CHAPTER - VI

PHYSICAL FEATURES AND ANATOMY OF *Rhinoceros unicornis*

The rhinoceros is the biggest of all the parissodactyla and third largest among the land animals. Its strong body with the unique presence of the horn and skin texture have attracted the attention of man from time immemorial. The presence of the odd number of toes in the feet is another major physical characteristic of this species.

Indian Rhino (*R. unicornis*) is a long, stout-bodied herbivore. Its colour is uniformly blackish-grey and the skin is devoid of hair except for a fringe on the margin of the ears, eye lids and some bristly hairs on lips and the tail. The studded skin is heavily folded in front, behind the shoulder and in front of the thighs. The horn of the male *R. unicornis* is usually long, stout and pointed with a broad base. The fore quarters are relatively bulky and shoulder portion is comparatively high (Table 25).

Studies on the black and the white species of rhinos (*D. bicornis* and *C. simum*) were carried out by several workers (Schenkel and Schenkel Hullingen 1969, Grzimek 1972) and recorded that both the African species have long heads, short tails, folded skin without hair, feet containing 3 hoofs and dentition with reduced canine teeth. Information on various
aspects of physical features and anatomy of *R. unicornis* is meagre. The earlier works of Peacock (1933), Crandall (1971), Patur (1980) and Jerdon (1984) on the species as reported from various regions although provides same information, yet detail records on the anatomical and physiological features are not sufficient.

The *R. sondaicus* or Javan rhinoceroses have almost similar features with *R. unicornis* but are different in size.

**MATERIALS AND METHODS**

(i) The physical features of *R. unicornis* were studied in living as well as in dead animals at the Assam State Zoo, Guwahati. One animal which died in a rail accident near the city subjected to study. Besides, rhinos in wild condition in Kaziranga National Park and Manas Orang and Pabitora Wildlife Sanctuaries of North East India were also keenly observed. The body weight was taken with a measuring-scale fixed along with the crane at the time of transportation when the animals were lifted by crane.

(ii) For morphological and anatomical studies of different body parts and organs of the species carcass specimens were collected from different Wildlife Sanctuaries, National Park and Assam State Zoo, Guwahati, the studies conducted at the concerned laboratories
of the College of Veterinary Science, Assam Agricultural University, Khanapara, Guwahati and Zoology Department, Gauhati University.

(iii) The different external and internal anatomical features were measured following the procedure outlined by Sisson (1953).

(iv) The organs, bones and viscera were dissected and different functional anatomical parts were studied, as per method described by Sission (1953).

Other methods are described in concerned chapter wherever necessary.

PART I

SURFACE ANATOMY (Physical features)

Three carcasses of R. unicornis were collected at different time from the Assam State Zoo, Guwahati for the anatomical study of the body as well as viscera. Observations were recorded and described.

Three adult, two males and a female R. unicornis were taken for the measurements of body surface.

The measurements of different parts of the body such as total body length, length from point of shoulder to the point of buttock,
length of the head, neck and tail, girth at the chest behind the shoulder, height at the shoulder were measured and the body weight taken and recorded in Table 25.

**TABLE - 25**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Female cm</th>
<th>Male I cm</th>
<th>Male II cm</th>
<th>Mean cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total body length</td>
<td>278</td>
<td>391</td>
<td>367.8</td>
<td>379.4</td>
</tr>
<tr>
<td>Length from point of shoulder to the point of buttock</td>
<td>191</td>
<td>223</td>
<td>159</td>
<td>191.00</td>
</tr>
<tr>
<td>Length of the head</td>
<td>80</td>
<td>116</td>
<td>110.8</td>
<td>113.4</td>
</tr>
<tr>
<td>Length of neck</td>
<td>39</td>
<td>58</td>
<td>51.8</td>
<td>54.9</td>
</tr>
<tr>
<td>Length of tail</td>
<td>58</td>
<td>62</td>
<td>62.1</td>
<td>62.05</td>
</tr>
<tr>
<td>Girth at the chest</td>
<td>246</td>
<td>273</td>
<td>255</td>
<td>264.00</td>
</tr>
<tr>
<td>Height at the shoulder</td>
<td>158</td>
<td>178</td>
<td>162</td>
<td>170.0</td>
</tr>
<tr>
<td>Body weight (kg)</td>
<td>1808</td>
<td>2020</td>
<td>1986.9</td>
<td>2003.45</td>
</tr>
</tbody>
</table>

The measurements recorded in Table 25 for a female and the average of two males were compared. All the measurements of the body parts studied in males were considerably higher than that of the females including the body weight.
The head and neck of the female were found comparatively shorter than that of the average of two males. Hence the size of the head appears smaller than the male comparatively is a sign of sexual dimorphism. Similar observation was recorded by Laurie (1982) in Asiatic rhinos. The body weight of male (2003.45 kg) was heavier than that of the female (1808 Kg).

(ii) **Skin:**

The skin of the *R. unicornis* is extremely thick with peculiar and distinctive heavy folds around the neck, shoulders and the thigh region. These folds are joined to each other by a thin skin which allows free movement. There are three such folds at the neck region, giving the appearance of a collar, the last of which forms the dewlap. The skin fold over the shoulder in *R. unicornis* is not continuous (unlike Javan rhino) all through the back.

The skin of *R. unicornis* is hairless except on its ears and on the switch of the young animals which disappear in old animals. There are numbers of skin projections or tubercles (Fig 26) over the skin folds of the flank, shoulders and hind quarters of *R. unicornis*. The skin although appears to be very thick is not very hard and can be sliced and very easily punctured with a hypodermic needle commonly used for large animals.
The skin folds of various regions of the body may be grouped as (Fig. 26, a, b, c).

<table>
<thead>
<tr>
<th>Region</th>
<th>No. of fold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neck</td>
<td>3</td>
</tr>
<tr>
<td>Shoulder</td>
<td>2 (Right and Left)</td>
</tr>
<tr>
<td>Buttock</td>
<td>2 (Right and Left)</td>
</tr>
</tbody>
</table>

A distinct sexual dimorphism with reference to skin fold in both sexes were observed where the neck folds were more distinct in the adult male than in the female. The skin of the new born animals was found to be light grey in colour with a visible reddish mucous membrane. The body trunk comprising the back and belly are devoid of projections. The skin projections in 10 x 10 cm² area were measured from skin fold of hind quarter as shown in Table 26 (Fig. 26, b).

**TABLE - 26**

* Skin tubercles of hindlegs of *R. unicornia*

<table>
<thead>
<tr>
<th>Area</th>
<th>Size</th>
<th>Number of tubercles</th>
<th>Diameter of the tubercles (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 x 10 cm²</td>
<td>Large</td>
<td>34</td>
<td>3.2</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>32</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>Small</td>
<td>27</td>
<td>1.2</td>
</tr>
</tbody>
</table>
FIG. 26(a-c): NECK FOLD(a), BUTTOCK(b), THIGH OF R. unicornis
### TABLE - 27

Measurement of horns of *R. unicornis*

<table>
<thead>
<tr>
<th>Parameters</th>
<th>* Measurement of horns in c.m.</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
<td>II</td>
<td>III</td>
<td>IV</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Girth at base</td>
<td>53</td>
<td>58</td>
<td>48</td>
<td>62</td>
<td>51</td>
<td>54.4</td>
</tr>
<tr>
<td>Middle part</td>
<td>32</td>
<td>39</td>
<td>31</td>
<td>42</td>
<td>35</td>
<td>35.8</td>
</tr>
<tr>
<td>End part*</td>
<td>21</td>
<td>24</td>
<td>20</td>
<td>27</td>
<td>20</td>
<td>22.4</td>
</tr>
<tr>
<td>Height (Length)</td>
<td>18</td>
<td>32</td>
<td>16</td>
<td>51</td>
<td>17</td>
<td>26.8</td>
</tr>
<tr>
<td>Weight (gm)</td>
<td>400</td>
<td>750</td>
<td>305</td>
<td>1082</td>
<td>375</td>
<td>582.4</td>
</tr>
</tbody>
</table>

**Note:** Measurement of the end part was taken 4 cm below the apex.

* Five numbers of horns were taken for the study which were in the possession of the Assam Forest authorities in Kaziranga National Park. Other information about the specimen could not be given owing to the lack of proper record such as sex, size and age.

Sexual dimorphism in regard to the size of the horn in *R. unicornis* was observed that the female has a smaller sized horn than the male rhinoceros (Fig. 27). A similar observation was recorded in the same species of rhinos by Laurie (1978). The size and shape also varies according to age.
FIG. 27(a-d): HORN OF *R. unicornis*; NEONATE WITHOUT HORN (a); HORN OF SUB-ADULT (b); HORN OF ADULT (c); SKULL SHOWING NO ATTACHMENT OF HORN (d).
Toes:

The R. unicornis are found to be the odd-toed or tridactyl animal having three hoofed toes in each foot, the total being twelve in number each tipped with broad, blunt nails; they are the outer growth of II, III and IV phalanges in origin from inside out, where the middle or the third one is the largest in size (Fig. 28). This largest toe is found to be the most weight bearing, while the remaining two, the IIInd and IVth are of almost equal in size. The toes of the hind legs are slightly bigger than those of the forelegs. The external upper surface of the toes is convex and smooth while the inner lower surface is concave and rough. At the time of birth, the toes are soft in texture. In three adult R. unicornis, the toes the legs measured as follows (Table 27).

<table>
<thead>
<tr>
<th>Specimen</th>
<th>IIInd toes</th>
<th>IIIrd toes</th>
<th>IVth toes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9.0</td>
<td>17.0</td>
<td>8.0</td>
</tr>
<tr>
<td>2</td>
<td>8.0</td>
<td>18.0</td>
<td>9.0</td>
</tr>
<tr>
<td>3</td>
<td>8.5</td>
<td>19.5</td>
<td>6.5</td>
</tr>
<tr>
<td>Mean</td>
<td>8.5</td>
<td>18.1</td>
<td>7.8</td>
</tr>
</tbody>
</table>

TABLE - 27

Measurement of the toes of the forefoot in three adult Rhinoceros unicornis
Hairs:

The R. unicornis is found to be almost completely hairless throughout its life except for some hairs on the eye lids, edges of the ears, a few in the upper and lower lips and switch of the tail. Observation on an aborted foetus in the advanced stage of pregnancy showed existence of the hairs on these parts of the body, indicating appearance of hairs which remains throughout life. The hair were found to be thick and short except the ones at the switch of the tail, which were long and wiry. Some physical characteristics of hair of eartip and tail were measured and recorded and presented in Table 28.

**TABLE - 28**

<table>
<thead>
<tr>
<th>Site of the hairs</th>
<th>No. of observations</th>
<th>Length (cm)</th>
<th>Diameter (mm)</th>
<th>Other Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ear tip</td>
<td>1</td>
<td>2.0</td>
<td>0.011</td>
<td>Brownish black in colour and thin</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>1.5</td>
<td>0.012</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>2.7</td>
<td>0.015</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>3.0</td>
<td>0.013</td>
<td></td>
</tr>
<tr>
<td><strong>Mean = 2.3, mean = 0.012</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tip of tail</td>
<td>1</td>
<td>3.0</td>
<td>0.015</td>
<td>Black in colour thick wiry in nature.</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>3.2</td>
<td>0.014</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>2.5</td>
<td>0.017</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>2.2</td>
<td>0.011</td>
<td></td>
</tr>
<tr>
<td><strong>Mean = 2.72 Mean = 0.014</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Similar to our observation Cave (1969) and Laurie (1979) observed the presence of hairs in the ears and tail of R. unicornis in Nepal, again Cave (1969) Grzimek (1972) and Laurie (1982) also in R. sondaicus.

