STUDIES ON CERTAIN ASPECTS OF THE BIOLOGY OF THE ONE HORNED RHINO, *Rhinoceros unicornis*

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C O N T E N T S

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CHAPTER - I

GENERAL INTRODUCTION

The *Rhinoceros unicornis* is one of the rare and precious species of wildlife of all time. This unique animal once roamed all over the world and dominated almost all wild creatures at one time. At present it inhabits some and small restricted areas of Asia and Africa. The rhinoceros is a vanishing mammal,not because of its failure to propagate in the evolutionary process, but because of extermination by human interference. Although the reproduction and prolificacy of this large herbivorous animal are checked due to physical change and growing competition with other herbivores for food and shelter,yet the principal cause of the reduction of this valuable species is attributed to the indiscriminate killing of it, particularly from the beginning of the 19th Century, from which time people gradually became accustomed to the use of firearms.

It is interesting to note that the world's two largest land animals alive today, the elephant and rhinoceros - are found in Africa and Asia, where they have existed from pre-historic times. Until a century ago they were in great abundance on both these continents. Now, there is considerable concern over the survival of these animals and special efforts must necessarily be made to save them from extinction.

Rhinoceroses are large utherial mammals under the order perissodactyla. Different living species of rhinos closely resemble one another. despite the fact that two of the species live on the African continent and three in Asia. Almost like Tapir (Tapiridae) the family Rhinocerotidae (McKenna, 1975, Eisenberg, 1981) consisted of many species during tertiary period, giving rise to various sub families. Among them, the Hyrachyidae and Hydracodontidae of North America were light-footed, slender limbed and hornless, resembling the contemporary members of equine (Equidae). They were extinct in Oligocene period. Further,there are some rhinoceros - like plump animals,whose appearance resembled that of hippopotamus in Eurasia and North America (e.g. Amynodontidae). Besides these various early extinct species, like sub-family Caenopodinae (Eotrigonias, Caenopus etc.) and species of two horned rhinoceros with various radiations (Dicerorhinus tagicus, Coelodonta antiguitoetis - the cold resistant long haired, thick coated long drawn skull and high crowned molars adapted for crushing hard grass, Dicerorhinus hemitoechus - wooly rhinoceros, Dicerorhinus kirchbergensis) and the Sumatran species Didermocerus sumaternsis are some contemporary species. Rhinoceros unicornis. can also be traced back to the tertiary (miocene) along with Gaindatherium browni. Rhinoceros sivalensis and Rhinoceros sinensis. the Javan species is the older of the two species remaining almost unchanged since the late Pliocene of more than a million years ago. Several large or giant sized species occurred from the ecocene to the miocene period and they were largest terrestrial as - *Paraceratherium*. *Indricotherium* and *Benaratherium* (*I. asiaticum* was five meter in height, 7 meter long). Besides the species like the slender footed, long legged, hornless rhinoceros like European species, *Aceratherium*, *Teleoceras* *Brachvpothe rium* and from Europe and North American species like *Diceratherium*- the two horns which occur side by side on the nose and Elasmotherium- a large sized species was available during the tertiary glacial period. They all lived in remote habitats, seemingly because they were not able to compete any longer with other ungulates. Above all, the human influence has basically changed wide areas of Africa and Asia. The two African species are *Diceros bicornis* or the black rhinoceros and *Ceratotherium simum* or the white rhinoceros. The former lives in Zululand, Uganda, African Republic and Congo, while the latter lives in South East Africa, Rhodesia, Transvaal, Kenya, Tanzania, Uganda and Ethiopia. The Asian species of rhinoceroses are the *Rhinoceros unicornis*, or the the Great Indian One horned rhinoceros living in India and Nepal), the *Rhinoceros sondaicus* or, the Lessor One horned rhinoceros living in Java and the *Didermocerus sumatrensia*, or the Sumatran rhinoceros living in Sumatra, Borneo and Malysia at present (Burton and Burton, 1984, Schenkel and Hulliger, 1969a).

Rhinoceroses are solitary animals. They graze alone or in small groups. They try to avoid other animals and become ferocious when disturbed by men or other animals. The male rhinoceros particularly becomes more aggressive and intolerant of the animals of the same sex in the presence of a female rhinoceros in heat.This fighting competition to overcome a partner in sex often leads to the death of one of them. Rhinoceroses have the peculiar habit of wallowing in mud pools. They take mud baths and lie down on the mud or water particularly during the hotter parts of the day during the summer months to avoid the scorching heat of the sun and to lower the body temperature. This wallowing may be attributed also to the mudtherupy against the bites of flies and insects and other ectoparasites (Patar 1980).

Rhinoceroses have a peculiar habit of defecating at a particular place for a long time where a huge dung pile is formed. A rhino, coming up to a dung pile, sniffs at it, may push his horn into it, and then shuffles through it with legs held stiff. After defecation the dung in scattered with kicks by the hindlegs. Most of the rhinoceroses follow their own dung pile or may also share the same by other animals of the species (Burton and Burgon, 1974). The rhinoceroses are purely herbivorous animals. The species R. unicornis, mainly lives on grazing on various species of plants, specially on grass, the tender shoots along with some aquatic plants of the habitat (Laurie, 1978 and Patar, 1980). The African rhinoceroses, the Ceratotherium simum lives on the leaves and bark of the plants and shrubs (Burton, 1975) and Diceros bicornis on browsing and grazing on grass, shrubs or leaves of trees. The young rhinoceros calf suckles the mother upto one year of age or even more, after which they start grazing.

R. unicornis is one of the largest of all perissodactyl animals and is 300 cm to 360 cm long and 150 cm to 180 cm high at the shoulder in adult stage. The legs are shorter in comparison to the body size but they are stout. The legs contain odd numbers of 3 toes in each, hence they are placed under the odd-toed animals or the 'Perissodactyla' The single horn located on the nose centrally in the Great Indian one horned rhinoceros is the main point of attraction of this species of animals. The african species and the Didermcerus sumatrensis on the other hand bears two horns, on the nose placed one behind the another, of which the front one is the bigger in size. The horn(s) is the weapon of defence against enemies.The horn in the male rhinoceros is more prominent than in the female. In certain species like R. sondaicus, the female bears no horn or in some individual, if it appears at all, it is rudimentary in size. It is found that if the horn is torn out or detached due to fighting, injury or by any other accident, the horn starts reappering.

The teeth of the rhinoceros are also large and stout, of which the canines are more prominent. The canine teeth are often used to attack and are the defensive weapon against enemies.

The rhino skin is also very peculiar, being almost hairless except for a tuft of hair at the tip of the tail and containing projections which is seen in most species. But there is exception in the case of _R_. _sumatrensis_, where the whole body is covered by thin short hair. There are well developed shield-like skin folds on the shoulders and the buttock region. The skin projections and the folds are more prominent in the Great Indian One horned species than in other species of rhinoceros.

A comparative review of the different physical features of 5 different species of rhinos is made in Table - 1.

TABLE - 1

Review of certain physical features of the five species of Rhinoceroses

Physical	_Ceretotherium simum_	_Diceros bicornis_	_Rhinoceros unicornis_	_Rhinoceros sondaicus_	_Didermocerus sumatrensis_
1. Body size	Largest	Medium	2nd largest	Smaller	Smallest
2. Head	Broad	Broad	Tapering	Tapering	Broad
3. Horn	Two horns in both sexes	Two horns in both sexes	Single horn in both sexes	Small single horn in male only	Two horns in both sexes

TABLE - 1 (Contd.)

Physical features	Ceretotherium simum	Diceros bicornis	Rhinoceros unicornis	Rhinoceros sondaicus	Didermocerus sumatrensis
4. Skin	Smooth and hairless	Smooth and hairless	With tubercles and hairless	With smaller tubercles and hairless	Smooth and hairy.
5. Skin fold	Absent	Absent	Prominent skin fold behind the shoulder and thigh	Smaller skin fold behind the shoulder and thigh	Absent
6. Teeth	Incissor teeth absent	Incisor teeth absent	Incisor teeth present	Incisor teeth present	Incisor teeth present
7. Lips	Upper lip square	Upper lip pointed	Upper lip pointed	Upper lip pointed	Upper lip pointed
8. Humps	Hump present	No Hump	No hump	No hump	No hump

The female rhinoceroses attains puberty at the age of 3½ to 4 years while the male attains it at the age of about 7 years (Rajkonwar and Baishya 1985, Misra, 1986). Their courtship behaviour or prebond fighting is very severely aggressive where the competitor bull rhinoceros or sometimes the female sex partner may succumb to death during the chasing and fighting. The length of the gestation period is 360-570 days (Morris 1968.). Normally gives birth to one calf per pregnancy, but twin birth are also reported in C. simun by Grzimek (1972). The rhino-calf can stand up after about 35 minutes of birth and starts suckling within 50 minutes of its birth (Bhattacharyya and Goswami, 1987).

In the rhinoceros it is difficult to ascertain the sex of the animal from a distance. The size of the animal, the size of the neck with its skin folds and the size of the horns are some of the criteria of distinguishing the male and female. The male generally possesses a large horn, more prominent neck fold.

Aim of the present investigation:

It has been found that although great emphasis has been placed on the conservation and propagation, along with creation of a suitable habitat for the rhino with particular reference to R. unicornis, there is yet meagre scientific information on the biology and other ecological parameters of the species. Further, in order to chalk out appropriate conservation and propagation policies and ideas of implementation, authentic and thorough scientific information on the different vital aspects of its biology is a primary need. In view of these facts, the present studies were made on the R. unicornis, the great Indian one horned rhinoceros. In relation to the biology and ecology of the habitat of the species in the Kaziranga National Park, the following parameters have been taken for the study.

(a) Taxonomic status and distribution in North East India and Assam in particular.

(b) Ecology of the habitat with reference to food and feeding habits both in natural and captive conditions.

(c) The general behaviour of the species concerning various aspects of grazing, wallowing, urination, defecation, locomotion, swimming and migration.

(d) Physical features and anatomy of the vital systems.

(e) Disease, causes of death and longevity.

(f) Conservation strategies etc.

MATERIALS AND METHODS

Studies on certain aspects of the biology of the one horned rhino *Rhinoceros unicornis* were carried out in different wildlife sanctuaries (Manas, Orang, Pabitora, Sonai - Rupai) and in the Kaziranga National Park. The studies were mainly carried out in the Kaziranga National Park under natural condition and in the Assam State Zoo, Guwahati under captive condition.

The materials used and the methodology followed for different aspects of the studies have been described, the result recorded and presented in tabular form and observations have been duly reviewed and discussed in the chapters concerned.

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CHAPTER - II

CERTAIN ASPECTS ON TAXONOMIC STATUS AND DISTRIBUTION OF *R. unicornis* IN ASSAM

Rhinoceros belongs to the ungulate group which is regarded as the odd-toed animal. Thre are three living families of Perissodactyla, the odd-toed ungulate which are the *Tapiridae*, *Rhinocerotidae* and *Equidae*. Before elucidating the taxonomic status of the rhinoceros group it would be worthwhile to have a comprehensive idea on the radiation of ungulate.

At the beginning of paleocene the ancestral ungulate had branched out into at least five lines as - Eparctocyana, Cete, Meridi ungulata, Phenacodonata and Tethytheria. The Cete soon became adapted to an aquatic life and have given rise to whales and dolphins, whereas the Eparctocyon radiation gave rise to a number of forms in North America and Asia that are now extinct, except the Tubulidentata and Artiodactyla order. Meridiungulata was a radiation that became isolated in South America at an early time and has become extinct. Phenacodonta radiated in North America and Europe to give rise to the newly defined condylartha and the Perissodactyla and Hyracoidea. Only the last two orders survived in the old world; whereas the Tethytheria appear to be an unique radiation giving rise to Desmostylia, Sirenia, and

Proboscidea. The details of the phylogeny of the ungulata are shown as follows (McKenna, 1975).

	Arctocyonia*
	Tillodontia*
	Embrithopoda*
Eparctocyana	Tubulidentata*
	Dinocerata*
	Artiodactyla
	Archaeoceti*
Cete	Odontoceti
	Mysticeti
	Liptoterna*
	Notungulata*
	Astropotheria*
Meridiungulata	Trigonostylopoidea*
	Xenungulata*
	Pyrotheria*
	Proboscidea
Tethytheria	Sirenia
	Desmostylia*
	Tapiridae
Perissodactyla	Rhinocerotidae
	Equidae

* Extinct

CLADOGRAM INDICATING THE RADIATION OF UNGULATA (McKenna, 1975).

All three families of Perrissodactyla are basically adapted for herbivoracity. The number of functional toes in Perissodactyla can vary from three to one, but the weight is generally on the third or central toe. In the evolution of this group there has been a trend towards reduction in the toe number and increasing adaptation for cursorial, extreme digitigrade locomotion,there has been an evolutionary trend away from brachydont dentition to high crowned hypsodont dentition in those species that have moved from browsing to grazing. During the tertiary period members of Rhinocerotidae were a numerous and widely distribution group in North America and the Eurasian region. Rhinoceros unicornis can be traced back to tertiary (Miocene-approximately 25 to 10 million years ago). Gaindatherium browni from the lower and middle Siwalic strata of India can easily be traced from the early tertiary genus Caenopus, and thus represents the original form of glacial species of R. sivalensis and R. sinensis, as well as the present day Indian and Javan rhinoceros (R. unicornis and R. sondaicus) (Grzimek 1972).

The African rhinoceros forms a distinct line including Diceros bicornis (Black rhino) and Ceratotherium simum (Square-lipped rhino). The sub-family Dicerotinae (D. bicornis and C. simum) may be traced back from oligocene with its early genus Dicerorhinus tagicus, including several glacial species like Coelodonta ontiquitatis, Dicerorhinus

<u>hemitoechus</u>, <u>D</u>. <u>kirchbergensis</u>. The Sumatran species <u>Dicerorhinus sumatrensis</u> also evolved during the glacial oligocene of the tertiary strata. Besides these three, there are large groups of rhinoceros of giant size and some of them have attaining more than 7 meters in length and 5 metres in height (Grzimek, 1972). These animals could not survive except in two regions viz. The African continent (2 species) and Asian regions (3 species).

The taxonomic status and present natural habitat (Table 2) of living five species of rhinos could be framed as follows (McKenna, 1975; Eisenberg, 1981).

Phylum	:	Chordata
Sub-Phylum	:	Vertebrata
Class	:	Mammalia
Sub-class	:	Theria
Infra Class	:	Eutheria
Grand order	:	Ungulata
Order	:	Perissodactyla
Family	:	Rhinocerotidae

i) <u>Rhinoceros</u> <u>unicornis</u> (The great Indian one horned rhinoceros).

ii) <u>Rhinoceros</u> <u>sondaicus</u> (The Javan small one horned rhinoceros).

Sub-family : iii) Diceros bicornis (African, hook-lipped black rhinoceros)
Dicerotinae

iv) Ceratotherium simum (African square-lipped white rhinoceros).

v) Didermocerus sumatrensis (Sumatran two horned rhinoceros)

TABLE - 2

Present natural habitat of the rhinoceros in the world

Sl.No.	Species of rhinoceros	Habitat
1.	Diceros bicornis (Black rhinoceros)	Africa - Central and South East Africa-Zululand, Uganda,Sudan, African Republic and Congo.
2.	Ceratotherium simum (White rhinoceros)	Africa-South East Africa-Angola,Rhodesia Transvaal, Kenya, Tengania, Uganda, Ethiopia and Somaliland.
3.	Rhinoceros unicornis (Great Indian one horned rhinoceros)	Asia - South East Asia - India, Nepal.
4.	Rhinoceros sondaicus (Small Javan one horned rhinoceros)	Asia, South Asia, Java.
5.	Didermocerus sumatrensis (Sumatran two horned rhinoceros).	Asia, South East Asia, Sumatra,Malyasia Burma and Borneo

Distribution of *Rhinoceros unicornis* in North East India:

The present range of the *R. unicornis* is confined to the Himalayan terrain from central Nepal, in a North Eastern direction along the Brahmaputra valley to the base of the Bhutan Himalayas. Several semifossilized remains were excavated from Peswar, Punjab and even in certain places of Uttar Pradesh and West Bengal. From the ancient writings like the 'Babur Namah' of the first Moghal Emperior Babar, and the excavation of the prehistoric sites of Mohenjodaro and the Indus valley civilization, it was found that the animal existed in large numbers from the Khyber pass in the west to Sadia of North East India and occupied the area from Kashmir to Indo-China (Misra, 1986; Crandall, 1964). The animal survived and proliferated. About 3 centuries ago, the banks of the Indus and Ganges were abundant in water, grass and thick deciduous tropical jungles which extended upto the Brahmaputra valley. Presently, it is restricted to Chitwan valley of Nepal the Brahmaputra valley in Assam and Jaldapara of West Bengal.

It might be presumed that in earliest times, the widely distributed species of *R. unicornis* was available in the flood plains of the Indus, the Ganges and the Brahmaputra valleys (Fig.1), where moist tropical climate with high rainfall and humid condition favoured the propagation of the speices. The migration of the species from Indus

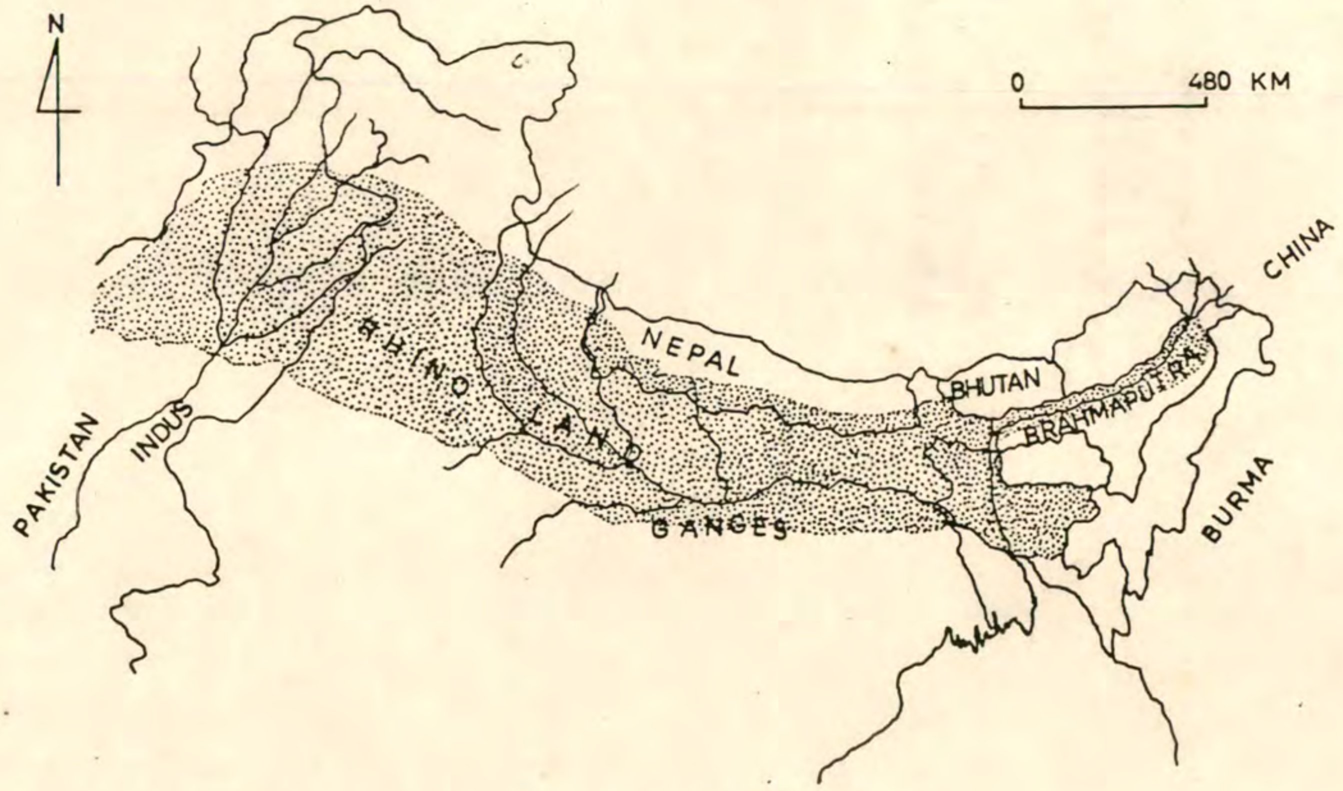

FIG. 1. ANCIENT RHINO LAND IN INDUS, GANGES & BRAHMAPUTRA VALLEY.

valley and Gangetic plains towards the Brahmaputra valley might have occurred due to the following factors:-

i) Gradual desertification of some places around the Indus valley and change of climatic condition from humid to dry along with decrease in rainfall (Bora, 1982; Subrahmanayam and Subrahmanayam 1965)

ii) Human inteference in the habitat of the speices, converting forest land into agricultural or industrial areas alongwith construction of roads or railways track.

iii) Merciless killing by kings or Emperors of those time along with reckless poaching.

iv) Increase in the number of domesticated animals sharing their grazing grounds.

All these factors particularly the human interefernces restricted the rhino population to some pockets as stated above.

The Kaziranga National Park has been providing a suitable condition for its propagation and in course of time from Kaziranga National Park the species has started migrating and established itself in other neighbouring wildlife sanctuaries. (Fig.2-6). and or other small pockets found suitable for their habitation. The distribution of the species to Manas, Orang, Pabitora, Laokhowa, and Sonai Rupai

Wildlife Sancturaries are all radiated stock from the Kaziranga National Park and there has been always movement of the species to and from Manas $\rightleftharpoons$ Orang or Orang $\rightleftharpoons$ Sonai Rupai, as well as from Kaziranga to Pabitora or Laokhowa (Fig. 2). The present habitat of *R. unicornis* (Table 3) and its continuous migration between the National Park and wildlife sanctuaries as well as adjacent forest reserves indicate that the small member of rhinos presently found in Jaldapara sanctuary and in the north part of Bangadesh adjacent to Jaldapara (West Bengal) might be the migrated stock from the Manas Wildlife Sanctuary or from Nepal or both.

TABLE - 3

Present natural habitat of *Rhinoceros unicornis* in Assam (India)

Habitat		Geographical location	Area (Sq. m.)
1.	Kaziranga National Park	Longitude - 92"-5'E to 93"-40'E Latitude - 26"-3'N to 26"-45'N	430
2.	Manas Wildlife Sanctuary	Longitude - 90"-30'E to 91"-30'E Latitude - 26"-30'N to 27"N	390
3.	Orang Wildlife Sanctuary	Longitude - 92"-5'E to 92"-20'E Latitude - 26"-20'N to 26"-35'N	72

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TABLE - 3 (Contd.)

Habitat		Geographical location	Area (Sq.m.)
4.	Pabitora Wildlife Sanctuary	Longitude - 92"E to 93"E Latitude - 26"-20'N to 26"-30'N	16
5.	Laokhowa Wildlife Sanctuary	Lontitude - 92"-50'E to 93"E Latitude - 26"-40'N to 26"-50'N	60
6.	Sonai-Rupai Wild-life Sanctuary	Longitude - 92"-20'E to 92"-40'E Latitude - 26"-45'N to 26"-55'N	175

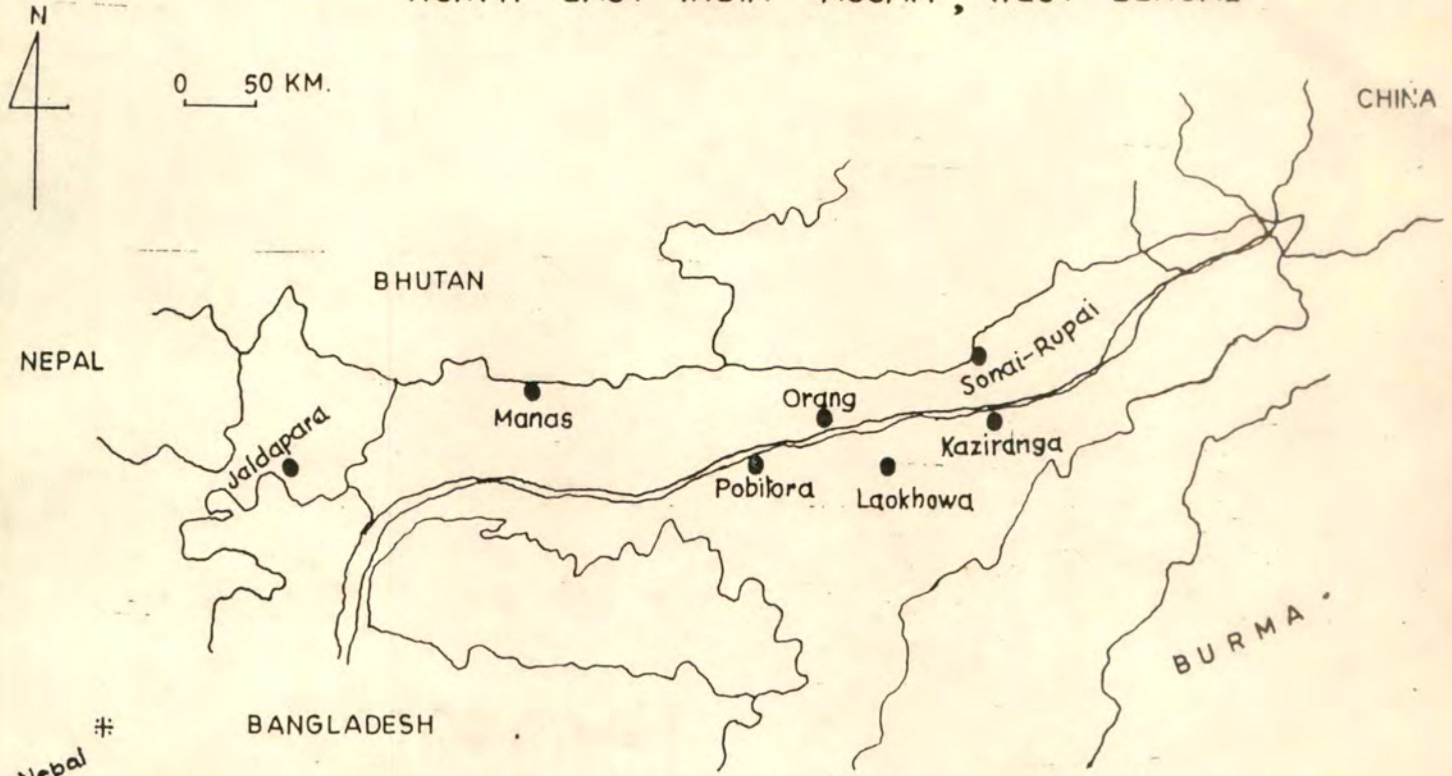
Movement of R. unicornis in Assam:

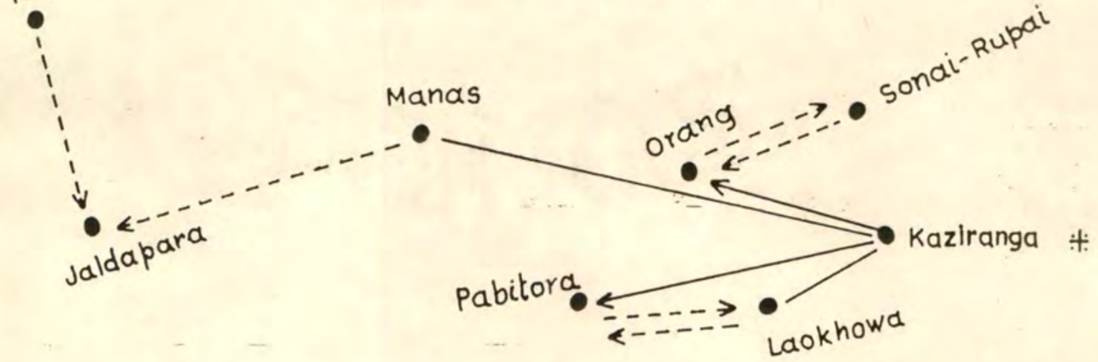
In the present study an attempt has been made in order to trace the movement of R. unicornis throughout the State of Assam and along the border of Arunachal Pradesh. Several problems have been encountered in the field of survey and in monitoring the movement of rhino simultaneously in the different districts of Assam. The movement and availability of rhino in different places have been recorded on the basis of the following:-

i) Personal observation.

ii) Press reports published in local newspapers/magazines/journals- followed by personal verification at the places concerned wherever possible.

MAP SHOWING DISTRIBUTION OF RHINOCEROS IN NORTH EAST INDIA ASSAM, WEST BENGAL





DISTRIBUTION PATTERN OF R. UNICORNIS FROM KAZIRANGA. (# ORIGINAL HOME)

(Fig.2)

iii) Report of the Range Officers/Field staff and the river patrol party of the Forest Department.

iv) Findings of footprints

The distribution of _R_. _unicornis_ in different districts of Assam are recorded and shown in the following Blocks (Table 4).

TABLE - 4 (Fig. 3)

Blocks		Districts
A	:	Jorhat, Golaghat, Nowgong and South Kamrup.
B	:	Darrang and Sonitpur.
C	:	North Kamrup, Nalbari and Barpeta.
D	:	Kokrajhar and Dhubri.
E	:	Majuli (River island).

Each block is comprised of districts contiguous to one another on either banks of the river Brahmaputra.

Block-A, (Fig. 4): The Kaziranga National Park is situated in the Jorhat district. The movement of rhinos to and from this region to neighbouring areas like Golaghat, Laokhowa and Pabitora Wildlife Sanctuaries at Nowgong is a continuous process throughout the year. The aggregation

DIFFERENT BLOCKS DEMARCATED DURING PRESENT STUDIES ON DISTRIBUTION OF R. unicornis.

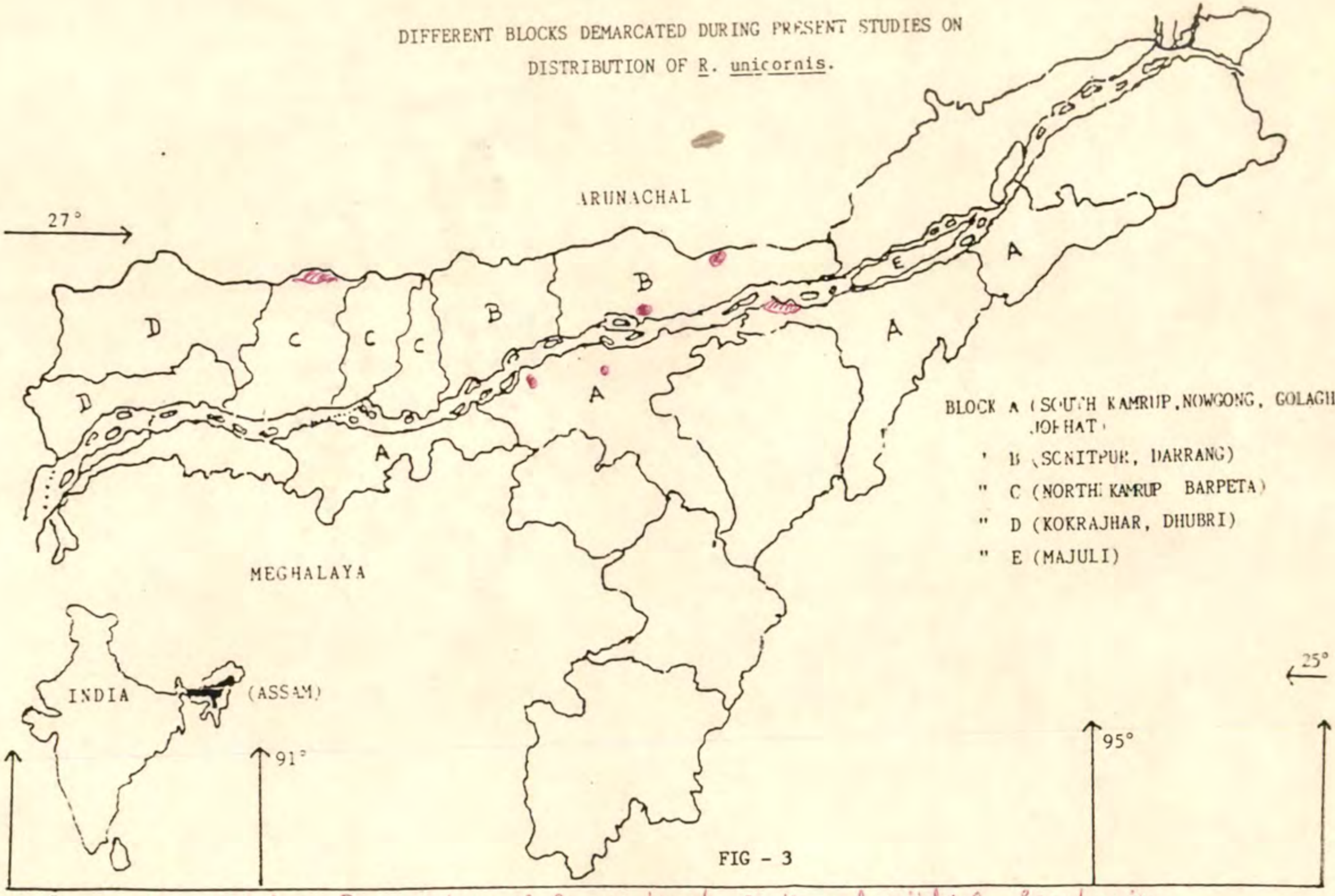


FIG – 3

Red mark showing the position of the National park and wild life Sanctuaries.

:ITE OF OCCURRENCE OF R. unicornis IN SOUTH KAMRUP, NOWGONG, GOLAGHAT & JORHAT

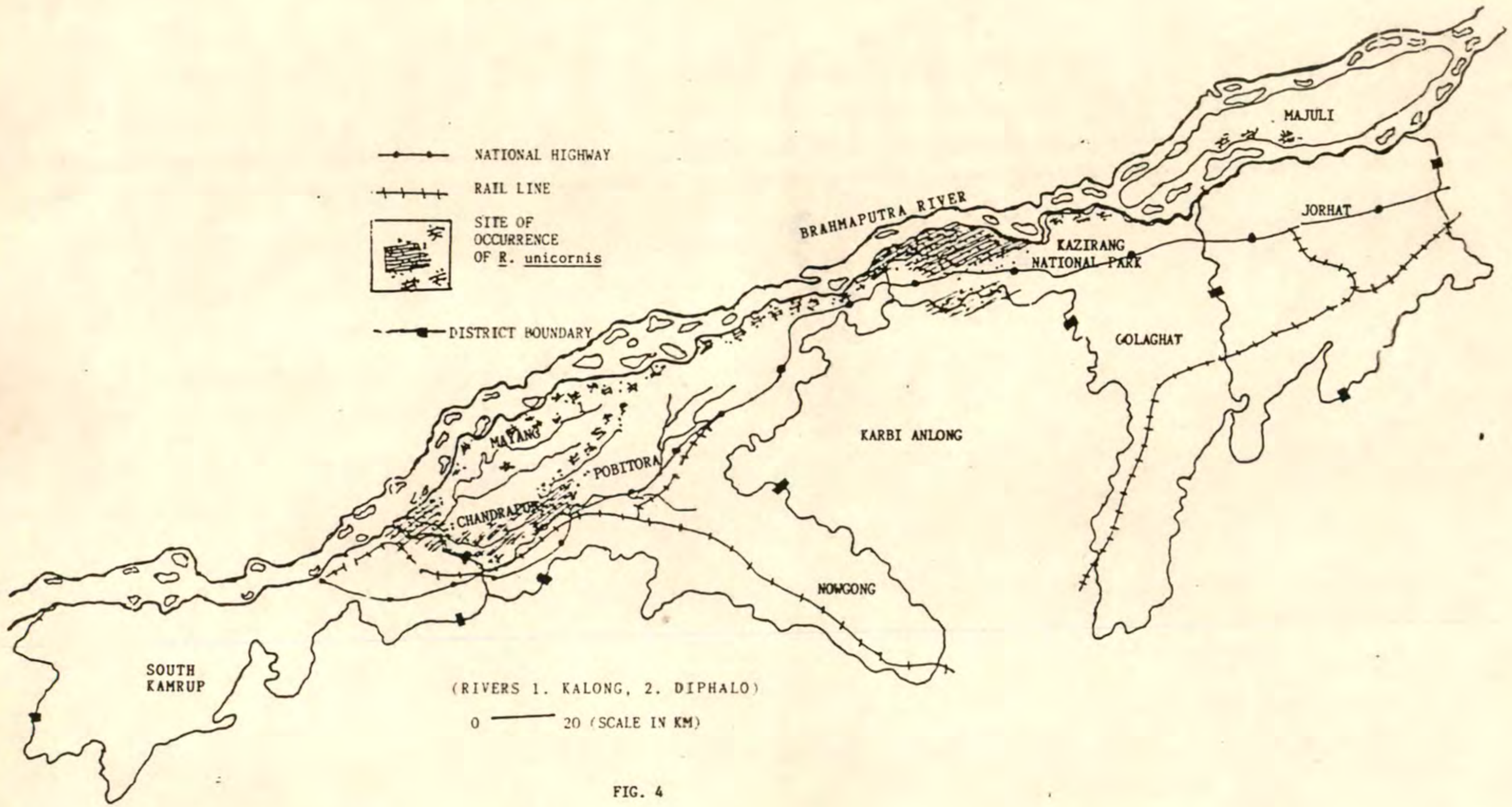


FIG. 4

of the species near Mayang (Nowgong) and Chandrapur (South Kamrup) forest reserve is noteworthy. The Chandrapur - Mayang reserve area situated in the south bank of the river Brahmaputra appears to be a new habitat of R. unicornis. The species is found to move between the river Brahmaputra and the railway tracks, which may be considered as the boundary line of their area of movement. The area convering about 250 square kilometers of Chandrapur - Mayang forest happens to be of a similar ecological conditions to that of Kaziranga National Park and is a suitable habitat for the speices. (However, no attemt has been made to study any ecological conditions of Chandrapur-Mayang areas. The comments on the similarity between Kaziranga and these regions have been made after visiting the said areas). The connecting routes between Chandrapur-Mayang reserve and Pobitora Wildlife Sanctuary ultimately lead to Kaziranga National Park.

Block-B (Fig.5): The Orang and Sonai-Rupai Wildlife Sanctuaries are located in this Block. R. unicornis move from Orang Wildlife Sanctuary along the bank of the river Brahmaputra from Darrang to the end of Sonitpur district. From October till April rhino inhabit and move around the bank of the river Brahmaputra. The species has been observed moving towards the border of Arunachal Pradesh - north of the river Brahmaputra covering a wide area from the river Dhansiri of Darrang to Sonai-Rupai river of Sonitpur District. Thus the species makes a

SITE OF OCCURRENCE OF R. unicornis IN DARRANG (A) & SONITPUR (B).

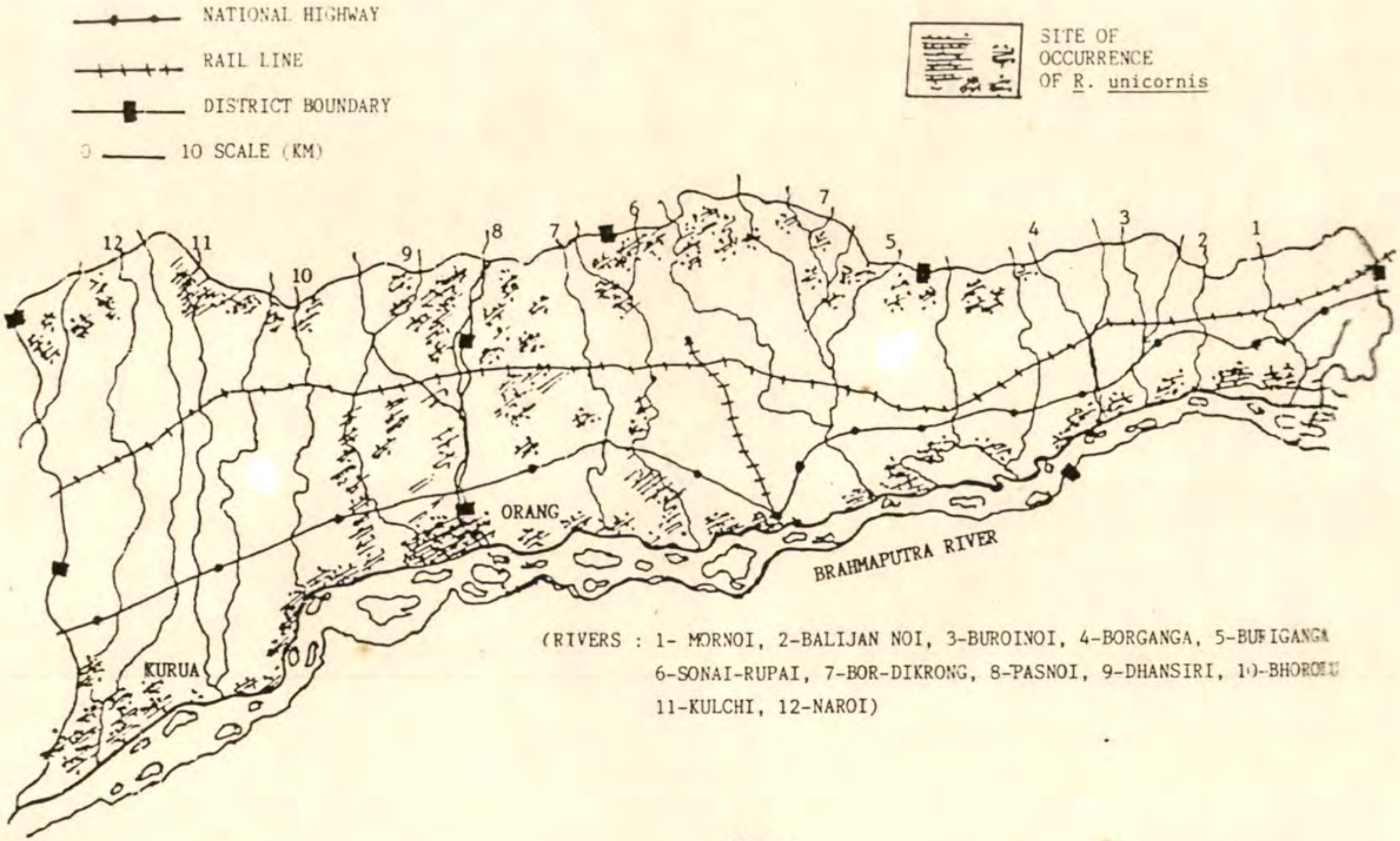


FIG - 5

wide ridge on the line or route of its movement from one place to the other. There are reports of locating rhinos movement as far as up to Buranoi of Sonitpur district crossing the railway lines, under large bridges of rivers Dhansiri, Mara-Dhansiri, Belsiri, Sonai-Rupai river etc. No reports are available of rhino movement beyond the Buranoi river through this route, whereas through the river bank of the Brahmaputra route the species was found moving up to Subansiri river in Lakhimpur district.

