processes resembled those of typical cervical vertebrae. The posterior articular facets were dorsal to the intervertebral foramen. The neural spine was massive and bifid (Fig 3), presenting two larger tubercles behind, and was slightly bent forward. The dorsal spines of both the sides were of same length, but the right one was wider than the left spine. The right caudal articular process was found to be larger and wider than the left one (Table 3). The foramina transversarium were found to be circular in shape. Unlike atlas, the foramen transversarium of left side was larger than that of the right one (Table 3). The major biometrical observations pertaining to the axis are presented in Table 3.

Table 1: **Biometrical data of skull of female Asiatic elephant**

Parameters	**Measurements (in cm)**
Skull length	45.7
Skull width	44.7
Skull Index	97.81
Skull base length	34.3
Cranial length	29.2
Cranial width	26.7
Cranial Index	91.43
Cranial height	34.3
Height of foramen magnum	7.6
Width of foramen magnum	6.6
Circumference of foramen magnum	25.4
Length of Palatine bone	29.2
Width of Palatine bone	8.9

Table 2: **Biometry of atlas vertebra of female Asiatic elephant**

Parameters	**Measurements (in cm)**
Length of body	5.1
Width of body	4.1
Length of left wing of atlas	6.5
Width of left wing of atlas at the base	1.7
Width of left wing of atlas at the tip	3.7
Length of right wing of atlas	6.3
Width of right wing of atlas at the base	1.5
Width of right wing of atlas at the tip	3.5
Length of left cranial articular facet	11.4
Width of left cranial articular facet	7.4
Length of right cranial articular facet	10.4
Width of right cranial articular facet	7.9
Maximum distance between two cranial articular facets	7.6
Length of left caudal articular facet	8.4
Width of left caudal articular facet	7.6
Length of right caudal articular facet	10.2
Width of right caudal articular facet	7.3
Maximum distance between two caudal articular facets	4.5
Diameter of left transverse foramen	3.1
Diameter of right transverse foramen	3.3
Vertical diameter of left intervertebral foramen	2.2
Transverse diameter of left intervertebral foramen	2
Vertical diameter of right intervertebral foramen	2.5
Transverse diameter of right intervertebral foramen	2
Distance between left intervertebral and transverse foramina	5.5
Distance between right intervertebral and transverse foramina	4.8
Vertical diameter of neural foramen	12
Transverse diameter of neural foramen	6.8
Circumference of neural foramen	38
Diameter of dorsal tubercle	2.5
Diameter of ventral tubercle	3.1

Table 3: **Biometrical observations of axis vertebra of female Asiatic elephant**

Parameters	**Measurements (in cm)**
Length of body	7.1
Width of body	5.6
Length of odontoid process	4.3
Length of left dorsal spine	7.9
Width of left dorsal spine	3.3
Length of right dorsal spine	7.9
Width of right dorsal spine	3.8
Maximum distance between two dorsal spines	4.3
Length of left caudal articular process	4.1
Width of left caudal articular process	3.3
Length of right caudal articular process	4.3
Width of right caudal articular process	4.1
Maximum distance between two caudal articular processes	5.6
Vertical diameter of neural foramen	9.5
Transverse diameter of neural foramen	8.5
Circumference of neural foramen	32
Diameter of left foramen transversarium	5.1
Diameter of right foramen transversarium	4.8

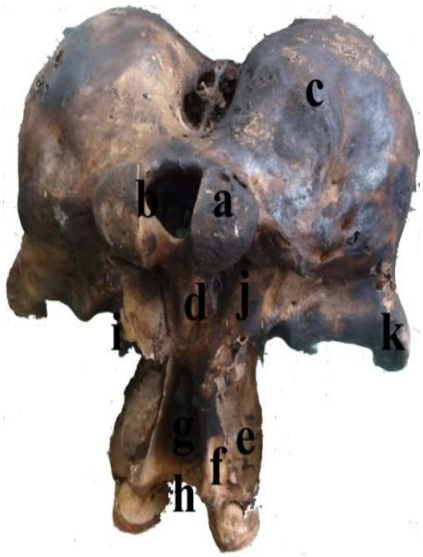

Fig. 1: **Ventral view of Skull of female Asiatic elephant (*Elephas maximus*) showing a) Occipital condyle, b) Foramen magnum, c) Exoccipital, d) Basioccipital, e) Maxilla, f) Premaxilla, g) Palatine, h) Palatine cleft, i) Pterygoid bone, j) Auditory bulla, k) Sqamous part of temporal bone**

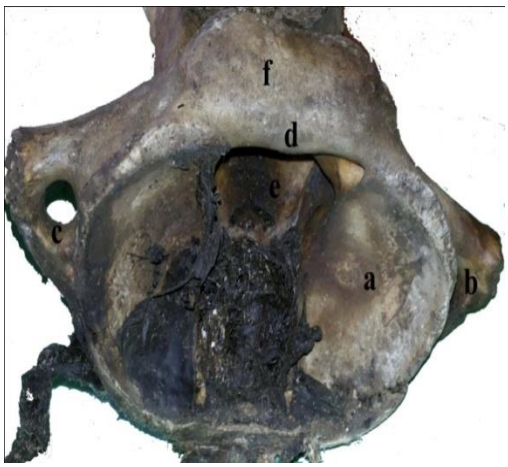

Fig. 2: **Cranial view of Atlas of female Asiatic elephant (*Elephas maximus*) showing a) Cranial articular facet, b) Transverse process, c) Foramen transversarium, d) Neural arch, e) Neural foramen, f) Dorsal arch**

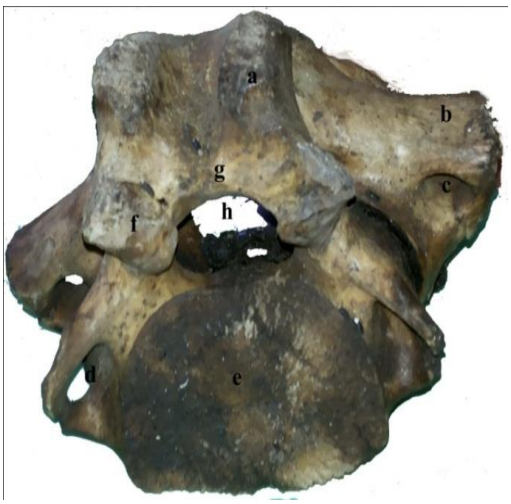

Fig. 3: **Caudal view of Axis of female Asiatic elephant (*Elephas maximus*) showing a) Dorsal spine, b) Transverse process, c) Foramen transversarium, d) Intervertebral foramen, e) Caudal articular surface of body, f) Caudal articular process, g) Neural arch, h) Neural foramen**

CONCLUSION

The present study on the skull, atlas and axis vertebra of the female Asiatic elephant of six years of age having height of about six feet can be useful in developing a baseline data for the particular species, sex and age group of the Asiatic elephant to meet vetero-legal implications. Further research is necessary to record the morphology and biometrics of the skull and entire vertebral column of the Asiatic elephant with regards to its age and sex.

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