**DISCUSSION**

Rhinoceros unicornis is physically strong and stout and renowned for its tough physique among the ungulata. Its unique characteristic is due to the presence of the heavy thick folded armed plating like skin with central single nasal horn. The body is almost hairless, although a certain number of hairs in the eye lashes, edges of the ear, tip of the tail and a few in upper and lower lips are present in this species. Completely hairless condition is found (Cave, 1969) in both African species (D. bicornis and C. simum) similar hair and skin pattern with reduced body size is found in Javan species (R. sondaicus) Cave (1969) Grzimek (1972). However, the Sumatran species R. sumatrensis shows an almost completely hairy condition throughout its life (Skaffe 1961, Cave 1969 and Laurie 1982) unlike the African species, the body coat colour of R. unicornis was found to be brownish grey.

The length of the head and neck of the female R. unicornis was comparatively shorter than that of the male and the height at shoulder in female is also comparatively less than the males showing sexual dimorphism. Besides, the male rhino is heavier in body weight than that of the female.
Skin revets as concentrated in thigh and shoulder regions are found only in *R. unicornis* and *R. sondaicus* while in the skin texture of the two African and Sumatran species, these pattern are completely absent.

**PART - II**

ENDOSKELETON OF THE *R. unicornis*:

The whole skeleton of *R. unicornis* comprises the bones of the skull, vertebral column, the hips and limbs. The bones are grey white in colour and heavy in nature. The skeleton is designed in keeping with the size and heavy weight of the body. A detailed study of the different parts of the skeleton are as follows.

The skull:

The skull of the *R. unicornis* as a whole, takes the form of a long four sided pyramid, the base of which is the posterior. The skull comprises the bones of the upper jaws or the maxilla, the cranial bones, occipital bones and the bones of the lower jaw or the mandibles. They are flat type of bones with a smooth outer surface. The head in the male is bigger and longer than that of the female. Pocock (1946) reported the sexual differences in the skulls of Asiatic rhinoceroses (Fig. 27).
**FIG. 27(e):** SKULL OF R. *unicornis.*

**FIG. 29(a-c):** DENTITION STRUCTURE IN LOWER JAW (a), SKULL SHOWING UPPER AND LOWER JAW (b); CANINE TEETH (c) OF R. *unicornis.*
(i) **The nasal bones:**

The nasal bones are convex, narrow, pointed in front and wide behind. The frontal third part of the bones is elevated which bears the horn in the upper region and makes the roofs of the two nasal apparatus (Fig. 27 c).

**Biometry of nasal bones:**

The nasal bones are paired bones (right and left), but in old specimen it is fused very closely and appeared to be single.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Measurement (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) Length of right nasal bone</td>
<td>27</td>
</tr>
<tr>
<td>(ii) Length of left nasal bone</td>
<td>27</td>
</tr>
<tr>
<td>(iii) Girth at base (right)</td>
<td>24</td>
</tr>
<tr>
<td>(iv) Girth at middle (right)</td>
<td>18</td>
</tr>
<tr>
<td>(v) Girth at apex (right)</td>
<td>6</td>
</tr>
<tr>
<td>(vi) Girth at base (left)</td>
<td>24</td>
</tr>
<tr>
<td>(vii) Girth at middle (left)</td>
<td>18</td>
</tr>
<tr>
<td>(viii) Girth at apex (left)</td>
<td>6</td>
</tr>
</tbody>
</table>

(ii) **The maxilla:**

The maxilla is a flat and wide bone, which forms the upper jaw. It is narrow in front and broad behind. The maxilla holds the teeth of the upper jaw along with other cranial bones. Among the cranial bones of *R. unicornis* the frontal bones are the biggest. They are
slightly concave and the external surface is smooth and wide. They form the fore head of the animal.

Biometry of maxilla:

\[
\begin{array}{ll}
\text{Parameters} & \text{Measurement (cm)} \\
(i) & \text{Total length of maxilla} \\
(ii) & \text{Girth at base} \\
(iii) & \text{Girth at middle} \\
(iv) & \text{Girth at apex} \\
\end{array}
\]

(iii) The mandible:

The mandible is a big, flat, triangular bone of the head which forms the lower jaw. The mandible holds the teeth of the lower jaw and also bears the base of the tongue. The condyle situated on the posterior end and was found almost perpendicular to its linear base (Fig. 27).

Biometrics of mandible:

\[
\begin{array}{ll}
\text{Parameters} & \text{Measurement (cm)} \\
(i) & \text{Length of mandible} \\
(ii) & \text{Girth at base} \\
(iii) & \text{Girth at middle} \\
(iv) & \text{Girth at apex} \\
v) & \text{Height of the condyle} \\
\end{array}
\]
(iv) **Occipital bone:**

The occipital bone is a strong irregularly annular shaped bone which forms the posterior part of the skull. It is articulated with the atlas, the first bone of the vertebral column. The joint of these two bones bears a ball and socket like arrangement which facilitates the movement of the head in all directions. (Fig. 27)

**TABLE - 30**

The meristic features of the skull of three adult *R. unicornis* (one female and two males)

<table>
<thead>
<tr>
<th>Skull parts</th>
<th>Measurement in cm.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Female</td>
</tr>
<tr>
<td>Total length of the skull</td>
<td>62</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Girth at the base of the horn</td>
<td>82</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Girth at the base of the skull</td>
<td>134</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Length of maxilla</td>
<td>66</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Girth of maxilla at the base of the horn</td>
<td>42.6</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Girth of the maxilla at its posterior end</td>
<td>62</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Three skull specimens *R. unicornis*, which were killed by poachers, were collected from the Forest Department at Kaziranga National Park for biometrical studies. The sex of the skulls were determined from the size and confirmed with the forest staff. From the colour of bones ossification of different bones of the skull and their weights the approximate age of the animals were determined to be above 30 years old. There were no signs of any abnormality or pathological features observed in the skull specimens.
(v) **The teeth:**

The teeth are present in both the upper and the lower jaws in R. unicornis. The teeth were not found to be equal in size and number in both the jaws. All types of teeth **viz.** incisors, canines, premolars, and molars were found to be present in this species (Fig. 27, e; 29 a,b,d,e).

The incisor teeth were found to be present in both upper and lower jaws and they were broad in adult animals, while the canine teeth were present only in the lower jaw. The canine teeth were well developed, in some animals noticed even from outside. They were found to be pointed as compared to other teeth. The premolar teeth varies from three to four in number while the molars were thee in one side. They were square in size and broad in diameter. The complete detail formula and their arrangement were found as follows:

<table>
<thead>
<tr>
<th>Number of teeth in one half of the jaws</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jaws</td>
</tr>
<tr>
<td>------</td>
</tr>
<tr>
<td>Upper</td>
</tr>
<tr>
<td>Lower</td>
</tr>
</tbody>
</table>

The upper jaw contains total of 14-16 teeth and the lower jaw contains total of 16-18 teeth. Altogether 30-34 teeth were present in both the jaws. From the above findings of dentation in the present studies the *Rhinoceros unicornis* may be classified under hypsodont, protocone.
DENTITION STRUCTURE IN UPPER JAW OF R. UNICORNIS.

Fig. 29. d
DENTITION STRUCTURE IN LOWER JAW OF R. UNICORNIS.

Fig. 29. e
The dentition of different species of rhinoceros could be compared as follows (Laurie, 1982).

<table>
<thead>
<tr>
<th>Species</th>
<th>Dentition Type</th>
<th>Species</th>
<th>Dentition Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>D. sumatrensis</td>
<td>Brachyodont</td>
<td>R. sondaicus</td>
<td>Brachyodont</td>
</tr>
<tr>
<td></td>
<td>protocone</td>
<td>R. unicornis</td>
<td>Hypsodont,</td>
</tr>
<tr>
<td></td>
<td>fold</td>
<td>D. dicornis</td>
<td>Brachyodont</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C. simum</td>
<td>Hypsodont</td>
</tr>
</tbody>
</table>

**Hyoid apparatus:**

The hyoid bones holds the tongue with its posterior end to the mouth cavity on its floor. It bears two distinct halves, right and left. The ventral surface is flattened and slightly rough for muscular attachment. However, in the present study, conditioned hyoid bones could not be obtained owing to the damage caused to the collected specimen.

**The vertebral column:**

The vertebral column is found to be the fundamental bony structure in *R. unicornis*. The vertebral column comprises the following vertebrae with their respective number in different regions (Table 31).

**TABLE - 31**

<table>
<thead>
<tr>
<th>Number and location of different vertebrae</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vertebrae</strong></td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>Cervical</td>
</tr>
<tr>
<td>Thoracic</td>
</tr>
<tr>
<td>Lumber</td>
</tr>
<tr>
<td>Sacral</td>
</tr>
<tr>
<td>Coccygeal</td>
</tr>
<tr>
<td><strong>Total</strong></td>
</tr>
</tbody>
</table>
The bones of the vertebral column specimen No. 2 (as shown in Table 31) only were selected by studying the different meristimatic characteristics of vertebral column.

The cervical vertebrae:

(i) The first cervical vertebra is also known as the atlas, which is an irregular ring like flat bone having no distinct body and spinous process. In *R. unicornis* the atlas contains two flat elongated wings. The Atlas articulates with occipital bone in front and the axis behind (Fig. 30). It measures as follows:

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Measurement (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of the Atlas</td>
<td>7.5</td>
</tr>
<tr>
<td>Breadth</td>
<td>38.0</td>
</tr>
<tr>
<td>Thickness</td>
<td>13.7</td>
</tr>
<tr>
<td>Length of the wing</td>
<td>17.0</td>
</tr>
<tr>
<td>Breadth of the wing</td>
<td>4.5</td>
</tr>
</tbody>
</table>

(ii) The 2nd cervical vertebra or the Axis is a long irregular and more or less cylindrical bone in *R. unicornis*. The body of the bone is stunted and the spinous process is broad. It articulates with the Atlas in front and 3rd cervical vertebra behind (Fig. 31).

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Measurement (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of Axis</td>
<td>15</td>
</tr>
<tr>
<td>Girth</td>
<td>38</td>
</tr>
<tr>
<td>Thickness</td>
<td>14</td>
</tr>
</tbody>
</table>
AXIS OF RHINOCEROS UNICORNIS
(ANTERIOR VIEW)

LATERAL VIEW OF AXIS OF RHINOCEROS UNICORNIS
(iii) 3rd to 6th cervical vertebrae were found to be almost similar in structure with that of 2nd cervical vertebrae.