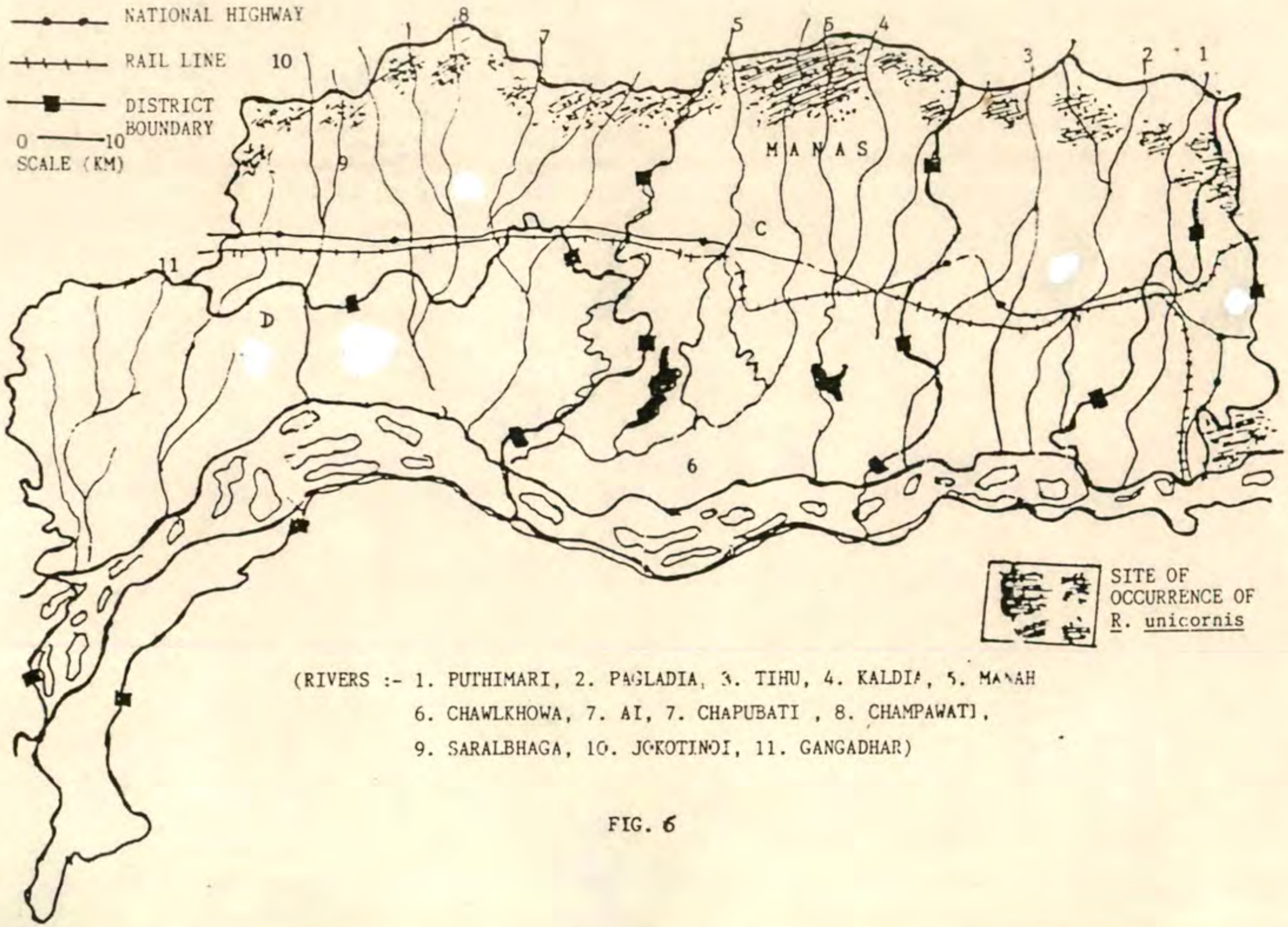
Block-C (Fig. 6): Block-C comprises of North Kamrup, Nalbari and Barpeta Districts. This Block is bounded in the north by foot hills of Himalayan ranges and in the south by the river Brahmaputra. Rhinos are found in the Mandakata area extending upto Amingaon. There are records of the constant movement of rhino in and around Mandakata, Kurua and few small char areas formed in the monsoon due to heavy silting of sand and debris of the river Brahmaputra. There are some instances of rhino attacks on the villagers of these areas.

The northern boundary of North Kamrup beyond Goreswar and Nokata at the base of the Bhutan hills marks the area where there is frequent occurrence of rhinoceroses. This northern route of rhino movement extends from Kaziranga through Sonitpur, Darrang, North Kamrup upto Manas Wildlife Sanctuary along the Nalbari, Barpeta and Kokrajhar districts. Further the Kakilabari forest reserve in Barpeta District where frequent occurrence of rhino has been encountered, has a connecting link with Manas Wildlife Sanctuary in which the rhino population is next to that of Kaziranga National Park.

Block-D (Fig. 6): Kokrajhar district showed a link between Manas and Jaldapara sanctuaries. The appearance of rhino along the northern belt in the foot hills of Bhutan is in continuation with Manas wildlife sanctuary is a significant bridge of rhino movement. Reports of the occurrence of rhino in Kokrajhar and Coochbehar District boundaries were very few except stray reports have been available through local press reporters. There was no evidence of the occurrence of rhino in Dhubri and Goalpara Districts.

Block-E (Fig. 4): Block E comprises of the biggest river island, Majuli in Jorhat District. There are few reports of the occurrence of rhinos in this place. The cause of its apperance here might be due to rhinos being swept aways by flood water either from the Kaziranga National Park or from other forest reserves of northern bank of the river Brahmaputra. In Table 5 the No. of R. unicornis encountered in different blocks besides the Kaziranga National Park and other wildlife sanctuaries are as follows:

SITE OF OCCURRENCE OF R. *unicornis* IN NORTH KAMRUP , NALBARI , BARPETA (C), KOKRAJHAR & DHUBRI (D).



(RIVERS :- 1. PUTHIMARI, 2. PAGLADIA, 3. TIHU, 4. KALDIA, 5. MANAH
6. CHAWLKHOWA, 7. AI, 7. CHAPUBATI , 8. CHAMPAWATI,
9. SARALBHAGA, 10. JOKOTINOI, 11. GANGADHAR)

FIG. 6

TABLE - 5

No. of *R. unicornis* encountered in different blocks (A-E) during 1984-1990.

Blocks		Line of movement	No. encountered in different years						
			1984	1985	1986	1987	1988	1989	1990
A.	i)	Chandrapur-Mayang	15	12	18	11	15	17	15
	ii)	Chandrapur-Mayang-Pobitora-Lawkhowa-Kaziranga	18	13	15	10	15	18	16
B.	i)	Along the bank of the river Brahmaputra	9	10	12	7	5	7	8
	ii)	Along the border of Arunachal Pradesh	8	7	7	5	9	7	8
	iii)	River Brahmaputra through Darrang and Sonitpur Districts up to Arunachal Pradesh	12	10	11	10	10	9	10
C.	i)	Mandakata-Kurua	9	8	10	5	9	8	9
	ii)	Northern belt of North Kamrup Nalbari and Barpeta Districts	10	9	10	11	10	5	8
D.	i)	Northern belt of Kokrajhar District	5	-	-	-	5	7	5
E.	i)	Majuli River island of Jorhat District.	-	-	1	-	2	3	2

The above number shown in Table 5 (A-E) are encountered in places outside the Sanctuary or National park.

The number of R. unicornis in each block and lines/routes of movement (Table - 5) have been duly confirmed after visiting the area as follow up action on the sources of information. However, there were unconfirmed reports of the existence of more rhinos in each block than those recorded in Table - 5.

DISCUSSION

The taxonomic status of rhinoceros showed that it is a small family with a five species radiation. Although ungulata as a whole is widely distributed with several radiated branches yet the perissodactyla group is a small number with 3 families only. Family Rhinocerotidae with its five living species radiated only in Africa, India and the South East Asian regions. The African species that includes D. bicornis - the hook liped black rhino C. simum - the square mouthed white rhino, the Asiatic speices that includes D. sumatrensis, which is a two-horned speices found in Sumatra and Borneo. R. sondaicus in Java and the one horned species R. unicornis is only confined to India (Assam and North Bengal) and Nepal are the radiated group of Rhinocerotidae. With its restricted habitat as well as distribution R. unicornis in India has shown certain significant modes of propagation and distribution in an around Kaziranga National Park. From its habitat and present distribution pattern it might be concluded that Kaziranga has been able to maintain its original home and from there the group has radiated or has migrated to Manas, Orang, Pabitora, Laokhowa, Sonai-Rupai area. The rhinos of Jaldapara might have come either from their original place i.e. Nepal or possibly have migrated from Manas. Recently, an attempt has been made to convert the Dudhwa National Park (80' E/28 N) of Uttar Pradesh (India) into the home of rhino. Certain experiments are being conducted, which will require some more time in order to establish their habitat and further propagation.

It has been observed that there was no record of movement of rhinos towards Goalpara, Dhubri, the eastern part of Lakhimpur and the entire Dibrugarh District, plains of Nagaland, which clearly indicates that regions are ecologically unsuitable for rhino habitation.

From the study of the routes of migration/movements of rhinos from their natural habitation e.g. Kaziranga National Park to other wildlife sanctuaries and neighbouring places, it might be concluded that some of the places like Mayang-Chandrapur appears to have some potentialities for the creation of a new rhino-land in the near future for allowing the further propagation of the speices. However, before doing so it would be necessary to make an indepth survey of the entire area in order to record its flora and fauna, annual rainfall, humidity temperature, waterbodies and other measures, as has been adopted to convert the Dudhwa National Park of Uttar Pradesh into new habitat of the great Indian one horned rhinoceros.

CHAPTER - III

HABITAT OF Rhinoceros unicornis IN NORTH EASTERN REGION OF INDIA

The primary requirement of a particular species of animal in the habitat is the environment conducive for its survival and propagation. It comprises mainly of availability of fertile soil, nutritions grass, source of drinking water, adequate rainfall, appropriate temperature, humidity and presence of flora and fauna for their interaction. The R. unicornis being one of the largest herbivore next to elephant, requires vast suitable grazing land with nutritious grass, shallow water bodies for wallowing ample space for relaxation and range of rain fall between 1100.8 mm and 2554.1 mm annually (Pathak 1978).

THE KAZIRANGA NATIONAL PARK:

The Kaziranga National Park is one of the famous National Parks of the world. The great Indian one horned rhinoceros (R. unicornis) is the main species of attraction along with some other rare flora and fauna found in the park. The National Park is in the North Eastern State of Assam, India and has a rich and varied flora and fauna, but is probably best known as the home of the largest existing population of great Indian one horned rhinoceros - R. unicornis. When Kaziranga was declared a reserve forst in 1908 it contained only a dozen rhinos (Gee, 1964). The reserve has been upgraded over the years - to a game Sanctuary in 1916, a Wildlife Sanctuary in 1950 and a National Park in 1974 - and the rhinos benefitted from conservation efforts. It is situated in between longitude 93°-5'E and 93°-40'E, latitude 26°-30'N and 26°-45'N. It covers the districts of Nagaon and Golaghat and is bounded by the river Brahmaputra in the North and the National Highway No. 37 along with the foot hills of Karbi Anglong. The climate of the Park is characterised by the tropical humidity along with the heavy rainfall in summer, particularly from June to August. The average annual rainfall recorded to be minimum 1100.8 mm, maximum 2554.1 mm and the temperature ranges from minimum 10.8°C (in January) to maximum 33°C (in June) with humidity - minimum 55 percent (in February)and maximum 88 percent (in December) Pathak (1978). The details on environmental parameters are described later on.

The mighty river Brahmaputra is flowing across the northern boundary of Kaziranga National Park. The tributaries Dipholoo, Bhangre, Borguri, Dirring, Kohora and Deopani of the Brahmaputra, flow through the Park from east to west. The soil of the Kaziranga National Park is alluvial plains. Due to the soft consistency of the soil, the tributaries change their courses frequently. The park is full of shallow water bodies (beels) and nullah which become inundated due to overflow of the tributaries and in rush of water from the Brahmaputra during the rainy season. Some times even two-third of the total area of the Park becomes submerged due to flood water, thus creating havoc for the flora and fauna of the Park.

The toal area of the Park is 429.96 sq.km. 42,496 hactares. It is predominantly covered by grassland with some forest area along with beels. Total water areas constitutes 5.5 percent of the total area of the park. Particularly in the eastern part of the Park there are tree forest while the western part covered by grasses and shrubs. The forest is of the evergreen and semi-evergreen type and often seen with cane breaks and heavy undergrowth. The vegetation is mostly composed of trees, shrubs and grasses (as shown in the results part of this chapter). A detailed studies on the Kaziranga National Park with reference to ecobiology of R. unicornis has been alucidated later on (Fig. 2, 7-15).

In the present investigation certain ecological aspects with reference to topography, type of vegetation - food plants of rainfall, humidity, temperature along with the mammalian fauna of the Kaziranga National Park have been studied.

THE MANAS WILDLIFE SANCTUARY:

The Manas Wildlife sanctuary is situated beween longitude 90°-30'E and 91°-30'E and Latitude 26°-30'N and 27°N and at the altitude of

FIG. 7. MAP SHOWING THE KAZIRANGA NATIONAL PARK, HABITAT OF RHINOCEROS UNICORNIS.
(Source: Wildlife division, Govt. of Assam, Forest Dept.)

FIG. 8-11: CERTAIN VIEW OF THE KAZIRANGA NATIONAL PARK.

FIG. 12 ; OTHER HERBIVORES FOUND IN THE NATURAL HABITAT OF *R. unicornis*.

Fig. 13

Fig 14

Fig. 15. (A)

FIG.13-15: TOPOGRAPHY OF THE HABITAT OF R. unicornis COVERING PLAIN AND SWAMP.

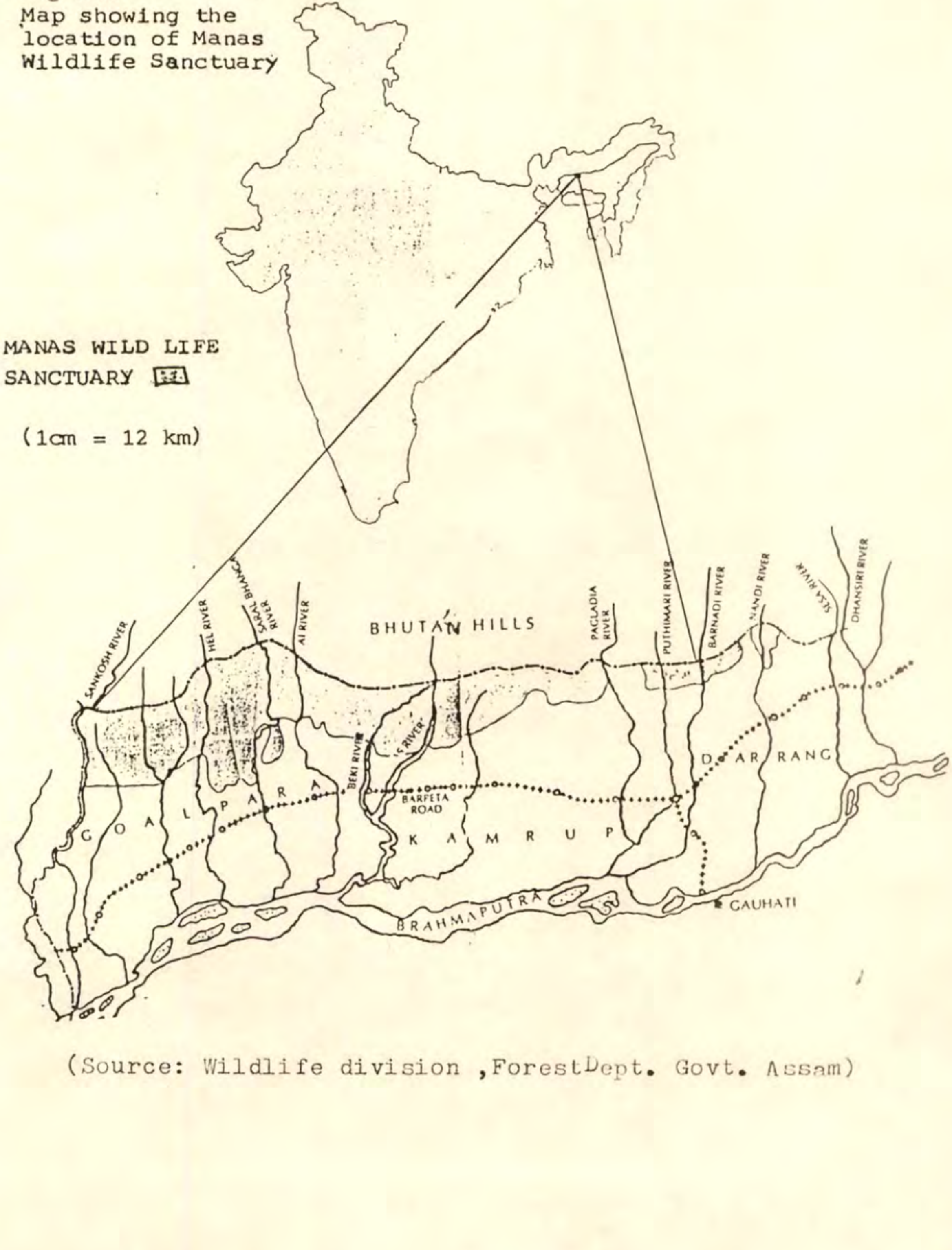
Fig. 15(B)

150m to 450m, above sea level in the North Eastern State of Assam in India. The total area of the sanctuary is 390 sq. km. The northern parts of the sanctuary are high and include the Bhutan foot-hills while the southern parts comprises of plains, grass lands and lowlying swamps. The water of streams is crystal clear and calm in the dry season.

The soil type varies from place to places being (i) sandy loam with rocks and (ii) alluvium (Debroy, 1988).

The Manas Wildlife sanctuary is one of the richest wildlife sanctuaries of the world possessing many rare and beautiful flora and fauna. It is mainly a reserve for tiger under the administrative control of Project Tiger, Government of India. It covers the northern parts of Dhubri, Kokrajhar, Barpeta and Nalbari districts of Assam. It occupies the foot hills of Bhutan, which is the eastern most branch of the Himalayan range. In the southern part human habitation along with Sal forest containing alluvial soil of recent origin and sizeable part of Manas Wildlife sancturary is covered by deep tree forest representing the Himalayan terrain (Fig. 16, 17, 18). The whole area of the Manas Wildlife sanctuary enjoys a tropical monsoon climate. The monsoon starts from the end of May and ends after September. The amount of rainfall at different locations varies from 2562 mm to 6278 mm and from the end of November to the beginning of April there is no rain, during this season the tributaries and streams exhibit a dry bed except

Fig .16
Map showing the location of Manas Wildlife Sanctuary



(Source: Wildlife division ,Forest Dept. Govt. Assam)

Fig. 17

Fig. 18

FIG.17-18: MANAS WILDLIFE SANCTUARY.

small channels of water running from northern hills to the southern plains, Debroy (1981).

The vegetation of the Manas Wildlife sanctuary consists of a wide spectrum of types and subtypes and associations of various plant communities. On a very broad classification it might be stated that the western part of the tract (West of the Aie river) is predominated by various subtypes of moist Sal (Shorea robusta) forest (East Himalayan upper Bhaber Sal, East Himalayn, lower Bhabar Sal and Eastern Tari Sal). In the eastern part, the absence of Sal (Shorea species) is conspicuous. Various serial states of riverine successions - Khoir-Sisoo forests, Simul patches and numerous combination of East Himalayan moist mixed deciduous types of forest occur in belts or patches throughout the area. Distinct belts and patches of Bhabar semi evergreen forests and wet miscellaneous semi-evergreen forest also occupy. In addition there are extensive areas covered by dry Savanna and wet Savanna formation. Other subtypes met with are pure patches of Koroi (Albezia procera) and occasional patches of Hollock (Terminalia myriocera) forest and very occasional canebreaks.

It has been found that the Manas Wildlife sanctuary exhibits an almost similar type of plant species that are associated with the habitat of R. unicornis in the Kaziranga National Park. A detailed survey of the various plant species was not included in the present study owing to the problem of attending to all the Sanctuaries at the same time. However, R. unicornis feeds on the same plant composition in their day-to-day life. A brief studies in Manas Wildlife sanctuary covering 200 km^2 have been shown in Table 6.

TABLE - 6

Topography of the studied are in Mans Wildlife Sanctuary

Total area km^2	Area covered Km^2	High land (hill) Km^2	Plains Km^2	Beels/low land Km^2
390	200	105	88	7
		(52.5%)	(44.0%)	(3.5%)

Mammalian species in the habitat of *R. unicornis* in Manas:

Varieties of mammalian species inhabit along with the Project Tiger Scheme of Manas Wildlife sanctuaries. In the present studies, the mammals recorded in the sanctuary have been listed. Although there is no detailed Census Report of various mammals in Manas, yet a list of the mammalian species are listed as follows (Table 7). There are 85 rhinos available in Manas. In the present investigation, however, no attempt has been made to enumerate the number of other mammals in Manas.

TABLE - 7

Mammals of Manas recorded in association with *R. unicornis*.

Common name	Scientific name	Common name	Scientific name
1. Royal Bengal tiger	*Pathera tigris*	9. Common langur	*Presbytis entellus*
2. Leopard	*Pantera pardus*	10. Indian civet	*Viverricula indica*
*3. Rhinoceros (85)	*Rhinoceros unicornis*	11. Common otters	*Lutra lutra*
4. Wild buffaloes	*Bubalus babalis*	12. Swamp deer	*Cervus davaeeli*
5. Elephant	*Eliphus maximus*	13. Hog deer	*Axis procinus*
6. Gaur	*Bos guarus*	14. Sambar	*Cervus unicolour*
7. Capped langur	*Presbytis ipleatus*	15. Pigmy hog	*Sus salvanius*
8. Golden langur	*Presbytis geeii*		

* Source Forest Department, Government of Assam

Environmental parameters of Manas Wildlife Sanctuary (Annual average, Debroy , 1980):

Parameters	Minimum	Maximum
Rainfall	2562 mm	6278 mm
Temperature	10.3°C	32.7°C
Humidity	60%	95%

THE ORANG WILDLIFE SANCTUARY:

The Orang Wildlife sanctuary is situated in the State of Assam, on the north bank of the river Brahmaputra from the latitude 26°20' to 26°35' North and longitude 92°20' to 92°50' East. The climate of the Sanctuary is tropical with heavy rainfall during summer amounting 2110.23 mm to 3166.36 mm (Bhattacharjee, 1983) in a year. The entire Sanctuary area is made up of flat alluvium of recent origin. It has a gradual steep towards the south which faces the river Brahmaputra. The soil varies from sandy loam clay to silt . The Sanctuary is somewhat plain in nature without possessing hilly areas. In the southern part of the Sanctuary, which is lower than the north, there are numerous beels and water pools which are of a perennial character. These beels serve as resting places of the rhinoceros during hot summer seasons of the year, where they wallow (Fig. 2).

Observing the habitat of R. unicornis in Orang Wildlife Sanctuary Bhattacharjee (1983) reported that the sanctuary is wildly covered by beels and low lands with scattered distribution of high lands and hillocks. The plains and low lands are covered by Saccharum species of long grass and acquatic plants while the high lands occupied by the tree forest consists of large trees like Bombex ciba, Dalbergia sissoo Gmelina arboroca, Michalia champak and Albizzia species.

The other animals inhabitating the Orang Wildlife sanctuary are Tiger (Panthera tigris), Leopard (P. pardus), Wild boar (Sus scrofa), Porcupines (Hytrix indica), common otters (Lutra lutra) and Assamese maccaques (Macaca assamensis).

Laurie (1978) in a study on the one horned rhinoceros (R. unicornis) of Nepal observed that the habitat of the rhinoceros mostly comprises Sal forest and flood plains. It consists of trees like Sal (Shorea robusta), Trewia undiflora, Litsaea monopatala etc. and grass like Saccharum, Spantaneum, S. munja, Cynodon dactylon and Imperata cylindrica.

Mammalian fauna in Orang Wildlife sanctuary:

There is no offical census report of the mammalian fauna of Orang wildlife sanctuary. In the present studies mammalian species recorded (Source: Forest Department, Government of Assam) were shown in Table 8.

TABLE - 8

Common name	Scientific name	Common name	Scientific name
1. One horned Rhinoceros (90)	Rhinoceros unicornis	6. Swamp deer	Cervus davauceli
2. The elephant	Eliphas maximus	7. Royal Bengal tiger	Panthera tigris
3. Leopard	Panthera pardus	8. Indian porcupine	Hytrix indica
4. Sambar	Cervus unicolour	9. Common otter	Lutra lutra
5. Barking deer	Muntjac muntjac	10. Sus scrofa	Sus scrofa

There are 90 R. unicornis in Orang (Forest Department, Government of Assam)

THE PABITORA WILDLIFE SANCTUARY:

The Pabitora wildlife sanctuary is the smallest wildlife sanctuary of Assam. It is located in the district of Nagaon on the south bank of the river Brahmaputra and situated between longitude 92°E and 93°E and latitude 26°N and 27°N Lauria (1978), Patar (1980). The altitude of the sanctuary is 50 m. bearing average rainfall 1588 mm. The total area of the sanctuary is 16 sq. km. comprising of low land and beels mostly.

Among the beels the 'Haduk beel' is famous. The sanctuary is covered by long grassy shrubs with scattered presence of tall trees. Few small hillocks namely the Bura-Buri pahar and the Mayang hillocks are part of the sanctuary. The herbivorous animals wre found grazing freely in this natural habitat. (Fig. 2).

The mammalian fauna inhabiting the Pabitora wildlife sanctuary in association with R. unicornis are Wild Buffalo (Bubalus bubalis), Swamp deer (Cervas davauceli), Hog deer (Axis porcinus), Barking deer (Muntiacus mutiac), Wild pig (Sus serofa), Common otter (Lutra lutra), Common langur (Presbytis entillus), Jackal (Canis surcus). There are 60 R. unicornis available in Pabitora (Source, Forest Department, Government of Assam).

THE SONAI-RUPAI WILDLIFE SANCTUARY:

The Sonai-Rupai wildlife sanctuary is situated on the foot hills of Himalayan range in Assam bordering Arunachal Pradesh. It is located between longitude 92°20'E to 92°40'E and latitude 26°-45'N to 26°55'N, occupying an area of 175 sq. km. The sanctuary is mostly occupied by tree forest which are semi-evergreen in nature. The wild mammals found are Great Indian one horned rhinocers (*R. unicornis*), Wild buffalo (*Bubalus bubalis*), Elephant (*Elephus maximus*), Tiger (*P. tigris*), Lepard (*P. pardus*), Indian Bison (*B. gaurus*), Sloth beer (*Melursus ursinus*), Wild boar (*Sus scrofa*), Swamp deer (*C. davauceli*) and Barking deer (*Muntiacus muntjak* (Fig. 2). There is no census report on any mammalian species.

MATERIAL AND METHODS

The studies with reference to the habitat of *R. unicornis* in the N. E. Region of India was carried out in the Kaziranga National Park.

(i) Blocks in the Kaziranga National Parks:

The survey with reference to flora fauna and certain environmental parameters of the habitat of *R. unicornis* were studied in 4 different blocks (Fig. 7B) covering 225 sq. km.

No.	Blocks
I	Bagori
II	Mihimukh
III	Arimorah
IV	Barbil

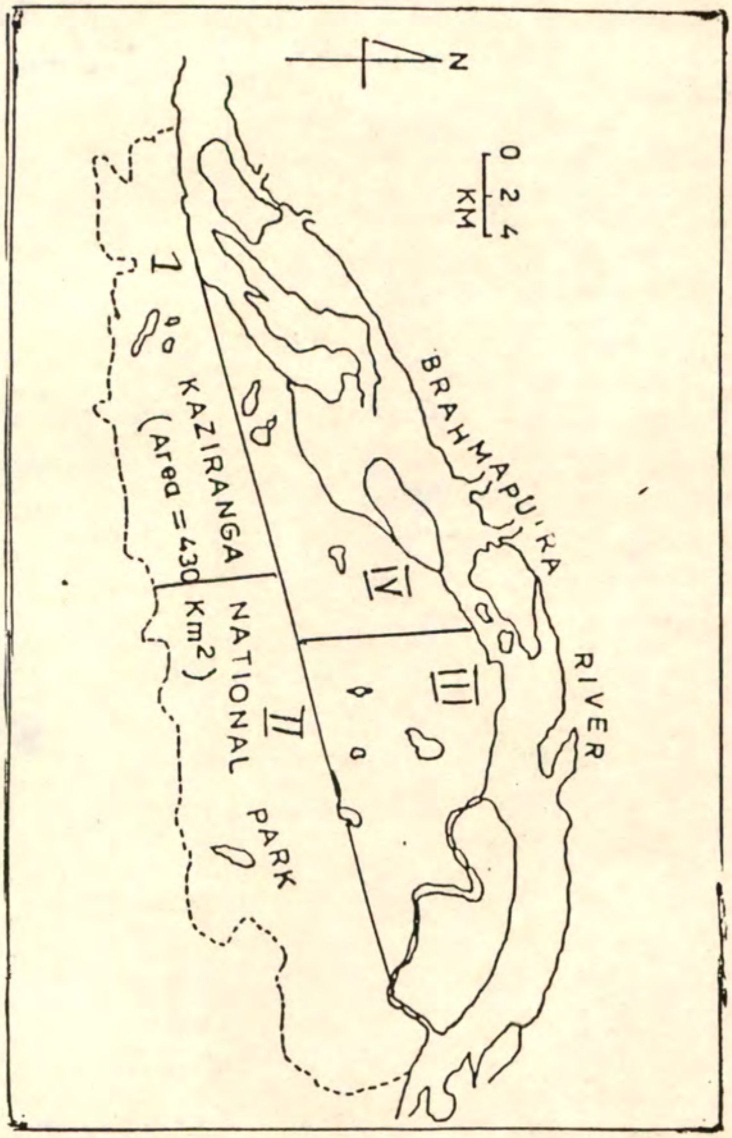


Fig. 7 B

Observation Blocks

(ii) **Identification of plant: (Food plant)**:

In surveying the plants available within the habitat of *R. unicornis*, it has been found that the animal feeds on almost all varieties of grasses, trees, of creepers including aquatic plants. However, a critical analysis was made on the type of plant usually consumed. The animal was followed during its grazing period and the grasses, shrubs/trees that were plucked or picked up during grazing by the animal were collected. The grass or shrubs showed the presence of saliva and loss or torn condition in the apical region. The identification of the plants has been followed after Dutta (1985).

(iii) **Observation in the National Park**:

The observations were made from jeep, elephant back, watch tower, and also walking in the habitat. Binoculars were often used at the time of obsrvation when necessary.

(iv) **Enumeration of animals**:

The number of animals in the different sanctuaries and particularly from the Kaziranga National Park were taken from the Census report of the Forest Department, Government of Assam and other Forest Department accounts (particularly the number of *R. unicornis* of 1990).

The enumeration of R. unicornis or other mammal in the Kaziranga National Park could not be attempted owing to several difficulties. Hence the population figure of the different animal is based on the statistics available with the Forest Department, Government of Assam.

The growth of population density of rhino and other herbivores population recorded from the Census records have been expressed from the exponential compound growth formula:

$Y_t = Y_o (1 + \alpha)^t$ (Croxton and Cowden, 1963); where Y_t = population at time t; Y_o = Population at time 0; t = interval period and α = compound annual grwoth rate.

(v) The rainfall, humidity and temperature of the Kaziranga National Park are were measured with the help of rain - gauge and hygrometer respectively installed in the offices of the Forest Department, Assam at Kohora and Bagori.

The readings were recorded every week for the period of the study.

RESULTS

In the present study a brief survey of the Kaziranga National Park has been done. Owing to experimental problems for attending all wildlife sanctuaries at a time, the other sanctuaries e.g. Manas, Orang, Pabitora and Sonai-Rupai, a detailed study could not be made. Hence, only certain parameters regarding the existence of rhinos and other mammalial faunas have been dealt with.

In the Kaziranga National Park, out of the total 430 sq. km. areas, 225 sq. km. have been included in the study, where 62 sq. km. (27.55%) was found to be high land, 142 sq. km. (62.11%) plains and 21 sq. km. (9.44%) low land/beels. In Manas wildlife sanctuary out of the total 390 sq. km. areas, 200, sq. km. has been studied where 105 sq. km. (52.50%) were found to be the high land, 88 sq. km. (44%) under plains and 7 sq. km. (3.5%) under low land (riverine/swampy).

In Kaziranga National Park, 29 percent of total area is covered by tree forest, 67 percent grass and shrubs and 4 percent was found to be covered by aquatic plants. In Manas wildlife sanctuary the vegetation comprises 35 percent tree forests, 62 percent grass and shrubs and 3 percent aquatic plants. In Orang wildlife sanctuary out of 1000 hectares taken under study, 30 percent was under tree forests, 60 percent under grass and shrubs and 10 percent was under aquatic plants. In Pabitora wildlife sanctuary, out of 1000 hectares studied, 22 percent was under tree forest, 71 percent under grass and shrubs and 7 percent under aquatic plants (Table 4).

Ecololgy of the Kaziranga National Park with reference to the presence of plants species as food plant, mammals and certain environmental parameters in association with the habitat of *R. unicornis*:

A survey has been carried out on the plants and mammals species in association with *R. unicornis* along with certain aspects of environmental parameters of the area such as rainfall, temperature and humidity (Tables 9-15).

TABLE - 9

Topography of the surveyed area.

Place of study	Total area (Km^2)	Area covered (Km^2)	Hill/high land (Km^2)	Plains (Km^2)	Beels/low land (Km^2)
Kaziranga	430	225	62 (27.55%)	142 (63.11%)	21 (9.44%)

Source : Forest Department Govt. of. Assam. 1990.

The plant species found in Kaziranga National Park are regarded as the food plants of *R. unicornis*. In Table 10, the survey of the plant species available in the habitat of *R. unicornis* is shown in detail. Most of the plants are the food plants of rhino and depending upon the situation and circumstances, the animal consumes these plants.

TABLE - 10

Plant species with their families associated with the habitat of *R. unicornis* in Kaziranga National Park. The species of plants (which are the food of the animals) shown in the table are arranged in alphabetical order and are maintained with the families concerned.

GRASS and SHRUB

Acanthaceae

Andrographis paniculata
Phlogacanthus curviflorus

Amaranthceae
Aquatic

Amaranthus spinosus
A. viridis

Anonaceae

Polyalthia jenkinsii

Apocynaceae

Nerium indicum
Rauwolfia serpentina

Asclepiadeceae

Calotropis gigantea

Chenopodiauae

Chenopodium album

Compositae

Ageratum conyzoides
Eupatorium odoratum

Ebenaceae

Diospyros peregrina

Gramineae

Andropogon aciculatus
Arundo donax
Bambusa baluca
B. tulda
Chrysopogon aciculatus
Cymbopogon pendulus
Erianthus filifolius
Erianthus ravaneal
Hemerthia compess
Hygroryza aristata
Hymnachne amplexicaulis

Imperata aurundane
I. cylindrica
Leersia hexandra
Neyraudia veynandiana
Phragmites karka

Gramineae

Pollinia cilitia
Pseudostachyum polymorphum
Saccharum arundinaceum
S. elephantium
S. nerenga
S. spontaneum
Vetiveria zizanioides

Labiatae

Leucus linifolia
Ocimum basilicum

Laurineae

Cinnamomum tamala
C. zeylanicum
Cassia fistula
C. tora
Desmodium laxiflorum
Erythrina suberosa
Flemingia strobilifera

Malvaceae

Urena lobata

Melastomaceae

Melastoma melabathricum

Moraceae

Ficus roxburghii

Myrtaceae

Eugenia fruticosa

Palmae

Calamus jenkinsianus
C. tenuis

Pinaceae

Cedrus deodara

Polygonaceae

Polygonum chinense
P. hamitonii

Rubiaceae

Saprosma ternatum

Rutaceae

Murraya exotica

Solanaceae

Solanum indicum

Scitamineae

Clinogyne dichotoma

Tamariscineae

Tamarix dioica

Umbelliferae

Hydrocotyle rotundifolia

H. asiatica

Urticaceae

Laportes crenulata

Verbenaceae

Clerodendrum infortunatum

Lantana camara

Zingiberaceae

Zingiberaceae

Alpinia allughas

A. molluccensis

TREES

Anacardiaceae

Mangifera indica

Spondias mangifera

Anonaceae

Alphonsea ventricosa

Polyalthia simiarum

Apocynaceae

Alstonia scholaris

Holarrhena antidysenterica

Wrightia tomentosa

Araliaceae

Heteropanax fragrans

Bignoniaceae

Oroxylum indicum

Stereospermum chelonoides

Bixineae

Gynocardia odorata

Hydnocarpus kurzii

Boraginanceae

Ehretia acuminata

Burseraceae

Boswelli serrata

Canarium benglense

Garuga pinnata

Capparidaceae

Crataeva religiosa

Combretaceae

Terminalia belerica

T. citrina

T. myriocarpa

Cornaceae

Nyssa sessiliflora

Cupulifereae or **Fagaceae**

Castonopsis indica

Datiscaceae

Tetrameles nudiflora

Dilleniaceae

Dillenia indica

D. scrabella

Dipterocarpaceae

Dipterocarpus macrocarpus

Shorea assamica

Elaeocarpaceae

Elaeocarpus floribundus

Euphorbiaceaa

Antidesma bunius

Biscofia javanjica

Emblica officinalis

Bridelia retusa

Mallotus philippensis

Sapium baccatum

Trewia nudiflora

Geraniaceae

Averrhoa carambola

Mansonia dipikae

Guttifereae

Garcinia xanthochymus

Kayea assamica

Mesua ferrae

Hamamelidaceae

Altingia excelsa

Hippocastanaceae

Aesculus penduana

Juglanelceae

Engelhardtia spicata

Lacythidaceae

Barringtonia acutangula

Lauraceae

Actino daphne obovata

Cinnamomum cecicodaphene

C. obtusifolium

C. tamala

litsea polyentha

Machilus bombycina

Phoebe goalparensis

Leguminosae

Albizzia julibrissin

A. lebbek

A. lucida

A. odoratissima

A. procera

A. stipulata

Bauhinia malabarica

B. purpurea

B. variegata

Erythrina indica

E. suberosa

Cassia fistula

Parkia roxburghii

Saraca indica

Tamarindus indica

Lythraceae

Duabanga sonneratioides

Lagerstroemia flosreginae

L. parviflora

Malvaceae

Bombax malabaricum
Kydia calycina

Magnoliaceae

Magnolia griffithii
Manglietia insignis
Michelia oblonga
Pchylarnax pleiocarpa
Talauma hodgsoni
T. phellocarpa

Meliaceae

Amoora wallichii
Azadirachta indica
Cedrela toona
Chikrassia tabularis
Dysoxylum hamiltonium
D. procerum
Melia azedarach

Moraceae

Artocarpus chaplasha
A. integrifolia
A. lakoocha
Ficus bengalensis
F. elastica
F. glomerata
F. infectoria
F. religiosa

Myriaticeae

Barringtonia acutangula
Euigenia jambolana
Myristica kingii

Myrtaceae

Eugenia operculata
E. praecox

Palmeae

Livistonia jenkinsiana
Phoenix sylvestris

Rhamnaceae

Zizyphus jujuba

Rhizophoraceae

Carallia integerima

Rubiaceae

Adina cordifolia
A. griffithii
Anthocephalus cadamba
Randia dumetonum

Rutaceae

Aegle marmelos
Evodia meliaefolia
Zanthoxylum budrunga

Sabiaceae

Meliosma simplicifolia

Salicaneae

Salix tetrasperma

TREES

Sapindaceae

Nephelium longana

Sapotaceae

Donella roxburghii

Simarubeae

Ailanthus grandis

Sterculiaceae

Pterospermum acerifolium

Sterculia alata

S. villosa

Styraceae

Symplocos racemosa

S. spicata

Theaceae

Schima wallichii

Tiliaceae

Echinocarpus assamicus

Elaeocarpus floribundus

E. ganitrus

E. robustus

Verbenaceae

Callicarpa arborea

Gmelina arborea

Premna bengalensis

P. latifolia

Vitex penduncularis

V. trifolia

Viteceae

Leea sambusina

AQUATIC

Alismatacea

Sagittaria sagittifolia

Araceae

Colocasia esculenta

Pistia stratiotes

Asteraceae

Enhydra fluctuans

Ceratophylaceae

Ceratophyllum durersum

Compositae

Xanthium strumarium /

Convolvulaceae

Ipomoea aquatica

I. reptans

Cyperaceae

Cyperus pilosus

Kyllingia brevifolia

Gramineae

Eleusine indica

Eragrostis unioloides

Hydrocharitaceae

Hydrilla verticilliata

Villisneria spiralis

Lamnaceae

Lemna pancicostata

Wolffia arrhiza

Leguminosae

Aeschynomene indica

AQUATIC

Najadaceae

Naja graminea

Nymphaeceae

Nelumbo nucifera

Nymphaea nelumbo

Potagnogetonaceae

Typha elephantina

Potedeniaceae

Eichhornia crassipes

Polygonaceae

P. hydropiper

Typhaceae

Typha elephantina

Mammalian species living in association R. unicornis in the Kaziranga National Park:

Several other mammalian species observed in association with R. unicornis in the Kaziranga National Park have been enumerated in Table 11. Food habits of herbivores were found to be similar to R. unicornis. Such herbivores graze in the same grazing ground, sharing the same vegetation with R. unicornis. The population density of herbivores along with R. unicornis per square kilometre and their growth rate are shown in Table .

Besides herbivores several carnivores and primates recorded in the Census report from 1966 to 1984 are shown below:

TABLE - 11

Number of herbivorus animals including R. unicornis in the Kaziranga National Park.

Species of herbivorus	Year of Census				
	1966	1972	1978	1984	1990 * (+)
1. *R. unicornis*	400	670	960	1080	1200
2. Wild buffalo (*Bubalis bubalis*)	550	600	660	700	**
3. Bison or Gaur (*Bos gurus*)	20	18	25	30	**
4. Elephant (*Elephas maximus*)	375	430	780	500	**
5. Sambar (*Cervus unicolour*)	300	200	300	350	**
6. Swamp deer (*Cervus devauceli*)	250	520	700	750	**
7. Hog deer (*Axis porsinus*)	4500 (Approx)	6250 (Approx)	8500 (Approx)	9500 (Approx)	**
8. Berking deer (*Muntiacus muntjac*)	100	100	100	100	**
TOTAL	6495	8788	12025	13010	

* Obtained from the Forest Department.

** Date could not be obtained.

(The record of Sloth bear (*Melursus porsinus*) is not included)

(+) Changkakaty, 1990: Chief Conservator, Wildlife Div. Govt. Assam.

Continued -

Species	Number in different year of census			
	1966	1972	1978	1984
Leopard*				
(Panthera pardus)	12	10	10	15
Wild pig				
(Sus scrofa)	500-600	600-650	800-900	3000-4000
Otter				
(Lutra lutra)	200-300	200-300	400-500	700-800
Hog badger				
(Arctonys collaris)	-	-	50	70
Capped langur				
(Presbytis pileatna)	-	-	25	50
Gibon				
(Presbytis geeii)	-	-	3	10

* Leopard includes tiger also as per census report. There is no census record on Tiger (Panthera tigris), but there are some tigers in the National Park.

TABLE - 12

Population density and percentage of increase of population of herbivorous animals in the Kaziranga National Park

1.	Total area of National Park 430 sq. km.					
		Year of Census				
		1966	1972	1978	1984	1990
2. (i)	Density of population of R. unicornis (Per Sq. Km.)	0.93	1.56	2.23	2.51	2.79
(ii)	Population growth between Census periods, per year in percentage.	-	11.25	7.21	2.08	1.85
3. (i)	Density of population of other herbivorous, excluding R. unicornis (per sq. km.)	14.17	18.87	25.73	27.74	*
(ii)	Population growth between Census period, per year in percentage.	-	5.54	5.85	1.30	*
4. (i)	Density of population of all the herbivorous including R. unicornis (per sq. km.)	15.10	20.43	27.96	30.25	*
(ii)	Population growth between census period, per year in percentage.	-	6.14	6.14	1.36	*

Population density of R. unicornis and some other herbivorcus mammal and percent increase in their population between census.report.

* Data could not be obtained.

Environmental parameters:

Certain environmental parameters of Kaziranga National Park were studied from 1985 to 1988. The different aspects such as rainfall, temperature and humidity were examined and recorded in Table 13, 14 and 15 respectively.

DISCUSSION

The study of the ecological status with respect to the topography of the natural habitat, types of vegetation and presence of other wild animals, reveals that the R. unicornis inhabitats the low lying wet plains, covered by long grasses along with trees where many large ungulates along with some other herbivores and carnivores are found.

The topography of the Kaziranga National Park showed that 63.11 percent of the park area was plain, 27.55 percent high land including hills and of 9.44 percent area are under beels, while in Manas wildlife sanctuary (52.50%) area was found to be under hills and high land, 44 percent under plains and 3.5 percent under low land. The topography of the Orang and Pobitora wildlife sanctuaries composed respectively of high land, hills - 50% and 30%, plain land 31.25% and 50%, low land 18.25 and 25%.