(iv) The 7th cervical vertebra found to have a distinct body and spinous processes. It is short and flat in comparison with other cervical vertebrae. It bears a well developed spine. The following measurements were recorded on the 7th cervical vertebra of an adult *R. unicornis* (Fig. 32)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Measurement (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of the vertebra</td>
<td>9.0</td>
</tr>
<tr>
<td>Breadth</td>
<td>8.5</td>
</tr>
<tr>
<td>Thickness</td>
<td>10.0</td>
</tr>
<tr>
<td>Length of spinous process</td>
<td>18.0</td>
</tr>
</tbody>
</table>

The thoracic vertebrae:

The thoracic vertebrae were found to be eighteen in number. They are characterised by the presence of a long spinous process on the dorso medial surface of the body of the bone and two facets on either side for lodging the head and tubercles of the ribs. The thoracic bones in this species were found to be rectangular in shape (Fig. 33). The first thoracic vertebra has the following biometry:

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Measurement (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of the 1st thoracic vertebra</td>
<td>8.5</td>
</tr>
<tr>
<td>Breadth</td>
<td>12.5</td>
</tr>
<tr>
<td>Thickness</td>
<td>11.0</td>
</tr>
<tr>
<td>Length of the spinous process</td>
<td>23.0</td>
</tr>
</tbody>
</table>
SEVENTH CERVICAL VERTEBRA OF R. UNICORNIS ANTERIOR VIEW

SEVENTH CERVICAL VERTEBRA OF R. UNICORNIS. (POSTERIOR VIEW)
FIRST THORACIC VERTEBRA OF **R. UNICORNIS** (ANTERIOR VIEW)

FIRST THORACIC VERTEBRA OF **R. UNICORNIS** POSTERIOR VIEW
The lumber vertebrae:

The lumber vertebrae comprise the bones of the loin and they are six in number. The body of the lumber vertebrae in this species is elliptical and contains small spines. The transverse process of the bones of the lumber region are long (Fig. 34). The measurements of a lumber vertebra are as follows:

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Measurements (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of the 1st lumber vertebra</td>
<td>7.0</td>
</tr>
<tr>
<td>Breadth</td>
<td>8.5</td>
</tr>
<tr>
<td>Thickness</td>
<td>6.5</td>
</tr>
<tr>
<td>Length of spines</td>
<td>15.0</td>
</tr>
<tr>
<td>Length of the transverse process</td>
<td>21.0</td>
</tr>
</tbody>
</table>

Sacral vertebrae:

Five to six numbers of sacral vertebrae are fused together in R. unicornis and form 'the sacrum' which might be described as a single bone. The bone as a whole takes the shape of a rectangle roughly of which the anterior end is broad. The anterior end bears two well developed triangular wings, which bear facets to articulate with the last lumber vertebra. The dorsal surface is rough and contains well developed spines. In R. unicornis the 1st spine of the sacrum is the longest, the 2nd is the thinnest, the 4th is the broadest and the last one is the smallest. The 1st and the last spines are free but the other spines are fused together. The ventral surface of the sacrum is smooth and concave. (Fig. 35a,b).
FIRST LUMBER VERTEBRA OF *R. UNICORNIS* (ANTERIOR VIEW)
THE SACRUM OF RHINOCEROS UNICORNIS

(DORSAL LATERAL VIEW)

FIG. 35(a,b): SACRUM OF R. unicornis, DORSOLATERAL (a); VENTRAL (b) VIEWS.
### Parameters

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Measurement (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of the sacrum</td>
<td>26.0</td>
</tr>
<tr>
<td>Anterior end</td>
<td>24.0</td>
</tr>
<tr>
<td>Breadth</td>
<td></td>
</tr>
<tr>
<td>Middle</td>
<td>15.0</td>
</tr>
<tr>
<td>Posterior end</td>
<td>10.0</td>
</tr>
<tr>
<td>1st spine</td>
<td>14.5</td>
</tr>
<tr>
<td>Length</td>
<td></td>
</tr>
<tr>
<td>Last spine</td>
<td>5.5</td>
</tr>
<tr>
<td>Length of the body of 1st vertebra of sacrum</td>
<td>5.5</td>
</tr>
<tr>
<td>Breadth of the body of 1st vertebra of sacrum</td>
<td>7.5</td>
</tr>
<tr>
<td>Thickness of the body of 1st vertebra of sacrum</td>
<td>4.0</td>
</tr>
<tr>
<td>Length of the body of last vertebra of sacrum</td>
<td>4.5</td>
</tr>
<tr>
<td>Breadth of the body of last vertebra of sacrum</td>
<td>3.5</td>
</tr>
<tr>
<td>Thickness of the body of last vertebra of sacrum</td>
<td>2.5</td>
</tr>
</tbody>
</table>

**The coccygeal vertebrae:**

The coccygeal vertebrae constitute the bones of the tail and the total number of the bones in the tail are found to be 17, in *R. unicornis* (Table 32). In old animals the 1st coccygeal vertebra is often fused with the sacrum. The first five of these vertebrae have a triangular shape at the beginning, then they take a cylindrical shape, gradually decreasing in size. The biometry of the 1st coccygeal vertebra is as follows (Fig 36).

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Measurement (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of the body of the vertebra</td>
<td>3.5</td>
</tr>
<tr>
<td>Breadth</td>
<td>3.7</td>
</tr>
<tr>
<td>Thickness</td>
<td>2.8</td>
</tr>
<tr>
<td>Length of the spines</td>
<td>3.2</td>
</tr>
</tbody>
</table>
TERIOR VIEW AND POSTERIOR VIEW OF R. UNICORNIS.

THE LUMBAR AND LAST COCCYGEAL VERTEBRAE OF R. UNICORNIS.
**TABLE – 32**

**Biometrics of the series of coccygeal vertebrae of R. unicornis**

<table>
<thead>
<tr>
<th>No. of vertebrae</th>
<th>Parameters</th>
<th>Length of the body (cm)</th>
<th>Breadth (cm)</th>
<th>Thickness (cm)</th>
<th>Length of spine (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td></td>
<td>3.5</td>
<td>3.7</td>
<td>2.8</td>
<td>3.2</td>
</tr>
<tr>
<td>2.</td>
<td></td>
<td>3.5</td>
<td>3.6</td>
<td>2.8</td>
<td>3.1</td>
</tr>
<tr>
<td>3.</td>
<td></td>
<td>3.4</td>
<td>3.5</td>
<td>2.7</td>
<td>2.9</td>
</tr>
<tr>
<td>4.</td>
<td></td>
<td>3.4</td>
<td>3.5</td>
<td>2.6</td>
<td>2.5</td>
</tr>
<tr>
<td>5.</td>
<td></td>
<td>3.2</td>
<td>3.4</td>
<td>2.5</td>
<td>2.3</td>
</tr>
<tr>
<td>6.</td>
<td></td>
<td>3.1</td>
<td>3.2</td>
<td>2.3</td>
<td>2.2</td>
</tr>
<tr>
<td>7.</td>
<td></td>
<td>3.1</td>
<td>3.2</td>
<td>2.3</td>
<td>2.1</td>
</tr>
<tr>
<td>8.</td>
<td></td>
<td>2.9</td>
<td>3.1</td>
<td>2.3</td>
<td>2.0</td>
</tr>
<tr>
<td>9.</td>
<td></td>
<td>2.9</td>
<td>3.1</td>
<td>2.2</td>
<td>2.0</td>
</tr>
<tr>
<td>10.</td>
<td></td>
<td>2.8</td>
<td>3.0</td>
<td>2.1</td>
<td>1.9</td>
</tr>
<tr>
<td>11.</td>
<td></td>
<td>2.7</td>
<td>2.7</td>
<td>2.1</td>
<td>1.3</td>
</tr>
<tr>
<td>12.</td>
<td></td>
<td>2.7</td>
<td>2.5</td>
<td>2.0</td>
<td>1.0</td>
</tr>
<tr>
<td>13.</td>
<td></td>
<td>2.6</td>
<td>2.2</td>
<td>2.0</td>
<td>0.8</td>
</tr>
<tr>
<td>14.</td>
<td></td>
<td>2.6</td>
<td>2.0</td>
<td>2.0</td>
<td>0.5</td>
</tr>
<tr>
<td>15.</td>
<td></td>
<td>2.6</td>
<td>1.8</td>
<td>1.9</td>
<td>0.2</td>
</tr>
<tr>
<td>16.</td>
<td></td>
<td>2.5</td>
<td>1.6</td>
<td>1.8</td>
<td>Trace</td>
</tr>
<tr>
<td>17.</td>
<td></td>
<td>3.0</td>
<td>1.5</td>
<td>1.6</td>
<td>Nil</td>
</tr>
</tbody>
</table>

**Ribs:**

The ribs are elongated, flat and paired bones which formed the lateral wall of the thoracic cavity. There are eighteen pair of ribs in R. unicornis. A typical rib of the animal composed of two surfaces, two borders, and two extremeties. The vertebral end contains a well
developed head, neck and tuberosity. The sternal extremeties are flattened and enlarged (Fig. 37).

The physical structure of the ribs recorded in *R. unicornis* was found to be same in all the 18 pairs. The following distinguishing characteristics were found in the first, tenth and the eighteenth or last rib in *R. unicornis*.

**The first rib:** In the present study the first rib was found to be short and wide in structure bearing minimum curvature in comparison to other ribs. It bears a large tubercle, a big head and a short neck. The biometrics of the first rib of an adult *R. unicornis* revealed the following characteristics.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Measurements (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total length of the rib</td>
<td>38</td>
</tr>
<tr>
<td>Maximum width of the rib</td>
<td>9</td>
</tr>
<tr>
<td>Minimum width of the rib</td>
<td>4</td>
</tr>
<tr>
<td>Diameter of the head</td>
<td>12</td>
</tr>
</tbody>
</table>

**The tenth rib:** The tenth rib of the *R. unicornis* was longest in size, thereafter the ribs reduced in length towards the last rib. It was found to be curved and contained distinct tubercle, head and neck.* The following measurement were recorded:

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Measurements (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total length of the tenth rib</td>
<td>92.0</td>
</tr>
<tr>
<td>Maximum width of the tenth rib</td>
<td>2.0</td>
</tr>
<tr>
<td>Minimum width of the tenth rib</td>
<td>1.8</td>
</tr>
<tr>
<td>Diameter of the head of the tenth rib</td>
<td>7.5</td>
</tr>
</tbody>
</table>
FIG. 43: PAIR OF RIBS OF RHINOCEROS UNICORNIS
(ANTERIOR VIEW)
The last rib: The last rib of the *R. unicornis* was slender, rounded and curved bone. It was the shortest of all the eighteen pairs of bones. The last rib of an adult *R. unicornis* showed the following measurements:

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Measurement (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total length of the last rib</td>
<td>35.00</td>
</tr>
<tr>
<td>Maximum width of the last rib</td>
<td>2.2</td>
</tr>
<tr>
<td>Minimum width of the last rib</td>
<td>1.8</td>
</tr>
<tr>
<td>Diameter of the head</td>
<td>2.9</td>
</tr>
</tbody>
</table>

Sternum:

The sternum or the thoracic bones consists of 6-8 bony segments which form the ventral wall. The anterior extremity is known as the presternum and is a hardened structure. The posterior extremity or the metasternum bears a blunt end which is known as the xiphoid cartilage. The total length of the sternum was recorded as follows:

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Measurement (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total length of sternum</td>
<td>65.0</td>
</tr>
<tr>
<td>Length of end of Xiphoid cartilage</td>
<td>28.0</td>
</tr>
</tbody>
</table>

Owing to the non-availability of good specimens sternum, detailed morphometrics study could not be made and recorded in the present study (Fig. 38).

The bones of the fore-limbs:

The thoracic limbs consists of many long stout bones along with their short and stout partners as they are the weight bearing bones.
They might be grouped as the scapula and their adjacent bones or the shoulder girdle, humerus, the carpal and meta carpal bones, and the phalanges. The humerus and the meta carpal bones give the main length of the fore legs in the *R. unicornis*.