TABLE - 13

Showing the monthly average rainfall in Kaziranga National Park during the period 1985 to 1988

Measurement in mm

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1985	0.3	38.2	147.6	305.2	143.4	327.7	267.1	184.0	219.3	74.6	15.4	22.5	1450.0
1986	18.5	16.0	19.8	289.0	103.4	137.2	238.3	239.4	216.6	238.1	30.5	7.4	2554.1
1987	2.3	25.4	78.9	84.4	94.0	215.2	565.8	197.7	504.3	58.6	2.7	23.6	1100.8
1988	2.0	37.3	64.6	105.2	290.8	269.4	263.5	227.0	151.9	128.9	46.8	0	1588.4

TABLE - 14

Showing the monthly average temperature of the Kaziranga National Park during 1985 to 1988

Measurement in celsius

Year	Amount	Jan.	Feb	March	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
1985	Minimum	10.8	12.8	18.1	20.8	22.4	24.9	25.1	25.9	24.7	22.1	15.7	12.8	19.6
	Maximum	23.6	24.8	29.1	30.6	31.3	31.6	30.4	32.5	31.5	30.7	17.5	17.9	27.6
1986	Minimum	11.2	11.7	15.7	20.0	22.0	25.1	25.7	25.4	24.3	20.8	17.1	12.2	19.2
	Maximum	23.6	27.0	31.5	29.8	31.4	33.0	31.7	32.7	30.4	28.6	27.0	24.3	29.3
1987	Minimum	10.9	13.3	17.0	20.2	22.7	25.3	25.4	25.5	25.0	22.5	18.4	12.7	19.9
	Maximum	24.5	27.3	27.9	30.5	32.3	32.2	30.9	31.2	31.0	29.6	27.5	24.9	29.1
1988	Minimum	11.6	13.9	16.9	20.3	22.7	25.3	26.0	25.8	24.9	22.4	17.3	14.5	20.1
	Maximum	24.1	27.3	28.9	31.0	30.1	31.8	32.0	31.1	31.4	30.0	27.6	24.9	29.1

TABLE - 15

Showing the monthly average humidity in Kaziranga National Park for the year 1988.

Measurement in percent

Year	Amount	Jan.	Feb.	March	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
1988	Morning (8.30)	85	78	70	75	83	80	85	89	85	85	85	88	82.3
	Evening (17.30)	69	55	58	61	72	79	79	84	81	81	77	79	72.9

The tree forest occupies mostly the high land and 25 percent of the areas are forested with different species of trees. The animals consumes leaves of the trees mentioned.

It has been found that high rainfall (1100-2554 mm/year),humidity (89%) and warm temperature provide a suitable environment for the habit of R. unicornis.

The present investigation reveals that the number of R. unicornis population in the Kaziranga National Park since 1966 till 1984 was not satisfactory, although apparently the total number found to have increased to 1080 in 1984 from 400 in 1966. The percentage of increase during 1966 to 1972 shows 9 percent, thereafter, it has gradually declined during 1972-78 and 1978-84 census periods to 7.21 percent and 2.08 percent respectively. It has further declined to 1.85 percent during 1990. Which is a matter of great concern. Various factors might have attributed to the gradual decline in the percent growth of R. unicornis population in the National Park, which are enumerated elsewhere. The situation demands immediate attention of the authority concerned, in order to take appropriate measures in the interest of conservation of the rare species of R. unicornis as well as other herbivores.

Six different herbivorous animals in addition to a *R. unicornis* were found to live together in 430 sq. km. area of the Kaziranga National Park. Comprising of high and plan land, tree forests, river beels and low lying areas. The population of each of the species excluding elephants were recorded as per census reports of 1966, 1972, 1978 and 1984 in Table 11. The population density per sq. km. of 430 sq. km. land area of the Park separately, for *R. unicornis* and six other commonly associated herbivorous together with *R. unicornis* have have been calculated and presented in the Table 12.

The results indicate gradual increase in the population density from 0.93 to 2.51 sq. km. during the census periods from 1966 to 1984 in case of *R. unicornis*. The population density of other herbivores excluding *R. unicornis* increased from 14.17 to 27.74 per sq. km. and 15.10 to 30.25 per sq. km. during the same census periods when all the herbivores including *R. unicornis* were taken together. Although there was apparent increase in the population of the herbivores including *R. unicornis*, since 1966 census till 1990, the rate of increase in the population considering 1966 as base year (Choudhury, 1978) it has been observed that there was 9 percent increase in *R. unicornis* population from 1966 to 1972 and the percentage gradually declined thereafter to 7.21 percent during 1972-78 and to 1.98 percent during 1978-84, census periods and to 1.85% upto 1990. Similarly the percent increase in the population of other herbivores also have shown similar trend (Table 12), indicating same affect on the population growth which requires to be viewed with great concern. The decreasing trend in the population growth might be due to different factors like

1. Shrinkage of grazing ground because of -

    (i) Reduction of total land area caused by continuous erosion in the northern border of the Park by the Brahmaputra river.

    (ii) Increase in the population density of herbivorous animals per sq. km. of grazing ground.

    (iii) Sharing of the grazing ground in the park by stray/domesticated cattle/buffalo inhabiting in the neighbourhood of the park.

    (iv) Damage of grazing grounds by frequent occurrence of flood.

2. Death of especially *R. unicornis* during flood, or accidents and mostly due to gradual increase in the incidence of poaching and other killings/death.

3. Migration to other wildlife sanctuaries or neighbouring forests in search of food.

All these factors required to be examined in proper perspective and adopt appropriate measure to reduce the population density either by increasing the park area or creating new rhino land, besides rescheduling the conservation policy in the interest of future propagation of the precious animals especially the rhino population in particular and other wild animals (herbivores) in general.

CHAPTER - IV

FOODS AND FEEDING HABITS OF Rhinoceros unicornis

Rhinoceroses are herbivorous animals. They depend chiefly on grasses, shrubs, plant leaves and occasionally on aquatic plants for their food. In captive condition, concentrate feed is added to the leafy palate. Scientific information regarding feeds and feeding habits of rhinoceros is very scanty.

Hubback (1939), Stickland (1967), Goddard (1968) and Borner (1979) in their studies on D. sumatransis reported that the behaviour with reference to types of food consumed may be concluded as saplings, leaves, twigs, shrubs and fruits. In case of R. sondaicus Hazewinkel (1933), Soley (1959), Schenkel and Schenkel Hulliger (1969)b and Hoogerwelf (1970) reported as saplings, shrubs, fruits, leaves, tall grasses, herbs and palms. Schenkel and Schenkel Hulliger (1969)a stated that the normal food items of the black rhinoceros are small trees, bushes, shrubs, some very low plants and even occasionally grasses. The feeding technique has to be adapted to the respective type of food plants. Generally some twigs or stems are seized with prehensile upper lip, pulled out, bent, then cut off with premolars and finally chewed from proximal to distal.

LaurieS(1978) has stated that R. unicornis (from Nepal) exhibit a wide variety of feeding methods, where feeding on tall grass, they use the prehensile upper lip to curl around the grass, stems and then bend the stems over, bite the tops off and chew them, drawing the tips into the mouth from side. In case of very tall grass rhinos often walk forward with stems between their legs, pushing the stems down; short grass and herbs are grazed closed to the ground. Aquatic plants are taken by ducking the head beneath the water some times to the level of the feet and a metre or more below the water surface. Rhinoceros keep their head under water for a period of upto 45 seconds, but ingest the feed only with their heads above water

Grzimek (1970) stated that black rhinoceroses (D. bicornis) have a peculiar fondness for twigs, where the pointed upper lip can grasp like a finger or hand. They graze on a grassy plain and sometimes uproot the tiny little new bushes. Observing the captive R. unicornis at the Basel Zoo, Grzimek (1970) further stated that it fed upon the basic diet of good quality hay which at times may be mixed with alfalfa, a special compound of oil cake and several cereals, necessary vitamins and minerals. An adult Great Indian rhinoceros eats about 15 kg of hay per day, 4 to 6 kg Basel's special compounds and drinks 80 to 100 litres of water per day in Basel Zoo. Describing the artificial feeding in neonate animals Walker (1986) stated that a rhinoceros calf has been reared successfully on a 1:1 mixture of skim milk powder and calf milk replacer diluted with water and supplied with vitamins and minerals. The author also stated that the rhinoceros calf suckle every half to 2 hours and therefore, must be fed accordingly.

Crandall (1971) elaborated the feed items of an adult female Indian one horned rhinoceros in captive state consisting of about 60 pounds of hay, usual alfalfa with clover or fine timothy, some time substituted with 10 pounds of commercial feeding pellets containing minerals and vitamin supplements. In addition, the animal was given raw white potatoes, carrot, cabbage or other green vegetables and two to three loaves of bread during the day.

In the present experiment a study has been undertaken regarding the food and feeding habits in different habitats as in natural habitat - Kaziranga National Park and in captive condition - Assam State Zoo. Although Laurie (1978) has reported on the foods and other habits of R. unicornis from the Nepal area, yet there is no other concrete report from the principal habitat of R. unicornis, North East India i.e. Kaziranga National Park.

METERIALS AND METHODS

The feeding habit of R. unicornis were studied under natural condition in the Kaziranga National Park, as well as under captive condition at the State Zoo, Guwahati, Assam. Under natural condition different modes of grazing on short grasses and browsing on tall grasses were observed. It was not possible to estimate the quantity of each type of grass and plants taken by the animal under natural condition ; under captive condition at the State Zoo study was made on routine supply of grass and other food items to the animal.

The identification of food plants has already been described in Chapter III.

R. unicornis were observed to feed on large varieties of other plants, besides the plant species available in the habitat described in Chapter III. No selective difference was observed between male and female irrespective of age groups, with regard to their picking-up habits of these plants while grazing.

DIFFERENCE STATUS OF FOOD PLANTS:

The food plants commonly available in the Kaziranga National Park preferred by R. unicornis have been described in Table 9. These plants are avilable throughout the year except during the monsoon, when they get damaged during floods due to deposition of silt over them or due to inundation for a long time. Out of all the plants described earlier, a few plants were observed to be the principal food plants of both the sexes of R. unicornis while grazing, irrespective of day and night. In view of these facts special attention was given in the selection and identification of these plants which are recorded in Table 16.

TABLE

TABLE - 16

The principal food plants chiefly preferred by R. unicornis in the Kaziranga National Park. The species are arranged in alphabetical order.

Name of the plant	Name of the plant
Amaranthus spinosus	Hydrocotyle asiatica
Andropogon aciculatus	Hygroryza aristata
Arundo donax	Hymenachue amplexicaulis
Bauhinia malabarica	Imperata aurundanae
Bombax malabaricum	I. cylindrica
Chenopodium album	Ipomea reptans
Cynodon dactylon	Leea sambasia
Cyperus pilosus	Leersia hexandra
Eichhornia crassipes	Listsea polyentha
Elaeocaupus	Moras alba
Erienthus filifolious	Nymphea lotus
E. revaneae	Phragmites karka
Erythrina suberosa	Pistia stratiotes
Ficus benglensis	Saccharum elephanteum
Hemarthia compess	S. spontenum
	Vetiveria zizanioides

Note: The details of pick-up/No. of bites frequencies of food plants by an adult male and female R. unicornis has been shown in Table 16A - Appendix A (Page 286).

In order to study the pick-up frequency of these plants, one adult male and a female *R. unicornis* were selected with specific identification marks in 3 (three) different places *viz*, Bagori, Arimorah and Mihimukh of the park. Further, the same animal sometimes could not be followed on each days of observation for various reasons (mainly because they change the particular spot next day or remain far away from the place of observation). They study was conducted for 7 (seven) consecutive days in each month during 1987-88, except during monsoon, for obvious reasons.

The pick-up frequency and number of each plant species were observed from a safe distance (50-100 metre) from the animal and the number recorded. However, the exact figure of pick-up on a particular speices of plant could not be ascertained or identified and recorded. It has been observed that in each pick-up depending upon the availability different species of food plants more than one species of food plant were taken together at a time which could not be identified due to constraints of visibility from a dinstance which had to be maintained for safety. The food plants identified as the first preferred group are recorded in Table 17. The study reveals that 85% of these food plants (Table 17) constitutes the total consumption of food plants per day by *R. unicornis.*

The first preference status plants as shown in Table 17 were expressed in percent after calculating the number of plant species collected for identification immediately after grazing from various grazing spots.

TABLE - 17

First preference status of food plants of R. unicornis observed in the Kaziranga National Park.

Arundo donax	Hymenachue aristata
Cyperus pilosus	Imperata cylindrica
Cynodon dactylon	Leersia hexandra
Erienthus revaneae	Phragmites karka
Hemarthia compess	Saccharum elephanteum
	S. spontenum

GRAZING HABIT AND PICK-UP BEHAVIOUR:

The habit of grazing and pick-up behaviour were studied in adult R. unicornis while grazing. Tall (about 40 cm in length) and short (below 40 cm in length) plants in two different periods of the year of studies - viz - September to January and February to August at Bagori, Mihimukh and Arimorah of the Kaziranga National Park. The observations have been recorded and presented in Table 18.

It was observed that R. unicornis used to pick-up both tall and short grasses continuously, with a short interval between each pick-up. While grazing in the area of tall grasses like S. elephanteum, S. sponteneum, P. karka, E. revaneae etc., the animal used to crush the stem of the grass with its fore legs and pick up both tender and mature leaves alongwith the branches, with the head down. The species was observed to have given more preference to tender shoots rather than mature leaves. Occasionally the animals were found to pluck the apical portions or the tender branches with leaves with its tongue without crushing the tall grass when it could reach with its head raised.

Difficulties were faced in counting the pick-up when the animal enters deep into the tall grasses while grazing.

The difference of time taken for pick-up (Table 18) might be due to the quantity of plants available at the site, to fill up the mouth.

FEEDING ON AQUATIC PLANTS:

The aquatic plants which R. unicornis feeds on are H. amplexus, I. hexandra, L. reptum, L. lanciust, P. shatistes, P. stralia, E. flueluans.

These plants grow in the water-bed of low lying arear or swamps. The R. unicornis grazes on these plants either from the bank or getting

TABLE - 18

Habit of picking up short grasses.

Places of observations	Period of observations	Nos. of animals	T.S.P.	N.P.	T.S.M.
Bagari	(i) Sept.-Jan.	30	50-180	30-50	30-90
	(ii) Feb. -Aug.	25	80-230	40-70	30-90
Mahimukh	(i) Sept.-Jan.	7	70-175	52-81	35-100
	(ii) Feb. -Aug.	5	92-210	60-80	30-95
Arimorah	(i) Sept.-Jan	3	105-250	72-90	40-98
	(ii) Feb. -Aug	2	110-215	75-110	42-95

Abbreviation:

T.S.P. = Time in second, spent for picking up plants at a time;

T.S.M. = Time in second, spent for mastication of each pick up;

N.P. = Number of pick-up during each T.S.P.

down into these low lying areas or swamps, ducking the head down into the water for 30 to 40 seconds for each pick-up. Plants were seen to be masticated by the animals between each pick-up by raising the head above the water.

The species was observed to consume vegetation under deep water by getting its body almost submerged keeping the back of the body only visible over water. Beside, the species could dive into deep water up to about 3 to 4 metres. While eating vegetation, it used to keep the head under water for 3-4 minutes for each pick-up and the duration varied depending perhaps upon the availability of vegetation.In addition to these aquatic vegetation _R. unicornis_ was found to consume tubers of water lillies grown on shallow and swampy water bodies.

FEEDING BEHAVIOUR DURING FLOOD AND IMMEDIATELY AFTER RECESSION OF FLOOD WATER:

Flood is an annual phenomenon in Assam and is a major catastrophe for flora and fauna of Kaziranga National Park. The floods occur two to five times in a year; the rivers within the Park overflow their banks and submerge more than 3/4 th of the total area of the Park. The area thus submerged remains under water for several days or weeks. During high floods the water of the Brahmaputra river also enters the Park. Almost all the wild animals have to take shelter on high land-of the Park or migrate to Karbi hills near by leaving the protected area of the Park, exposing themselves to the easy hunt of poachers. In addition, the death of adult rhinos and young calves occur due to accidents taking place while crossing the road. Some are swept away by swift current of flood water. Recurrent floods and slow receding of flood water submerges the vegetation for long periods, maintaining the swampy nature of the ecosystem causing decay and deposition of sand-silt over them, arresting growth of vegetation, thus creating scarcity of food for herbivorous animals, like rhinos, buffaloes, deer etc. After recession, of the flood water until new grasses grow, migrated animals, prefer to live away from the Park returning after the recession of the flood water.

During such situations animals which did not migrate and lived in the Park and in the neighbourhood had to feed on aquatic plants and tall grasses. The animals were found to change the habit of feeding towards semibrowser during flood.

The animals which move to the Karbi hills, on the southern boundary of the Parks and across the National Highway - 37 during flood are forced to pick-up any form of vegetation particularly small trees in the hills besides similar plants those are available in the Park. R. unicornis generally chews the barks of trees and plucks the tender branches and leaves of bamboos (Bambusa vulgaris) and bananas (Musa sapientum) which are available in the foot hills. Water hyacinths (E. crassipes) are one of the commonly available aquatic plants along with other growing in the low-lying areas of the Park and its quantity is further increased by the in rush of flood water flowing from the river Brahmaputra, which carries these plants in abundance. Consumption of aquatic plants by R. unicornis increases during flood and immediately after its recession.

PROBLEMS ASSOCIATED WITH FOOD HABITS OF R. unicornis DURING AND AFTER FLOOD:

A large number of R. unicornis found to suffer from diarrhoea during and after the flood as observed from the semi-liquid consistency of the faecal discharge at the site of dung pile. This might be due to consumption of E. crapssips (water hyacinth) in large quantity. In addition to this faecal examination of the dung samples collected at random, from different dung piles revealed existence of parasitic ova in the faecal discharges.

The parasitic infection might be also a contributing factor for loose dung, during and after flood.

The general health of R. unicornis was found to deteriorate with shrunken belly during the month of July to September. This might be due to scarcity of food along with stress and strain encountered during flood and immediately after.

FOOD PREFERENCE AFTER BURNING OF THE FOREST AREA:

The process of grass burning in a specified area is practised annually in order to procure new grass and for removal of old dry leaves that usually accumulate during the dry winter season. Generally burning of forest area is done during December and February every year. This is essential for facilitating natural growth of vegetation and also for easy patrolling by forest staff, beside arresting the growth of unwanted weeds. Inspite of the devastation caused by recurrent flood, burning of grass land is essential for maintaining the ecosystem most suitable for R. unicornis at Kaziranga National Park.

During this period of burning the particular area, rhino leaves that area and seeks shelter in other nearby places. However, by the end of February-March the maximum number of rhinos come to the place to eat newly grown shoots of grasses. Although the animals come out from the burnt area and stay out of it for quite sometime some rhino showed different behavioural patterns when approaching and coming within the boundary of the burnt area. Two days after the area has been burnt some R. unicornis (1987, n=7, 1988, n=8) move towards the burnt land and chew the half-burnt or roasted stems of species such as _Saccharum arundinaceum_, _S. merenga_, _S. spontaneum_. The taste of the burnt stem may prove to be a delicacy for the rhino. There are instances of _R. unicornis_ inhabiting an area for 6-8 hours after it is burnt (Fig. 19).

NATURE OF GRAZING:

R. unicornis eat grasses systematically at a place for some time (5 to 7 minutes) keeping the head down. The animal cannot normally eat upto the root of the grass as buffaloes. Further, the rhino appears to be less selective in their feeding habits than deer and buffaloes.

FOODS AND FEEDING IN NEONATE AND CALF:

Being a higher mammal the rhinoceros calf is seen dependent on mother's milk. The neonate calves in their natural habitat depend solely on mother's milk upto two months of age and thereafter they pick-up grasses slowly. At this age the calves follow their mothers on her heel while grazing and suck as they moving (Fig.19A).

The calves of the _R. unicornis_ start picking up tender grasses from this age onward and are often seen to be licking the soil or mud. The calf suckles for over one year. At the same time it practices grazing under the guidance of the mother, before leading an independent life. Neonates, while grazing, eat tender leaves and apex of grasses.

OBSERVATION ON FEEDING OF CAPTIVE RHINOCEROS CALF:

Observations on Zoo-born captive rhinoceros calf show that the new born calf started suckling after 58 minutes of birth. The calf approaches the mother with a staggering movement, from front side to rear and tries to catch the teat by the lips. On the first day, it suckled only 4 times in 12 hours of observation but on 2nd day the calf suckled 14 times and on the 3rd day 12 times. After 38 days it usually picks succulent grass and is able to gradually graze on its own.

FEEDING AN ORPHAN CALF:

Two rhinoceros orphan calves were successfully raised with the help of artificial feeding. The rhino calf some times becomes orphaned due to the merciless killing of the mother by poachers or flooded out by strong current of flood in their natural habitat. Sometimes the mother rhinoceros enters the crop field and she is driven out by the dwellers but the young calf remains in the crop field. The calves recovered from these situations are brought to the State Zoo, Guwahati and reared by artificial feeding consisting of the food items of cows milk, boiled rice with, ripe banana, concentrate feed including gram, wheat bran added with mineral mixture and vitamins. The details of the feeding chart upto 6 months have been shown on Table 17.

FOODS AND FEEDING OF ADULT RHINOCEROS IN CAPTIVITY:

Seven adult *R. unicornis* have been reared and displayed for visitors at Assam State Zoo, Guwahati. On observation it was seen that the daily ration for rhinoceros comprises of green grass, concentrate mixture, banana, and common salt. Mineral salts are provided for licking monthly comprising 500 gm per year per animal. The food items contain

(a) **Grasses:**

1. *Hymenachne amplexicauli*
2. *Leersia sexandra*
3. *Bracharia mutica*

(b) **Tree leaves:**

1. *Bauhinia malabarica*
2. *Ficus indica*
3. *Ottochalora nodosa*

(c) **Concentrate feed include:**

1. Gram
2. Black gram
3. Wheat bran

(d) **Fruits:**

1. Bananas

(e) **Minerals:**

1. Common salt
2. Commercial mineral salt for licking.

Daily quantitative requirement for each adult R. unicornis at Assam State Zoo, Guwahati is computed as follows:

1.	Green (comprising grass or tree leaves)	...	100 kg
2.	Concentrate feed (including Gram - 2 Kg) Black gram - 2 Kg) Wheat bran - 1 kg)		
3.	Banana (Generally given 10 numbers without peeling).	...	2 Kg
4.	Common salt	...	20 gm
5.	Mineral mixture (occasionally)		

Mineral mixture composition -

Kalzol B_{12}

i)	Tribasic calcium phosphate	...	0.24 gm
ii)	Vitamin D_3	...	400 IU
iii)	Vitamin B_{12}	...	5 mg

TABLE - 19

Artificial feeding schedule for an orphan (30 days old)
Rhinoceros unicornis calf.

Duration	Food items and proportion	Hours of feeding			
		6.00-7.00	10.00-11.00	14.00-15.00	19.00-20.00
a) Upto 90 day	i) Cows milk (litres)	3	3	3	3
	ii) Boiled rice (1.5 kg) + cows milk (1 litre) + ripe banana (0.5 kg)	-	-	3 Kg	-
b) From 90 to 180 days	i) Cow's milk (litre)	3	3	-	3
	ii) Boiled rice (1.5 kg) + cows milk (1 litre) + ripe bananas (0.5 kg)	-	3	-	3
	iii) Grass	5 Kg	-	5 Kg	-
c) From 180 days onwards	i) Green grass	30 Kg	-	-	20 kg
	ii) Concentrate food	-	3 Kg	2 Kg	-

Besides these feeds the green is supplied in the morning around 8.00 a.m. and the concentration feed is supplied at 2.00 p.m. with bananas and salt for adult R. unicornis.

DISCUSSION

The food items and feeding habits of R. unicornis have been studied in the natural habitat at Kaziranga National Park. It is clear that this species is completely herbivorous. Similar observations are also reported by Grzimek (1970), Patar (1980) and Laurie (1978). The R. unicornis is found to be fond of grazing on short and tender grasses like Hemarthia compess, Cynadon dactylon, Erianthes and young shoots of Saccharum species of grasses. To encourage the easy grazing burning is carried out annually , by which the old dried grasses and debris are burnt to facilitate the easy access and appearance of new shoots in the grass field. Pathak (1978) described the process of burning practised in the Kaziranga National Park. The new born calf was found solely to depend upon mother's milk upto two months of age, then slowly picked up the tender grasses by the guidance of the mother. The R. unicornis calves were seen to be affectionately guarded upto one year of age.

The present findings depict certain significant issues regarding the plant species that may be regarded as essential for maintaining the habitat as well as food of the animal. Species like E. raveneae, *Hemarthia compess*, *Cynodon dactylon*, *Arundo donax*, *Phragmites karka*, *Saccharum elephantium*, *S. spontaneum*, *Cyperus*, *Hymnachne amplexicaulis*, *Leersia hexandra*, etc. are vulnerable species as both male and female rhino prefer to have these species as first grade preference food plant. However, in the present studies, the sexual dimorphism in the preference for a particular food plant could not be ascertained. The identification of chiefly preferred food plants of *R. unicornis* would definitely help in planning a new rhino-land with reference to the abundance of those particular food plants.

The present study conducted on five captive *R. unicornis* in the State Zoo, Assam, Guwahati, revealed that the animals maintain sound health by feeding on a daily ration of green (100 kg), concentrate feed (7 kg) with monthly supply of 500 gm minerals for licking. Grzimek (1970) and Crandall (1968) also observed such rationing in different Zoos in their observation. Artificial feeding of 3 orphan *R. unicornis* calves with 8 litres of milk in 4 different doses, 2 kg of ripe peeled banana supplemented with vitamins were found to be optimum for maintaining sound health. In the second month, the quantity of milk was increased to 15 litres. The reports of Walker 1986) also revealed and successful rearing of rhinoceroses calf by artificial feeding on milk products. These findings support the present study. It has been found that *Saccharum* species were the most frequently recorded food types.

The food and feeding habits of different species of rhinoceroses have been studied by various workers in various places of Africa and Asia. The comparative behaviour with reference to the types of food consumed may be concluded as - saplings leaves, twigs, shrubs, fruits - in the case of D. sumatrensis (Borner, 1979; Hubback, 1939; Strickland 1967; Goddard, 1968); saplings, shrubs, fruits, leaves, twigs, tall grass, herbs, palms - in the case of R. sondaicus (Hazewinkel, 1933; Hoogerwerf, 1970; Schenkel and Schenkel-Hulliger, 1969b; Sody, 1959); short + tall grass, shrubs, herbs, leaves, occasionally fruits, aquatic plants - in the case of R. unicornis of Nepal (Laurie, 1978; 1982); leaves, twigs, shrubs, herbs - in the case of D. bicornis (Goddard, 1968; 1970; Mukinya, 1973; Schenkel and Schenkel - Hulliger, 1969a) and short grass - in the case of C. simum (Owen - Smith, 1973).

CHAPTER - V

GENERAL HABITS : BEHAVIOURAL ECOLOGY OF R. unicornis

Rhinoceros unicornis being a majestic animal in its outward appearance and its habits, draw the attention of the naturalist, wildlife lover, forest-worker and the people in general. It shows certain special and unique behaviour patterns which establishés for its specialized habits and habitat for its survivability, propagation and distribution. Owing to these characteristics R. unicornis are now resctricted to certain habitats. The following are the details of the habits observed in different wildlife sanctuaries as well as in Kaziranga National Park.

There are several studies on the black rhinoceros by various authors on the general habit, grazing, track making, reproduction, home range, mating courtship and urination etc. (Goddard, 1966, 1967; Guggisberg, 1966; Laurie , 1978; ngg el, 1966; Ritchie, 1963; Schenkel and Schenkel-Hulliger, 1969a). Laurie (1978) studied the habits and habitat of R. unicornis from the Nepal area and has given valuable informations on the habits of the species. Very little information is available regarding the general habits of the species from wildlife sanctuaries and Kaziranga National Park of N. E. region. A very few workers have studied certain aspects of the habits and habitat of the species. Goswami et al. (1987), Bhattacharyya and Goswami (1987), Patar (1980) and Dutta, (1990), have studied the aspects of grazing, reproductive and urination behaviour of the species. In the present investigation certain aspects of the general habits have been observed and analysed.

MATERIALS AND METHODS

The general habits of the R. unicornis have been observed at Bagori range of Kaziranga National Park where the maximum numbers of rhinoceros could be seen. The observations were mainly made from the forest observatory, elephant's back and jeeps were also used. Normally the observations were made between 5 a.m. and 8 p.m. Nocturnal behaviour was also observed covering the period from 8 p.m. to 12 mid night and 1 a.m. to 4 p.m. and recorded accordingly during the full moon period within the visibility range from the watch tower. Night observations were made during February and March (1986, 87). After burning the tall grasses, during February and March, facilitated the observation during night.

IDENTIFICATION OF INDIVIDUAL RHINOS:

Identification for spotting of a particular rhino was made from its individual features such as shape of the cuts in the ear, wounds, scars on any part of the body, folds of the skin and mud marks or are recognized as members of a stable group (mother and calf). Further, recognition from a distance was made by binoculars and photographs taken at a close distance had given fairly satisfactory idea for recognition of a particular rhino. Male and female sexes of the species were clearly recognised as described from the external appearance of genitalia , horn size, general body size, urination postures, etc. Parturition behaviour was studied in captivity and the studies on neonate were conducted after its birth in the Assam State Zoo, Guwahati.

1. **LOCOMOTION**:

In *R. unicornis*, three types of movements have been observed depending uipon the time of movement and reaction of the environments and availability of palatable grass. These are

(i) easy walking

(ii) roaming

(iii) galloping.

(i) Easy walking was observed in *R. unicornis* in calm and quiet grazing places where plenty of grasses (10-35 cm) were available. After wallowing the animals walk easily and graze in a small place. The mother rhinoceros with suckling calves grazes very slowly and easily, guiding the young ones. Generally the animal grazes by lowering the head for a long time.

(ii) Roaming: Certain R. unicornis have been found roaming to distant places within its habitat in search of grazing place, water or wallow. They roam freely alone or in a small group (3-5) in dry winter when the days are sunny. It was observed that the individual rhinoceros some times used to cover a distance of 3-4 km at a stretch. They might even roam from 5 a.m. to 5 p.m. in search of food or water. The rhinos in groups maintain a distance from each other about 10-15 metre under the leadership of a bull rhino.

(iii) Galloping was seen in R. unicornis, when they were frightened or disturbed. Galloping with the velocity of 30 km per hour (covering 1 km at 2 minutes) in individual animals were recorded. It was seen that after galloping a few metres it looked back to the disturbing agent and started galloping again. During galloping the rhino moved the left forelegs first followed by the right forelegs and subsequently the hind legs.

2. **HABITS**:

3 Different habis could be distinctly identified from the observations made during three seasons of the year viz. grazing, rest (relaxation), sleep and wallowing.

(i) **Grazing**:

The R. unicornis, is essentially a grazer and was found grazing most of the time both during day and night. Observation on a groups of rhinoceroses in 3 different seasons (Table 20) revealed that R. unicornis spent most of the time grazing preferably from 5 a.m. to 8 a.m. and from 2 p.m. or 3 p.m. onwards upto 5 p.m. During the night also it was found to spend a considerable amount of time grazing from 8 p.m. to 11 p.m. and 2 a.m. to 5 p.m. during all seasons. Between each grazing times the species used to rest, relax and sleep or wallow during hot summer days.

(ii) **Rest, relaxation and sleep**:

Between the grazing times the species used to rest, relax and sleep or wallow during hot summer days. The time of relaxation and sleep have been recorded and presented in Table 20.

TABLE - 20

Grazing, rest and wallowing times of Rhinoceros unicornis observed in in Kaziranga National Park in 3 different seasonin Bagori, 1987.

Season-I - JKUNE - OCTOBER

Day time	5 am - 8 am	Grazing
Diurnal Rhythm with reference	8 am -11 am	Rest, standing, sleep.
to grazing, wallowing and	11 am - 3 pm	Wallowing, relaxation.
rest	3 pm - 6 pm	Grazing.

TABLE - 20 (Contd.)

Noctournal Rhythm with reference to grazing and rest.	6 pm - 8 pm	Grazing, rest,drinking water.
	8 pm -11 pm	Grazing.
	11 pm - 2 am	Rest, standing, sleep.
	2 am - 5 am	Grazing.
	Session-II - NOVEMBER - FEBRUARY	
Diurnal Rhythm with reference to grazing, wallowing and rest	5 am - 8 am	Grazing
	8 am -10 am	Rest,standing,sleeping
	10 am - 1 pm	Wallowing
	1 pm - 5 pm	Grazing.
Nocturnal Rhythm with reference to grazing and rest.	5 pm - 8 pm	Rest,standing, sleep.
	8 pm - 1 am	Grazing.
	1 am - 3 am	Rest.
	3 am - 5 am	
	Session-III - MARCH - MAY	
Diurnal Rhythm with reference to grazing, wallowing and rest.	6 am - 8 am	Grazing
	8 am -10 am	Rest
	10 am - 2 am	Wallowing, relaxation
	2 pm - 5 pm	Grazing.
Nocturnal Rhythm with reference to grazing and rest.	5 pm - 8 pm	Rest
	8 pm -11 pm	Grazing
	11 pm - 2 pm	Rest, sleep.
	2 am - 5 am	Grazing

(iii) **Wallowing**:

R. unicornis has been observed to be a habitual wallowing herbivore. Irrespective of their age they were found to wallow 3 to 4 times during summer in shallow and static water bodies continuously for 1 to 3 hours at a time. During winter the number of wallowing is comperatively less than in summer. Rhinoceros were not seen wallowing in running water. Each of the R. unicornis of a group was observed to have used separate or own track for approaching the wallowing water bodies and leaving it through the same track in different directions after wallowing. Another interesting habit of the species was observed that while wallowing in the water bodies, they always face the bank of the water bodies. Perhaps, to keep an eye on approaching enemies, if any. (Fig. 20, a-e).

Wallowing is done for keeping the body temperature low during hot summer days and at other times to get rid of ectoparasites which harbour in their skin folds.

The present observation was made in 3 large swampy areas each measuring approximately 1 square kilometre near Bagori region of the Kaziranga National Park. A study with reference to time and number of R. unicornis which wallowed from morning till evening has been recorded for 7 consecutive days in a months during July, December and April, (1987, representing summer, winter and pre monsoon). The average value of the findings were recorded in Table 21.

TABLE - 21

Number of R. unicornis wallowed during different times and months in 3 different wallowing places in Bagori region of the Kaziranga National Park.

Time	July			December			April		
	Wallowing Places								
	1	2	3	1	2	3	1	2	3
5 AM - 8 AM	2	1	2	1	-	1	1	-	1
8 AM - 12 AM	7	8	6	4	3	3	4	5	5
12 AM - 3 PM	3	4	3	2	2	3	3	4	2
3 PM - 6 PM (*)	1	1	-	-	-	-	2	1	1

* Owing to the decrease in the length of the day in December, the evening observations on wallowing were made from 3 PM - 4 PM.

Track and sub-tracts:

R. unicornis were found to enjoy grazing in open grazing grounds around a beel or water body, near the places of wallowing. They defecate in other selected places and drink water in rivers nullahs away from their place of shelter, but in their own home range comprising around

Fig.19A: Calf.↑

FIG. 19 : R. unicornis AFTER BURNING THE GRASS IN THE KAZIRANGA NATIONAL PARK.

Fig. 20. A

Fig. 20. B

Fig. 20. C

Fig. 20. D.

FIG. 20 : WALLOWING (a - IN CAPTIVE CONDITION; b-d IN THE KAZIRANGA NATIONAL PARK) OF R. unicornis.

10 Hectares of area in the park. They usually travel through the same tracks for their day to day activities. While walking to these places through the same paths daily the vegetation over the path gets crushed and destroyed, creating tracks which are apparently straight. (Fig. 21,22).

Sub-track:

Several sub-tracks were also found to develop for grazing, wallowing and defecation. In Fig. 20b the mode of sub-track formation by the individual rhino on all occasions was relating to the site of the swamp (for wallowing) and grazing field. The sub-tracks were formed in the following ways:-

(i) Movement in the main track followed by

(ii) Defecation or urination away from the main track

(iii) After (ii) the animal used to keep the head in an upward posture to locate any new swampy areas or grazing field or tender grass close to the defecation/urination site. It was always supposed to be at a short distance of about 20 metre as the animal is a short sighted species.

(iv) On finding a new location the animal moves through another track from the main track to the new location via the defecation site.

(v) Further, from the side track so developed, the animal moved through another track from the main track to find out the destination of wallowing or grazing ground.

In this way several tracks or subtracks used to develop on the paths of their movements making a criss-cross pattern in the entire home range field. (Fig. 21).

Parameters of tracks:

The parameters of several main tracks and sub tracks such as length (from base to destination) and breadth were measured as shown in (Fig. 22). The main track along with sub tracks as shown in the figure has been considered an unit for convenience of description.

The interpretation on the topography of the main and subtracks were made after examination of 10 different sites in the park within Bagori and Arimorah.

Number of individuals or association in the tracks:

Number of rhinos found to be in association with each other in main or subtracks were examined and following findings were made. The number within the paranthesis shows the number (n) of individual

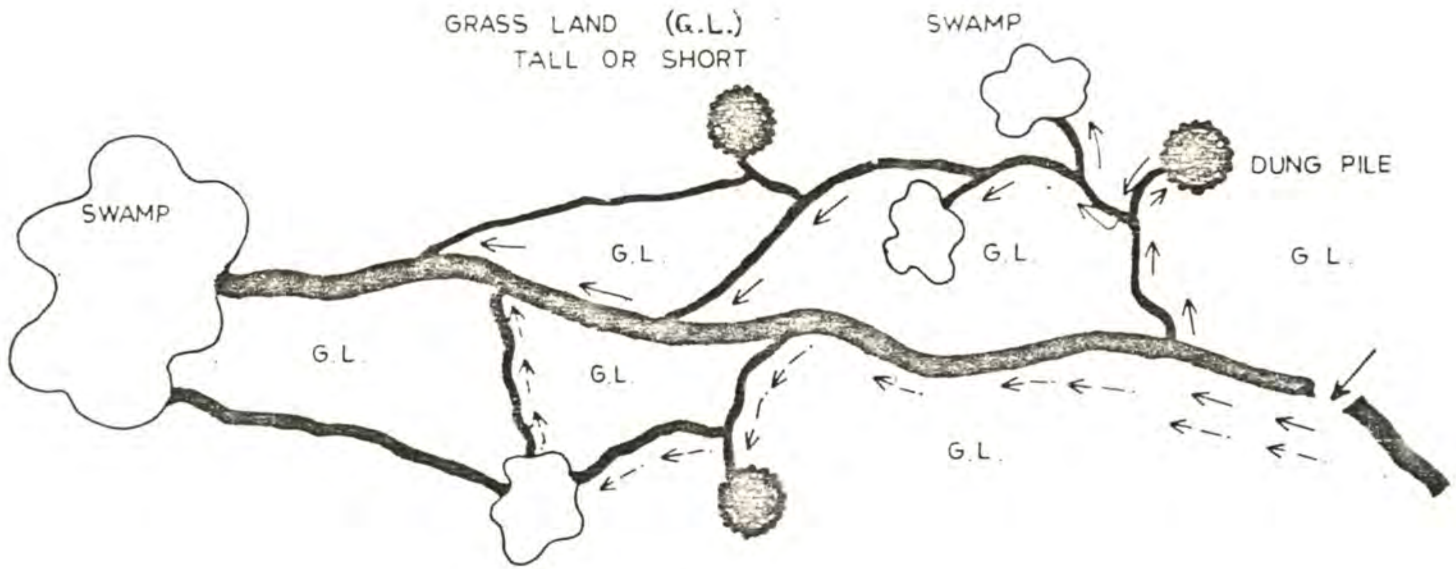


FIG. 21 MAIN TRACK AND SUB TRACKS FORMATION BY
IN KAZIRANGA NATIONAL PARK.

(Note : The width of the tracks (dark bands) were measured by taking the average of the width of 10 such main and sub-tracks. The average(mean) value of each such position (A–H) was found to be :—— A:1.6m; B:1.3m; C:1m; D:0.8m; E–H:0.6m.

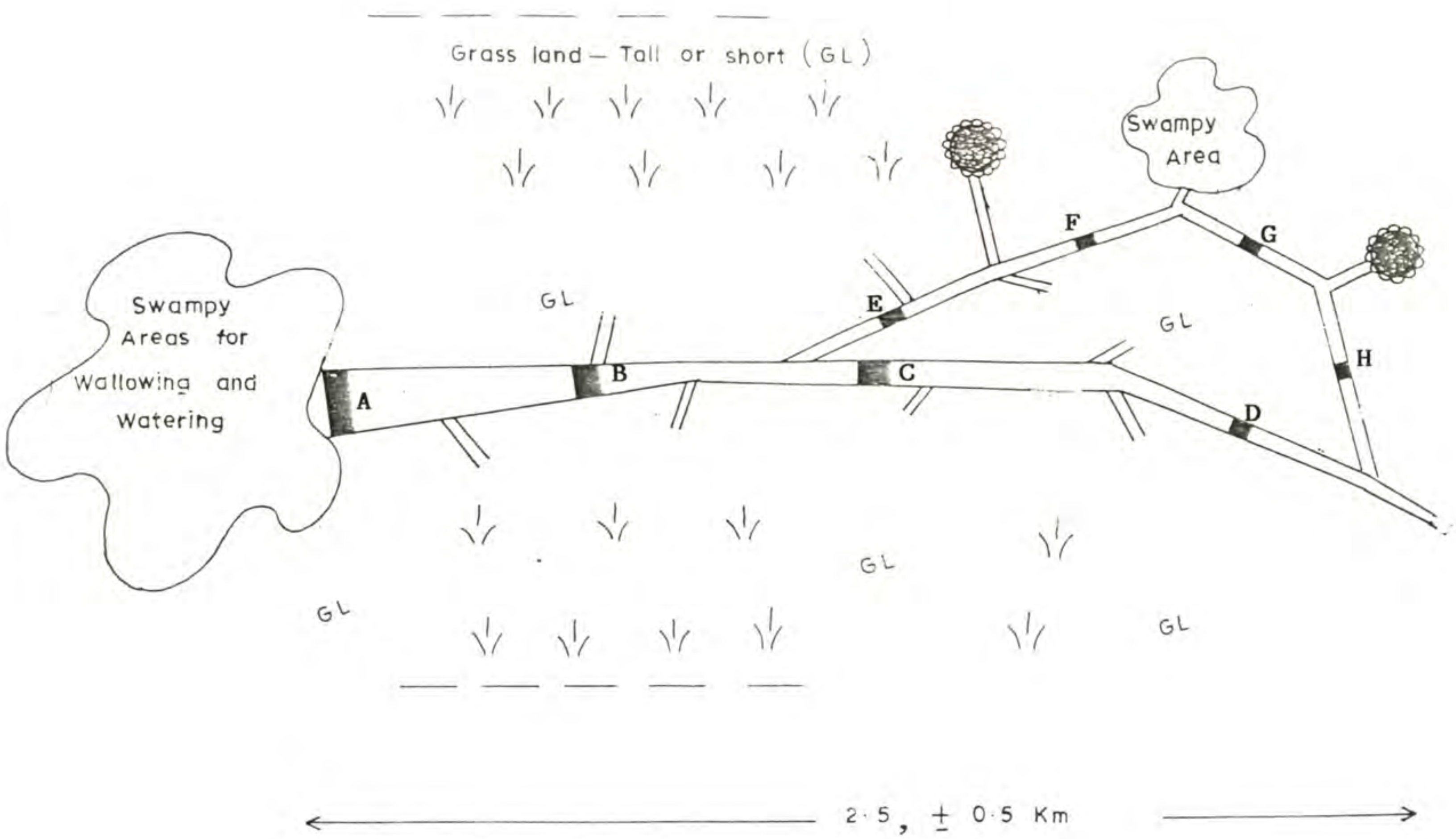


FIG. 22 SCHEMATIC STRUCTURES OF THE MAIN AND SUB–TRACKS OF RHINOCEROS UNICORNIS.

recorded within 30 days of observation during the month of November (1987) in one site (taking one unit of track, sub-track) of Bagori region.