The scapula (Fig. 39) is a flat and wide triangular bone which bears the two surfaces, two borders and two ends. The lateral surface is rough and divided by the presence of a longitudinal scapular spine, while the costal surface is smooth in this species. The measurements of the scapula was recorded as follows:

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Measurements (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of the scapula</td>
<td>48.0</td>
</tr>
<tr>
<td>Width at the broader end</td>
<td>53.5</td>
</tr>
<tr>
<td>Diameter of the neck</td>
<td>30.0</td>
</tr>
<tr>
<td>Height of the tuber spine</td>
<td>10.5</td>
</tr>
</tbody>
</table>

The humerus: Humerus is short and stout and articulates with scapula above and redius and ulna below. The proximal end of the humerus contains the head, neck and two tuberosities to form the shoulder joint with the scapula, where the distal extremity possess two condyles to join with the radium and ulna. The shaft or the body of the humers in *R. unicornis* is cylindrical and takes a twisted appearance (Fig. 40a). The measurements of the humerus was recorded as follows:
**FIG. 39: SCAPULA OF RHINOCEROS UNICORNIS**
HUMERUS OF RHINOCEROS UNICORNIS (Fig. 40, a)

RADIUS AND ULNA OF RHINOCEROS UNICORNIS (40, b)
Parameters Measurements (cm)
Length of the humerus 54
Circumference at proximal end 43
Circumference at mid shaft 26
Circumference at distal shaft 30

The radius and ulna: The radius and ulna are loosely fused in the adult and constitute the major portion of the length of the fore limb in the lower extremity. Both the bones are long in R. unicornis, but the radius is short and stout, while the ulna is longer of the two and slightly curved in nature. The proximal end or the head of the radius is flat and wide, which articulates with humerus, while the distal extremity is compressed and articulates with the carpal bones. In R. unicornis, the ulna is well developed and almost of the same size throughout its length (Fig. 40b). The biometrics of the radius and ulna recorded are as follows:

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Radius (cm)</th>
<th>Ulna (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total length</td>
<td>39.0</td>
<td>45.0</td>
</tr>
<tr>
<td>Circumference</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proximal</td>
<td>38.0</td>
<td>29.0</td>
</tr>
<tr>
<td>Distal</td>
<td>34.0</td>
<td>26.2</td>
</tr>
</tbody>
</table>

Carpal and metacarpal bones: The carpal bones are irregularly square in size which are placed in three rows, followed by the metacarpal bones. The metacarpal bones are three in number and retain the characteristics of the long bones, having a short and rounded body and two extremities (Fig. 41 a,b).
CARPAL BONES

RADIAL CARPALS

METACARPAL BONES

NAILS

ULNAR CARPALS - METACARPAL BONES

NAILS

CARPAL BONES

ULNAR CARPALS

METACARPAL BONES

NAIL-CORE

BONES OF THE THORASIC LIMBS OF R. UNICORNIS (DORSAL VIEW)

Fig. 41.a

BONES OF THE THORASIC LIMB OF R. UNICORNIS (VENTRAL VIEW)

Fig. 41.b
Biometrics of Metacarpal bones

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Medial (cm)</th>
<th>Central (cm)</th>
<th>Lateral (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>7</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>Circumference</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mid shaft</td>
<td>6</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>Proximal</td>
<td>7</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>Distal</td>
<td>6</td>
<td>7.5</td>
<td>6</td>
</tr>
</tbody>
</table>

The Bones of the digits of the fore legs:

In *R. unicornis* three digits are present, one in each toe which again contains three phalanges in each digit along with sesamoid bones. The bones of the phalanges are irregular, long bones while the sesamoids are rounded. The third phalanx tapers towards its distal end which contains the nail like (Fig. 41, a,b) hoof.

The bones of the pelvic limbs:

The bones of the pelvic limbs in *R. unicornis* comprises of the pelvic girdle, the femur, tibia-fibula, patela, tursus, meta-tursus and the phalanges.

The pelvic girdle: The pelvic girdle consists of two oscoxae or heap bones, which are fused together ventrally at the pelvic symphysis and dorsally with the sacrum of the vertebral column. Oscoxae are the
largest of all the flat bones of the *R. unicornis*. Each of the two oscoxae on the right and left are fused with each other ventrally to form the floor of the pelvic girdle which comprises of three flat bones on each side such as (Fig. 42):

(i) Ilium,
(ii) Ischium, and
(iii) Pubis.

These three bones join in a deep cavity to accommodate the head of the femur known as the acetabulum. The ilium is the largest of the three pelvic bones and forms the lateral wall (side) of the pelvic cavity. In *R. unicornis* it is irregularly triangular in shape and possesses two surfaces and three borders. The dorsal end of the ilium is very wide and is called the wing. The surface is smooth and the borders are thin in nature. Ischium is the second largest of the three bones and forms the posterior part of the floor of the bony pelvis. The ischium is a flat and irregularly rectangular bone in shape. The pubis is the smallest of the three bones and forms the anterior part of the floor on the pelvis. The biometrics of the bony pelvis of the *R. unicornis* recorded to be as follows:

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Ilium (cm)</th>
<th>Ischium(cm)</th>
<th>Pubis (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>42.3</td>
<td>17.0</td>
<td>16.2</td>
</tr>
<tr>
<td>Anterior end</td>
<td>110.3</td>
<td>46.0</td>
<td>34.9</td>
</tr>
<tr>
<td>Girth</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mid saft</td>
<td>24.4</td>
<td>15.6</td>
<td>12.4</td>
</tr>
<tr>
<td>Near acetabulum</td>
<td>41.4</td>
<td>27.0</td>
<td>29.1</td>
</tr>
</tbody>
</table>
PELVIC BONES OF RHINOCEROS UNICORNIS
(FRONT VIEW)

PELVIC BONES OF RHINOCEROS UNICORNIS
(LATERAL VIEW)

Fig. 42
Dimension of the pelvic cavity:

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Measurement (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sacropubic diameter (Perpendicular)</td>
<td>37</td>
</tr>
<tr>
<td>Right ilium to left ilium (Base)</td>
<td>31</td>
</tr>
</tbody>
</table>

The femur: The femur forms the bone of the thigh and possesses the true characteristics of the long bone in R. unicornis. It consists of proximally a large round head to fit with the acetabulum of the pelvic girdle. The shaft of the femur is smooth, long and cylindrical. The distal end is narrower and attached with the patella (Fig. 43a). The following biometrics were recorded:

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Measurement (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>62.1</td>
</tr>
<tr>
<td>Circumference at proximal end</td>
<td>36.3</td>
</tr>
<tr>
<td>Circumference at shaft</td>
<td>24.4</td>
</tr>
<tr>
<td>Circumference at distal end</td>
<td>30.0</td>
</tr>
</tbody>
</table>

Tibia and fibula: The tibia forms the lower part of the hind leg which is bigger than the fibula. The fibula is slender in nature. The tibia is long and rounded in structure. The proximal end of tibia is large (Fig. 43b). The following biometrics of tibia are recorded.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Measurements (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of the tibia</td>
<td>40.1</td>
</tr>
<tr>
<td>Circumference at neck</td>
<td>26.5</td>
</tr>
<tr>
<td>Circumference at shaft</td>
<td>21.4</td>
</tr>
<tr>
<td>Circumference at distal end</td>
<td>27.2</td>
</tr>
</tbody>
</table>
Tarsal and metatarsal bones:

The tarsal and metatarsal bones (Fig. 44) are placed in three rows. The tarsal bones are square to round in shape while the metatarsal bones are longer in comparison to tarsal. The metatarsal bones of the R. unicornis reveals the following biometrics.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Medial (cm)</th>
<th>Central (cm)</th>
<th>Lateral (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>6</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>Circumference</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(i) Mid shaft</td>
<td>5</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>(ii) Proximal end</td>
<td>6</td>
<td>7</td>
<td>4.5</td>
</tr>
<tr>
<td>(iii) Distal end</td>
<td>5</td>
<td>6.5</td>
<td>5.5</td>
</tr>
</tbody>
</table>

The bones of the digits of the hind legs of the R. unicornis:

The R. unicornis has three phalanges in each digit of the hind leg. The phalanges are longer and rounded in appearance in which the sesamoids bones are rounded and irregular in shape. The third phalanx is somewhat pointed and possesses nail like hoofs (Fig. 44).

DISCUSSION

The endoskeleton of R. unicornis is relatively strong, stout and well built. From the studies of different parts of the endoskeleton of this rare species, certain unique or specialized features occupy
TARSAL BONES

TIBIAL TARSAL

META TARSAL BONE

FIG. 44a, BONES OF THE HIND LIMBS OF R. unicornis (DORSAL VIEW)

FIBULAR TARSAL

FIRST PHALANX

SECOND PHALANX

THIRD PHALANX

NAILS

TARSAL BONES

FIBULAR TARSAL

1st PHALANX

2nd PHALANX

3rd PHALANX

META TARSAL

NAIL CORE

FIG. 44b, BONES OF THE HIND LIMBS OF R. unicornis (VENTRAL VIEW)
a prominent position. These unique features are quite distinct from other species of rhinoceros which are discussed in detail. As a whole the endoskeleton of *R. unicornis* shows a greater similarity with that of the horse.

The nasal bones are complete and long, which bear the horn. The nasal bone in the horse is not exactly complete like the rhinoceros whereas in other ungulata it is incomplete. The single horn, borne by the nasal bones do not show any horn core which is one of the unique characteristics of other ungulata. This proves that the horn is the modification of skin but not that of the bone. The maxilla is heavy, bearing the upper two rows of teeth, as found in the horse. The teeth of the upper jaw are bigger than those in the lower jaw. It bears 14 to 16 teeth, where there is the absence of canine teeth. Premolar teeth vary from 3 to 4 in number on each both upper and lower jaws. Mandible is longer than the maxilla. Canine teeth are present and the total number of teeth in the lower jaw is 16 to 18, showing altogether 30 to 34 in total. Whereas in horse, the total number of teeth are 40-42. Canine teeth are found in both the jaws, although it takes 3 to 4 years to develop or grow in calf (Sisson, 1953). In the rhinoceros the canine teeth are found in the new born calf. The new born calf shows the presence of molars and canine, but incisors appear after 3-4 months. As a whole the head is heavy and triangular in structure.

The vertebral column, consisting of the vertebral formula as shown, has similarities with the horse.
R. unicornis = C_T_{18}L_5S_5C_{16-18}

Horse
(Equus caballus) = C_T_{18}L_6S_5C_{15-21} (Sisson, 1953)

It follows the constant cervical vertebral number like other mammals. Atlas is broad and flat and both wings are well developed. Axis is longest of all vertebrae. Sacrum is generally a fused vertebrae consisting of 5 bones with long spinous processes. In many cases, the first coccygeal vertebrae are fused to increase the total number of bones of the sacrum to six. In the horse and other ungulata the sacrum mostly consist of 5 vertebrae. Bones of coccygeal vertebrae are short and stout. Upto the seventh coccygeal vertebrae, but beyond the seventh the bones decrease both in form and size.