(i) Both mother and calf (n=5) were always found associated with each other in the main or subtracks. The calf always followed the mother.

(ii) While roaming through the track the male rhino follow one another (n = 10) with an interval of 30 to 60 minutes maintaining a distance of about 70-100 metres apart. Thereafter, the animals enter into different sub-tracks. Although during their movements no aggressive behaviour could be noticed but in two occasions adults rhinos moving in a close proximity,less than approximately 30 metres between one another were found to express aggressive behaviour. However, one of the pairs disappeared without any fighting incidence; while the other pair faught for about 15 minutes and later disappeared from the track towards othersides.

(iii) (a) Certain associations in the tracks were observed between two females (n=6) of same size or age where they maintained 30 - 50 metres distance apart from each other.

(b) Further, two female (n=3), old cows and a young cow (which were with their last calves) also followed the same track to maintain the association.

(iv) Temporary association of a male and one or two females (n=3) were seen during mating or premating periods.

Use of tracks by other animals:

(i) The tracks used by rhino or groups of rhinos were also seen to be used by other ungulates like deer, buffalo, pigs and also by carnivores like tiger etc.

(ii) Elephants were found to use the same track rarely, but the damage of the tracks was always associated with the movement of a herd of elephants and damaging/crushing of long and tall grass as well as shrubs by the side of the tracks.

Behaviour of rhino in the track:

(a) Male rhino rather than the female rhino was observed to be always suspicious in nature while moving. The male always used to stop after going 5 to 7 metre and raised the head and moved it in both directions. Further, the animal used to breathe rapidly.

(b) Whenever, another adult male of a different group happened to use the same track and was sighted the host male would show its aggressive behaviour so that the other male would go away from that track. Interestingly enough the subadult males were always welcome to use the track by the adult male. However, adult or subadult female had no problem while using the track and the first adult male if any in the track would not show any aggressive behaviour.

(c) Wherever, any rhino urinates by the side of their track, other rhinos stop there and smell the area for sometime (2-3 minutes).

(d) Occasionally rhino bulls (n=4) were observed to scrape the grazing ground, or a small bush and knock it down with its horn and completely smash it. These type of scrapes were found near the track.

Persistency of Rhino-tracks:

The tracks and sub-tracks do not remain permanently in an area. During floods the tracks disappear. After recession of the flood water, when the rhinos move in search of grazing gounds, water, wallowing places and for defecation, new tracks are formed on their route of daily movement to these places. R. unicornis has the habit of moving in the same track.

In the present studies 10 units of tracks and sub-tracks were marked in the month of April at 10 different places in Bagori region of the park for their period of persistency. The persistency was examined after the recession of the flood. The records have been presented in Table 21.

TABLE - 21

Persistency of tracks used by *R. unicornis*

Year	Units of track (No.) marked in 10 different sites during April	No. of units persistent after recession of flood	No. of units damaged
1984	10	7	3
1985	10	6	4
1986	10	8	2
1987	10	6	4
1988	10	2	8
1989	10	5	5

3. **MIGRATION:**

As a principle animals migrate from one place to another in search of food and shelter, and for the purpose of reproduction. The factors responsible for migration of R. unicornis to and from the Kaziranga National Park or other wildlife sanctuaries are mainly due to -

(a) Flood.

(b) Scarcity of food.

(c) Burning of forest land.

(d) Special taste which develops with new seedlings of paddy field.

(e) Infighting or aggression.

(f) Disturbances by poachers.

(g) During matting seasons.

(a) **Flood**:

The seasonal occurrence of flood is a serious and one of the main causes responsible for migration of R. unicornis from Kaziranga National Park. It has been found that almost 80-90% of the total area is usually flooded during the monsoon every year. In the present investigation from 1983 to 1989, the flood of 1988 caused serious damage to the rhino population. During the flood the animal migrated to the nearby hills (Karbi hills) and even to the adjoining tea-estates. The species moved here and there in search of food and shelter, encroached the areas of human habitation, eating plants, crops, vegetables and horticultural plants etc. Some of them migrated to Laokhowa and Pabitora sancturaries, few others crossed the river Brahmaputra and finally reached Orang. During the migration many of them lost their lives in the hands of poachers, due to disease, railway accidents and drawning, thereby reducing the population of rhino in the National Park.

(b) During the flood most of the grass lands were inundated with the overflowing of the rivers flowing through the park and in rush of flood water from mighty Brahmaputra river, damaging the grass land and other vegetation which creates scarcity of food for all the herbivorous animals in the park.

Continuous drought during the dry season, from October till the end of April or May, in absence of winter rain, causes the animal to migrate from the park to nearby areas.

(c) Besides floods, the burning of tall grass by the forest department and occasionally accidental fires create scarcity of food for grass eating herbivorous animals, thereby compelling species to migrate temporarily to nearby hills and stays till new grass sprouts in the park.

(d) Special taste along with new plant shoot or seedling:

Some rhinos from the National Park and other wildlife sanctuaries temporarily migrate to neighbouring areas for grazing on newly grown paddy seedlings during monsoon and winter crops during November till April.

(e) Infighting or aggression:

Infighting or aggression takes place between adult males. Sometimes they chase each other and even come out of the Kaziranga National Park, thus loose their track, and sometimes get killed in the new environment.

(f) Disturbance by poachers:

It has been recorded that a pair of male and female rhinos were disturbed by poachers and chased for shooting. They were ultimately chased upto the newly constructed Brahmaputra bridge. However, timely intervention by the Forest administration saved the rhinos from being killed. This type of disturbance is also one of the causes of migration.

(g) Mating season:

R. unicornis mates during the months of October to April. During this period both male and female run and chase each other for a long distance and sometimes they cross the boundary of the Kaziranga National Park. On one occasion a couple was found to cross - the National Highway and enter the jungles at the foot hills of Karbi Hills and on another occasion they crossed the eastern part of the boundary and entered the Bokakhat region. This type of migration is purely temporary and after 3-5 days they return to the National Park. However, there are a number of instances of temporary migration as reported by the nearby villagers.

4. DEFECATION AND MAKING DUNG HEAP:

R. unicornis were found to have the habit of defecating in a particular place daily for a considerable period of time creating a dung heap or pile. The species has a peculiar habit of approaching the dung heaps by its back from quite a distance from the dung heap for defecation. The dung heaps were seen in single or in clusters. Single large dung heap was found to have the circumference at the base of 6.5 m and 85 cm in height. Cluster of 4 dung heaps were recorded in 10^2 m area in the Kaziranga National Park, during the study.

Several animals (more than 3 rhinos) were found to use the same site in the formation of dung heap. Three categories of such sites were seen and recorded - (i) grazing ground, (ii) tree-forest areas, and (iii) area near wallowing place (swamps or beels). The later two sites were used by a number of rhinos of the same group. In Table 22, records of observations made in 3 different seasons (1987) in the 3 categories of sites are presented:

TABLE - 22

Season	Sites	Number of individuals used to defecate in the site
Pre-monsoon	Grazing grounds	1A♂, 1A♀, 1SA♂, 1SA♀, 1IYC = 5
(Dec., Jan., Feb., March)	Near beels or Swamps.	1A♂, 2A♀, 1SA♂, 2SA♀ = 6
	Tree forest area	1A♂, 1A♀, 1SA♀ = 3
Monsoon	Grazing grounds	1A♂, 1A♀, 1SA♂, 2SA♀ 1C, 1IYC = 7
(Apr., May, June, July)	Near beels or Swamps	1A♂, 1A♀, 1SA♂, 1IYC = 4
	Tree forest area	1A, 2SA♀, 1IYC = 4
Post-monsoon	Grazing ground	1A♂, 2A♀, 1SA♂, 1SA♀, 1IYC = 6
	Near beels or swamps	1A♂, 1A♀, 1SA♂, 1SA♀ = 5
	Tree forest area	1A♂, 1A♀, 2SA♀ = 4

A = Adult; SA = Sub adult; IYC = One year calf; C = Calf.

(a) The dung heaps were observed to persist for 4-6 months during the dry season and were wiped out by monsoon flood and during forest burning. These situations compelled the species to change the place of defecation.

(b) Frequency of defecation and its quantity:

R. unicornis were observed to defecate 3 to 4 times a day and 6 to 10 kg of fecal matter were excreted per rhino per day in healthy condition.

(c) Scattering of dung heap:

During winter and drought seasons the members of the speices were found to scatter the dry part of the dung pile with their legs so as to expose some wet dung underneath in order to emit the smell of the dung from a distance to help the animal to locate the dung pile of their group. The dung of rhino has a peculiar smell since they possess the power of distinguishing the dung of their own group from that of others by their sensory organ.

5. **URINATION**:

Males *R. unicornis* were observed to pass urine in a backward direction like feline speices, quite apart from its hind legs medially as in non-erect state of the penis drawn upward and backward. The male rhinoceros passes urine in the forms of jets which reaches the ground 1.8 m behind the hindlegs. In case of female the force of urination was seen to be weak and they pass urine within 70 cm distance from the hindlegs showing a common feature as found in other ungulata. However, in heat period the female squirts frequently in small quantities.

It has been found that about 3.6 ± 0.2 litres of urine (n=4) are usually discharged by both male and female. The animal uninates a little away from the track. While moving in the track the animals use their nose frequently to smell other rhino. (Fig. 23).

6. VOCALIZATION:

Different vocalizations were heard during the present investigation and the different types of sounds produced by the animal were heard which might be placed in certain specific categories. The description of each vocalization or sounds are thus described following the context in which it was observed and their interpretations are as follows:

(i) Vibration of lips: A lip vibration sound could be heard while the animal was in grazing condition (n=9), without disturbance of any kind. During the period no anxiety or movement of head or tail could be seen. This type of vibrating sound, similar to the sound produced by horses by vibrating their lips, has been observed also in the rhino in captive condition (n=9). The sound appeared to have no communicative function.

(ii) Snort: A snort is a sound produced by blowing air from the lungs through the nostrils. R. unicornis, both adult male (n=24) and female were found to snort (n=22), which is an expression of initial contact call with the fellow animal. Laurie (1982) reported that the adult female snorted at the highest rate. In the present experiment it has been seen that sometimes the adult male (n=4) snorted in excitement after seeing a visitor at a short distance (15-20 metres). During the courtship the animals snort.

(iii) Honk: It is a loud sound with low pitched guttural vocalization producing certain sound with metallic interaction. It can be heard from more than 100 metres and is associated with prolong agonistic interaction. It is a loud vocalization, found to be produced only by adult male (n=16) and rarely by adult female (n=3) R. unicornis.

(iv) Bleat: It is a low pitched sound like the bleating of sheep, but shorter and mainly observed to be produced by the adult and sub-adult female rhino (n = 6) along with calf (n=7). Both the cow and the calf (n=6) produce this sound in order to communicate with each other. Further, bleating was heard between sub-adult (n=5) females. when they move in a track about 30-40 metres distance apart from each other. It is a single-tone loud vocalization produced by opening the mouth with the head hold low and ear pinnae held back. Adult rhino of both the sexes (n=4) were found to blent during their interaction.

(v) Roar: Roaring by R. unicornis was commonly observed when two bulls meet face to face as a sign of antagonistic interactions (n=4). Roaring between adult male and adult female (n=12) was also observed.

(vi) Squeak-pant: It is a half aspirutory and half vocal and variable sound in between honk and snort (Laurie, 1982). Adult males (n=7) were only found to produce such a sound during prolonged chasing as well as courtship.

(vii) Neigh: Neigh is a sound similar to the neighing of a horse but without the staccato. It is high pitched sound and may be termed as whistling sound. This sound was found to produce by oestrous females (n=9) in order to communicate with the male.

(viii) Shriek: This is also a high pitched sound which is higher than the neigh. It was observed to have been produced by both bull (n=6) and cow (n=9) when suddenly they see any man, elephants or motor vehicle at a close distance of about 10 metre or so. This type of sound is an expression of the motivational component of fear or anger or exclamation mark. Sometimes aggressive bull chases the agent immediately after making this wild piercing scream and there are reports that sometimes the animal try to hit the vehicle.

(ix) Moo-grunt or Gronk: It is a short grunt produced inside the throat by the calf of less than one year of age (n=4) and was observed to be a direct contact sound with their mothers. After producing the sound the calves moved towards their mother.

7. **SWIMMING**:

R. unicornis, an inhabitant of wet land eco-system around alluvial plains of the mighty river Brahmaputra and its tributaries and marshy areas and shallow water bodies is accustomed to recurrent high floods during monsoon and therefore is well habituated to swimming. The animal can cross the river Brahmaputra from one bank to the other during high flood - due to its strong and stout legs and strength of the body. Even tender calf of 10 days old (n=2) were seen to swim actively with the guidance of their mothers.

8. **RELATIONSHIP OF R. unicornis WITH OTHER ANIMALS**:

(a) **Relationship with deer**:

R. unicornis develops a peaceful relationship with various species of deer (Swamp deer - Cervis duvauceli / 756; Sambar - Cervis unicornis / 358; Hog deer - Muntiacus muntjac / 580) (Census Report

1984). No aggressive behaviour could be seen between any species of deer and rhinos. It was seen that most of the time a herd of deer remained in association with adult male and female (n=34) or even with sub-adult rhinos (n=3).

During the entire period of observation aggressive behaviour was encountered only twice with rhino bulls (n=2) and with herds of hog deer (Axis porcinus, n=10 and n=7), where the bull chased the herd.

The distance between the rhino and the individual deer varied from 2-10 metres (Fig. 12).

(b) **Relationship with water buffalo**:

There are more than 700 water buffaloes (Bubalus bubalis) in the Park. 1984 Census report showed their number as 677. The species lives in a big herd with one adult bull as the leader of the herd. Besides the water area such as swamps, beels or low lying area including the small stream, the buffalo remain grazing during morning and evening. The relationship with rhinos has been critically observed and it has been found that both species did not show any aggressive behaviour during wallowing in water as well as while grazing.

(c) **Relationship with wild boar**:

The 1984 Census report recorded the presence of a large number (36-45) of wild boar (Sus scrofa). There was no encounter observed.

(d) **Relationship with elephant**:

During the present study 4 herds of elephants Elephas indicus were seen wallowing in association with rhinos in Diphlu river and in swamps near Arimorah station of the National Park. No encounter between stray or a herd elephants could be observe of during the period.

There are records (n=3) of elephants which are used by forest workers, tourists or visitors were attacked by some rhino bulls (adult male, n=3), showing aggressive behaviour. They stood for more than 1.5 minutes, after which the rhino slowly disappeared from the spot. After retreating about 15-20 metres, the bull once again stood showing aggressive behaviour. (Fig. 24).

(e) **Relationship with carnivores, specially with members of the cat family**:

Various species of the cat family viz., tiger (Panthera tigris), leopard (P. pardus), jungle cat (Felis chaus), leopard cat (F. bengalensis) are available in the Kaziranga National Park. In the present investigation several encounters were observed with tiger and rhinos, specially with rhino calves (n=7). Attack or killing of calf and sub-adult rhino by tigers is a common encounter and a record of 12 number of such cases of tiger attack were recovered, and treated. The details of tiger attacks have been illustrated in Chapter VII.

(f) **Relationship with other ungulata**:

As the National Park is encroached by human habitation, a large number of cattle acquire access to the grazing grounds along the side of the National Highway which ranges from Burapahar hill to Bokakhat sub-division and very often rhino could be seen grazing along with these cattle without any aggressive behaviour from either side thus showing the signs of 'Live and let live' and "peaceful co-existence".

(g) **Relationship with cattle egret and crow**:

The cattle egret (Bubulcus ibis) was often found in association with the rhino. During grazing or roaming the bird were seen either on the ground or sitting on the back or the buttock or on the shoulder region of the rhinos. The animal did not show (n=85) and feeling of disturbance and aggressiveness towards the bird. The egrets were seen to pick up mites or flies from the skin folds of the animal. When the bird flies, at once the rhino stands upright and tries to locate any object such as human or elephant or vehicles and others around.Generally the birds flies whenever such objects were seen approaching. The birds therefore, serves as an effective guard for the R. unicornis.

(h) It was observed that except during stress condition such as floods when there was scarcity of grass and other plant food, the rhino lives in absolute harmony with other animals of the park like black bear (Ursus thibetanus), sloth bear (U. ursinus), monkey, langur gibbon, several avian fauna, reptiles, amphibians associated along with the large variety of invertebrate species, and there was no such encounter or any special characteristic behaviour or hostile relationship with these animals.

(i) **Reaction with man**:

R. unicornis has poor eyesight and as such would not be alarmed unless the man was seen at a distance of 30-40 metres, or it could easily locate a moving man within 30-40 metres (n=39), and got alerted - with head raised and moving ears. However, if a man or a vehicle remains motionless even within 25-30 metres it would not show any interest. There are records of a man being chased alone or along with the vehicle by the rhino bull. A mother rhino with calf at heel is very ferocious and would not tolerate even the bull of the group, not to speak of man or other animals. (Fig. 24).

In the present investigation adult female (n=24) showed intense alertness and remained in standing position by keeping the head upwards. Female rhino associated with the calf (n=4) and with sub-adult calf (n=5) were found becoming more alert and remained standing for 2 to 4 minutes and tried to send signal of danger towards the calf and thereafter left the place with their calves calmly.

Perception of human scent usually interacts with excitement which was followed by moving away from the place.

FIG. 23 : URINATION OF MALE R. unicornis.

FIG. 24 : REACTION OF R. unicornis WITH MAN ALONG WITH ELEPHANT.

Fig. 24, a Mother with suckling calf.

(j) **Reaction to vehicle**:

The reaction to vehicles was found to be rather different, as the smell of petrol or diesel agitates the olfaction in different ways. In certain cases (n=9) the animal did not show any interest when vehicles were at a distance of 30-40 metres, when the rhinos were grazing by the side of roads inside the park. However,on other occasions (n=7) they became alert even when the vehicles were at a distance of 80-100 metres. The sound of the vehicle always disturbes the grazing animals, and often run away after hearing the sound of the moving vehicle. On one occasion there was an attack on the vehicle, however, without a major damage.

(k) **Relationship with other rhino**:

(i) **Interaction of rhino bull with other rhino bulls**

(a) *R. unicornis* bull by nature is a carefree animal without any responsibility except propagation of its family. It may be termed as a lonely animal, living only to eat, sleep, wallow and roam in the wild park. One might find many rhino males as well as females including young calves on the same grazing ground, but they are not from a single group. It was observed that rhinos donot object to the right of grazing of other animals including its own species, on the same grazing ground. As such, rhino bulls, although they like to dominate the grazing ground on its home range, do not object to other rhinos even a bull from another range grazing on the same ground when it maintains a considerable distance of about 30-40 metre but becomes aggressive and snorts if the bull from other ranges approach very close. However, fighting amongst individual rhinos were not uncommon.

Fighting between bulls before mating (n=2) ended with death of the weaker ones and serious injury to one of the contestants. The fight last for 30 minutes. On another occasion an oestrous female rhino was found to accompany a rhino bull. When another bull from other range tried to approach the oestrus female, it was chased to a long distance outside the home range of the accompanied one.

(l) **Relationship with other sub-adult male and female**:

Sub-adult male and female did not show any aggression among themselves. They maintained an almost cordial relationship and lived in harmony while grazing in a common field forming a group of 2-4 ; n=7). This relationship, however, did not last long especially with males.

Sub-adult male/female of a group (n=4) was found to show peaceful behaviour. Sometimes both sexes were found to come together and smell each other.

(m) **Cow-calf relationship**:

(i) *R. unicornis* cow exhibited a special maternal care, towards their calves. The neonates were looked after extremely carefully upto 2-3 months (n=4) of age, and the calf suckled the mother from the hind side by introducing its head between the two hind legs of the cow (Fig.24,a). The mother sometimes touched the body of her calf with the lips (n=4) or licked it (n=6).

(ii) The calf remained in association with the mother upto 3 to 4 years of age and the cow took special attention all the time protecting against carnivores, man (n=6) and vehicles (n=3).

(iii) Sub-adult animals belonging to the particular cow were observed to remain in association at the time of grazing (n=15) or even during wallowing (n=9). This continues upto the age of 4 to 5 years or till attaining sexual maturity (Fig. 25). Nose to nose contact by mother with sub-adult offspring were noticed in (n=4) cases.

(n) Association of bull and cow:

Except during the mating or premating season, a bull and a cow form a temporary association for a short while (20-30 minutes). They later separated from each other was observed in (n=18). The relationship in detail in Part II of the present chapter.

(a) The bull-cow association has been observed while grazing (n=7), wallowing (n=7) for a shortwhile.

(b) A long time association (n=3) pairs lasting for more than 4-5 days was observed when both animals of the pairs came out of the Kaziranga National Park (n=1), from Pabitora (n=1) and Manas (n=1) and during pre-monsoon period near Chandrapur (n=2) and Mayang (n=1) which are 60 km away from the Kaziranga and 30 km from Pabitora and Laokhowa. This type of long association was not related with mating or pre-mating, but owing to temporary migration from their own home range in search of food.

(c) During floods they remain in association on high land for long time depending upon the lowering of water level.

Home range/Range of distribution:

(a) Home-range of *R. unicornis*.

The study on the home-range or its distribution pattern with reference to feeding and wallowing, defecation and roaming areas of *R. unicornis* had signified that the species require relatively less area during summer, which might be associated with occurrence of flood and abundance of food material. The grass and food plants grow luxuriently during summer and monsoon. Male *R. unicornis* requires a wider or greater home range irrespective of summer or winter. Laurie (1982) described the home range of different speices of rhino, including the R. unicornis of Nepal, where, he cited that R. unicornis requires 2-11 sq. km. In present study it is observed that the groups of Rhino used certain area of the Park covering 30 to 40 sq. km. for their day to day activties which can be stated as home range, but it was not so well demarketed.

(b) Observation of distribution range of adult and sub-adult male and female with reference to their movement range:

The requirement of land area for grazing, defecation, wallowing, rest, roaming for an adult R. unicornis in the Kaziranga National Park was considered as home range. R. unicornis move from their place of shelter for grazing, defecation, wallowing daily within their home range of about 10 hectares (Lahan 1987) during monsoon occasionally even beyond it in search of food. During flood and burning of forest grass land, the movement range of both the sexes of the species were observed and recorded during June-July, and December-January of 1986-87 form 5 am to 5 pm, and presented in Table 23.

TABLE - 23

Movem **Movement of range of R. unicornis**

Month	Identification mark	Sex	(A)/(SA)	Kilometer moved (Long diameter)
June-July	(i) Cut marks in the ears.	Male	(A)	4
	(ii) Would mark in the shoulder.	Male	(A)	4.5
	(iii) Wound mark in Buttock	MaLe	(A)	3.5

TABLE - 23 (Contd.)

Month	Identification mark		Sex	(A)/(SA)	Kilometer moved (Long diameter)
	(iv)	Cut mark in the Fascial portion	Female	(A)	2
	(v)	Cut mark in the tip of ear	Female	(A)	2.5
	(vi)	Cut mark in the thigh	Female	(SA)	2
	(vii)	Cut mark in shoulder	Male	(SA)	3
December-January	(i)	Cut mark in the thigh	Male	(A)	6
	(ii)	Cut mark in the ears.	Male	(A)	6.5
	(iii)	Cut mark in the ear.	Female	(A)	4
	(iv)	White mark in the buttock.	Male	(SA)	5
	(v)	Mud deposition in the base of horn.	Male	(SA)	5
	(vi)	Cut mark in the shoulder region region.	Female	(A)	3.5

(A) = Adult, (SA) = Sub-adult.

From the above Table (Table 23), it has been observed that the animal moved for a long distance upto 4-6.5 sq. km. (both sexes) during winter (December-January). The range of movement was restricted during the summer or rainy seasons where it showed 2-4.5 sq. km. only. Further, the male including adult and sub-adult showed a wide or long range from 4-6 sq. km. in winter (December-January) and 3-4.5 sq. km. in rainy season (June-July) which is comparatively less in the case of the female, 3.5-4 sq. km. in winter (December-January) and 2-2.5 sq.km. in rainy seasons (June-July).

Communication:

(a) Sound signals:

In addition to different sound signals described earlier Rhinos communicate with each other in a group by a number of ways.

(b) Olfactory signals:

R. unicornis always were found to sniff or smell during their movement along the tracks of their movement. They usually sniff the ground with concentration in the places of urination and defecation that has been used by other rhinos. Further, the pedal scent gland performs a significant role in leaving the scent and rhinos follow each other particularly the male in search of oestrus female and other members of the group.

(c) Urination:

The details of urination have been described earlier. Further, some adults male often drag their hind toes in the earth and rub the head in bushes (n=4) and thus, help the other members of their group to follow the route etc.

(d) Defecation:

In earlier parts (Part I of this chapter) a detail study on defecation has been illustrated. Dung piles were used for defecation by the same group in a common place. Further, scraping of old semidried dung piles helps the animal to obtain the smell of dung in order to locate the place of defecation.

(e) Visual signals:

Although it has poor eye sight, yet it can see man or other object or agents from a distances of 30-40 metre. Different interaction with various types of animal and man have been illustrated earlier.

(f) Nocturnal behaviour:

Nocturnal behaviour was observed only during the period of full moon in February and March (1985-1987) from the watch tower from 8 pm till morning. However, no special peculiarities could be observed. From the watch tower the animals were seen grazing as usual. As visibility was poor other studies were not attempted.

DISCUSSION

Various group of ungulates have certain specialised community organisation which are unique with reference to the environment, food and feeding habits, reproductive and different behavioural ecology of the group of spices (Jarvis, 1969; Mekenna, 1975; Owen-Smith, 1971, 1973; Lockhart and Eisenberg, 1972; Estes, 1974; Geist, 1974; Jarman, 1974). The social organistion of the species has a direct influence of the environment which places the R. unicornis in a particular habitat along with the group formation, communication and reproductive habits that have been followed by the members of the species.

The locomotion, grazing and wallowing habit of the species showed certain cycles with reference to the time spent on feeding, rest and wallowing. The wallowing habit is a process or measure of reducing excessive heat of the body and elemination of ecto-parasite and get relief from its menace. Track formation,of defecation, urination and wallowing are natural phenomena, similar phenomena have been described by Schankel and Schankel-Hulliger (1969) and Laurie (1978, 1982) etc. in other species of rhinos.

Various processes involving in communication and interaction of R. unicornis are characteristic and are prevelent in all other species of rhinos.

Different sounds which are involved in the process with reference to fighting or chasing during premating and mating times, during disturbance by various agents, sending messages to the calf by the cow or vice-versa are similar to most other wild animals. In the present investigation altogether 9 different sounds were detected corresponding with the communication. The urination posture of male and common defecation sites are some of the special characteristics of Rhinocerotidae. Further, the defecation and urination processes are directly involved with the communication and their group behaviour. The olfactory sense receiption is quite strong which compensate for the poor vision of the species. Further, identification of non-moving objects as disturbing elements are some of their peculiar instinct regarding their vision.

R. unicornis is basically a peace-loving animal dwelling in association with other ungulata or herbivores as well as carnivores. However, protection of their calves was one of the causes of their animosity where several attack of tigers have been recorded. During the present investigation herbivores were found to live in good harmony with R. unicornis. The association of the cattle egret is a phenomenon of commoncialism, where the bird acts as remover of ectoparasite or flies and further acts as a signal of communication with reference to any disturbing elements for the rhinos.

The study on the home-range or its distribution pattern with reference to feeding, defecation wallowing, rest and rooming areas of *R. unicornis* signifies that the species require relatively less area during summer, which might be associated with occurrence of flood and abundance of food plants which grow luxuriantly during summer and monsoon. Male *R. unicornis* requires a wider or greater home range irrespective of summer or winter. Laurie (1982) described the home range of different species of rhino, including the *R. unicornis* of of Nepal, where he cited that *R. unicornis* require 2-11 sq. km.

PART - II

REPRODUCTIVE BEHAVIOUR IN *R. unicornis*:

R. unicornis is an endangered species of wildlife and hence its reproduction and survibility are the major issues from the point of conservation of this precious wild animal. An attempt has been made to study certain aspects of the reproductive behaviour of *R. unicornis* under the eco-system of Kaziranga National Park and in captive condition at the State Zoo, Guwahati, Assam. Data pertaining to the reproductive pattern of the species were also collected from the Forest authority.

Laurie (1978) stated that external signs and symptoms of oestrus in *R. unicornis* were difficult to notice, as such information on reproductive behaviour is limited. Oestrus in the present study was confirmed by observing the acceptance of the male by the female and/or from the act of cooperation. In the oestrus period associations between adult male and adult female were found to last for three days or sometime more, during which copulation took place intermittently as in the case of the horse. 29 Occurrences of oestrus were observed out of which 20 were observed to last only for one day and in some occasions females were seen to be away from males on the next day. Although the occurrences of oestrus observed were not shown to last for more than one day it was suspected that there might have intermittent associations with the adult male for two days or more. Further, the recurrence of oestrus was found to be most frequent which was at intervals of 27 to 32 days, counting the intervals between the time of first detection or activity till it maintained associations, while in certain cases after 42 days of interval the females copulated or accepted the males.

Chaturvedi (1968) reported that the desire for courtship and copulation in the male and female does not synchronize all the time so they are termed as reluctant breeders. Observing the breeding biology of R. unicornis at Kanpur Zoo, Mishra (1986) stated that a female in heat, sprays urine, while the vagina flashes. At the same time she utters a rhythmic call, a whistling sound (rutting call that is produced by passing air in and out during breathing).This sound may be attributed to the result of grunting after a hot chase by the male. The female comes to heat after every 46-48 days and remains so for approximately 24 hours. However, the intervals between heat may vary between 38 to

58 days. Shortly after the heat begins the animals will chase one another. Usually a rest period of several hours follows these chases, and the animals will stand besides each other. After many hours, attempts to mount take place but only after several attempts the bull's penis becomes erect enough to achieve intromission. Both animals remain in copulating posture for about 60 minutes.

The length of the gestation period was obsrved to vary from 360 to more than 570 days and number of calf per birth was one (Morris, 1968). The female rhinoceroses were found to be excellent mothers in captivity and most of the calf born were reared successfully. The neonate calf weighed 50 kg and 105 cm in length at Kanpur Zoo.

Alikhan and Choudhury (1987) reported that when in oestrus, the female behaved very restlessly with switching of the tail, micturition at short interval of time, emitted low grunting noises and approached the partition wall of the male enclosure repeatedly. The interval of the oestrus cycle was 48 days and the duration of oestrus was abotu 24 hours. They observed that before mating the male and the female chased each other while female was seen to be more aggressive.

Observing the parturition process Sanyal (1892) stated that the rhinoceroses showed restlessness and acute labour pain before giving birth.

OBSERVATIONS ON THE REPRODUCTIVE BEHAVIOUR ON CAPTIVE *R. unicornis*:

1. Oestrus behaviour in female:

A Zoo born female *R. unicornis* was found to exhibit the following Oestrus signs and behaviours, which were recorded as follows:

(i) The female exhibited the signs of 1st oestrus at the age of 7 years. The animal became restless and lost her interest in food and water.

(ii) She looked hither and thither raising her head with production of grunting sound.

(iii) The vulvae were swollen and became pink red in colour and flashes accompanied by frequent micturation.

(iv) In the presence of male rhino she tried to agitate him by chasing, biting and keeping her head on the shoulder of the male.

(v) The oestrous period was found to last for 16 hours and the length of the oestrus cycle obsrved in two successive cycles were recorded to be 38 days and 46 days.

2 The mating behaviour of male *R. unicornis*:

(i) A male *R. unicornis* calf playfully mounts over a female even at the age of 6 months.

(ii) Successful mating was seen at the age of 8 years in the captive state.

(iii) In the captive state when a male _R. unicornis_ was released to a female in oestrous, he took some time to be sexually aroused.

(iv) The male smells the urine and licks the vulvae of the female in oestrus.

(v) An adult male rhinos was found to chase the female in oestrus when did not cooperate with him. On the contrary the male attempted to mount the cooperating female. The mating become successful after one or two unsuccessful attempts of mounting.

(vi) In successful mating the male _R. unicornis_ mounted the oestrous female keeping the two fore legs around the shoulder of the female and grasped her keeping the weight of the body on his hind legs. Rhythmic thrust of force was given for intromision of the penis.(Fig. 25, a-d)

(vii) The time of ejaculation could be ascertained by postures of the mating moment when the lumber region of the male was contracted with trembling and keeping the head of the male still on the female's shoulder.

(viii) The process of mating took place in two sequences:

First : It took 42 minutes (mounting period).

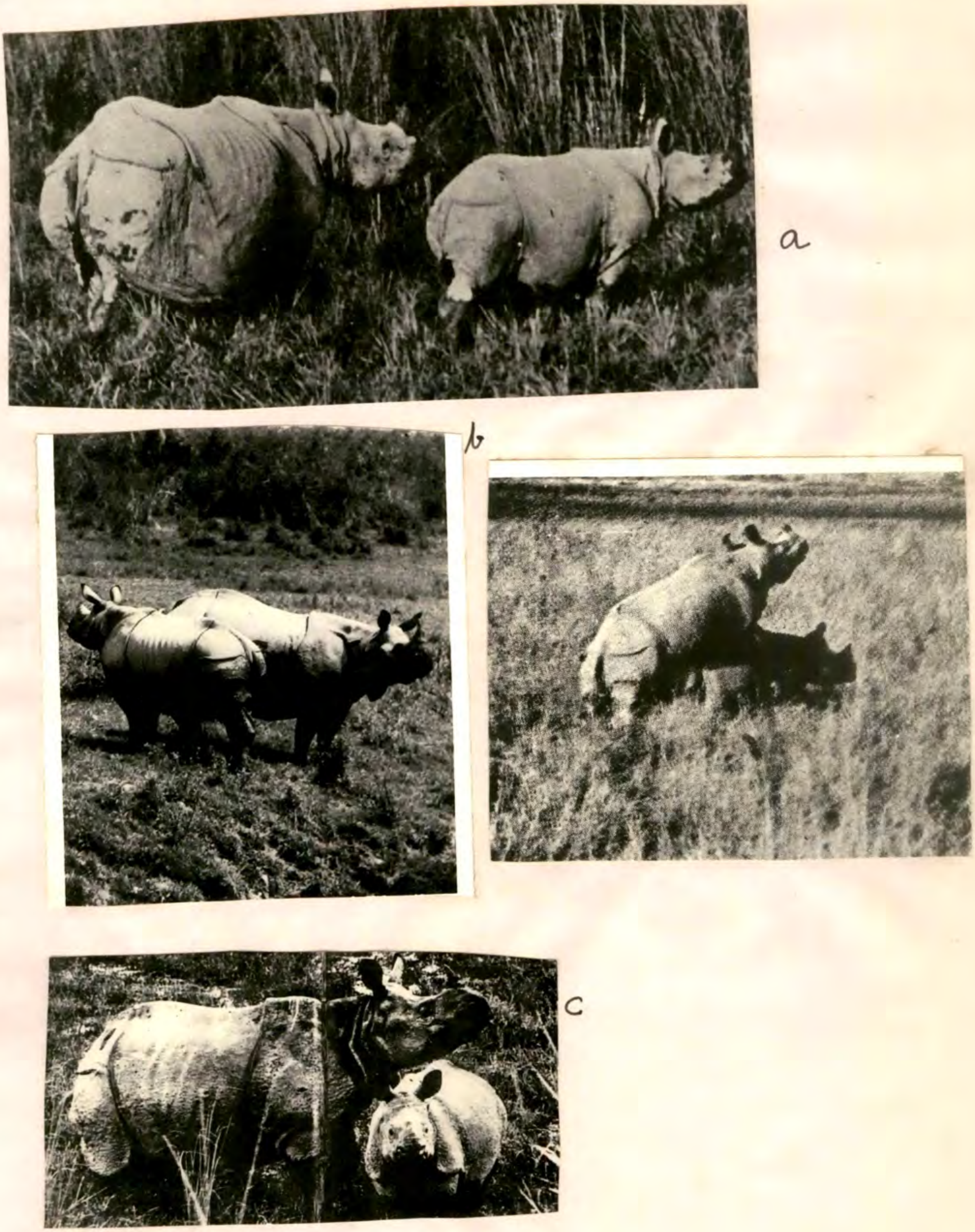


FIG. 25(a-d): PRE-MATING PAIR (a,b); MOUNTING OVER THE FEMALE (c), (d)
R. *unicornis*.

Second: After 3 hours of 1st sequence, second time mating was observed which lasted 50 minutes.

(ix) After the mating was over the male took food and water and was found roaming in a friendly manner with the female guarding her for 3 days post oestrus.

(x) Length of gestation period was recorded to be 461 days (n=1). In the other case the premating and mating behaviour could not be observed but the gestation period was recorded was 506 days.

(xi) The intercalving period (n=1) recorded in 2nd calving were 1 year 8 months 19 days i.e. (624) days.

SIGNS OF OESTRUS AND MATING BEHAVIOUR OBSERVED IN NATURAL HABITAT OF KAZIRANGA NATIONAL PARK:

The mating season of *R. unicornis* in the Kaziranga National Park was observed from November to April. The oestrus behaviour of female (n=4) and mating behaviour of the male (n=4) were observed. The sexual behaviour of rhinoceros female was rèlatively inconspicous and less marked in the absence of bull. During courtship the animals snort, sniff or occasionally squeak. Prior to few days of mating a premaing bond was initiated between bulls and cows, they remain together in their daily activities such as feeding, resting and wallowing and might sleep together in close contact. No hostile behaviour were seen between them and the bull even tried to defend the cow in case of disturbance by other animals or approach of man. The signs and symptoms recorded on (n=4) females were as follows:

(i) The female in oestrus were found to be restless, and

(ii) The length of oestrus cycle varied from 24 to 49 days. The details are tabulated as follows:

Year, Months	Cycle length(days)	Identifying mark for the female (n = 4)
1987, December	24	Cut mark in the right ear
1988, January	39	Wound in the shoulder
1988, February	46	Wound in the left thigh
1988, March	49	Cut mark in both ears.

(iii) More than one male were seen to follow the female in heat followed by vigorous fighting among the competing males and some of them were injured.

(iv) The female were often seen to fight with the male before coming to a compromising courtship state and allowed the male to mount.

(v) During mating the bull tried to contact the oestrous cow. In some cases the cow tried to go away from the male. Sometime the cows were seen to rush at the bull and snort. Under such circumstances mating occurs through a rough kind of courtship (Fig. 25, a-d).

(vi) During mating, the male was found to adjust his fore legs on the shoulder of the cow, maintaining and upright posture and the tail in an almost horizontal position for few seconds (Plate, Fig. 25c).

(vii) Act of mating took place for (n=4), 48, 70, 65, 80 minutes respectively.

(viii) After completion of mating the pair was found to maintain a post-mating bond in which they graze together in the same grazing ground and or wallowing in the same wallowing place after which the male departed from the female so also the female and did not allow any male to come close to her even after the birth of the calf till the calf attains the age of 1½ to 2 years.

OBSERVATIONS ON THE PROCESS OF PARTURITION:

The knowledge of the process of parturition in any species is of utmost significance from reproductive and managmental points of view. It is more so in rhinoceros, as it is one of the most valuable and rare kind of wildlife. In the wild state, the mating of the rhinoceros takes place unnoticed in grazing places and the process of parturition is also accomplished. Very little knowledge has been gathered on the process of parturition, the neonate and maternal behaviour of the rhinoceros. Because of the fighting behaviour among the rhinoceros particularly with the animals of opposite sex, the advanced pregnant animals need to be separated to avoid possible injury to the pregnant animals, abortion or injury to the neonate rhino calf. The present study has been conducted to gather knowledge about the process of parturition and its different sequences in captive rhinoceros to reduce the hazards mentioned.

The different symptoms of parturition were not found to be distinct in rhinoceros, except restlessness. The birth starts with episodes of labour and lasted about for an hour then the water bag appeared. The actual time taken from the appearance of water bag to the expulsion of the foetus was found to be 22 minutes and the time taken from expulsion of the foetus to the expulsion of the placenta was 190 minutes. The placenta was of the diffuse type. The findings have been recorded in Table 24. The new born calf started standing after 35 minutes of birth. The total body length of the foetus was found to be 105 cm, while the girth at chest and height at shoulder were 93 and 45 cm respectively. The data have been shown in Table 24. On the very first day of birth the rhino calf was found to be in a staggering gait and took time to locate the udder to suckle. It suckled perfectly only for 6 times on the first day. On the second day it could run and climb to a slant of the enclosure and followed the mother. It suckled milk

14 times on the second day. On the third day, it suckled 12 times, ran and followed the mother in water, as observed from 7am to 7 pm. The mother was found to be very affectionate to the newly born calf. She guarded the neonate calf grazing nearby. The mother rhino was found to lif t one of the hindlegs to facilitate the calf to suckle. When the calf was separated, the mother searched for it by moving hither and thither with a grunting sound.

TABLE - 24

Observation on the act of parturition

Parameters	1st calving	2nd calving
1. Date of parturition	11th May, 1987	20th March 1989
2. Age of male/female at the time of parturition	12 year 3 months 11 days/9 year 4 months 2 days.	14 year/11 year 2 months 21 days.
3. Length of parturition	382 min.	905 min.
4. Duration of labour pain.	170 min.	760 min.
5. Time taken for explusion of the foetus aftr appearance of the water bags.	22 min.	25 min.

TABLE - 24 (Contd.)

Parameters	1st calving	2nd calving
6. Time taken for expulsion of the placenta after expulsion of the foetus.	190 min	120 min.
7. Weight of the placenta	Not recorded	4.2 kg

TABLE - 25

Biometry of new born calf

i) Colour of the calf	Grey white	Grey white
ii) Sex	Male	Male
iii) Total length (cm)	105	110
iv) Girth on chest (cm)	93	97
v) Height (cm)	45	66
vi) Length of head (cm)	30	37
vii) Girth of head (cm)	93	98
viii) Girth of neck (cm)	54	58
ix) Length of tail (cm)	54	57

DISCUSSION

In present study on the behavioural econoly of the reproduction strategies of R. unicornis on captivity has revealed that it is a polyoestrus ungulate showing distinct and pronounced oestrus symptoms. A similar observation has been recorded in R. unicornis inhabiting Nepal (Laurie, 1982).

The oestrus cycle of R. unicornis recorded in the present investigation were 38 to 46 days in captivity in State Zoo, Guwahati, Assam and 24 to 49 days under natural condition in Kaziranga National Park. The minimum 24 and 38 days and maximum of 46 and 49 days almost similar to figures recorded by Laurie (1982) in Nepal. The minimum days recorded by Kakati and Rajkonwar (1972) needs further investigation The maximum days observed by Kakaty and Rajkonwar (1972), Grzimek (1972), Chaturbedi (1928), Laurie (1982), Misra (1986) are similar to the present findings.

The time taken and the frequency of mating of R. unicornis in captive male found to be 42 minutes in its first sequence of mating and the second sequence after three hours of the first attempt and the mating lasted for 50 minutes. In wild condition of the Kaziranga National Park the observation of 48 to 80 minutes (n=4); 48, 70, 65 and 80 minutes in the single sequence of mating only has been seen. The longest period of mating recorded was 83 minutes (Grzimek, 1972) and 60 to 90 minutes (Kakaty and Rajkonwar, 1972), (Laurie 1982) reported 30-60 minutes mating time in R. unicornis of Nepal.

The earlier study revealed (Kakaty and Rajkonwar, 1972) that R. unicornis prefer to breed during the months from April to June, in the present study it was found to be November to April. The length of gestation period of R. unicornis in the present study was found to be 461 and 506 days in two different pregnant females. A wide range of gestation periods were recorded by different workers in R. unicornis at different places are as follows:

	Gestation period (days)	Workers and year of record
I	570 (19 months Calcutta Zoo)	Ali, 1927.
II	462-488	Morris and Jarvis, 1959.
III	462-488	Tong, 1960.
IV	462-488	Lang, 1961.
V	360-570	Morris, 1968
VI	488	Crandall, 1964.
VII	480	Chaturvedi, 1968.
VIII	462-489	Grzimek, 1972.
IX	474 (Assam State Zoo)	Kakaty & Rajkonwar, 1972.
X.	462-488	Buechner et al., 1975.
XI	462-488	Lang et al., 1977.
XII.	462-488	Maurice & Burton, 1975.