Ribs are paired bones protecting the thoracic vital organs. They are flat bones and stouter than those of the horse. Ribs increase in size upto the 10th like other ungulata and gradually diminished in size from 11th onward to the last ribs which become rounded in shape in the last 2 to 3 ribs. In the horse the ribs are lighter and curved, and are of an equal number like R. unicornis. Scapula is a triangular and flat bone bearing a high tubercle on its lateral surface in order to hold the heavy and strong muscles of the shoulder. It is known as the spine of the scapula. In the horse it is narrow and longer than that of the rhino. The pelvic girdle is the biggest of all flat bones
and bears two symmetrical halves. The ilium bears the modified wings or allale to hold the thigh muscles. Structurally it is similar to the horse. Humerus in rhinoceros is a long bone bearing distinct heads and shaft or body and is heavy in structure. Femur is the longest bone in the body of R. unicornis bearing a distinct rounded head which joins with the pelvic girdle. Radius and ulna are completely separate bones. Ulna is longer and is placed over the radius. In the horse radio-ulna is a fused bone showing a single structure from anterior to posterior. The ulna is fused with the radius at the extreme anterior end.

Tibia of R. unicornis is longer and stouter than that of the horse, where in the latter it is a small bone which ends in the mid length of the fibula. Metacarpal bones in R. unicornis are 3 in number comparing to 2nd, 3rd and 4th, whereas in the horse there are only single metacarpal bones. It may be mentioned that the horse in ancient times had three toes with 3 metacarpal bones (McKenna, 1975). During the process of evolution it lost the other 2 toes and hence the horse of modern times contains only one toe. Rhinoceros and horse which are grouped under perissodactyla maintained the same number of toes in ancient time (Oligocene), but the horse, later started losing the other toes, whereas there is no such evolution in the Rhinoceros group. At present all the species of rhino possess 3 toes with 3 metacarpal bones.

Phalanges of R. unicornis are not separate and visible externally but they bear an independent origin from the 3 separate metacarpal
bones or counterparts in the hind legs which are known as the meta-
tarsals with 3 segments - 1st, 2nd and 3rd phalanges. Nails adhere
to the last phalanges which can be seen externally. The mid phalanx
is strong and largest, bearing the entire body weight of the animal.
The horse which has a single metacarpal bone bears 3 segments of
phalanges with a single hoof in each leg.

As a whole the endoskeleton of R. unicornis is seen to be heavy,
well built and strong in respect to the size of the animal.

PART - III

THE ANATOMY OF THE DIGESTIVE SYSTEM OF R. unicornis

The digestive system:

The digestive system of R. unicornis is meant for reception
digestion, assimilation and excretion of food for the growth and
maintenance of the body. It comprises of the alimentary canal, digestive
glands and other accessory organs. The alimentary canal comprises of
the following parts:— (i) Mouth, (ii) Pharynx, (iii) Oesophagus, (iv)
Stomach, (v) Small intestine, (vi) Large intestine and (vii) Anal
aperture. (F, p. 45)

Digestive glands are —

i) Liver

ii) Spleen, and

iii) Pancreas
The mouth is the starting point of the alimentary canal, which is closed and guarded with the lips in front (Fig. 46 a, ). In R. unicornis the lips are movable and active and are used as prehensile organs. The upper lip in this species is pointed and ends in a finger like projection. The mouth cavity is guarded by thirty to thirty four teeth and the two mandibles in front and the sides and by root of the tongue and epiglottis at the posterior. The roof and the base are guarded by the palate and body of the mandible and mylohyoid muscles. (Fig. 46 b, ).

The tongue in R. unicornis is a prehensible muscular organ with a spatulated end. It is situated on the floor of the mouth and between the two mandibles. The posterior or the root of the tongue is fixed while the anterior end is free. The dorsal surface of the tongue of R. unicornis is rough while the ventral surface is smooth. The following are the biometrics of a tongue of an adult R. unicornis is rough while the ventral surface is smooth. The following are the biometrics of a tongue of an adult R. unicornis. (Fig. 46c).

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Measurements (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total length</td>
<td>34.0</td>
</tr>
<tr>
<td>Length of free part</td>
<td>22.0</td>
</tr>
<tr>
<td>Breadth at base</td>
<td>11.0</td>
</tr>
<tr>
<td>Breadth at middle</td>
<td>7.0</td>
</tr>
<tr>
<td>Breadth at tip</td>
<td>9.0</td>
</tr>
<tr>
<td>Thickness</td>
<td>2.5</td>
</tr>
</tbody>
</table>
FIG. 45: ALIMENTARY CANAL ALONG WITH DIGESTIVE GLANDS OF \textit{R. unicornis}.

FIG. 46(a, b, c): LIPS (a) AND UPPER PALATE (b, c) OF \textit{R. unicornis}.
The whole mouth cavity is cylindrical and elongated in *R. unicornis* and it connects with the pharynx in the posterior.

The pharynx is a funnel shaped musculo-serous sac which connects with the oesophagus in a posterior position.

The oesophagus is a large hollows musculo-membranous tube which is 1.7 to 2 meters long in full grown adult animal. The oesophagus connects with the stomach.

The stomach is the largest part of the alimentary tract. It looks like a curved sac of which the ventral part is convex. The greater curvature is extensive which is 0.8 to 1.2 meters in length, in an adult while the lesser curvature is short (Fig. 47). The stomach is situated on the left side to the median plan. It is a simple bag like structure. The stomach in *R. unicornis* like other non ruminants (perissodactyla) is simple, undivided and comparatively smaller than the ruminants. *R. unicornis*, being a herbivorous animal, requires the assistance of micro-organisms in its digestive tract to break down indigestible plant cellulose into digestible starch and sugars. The stomach is connected with the small intestine.

The small intestine is the longest and most tortuous in its course. It begins with the pylorus and terminates at the lesser curvature of the caecum. The small intestine comprises of the visceral part of the abdomen and it is 22 to 24 meter long in *R. unicornis*. 
FIG. 47(a,b) : STOMACH, INTACT(a); SECTION SHOWING INTERNAL STRUCTURE (b) OF R. unicornis.

FIG. 48(a,b) : LIVER; WITH OTHER GLANDS (a) AND FREE LIVER (b) OF R. unicornis.
It connects with the large intestine in the lower most part of the alimentary canal which begins with the caecum and ends with the rectum. It is also musculo-membranous structure and wide in diameter throughout its course.

The caecum is a part of the large intestine and is very voluminous which looks like a big comma.

The colon is the anterior part of the large intestine and is sacculated and large.

*R. unicornis* is a non-ruminant herbivore, its intestine and colon are large and long. The caecum in which bacterial digestion of cellulose takes place is the largest part of the entire length of the digestive tract. In *R. unicornis* the digestive tract possess many blind pockets, where the food substances are macerated and fermented. There is no gall bladder in *R. unicornis*, this being one of the peculiarities of this species. Unlike other simple stomach non ruminants, the upper half of the stomach of *R. unicornis* has a mucous membrane and the lower half has some villi like projections as ruminants. These two halves of the stomach are separated by a fold. The final digestion of food takes place at the lower half of the stomach.

The anatomical structures of the stomach of the *R. unicornis* reveals that although *R. unicornis* is apparently a simple stomach non-ruminant, yet in the true sense it is neither a true simple nor a true complex stomach herbivore and could be placed between both types.
The length of different parts of the alimentary canal recorded the visera of 2 adult *R. unicornis*.

<table>
<thead>
<tr>
<th>Parts of alimentary canal</th>
<th>Measurement M in 1 and 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mouth and pharynx</td>
<td>0.9 - 1.0</td>
</tr>
<tr>
<td>Oesophagus</td>
<td>1.7 - 2.0</td>
</tr>
<tr>
<td>Stomach</td>
<td>0.8 - 1.2</td>
</tr>
<tr>
<td>Small intestine</td>
<td>22.0 - 24.0</td>
</tr>
<tr>
<td>Large intestine</td>
<td>8.0 - 9.0</td>
</tr>
<tr>
<td>Total length</td>
<td>33.4 - 37.2</td>
</tr>
</tbody>
</table>

**Rectum:**

The rectum is the lowermost or terminal part of the excretory system which extends from the pelvic inlet to the anal apperture. It is a large voluminous tube which gives a flask-shaped dilatation known as ampulla recti. It ends in the anal apperture which is guarded by rectal muscles.

**The liver:**

The liver is found to be the largest gland in the body of the *R. unicornis*. It is situated in the abdominal cavity under the diaphragm. The liver takes the position from median plan to right side in the body cavity. It is lobulated and is reddish brown in colour. There are three distinct lobes viz. the right, middle and the left lobes. Owing to its soft consistency the liver of the
rhinoceros possesses some impressions on its surface and is quite distinct from the adjacent organs. The following are the biometrics of the liver of an adult *R. unicornis* (Fig. 48).

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Measurement (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Girth at middle</td>
<td>102.0</td>
</tr>
<tr>
<td>Length</td>
<td>83.0</td>
</tr>
<tr>
<td>Breadth</td>
<td>24.0</td>
</tr>
<tr>
<td>Weight</td>
<td>12.3 Kg</td>
</tr>
<tr>
<td>Number of lobes</td>
<td>3 (three)</td>
</tr>
</tbody>
</table>

**Gall bladder:**

In all three specimens carefully dissected, there was a noticeable absence of the gall bladder. The matter regarding this point is still under scrutiny. A similar example of the absence of the gall bladder is to be found in the horse. Hence, in *R. unicornis*, which is close to the equidae family, the absence of the gall bladder might have some verifiable justification.

**Pancreas:**

Pancreas is situated transversely dorsal to the wall of the abdomen. It is a long, elongated glandular mass, flattened dorsoventrally. It extends transversely from the duodenum to the spleen lying in the transit partially dorso caudal end of the stomach.
FIG. 49(a, b) : SPLEEN; MEDIAN (a) AND LATERAL (b) VIEW OF R. unicornis.

FIG. 50(a, b) : HEART; LATERAL VIEW (a); PULMONARY SURFACE (b) OF R. unicornis.
The spleen:

In *R. unicornis* the spleen is an elongated purple black gland situated in the abdominal cavity in the vicinity of the stomach. It is a soft and pliable organ, but not friable like the liver. The spleen is curved and thin edged in *R. unicornis*. It possesses two surfaces, two borders, and two extremities. The biometrics of the spleen of an adult *R. unicornis* are recorded as follows (Fig. 49):

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Measurements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total length</td>
<td>78.0 cm</td>
</tr>
<tr>
<td>Width</td>
<td>37.0 cm</td>
</tr>
<tr>
<td>Thickness</td>
<td>12.0 cm</td>
</tr>
<tr>
<td>Weight</td>
<td>1.8 kg</td>
</tr>
</tbody>
</table>

**DISCUSSION**

As the species *R. unicornis* is a herbivorous animal the oral cavity with its dental structure is suitably adjusted for its herbivorous consumption. Further, because the species feeds upon tall and coarse grass, the use of the prehensile lips is a unique characteristic in relation to its food and feeding habits. Both the upper and the lower lips are used for grasping and twisting the tall grass inside the mouth. The species shows certain similarities with Tapir groups of animals belonging to Tapiridae of the same order parissodactyla. The oesophagus is a long and straight tube with inner muscular lining.
The stomach is the large dilatation of alimentary track behind the diaphragm and is sharply curved. Although it is a herbivorous animal yet unlike other herbivorous ruminants like cattle, buffalo and goats, there is no compartment in the stomach. The stomach is almost similar in structure to that in the horse. In *R. unicornis* it is smaller as compared to its body size and requires the assistance of microorganism to break down indigestible cellulose contents of grass into digestible starch and sugar. The function is carried out by the caecum which is the largest part of the entire length of the digestive tract. The maceration and fermentation of the food in *R. unicornis* takes place in several blind pockets found in the intestine. The anal apperture which is the outlet of the alimentary track is guarded with a bunch of sphinctor muscles. In this species the rectal muscles appear to be weak as cases of rectal prolapse often met with in captive condition.