The concept of a long gestation period of large animals as compared to small mammals has been observed in case of the elephant 615-650 days, which may be cited as an example (Roberts,1971). The gestation periods of R. unicornis, D. bicornis, C. simum have similarities although D. sumatrensis has a very short period ranging from 212-240 days (Sanyal 1892; Bartlet 1873; Morris and Jarvis 1959; Tong 1960; Lang 1961, Krishna-Gowada 1969; Buechner et al. 1975 Schaurte 1969; Pienaar 1970; Owen and Smith 1973; Lang et al. 1977). Further it may

The present investigation (n=2)after observations of restlessness and discomfort the time taken from the appearance of the water bag to the expulsion of the whole foetus was recorded to be 22-25 minutes while the expulsion of foetal membrane took 120 and 190 minutes.Some of the earlier reports(Ghoirola,1987) showed that the 30 minutes required from the time of appearance of the water bag to the time of complete expulsion of the foetus and 2-4 hours for expulsion of the placenta. Grzimek (1972), observed an almost similar period of duration of parturition which is about 22 minutes in the case of *R. unicornis*. The placenta was found to be of the diffuse type (Goswami *et al*., 1987). The foetus or neonate calf took 35 to 50 minutes to stand and 50-52 minutes to start its suckling habit after birth. In the present study, the *R. unicornis* was found to be an excellent mother who permitted frequent suckling and extended extensive protection to the calf. The maternal care of other rhinoceroses as reported by Schenkel and Schenkel-Hulliger (1969a) is almost similar with *R. unicornis* observed in the present study.

The calf of *R. unicornis* (n=2) were born strong and healthy, with some differences in the weight (60/64 kg), height (45/66cm), girth on chest (93/97 cm), length (105/110 cm), length (30/37 cm) and girth (93/98 cm) of head or even the tail length (54/57 cm). These variations although appears to be slightly different but might not be significantly different. Earlier reports on the body length of the neonate calf (Barua, 1969) showed almost the same length. However, the height recorded in the present study is less than the report of Grzimek (1972). (Table 25).

The intercalving period observed in the present study was 624 days which is less than earlier records. Kakati and Rajkonwar (1972) reported 840 days in R. unicornis which gave birth to its first calf at the age of 5 years 10 months and 21 days. The present observations was recorded upon two females which were quite matured (one was 9 years and the other was 11 years old).

Detailed investigative and long time observation at different environments (such as captive and wild condition) are of utmost significant for understanding the ecobiology with reference to the reproductive behaviour of R. unicornis.

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), Patar (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 diffrent 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 alongwith the crane at the time of transportation when the animals were lifed by crane.

(ii) For morphological and anatomical studies of different body parts and organs of the species carcase/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 concered chapter wherever necessary.

PART I

SURFACE ANATOMY (Physical features)

Three carcases 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

Body measurements of three adult Rhinoceros unicornis

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

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).

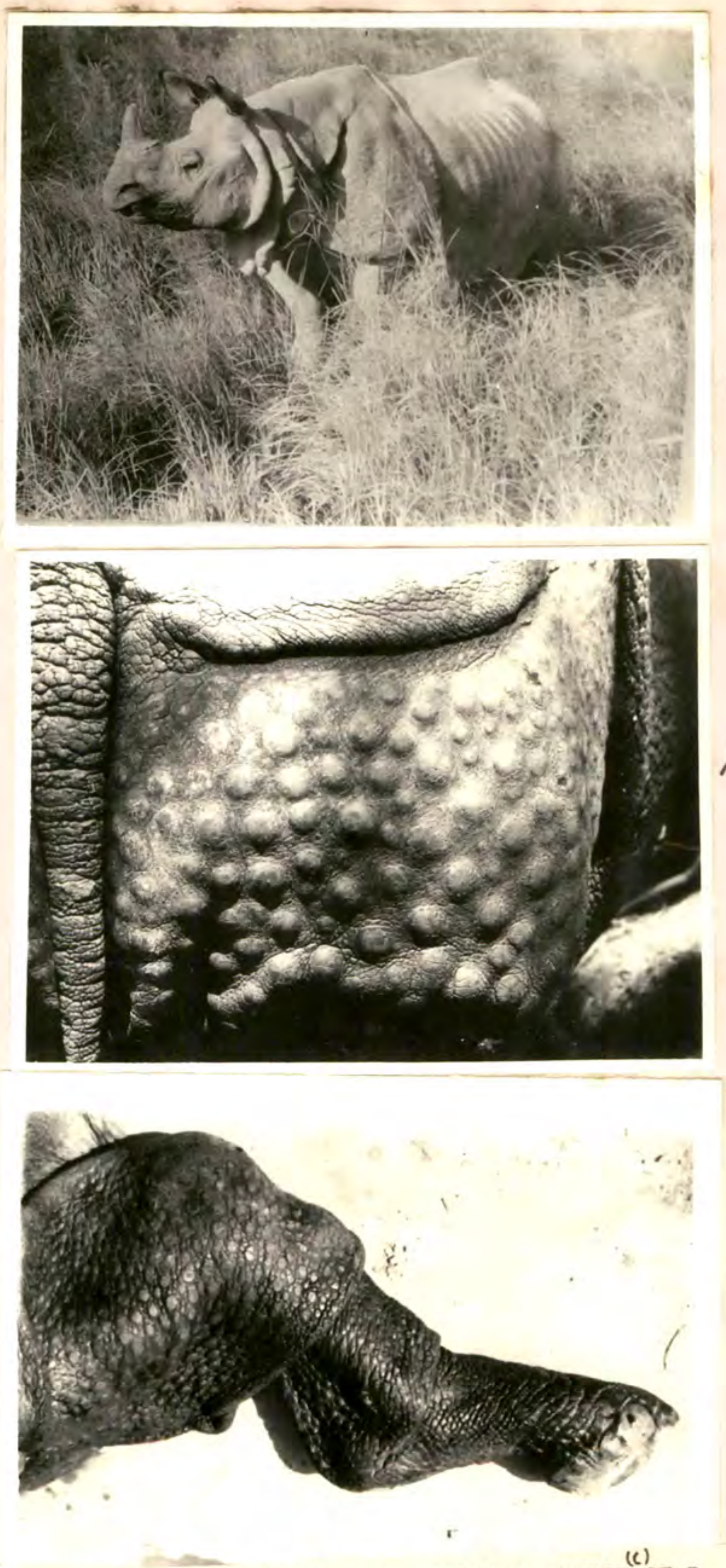
Region	No. of fold
Neck	3
Shoulder	2 (Right and Left)
Buttock	2 (Right and Left)

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 cm^2 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. unicornis**

Area	Size	Number of tubercles	Diameter of the tubercles (cm)
10 x 10 cm^2	Large	34	3.2
	Medium	32	2.5
	Small	27	1.2



a

b

c

FIG. 26(a-c): NECK FOLD(a), BUTTOCK(b), THIGH(c) OF *R. unicornis*

TABLE - 27

Measurement of horns of R. unicornis

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

* * Measurement of the end part was taken 4 c.m. 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.

a

b

c

d

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 IInd 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 - 27

Measurement of the toes of the forefoot in three adult *Rhinoceros unicornis*

Specimen	Measurement (cm)		
	IInd toes	IIIrd toes	IVth toes
1	9.0	17.0	8.0
2	8.0	18.0	9.0
3	8.5	19.5	6.5
Mean	8.5	18.1	7.8

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

Some physical characteristics of hairs from ear and tail

Site of the	No. of observations	Length (cm)	Diameter (mm)	Other Characteristics
Ear tip	1	2.0	0.011	Brownish black
	2	1.5	0.012	in colour and
	3	2.7	0.015	thin
	4	3.0	0.013	
		Mean = 2.3,	mean = 0.012	
Tip of tail	1	3.0	0.015	Black in colour
	2	3.2	0.014	thick wiry in
	3	2.5	0.017	nature.
	4	2.2	0.011	
		Mean = 2.72	Mean = 0.014	

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 speices (*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 stúdy 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).

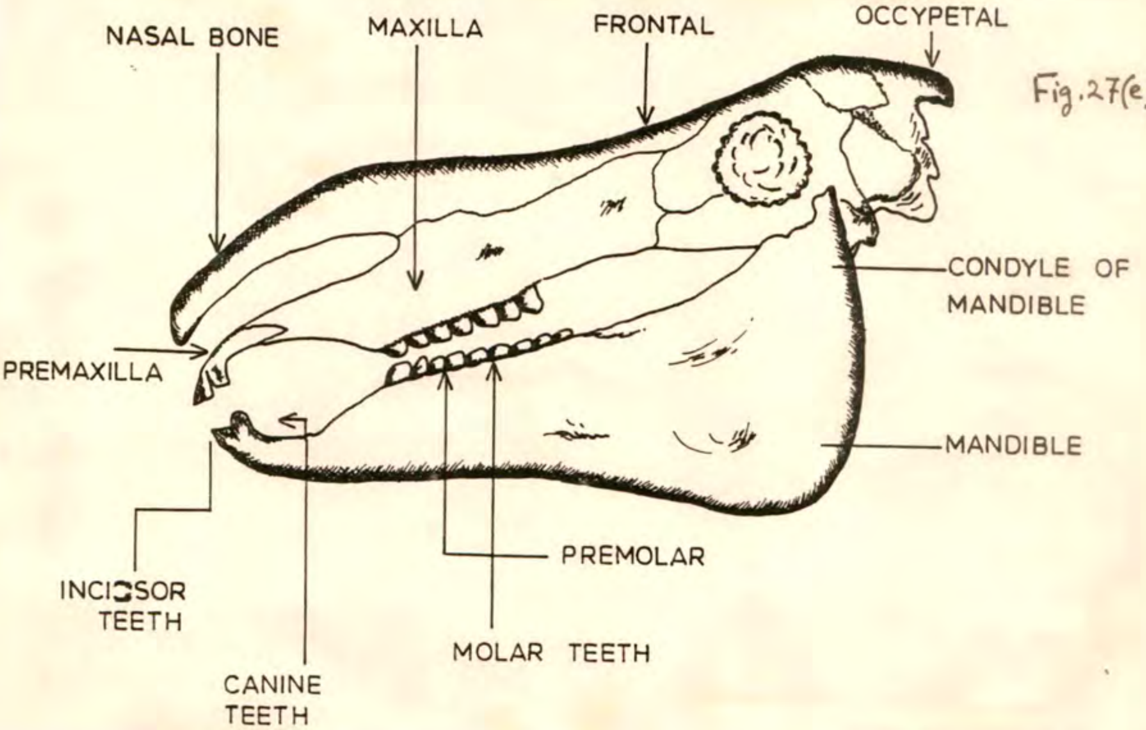


Fig. 27(e)

Fig. 29 (a)

Fig. 29. (b)

Fig. 29. (c)

Fig 28

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) <u>The nasal bones</u>:

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 apparature (Fig. 27 c).

<u>Biometry of nasal bones</u>:

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

Parameters		Measurement (cm)
(i)	Length of right nasal bone	27
(ii)	Length of left nasal bone	27
(iii)	Girth at base (right)	24
(iv)	Girth at middle (right)	18
(v)	Girth at apex (right)	6
(vi)	Girth at base (left)	24
(vii)	Girth at middle (left)	18
(viii)	Girth at apex (left)	6

(ii) <u>The maxilla</u>:

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:

Parameters		Measurement (cm)
(i)	Total length of maxilla	60
(ii)	Girth at base	76
(iii)	Girth at middle	68
(iv)	Girth at apex	42

(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:

Parameters		Measurement (cm)
(i)	Length of mandible	54
(ii)	Girth at base	60
(iii)	Girth at middle	52
(iv)	Girth at apex	31
(v)	Height of the condyle	48

(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)

Skull parts	Measurement in cm.		
	Female	Male (I)	Male (II)
Total length of the skull	62	71	78
		Mean 74.5	
Girth at the base of the horn	82	86	92
		Mean 89.0	
Girth at the base of the skull	134	143	154
		Mean 148.5	
Length of maxilla	66	74	79
		Mean 76.5	
Girth of maxilla at the base of the horn	42.6	51	54
		Mean 52.5	
Girth of the maxilla at its posterior end	62	70	74
		Mean 72.0	

TABLE - 30 (Contd.)

Skull parts	Measurements in cm.		
	Female	Male (i)	Male (ii)
Length of nasal bone	34	42	46
		Mean 44.0	
Breadth of nasal bone	8	12	17
		Mean 14.5	
Length of the mandible	49	58	62
		Mean 60.0	
Girth of the mandible at middle	43	45	48
		Mean 46.5	

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) <u>The teeth</u>:

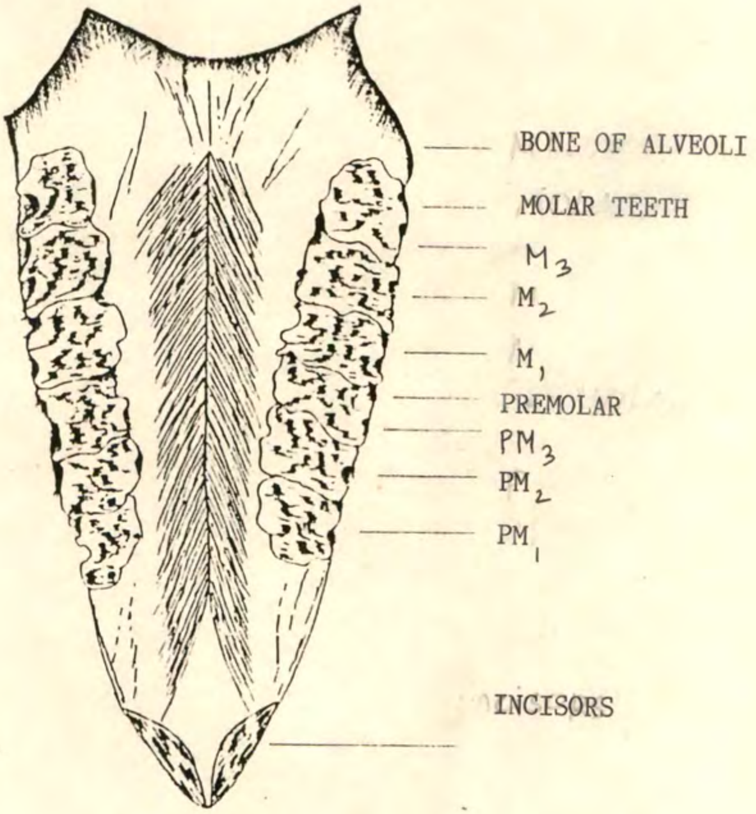
The teeth are present in both the upper and the lower jaws in *R. unicornis*. The teeth were not found to be equal in size and number in both the jaws. All types of teeth *viz.* incisors, canines, premolars, and molars were found to be present in this species (Fig. 27, e; 29 a,b,d,e).

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 wre 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:

<u>Number of teeth in one half of the jaws</u>

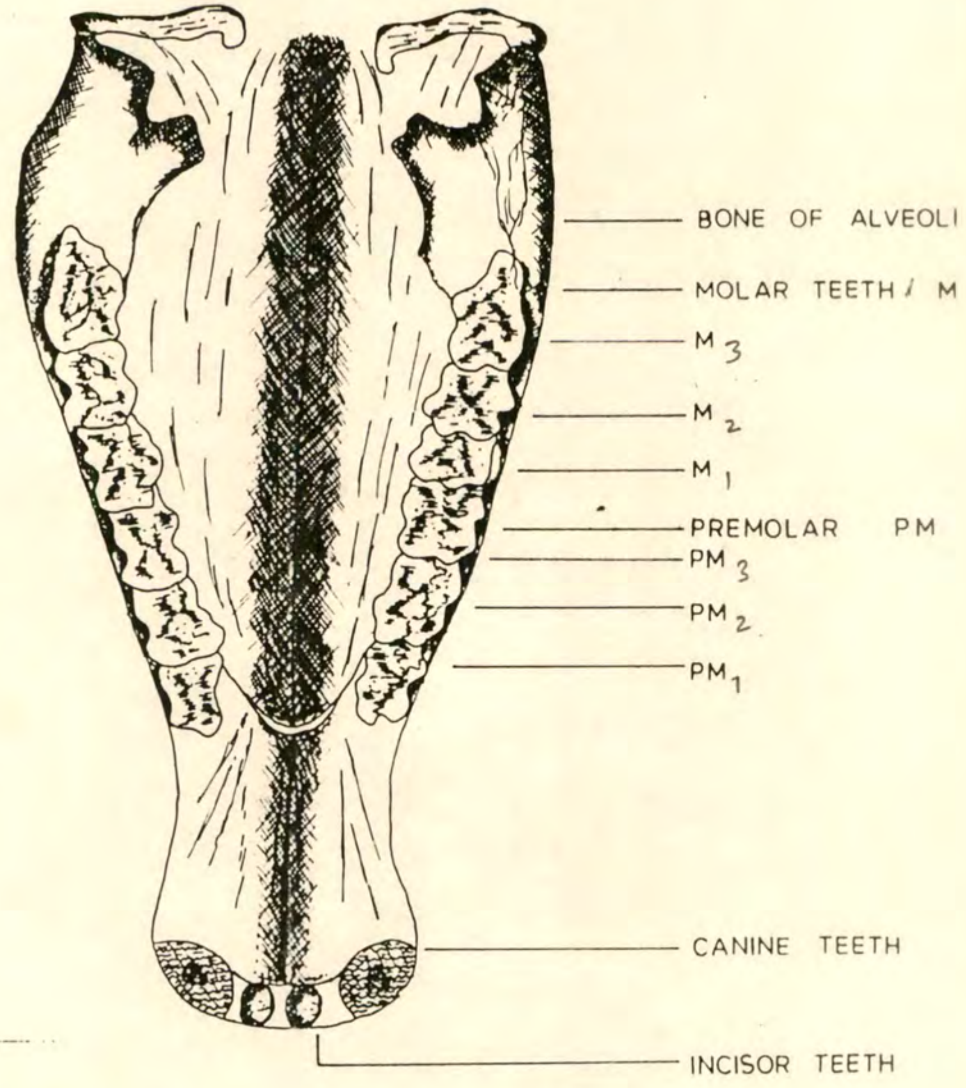
Jaws	Incisor	Canine	Premolar	Molar	Total
Upper	1	0	3-4	3	7-8
Lower	1	1	3-4	3	8-9

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).

D. sumatrensis	*R. sondaicus*	*R. unicornis**	*D. dicornis*	*C. simum*
Brachyodont protocone fold	Brachyodont	Hypsodont, protocone fold	Brachyodont	Hypsodont

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

Number and location of different vertebrae

Vertebrae	Number	Location
Cervical	7	Neck
Thoracic	18	Thorax
Lumber	6	Lower back
Sacral	5-6	Loin
Coccygeal	17-19	Tail
Total	53-56	

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.

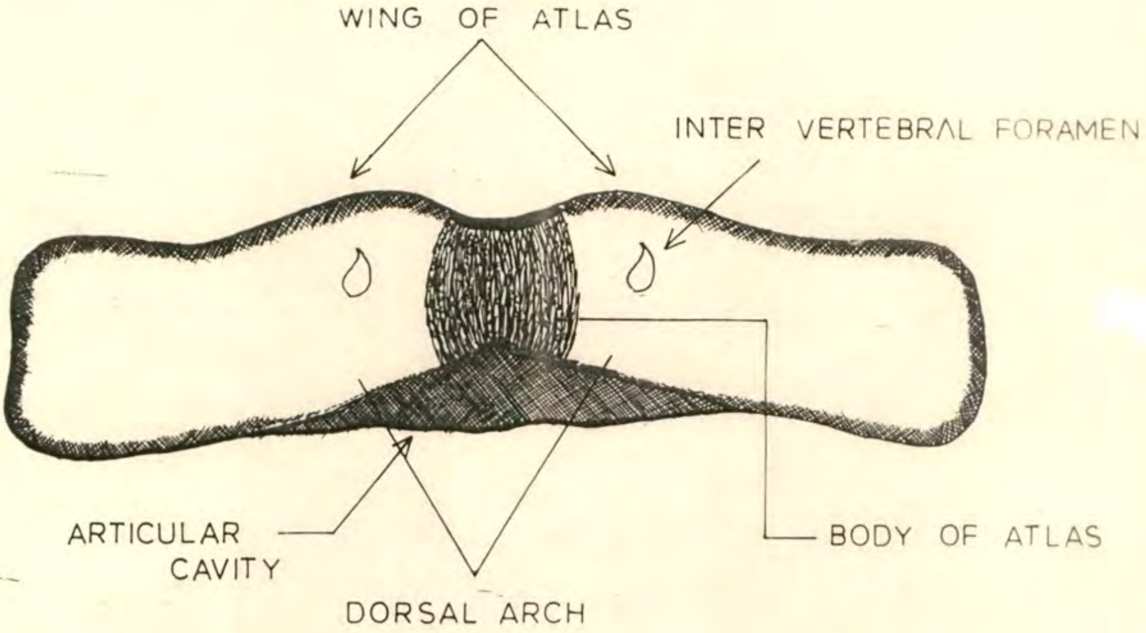
<u>The cervical vertibrae</u>:

(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 occypital bone in front and the axis behind (Fig. 30). It measures as follows:

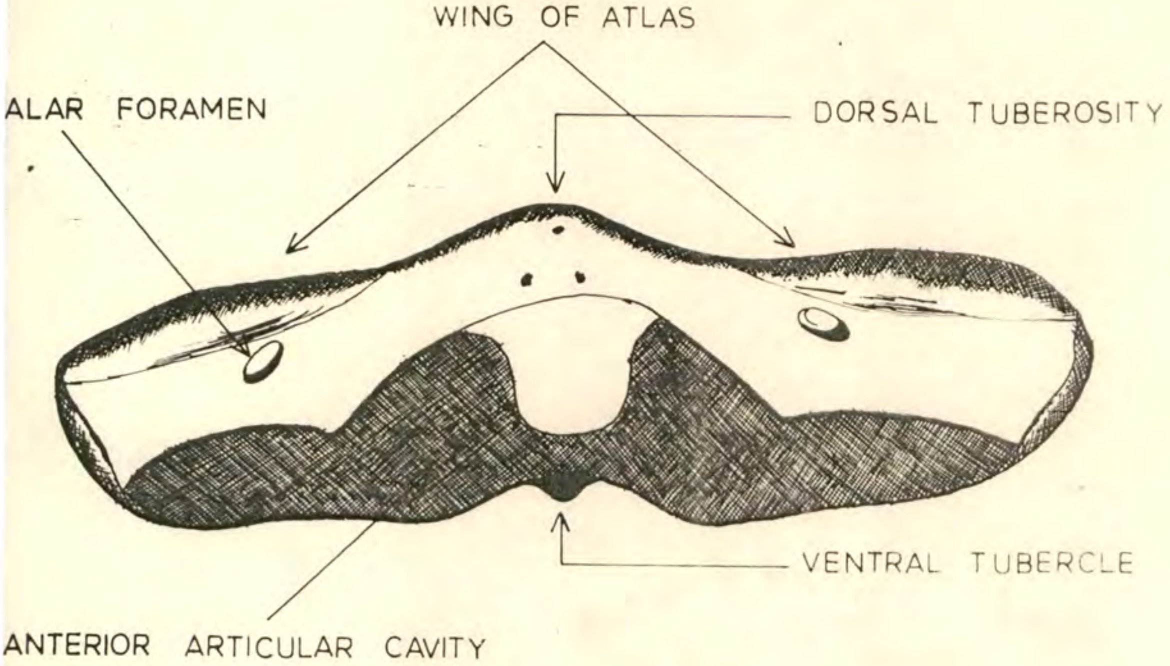
Parameters	Measurement (cm)
Length of the Atlas	7.5
Breadth	38.0
Thickness	13.7
Length of the wing	17.0
Breadth of the wing	4.5

(ii) The 2nd cervical vertibra 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 vertibra behind (Fig. 31).

Parameters	Measurement (cm)
Length of Axis	15
Girth	38
Thickness	14

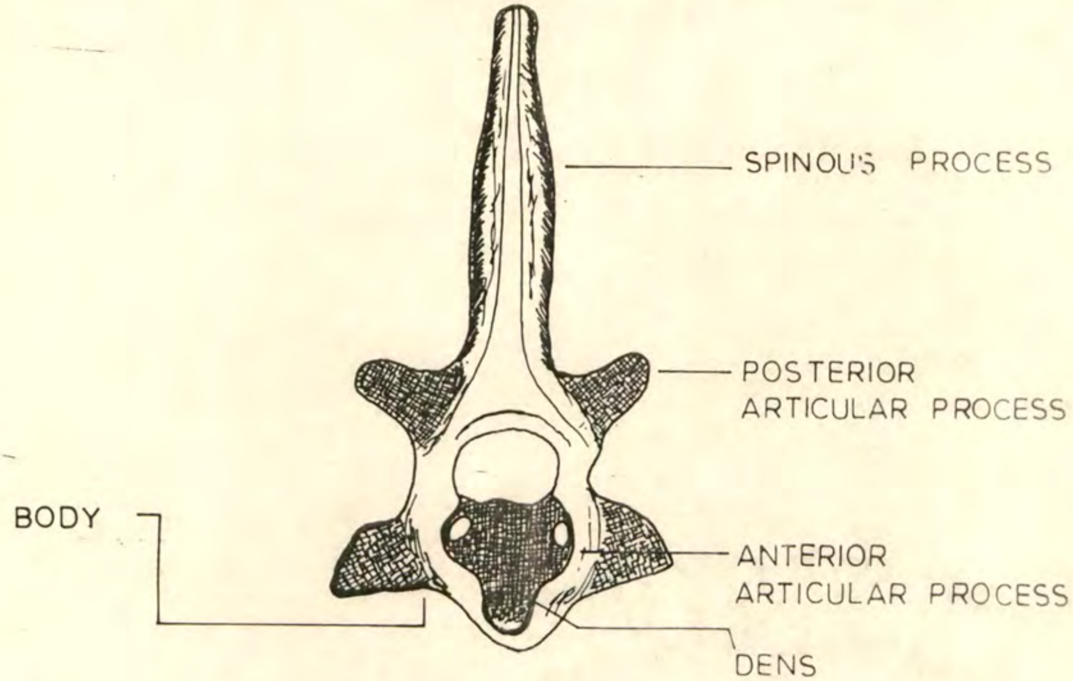


ATLAS OF RHINOCEROS UNICORNIS (DORSAL VIEW)

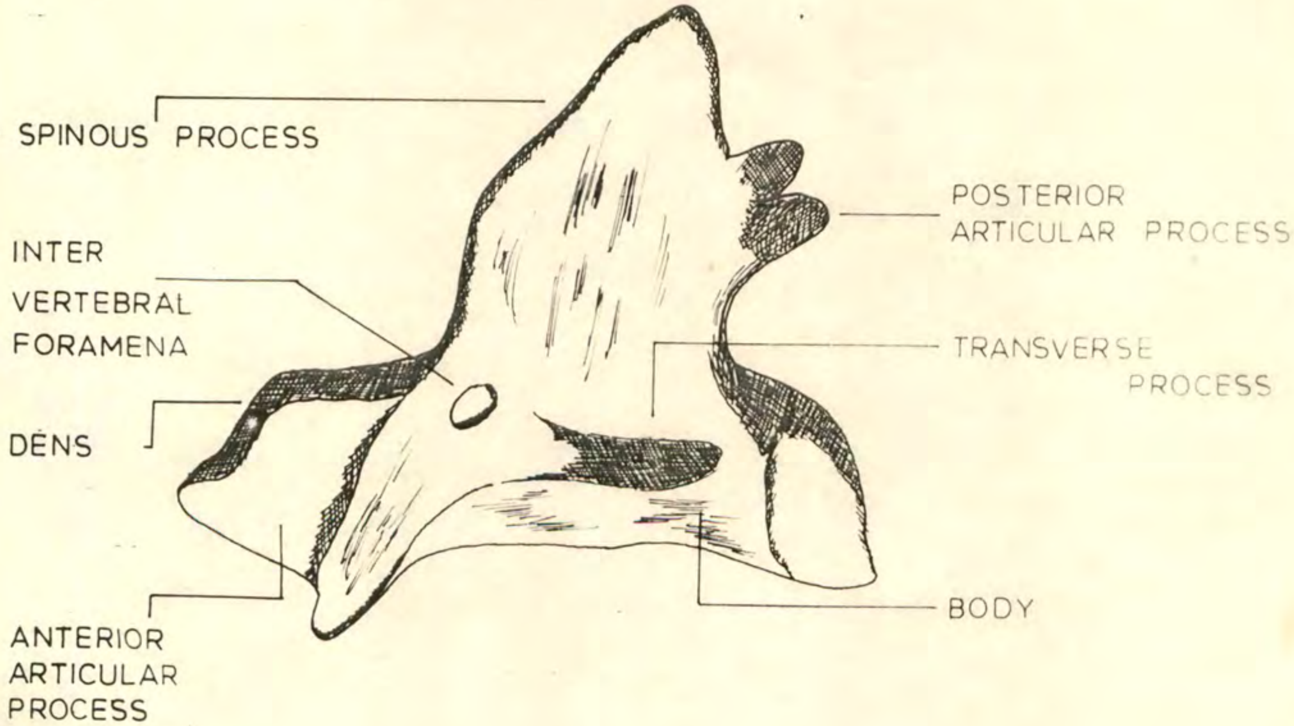


ATLAS OF RHINOCEROS UNICORNIS (ANTERIOR VIEW)

Fig. 30



AXIS OF RHINOCEROS UNICORNIS
(ANTERIOR VIEW)



LATERAL VIEW OF AXIS OF RHINOCEROS UNICORNIS

Fig. 31

(iii) 3rd to 6th cervical vertibrae were found to be almost similar in structure with that of 2nd cervical vertibrae.

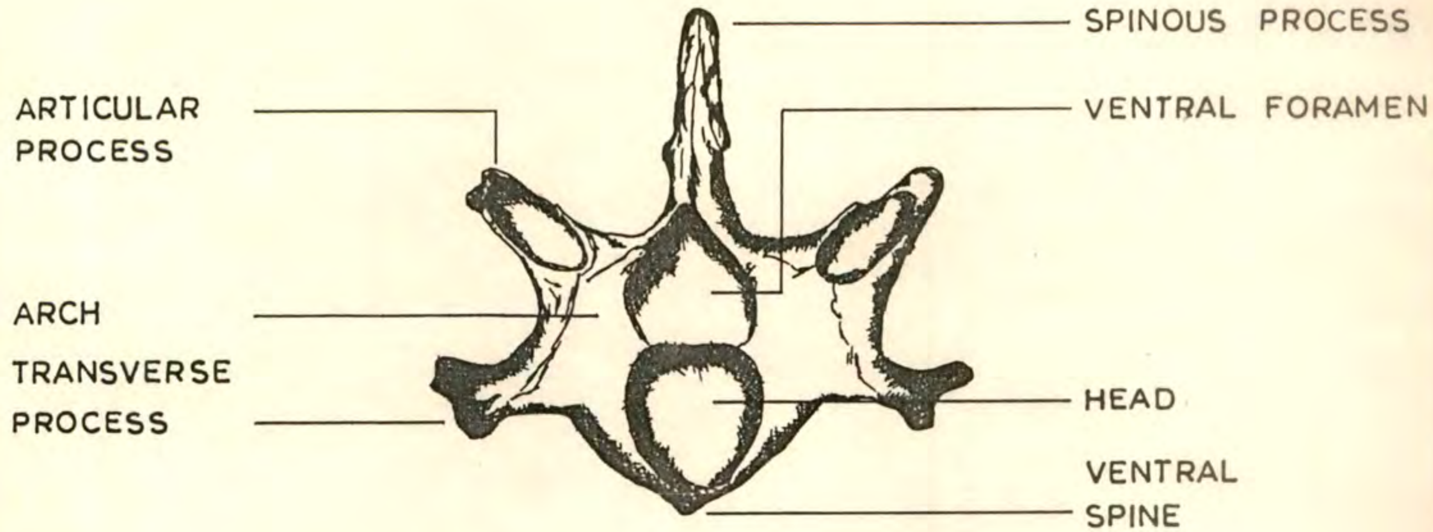
(iv) The 7th cervical vertibra found to have a distinct body and spinous processes. It is short and flat in comparison with other cervical vertibrae. It bears a well developed spine. The following measurements were recorded on the 7th cervical vertibra of an adult R. unicornis (Fig. 32)

Parameters	Measurement (cm)
Length of the vertibra	9.0
Breadth	8.5
Thickness	10.0
Length of spinous process	18.0

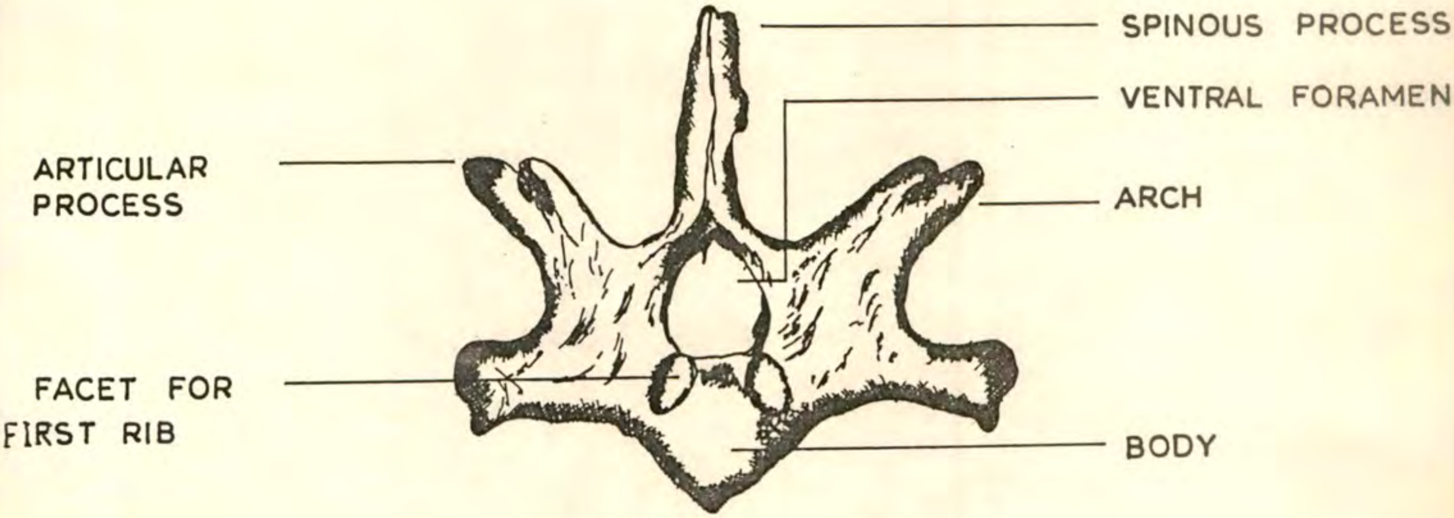
The thoracic vetebrae:

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:

Parameters	Measurement (cm)
Length of the 1st thoracic vertebra	8.5
Breadth	12.5
Thickness	11.0
Length of the spinous process	23.0

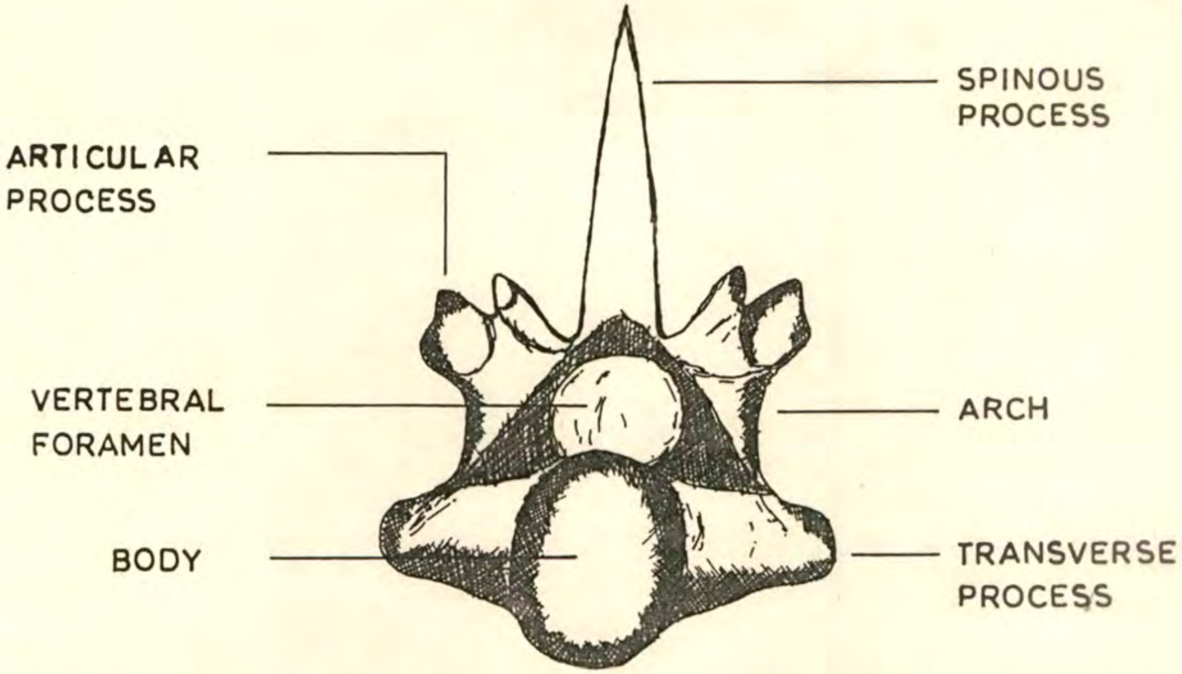


SEVENTH CERVICAL VERTEBRA OF R.UNICORNIS ANTERIOR VIEW

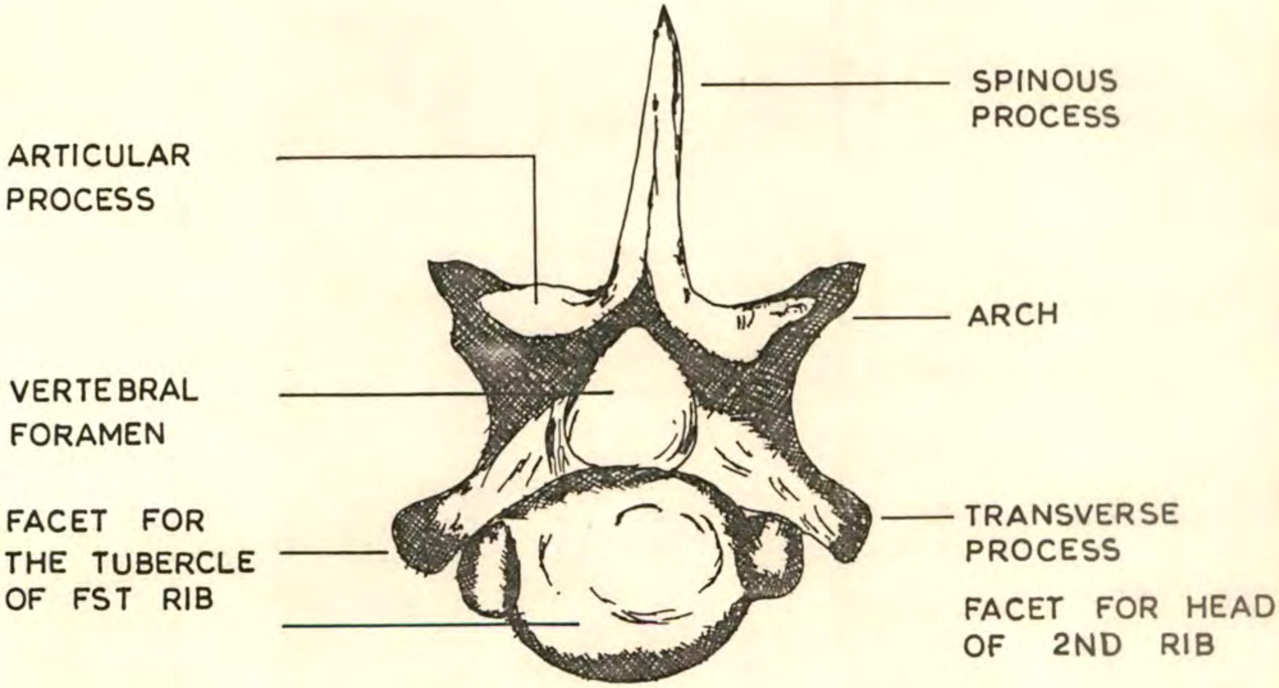


SEVENTH CERVICAL VERTEBRA OF R.UNICORNIS. (POSTERIOR VIEW)

Fig. 32



FIRST THORACIC VERTEBRA OF R. UNICORNIS (ANTERIOR VIEW)



FIRST THORACIC VERTEBRA OF R. UNICORNIS POSTERIOR VIEW

Fig. 33

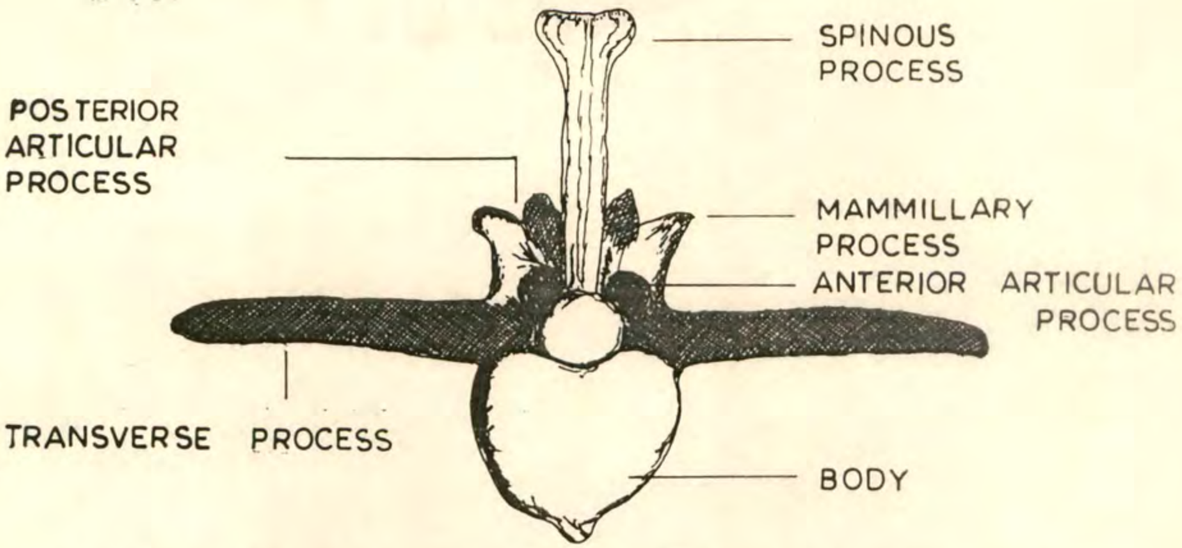
The lumber vertebrae:

The lumber vertebrae comprise the bones of the loin and they are six in number. The body of the lumber vertibrae 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:

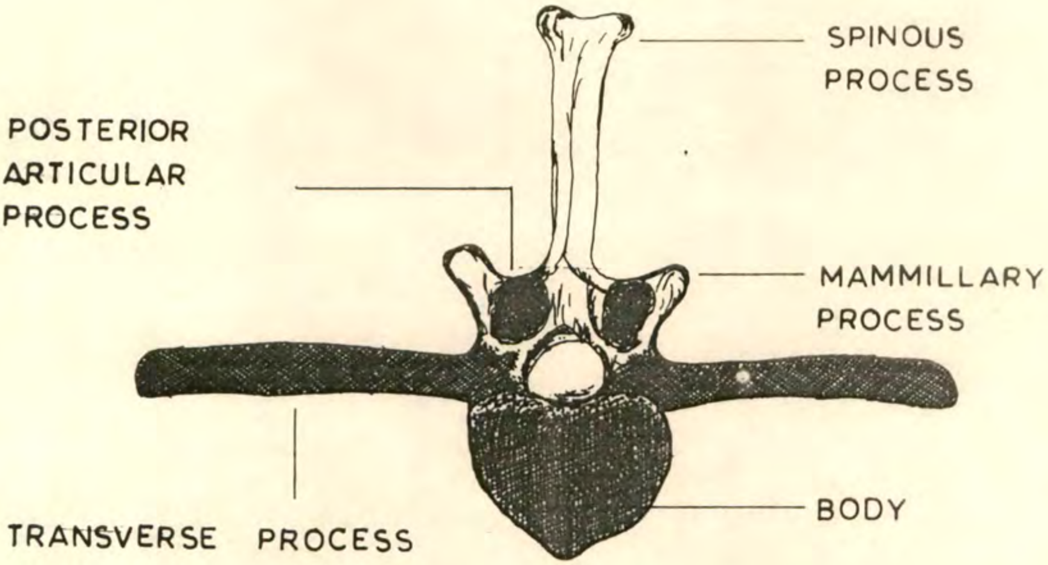
Parameters	Measurements (cm)
Length of the 1st lumber vertebra	7.0
Breadth	8.5
Thickness	6.5
Length of spines	15.0
Length of the transverse process	21.0

Scaral vertebrae:

Five to six numbers of sacral vertibrae 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 vertibra. 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)



FIRST LUMBER VERTEBRA OF R. UNICORNIS (POSTERIOR VIEW)

Fig. 34

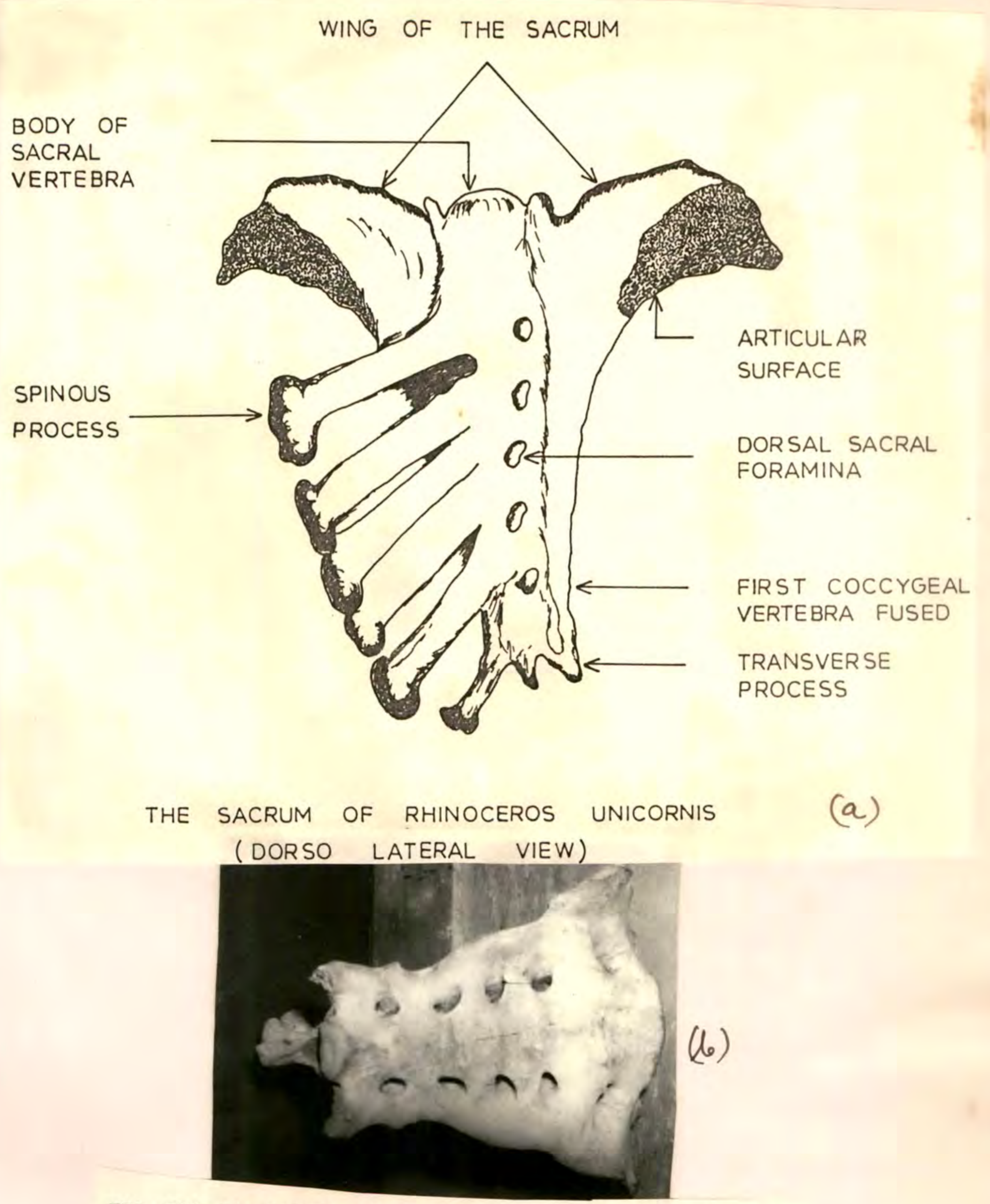


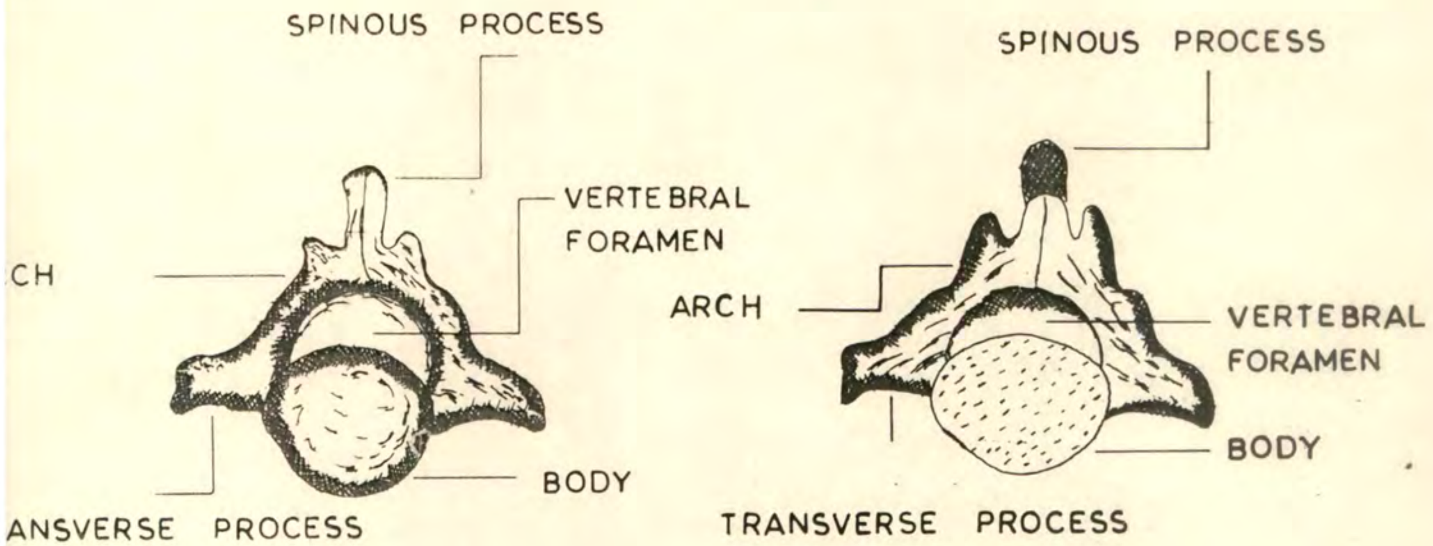
FIG. 35(a,b): SACRUM OF <u>R</u>. <u>unicornis</u>, DORSOLATERAL (a); VENTRAL (b) VIEWS.

Parameters		Measurement(cm)
Length of the sacrum		26.0
	Anterior end	24.0
Breadth	Middle	15.0
	Posterior end	10.0
Length	1st spine	14.5
	Last spine	5.5
Length of the body of 1st vertebra of sacrum		5.5
Breadth of the body of 1st vertebra of sacrum		7.5
Thickness of the body of 1st vertebra of sacrum		4.0
Length of the body of last vertebra of sacrum		4.5
Breadth of the body of last vertebra of sacrum		3.5
Thickness of the body of last vertebra of sacrum		2.5

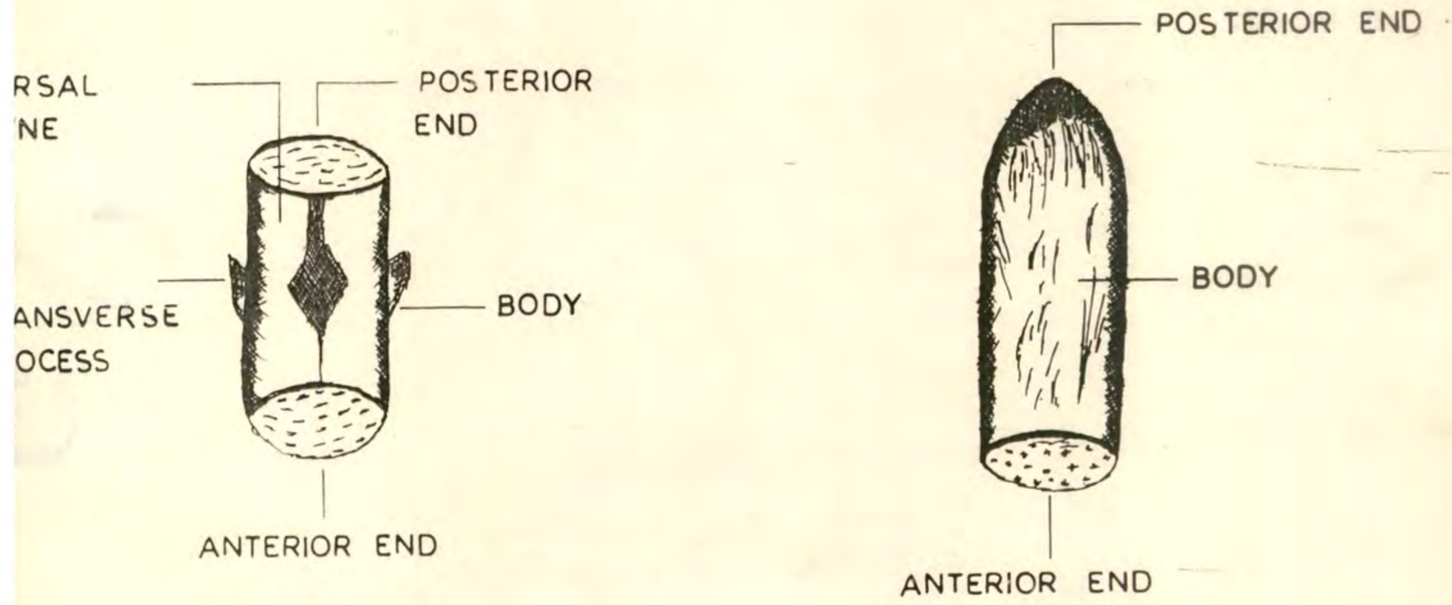
The coccygeal vertibrae:

The coccygeal vertibrae 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 vertibra is often fused with the sacrum. The first five of these vertibrae have a triangular shape at the beginning, then they take a cylindrical shape, gradually decreasing in size. The biometry of the 1st coccygeal vertibra is as follows (Fig 36).

Parameters	Measurement (cm)
Length of the body of the vertebra	3.5
Breadth	3.7
Thickness	2.8
Length of the spines	3.2



TERIOR VIEW AND POSTERIOR VIEW OF R. UNICORNIS.



/ELVE AND LAST COCCYGEAL VERTEBRAE OF R. UNICORNIS.

Fig. 36

TABLE - 32

Biometrics of the series of coccygeal vertebrae of R. unicornis

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

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 charactristics 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.

Parameters	Measurements (cm)
Total length of the rib	38
Maximum width of the rib	9
Minimum width of the rib	4
Diameter of the head	12

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:

Parameters	Measurements (cm)
Total length of the tenth rib	92.0
Maximum width of the tenth rib	2.0
Minimum width of the tenth rib	1.8
Diameter of the head of the tenth rib	7.5

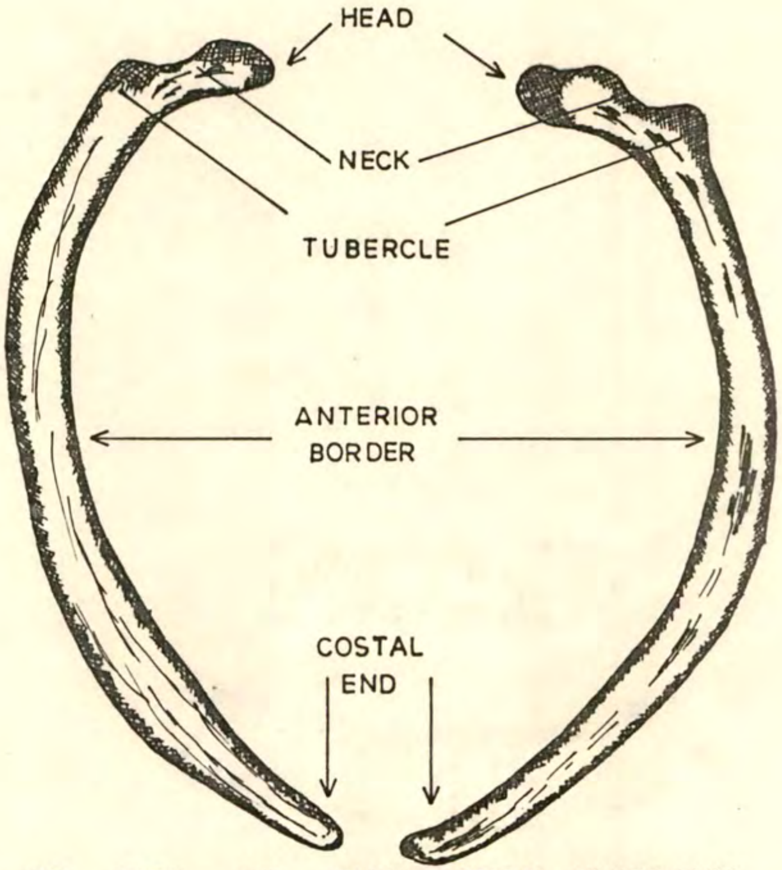


FIG.43: PAIR OF RIBS OF RHINOCEROS UNICORNIS
(ANTERIOR VIEW)

Fig. 37

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:

Parameters	Measurement (cm)
Total length of the last rib	35.00
Maximum width of the last rib	2.2
Minimum width of the last rib	1.8
Diameter of the head	2.9

Sternum:

The sternum or the thorasic 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:

Parameters	Measurement (cm)
Total length of sternum	65.0
Length of end of Xiphoid cartilage	28.0

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.

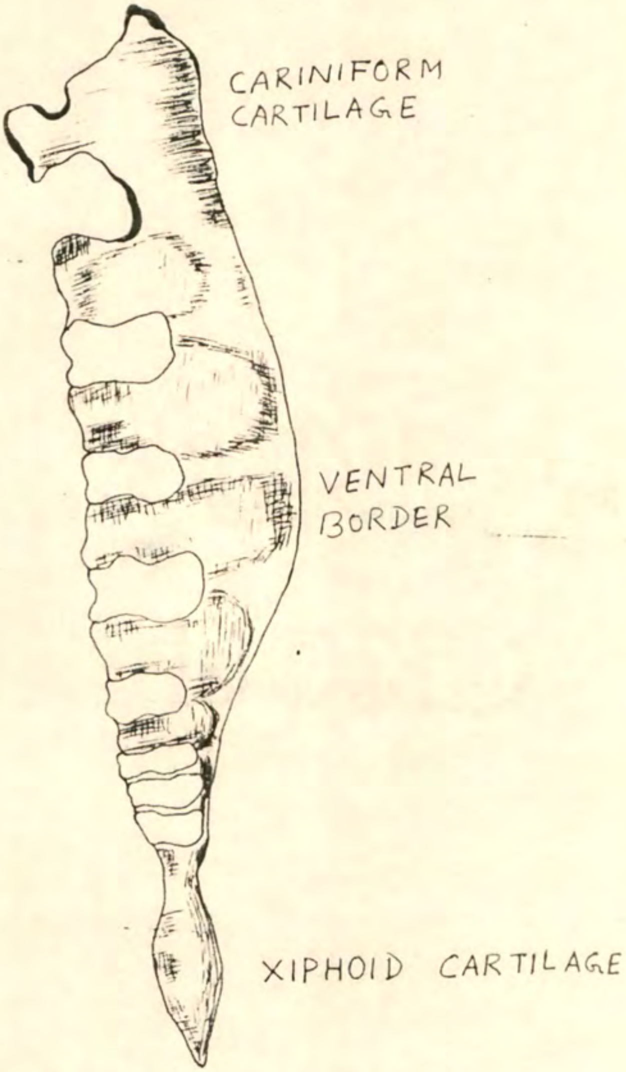


Fig. 38. STERNUM OF *R. unicornis*

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:

Parameters	Measurements (cm)
Length of the scapula	48.0
Width at the broader end	53.5
Diameter of the neck	30.0
Height of the tuber spine	10.5

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:

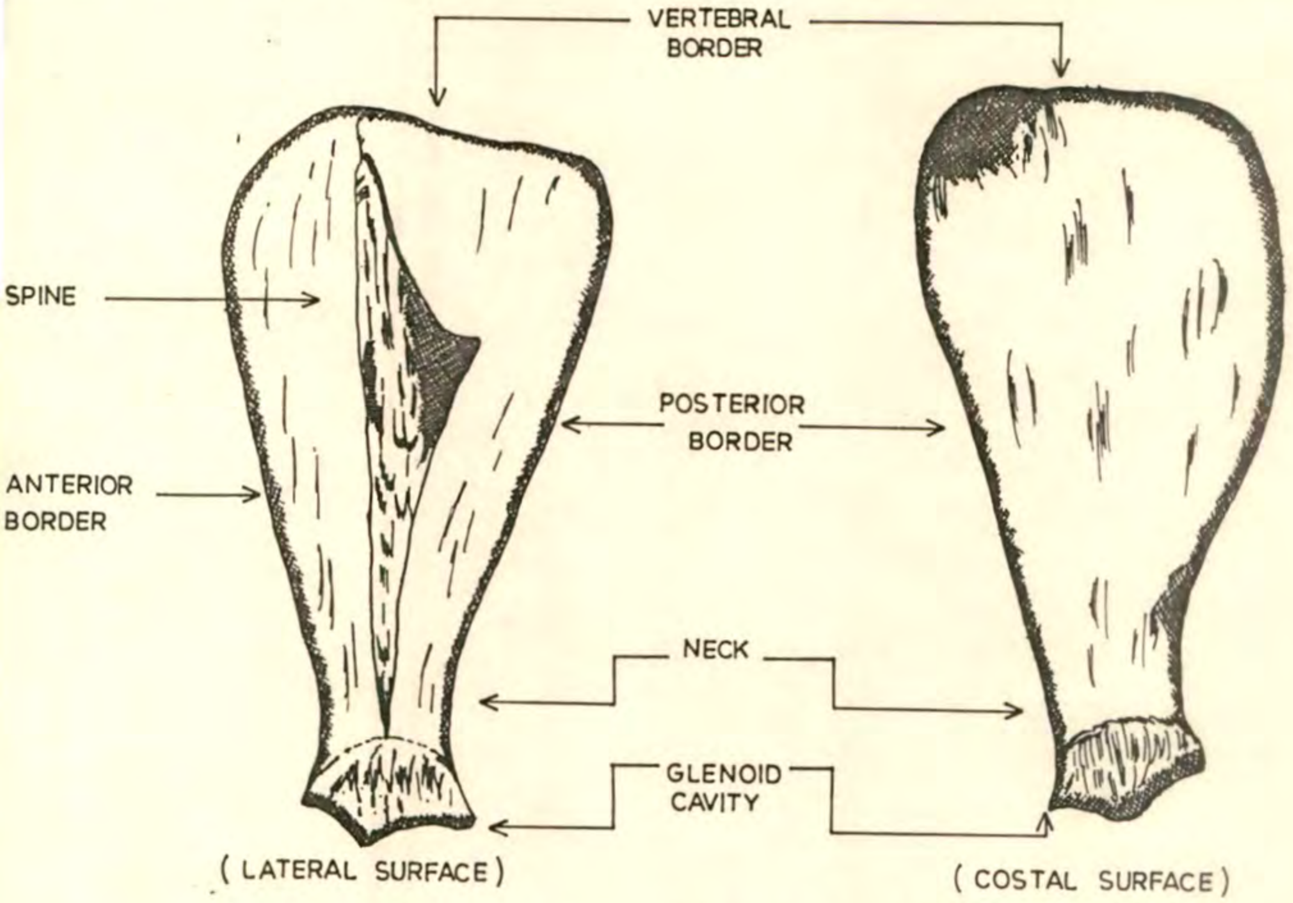
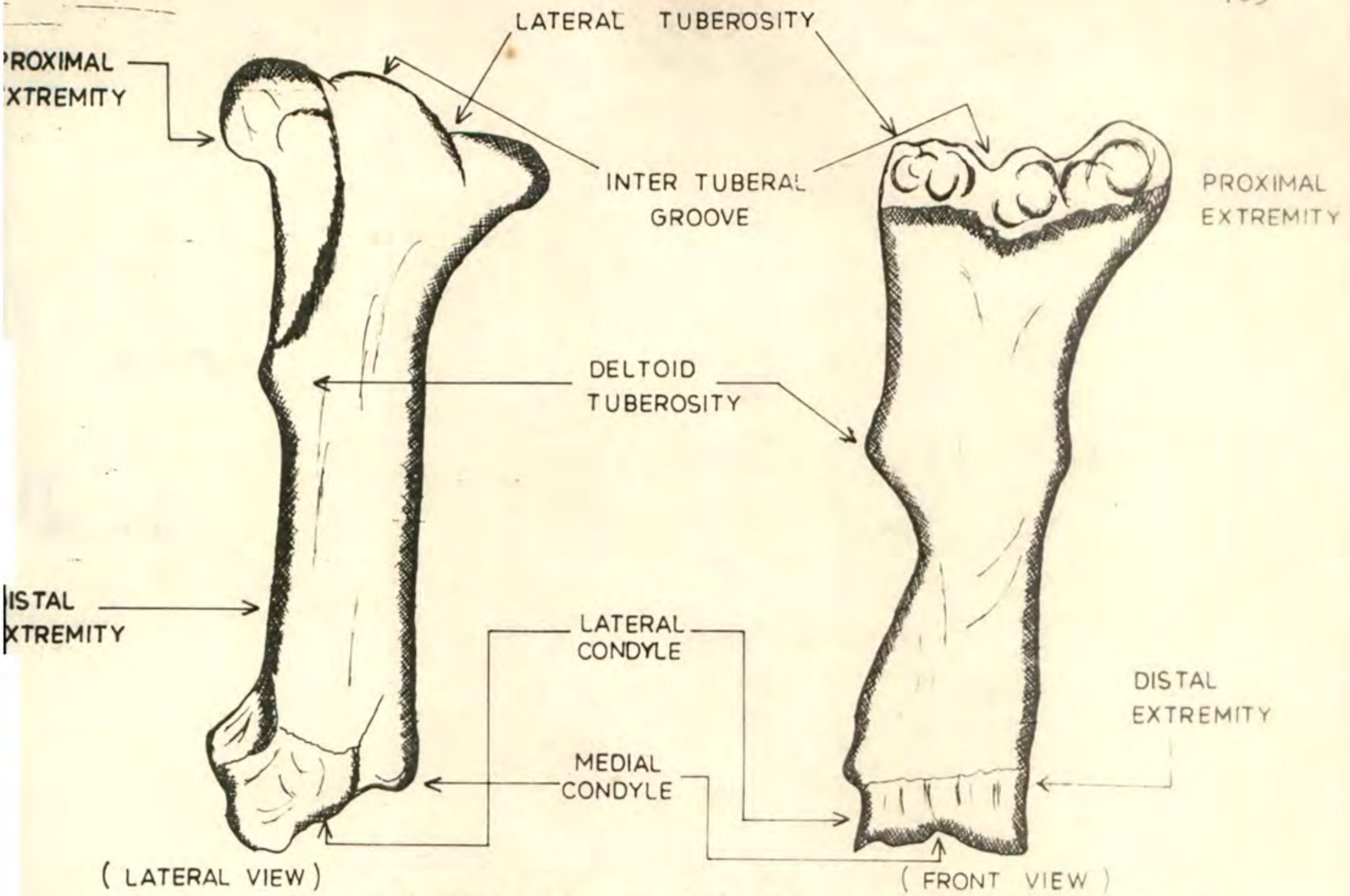
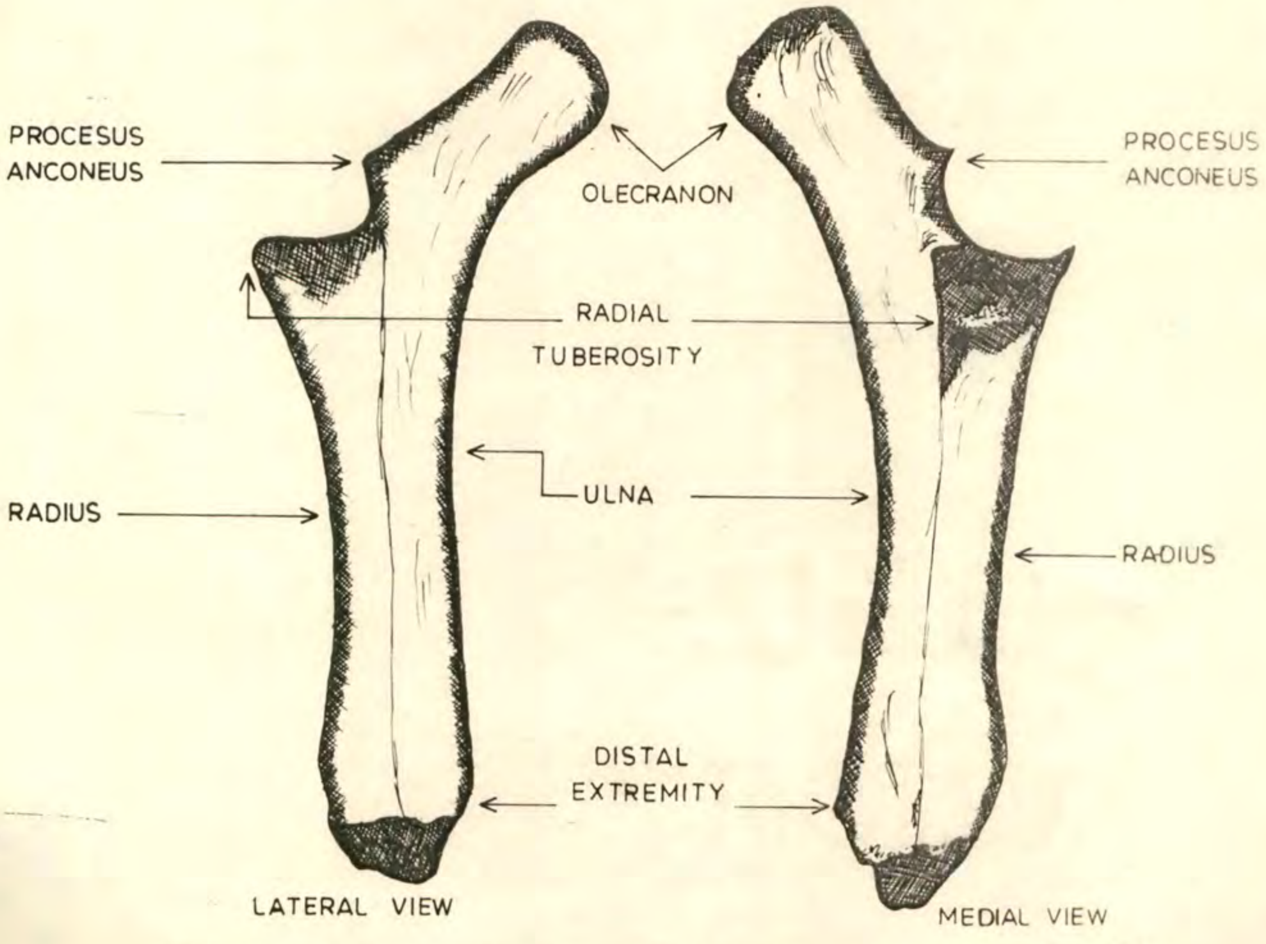


FIG. 39: SCAPULA OF RHINOCEROS UNICORNIS



HUMERUS OF RHINOCEROS UNICORNIS (Fig. 40, a)



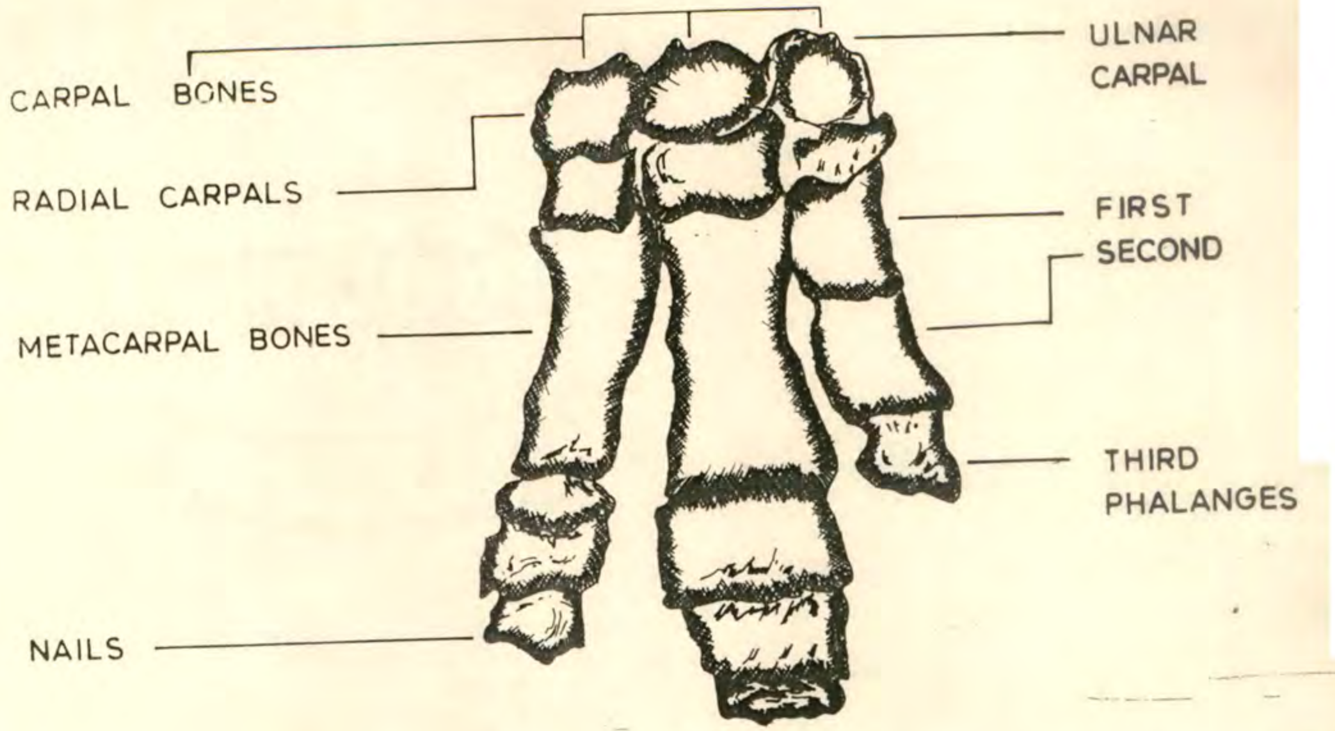
RADIUS AND ULNA OF RHINOCEROS UNICORNIS (40, b)

Parameters	Measurements (cm)
Length of the humerus	54
Circumference at proximal end	43
Circumference at mid saft	26
Circumference at distal saft	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:

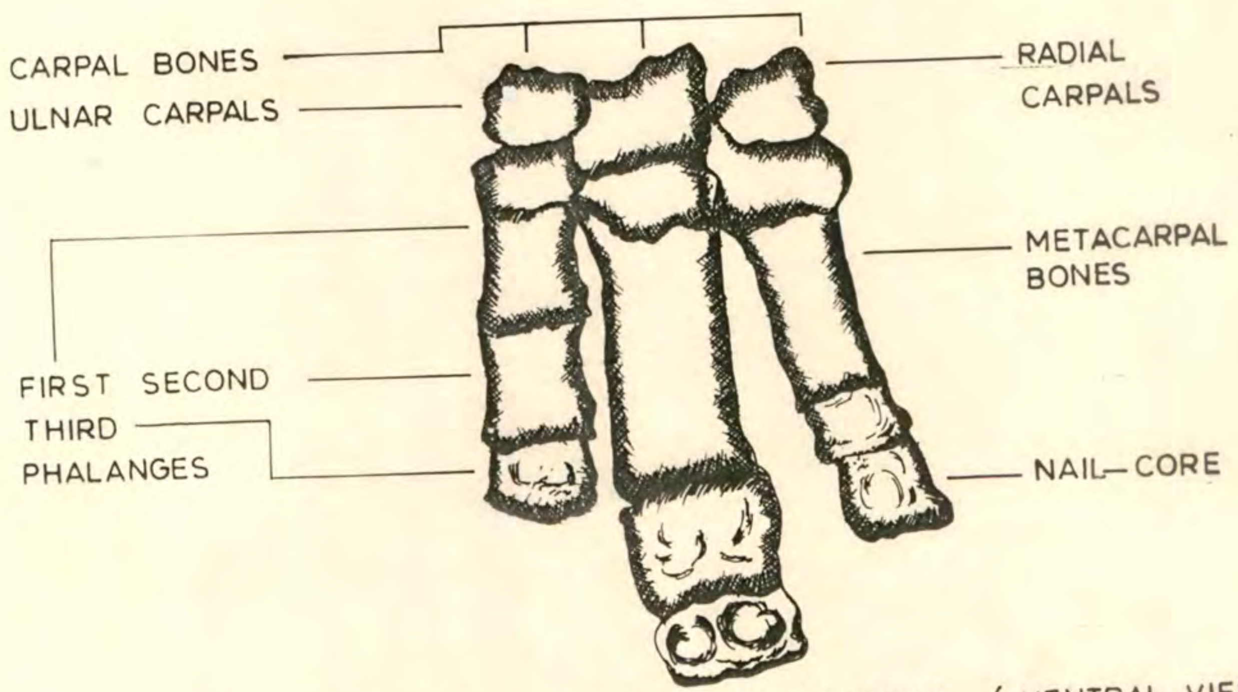
Parameters		Radius (cm)	Ulna (cm)
Total length		39.0	45.0
Circumference	Proximal	38.0	29.0
	Distal	34.0	26.2

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 extremeties (Fig. 41 a,b).



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

Parameters	Medial (cm)	Central (cm)	Lateral (cm)
Length	7	9	6
Circumference -			
Mid saft	6	7	5
Proximal	7	8	5
Distal	6	7.5	6

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):

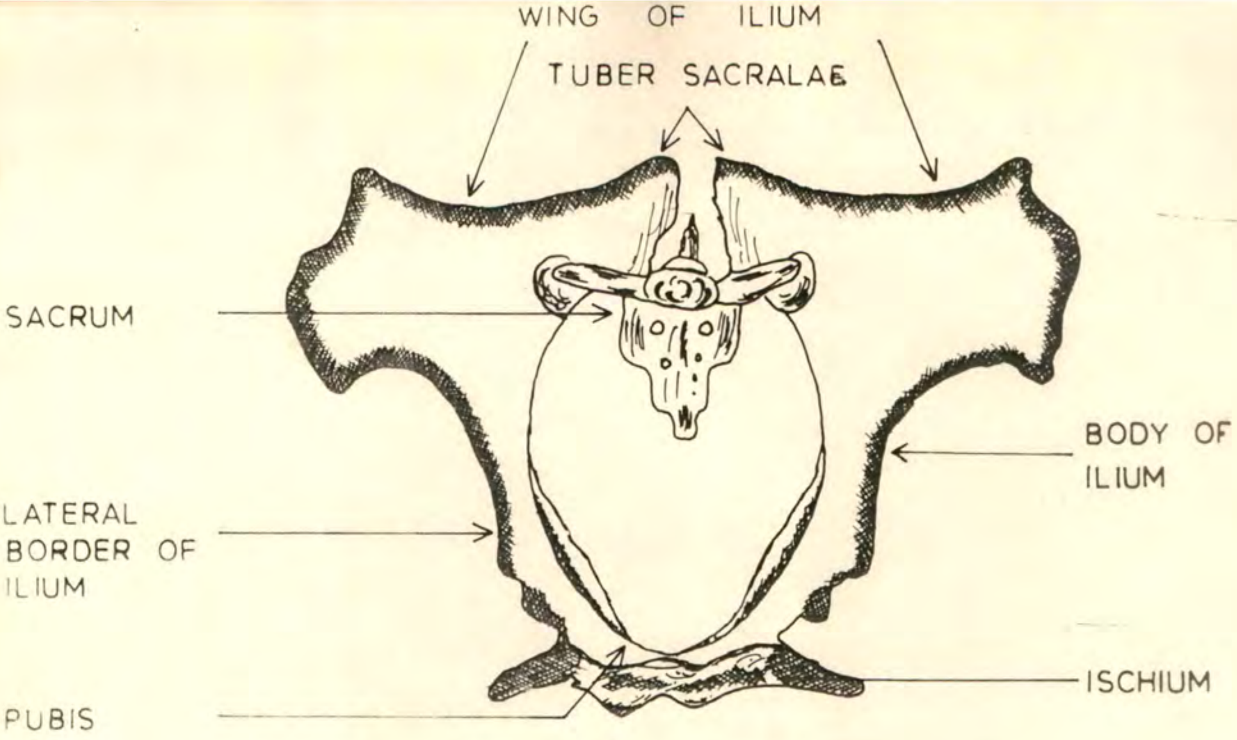
(i) Ilium,

(ii) Ischium, and

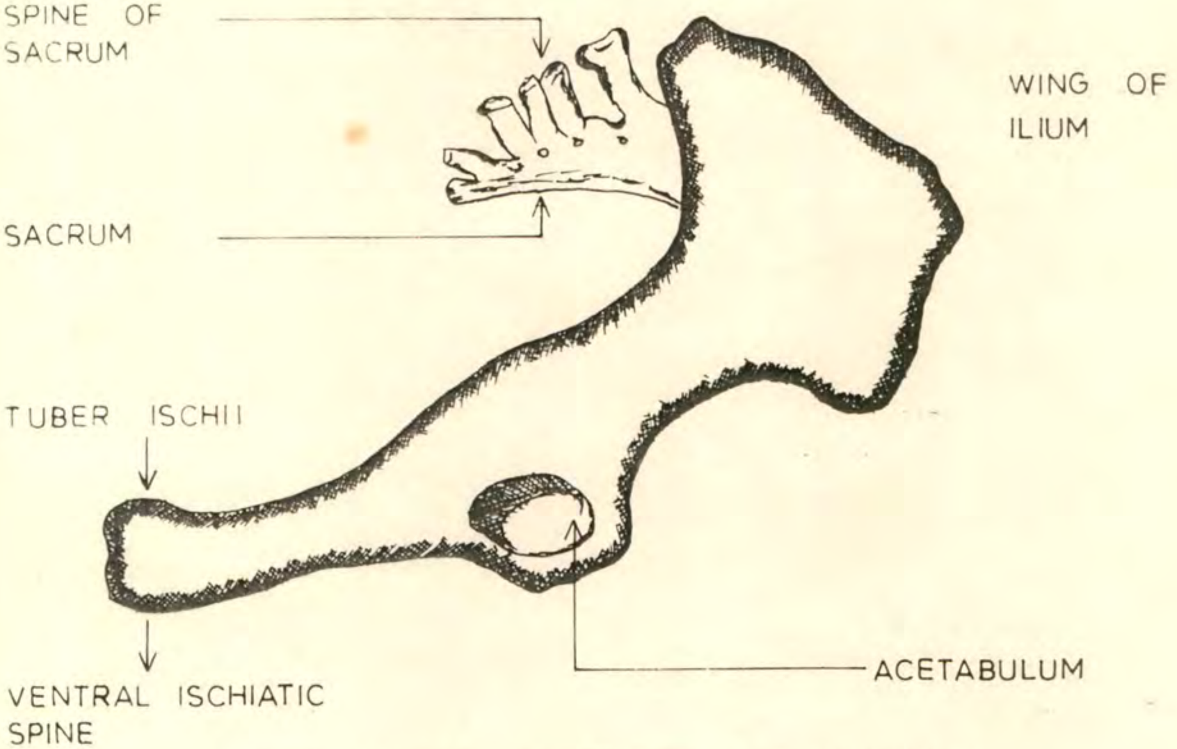
(iii) Pubis.