The gall bladder is absent and this is a noticeable similarity with the horse. The other digestive glands like liver and pancreas are almost similar in structural organization with those of the horse and do not show any special characteristics in rhino.

**PART IV**

**HEART:**

The heart of *R. unicornis* is a large musculo-fibrous conical organ situated in the thoracic cavity. It possesses two surfaces,
a broad base and a narrow apex. The heart is found to be free in the thoracic cavity except being bounded by the large blood vessels at its base. The base of the heart is reddish; while the apex is purple in colour (Fig. 50). Both auricles and ventricular septums are separate and well developed. The following are some biometrics of the heart of an adult specimen of *R. unicornis*.

### TABLE

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Measurement (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>i) Total length from base to apex</td>
<td>31.2</td>
</tr>
<tr>
<td>ii) Girth at base</td>
<td>48.0</td>
</tr>
<tr>
<td>iii) Weight</td>
<td>8.8 Kg</td>
</tr>
<tr>
<td>iv) Longitudinal length of</td>
<td></td>
</tr>
<tr>
<td>(a) right atrium</td>
<td>20.8</td>
</tr>
<tr>
<td>(b) left atrium</td>
<td>22.1</td>
</tr>
<tr>
<td>v) Width at the widest part (base)</td>
<td></td>
</tr>
<tr>
<td>(a) right atrium</td>
<td>7.1</td>
</tr>
<tr>
<td>(b) left atrium</td>
<td>9.0</td>
</tr>
<tr>
<td>vi) Width at the base of ventricles (both)</td>
<td>16.2</td>
</tr>
<tr>
<td>vii) Diameter of the</td>
<td></td>
</tr>
<tr>
<td>(a) cranial venecava</td>
<td>9.7</td>
</tr>
<tr>
<td>(b) Caudal venacava</td>
<td>5.9</td>
</tr>
<tr>
<td>viii) Diameter of large pulmonary vein (root)</td>
<td>5.8</td>
</tr>
</tbody>
</table>

### DISCUSSION

It has been found that the functional anatomy of the heart and its associates are similar to the heart of other mammals, or more
specifically to ungulata. From the present findings and earlier reports (Bhattacharjee et al., 1987), certain specific peculiarities could be isolated from other ungulata.

Owing to the non-availability of fresh carcases/specimens the nature of arterial and venous system could not be studied. However, from the dissected specimen after 48-72 hours of death (death caused after killing by the poachers) it has been found that it possesses an almost similar circulatory system as the horse.

The present findings of the measurements of the different parts of heart recorded in Table are similar to that of the records obtained by Bhattacharjee et al. (1987).

PART - V

RESPIRATORY SYSTEM:

R. unicornis bears the general plan and mode of the respective organs with reference to the functional anatomy and physiology of respiratory system of other ungulata. The respiratory system comprises a series of respiratory apparatus including nasal cavity, larynx, trachea, bronchial tubes and a pair of well developed lungs (5:5). Functional anatomy:

Nasal apperture: The nasal apperture comprises the external nasal opening and the tube leading to larynx. The two external nasal openings
are divided by a large cartilageneous nasal septum which divides the opening into two equal halves, like other ungulata.

The external openings of the nasal apperture are semilunar in shape, where the anterior part is wider 22 cm in diameter and tapering towards the posterior with 15cm in diameter in each nostril.

Total length of the nasal apperture from the external opening upto the larynx is 52 cm.

**Larynx**: It is short tubular region which ends in the pharynx and tracheal tube. It has the epiglottis and thyroid wing of the tube in the anterior side. This is supported by arytenoid and lamina in the lateral side and cricoid in the posterior side.

**Trachea**: The trachea, a cartilageneous pipe extends from the larynx to the hilus of the lungs, where it divides into the right and the left bronchial tubes, i.e., bronchi. It is almost cylindrical in shape, whereas the cervical region is somewhat depressed dorsoventrally. The different parameters of the trachea and bronchial tubes are shown as follows (Fig. 51).
<table>
<thead>
<tr>
<th>Parameters</th>
<th>Measurements (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>i) Total length of the trachea</td>
<td>106.0</td>
</tr>
<tr>
<td>ii) Length of the body of the trachea</td>
<td>88.0</td>
</tr>
<tr>
<td>iii) a) Circumference of the trachea in one surface</td>
<td>13.0</td>
</tr>
<tr>
<td>b) Circumference of the trachea at the point of junction with the thrynix.</td>
<td>16.0</td>
</tr>
<tr>
<td>iv) Circumference of the inner lumen of the trachea</td>
<td>11.0</td>
</tr>
<tr>
<td>v) Diameter of the inner lumen of the trachea</td>
<td>2.9</td>
</tr>
<tr>
<td>vi) Length of the bronchial tube</td>
<td></td>
</tr>
<tr>
<td>a) Left</td>
<td>18.0</td>
</tr>
<tr>
<td>b) Right</td>
<td>19.0</td>
</tr>
<tr>
<td>vii) Circumference of outer surface of the bronchial tube.</td>
<td>9.0</td>
</tr>
<tr>
<td>viii) Circumference of inner surface of the lumen of bronchial tube.</td>
<td>7.0</td>
</tr>
<tr>
<td>ix) Diameter of the lumen of bronchial tube</td>
<td>1.7</td>
</tr>
<tr>
<td>x) Breadth of the cartilage in the body of the trachea</td>
<td>1.5</td>
</tr>
<tr>
<td>xi) Breadth of the cartilage in the bronchial tube.</td>
<td>1.2</td>
</tr>
</tbody>
</table>

The tracheal rings which are arranged over the trachea show certain structural peculiarities. The rings, instead of being completely...
FIG. 51: TRACHEA AND LUNGS OF R. unicornis.

FIG. 52(a,b): URINARY SYSTEM; KIDNEY (a); URETHRA AND URINARY BLADDER (d) OF R. unicornis.
circular in structure, are generally not completed in the dorsal side. It forms the shape of the alphabet 'C' in the body of the trachea, whereas it is almost completely circular in the bronchial tubes.

**Lungs:** The lungs, consisting of right and left lobes, occupy the greater part of the thoracic cavity. Both lobes of the lungs are similar in structure, except that the right lobe is slightly larger in size. Each lung is soft, spongy and highly elastic, occupies thoracic cavity of the (Fig. 51) animal. It was observed that a calf of less than six months of age had a well developed lungs. The following are the salient features of the lungs.

(i) The lobes in both the lungs have 5 outer fissures, out of which 3 fissures mark 3 distinct external lobes, whereas other 2 lobes are not distinct.

(ii) Both lobes occupy the pleural or thoracic cavity between 5th and 18th thoracic vertebrae.

The measurement of the lungs taken in the collapsed stage of the lungs, after opening of the thoracic cavity are given below. The measurement of lungs in the living stage might be different.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Measurements (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Approx. diameter of the lungs in thoracic cavity</td>
<td>56.0</td>
</tr>
<tr>
<td>Approx. length of the lungs in thoracic cavity</td>
<td>50.0</td>
</tr>
<tr>
<td>Breadth of the left lungs</td>
<td>25.0</td>
</tr>
</tbody>
</table>
Parameters  Measurements (cm)
Breadth of the right lungs  28.0
Length of the left lung  50.0
Length of the right lung  48.0

DISCUSSION

The respiratory system, with its associated organs, is almost similar to that of other ungulata. However, certain points could be isolated as specialities which are observed in the present findings. Mention may be made with respect to (i) nasal bones and nostrils which are more developed in this species, (ii) the two lungs, which are voluminous, occupy the entire thoracic cavity. The coastal impressions on the wall of the lungs are not distinct.

PART - VI

URINARY SYSTEM:

The urinary system of *R. unicornis* consists of two muscular kidneys with their ureters and a single urinary bladder (Fig. 52a).

Kidney:

The two kidneys are situated on the dorsal wall of the abdomen underneath the lumber vertebrae. They are conical in shape and the outer surfaces are convex with a honeycomb like external appearance. The colour of the kidneys is dark. The two ureters from each kidney
arise in a mid-lateral position of the hilus and end independently in the urinary bladder. (Fig. 52b).

Urinary bladder:

The urinary bladder, a single organ, is the natural reservoir of urine. It is musculo-fibrous in structure and greyish-white in colour in R. unicornis. The capacity of the urinary bladder in an adult R. unicornis is found to be 3.5 to 4 litres. Both right and left ureters join independently in the urinary bladder carrying the waste products. Two urinary bladders of a month old calf and an adult 40 years old rhino were examined and certain measurements were taken and recorded.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Calf</th>
<th>Adult</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of urinary bladder</td>
<td>12.0 cm</td>
<td>18.0 cm</td>
</tr>
<tr>
<td>Breadth of urinary bladder</td>
<td>7.0 cm</td>
<td>11.0 cm</td>
</tr>
<tr>
<td>Area of urinary bladder</td>
<td>84 sq.cm</td>
<td>198 sq.cm</td>
</tr>
<tr>
<td>Thickness of the wall of urinary bladder</td>
<td>1 mm</td>
<td>1.6 mm</td>
</tr>
<tr>
<td>Length of urethra</td>
<td>11.0 cm</td>
<td>17.0 cm</td>
</tr>
</tbody>
</table>

Urethra:

The urine accumulated in the bladder is expelled through the tubular urethra. It has a wide opening at the end which progresses into the male or female genital organs (Fig. 52b).

Urine:

Urine is the major excretion of the body, through which metabolic waste products are eliminated from the body in fluid media. Laymen
hold the belief that the urine of R. unicornis has some medicinal value so it is used as a remedy for various ailments. Patar (1980) stated that the rhino's urine has high demand, and a bottle containing 400-500 ml of urine is sold at the rate of 5-10 rupees almost regularly in the State Zoo, Assam. The information and scientific data regarding the physical properties of the urine of R. unicornis are meagre.

Duke (1964) observing the physical properties of the urine of the domestic animals stated that when urine is shaken or agitated it produces foam. The urine possesses an amonical odour with a cludy appearance which produces sediment on standing. The specific gravity of urine of all the species of animals falls within the range of 1.025 to 1.030 with a maximum value 1.045. Further the author stated that the hydrogen ion concentration (pH) of herbivorous animals like horse, cattle and sheep normally falls between the range 7 to 8 which is alkaline in nature. The normal urine sample does not contain albumin or any protein as the protein molecules are absorbed by the glomarular membrane.

The normal range of specific gravity falls between 1.003 and 1.060. While the urine of herbivorous animals shows an alkaline reaction, that of flesh eating animals shows an acid ration. The colour of urine of horse and cattle is yellow, with a peculiar ammonia like odour and devoid of protein like albumin and sugar.
In the present study similar anatomical features of the urinary system found in most herbivorous animals were observed in *R. unicornis*. The characteristics of the urinary system in this species are two kidney, urter and one urinary bladder. The surface of the two kidneys reveals reticular or honeycomb appearance, and a thick walled musculo-membranous urinary bladder.

The physical properties of the urine of the species studies have been recorded in Table 34.

**TABLE - 34**

Physical properties of the urine of *R. unicornis*.