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:

Parameters		Ilium (cm)	Ischium(cm)	Pubis (cm)
Length		42.3	17.0	16.2
	Anterior end	110.3	46.0	34.9
Girth	Mid saft	24.4	15.6	12.4
	Near acetabulum	41.4	27.0	29.1



PELVIC BONES OF RHINOCEROS UNICORNIS
(FRONT VIEW)



PELVIC BONES OF RHINOCEROS UNICORNIS
(LATERAL VIEW)

Fig. 42

<u>Dimension of the pelvic cavity</u>:

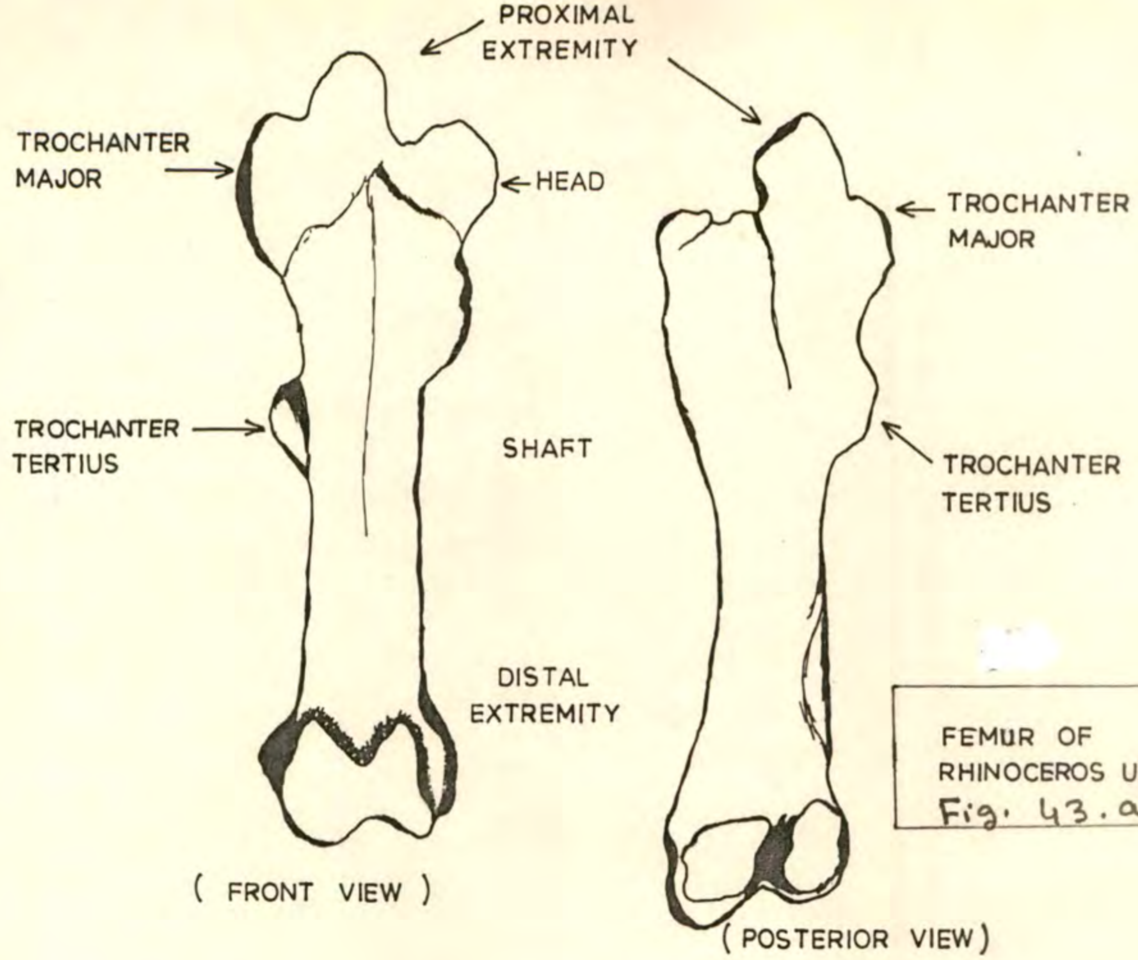
Parameters	Measurement (cm)
Sacropubic diameter (Perpendicular)	37
Right ilium to left ilium (Base)	31

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

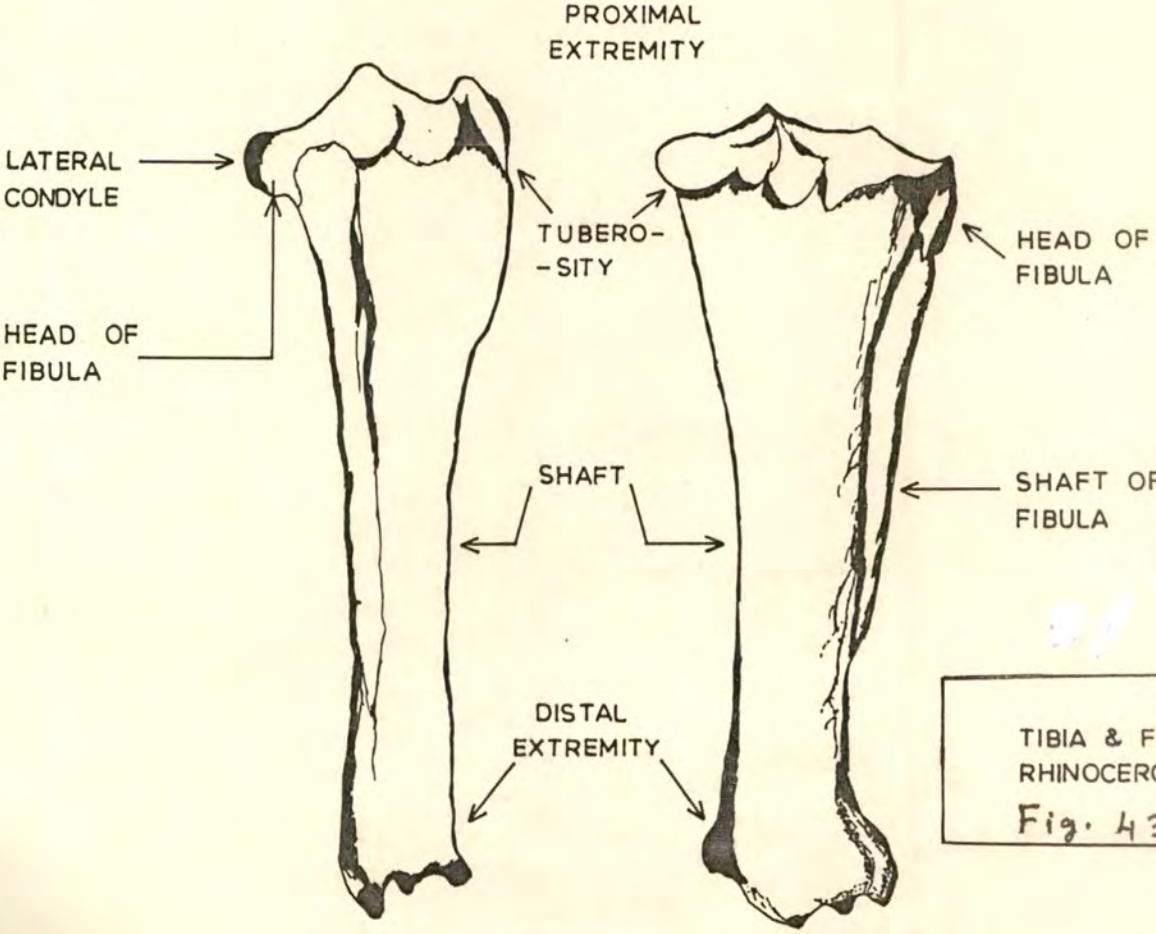
Parameters	Measurement (cm)
Length	62.1
Circumference at proximal end	36.3
Circumference at shaft	24.4
Circumference at distal end	30.0

<u>Tibia and fibula</u>: 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.

Parameters	Measurements (cm)
Length of the tibia	40.1
Circumference at neck	26.5
Circumference at shaft	21.4
Circumference at distal end	27.2



FEMUR OF
RHINOCEROS UNICORNIS
Fig. 43.a



TIBIA & FIBULA OF
RHINOCEROS UNICORNIS
Fig. 43.b.

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.

Biometrics of Metatarsal bones

Parameters		Medial (cm)	Central (cm)	Lateral (cm)
Length		6	8	5
Circumference				
(i)	Mid shaft	5	6	4
(ii)	Proximal end	6	7	4.5
(iii)	Distal end	5	6.5	5.5

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

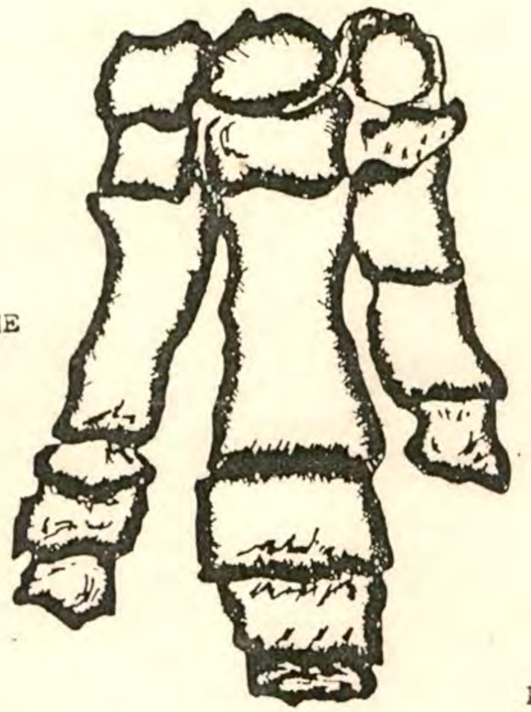


FIG. 44 a., BONES OF THE HIND LIMBS OF R.unicornis(DORSAL VIEW)

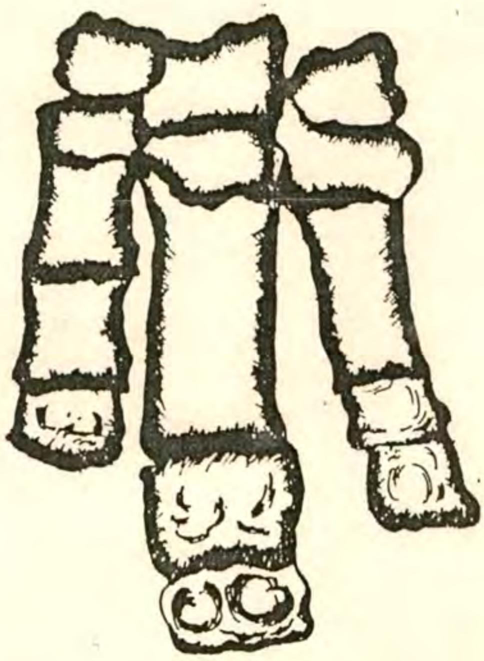


FIG. 44 b, BONES OF THE HIND LIMBS OF R.unicornis(VENTRAL VIEW) a prominent position. These unique features are quite distinct from other species of rhinoceros which are discussed in detail. As a whole the endoskeleton of R. unicornis shows a greater similarity with that of the horse.

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 coloumn, consisting of the vertebral formula as shown, has similarities with the horse.

R. unicornis $= C_7T_{18}L_6S_5C_{16-18}$

Horse
(Equus caballus) $= C_7T_{18}L_6S_5C_{15-21}$ (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 vetebrae 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 vetebrae. 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 metatarsals 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. (Fig. 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).

Parameters	Measurements (cm)
Total length	34.0
Length of free part	22.0
Breadth at base	11.0
Breadth at middle	7.0
Breadth at tip	9.0
Thickness	2.5

Fig. 45

Fig. 46, a

Fig.46 (b)

Fig 46.c

FIG. 45: ALIMENTARY CANAL ALONG WITH DIGESTIVE GLANDS OF R. unicornis.

FIG. 46(a,) : LIPS OF R. unicornis

FIG. 46(b,) : UPPER PALATE (b) TOUNG (c)

The whole mouth cavity is cylindrical and elongated in *R. unicornis* and it connects with the pharynx in the posterior.

The pharnyx is a funnel shaped musculo-serus sac which connects with the oesphagus in a posterior position.

The oesphagus 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 herbivorours 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

Fig. 47. b.

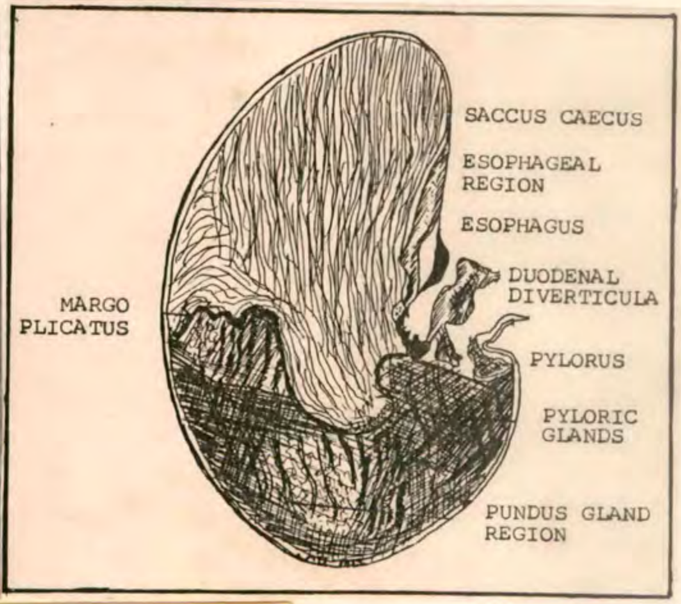


Fig. 48 a.

Fig. 48. b.

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.

Parts of alimentary canal	Measurement M in 1 and 2
Mouth and pharynx	0.9 - 1.0
Oesophagus	1.7 - 2.0
Stomach	0.8 - 1.2
Small instestine	22.0 -24.0
Large intestine	8.0 - 9.0
*Total length	33.4 -37.2

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).

Parameters	Measurement (cm)
Girth at middle	102.0
Length	83.0
Breadth	24.0
Weight	12.3 Kg
Number of lobes	3 (three)

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 veritable justification.

Pancreas:

Pancreas is situated transversely dorsal to the wall of the abdomen. It is a long, elongated glandular mass, falttened dorsoventrally. It extends transversely from the duedenum to the spleen lying in the transit partially dorso caudal end of the stomach.

Fig. 49. a

Fig. 49. b.

Fig. 50(a)

Fig. 50. b.

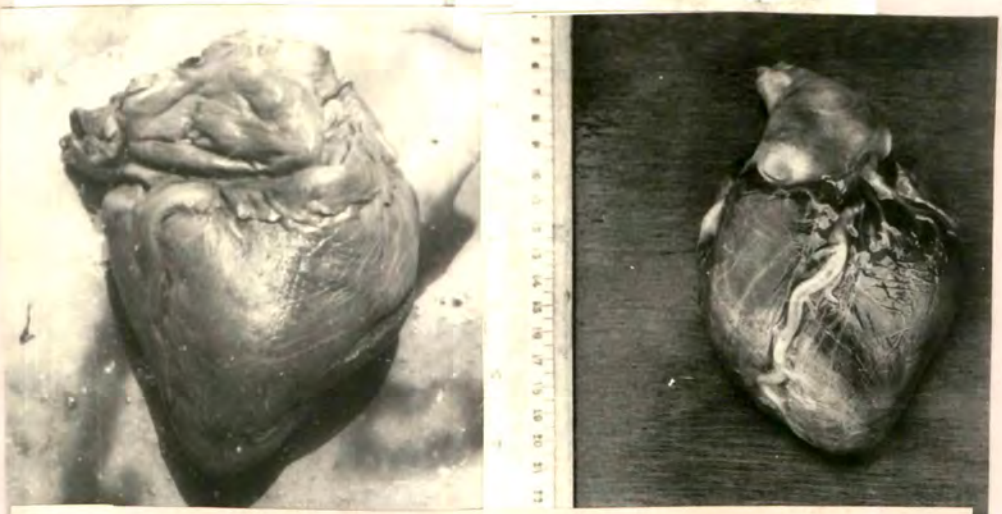


FIG. 49(a,b) : SPLEEN; MEDIAN (a) AND LATERAL (b) VIEW OF <u>R</u>. <u>unicornis</u>.

FIG. 50(a,b) : HEART; LATERAL VIEW (a); PULMONARY SURFACE(b) OF <u>R</u>. <u>unicornis</u>.

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 oorgan, but not friable like the liver. The spleen is curved and thin edged in R. unicornis. It possesses two surfaces, two borders, and two extremites. The biometrics of the spleen of an adult R. unicornis are recorded as follows (Fig. 49):

Parameters	Measurements
Total length	78.0 cm
Width	37.0 cm
Thickness	12.0 cm
Weight	1.8 kg

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 uipper 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 micro-organism 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 gdall 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 thorasic 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 -

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

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 Bhattacharyya 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 (Fig. 51)

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 aterior part is wider 22 cm in diamter 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 supproted 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).

	Parameters	Measurements (cm)
i)	Total length of the trachea	106.0
ii)	Length of the body of the trachea	88.0
iii)	a) Circumference of the trachea in one surface	13.0
	b) Circumference of the trachea at the point of junction with the thrynix.	16.0
iv)	Circumference of the inner lumen of the trachea	11.0
v)	Diameter of the inner lumen of the trachea.	2.9
vi)	Length of the bronchial tube	
	a) Left	18.0
	b) Right	19.0
vii)	Circumference of outer surface of the bronchial tube.	9.0
viii)	Circumference of inner surface of the lumen of bronchial tube.	7.0
ix)	Diameter of the lumen of bronchial tube	1.7
x)	Breadth of the cartilege in the body of the trachea	1.5
xi)	Breadth of the cartilege in the bronchial tube.	1.2

The tracheal rings which are arranged over the trachea show certain structural pecularities. The rings, instead of being completely

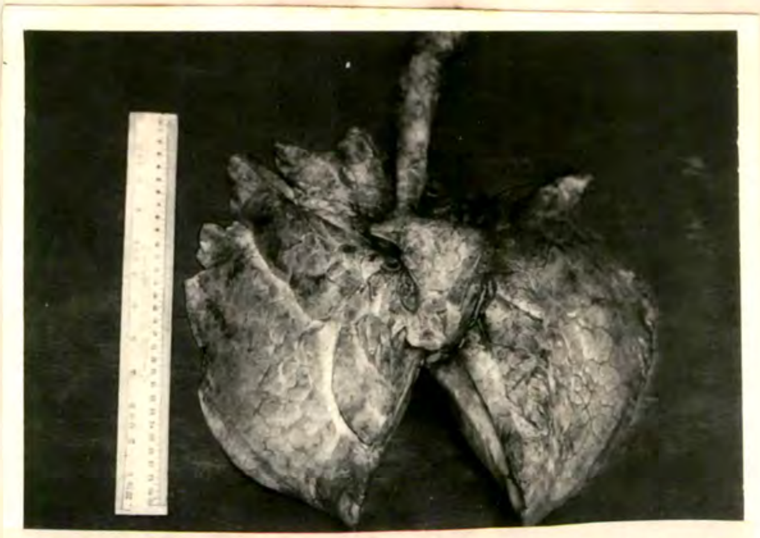


FIG. 51 : TRACHEA AND LUNGS OF R. unicornis.

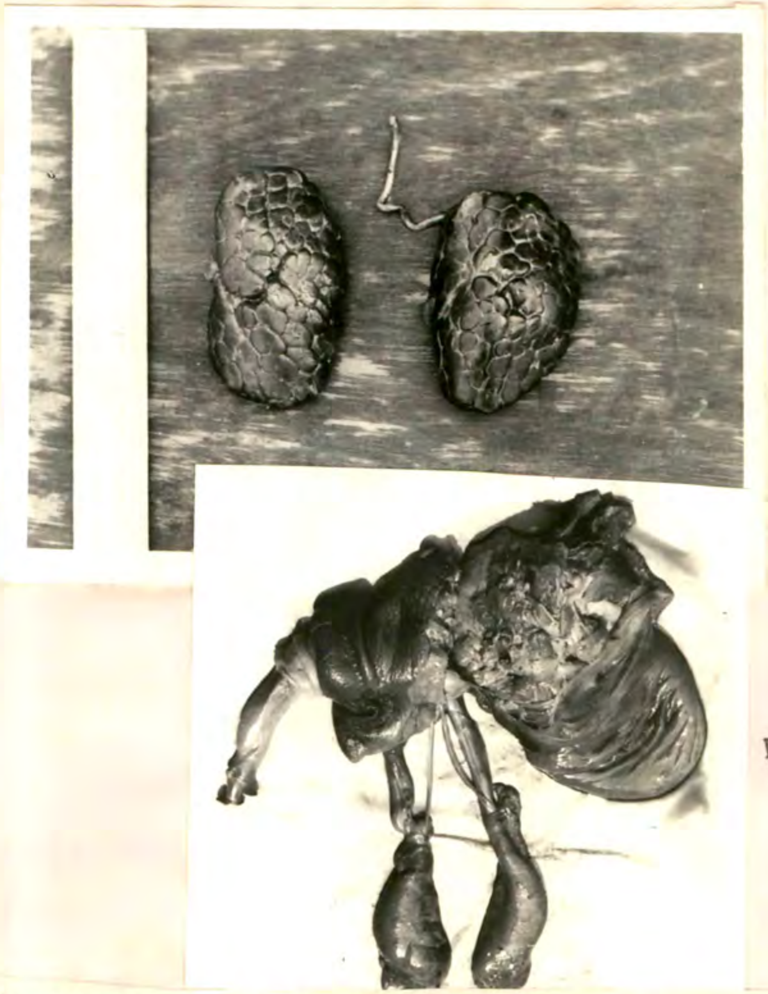


Fig. 52(a)

Fig. 52(b)

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 thorasic 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.

Parameters	Measurements (cm)
Approx. diameter of the lungs in thoracic cavity	56.0
Approx. length of the lungs in thoracic cavity	50.0
Breadth of the left lungs	25.0

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 independantly 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.

Parameters	Measurements	
	Calf	Adult
Length of urinary bladder	12.0 cm	18.0 cm
Breadth of urinary bladder	7.0 cm	11.0 cm
Area of urinary bladder	84 sq.cm	198 sq.cm
Thickness of the wall of urinary bladder	1 mm	1.6 mm
Length of urethra	11.0 cm	17.0 cm

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 eleminated 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 raction. 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 re ticular 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.

Sl. No.	Parameters	Samples			Mean
		1st	2nd	3rd	
1.	Volume (lit)	2.80	3.20	3.75	3.56
2.	Colour	Yellow	Yellow	Pale yellow	Yellow
3.	Foam	Present	Present	Present	Present
4.	Odour	Amonical	Amonical	Amonical	Amonical
5.	Transperancy	Turbid	Turbid	Turbid	Turbid
6.	Sediment	Present	Present	Present	Present
7.	Specific gravity	1.020	1.022	1.025	1.022
8.	pH	7.20	7.22	7.20	7.21
9.	Sugar	No trace	No trace	No trace	No trace
10.	Albumin	No trace	No trace	No trace	No trace

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 develops,slowly 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 speices 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 climateric 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) sated that the female R. sondaicus the Javan rhinoceros bears no horn or if at all it is redumentary 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. 52 a)

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 upto atleast 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 musculocuteneous 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 postmortum 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.53a) but is only elongated in new born calf

(Fig. 53a). The length, breadth and thickness of an adult R. unicornis testes were recorded as follows:

Parameters	Measurements (cm)	
	Adult (40 Yrs.)	New born
Length	17.0	8.0
Breadth	8.0	3.7
Thickness	3.5	1.8
Weight	750 gm	23.8 gm

The epididymis of the R. unicornis is a thick walled musculoserous 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 tubuler 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 (Fig53 b).

The Penis:

The penis is the copulatory organ of the male. It is more or less cylindrical in shape and musculo-fibrous in structure (Fig53 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,

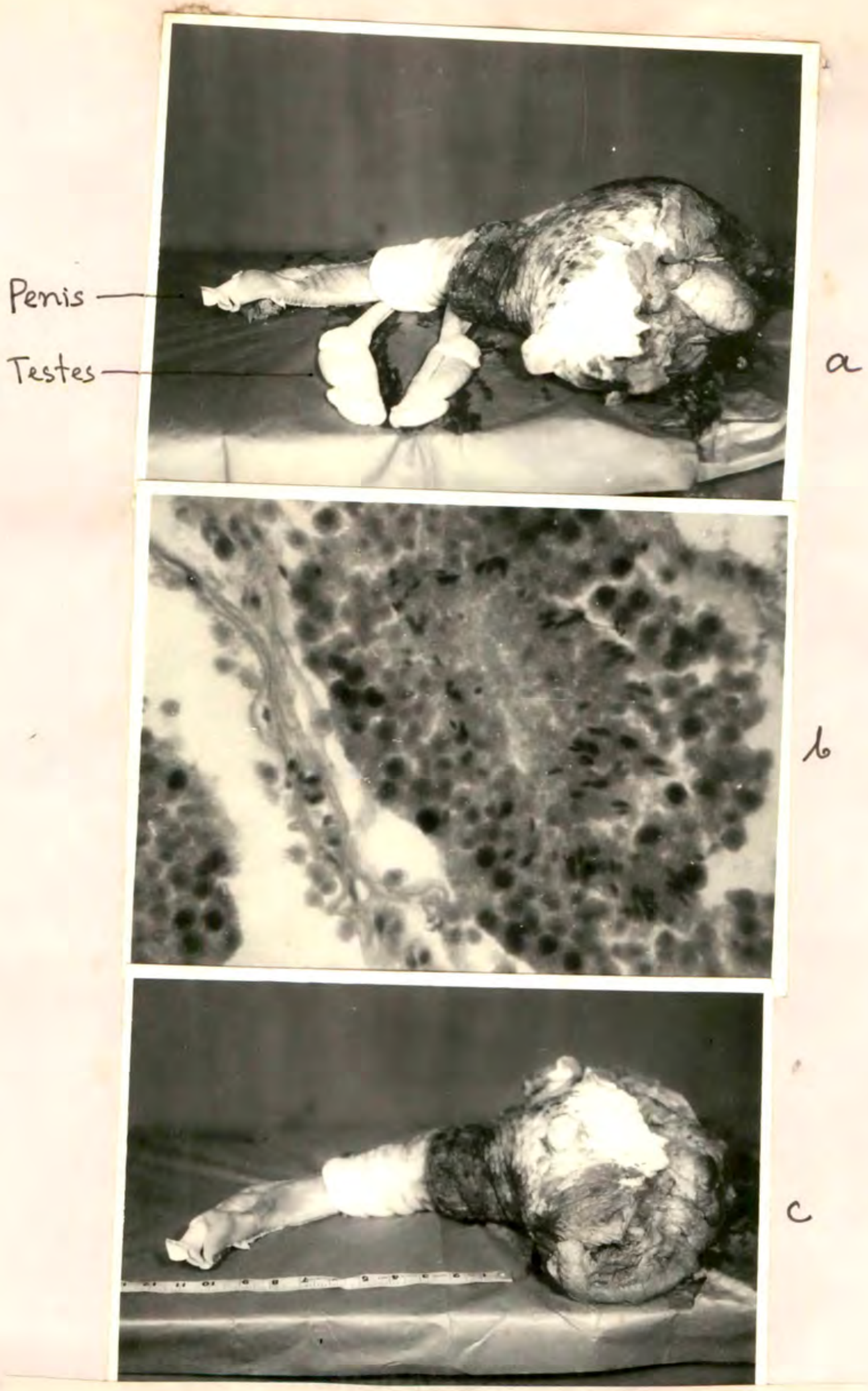


FIG. 53(a-c) : TESTES (a) AND HISTOLOGICAL STRUCTURE OF TESTE (b) AND MALE GENITAL ORGAN, (c) SHOWING THE PENIS ALONG WITH ADJACENT MUSCLES WITH SPERMATIC CHORD (c) OF R. unicornis.

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*.

Parameters	Measurement (cm)
Total length of the penis	85.0
Total length of free part	30.0
Diameter of the root	30.0
Diameter of the middle part	20.5
Diameter of glans	13.5

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, implanatation 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

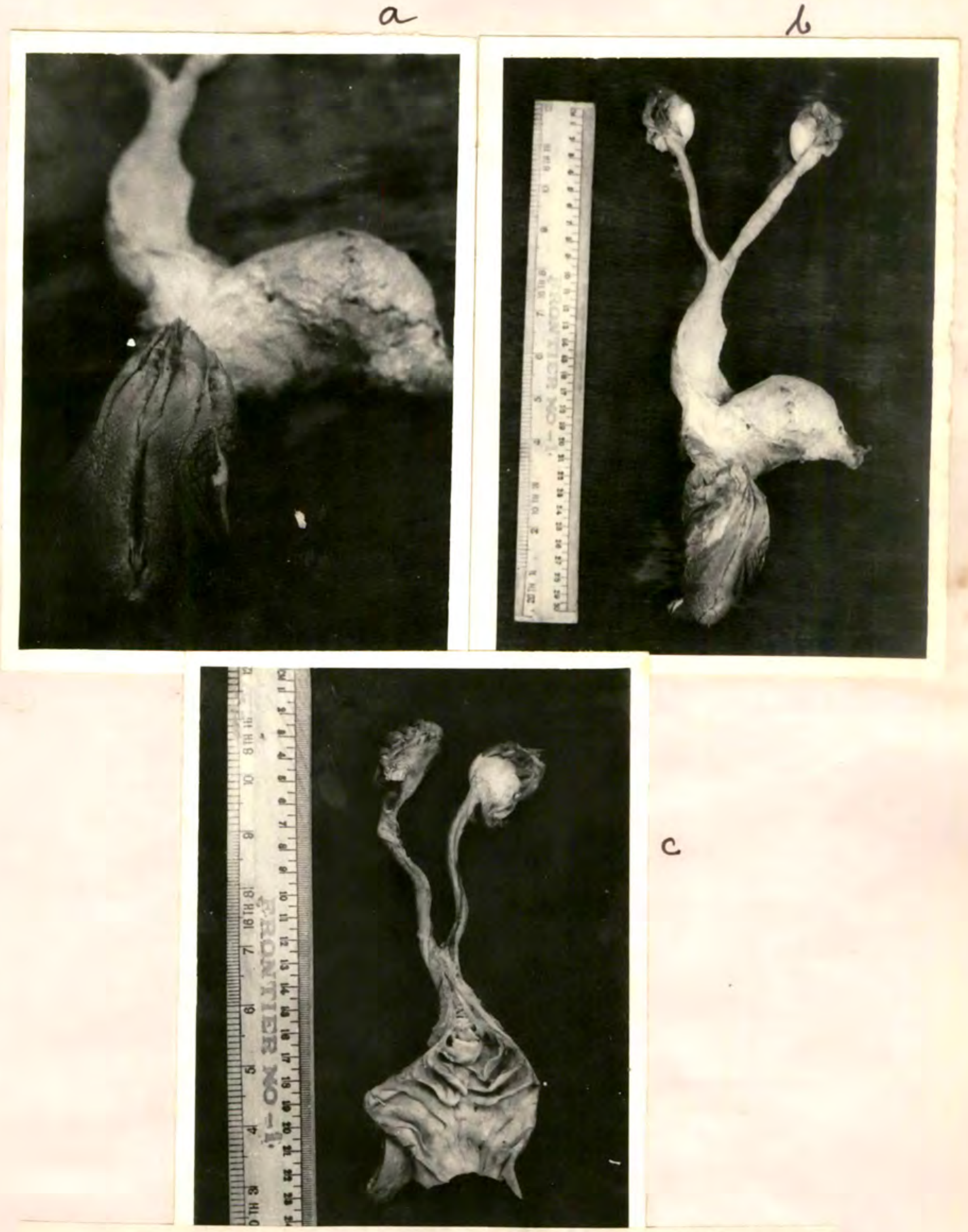


FIG. 54(a-c) : FEMALE GENITAL ORGAN; VAGINA (a), OVARY, OVIDUCT, BLUDDER (b); INTERNAL STRUCTURE OF CERVIX OF UTERUS (c) OF <u>R</u>. <u>unicornis</u>.

were found consisting of the following perts (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.

Parameters	Measurement	
	Right ovary	Left ovary
Length	5.0	5.0
Width	3.2	3.5
Thickness	2.1	2.6
Weight	8.2gm	10.2 gm

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

Two oviducts are oof very zigzag musculoseruous 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) **Vigina**:

The vagina is a musculo-membranous hollow structure which acts as the 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).

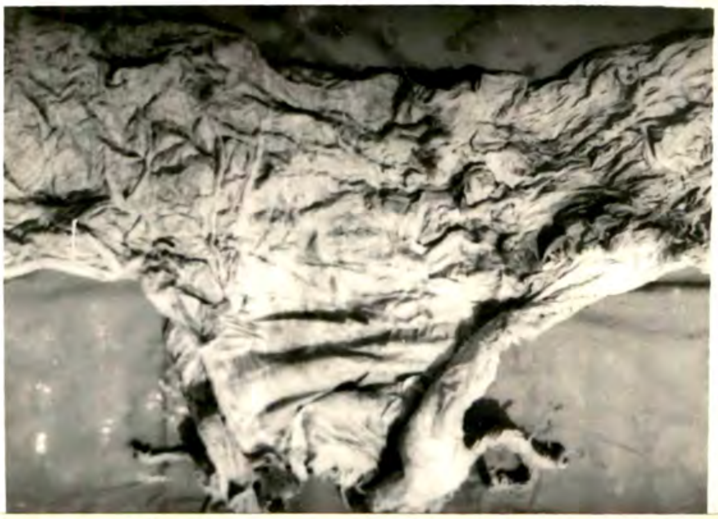
Placenta of R. unicornis:

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 acquatic 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 caputured 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

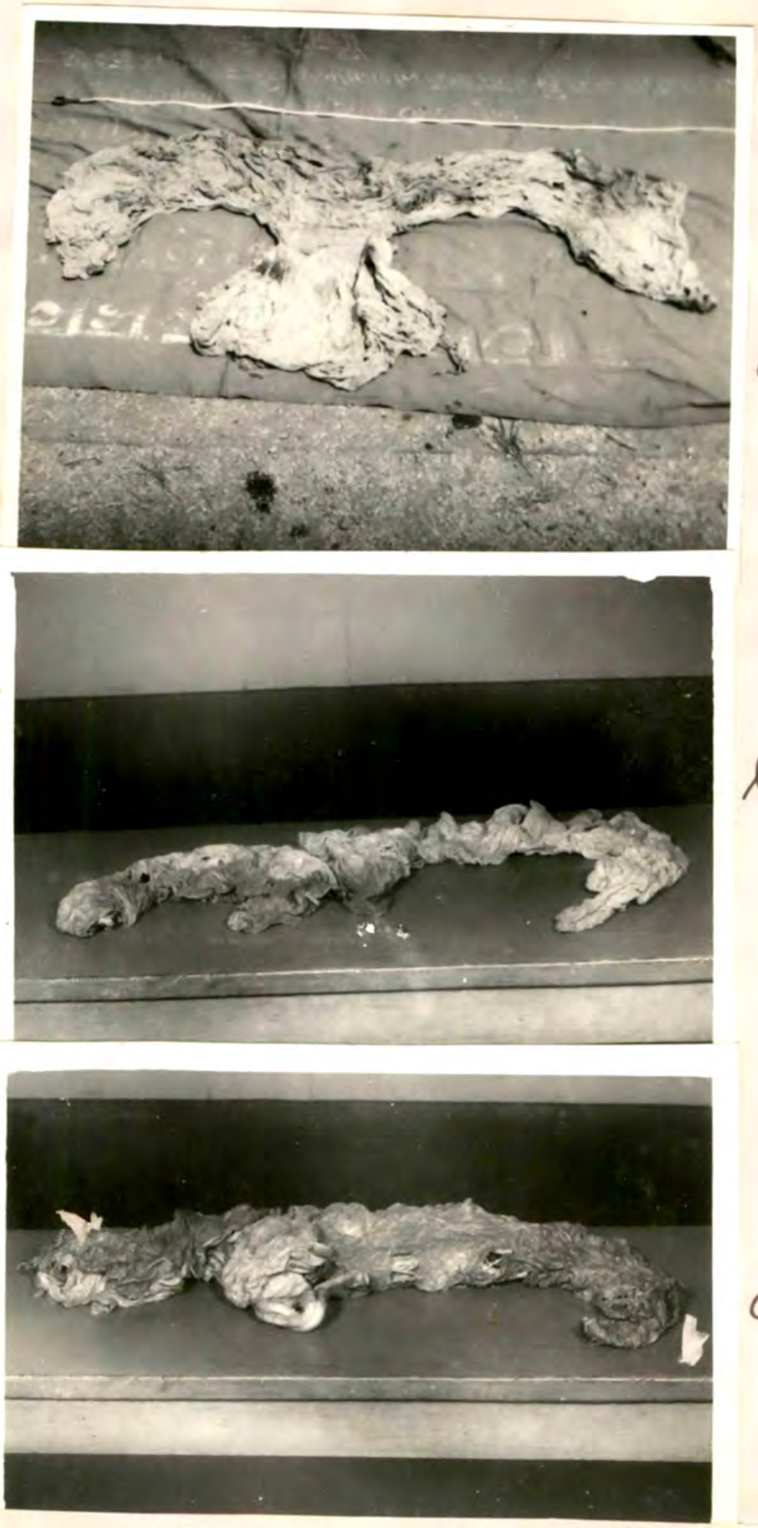
a



b

c

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.



a

b

c

FIG. 56(a,b,c): 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 endowmertrium 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.		

d.

e

f

FIG. 56(d,e,f) : PLACENTA OF R. unicornis (d,e) AND RUMINANT(f) SHOWING THE NATURE OF VILLI.

(ii)	Length of the umbilical chord, free part	--	22 cm
(iii)	Circumference of the umbilial chord at the base	--	3.5cm(right) 3.8cm(left)
	at detachment	--	2.5cm(right) 2.5cm(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 ae present throughout both the horns of the placenta. However, there were certain gaps which appeared like striations. Generally the places through which blood vessels comming 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 0.5mm to 1.5mm as follows:

The measurements of

(i)	Microvilli at the base of 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 indeciduate type, as there was very little dmage 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 classfied under diffused type of placenta. It was neither like that of primates nor ruminants; rather it simulates with that of horse and tapir 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 rudumentary 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.57a). 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:

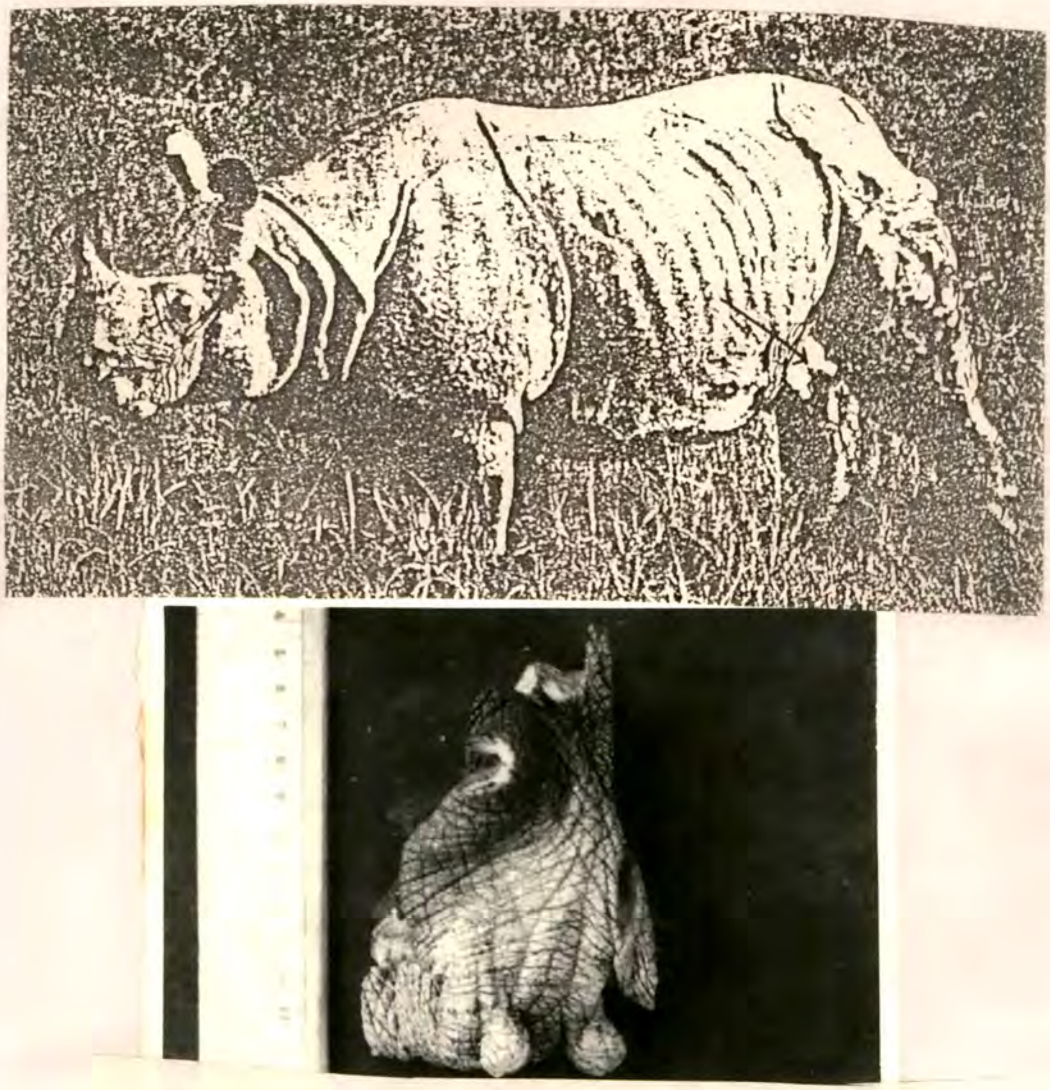


FIG. 57(a,b) : MAMMARY GLAND OF SUCKLING COW (a) , AND RUDIMENTARY TEAT OF MALE *R. unicornis*.

Parameters	Measurements (cm)
Total length of the udder	20-22
Girth at middle	56-58
Girth of the free part at the base of the teat.	20-23
Length of the teat	4- 6
Diameter of the teat	7- 9

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 vagima 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 testis were found to be located in the pelvic cavity. The testes, like those of the elephant do not possesses 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 inthe 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 will 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 psotion 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 orthree 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 of the udder and lenghth of the teat were found to be 22, 58 and 5 cm respectively in a suckling mother.

CHAPTER - VII

COMMON DISEASES AND OTHER CAUSES OF MORTALITY IN *Rhinoceros unicornis*

The prevalence of some common diseases among wildlife has been one of the major factors associated with the decline in numbers of some species of their population. Although the information available on the occurrence of diseases among wild animals in the country is meagre and fragmentary, yet there is ample evidence to suggest that these diseases have been frequently responsible for the heavy loss of wildlife in different parts of the country.

R. unicornis rarely suffers from diseases in its natural habitat and even in captive condition. Its health problems are minimum due to its solitary habit that it exhibits lesser infections (Arora, 1986). A study of available records revealed the following information regarding disease and causes of death of *R. unicornis*. The causes may be divided into :- Parasitic, Bacterial, viral, systemic disorders and other causes.

Infection due to helminth parasite is a common disease and records on *Fasciola gigentica* (Bhattacharjee and Haldar, 1971); *Anoplocephala* (Jones, 1979, Ali and Ramkrishna, 1983); *Haemoncus* and *Strongylus* (Deka and Barua, 1985) are available.

Outbreak of anthrax has been reported in wild condition in the Kaziranga National Park (Choudhury, 1964) as well as in captive condition (Roychoudhury, 1985). Salmonella and Staphylocoecus aureus infections are some common bacterial infections prevalent in captive R. unicornis. Several workers have reported the presence of these infections from different Zoological Gardens (Kings, 1965; Windson and Ashford, 1972; Williamson et al. 1975; Schmidt and Hartfiel, 1976; Jones, 1979 Silberman and Fulton, 1979). Ali and Ramkrishna (1983) reported the occurrence of tuberculosis in 2 species of rhinoceroses from the Hyderabad Zoo. Further, abortion of the foetus is often seen both in captive as well as in wild condition which sometimes lead to various complications like septicaemia and pyaemia, toxaemia etc. (Arora, 1985).

Viral infections like rabies was reported in captive R. unicornis By Das (1965), Mukherjee et al. (1984) and Arora (1985).

Bone diseases like Osteoarthritis (Hamerton, 1939; Arora, 1985) and a report on horn cancer (Nandi and Deb, 1972) and uterine fibroma (Arora,1985) were reported from rhinoceroses in captivity.Transportation during a prolonged period of time also leads to several health problems in rhinoceros(Arora, 1985).

MATERIALS AND METHODS

OBSERVATION IN CAPTIVE CONDITIONS: Nine ceptive R. unicornis of different ages maintained at Assam State Zoo, Guwahati, were observed for their health problems during the period of study. The sick animals were kept under constant observation till their death. Postmortem examinations were conducted and other pathological examinations were carried out to ascertain the causes of their death.

Faecal samples were collected at the time of defecation and examined for detection of internal parasites in the samples. Urine samples were collected to examine in the change of physical properties, if any.

In Kaziranga National Park: Faecal samples from different dung heaps of R. unicornis were collected once in three months from different blocks for one year and examined microscopically following floatation and sedimentation methods described by Soulsby (1971) for presence of ova of endoparasites.

RESULTS

PARASITIC DISEASES:

In wildlife parasitic diseases are found to be very common in all species. In the present study, faecal samples from different sites of defecation of R. unicornis in wild condition were collected (Soulsby, 1971), examined microscopically and identified as described by Raquib et al. (1973), for detection of parasitic ova. The record has been presented in Table 35.

Faecal samples of R. unicornis under captive condition at the Assam State Zoo, Guwahati also were collected and examined. The record has been presented in Table 36.

In both cases the faecal samples were collected and examined once in three months from January to December for a period of one year.

MODE OF ABUNDANCE IN THE FAECAL SAMPLES:

In order to obtain an idea of the mode of abundance of various parasites in the rhino (specially of helminthes) several faecal samples were collected from rhinos in captive (Assam State Zoo, Guwahati) as well as from the natural or wild condition from the Kaziranga National Park. The faecal matter i.e. 20 g sample from the fresh dung piles was collected and number of ova or cysts seen were calculated in the microscopic field. The rate of abundance was calculated from one unit (each unit comprises of 5 sets of samples containing 20 g in each set) and expressed as -

+ = Minimum load of the parasites

++ = Medium load of the parasites

+++ = High load of the parasites

++++ = Heavy load of the parasites (which is higher than the +++).

The abundance of various parasites species (Helminths) observed and recorded from the faecal samples collected from captive (Assam State Zoo, Guwahati) as well as from the wild condition (Kaziranga National Park) (Fig. 58) are presented in Tables 35 and 36.

FIG. 58 : PARASITES RECOVERED FROM R. unicornis.

TABLE - 35

Abundance of helminthes in the faecal samples collected from the captive condition. The mean observations from 5 different sets were expressed in the respective quarter of the year.

Name of the Parasites	1st quarter January to March					2nd quarter April to June					3rd quarter July to September					4th quarter October to December				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
F. gigentica	+	-	++	-	++	++	++	+	++	-	+	+	+	+	++	+	++	+	-	-
Paramphistomum	-	+	-	+	-	++	+	++	++	+	+	+	-	-	+	+	++	++	++	++
S. mansoni	++	++	++	++	++	+	+	++	+	++	+	++	++	++	++	++	-	+	++	++
A. magna	+	+	+	+	+	+	+	++	+	+	+	++	++	+	+	+	+	+	+	+
A. perfoliata	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Ancylostomata	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Halmonchus	++	++	++	++	++	++	++	++	+	++	+	++	++	-	++	++	++	++	++	++
Ostertagia	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Strongyloides	++	++	++	+	++	++	+	++	+	+	+	+	+	++	+	++	+	+	+	+
Ascaris	+	++	+	+	+	+	++	++	+	++	+	+	++	+	+	+	+	+	+	+

NOTE: Table 35 revealed that under captive condition the rhinos had only medium load of parasites (++) occuring through out the year. Infection due to A. perfoliata, ancylostoma and Ostertegia were found to be minimum.

TABLE - 36

Abundance of helminthes in the faecal samples collected from the wild condition.

The mean observations from different 5 sets (places) was expressed in the respective quarter of the year.

Name of the Parasites	1st quarter January to March					2nd quarter April to June					3rd quarter July to September					4th quarter October to December				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
F. gigentica	++	+	+	-	++	-	-	+	++	++	++	++	+	+	+	++	++	++	+	+
Paramphistomum	+	++	-	=	+	++	-	-	+	+	-	++	+	++	+	++	++	++	+	-
S. mansoni	++	++	-	++	+	+	+	+	+	-	++	++	++	+++	-	+++	+++	++	+++	++
A. magna	-	+	++	+	++	++	++	+	+	++	+	++	+	+	-	++	++	+	++	+
A. perfoliata	++	++	+	++	++	++	+	++	+	-	++	+	+	++	+	++	++	+	++	+
Ancylostomata	++	++	++	-	++	++	++	++	+	++	-	+	-	+	+	+	+++	++	++	+
Halmonchus	++	+++	+++	++	+++	++	++	++	++	++	+	++	+	-	+	++	+++	+++	++	++
Ostertagia	++	+++	+++	+++	++	++	+	+	+	+	+	+	+	+	+	++	+++	+++	+++	++
Strongyloides	++	++	++	++	++	++	++	++	++	++	++	+	+	++	+++	+	++	+	++	+
Ascaris	-	-	+	-	+	-	-	-	++	-	+	++	++	++	+	++	++	+	++	++

NOTE: Table 36 above revealed that in wild condtion medium to high load of infection due to parasites listed in the table were found to occur throughout the year. The load due to S. mansoni was highest during 4th quarter, i.e. October, November and December and highest due to Haemonchus and Ostertegia during 1st quarter and 4th quarters. The difference of one + of Halmonchus in the 4 the quarter attributed to render sampling error.

SYSTEMIC DISORDERS:

Tympanites:

A case of tympanites had been recorded in Assam State Zoo, Guwahati in captive condition, leading to death of the animal. The cause of the death could not be ascertained. Postmortem examination of the carcass, revealed heavy infestation of endoparasites.

Cardiac failure:

An adult male *R. unicornis* (length 291 cm, height at the shoulder 165 cm) was caught and caged from the Brahmaputra Char area. The animal died after 2 days of capture. The postmortem examination showed blood clot and congestion in the ventricular chambers of the heart and was suspected as a case of cardiac failure. This might be due to the stress and strain encountered during the capture and transportation.

Still birth:

A female *R. unicornis* in advanced stage of pregnancy was caught and transported by road. The animal gave birth to a dead calf at the end of the journey. The calf was found to be almost fully developed. This was another case of death due to stress and strain encountered during capture and transportation.

Horn decay:

A few cases of horn decay had been observed both in wild (n=1) and captive (n=3) rhinoceroses. It was ascertained that horn decay was primarily due to its being rubbed against the concrete walls of the Zoo under captive condition as well as on the trees while in wild condition.Predisposing cause might be due to irritation by ectoparasites at the site of horn or the head region leading to rubbing the horn against any object to get relief from the agony.

Wounds and Ulcers:

Wounds and ulcers are often found to occur in R. unicornis owing to fighting among themselves or from injury inflicted by poachers or other unknown causes. Such wounds or ulcers were treated (n=1) with $KMNO_4$ solution, oil terebinth and dressing oil for 5 days. It was found that the wound started healing after 30 days and the animal recovered completely.

OTHER CAUSES

Poaching:

Altogether 361 adult R. unicornis were killed by poachers during 1980-88 at Kaziranga National Park. (Table 40). Three different methods of killing were employed by the poachers in Kaziranga National Park. The methods were as follows:-

Digging pits: Poachers usually dig a pit on the rhino track which varies from 3.0 to 3.5 meters long, 3.0 to 3.5 meters wide and 2.00 to 2.25 meters deep. The pit is covered first by a thin canopy of bamboo net which is usually laid lengthwise and later breadthwise, and covered by grass of various size in order to give an impression that the track is clear and there is no obstruction. Besides these some pointed bamboo sticks are fixed at the bottom of the pit so that it will pierce the animal as soon as it falls into the pit. The R. unicornis moving along the track as usuall falls down unknowingly into the pit and gets pierced by the pointed bamboo stick. It dies in great pain or the poachers kill the distressed animal for recovering the horn from the head. Altogether 4 such pits were detected and examined.

Gun shots: In recent years fire arms are found to be used by poachers to kill the animal. The poachers generally aim at the head or the heart. Sometimes the animal escaped with severe injury and died after 4-10 days. 5 Cases of death owing to bullet injury were found and bullets recovered from head (n=2) and from the chest region (n=3). Altogether 193 cases of death of R. unicornis due to gun shots were recorded during the present observation.

Using poisonous plant:- Malacious practice adopted by the poachers using some poisonous plant along with the grasses was detected recently to kill rhino. Postmortem examination of ingested food collected from the carcas was subjected to chemical analysis which revealed the presence of aconite (poisonous plant alkaloid) in one suspected cases of death due to poisoning.

DROWNING DURING FLOODS:

Floods during the monsoon are one of the major causes of death for calves as well as the adult rhino. The Kaziranga National Park is generally flooded more than once every year. Forty one cases of death due to drowning during flood were recorded (Table 37) during the present investigation (1988).

TABLE - 37

Death of different age groups of *Rhinoceros unicornis* due to drowning

Stage of animal	No. of animals
1. Calves	30
2. Aduilt male	5
3. Adult female	2
4. Sub-adult male	1
5. Sub-adult female	3
Total	41

KILLED BY TIGERS:

Tiger are dreaded enemies of the new born rhino calf. Moreover as the Manas Wildlife Sanctuary has been declared "Project Tiger" and possesses a large number of tigers, the attack on young *R. unicornis* is found to be common every year. Incidences of 12 (twelve) rhino calves killed by tigers in the Kaziranga National Park were recorded during the present study. Besides one subadult male rhino attacked by a tiger rescued by the forest staff (1988). Treatment of the wound and other ailments was done regularly by the forest Veterinary Personnel and it was completely cured after 30 (thirty) days of treatment.

DEATH DUE TO FIGHTING

Fighting among the adult males due to competition over an oestrous female and premating fighting in case of females were not uncommon in *R. unicornis*. Two cases including one male and one female casualties were recroded during the present study.

ACCIDENTS:

Casualties of *R. unicornis* due to various accidents wre recorded in all the Wildlife Sanctuaries and National Park, in Assam. The causes of accidents were found to be as follows:-

i) Road accidents
ii) Rail accidents
iii) During wallowing.
iv) Caging and transport.

Road accidents:

The National Highway No. 37 runs on the South Eastern border of the Kaziranga National Park when the rhinoceros crosses this Highway particularly at night and especially during floods they are very often knocked down by heavy vehicles plying through the roads, resulting in the death of the animals. Three such cases of death were recorded during the period of study.

Railway accidents:

The N.F. Railway track runs very close to the Pobitora Wildlife Sanctuary. The rhinoceroses of this sanctuary, while going to graze in the nearby paddy fields have to cross the railway lines. Incidentally they were found to have been knocked down and killed by the running trains. Two such cases were recorded during the present study.

During wallowing:

The Kaziranga National Park possesses plenty of mud pools or swamps in which the rhinoceroses enjoy wallowing. Occasionally the animals were found to get caught in the deep and heavy mud and clay of the pool/swamp and due to its heavy body could not come out of it. Subsequently, the more they struggle to come out the more they go deeper and finally die after a few days. The young and weak animals were reported to be the common victims of such incidences. Two such cases one adult female and other sub-adult male were recorded during the present study.

Caging and Transportation:

The *R. unicornis* is very attractive show animal in the Zoo and as such, has great demand in the Zoological gardens. For this purpose, they have to be captured by various methods and then caged and transported to the destination. The animals become exhausted due to the stress and strain of these process leading to the death of some of these rhinos.

One case of death during caging and 2 (two) cases of death during transportation were recorded during the present study period.

Senility:

R. unicornis also has a regulated life span like other animals. Death owing to old age was found in captive as well as in the natural habitat. The senility was assumed or based on examination of its bulky body size and size of the teeth and wear and tear of dentition. In the present study 2 (two) carcases (No. I and No. II) were obtained from Assam State Zoo, whereas another carcas (No. III) was collected from Kaziranga National Park. Postmortem examination were carried out on these three carcases in order to ascertain the cause of death due to senility or otherwise.

TABLE - 38

Showing the physical features of the *R. unicornis* suspected to die due to senility

Body parameters	Specimen collected from Assam State Zoo, Guwahati		Specimen collected from Kaziranga National park
	Specimen No. I	Specimen No. II	Specimen No. III
1. Total body length (cm)	391	368	410
2. Length from point of shoulder to point of buttock (cm).	223	191	231
3. Head length (cm)	116	80	120
4. Neck length (cm)	58	52	61
5. Girth at chest (cm)	266	258	275

TABLE - 38 (Contd.)

Body parameters	Specimen collected from Assam State Zoo, Guwahati		Specimen collected from Kaziranga National park
	Specimen No. I	Specimen No. II	Specimen No. III
6. Shoulder height (cm)	178	162	185
7. Body weight (Kg)	2020	1987	2085
8. Body colour	Light grey	LG	
9. Condition of the teeth.	a) Decayed and loose in arrangement.		
	b) Incisor lost	IL	IL
	c) Canine teeth were seen prominently from outside.		
10 Ear	Serrated shrunken and reduced in size	SSR	SSR
11. Horn			
(a) Growth	FG	FG	FG
(b) Height (cm)	51	57	61
(c) Girth at base (cm)	62	64	67
Girth at middle (cm)	42	44	47
Girth at end (cm)	27	30	35
(d) Weight (g)	1082	1100	1150

LG = Light grey, FG = Fully grown, IL = Incisor lost, SSR = Serrated shrunken and reduced in size.

A careful examination of the body parts and postmortem examination of 3 (three) carcases did not reveal any pathological or other abnormalities as the cause of death.

The analysis of the records in the table 38 revealed that the animals were quite old and hence their death might be only due to senility. There are several reports on the life span of the R. unicornis observed in different zoological gardens and in wild condition. In the present observation the maximum period of longevity has been observed to be 59 years (Table 39).

TABLE - 39

Life span of Rhinoceroses estimated by different workers.

Workers	Life span
1. Sterndale, 1882	45
2. Blanford, 1888	i) 100*
	ii) 50-60
3. Sanyal, 1892	47
4. Flower, 1931	40
5. Collings, 1968	38
6. Arora, 1985	40
7. Misra, 1985	i) 40 years 11 months 11 days.
	ii) 38 years 8 months 1 day.
8. Present observation	i) 59
	ii) 51

* Wild

DISCUSSION

In recent years wildlife diseases have assumed considerable significance, specially due to enchroachment to forest land by landless people as well as villagers in the neighbourhood of Wildlife Sanctuaries and National Park in Assam, who rear livestock for various purposes. Diseases of wild and domestic animals are alike and are intercommunicable. Therefore, such diseases have emerged as an important field of epidemiological research. There is an increasing need to understand the nature and extent of these diseases from the stand point of wildlife conservation particularly in a country like India where the great diversity of wild fauna is one of its magnificant natural assets. Since wildlife constitutes one of the important reservoirs of numerous infectious diseases, affecting domstic livestock, it is necessary to detect and control, these diseases in the infected focii.

From the findings of the present investigation and other available information, it has been observed that death or reduction of the number of R. unicornis due to diseases and injuries have occasionally been encountered in captive and wild conditions, though most diseases are not so common, particularly in the wild state. There must be some diseases, yet undetected due to various constriants in their wild condition.

In the present study problems relating to diseases like tympanites, which is caused due to the formation of gas in the stomach, followed by diarrhoea and dehydration ,incidence of parasitic infestation in the gastrointestinal tract, stillbirth and horn decay have been encountered. Several cestodes (e.g. Anoplocephala, Moniezya) nematodes (Haemoncus, Ostertagia and Ancylostoma), trematodes (Fasciola) and protozoan (Coccidia) species were detected. It may be mentioned that some parasites were found to establish a commenselism phenomenon in this species. This was ascertained after postmortem examination of the carcases collected after death due to the poaching or accidents, which were otherwise found to be healthy.

The occurrence of protozoa and helminthes parasites was found to be common in R. unicornis. In the present investigation it has been observed that the load of parasites in animal under captive condition, was less than in the animals under wild condition. Heavy load of Anoplocephala (A. magna, A. perfiliata) and Ascaris (Haemoncus, Ostertagia) were detected frequently in the collected faecal samples, from dung heaps. Further, there was a tendency to show a higher load of parasites during the months of December to April. The parasitic load in the captive animals was routinely checked. Inspite of this reinfestation might have occurred from external sources like contamina ted feed and water.

The parasites which were detected in R. unicornis in the Kaziranga National Park in the present study were found to be common in domestic cattle and buffaloes, indicating cross infection between domestic and wild animals i.e. R. unicornis.

Tympanites was found to occur in captive animals due to the consumption of high proteinous diets, without adequate movement or exercise.

Cardiac failure was recorded in *R. unicornis* resulting from stress and strain of capturing operations and transportation thereafter.

As a whole *R. unicornis* was observed to be less succeptible to various diseases as compared to domestic animals, which might be due to its pollution -free environment as well as free living, usually in solitude.

Flood is one of the major causes of death due to drowning in calves and subadult animals. The receeding flood water are also the carrier of various infections.

Poaching is another major cause of death in adult *R. unicornis* and poses a serious problem in the conservation of this precious species. A large number of animals annually become the victims of unscrupulous poachers mainly due to the presence of its valuable horn. The number of rhinos killed by poachers and deaths due to other diseases or natural calamities from 1980-1988 have been recorded in Table 40. (Source, Department of Forests, Government of Assam).

TABLE - 40

Year	Rhinos killed by poachers	Death of Rhinos owing to disease or in natural calamities	Total
1980	28	38	66
1981	24	39	63
1982	26	48	74
1983	37	48	85
1984	39	24	63
1985	48	26	74
1986	36	48	83
1987	40	53	93
1988	84	39	123

CHAPTER - VIII

CONSERVATION AND PROPAGATION STRATEGIES

In the process of exploitation of the earth's nature preserves by man for expanding population, and indiscriminate killing of the voiceless denizens for sport and for immediate profit, the world has witnessed the extinction of many reptiles, birds, mammals (Mukherjee, 1966) and other rare and magnificent animals from the surface of earth. The great one horned Indian Rhinoceroses, *Rhinoceros unicornis* also would have met the same fate, had not strict protection been extended to the few surviving species since the turn of this century, when it was recorded that barely a dozen rhino existed in Kaziranga National Park.

It was no doubt that *R. unicornis* was in large number in earlier centuries and it was prevailing from Indus valley, through the Ganges and extended upto the Brahmaputra valley. The indiscriminate killing or hunting by earlier kings, Emperors or other high influential persons of those times as well as the superstitions about the use of the rhino horn led to the decrease of the population of the animal. Besides all those, human interference with reference to killings, hunting or superstition, the environment also played a major role in diminishing the population of the rhino. In this context the change of climatic and other environmental conditions of Indus and Ganges valley which led to gradual dry climate and consequently loss of the earlier original habitat. Presently the species is found to survive in certain restricted pockets of North East India viz., the Kaziranga National Park and other wildlife sanctuaries of Assam viz., Manas, Orang, Pabitora, and Sonai-Rupai. It might be considered as the original home of *R. unicornis* along with Nepal.

As a whole certain policies of conservation and propagation of the species might be suggested after citing various causes of reduction of present number of the species as well as future strategies to conserve this rare species along with preserving its ecology of the habitat. It is clearly evident that the position of the species in Assam, North East India had been redeemed and it is a glaring example of how the destructive hand of man, on the contrary could also do a lot for their protection and survival if one considers the earlier number which was not more than a dozen in 1908. The figure rose upto 250 after 50 years and about 400 in 1966 only became more satisfactory in 1972 with percentage of increase being 11.25.

Thereafter, the percentage declined gradually 7.21 in 1978, 2.08 in 1984 and 1.88 in 1990 (Table 12). Patar (1977, 1980) showed that the annual increase in percentage of rhinos in Kaziranga National Park was decreasing uniformly at about 0.75 percent. This data was based on the Census reports of 1966, 1972 and 1978. However, the present investigation showed that the population growth per year during census periods from 1966 to 1990 gradually declined from 11.25 to 1.85 (Table 12) which require serious attention or strategies for its future conservation.

The entire facts leading to the tendency of decrease of the rhino population and the strategies to be followed could be summarised under two distinct heads - which would focus the (1) causes of its decrease as well as the (2) policies to adopt for the protection, conservation and propagation of the species.

1. **Causes of decrease of Rhino population**:

Possible causes oof decrease in Rhino population in the Kaziranga National Park.

(A) Human intereference in the habitat of *R. unicornis*:

(i) Superstitions hased upon certain parts of the body of rhino such as horn and nails are major attractions among the people leading to indiscriminate killing of rhinos by hunter or poachers is one of the major causes of decrease in rhino population.

Various stories, lores or beliefs which can be expressed as superstitions are prevalent along with the belief of medicinal value of urine, flesh, horn, skin etc. causes curious effects among people and they become crazy in order to have those things. These superstitions have been prevailing from time immemorial and nobody can say when it will end. Poachers are taking advantage of and thus they kill the animal mercilessly by adopting various means.

(ii) Encroachment of natural habitat of *R. unicornis*:

It has been found that there are some illegal occupants who have established their settlements in an around the Kaziranga National Park. This leads to various problems relating to safe movement of the animal and change in the ecology of the Park. The general problems created by these factors are summarised as -

(a) Encroachment of the land of the National Park by human habitation has resulted in conversion of forest land into cultivable land for various crops, construction of drains, pruning of high lands, and removal of earlier vegetation have changed the soil characteristic and the topography relating to the natural habitant of the species.

(b) Excess of domesticated animals within the Kaziranga National Park: Domesticated cattle, goats and pigs reared by the neighbouring villagers enter within the boundary of the National Park for grazing. It has been observed that from the Buhrapahar area onwards upto Bokakhat region along the National Highway a large number of such domesticated animal usually enter daily and graze or roam within the boundary of the Park. These animals are the carriers of various parasitic, bacterial and viral diseases of wild and domesticated animals all the time. Several parasites of domesticated animals have been recovered and recorded during the present investigation. The occurrence of a highly contagious disease, anthrax was reported in the rhino population by Choudhury (1964) and Pathak (1978).As such needs careful consideration of taking preventive measures against occurrence of such diseases not only in the rhino population but also among other animals in the Park, as well as other sanctuaries.

(iii) Urbanization:

Urbanization tendency and development of township in an around rhino habitat and in this context the development of the townships-Kaziranga and Bokakhat are noteworthy. Although the development of certain establishments are unavoidable and at present not creating any serious problem but possibility of creating disturbance in the habitat of rhino in future cannot be ruled out since urbnnization programme always expands and there is every possibility of expansion towards the boundary of the Kaziranga National Park.

(a) Besides, along with urbanization certain other ancilliary developments such as the constructions of present National Highway, roads between the Karbi plateau hills and the National Park have created a demarcation between the park and the hill areas. During floods the animal usually cross the Highway which runs from Buhrapahar hill range of Karbi plateau upto Bokakhat. Several records of accidents by vehicles plying through the National Highway leading to the death of many rhino have been reported earlier. Further, construction of some other roads or subway for going to different tea estates are sources of problems.

(b) There is the proposal for the construction of a broad guaze railway lines along the side of the National Highway in the near future, which if implemented would pause a great threat not only to the rhinos at Kaziranga National Park, but also to other wild species of flora and fauna as well.

(B) Natural calamities and environmental problems:

(i) Flood:

The river Brahmaputra is the immediate boundary of the Park and during monsoon the river overflows the northern bank and flood water submerge 75-80% of the total land mass. The occurrence of floods every year is one of the major causes of decrease in the rhino population. In 1988 several rhino calves (n=30) including subadult (n=4) and adult rhino (n=7) were swept away by flood and died of drowning. The flood sometimes occurred more than 4 times (in 1988) which caused serious damages to the habitat and the propagation of the rhino. It can easily be imagined the magnitude of damage, as the flood water sometimes remains for more than 10-20 days.

High floods submerging the whole Park and the high land inside the park deprive the animals from food and shelter. The animals are compelled to concentrate and take shelter on the roads, high lands and in the Karbi plateau. A large number of animals migrate from the sanctuary to the nearby Karbi hills (Mikir hills), crossing the National Highway.

(ii) Soil erosion:

Every year large chunks of land from the northern boundary of the park are eroded away by the Brahmaputra river. New river islands are also formed near park. But owing to legal complications such islands can not be added into the park. Further, the new areas formed by silt deposition adjoining the park takes time to stabilize and support growth of vegetation. The seriousness of the damages done by erosion can be gauged from the fact that the present area of the Park is 37,822.43* hectares against the original 42496 hectares. Further, the

* Note: Choudhury, 1985.

areas of erosion go on changing along with the change in the course of the Brahmaputra river. In fact the lower reaches of the Brahmaputra near Kawaimari area was found to be severely affected. All the observations and calculations were made on the basis of original area of 430 sqm.k.m. The loss of land due to erosion etc. were not accounted for in the present studies owing to non-availability of official record on this.

(iii) Drought:

The occurrence of drought during February and April hampers the growth of new seedlings of the (particularly at the burning sites) grasses. The burning of forest usually practice every year from December to March. The growth of grass seedling is greatly affected if there is no rainfall at the end of February or in March which creates temporary scarcity of fodder for the animals inhabiting the Park.

(iv) Emergence of exotic growth of weeds:

It has been observed that certain exotic plants (weeds) such as *Eichhorning crassipes* (water hyacinth), *Mikenia* etc. (Dutta, 1985) are expanding so much that 90 per cent of the entire aquatic vegetation is water hyacinth. Although the rhino consumes this plant as a food item, yet its preference is occasional and only during wallowing they consume it. The water hyancinth has invaded almost all the rivers, swamps and beels of the National Park. Due to its rapid growth and excessive spreading capacity, the species has covered the entire aquatic space. The water hyacinth that were removed during winter accumulated on the banks of the beels, rivers or swamps form a thick layer of drymass and it prevents the grwoth of other grass or vegetation.

Mikenia another weed is a climber and has spread in many areas of the parks inhibiting development and growth of other plants. This plant is not consumed by rhinos.

2. **Strategies to be developed for conservation and propagation *R. unicornis*:**

(A) Restriction of human interference:

(i) Hunting, killing or poaching should be declared as extreme offence, and completely stopped by strict enforcement of laws against them. Patrolling by security guards all around the boundaries of the park must be intensified, all the vulnerable points especially the northern boundary must be given special attention. Arm guards with modern fire arms with adequate training of their use and patrolling techniques be deployed. They may be provided with handy wireless equipment wing stationed in the park for help or reinforcement when ever felt necessary at the sight of notorious poachers.

(ii) The encroachment by human habitat in the Park area and excess of domesticated animal to the park should be stopped and cultivation of land inside the park by people from neighbouring villages be stopped in the interest of safety of the conserved animals against infections diseases as well as help reducing poaching.

(iii) No further extension of Highway, subway or even the proposed railway lines along the boundary line of the Park, be allowed in the larger interest of conservation of precious wildlife of the park.

(B) <u>Control of natural and environmental parameters:</u>

(i) <u>Flood and erosion</u>:

Flood and erosion is a problem of annual occurrence which someties occur 3-4 times (or even more) in a year along with erosion along the boundary line of the river Brahmaputra. The control of flood by construction of embankments with provisions of entry and discharge of water to and from the park. Development of certain high lands as platforms are of utmost significance. State Forest Department of Assam (India) has built a few such high lands or platforms inside the park having 180 metre in length, 18 metre in width and 3 metre in height which has helped a large number of animals during floods of 1987 and 1988. A proper planning and design for regulation of flood water require an extensive exercise.

In this connection, the Central Government agencies of India, World Wildlife Fund or United Nations and World Bank etc. may be requested for their assistance to study the problem and provide financial assistance for its control permanently in order to save the precious wildlives of the Kaziranga National Park.

(ii) Control of growth of weed plants:

(a) Control of growth of exotic weed plants like water hyacinth and mykenia should be regularly done by means of mechanical or manual device to clean the water bodies, 90 percent of which are covered up with water hyacinth.

(b) It has been observed that certain areas of the park are devoid of the most common food plants like *Andropogon*, *Chrysopogon*, *Cyndon*, *Saccharum*, *Imperata*, *Erianthus*, etc. commonly consumed by *R. unicornis*. These species of plants may be planted in those areas. This plantation of the above mentioned food plants would create a favourable change in the ecology of the area.

(C) Soil and water analysis of the area adjacent to the Tea Estates:

(i) The frequent use of organic compounds such as pesticides, weedicides and other chemicals in the tea industry adjacent to the boundary of the Kaziranga National Park should be constantly monitored in order to prevent contamination of grass land in the park by these injurious agents.

The drainage system emerging from the tea estate should be diverted away from the direction of Kaziranga National Park.

(D) Health monitoring programme of wildlives:

(i) Certain health monitoring programme of the wild animal inhabiting the Kaziranga National Park should be developed. Although it is a very difficult task, yet the routine examination of faecal samples and the general health condition and treatment of injured animals may be developed with a mobile van unit within the Park and record maintained. In the present investigations several species of parasites were detected from the faecal samples of rhino. The occurrence of epizootic diseases that are prevalent in domestic animals, cannot be ruled out. Hence, a constant vigil should be enforced for preventing the excess of domesticated animals into the National Park.

Further apparently diseased animals with debilitaed condition should be removed from the park and if necessary killing or shooting out of such animals should be carried out.

(ii) Domestic animals of the villages around the National Park should be regularly vaccinated against contageous and infectious or serious diseases.

(E) Creation of new Rhino-land:

(i) There are certain forest lands which are ecologically suitable for rhino habitation might be converted into rhino-land by declaring it as a sanctuary. In the present investigation the area from the Mayang reserve upto Chandrapur/Panikhaiti where certain numbers of rhinos occasionally found to roam or graze, appears to be almost like that of Kaziranga National Park. The area is about 120-150 sq. km., adjoining the river Brahmaputa. There are several streams and swamps along with the Kapili river and other small tributaries. These area appeared to be potential rhinoceros habitats which will furnish about 150 sq. Km. pure forest areas.

(F) Expansion of Kaziranga National Park:

An expansion programme has been drafted in order to expand certain areas along the side of the river Brahmaputra and that of Karbi hills, which have not been implimented might be due to administrative and other reasons. The expansion of the park will definitely create more area for the species.

(G) The movement of elephant:

Due consideration should be given to the proposal of Lahiri and Sonowal (1973) for regulating the number of elephant population in the Kaziranga National Park. This is required to prevent scarcity of fodder grown for the rhinos in the park since the elephants and rhinos use the same grass as their food.

(H) Rhino capturing:

The population density per sq.km of R. unicornis in the Kaziranga National Park has since 1966 increased from 0.93 to 1.56 in 1972, 2.23 in 1978, 2.51 in 1984 and 2.79 in 1990, which might be one of the causes of gradual decline in the percent growth of rhino population in the park. Hence a few Rhinos may be captured every year to reduce the density.

(I) Environment education and awareness programme:

(i) To create an awareness about the great animal which is on the verge of extinction with a limited distribution only in North East India and Nepal, certain awareness programme should be organised. A typical system of education should be incorporated from the level of primary education and also in the adult education programme of the country. The use of mass media like newspapers, television, radio and even public posters could change the entire idea of killing, hunting or poaching such rare animal. This awareness programme is of utmost significance which will make a direct impact on the conservation strategies of the flora and fauna of our great land.

(ii) Environmental club/organisation:

Voluntary organisation or clubs of young persons interested in preserving nature especially the flora and fauna might be involved in creating awareness programme amongst the growing genertion. The organisation of meetings, symposia or audio visual programme and demonstration etc. are some of the measures of implementing such ideas. There should be a collaborative programme for implementation of the objectives of conservation and propagation with those voluntary organisation and the Government Departments.

(J) Special conservation programme:

Considering its importance of being the only original home of the rhino and dwelling place of several other vanishing and rare species (Gee, 1964) and other national importance the Kaziranga National Park should be incorporated under the special programme of conservation policies of Government of India as well as of United Nations.

(K) Captive breeding programme:

It is essential that captive breeding programme be taken up for *R. unicornis* in certain selected Zoological gardens of India. This will help to understand the reproductive behaviour and physiology in details and further rehabitation programme in the newly created ecosystem or rhino-land.

(L) Research and monitoring for long time observation:

A thorough research and long time observation on the behavioural ecology concerning its propagation and reintroduction in new rhino-land is essential in order to conserve this rare animal. Hence, the Forest Institutions, other academic institutions, Government agencies and United Nation should chalk out a common strategy about its research and monitoring for long time observation. This is one of the major weakness of our wildlife conservation programme and the action plan aims to develop this particular aspect with the inclusion of national data bank on wildlife ecosystem, and R. unicornis in particular.

Nature has endowed India with such abundant and varied flora and fauna, particularly in North East India where the ecosystem has distinct and unique feature. The habitat of R. unicornis in the Kaziranga National Park and its further distribution or occurrence in other wildlife sanctuaries has shown a specific ecosystem pertaining to its survival and propagation. The two decades covering the fifties and the sixties of this twentyeth century saw an attitude of total neglect and irresponsibility leading to massive and unprecedented destruction of wildlife and especially the rhinoceros in particular and their habitat, a process that has not been totally arrested yet. Fortunately, however, the seventies onwards have witnessed a change of approach and the attitude, a new sense of awareness about the environment and causes of death or decreasing trend of the population of R. unicornis.

The Indian Board of Wildlife has taken up various plans and measures since 1980 under Chairmanship of the late Prime Minister Smt. Indira Gandhi. The development of a National conservation strategy on the lines of the world conservation strategy for attaining sustainable development through the conservation of living natural resources has already been taken up (Majupuria, 1986; Rao, 1986; Singh 1984; Stracey, 1966).

In the present studies regarding the concept of conservation and propagation of R. unicornis with reference to the habitat of Kaziranga National Park certain suggestions are enlisted. Earlier Goswami et al., 1987; Bhattacharyya and Goswami, 1987 described certain reproductive, distribution and migration strategies of R. unicornis from its original home. There is no doubt that the objectives and management practices of Kaziranga National Park are mainly oriented towards the conservation of rhinos, although it is a place for the habitat of large number of other precious mammals, birds, reptiles, fish and other invertebrate fauna along with the various flourishing vegetation. The different analysis and their causes are described for the diminution trend of rhino population from 1972 onwards are alarming and whatever might be the rate of increase of population, it is necessary either to increase the area or buffer zone of rhinos in Kaziranga or to reintroduce rhino in the neighbouring natural habitats. Several suggestions are made for the increase of the area of Kaziranga National Park by creation of new rhino-lands in the natural habitats with proper aforestation to enable the rhinoceroses to feed, breed and maintained sound health for its propagation. (ii) to encourage the increase of the present rhino population in the existing sanctuaries (viz. Manas, Orang, Pabitora, Sonai-Rupai etc.), the well planned habitat management programmes should be taken.

Thus it might be concluded that to propagate the rhino population the area of the Kaziranga National Park should be increased and it should be suitably managed for the purpose and the other natural habitats also should be taken care of side by side. Otherwise, after few years, it will jeopardise the propagation of the population as well as the general eco-biology of the *R. unicornis* with reference to the ecology of the Kaziranga National Park.

SUMMARY

Studies on certain aspects of the biology of the one honred Rhino R. unicornis, were undertaken primarily in the Kaziranga National Park, and partially in other neighbouring wildlife sanctuaries, viz. Manas, Orang, Pabitora and Sonai-Rupai of Assam,India. Observations were also made on captive stock maintained at the Assam State Zoo, Guwahati. The study on different behavioural and biological aspects were made and recorded, with reference to distribution and taxonomic status, ecology of the natural habitat, food and feeding habits, general behaviour, physical features and anatomy common diseases, causes of death and longevity.

i) Of the living Rhinocerotidae family under grand order 'Ungulata', order 'Perissodactyla', only 5 species exist in the Africa and Asian continents. Other species of Rhinocerotidae which flourished in the tertiary period became extinct owing to the failure to cope with the evolutionary process or competition with other ungulata. The taxonomic status of 5 species of living rhinoceroses are as follows.

Phylum	:	Chordata
Sub-phylum	:	Vertebrata
Class	:	Mammalia
Sub-class	:	Theria
Infra-class	:	Eutheria

Grand order	:	Ungulata
Order	:	Perissodactyla
Family	:	Rhinocerotidae
		i) Rhinoceros unicornis (The Great Indian one horned rhinoceros).
		ii) Rhinoceros sondaicus (One horned, small Javan rhinoceros)
Sub-family-	:	iii) Diceros bicornis (African, black and hook-lipped rhinoceros).
		iv) Ceratotherium simum (African ,white square-lipped rhinoceros).
		v) Didermocerus sumatrensis (Two horned Sumatran rhinoceros).

ii) Although R. unicornis was widely distributed from the Khyber Pass to Sadia (North East India) upto the sixteenth century with the presence of some individual animals in West Bengal and Nepal, the present study reveals the presence of R. unicornis mostly in the Kaziranga National Park along with nearby Sanctuaries with Manas, Orang, Pabitora of Assam.

iii) The movement of R. unicornis along the North and South banks of the River Brahmaputra from the districts of Kamrup to Jorhat, the absence of their record of occurrence in Karbi Anglong and beyond towards South Kamrup, and further occurrence in the great river island, Majuli is noteworthy. There is no record of the occurrence of R.

unicornis in Dhubri, Goalpara as well as in the upper reaches of North Lakhimpur district in the northern bank of the river Brahmaputra.

iv) Altogether 220 food plants of 76 families were identified from the grazing ground of R. unicornis in the habitat of the Kaziranga National Park.

v) The Population density of R. unicornis along with other herbivores sharing the same food plants was analysed from the respective census reports. There is a gradual decline of growth in the number of R. unicornis in subsequent years. The percent grwoth rate showed a graudal declination from 11.25% (1972) to 7.21% (1978),2.08% (1984)and 1.85% (1990) observed during present studies. The population density of R. unicornis per square kilometre showed a gradual increase from 0.93 (1966) --- 1.56 (1978) --- 2.23 (1984) to 2.79 (1990) during the present observation in the Kaziranga National Park.

vi) The environmental parameters recorded were rainfall, minimum 1100 mm and maximum 2554 mm, temperature minimum 10.3°C and maximum 32.7°C and humidity, minimum 60% and maximum 95% in the Kaziranga National Park.

vii) The R. unicornis has been observed to feed chiefly on grasses in the natural habitat. The grasses include tall and short varieties, shrubs and aquatic plants. The animal spent most of the time in the day in grazing. Though the animal was found to pick up varieties of species while grazing, it prefers mostly the following species of grasses: Erianthus ravenae, Cynadon dactylon, Hemerthia compess, Arundo donox, Imperata cylindrica, Pollinia cilitia, Pseudostachyum polymorphum Saccharum, arundinaceum, S. elephantium, S. nerenga, S. spontaneum, Vetiveria zizaniodes etc.

viii) The The scarcity of food during and immediately after floods has been observed, where the animal suffers from starvation and the development of diarrhoea and other diseases like parasitic infections etc. The feeding behaviour during grazing, floods and during the burning of the forest has been observed in different periods.

(ix) In the captive state R. unicornis were supplied with 100 kg of grass along with 5 kg of concentrate (mixed feed), with the addition of 2 kg of fruits and 20 g common salt. In some cases they were supplied with mineral mixture too. This food ingradients were supplied daily to an adult animal.

x) The rhino calves are naturally brought up on the mother's milk. During their early life they solely depend upon the mother's milk upto 2 months of age. Thereafter, they start picking up new succulent grass occasionally,while moving with the grazing mother.

xi) The tender calves could be well raised by feeding on cow's milk along with the supplement of mineral mixture, starting with a dose of 8 litres of milk which was increased upto 15 litres per day per calf. Boiled rice and banana were given as solid starter foods.

xii) The R. unicornis were found to possess habits consisting of easy walking, roaming, galloping, free grazing, wallowing, swimming, defecation and making dung heaps, urination by passing jets of urine different types of vocalization for communication among themselves, having symbolic relations with other ungulates and birds, reactions to man and other adult male rhino, maintaining the cow-calf pair and adult male-female pair.

xiii) The duration of oestrus lasted for 26 hours. The duration of oestrous cycle was found to vary from 38 to 46 days in the captive state and 24 to 49 days in the natural habitat at the Kaziranga National Park. The length of gestation period was 461 and 506 days as observed in 2 cases. The act of parturition was observed as - duration of labour pain varied from 170 to 760 minutes; the time of expulsion of the foetus varied from 22 to 25 minutes; time taken from expulsion of foetus to expulsion of placenta varied from 120 minutes to 190 minuts; weight of the placenta 4.2 kg inter-calving period 624 days. The biometrics of the new born calf were recorded as length 105 to 110 cm, girth 93 to 97 cm, height 45 to 66 cm and body weight 60 to 64 kg.

xiv) The study of the physical features and anatomy of the adult R. unicornis revealed the following biometrics - total body length

345.6 (278-391) cm, length of head 92.6 (80-116) cm, length of body (from point of shoulder to point of buttock), 191 (159-223) cm, length of neck 49.6 (39.58) cm, length of tail 60.7 (58-62) cm, girth at chest 258 (246-273) cm, height 166 (158-178) cm and body weight 1938.3 (1808-2020) kg. The size of the head in the male is bigger than in that of the female.

xv) The skin of the R. unicornis is peculiar with an armour like plating with possesses some rivets like out of growth "tubercles" or projections. The projections were found to be of different sizes large, medium and small numbering 34, 32, 27 respectively counting over an area of 10 x 10 cm^2, on the buttock region. A distinct sexual dimorphism with reference to skin folds in both sexes was observed, where the neck folds were more distinct in the adult male than in the female.

xvi) The single median horn on the nose is the main point of attraction of the species. The biometrics of the horn were found to be; girth at base 48 to 62 cm, middle part 31 to 42 cm, end part 20 to 27 cm, height 16 to 51 cm, weight 300 to 1082 gm. The horn is a modified skin, there is no horn core. Female R. unicornis has a smaller horn than the male is a characteristic point for distinguishing the sex from distance.

xvii) The R. unicornis was found to bear 3 nails in each leg, numbering 12 in total. The nails are almost of equal size.

xviii) The R. unicornis was found to have very scanty hair on its body. These are distributed only on the eye lids, edges of the ears, and the switch of the tail. The maximum length and the diameter of the hair were found to be 3.2 cm and 0.017 mm respectively.

xix) The endo-skeleton of the R. unicornis was found to be very strong and stout. The maxilla was found to be very heavy, bearing the nasal bones and the upper jaw. The nasal bone is completely curved and pointed which bears the horn and unlike other ungulates it is complete. The mandible is lighter than the maxilla and bears the lower teeth. The total length of the maxilla was found to be 60 cm, girth at middle 68 cm and in mandible 54 cm and 52 cm respectively, while the total length of the skull was found to be 70.3 cm and girth at base to be 143.6 cm. The arrangement of the teeth were found to be $2(\frac{1}{1} + \frac{0}{1} + \frac{3\text{-}4}{3\text{-}4} + \frac{3}{3})$ total 30-34. There is no canine teeth in the upper jaw. The vertebral column comprises a series of bones with cervical (7), thoracic (18), lumber(6), sacral (5-6) and coccygeal (17-19), total 53-56. The bones of the fore limbs consist of scapula or shoulder girdle, humerus carpal bones, meta-carpal bones and the phalanges on both right and left sides. The ribs are the paired bones and they are eighteen in number. The bones of the hind limbs are heavier than the fore legs. They comprise the pelvic girdle, the femur, the tibia and fibula, petala, tursus, meta tursus and phalanges.

xx) The digestive system was found to consist of the mouth, pharynx . oesophagus, stomach, small intestine, large intestine and anal aperture, while the digestive glands consist of liver, spleen, and pancreas. The tongue which is the prehensile organ of the R. unicornis, is muscular with many glands on its dorsal surface; the ventral surface is smooth as in the horse and other herbivores.

(xxi) The heart of R. unicornis is a musculofibrous conical organ which possesses two surfaces, a broad base and a narrow apex. The lungs are spongy and extensive in structure. The urinary system consists of kidney, urinary bladdar and urethra. The urine of R. unicornis is peculiar, its specific gravity is 1.022 with colour yellow, and volume 3.36 litre. The urine showed sedimentation on standing and forms foam on shaking.

xxii) The genitalia of the female R. unicornis comprises two ovaries, two oviducts, two horns, body of the uterus, cervix, vagina and two vulvar lips, while the male genitalia comprises the two testes without scrotum and penis along with their accessories. The male copulatory organ is the penis. The penis of R. unicornis on its glans part possesses 3 rows of petal like structures. The placenta of the R. unicornis is of the diffuse type. The mammary glands are two in number and inguinal in position.

xxiii) The rhinoceros suffers rarely in natural habitats, but diseases are detected in the captive state. Diseases like diarrhoea, tympanites, cardiac failure, still birth, horn decay, wound and ulcer, parasitic disease were detected in the study. Death due to poaching, drowning during flood, killed by tigers, death due to fighting, due to accidents, senility were recorded during the study.

xxiv) Positive thoughts about the future conservation of the species have also been contemplated in this study, in order to check the causes of diminution, extension of habitat, periodical examination of the existing habitat with reference to food plants, soil and flood problem along with diseases. Extension education with regard to love and sympathy for the R. unicornis was suggested. A detailed analysis of the causes of the decreasing tendency of the population and other problems of the R. unicornis in the Kaziranga National Park, along with possible remedies and developmental aspects for propagation and conservation and creation of a new Rhino land have also been elucidated.

The research on the Biology of reproduction in further detail alongwith the ecology studies would provide informations on measures to be adopted for future propagation and conservation of the valuable endangered species.

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APPENDIX-A

TABLE 16A

Table showing No. of pick up/bites observed in an adult male and female rhino from morning to evening (5 a.m. to 5 p.m.)

Food plants	Adult Male (n=1)	Adult Female(n=1)
Amaranthus spinosus	2	-
Andropogon aciculatus	8	3
Arundo donax	195	180
Bauhinia malabarica	-	2
Bombax malabaricum	10	19
Chenopodium album	10	6
Cynodon dactylon	190	218
Cyperus pilosus	122	152
Eichhornia crassipes	6	3
Elaeocaupus	2	1
Erienthus filifolious	75	109
E. revaneae	235	200
Erythrina suberosa	35	12
Ficus benglensis	12	18
Hemarthia compess	200	228
Hydrocotyle asiatica	7	16
Hygroryza aristata	9	13
Hymenachue amplexicaulis	174	158

TABLE 16A(Contd.)

Food plants	Adult Male(n=1)	Adult Female (n=1)
Imperata aurundanae	85	60
I. cylindrica	179	190
Ipomea reptans	42	30
Leea sambasia	7	-
Leersia hexandra	102	125
Listsea polyentha	7	15
Moras alba	5	8
Nymphea lotus	10	15
Phragmites karka	188	197
Pistia stratiotes	15	7
Saccharum elephanteum	130	145
S. spontenum	112	98
Vetiveria zizanioides	80	45