<table>
<thead>
<tr>
<th>SI. No.</th>
<th>Parameters</th>
<th>1st Samples</th>
<th>2nd Samples</th>
<th>3rd Samples</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Volume (lit)</td>
<td>2.80</td>
<td>3.20</td>
<td>3.75</td>
<td>3.56</td>
</tr>
<tr>
<td>2.</td>
<td>Colour</td>
<td>Yellow</td>
<td>Yellow</td>
<td>Pale yellow</td>
<td>Yellow</td>
</tr>
<tr>
<td>3.</td>
<td>Form</td>
<td>Present</td>
<td>Present</td>
<td>Present</td>
<td>Present</td>
</tr>
<tr>
<td>4.</td>
<td>Odour</td>
<td>Amonical</td>
<td>Amonical</td>
<td>Amonical</td>
<td>Amonical</td>
</tr>
<tr>
<td>5.</td>
<td>Transparency</td>
<td>Turbid</td>
<td>Turbid</td>
<td>Turbid</td>
<td>Turbid</td>
</tr>
<tr>
<td>6.</td>
<td>Sediment</td>
<td>Present</td>
<td>Present</td>
<td>Present</td>
<td>Present</td>
</tr>
<tr>
<td>7.</td>
<td>Specific gravity</td>
<td>1.020</td>
<td>1.022</td>
<td>1.025</td>
<td>1.022</td>
</tr>
<tr>
<td>8.</td>
<td>pH</td>
<td>7.20</td>
<td>7.22</td>
<td>7.20</td>
<td>7.21</td>
</tr>
<tr>
<td>9.</td>
<td>Sugar</td>
<td>No trace</td>
<td>No trace</td>
<td>No trace</td>
<td>No trace</td>
</tr>
<tr>
<td>10.</td>
<td>Albumin</td>
<td>No trace</td>
<td>No trace</td>
<td>No trace</td>
<td>No trace</td>
</tr>
</tbody>
</table>
In the present study the average volume of urine was recorded to be 3.56 litre, yellow in colour, producing foam while agitated, turbid in nature and sediments heavily deposited when kept standing. The odour of the urine is amoniacal, baring pH 7.21 and is alkaline in nature. Normal urine is free from sugar or protein. In general, the results simulates the findings of Duke (1964).

**PART VII**

**ANATOMY OF MALE AND FEMALE REPRODUCTIVE SYSTEMS:**

There are several thousand mammalian species, but reproductive biology has been extensively studied in less than 25 species, namely - rodents (Rodentia), rabbits (Lagomorpha), primates (including man), farm animals and a few marsupials. Some of these species are characterized by peculiar reproductive phenomena, such as restricted sexual season, absence of estrus, present of menstruation, dissociation of ovulation and estrus, nonspontaneous ovulation, spontaneous multiple ovulation with limited implantation, delayed implantation, and ovulation during pregnancy.

The animals which man has domesticated over the centuries to meet his own needs for food, clothing, power or companionship include cattle, sheep, goats, pigs (Artiodactyla); horses and asses (Perissodactyla) cats and dogs (Carnivora). These animals vary with respect to sexual season, sexual cycle, gestation period, type of placenta, litter size, lactation period and susceptibility to reproductive diseases. For
example, cattle, pigs and chickens breed throughout the year, horses and asses in spring, and most sheep and goats in the fall. These seasonal variations are not so evident in tropical zones compared to temperate and frigid zones, where periodicity is very seasonal. Furthermore, these variations are less evident in domesticated than in wild species.

The activity of the gonads and the accessory glands are influenced directly or indirectly by hereditary factors, ambient temperature, photoperiod, the nutrition. The reproductive cycle is regulated by interactions between the central nervous system, the pituitary, and the gonads. The hypothalamus controls the secretion of gonadotropins by releasing a regulatory substance into the portal blood.

The neonate in placental mammals is very immature and depends on maternal care. The stages of development at birth vary greatly in different species and determines the extent to which parental care is required. In the rat and rabbit, neonates are born blind, naked, and with a poorly developed thermoregulatory system. Thus, they require a warm maternal nest. In ungulates, the young are born in an advanced stage of development and can fend for themselves in a few days. The extent of the social interactions between the mother or her young one also varies widely and is necessary for the full development of the physical and behavioural characteristics of the species.

The efficiency of reproduction in a given species depends on the length of the sexual season, frequency of oestrus, number of
ovulations, duration of pregnancy, litter size, suckling period, puberty age, and duration of the reproductive period in the animal's life. In general, the age at which puberty is attained is earlier in smaller sized species than in large ones, as well as in females compared to males. There is no definite age at which reproductive functions cease abruptly during life, constituting menopause or climacteric in human. Many other female mammals, however, die before arrest of reproductive functions occurs (Hafez, 1974).

Rhinoceroses are sexually dimorphic animals. The sexual dimorphic characters may be analysed as follows:

Owing to its large size and peculiar anatomical configuration, it is difficult to identify a particular animal from a distance in terms of its sex. The common method of sexual differentiation by observing the male genital organs, particularly the testicles is not applicable in this species as the testicles do not hang out between the thighs. On the contrary, they are intrapelvic. In the female too common and distinctly visible female genitalia as the vulvae in many animals are not easily seen in R. unicornis females as they are comparatively small and hidden by the root of the tail.

Laurie (1978) studying the ecology and behaviour of rhinoceros reported that the male rhinoceroses are bigger in size with distinct neck folds. Pathak (1978) also observed that the neck folds are
prominent and horns are bigger in the male. The female with her suckling calf are often a plausible clue to the sexual identification of *R. unicornis*. Burton and Burton (1975) stated that the female *R. sondaicus* the Javan rhinoceros bears no horn or if at all it is rudimentary for which it can be identified from male.

**Sexual dimorphic characters:**

The following differential characteristics in male and female *R. unicornis* were observed in the present study.

1. The male *R. unicornis* was found to be physically bigger than the female of the same age.
2. The horn and the head as a whole in male *R. unicornis* is bigger and longer than that of the female.
3. The neck fold of the male *R. unicornis* is more prominent than the female. Particularly the folds are developed ornamentally, on the ventral side.
4. When passing urine, the male *R. unicornis* discharge it in a strong jet to a distance of at least 1.5 metres from its hind legs, while the female discharges urine in a large condition was found to be helpful in selecting male and female at the time of urination.
5. In case of old or weak ones the glans penis generally comes out through the sheath. Observing this part of the male genital organ male could be distinguished from the female.
6. In the case of advanced pregnant or suckling female *R. unicornis*, the sex can be detected from the well developed udder. (Fig. 11)

7. Association of mother and the calf pair gives a clue for sexual differentiation where the mother is said to be an excellent caretaker. She guards her calf up to at least one year, during which the mother grazes, feeds and stays near the vicinity of the calf. So an adult rhinoceros grazing with a tender aged calf and guarding it, could be detected as female.

**Anatomy of male reproductive system:**

Male reproductive system is composed of testes, epididymis and panis (Fig. 53a).

**Testes:**

The testes are the primary organs of sex in the male. The perusal of available literature reveals no scientific data with regard to the testes in *R. unicornis* are like those of elephants.

The scrotum, a musculocutaneous pouch which encloses the testes in most of the mammals was found to be absent in *R. unicornis*. When the body cavity was dissected and opened during the postmortem examination of male carcass. In the present study the testes were found to be lodged in the abdominal cavity. The testes are elongated, oval in shape in the adult (Fig. 53b) but is only elongated in new born calf
The length, breadth and thickness of an adult *R. unicornis* testes were recorded as follows:

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Measurements (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Adult (40 Yrs.)</td>
</tr>
<tr>
<td>Length</td>
<td>17.0</td>
</tr>
<tr>
<td>Breadth</td>
<td>8.0</td>
</tr>
<tr>
<td>Thickness</td>
<td>3.5</td>
</tr>
<tr>
<td>Weight</td>
<td>750 gm</td>
</tr>
</tbody>
</table>

The epididymis of the *R. unicornis* is a thick walled muscoserous convoluted tube adhering to the medial wall of the testes. The head and the body of the epididymis were found to be enlarged.

Histological structure of the testes observed under microscope revealed the following features:

i) The seminiferous tubules were distinctly seen.

ii) The sperms in their different stages of development were observed inside the seminiferous tubes.

iii) Presence of prominent interstitial cells were noticed in the section (Fig 53 b).

**The Penis:**

The penis is the copulatory organ of the male. It is more or less cylindrical in shape and musco-fibrous in structure (Fig 53 c).

The prepuce was well developed and it protrudes 12 cm from the abdominal plane. The diameter of the tip of the prepuce at the normal,
FIG. 53(a-c) : TESTES (a) AND HISTOLOGICAL STRUCTURE OF TESTE (b) AND MALE GENITAL ORGAN, (c) SHOWING THE PENIS ALONG WITH ADJACENT MUSCLES WITH SPERMATIC CHORD (c) OF R. unicornis.
non-erect state was 18 cm. When the penis was withdrawn from the prepuce it takes the shape of letter 'Z' with the glans penis facing backwards. The glans has a peculiar shape having three rows of petal-like structure. The free part was seen to be tapering towards the glans. The following were the different biometrical details of penis of an adult R. unicornis.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Measurement (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total length of the penis</td>
<td>85.0</td>
</tr>
<tr>
<td>Total length of free part</td>
<td>30.0</td>
</tr>
<tr>
<td>Diameter of the root</td>
<td>30.0</td>
</tr>
<tr>
<td>Diameter of the middle part</td>
<td>20.5</td>
</tr>
<tr>
<td>Diameter of glans</td>
<td>13.5</td>
</tr>
</tbody>
</table>

In order to obtain a clear idea of the structure of the penis 2 other specimens were dissected after being procured from the Kaziranga National Park. It was found that all the samples collected showed similarity in structure.

**Anatomy of female reproductive organs:**

The reproductive system consists of a chain of well synchronized events extending from estrus and ovulation through fertilization, implantation and pregnancy, and terminating in parturition and lactation.

The female genitalia were found lying in the pelvic cavity of the *R. unicornis* in its non-pregnant state. The whole genitalia
FIG. 54(a-c): FEMALE GENITAL ORGAN; VAGINA (a), OVARY, OVIDUCT, BLUDDER (b); INTERNAL STRUCTURE OF CERVIX OF UTERUS (c) OF R. unicornis.
were found consisting of the following parts (Fig. 54; a, b, c).

i) Two ovaries,
ii) Two oviducts or Fallopian tubes.
iii) Two horns of the uterus
iv) The body of the uterus.
v) The vagina, and
vi) The vulva.

(i) **The ovaries:**

The ovaries are the primary organs of reproduction in the female. They were found to be two in number - the right ovary and the left ovary; and attached to the floor of the pelvic cavity with ligaments. The lateral free surfaces of the two ovaries were found to be convex, and the free surface of the left ovary was found to be undulated due to presence of some growing follicles. As a whole, the ovaries of *R. unicornis* were oval in shape.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Right ovary</td>
</tr>
<tr>
<td>Length</td>
<td>5.0</td>
</tr>
<tr>
<td>Width</td>
<td>3.2</td>
</tr>
<tr>
<td>Thickness</td>
<td>2.1</td>
</tr>
<tr>
<td>Weight</td>
<td>8.2 gm</td>
</tr>
</tbody>
</table>

(ii) **The oviducts or Fallopian tubes:**

Two oviducts are of very zigzag musculoserosous tubes which end in a funnel like enlarged anterior part to receive the ova from the ovary when released. Posteriorly this connect with the horns of
the uterus. Each was found to be 35 cm in length and 0.4 cm in diameter (Fig. 54).

(iii) **The two horns of the uterus:**

The two horns or cornua of the uterus were well developed. They lie parallel to each other in the pelvic cavity. The two horns were equal in size and connected at the posterior end with the body of the uterus. Each of them measured 38 cm in length and 6 cm in diameter (Fig. 54).

(iv) **The body of the uterus:**

The body of the uterus in *R. unicornis* is a comparatively thin-walled hollow pouch which bifurcates at the anterior and connects with the horns. It is constricted in the posterior to form the neck or cervix of the uterus. The cervix is thick-walled and cylindrical in shape. Cervix consist of 3 to 4 rows of annular rings internally in the species. The body of the uterus was found to be 7 cm long and 9 cm wide.

(v) **Vagina:**

The vagina is a musculo-membranous hollow structure which acts as the copulatory organ in the female *R. unicornis*. The length of the vaginal tube was found to be 38 cm while the diameter as 16 cm (Fig. 54a).
(iv) **The vulva:**

The two vulvar lips of the *R. unicornis* are thin and elongated. They are located in the tail groove. When the tail is lifted, it may be observed that vulvae appears to be whitish brown in colour. The vulvar lips were found to be 15 cm in length and 4 cm in thickness (Fig. 54a).

**Placenta of *R. unicornis***:

The placenta is the transitory reproductive organ, developed in the uterus of the mammal after conception, which facilitates the supply of nutrition from mother to the growing foetus. It lodges the latter: in the aquatic state essential for prenatal development. The structure and nature of placenta has been recently described (Goswami et al., 1987) which was collected from birth sample of an aborted *R. unicornis* (Fig. 55, a, b, c).

In the present studies two samples of placenta were studied.

**1st sample:** The placenta of an adult female *R. unicornis* captured for sending to other Zoo in India which aborted on the 2nd day after capture. The placenta was collected after she gave birth to a premature calf. Pregnancy was nearing its completion showing normal size of the tactus size with growth of nails and hairs. However, the exact period of gestation was not possible to record, as the animal was captured in the Pabitora Wildlife Sanctuary and aborted on the 2nd day of the capture. The age of the female was not clearly known, but from the
FIG. 55: PLACENTA OF R. unicornis, WHOLE PLACENTA (a), PLACENTA WITH UMBILICAL CHORD (b), VILLI AND MICROVILLI (c); PLACENTA WITH ONE END OF THE HORN ATTACHED WITH CHORION INTERNAL WALL ATTACHMENT WITH FOETUS.
FIG. 56(a,b,e): GROSS VIEW OF PLACENTA OF PERISSODACTYLA:  
(a) - R. unicornis, (b) - Tapir; (c) - Horse.
external morphology of the animal it might be around 16 to 20 years old. The aborted placenta was collected and studied as given below:

i) Weight of the placenta - 2400 gm

ii) Length of the placenta in the gravid horn - 102 cm

iii) Length of the placenta in the non gravid horn - 48 cm

iv) Thin in structure.

v) It was white and transparent, when weighed out.

vi) Area of attachment with the endowmertriurn was found all over the amino-chorial surface.

vii) Whole amnio-chorial surface of the placenta contain innumerable micro villi.

viii) Anatomically it can be placed under diffuse type of placenta.

2nd case: Another placenta was collected from the State Zoo, Assam after parturition of a full grown male calf and the detail studies of the same was conducted as follows:

(a) Weight of the placenta -- 4200 gm

(b) (i) Placenta shows the presence of distinct body.

(ii) Free part of the body's length -- 65 cm

(iii) Circumference of the body in the base of the horn. -- 84 cm

(iv) Circumference of the body in the middle -- 90 cm

(v) Circumference near the cervix -- 78 cm

(vi) Length of both horns including the junction of the body. -- 171 cm
(c)  (i)  Length of right horn  
(from centre of the body to the apex)  --  81 cm

(ii)  Breadth at the junction of horn  --  21 cm

(iii) Breadth at middle of the horn  --  26 cm

(iv) Breadth at the apex  --  6 cm

(d)  (i)  Length of the left horn  
(from centre of the body to the apex)  --  90 cm

(ii)  Breadth at the junction of the horn  --  21 cm

(iii) Breadth at the middle of the horn  --  25 cm

(iv) Breadth at the apex of the horn  --  4 cm

(e)  (i)  Circumference of the right horn at  
the junction.  --  90 cm

(ii) Circumference of the right horn at  
the middle.  --  58 cm

(iii) Circumference of the right horn  
at the apex.  --  12 cm

(f)  (i)  Circumference of the left horn at  
the junction.  --  40 cm

(ii) Circumference of the left horn at  
the middle.  --  50 cm

(iii) Circumference of the left horn at  
the apex.  --  9 cm

(g)  (i)  Umbilical chord is distinct and clearly  
visible with its stout branches and further  
ramification. Two chords are distinct  
and separated from each other.
FIG. 56(d,e,f): PLACENTA OF R. unicornis (d) AND RUMINANT (f) SHOWING THE NATURE OF VILLI.
(ii) Length of the umbilical chord, free part -- 22 cm
(iii) Circumference of the umbilical chord
at the base
3.5 cm (right)
3.8 cm (left)
at detachment -- 2.5 cm (right)
2.5 cm (left)
(iv) Length of the umbilical chord after
detachment from the mother found in
the foetus (foetal umbilical chord)
-- 9.0 cm

After cleaning weight of the placenta -- 2400 gm

(h) Nature of villi: - They are present throughout both the horns
of the placenta. However, there were certain gaps which appeared like
striations. Generally the places through which blood vessels coming
from the umbilical chords were passing showed the presence of less
number of villi rather than other parts of the body. The size of the
villi ranged from 0.5 mm to 1.5 mm as follows:

The measurements of
(i) Microvilli at the base of the horns 0.13 (±0.2) mm
(ii) Microvilli at the middle of the horn 1.00 (±0.1) mm
(iii) Microvilli at the apex of the horn 0.50 (±0.1) mm

The placenta of R. unicornis might be placed under indediduate
type, as there was very little damage done to the maternal uterine tissue.
The anatomical structure of the amnio-chorial surface to the villi
were in apposition with endometrium - forming numerous villi and
microvilli. The area with the endometrium was found all over the amnio-
chorial surface. The present study agrees with that of Robert (1971) and Arthur (1973) on the placenta of the mare, where the villi were seen in the amnio-chorial surface and this was classified under diffused type of placenta. It was neither like that of primates nor ruminants; rather it simulates with that of horse where there is loose attachment of the placenta with the internal tissue of the uterus of the mother (Fig. 56 b, c). It showed that there were less possibilities of bleeding and eruption of the uterine tissue sac. It is diffuse as in humans but unlike that of the ruminants. The points of attachment between maternal placenta and the foetal parts were innumerable. (Fig. 56 d, e, f)

Mammary gland of Rhinoceros unicornis:

The mammary gland or udder in the female is the organ for secreting milk to nourish the young one as the name mammal indicates. A rudimentary non-functional skin supports the mammary glands. This skin is also present in male mammal (Fig. 57 a, b).

The mammary glands are two in number and situated in inguinal region in R. unicornis. Each mammary gland is in the form of a cone, with a teat in the apex. The two mammary glands fuse mid vertically to form a single udder (Fig. 57 b). It is completely hairless, the reddish brown in colour. The ventral end at the teat is free. The teats are well developed. They are not long but wide in diameter. The biometrics of the udder of a suckling R. unicornis cow recorded as follows:
FIG. 57(a,b) : MAMMARY GLAND OF SUCKLING COW (a), AND RUDIMENTARY TEAT OF MALE R. unicornis.
<table>
<thead>
<tr>
<th>Parameters</th>
<th>Measurements (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total length of the udder</td>
<td>20-22</td>
</tr>
<tr>
<td>Girth at middle</td>
<td>56-58</td>
</tr>
<tr>
<td>Girth of the free part at the base of the teat.</td>
<td>20-23</td>
</tr>
<tr>
<td>Length of the teat</td>
<td>4-6</td>
</tr>
<tr>
<td>Diameter of the teat</td>
<td>7-9</td>
</tr>
</tbody>
</table>

**DISCUSSION**

Though a large and sexually dimorphic animal, it is difficult to identify the sex of *R. unicornis* from a distance as the testicles in male are intra-pelvic and the vagina in female is hidden by the tail. However, sex differentiation might be made possible by observing the size of the head and horn which are bigger in the male than those of the female. Distinct ornamental neck folds in the male are also an additional point in distinguishing the sex. Cow and calf pair gives a definite clue to identification of the female, and the appearance of the male genital organ from its sheath in the aged male rhinoceros also signifies the male. Similar findings were also observed by Laurie (1978) on the study of sexual physical differences in *R. unicornis* and the testes were found to be located in the pelvic cavity. The testes, like those of the elephant do not possess the scrotum.

The testes of *R. unicornis* are elongated and oval in the adult and elongated in the new born calf. In an adult *R. unicornis* (n=1, 40 years old) the testes measured twice as long than in the new born
calf; the weight is almost 30 times more and twice the tests of an adult *R. unicornis*. The epididymis follows a zigzag pattern in its course. The prepuce or sheath is well developed and situated medially in front of the inguinal region. In its non erect state, when the penis is withdrawn from its sheath it takes the shape of the letter 'Z'. The glans penis is formed of three rows of petal-like projections. The penis of *R. unicornis* faces backward between the two thighs in the nonerect state, but it faces towards the front when erect, at the time of copulation. The penis shows a peculiar characteristic which does not possess any affinity with its allied taxonomic group. The occurrence of petal shaped glans penis is the special characteristic of the penis of *R. unicornis*. Further like the elephant the penis of *R. unicornis* is drawn backwards in its nonerect stage. The *R. unicornis* urinates in the posterior direction.

The female genitalia consist of two ovaries, two Fallopian tubes, two horns and abody of the uterus, the vagina and two vulvar lips. The two ovaries of the *R. unicornis* are oval in shape and the left ovary is bigger than the right. The two fallopian tubes are convoluted in nature and forms the inner most part of the tubular genitalia. The two uterine horns of *R. unicornis* are well developed and are equal in size. Young (1962) reported that the uterus of the rhinoceros is bicornuate, as observed in the present study. The thin-walled and hollow uterus narrows in the posterior end to form the cervix, and bifurcates to join the two horns anteriorly. The vagina, the copulatory organ in the female is a well developed, hollow, musculo-membranous tube
which is generally 38 cm long and 16 cm in diameter. The two vulvar lips are the outermost part of the female genital organs.

In the present finding the functional anatomy of the female reproductive system shows certain features which are unique for the animal. These are namely - (i) the fallopian tube is bigger in size in comparison to other ungulates, (ii) the valvar lips are thin and elongated which are normally quite fleshy in other ungulaes.

The placenta of R. unicornis is of the diffuse type, and thin in structure. The whole amniochorial surface of the placenta possesses innumerable villi and micro villi. Young (1962) reported that the placenta of rhinoceroses is of the diffused type with large amniotic sac which is in accordance with the findings in the present study. The weight of two placentae found to weigh 2400 gm in the case of aborted one and 4200 gm in case of matured pregnancy. The difference between the two were obvious for the reasons indicated.

The two mammary glands of the R. unicornis fuse to form the udder, which found to be inguinal in position it is completely hairless. In comparison to the body size of R. unicornis, the mammary glands were not found to be so well developed. Two or three days prior to parturition and upto mid suckling period the udder is visible from a distance. Beyond this period it becomes atrophied and is hidden between the two thighs. The length, girth, and length of the teat were found to be 22, 58, and 5 cm respectively in a suckling mother.